CYCLOPEDIA OF FARM CROPS

L H BAILEY

Cyclopedia of Farm Crops

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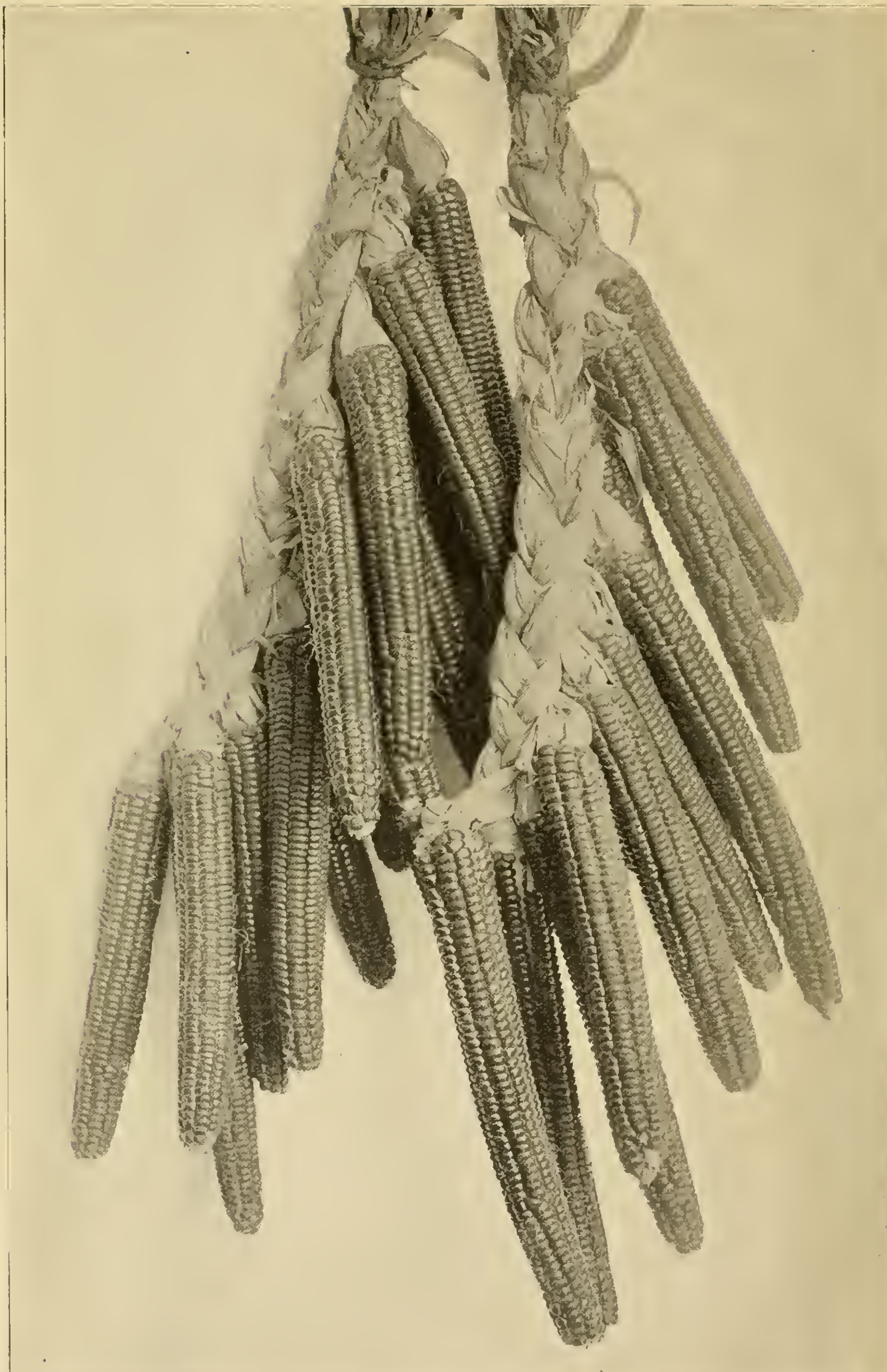

Plate I. Maize. The flint type, much grown in the northeastern country.

CYCLOPEDIA OF FARM CROPS

A popular survey of crops and crop-making methods in the United States and Canada

EDITED BY

L. H. BAILEY

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PREFACE

Within the area of North America north of Mexico, the range of agricultural cropping comprises one hundred to two hundred kinds of plants, not counting the many horticultural and very special things grown for ornament and personal satisfaction. An account of these plants, together with the methods of growing them, is contained in this Cyclopedia, to which more than one hundred experts have contributed.

It is not sufficient, in these days, merely to know the kinds of plants and how to grow them. The reader should have a background of other plant knowledge, as a part of his agricultural education. This Cyclopedia aims to provide this introduction and preparation in such articles as those relating to the structure and physiology of plants and to their response to artificial stimulus, and in those touching the modification of plants under the hands of the plant-breeder. The diseases of plants and the insects that attack them come also within the range of this knowledge of preparation; and the kind of efforts now undertaken to enrich our agriculture and horticulture by the introduction of promising plants from other parts of the world should also be understood. These all contribute to the education of the mental attitude.

The reader having come intellectually prepared to the subject of crop-growing, he will want to know the principles underlying cropping and rotation systems, the management of weeds, the growing of plants under covers of various kinds, and the accumulated experience of seeding, planting, and transplanting. To this part of the subject are added tables and lists of yields and legal weights in the United States and Canada.

The foregoing subjects comprise about one-fourth the text of the volume, covered in Part I with seven chapters. Part II covers the manufacture of crop products in the way of canning, preserving, evaporating and pickling, and the making of juices. The larger commercial operations in these fields are, of course, not described, for they belong in industrial manufacture rather than in agriculture.

These general subjects having been dismissed, the reader comes to the alphabetic list of crops. For the most part, the horticultural crops and plants are omitted as they are very numerous, and they are specially discussed in the Editor's Standard Cyclopedia of Horticulture. To add them would increase the size and expense of this work beyond all bounds, for the subject requires, even for brief treatment, six large volumes in the other Cyclopedia. However, fruit-growing and truck-growing are treated, as these run to large-acreage operations and partake of the nature of general agriculture. Particular attention is given to the farm forest subject. Although it is sometimes said that forestry begins where farming ends, the two are only complements one of the other, comprising different ways of cropping the land. To grow a woodlot is only one form of agriculture, and it is a form that must greatly increase in importance as we enter the domain of public economy that demands the best utilization of neglected lands. It is a sharp reflection on our State policies that so many of these lands in natural forest regions still remain repulsive and waste.

As an educated point of view is essential to the joyful approach to the subject of cropping, so is a similar mental preparation useful in the discussion of the particular crop. Therefore, something of the nativity, naming, distribution and other factors introduces the crops, in a form as condensed as is consistent with accurate statement. A closer study of the plants themselves is essential to a masterful hold on the cropping subjects. The trained observation is directly useful, also, in the understanding of the diseases and insects that follow the crops of man as they also follow the crops of nature.

The reader may find in this volume much information on crops that are scarcely agricultural in a large sense and which are not included in the Cyclopedia of Horticulture. Thus the article on Medicinal Plants provides a ready cyclopedic reference in an interesting field, as also those on Fiber Plants, Incidental Forage-like Plants, Oil-bearing Plants, Paper-making Plants, Dyes and Dyeing. It is often difficult to find such information in available form.

The book is not unrelated to the home, as the article on the Home Gardens testifies, as well as that on Ornamental Plants. It is the aim of educators to converge all the agricultural riches into the betterment of rural homes.

This much the Editor has felt impelled to say as a reason for the re-publication of this volume. The Cyclopedia of American Agriculture is for the present out of print, as such. The great expense of book manufacturing at present precludes the immediate reprinting of it as a whole, and the demand has disposed of all the stock of former printings. The volumes on Crops and Animals are separately called for to such an extent that they are republished, however, to continue as much as possible of the old work, each as a Cyclopedia in itself. The work of the many persons who wrote the articles is timely and useful and deserves perpetuation.

L. H. BAILEY.

November 14, 1921.

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PART I

THE PLANT AND ITS RELATIONS

PLANTS AND ANIMALS COMPRISE THE PRODUCTS OF AGRICULTURE. The plants make it possible for the animals to live. The purpose of this volume is to discuss the plant products of the farm; and the first general subject that may receive attention is a discussion of the plant in its physiological relations with its environment and with various practices of the cultivator.

In its broadest application, agriculture is concerned with all plants that are grown by man, whether for his own direct use in food and clothing and shelter, or for his animals, or for the gratification of his æsthetic tastes. The kinds of plants that are grown for his own sustenance and protection and for his animals are comparatively few, and they are the ones intended in this Cyclopedia. The number that are grown to satisfy his artistic tastes are legion and they cannot be enumerated here; these are recorded, for this country, in the Editor's Cyclopedia of American Horticulture. All so-called horticultural plants and crops, whether for food or ornament, are included in that work, and therefore the fruits and vegetables are given only short and summary treatment in the present volume; and for the same reason, discussions of horticultural practices are omitted here.

The vegetable kingdom is of marvelous diversity. Any observing person has only to recall the range of his own observation to illustrate how true this is. From trees to water-plants and ferns and mushrooms and sea-weeds is a far sweep of organic forms. A glance at the contrasts of Figs. 1 to 3 enforce this range of the vegetable kingdom. Some of its members, as the bacteria, are even microscopic and not attached to the earth or other support. Some of these minute forms have the power of moving in their liquid habitation. The bacteria subsist on food organized by other plants or by animals, sometimes existing on the living body, when they are said to be parasitic, sometimes on disorganizing or decaying matter, when they are said to be saprophytic. Some plants, of larger size and more complex structure, become individually attached to a host plant, practically taking root thereon, as the mistletoe. Such plants may have foliage or green leaves, or they may be blanched and unable to organize food for themselves. The mushrooms and toadstools, representing the so-called higher fungi, are saprophytic on decaying matter in the ground or in old logs and litter. Most plants, however, are earth-parasites, fixed in the soil, drawing their food from it and supplementing this supply from the carbon of the air. Plants have become adapted to all places on the earth where life is possible, modified in duration, form, stature and physiological action. They have also become adapted to the struggle for existence with each other, contending for space and light. Some are creepers on the ground; others climbers on rocks and on their fellows; others tower above all competitors. Some are adapted to shady places. Some inhabit the water; others have escaped to the marshes, the plains and the hills. In the long processes of time, one kind has given rise to other kinds. Some forms have died and are lost. The plant creation is plastic, abounding and living. This creation stands between man and the soil of the earth.

Fig. 1. The parts of one of the flowering or seed-bearing plants. One of the ornamental beans.

The most marked division line in the vegetable kingdom is between the flowerless plants and the flowering plants, the former including all bacteria, yeasts, fungi, algæ (to which the sea-weeds belong), liverworts, lichens, mosses, ferns. The demarcation between these two groups is not so marked morphologically as it was once supposed to be, and the present tendency is to drop the distinction as respects the flowerless or flowering feature, and to speak of one group as spore-bearing and the other as seed-bearing; even this distinction is not wholly true, but the morphological phase of the subject does not need consideration here, and the two groups, being natural, may be maintained even if the terminology is unsatisfactory. The seed-bearers naturally divide into the gymnosperms, in which the ovules are naked (not inclosed in an ovary or pericarp), and the angiosperms, or ovary-bearing plants. The former include the pines, spruces, firs, larches, cedars, yews, and some other woody plants. Geologically, the group is old. The angiosperms comprise all the remainder of the flowering plants, making up by far the larger part of the conspicuous flora of the earth.

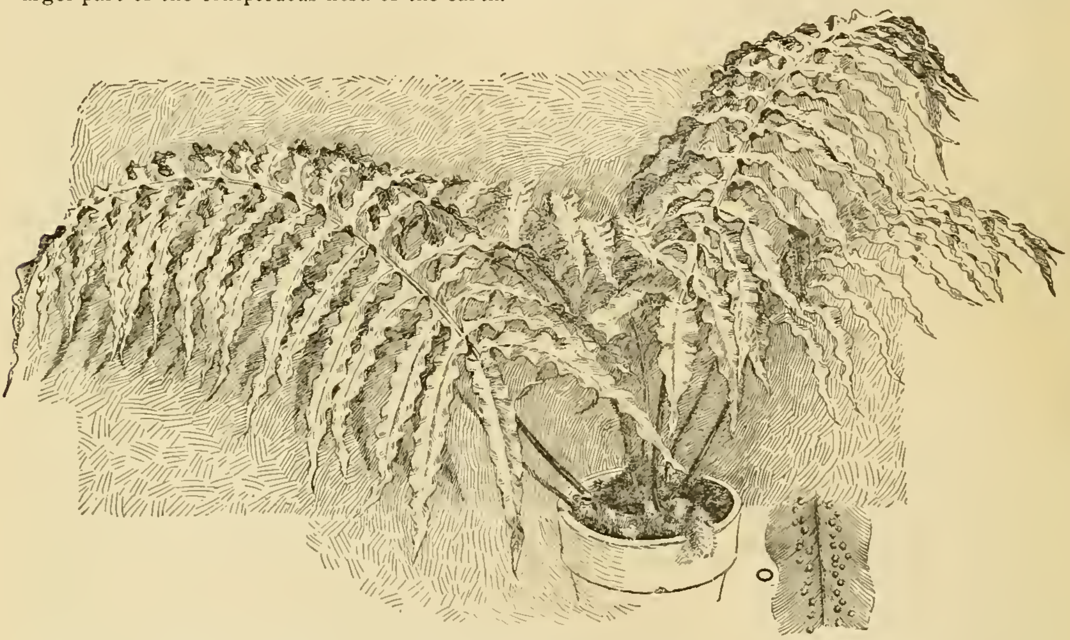

Fig. 2. A fern, one of the vascular (or vessel-bearing) flowerless plants. The fruit-bodies, bearing spores, are shown on the back of a leaf at O.

The custom has arisen of designating the kinds or species of plants by Latin-form names in two parts,— the first part or word standing for the genus or race-group, and the second part standing for the particular species or kind. Thus, all kinds of true clover belong to the genus Trifolium. The alsike clover is *Trifolium hybridum;* the white clover, *T. repens;* the common red clover, *T. pratense*; the berseem, *T. Alexandrinum.* Varieties of species, or subordinate forms, are designated by a third Latin-form word, as *Trifolium pratense* var. *perenne*, for the true perennial form of red clover. These names are always used with precision for one particular kind of plant, and they afford the only means of designating them accurately. Common or English names are of little service, as now used, in distinguishing species accurately.

Plants are also assembled in families, which are groups comprising genera that naturally resemble each other in certain bold or general characters. The farmer is specially concerned with the members of some of the family associations. The grass family, or *Gramineæ*, includes all the true grasses and the cereal grains, such as maize, wheat, oats, barley, rye, rice; also, sorghum and sugar-cane. The rose family, *Rosaceæ*, contains many of the fruits,— all the stone-fruits and pome-fruits, raspberry, blackberry, strawberry. The pulse family, *Leguminosæ*, comprises the nitrogen-gatherers,— all peas, beans, clovers, vetches, alfalfa. The mustard family, *Cruciferæ*, includes all the mustards, cabbages and kales, rape, turnip and rutabaga, radish. The nightshade family, *Solanaceæ*, includes potato, tomato, egg-plant, pepper, tobacco. The rue family, or *Rutaceæ*, comprises all the citrous fruits, as orange, lemon, lime, kumquat, grape-fruit. Other families contain only one or two agricultural plants of commanding importance; as cotton, of the *Malvaceæ* or mallow family; flax, of the *Linaceæ* or flax family; buckwheat, of the *Polygonaceæ* or knotweed family; beets and mangels, of the *Chenopodiaceæ* or pigweed family; sweet-potato, of the *Convolvulaceæ* or morning-glory family.

The number of distinct species of flowering plants now described is about 125,000. What this vast number has so far contributed to the food requirements of man has been made the subject of an inquiry by Sturtevant (Agricultural Science, iii, p. 174). Basing his list on Bentham and Hooker's "General Plantarum" (1862–1883), in which about 110,000 species of flowering plants are recognized, in some 200 families and 8,349 genera, he arrives at the following figures: 4,233 species, belonging to 170 families and 1,353 genera, are known to have furnished food for man either habitually or during famine periods; 1,070 species, belonging to 92 families and 401 genera, are or have been cultivated for human food. Among

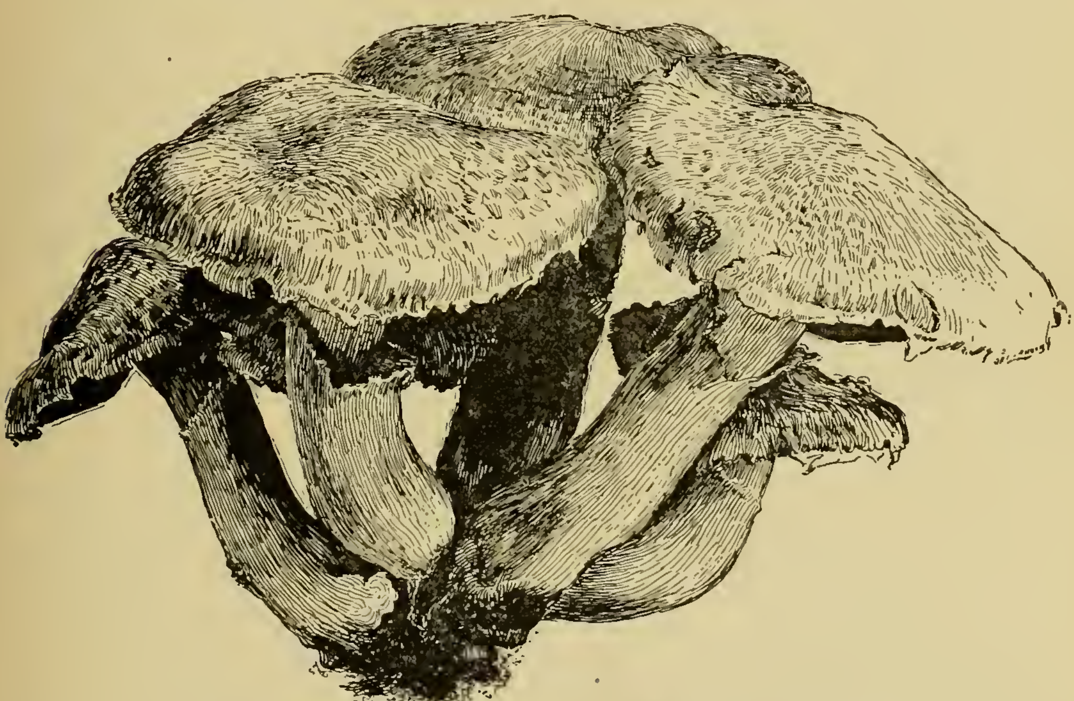

Fig. 3. A mushroom, one of the non-vascular flowerless plants. It is saprophytic.

flowerless plants 431 species have been recorded as edible, but only 5 or 6 are cultivated. In other words, about 3½ per cent of the known species of flowering plants furnish parts which can be eaten, and nearly 1 per cent are or have been cultivated for human food. About 300 species are cultivated to an important or commercial extent.

De Candolle, in "Origin of Cultivated Plants," discusses the origins of 247 species which are "cultivated on a large scale by agriculturists, or in kitchen-gardens and orchards." These belong to 51 families. They may be tabulated as follows:

Native to the Old World	
A. Cultivated for more than 4,000 years	44
B. Cultivated more than 2,000 years	47
C. Culture less than 2,000 years	61
Doubtful	47
	199

Native to the New World	
D. Very anciently cultivated	5
E. Cultivated when America was discovered, but less ancient	24
F. Cultivated only since discovery of America	6
Doubtful	10
	45

Of A, 50 per cent are annuals, 5 per cent biennials, 4 per cent herbaceous perennials, 41 per cent ligneous perennials.

Of C and F, 37 per cent are annuals, about 8 per cent biennials, 33 per cent herbaceous perennials, and about 22 per cent ligneous perennials.

Among all seed-bearing plants, "the annuals are not more than 50 per cent, and the biennials 1 or at most 2 per cent. It is clear that at the beginning of civilization plants which yield an immediate return are most prized. They offer, moreover, this advantage, that their cultivation is easily diffused or increased, either because of the abundance of seed, or the same species may be grown in summer in the North, and in winter or all the year round in the tropics."

Of the 247 species, 193 have been found wild, 27 half-wild or spontaneous and 27 are entirely unknown in a wild condition. Of the species in A and D, 63 per cent are known wild, and, of less than 2,000 years, 83 per cent.

Seven species (including the broad bean, tobacco, wheat and maize) appear to be extinct (or at least unknown) in a wild state.

The nativity of three ancient species of the group A is unknown—common bean (*Phaseolus vulgaris*) and two squashes (*Cucurbita moschata* and *C. ficifolia*).

The very ancient species, group A, "are especially plants provided with roots, seeds, and fruits proper for the food of man. Afterwards come a few species having fruits agreeable to the taste, or textile, tinctorial, oil-producing plants, or yielding stimulating drinks by infusion or fermentation. There are among these only two green vegetables, and no fodder. The orders which predominate are the Cruciferæ, Leguminosæ, and Gramineæ."

In De Candolle's discussion are not included several North American species that are now cultivated, as the native plums, cherries, raspberries, blackberries, and even the native grapes (on which a good part of our viticulture is founded). The addition of these would modify some of the above figures. For accounts of these plants, see Bailey's "Evolution of Our Native Fruits."

The Standard Cyclopedia of Horticulture (1914-1917), the six-volume work founded on the earlier Cyclopedia of American Horticulture, accounts for 20,602 species of plants, offered by dealers and known in cultivation for food, ornament, fancy, medicine and other uses. In addition to these species, 6,715 recognized Latin-named varieties are accounted for, making a total of 27,317 plants known to cultivation within the range of the Cyclopedia. The total number of binomial and trinomial botanical names admitted is 39,775, a good many of which, of course, are regarded as synonyms or duplicates. Of the more than 27,000 Latin-named species and varieties, 2,753 are native in North America north of Mexico. It is seen, therefore, that the western hemisphere is contributing great numbers of plants to domestication; if to this number are added the species derived from the hemisphere south of the Rio Grande, the contribution takes on great importance. Yet the species desirable for cultivation and known only in the wild are more numerous than we appreciate.

Cultivated plants may be thrown into four broad classes: those grown for domestic animals; those grown to provide shelter and clothing for man; those that provide edible, condimental or medicinal parts or products for man; those that appeal to the artistic impulses. These are not cultural groups however; nor is it possible to make any consistent cultural classification, since all groups overlap. Perhaps we cannot do better, as a rough working classification, than to make the following somewhat indefinite associations:

Forage and fodder crops
Cereal grains
Root crops
Fiber crops
Sugar plants
Oil plants
Dye-stuff plants
Beverage-producing plants
Stimulants
Aromatic and medicinal plants
Perfumery plants
Fruit (pomological) crops
Vegetable-garden crops
Ornamental plants
Timber crops
Manuring crops

In the present volume it is proposed to consider in some detail the important field crops, excepting such as ordinarily fall under the department of horticulture. The leading medicinal crops are admitted for brief discussion, and many incidental plants are mentioned, in order to make the book useful for reference. It is the purpose of this Cyclopedia to catch the spirit of the main agricultural industries in North America.

CHAPTER I

STRUCTURE AND PHYSIOLOGY OF THE PLANT

PLANTS EXERCISE TWO SETS OF FUNCTIONS,—GROWTH AND REPRODUCTION. The higher plants may be said to have three sets or classes of organs: those that have relation with the soil; those that have relation with the atmosphere and sunlight; those that are concerned in reproduction. For purposes of identification and description, and to enable him to read current literature intelligently, the farmer needs some account of these organs, and perhaps, also, of some of the gross features of the anatomy of the stem.

The external organs.

The organs of the root series are the least differentiated. We do not distinguish plants by means of their root characters, both because the roots are not clearly designative in most cases and because they are hidden. The most that we ordinarily do is to divide roots into fibrous-form and tap-form. The parts of the root are distinguished as to their physiological functions rather than their taxonomic or descriptive values. The general form of the root is determined by the species; but its details are conditioned on the particular soil in which it grows. It is often said of orchard trees that the roots extend as far as the branches of the top; but the root system may be less or more than the top in horizontal and vertical extent, depending on circumstances. Yet there is a distinct root "habit" even as between varieties of apple trees. In the annual crops, the root habit is often characteristic, and it needs much more attention than it has yet received by cultivators (Fig. 4). The farmer may examine carefully the leaves and stalks of his grass and wheat, but he seldom examines the roots. Food for man and his animals is provided by many thickened roots, as the greater part of the substance of carrots, parsnips, turnips and beets.

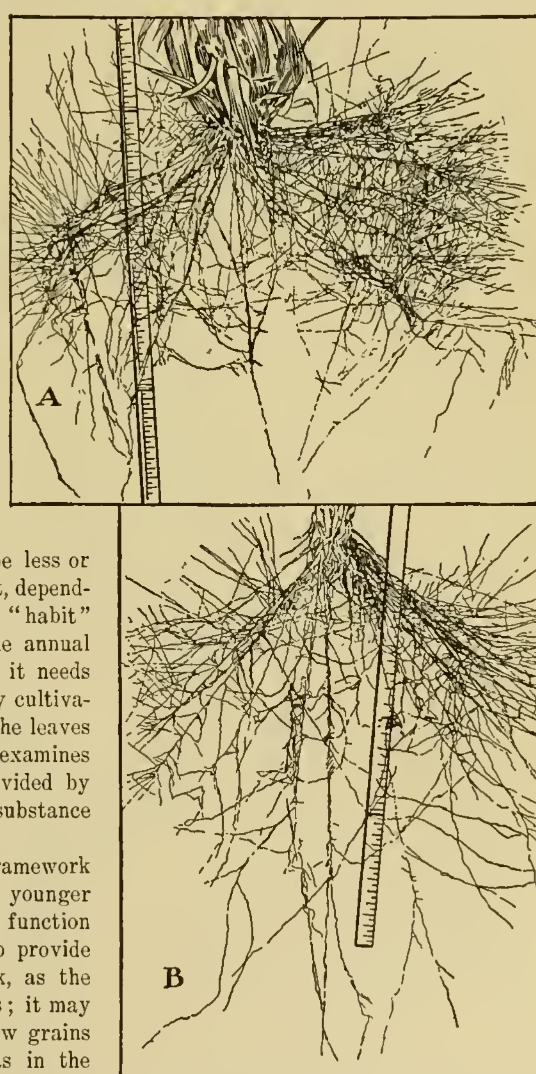

Fig. 4. Comparison of root systems of barley (above), and Indian corn (below). (Minnesota Experiment Station.)

The stem, as named by the botanist, is the framework on which the leaves and flowers are borne. The younger growing parts of it, containing chlorophyll, may function as foliage; but the main office of the stem is to provide support. The stem may be very short and thick, as the "crown" of turnips and beets, carrying the leaves; it may be exceedingly slender and light, as in the straw grains and grasses; or it may be high and massive as in the trunks of trees. Sometimes the stem is subterranean, in which case it is distinguished from roots by its buds or "eyes," and rudimentary leaf-scales: the tuber of the Irish or round potato is an example, and also the creeping rhizomes of quack-grass and other grasses. It will be noted, from this discussion, that the botanist, by the word stem, means to designate the leaf-bearing axis and its branches and modifications, and not the stalks of leaves and flowers. Thus, in the plantain and dandelion (Figs. 5, 26), the stem is very short, bearing a rosette of leaves at the ground; and from this arise the flower-stalks. In useful products, the stem provides timber, some of the fibers, and much of the forage; and it also provides human food, as in the potato, asparagus, onion, kohlrabi, sugar-cane.

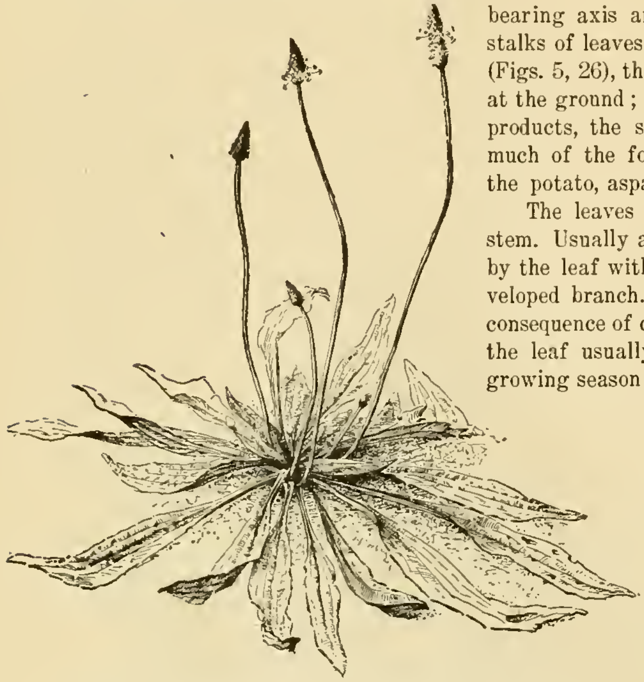

Fig. 5. A so-called stemless plant (narrow-leaved plantain), the stem rising little above the ground. The long flower-stalks (in such cases called scapes) spring from the stem.

The leaves arise normally from the joints or nodes of the stem. Usually a bud is borne in the axil or upper angle made by the leaf with the stem. The bud is a very short and undeveloped branch. If the plant is dormant a part of the year in consequence of cold or dry, or because of other hereditary habit, the leaf usually falls and the bud remains quiescent till the growing season returns: it is then spoken of as a winter bud. Sometimes the bud remains quiescent, but alive, for a longer period, in rare cases even for years: it is then called a dormant bud (Fig. 6). The older the dormant bud, the less the likelihood that it will grow, in case necessity should arise. The common notion that old dormant buds are readily forced into growth by pruning needs correction. In cases of heavy pruning, new shoots on old wood are more likely to arise from buds that are formed for the occasion, without reference to leaves and without order; these are known as adventitious buds (Fig. 7).

If the bud "grows,"—that is, if anything issues from it—it produces a branch. The branch may be exceedingly short, and bear only one or two leaves, or it may be several feet long and bear many leaves. If its destiny is to produce only foliage, it is known as a leaf-bud; if to produce flowers, it is known as a fruit-bud or flower-bud. Peaches and apricots produce typical fruit-buds (Figs. 8, 9). Apples and pears bear both true leaf-buds, and fruit-buds that give rise to flowers and leaves (Figs. 6, 10)—for the flowers of these trees are in clusters or bouquets accompanied by foliage.

Fruit-buds are distinguished by shape and position. In shape, as compared with leaf-buds they are usually relatively broader and more rounded, and they are likely to be more conspicuously fuzzy (Figs. 6, 8, 11). The position of the fruit-bud varies with the species. In most of the pome fruits — apples and pears — these buds are on spurs (very short branches, Fig. 6), or sometimes terminal on long axial shoots. In peaches, the fruit-buds are lateral on the current year's growth, usually one on either side a leaf-bud (Fig. 8). In plums and apricots, they are both on spurs and lateral on the long growth. The production of fruit-buds may be influenced to some extent by pruning, although this influence is not exact and definite. Pruning should always be practiced in full knowl-

Fig. 6. Fruit-buds of apple, on spurs; a dormant bud at the top.

Fig. 7. Adventitious shoots or "suckers."

edge of the position of the fruit-buds, in order that such buds may be saved or thinned, as the case may require. Merely to cut off limbs does not constitute pruning.

A leaf may comprise three parts,—the expanded part or blade; the stalk or petiole; appendages at or near the base of the petiole, known as stipules. These parts are shown in Fig. 12. Very many kinds of leaves bear no stipules. Many leaves also lack petioles or are sessile. The blade of the leaf is distinguished in form by comparing it with geometrical figures, as circular, rhomboidal, ovate, oblong, linear; or with familiar objects, as kidney-form or reniform, heart-shaped, lanceolate or lance-form, needle-shaped. The margins are distinguished as serrate or saw-toothed, dentate or toothed, sinuate or wavy, or as entire; and many other technical terms are used in descriptive works to distinguish leaves, in order to identify the species to which they belong. The leaf-blade may be of one piece, when it is said to be simple; or of two or more separate pieces, when it is said to be compound (Fig. 13). Leaves are common sources of food for domestic animals, forming a good part of the substance in hay and forage; they also afford human food in lettuce, rhubarb (petioles), celery (mostly petioles), salads and "greens."

Fig. 8. Two fruit-buds of peach, with a leaf-bud between.

All plant organs are usually explained in terms of roots, stems or leaves,—that is to say, the other organs are supposed to be derived from one or the other of these three types. Thorns and spines are branches (stems) in the hawthorns; leaves in the barberry; stipules in the common locust; outgrowths of the stem in common briars and many desert plants. Climbing organs are roots in the English ivy, trumpet creeper and poison ivy; main stems in hop and morning-glory; branches in the grape and Virginia creeper; leaf-blades in peas; petioles in some species of clematis; probably stipules in some kinds of smilax.

Fig. 9. Flowers of peach, one from each bud.

Flowers are supposed to be historically derived from leaves, as explained in the succeeding article. The parts of a flower may be in as many as four series (Fig. 14),—the calyx or outer part, usually most like the foliage leaves; the corolla, usually the showy part; the stamens or pollen-bearers; the pistils or seed-bearers. If the calyx has separate leaves, they are called sepals; if the corolla has separate leaves, they are called petals. The end of the stem on which the flower sits is called the receptacle or torus. All these parts are explained in Figs. 14, 15, 16, 17, 18, 40. Often, numbers of flowers are combined into one group or cluster; sometimes the cluster is so dense and definite as to appeal to the non-botanist as one flower, as in all the composites, of which the sunflowers and asters and goldenrods and thistles are examples (Fig. 16). Sometimes the cluster is less definite and yet compact enough to make a single impression, as in the clovers. Dried flowers form part of the substance of hay and forage. Flowers or flower parts or heads are sometimes eaten by man, as in the true artichoke, and also in cauliflower and pineapple in which the edible part is made up of a mass of thickened stem and flowers.

Fig. 10. A spur of apple, showing the leaves and flowers that came from the terminal fruit-bud.

The fruit, in technical and botanical usage, is the ripened pericarp (or ovary) and all the parts that are coalesced with it. In the agricultural plants, the pericarp may or may not be wholly free of adjacent parts. It is free in the cereal grains, and also the pod-fruits of the legumes (peas and beans and all their kin), the fruits of the orange kind, of tomatoes and peppers, the stone-fruits, and cotton, and the banana. The apple and pear are carpels (a compound pistil) imbedded in a thickened stem, the carpels forming the core. Melons, pumpkins and squashes are of similar morphology,—the turban squashes show the structure. The strawberry has many fruits imbedded in a pulpy stem or torus. The raspberry is formed of many cohering drupes. The blackberry is formed of cohering drupes attached to a specialized torus or stem. The fig is a hollow torus or stem with many fruits on the inside; it may be likened to a strawberry turned inside out. The mulberry is a cluster of ripened fruits; the bread-fruit is similar. The gooseberries (Fig. 19) are ripened ovaries, the dried flower-parts remaining attached. Currants are similar, but the flower-parts usually drop early. Some fruits, as the chestnut (Fig. 20) and walnut, are contained in burs or husks that are no part of the fruit itself.

Fig. 11. Cluster of fruit-buds of sweet cherry, with one pointed leaf-bud in center.

The stem structure.

The internal structure of the plant does not give rise to such definite parts or organs as appear in the external conformation. The plant-body is made up of cells. Some of these cells perform one work and some perform another work. The fundamental tissue is parenchyma. In this tissue the cells are very similar one to another, more or less cubical or equal-sided, or at least not greatly elongated. The vital processes take place in the parenchyma. Out of the parenchyma the other and special kinds of tissue develop.

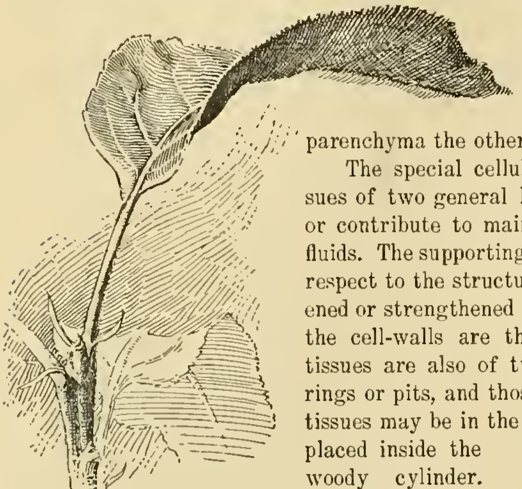

Fig. 12. Leaf of apple, showing blade, petiole, and small narrow stipules.

The special cellular structures in the stem are chiefly mechanical tissues of two general kinds of elongated cells,—those that support the plant or contribute to maintain its form and stature, those that transport the fluids. The supporting tissues, giving rigidity to the plant, are of two kinds in respect to the structure of the cell-wall: those in which the cells are thickened or strengthened in the angles (collenchyma, Fig. 24), and those in which the cell-walls are thickened throughout (sclerencyhma). The conducting tissues are also of two kinds: those with trachea-like walls, marked with rings or pits, and those with punctured or sieve-like walls. The supporting tissues may be in the epidermis of young or of small stems, in the bark, or placed inside the woody cylinder. The conducting tissues are usually definitely placed, and these we may consider further.

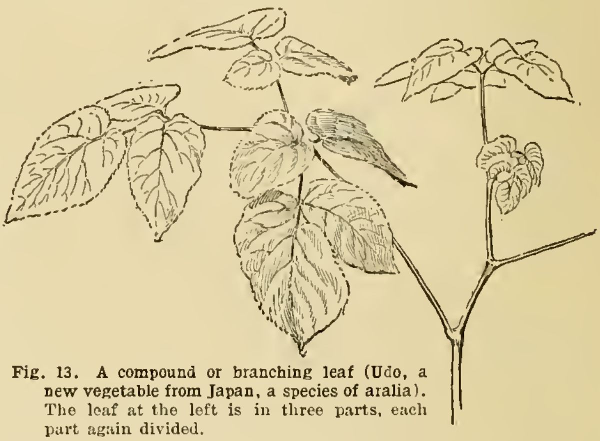

Fig. 13. A compound or branching leaf (Udo, a new vegetable from Japan, a species of aralia). The leaf at the left is in three parts, each part again divided.

The development of these mechanical tissues (for transportation and support) results in the formation of vessels, or systems of specialized tissue in particular parts of the stem. Vessel-bearing plants are said to be vascular, in distinction from certain very low orders of plants in which no special tissues of this kind have been developed.

It is well known that trees of temperate climates and very many other plants have a distinct and separable bark and that they increase in diameter by "rings" added on the woody cylinder. On the other hand, palms, grasses, bananas and many other mostly herbaceous plants increase in diameter by means of tissues scattered through the stem; these plants do not make an annual ring, and they rarely branch extensively. The former kinds of plants were formerly called exogens, or outside-growers, and the latter endogens or inside-growers. These terms are now given up, however, as not expressing good anatomical distinctions. These classes of plants are now named from the cotyledon or seed-leaf characteristics,—the former having two leaves on the embryo plant, and called dicotyledons; the latter having one leaf in the seed or embryo, and called monocotyledons.

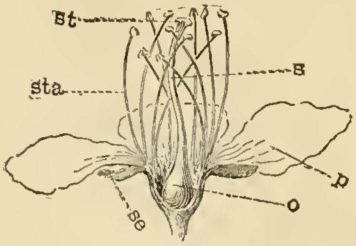

Fig. 14. Parts of the plum flower. *se*, sepal; *p*, petal (three are shown); *sta*, stamens; *os*, pistil, in three parts—*o* the ovary, *s* the style, *st* the stigma. The top of the stem (below *o*) is the torus.

Fig. 15. Flowers of a lily, showing six leaf parts, six stamens, and one style.

In most dicotyledonous plants we all recognize three fairly distinct parts of the stem, at least at some epoch in the life of the plant: the bark, the woody part, the pith. These parts are usually not clearly set off in the minute anatomical structure, however; but we may pause a moment to discuss them. Long tissues, extending lengthwise the stem or leaf, formed of elongated cells placed end to end or closely interlapping, are usually associated in more or less definite strands or bundles (Fig. 21). It is these strands, or parts of them, that produce the commercial fibers.

The bundle, running lengthwise the stem, is composed of two parts or regions: the xylem or wood part, lying on the inward side of the bundle as it stands in the stem; the phloëm or bark part, lying on the outward side. These bundles stand side by side around the outside of the woody cylinder, with the pith or undifferentiated parenchyma at the center of the cylinder. These bundles therefore make a continuous ring. However, the bundles are themselves supplied, when growing, with living parenchyma, called cambium, from which new cells are formed for both the xylem and phloëm regions of the vascular bundles. Inasmuch as the bundles form a ring about the stem, so the cambium that accompanies them also forms a ring. The parenchyma tissue extends outward from the pith between the bundles (or the bundles are imbedded in the parenchyma), causing the rayed appearance of the stem in cross-section.

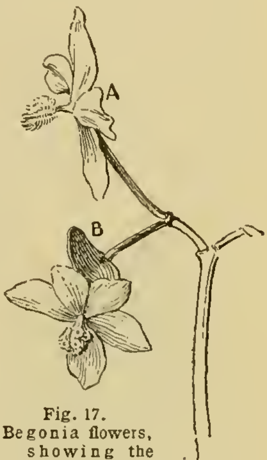

Fig. 17. Begonia flowers, showing the sexes separate. Staminate or male flower above; pistillate or female beneath. The seed-pod or ovary is shown at B; at A there is none.

Fig. 16. A daisy or whiteweed, one of the compositæ. Very many flowers compose the head, the outer ones each bearing one long petal or ray.

The xylem part of the bundle contains the trachea-like spiraled or pitted vessels. These are the routes through which the water ascends from the root. The phloëm part containing the sieve-tubes transports the organized food, or "elaborated sap," after it has been formed in the leaves; this food is transported to all parts of the plant to build new cells, or sometimes to be stored until needed. The supporting tissue may be associated with the vascular, or fibro-vascular, bundles. Bast is schlerenchyma tissue growing with the phloëm. The xylem and phloëm regions separate as they grow, the former becoming part of the wood and the latter part of the inner bark. The outer separable part commonly called bark is a very complex structure, being formed of the cortex or skin of the stem and the cork and strengthening tissues formed therein, the old and dead or dying phloëm, and the new phloëm that is just forming from the cambium in the vascular bundle. The xylem grows old and dies; the dead tissue becomes filled and hardened in firm wood; new xylem tissues are added on the outward side. The phloëm grows old and dies; the dead parts are added to the bark; new phloëm tissues are added on the inward side. The fibers of hemp and flax are derived from the phloëm.

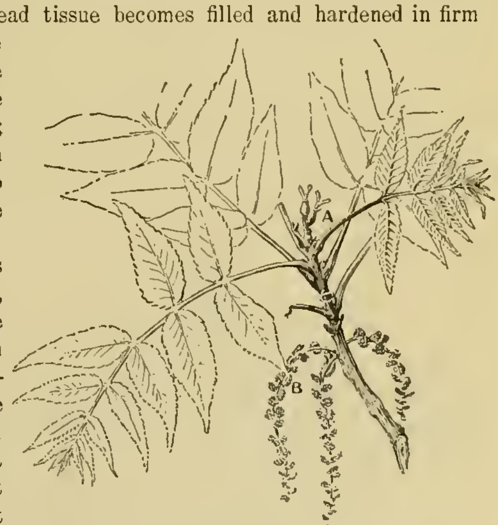

Fig. 18. Separated sexes in black walnut. The staminate flowers (in clusters called catkins) at B; pistillate flowers, each with two stigmas, at A.

In monocotyledonous plants, as grasses, sedges, orchids, bananas, palms and all lily-like plants, there are vascular bundles with xylem and phloëm regions, but the bundles are scattered through the stem and therefore do not form an exterior ring, and there is no true pith. Moreover, these bundles do not contain cambium, and therefore, the stem does not increase much in thickness and does not have a distinct separating bark (Fig. 22). The fibro-vascular bundles are very evident in the stem of Indian corn, and can be pulled out. There are some commercial fibers produced by plants of the dicotyledonous kind. Manila hemp is from a species of banana, and sisal hemp, from an agave, one of the century plant group; these fibers are derived from the entire bundle, both xylem and phloëm, and this origin probably accounts for their stiffness and hardness and their resistance to abrasion.

Longevity of the plant.

In duration, plants are of extreme types. Some kinds live only a few weeks; some of the trees live for many centuries. It is customary to classify all plants into three groups as respects duration: annuals, living not more than one year from seed to seed, as the cereal grains and most garden vegetables; biennials, living two years, usually perfecting seed the second year, as beets and parsnips, common mullein; perennials, living more than two years, as asparagus, alfalfa, bushes and trees. These divisions are not at all exact, however. Annuals are of longer or shorter life within the year, some maturing and dying very quickly from the seed, as the garden cress, and others requiring practically the twelvemonth. Some plants are annual because they are destroyed by frost, and others because they normally complete their growth: the latter, of course, are the true annuals. Those that would outgrow the year if they had opportunity have been called plur-annuals: they are plants that have been taken into a shorter-season year, as tomato, castor bean. Plants that are annual in one region, therefore, may be biennial or perennial in another region. Some plants are apparently annual although they live from year to year, carrying themselves over by means of bulbs or tubers, as onions and potatoes: these have been called pseud-annuals (false annuals). The mullein, bull thistle and teasel are true biennials, part of the growth occurring one year and the completion of the life-cycle the second year. Certain perennials have been bred by man to be biennials, as the cabbage and probably some root crops. Some of the root crops are really annual, as they complete the full cycle in one season if started early, as the radish. Whether a plant is biennial is often determined by the region in which it grows. There is the widest range in the length of life of perennials. Red clover is a perennial, but very imperfectly so; some forms of it thrive only two years, although they may persist longer. Most perennial herbs are at their greatest vigor the second and third years, as the strawberry, and then gradually weaken, and sometimes even die before very old, new plants having been formed in the meantime. Gardeners know that the best bloom with pinks and hollyhocks and many other showy perennials is secured from plants that are only two or three years old. Sometimes the renewal is accomplished by dividing the old roots.

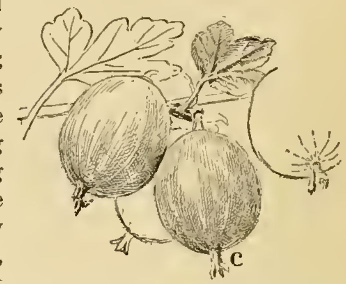

Fig. 19. The gooseberry is a true fruit, or ripened ovary. The remains of a flower are shown at *c*.

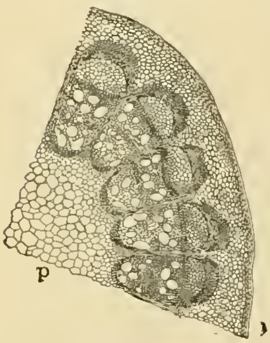

Fig. 21. Vascular bundles in stem of moonseed. The xylem part, with large openings, is on the inner side, the phloem on the outer side. Pith at P.

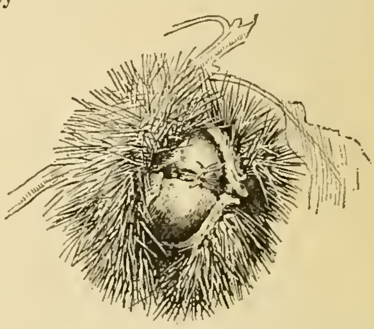

Fig. 20. In the chestnut, the nuts are the true fruits. They are contained in a husk.

Societies of plants.

Since plants contend with each other and since different kinds have been driven into similar places or regions, it follows that certain kinds have come to grow together, forming plant societies or communities. A certain set of plants live together in a swamp, and another set on a hill, another in a meadow, and another set in a cotton-field or a corn-field. Certain plants grow under or over other plants: grass and bushes may grow under trees; corn grows above the pumpkins that are planted with it. Wherever plants grow, they are in societies; that is, they grow together for certain reasons,—they are adapted to each other or to

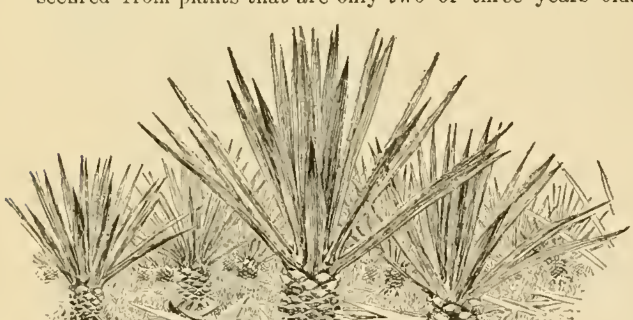

Fig. 22. The columnar trunk or stem of a monocotyledonous plant, not increasing much in diameter. Henequen (*Agave rigida* var. *elongata*), sixth crop being cut, two outer rows of leaves cut every eight months. Yucatan.

the place. Some societies seem to be largely accidental in population, however, and others seem to be governed by definite laws or relationships. These laws of adaptation are very little understood. It is now suspected that there may be positive physiological incompatibility between some kinds, and tolerance, congeniality or even symbiotic relationships between others. Under some kinds of trees, for example, certain kinds of herbaceous plants may thrive and others may perish, even when both are equally exposed to sunlight: it is doubtful whether this difference is to be explained by competition for food or moisture. We do not know why some weeds thrive in a corn-field and others do not. There may be bacterial or other organic relations between some kinds. There may be root-excretions that are hurtful to some plants and harmless or even useful to others. Perhaps the crop rotations that experience has found to be useful are dependent in some measure on such vital relationships as these.

THE PLANT: ITS STRUCTURE, LIFE-PROCESSES AND ENVIRONMENT

By *W. J. V. Osterhout*

Plants resemble animals in their fundamental life-processes and in their essential requirements of food, air, water, warmth and light. But the green plants possess an important advantage over animals since they are able to manufacture food from air and soil-water. This process depends on the action of chlorophyll (leaf-green) in the sunlight, by the absorption of which the necessary energy is supplied. Other differences between animals and plants, as that plants take up food in dissolved form only and have cellulose walls, are of minor importance.

The cell: protoplasm.

Plants are composed of cells of microscopic size, the outer walls of which are usually of cellulose (the substance of which paper is made). Figs. 23, 24 represent plant-cells. Within the non-living cell-wall is contained the living part, consisting of a transparent, jelly-like colloid substance called protoplasm. Its principal constituents, besides water, which constitutes 80 to 90 per cent of the plant, are proteids (white of egg substance), fats and oils, sugars and various salts.

Protoplasm is able to build new living protoplasm from the lifeless materials at its disposal; it can grow and reproduce; it has the power of movement and of responding to stimuli. It conducts complex chemical processes (metabolism), by means of which the living substance is built up (constructive metabolism) or torn down (destructive metabolism).

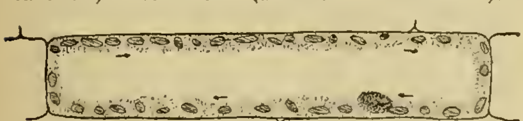

Fig. 23. A plant cell. The figure shows the rotation of protoplasm. (Elodea, or Anacharis.)

All the characters of the organism are an expression of the activity of its protoplasm. As long as certain chemical and physical processes take place in the protoplasm we say the organism is alive; when these stop, we say that it dies. Such substances in the cell as enter into these processes we regard as living; others, as starch grains, which take no part in them, we regard as dead. The latter may at any time enter into these processes, as when starch is converted into sugar, and so become part of the living substance. The transformation of lifeless into living substance, and vice versa, is constantly taking place. Protoplasm may be killed in a variety of ways, as by electric shock, heat, light, mechanical injury or poisonous substances.

Within the protoplasm, or cytoplasm, of the cell is contained a body, usually spherical or ellipsoid in shape, called the nucleus. It contains a deeply staining substance called chromatin. There is abundant evidence that the hereditary characters, those handed down from parent to offspring, are somehow bound up in the chromatin, and that it is the union of chromatin from both parents in the act of fertilization which causes the offspring to partake of the characters of both. It has been demonstrated that if the offspring receives protoplasm from both parents but chromatin from only one, it shows the characters of only that one.

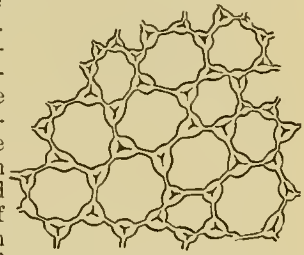

Fig. 24. Common cell forms. The walls are thickened at the angles, forming strengthening tissue. This kind of tissue is known as collenchyma (page 8).

The division of the cell is accompanied by a division of the nucleus, which may be either direct (amitosis) or indirect (mitosis). In direct division the nucleus constricts in the middle and the two halves simply pull apart. In indirect division the chromatin breaks up into a number of bodies (chromosomes), whose number is constant in each species. They arrange themselves on a spindle-shaped body, known as the mitotic spindle, and each chromosome breaks into two, the halves going to opposite ends of the spindle and there forming daughter-nuclei. A cell-wall is formed midway between these, dividing the cell into two (Fig. 25).

Plant organs: structure and function.

The plant body is divided into root, stem and leaf. The structure of each of these organs is adapted to the work it performs. Structure and function will here be considered together.

The root.—The principal work of the root is to explore the soil for moisture. It is unerringly guided downward by gravity, which acts as a stimulus, causing the upper side of the root to grow faster than the lower side, hence forcing the tip downward, no matter how it be placed. Moisture attracts the root very strongly; roots have been found in cisterns as much as 200 to 300 feet from a tree.

There are two principal kinds of roots, one of which, the tap-root (Fig. 26), goes deep into the soil, growing straight down and sending out lateral roots at intervals. The other spreads out near the surface of the soil (Fig. 27) and consists of a mass of fine rootlets. It has the advantage of establishing itself quickly and absorbing moisture vigorously from the start, thus inducing a rapid growth of the plant. But it cannot utilize the deeper soil food nor withstand drought. On the other hand, tap-roots many endure long periods of drought: the long-rooted Peruvian cotton is said to survive a rainless period of six years.

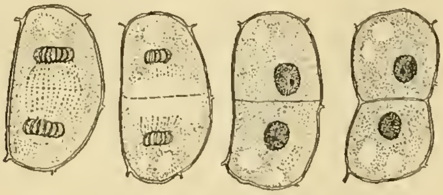

Fig. 25. Four steps in process of cell-division. Mother-cell at left, far advanced in divison; daughter-cell at right.

A well-developed root system forms a mass of finely interlacing filaments that thoroughly explore the soil. The total length of these has been estimated at a quarter of a mile for a vigorous corn plant, while measurements on a squash vine proved the root to be over fifteen miles in length, the greater part of this being produced at the rate of a thousand feet per day.

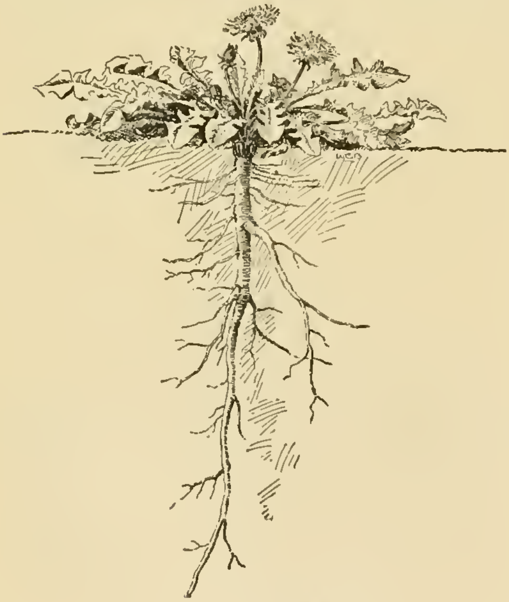

Fig. 26. Tap-root. Dandelion.

Because of need of air, most roots are unable to thrive in wet soil, and their best work is done in soil in which the water is held in a thin film around the soil-particles. Each particle constitutes a minute water reservoir. To reach and tap these reservoirs is the work of the root-hairs, which appear just back of the root-tip as outgrowths from the surface cells of the root (Figs. 28 and 29). They force themselves energetically between the soil-particles and attach themselves so closely that they often break off rather than loosen their hold when the root is pulled up. Thus they come into contact with the water-films that surround the particles, and by means of water-attracting substances within the root-hair they pull the water away from the particles. As each tiny reservoir is emptied of its supply, water flows in from surrounding ones and these also yield up their stores.

The water passes from the root-hair through the soft outer tissue (cortex) to the wood-cells, in which it passes directly to the leaves. These thick-walled wood-cells form groups that alternate with groups of thin-walled tissue or bast which conveys proteids and other food from the leaves to the root and to other parts of the plant. The wood and bast are surrounded by a row of small cells (endodermis), whose closely joined walls prevent the entrance of air, which would impede the progress of water in the wood-cells.

Fig. 27. Fibrous roots. Maize. Aërial or brace roots are shown at *o o*.

The absorptive surface of the root may be increased from seven to seventy-five times by the root-hairs. The fine roots, on which the root-hairs are principally produced, are known as "feeding roots," and all tillage should be practiced with special reference to them. Tillage aids the work of the root by increasing the air and water-supply, and by loosening the soil. Roots will penetrate hard soil, or even hard substances like sealing-wax, but they grow very slowly under such conditions. They may develop a pressure of 50 to 100 pounds per square inch. The root-cap protects the delicate tip as it is forced into the soil.

The water absorbed by the root contains mineral substances. If the plant is burned, these will remain in the form of ashes. By growing plants in distilled water, to which has been added chemically pure salts in various combinations, it has been found that certain substances are indispensable to the plant while others are not. The indispensable substances comprise four bases and four acids. The bases are potash, lime, magnesium and iron; the acids are nitric, phosphoric, sulfuric and carbonic—the carbonic acid absorbed from the air by the leaf. If all these substances, with the exception of carbonic acid, be dissolved in distilled water, plants can be grown in the solution and will produce mature seed; but if any of the substances be lacking in the solution, except carbonic acid, growth will soon cease. All these substances are present in the soil, together with others of little or no value, as alumina, silica and others, but in order that the plant may absorb them they must be dissolved in the soil-water. Most of them exist in the soil in compounds that are but little soluble in water. The soil-water contains carbonic acid, derived principally from decaying organic matter, which has a decidedly solvent action. In addition, the root constantly excretes carbonic acid, which dissolves the plant-food within its reach. By the excretion of acid, roots may etch polished marble surfaces; and they impart to distilled water an acid reaction.

Roots of many members of the pea family supply themselves with nitrogen from the air by means of the bacteria which inhabit tubercles on their roots. Roots of forest trees frequently make use of decaying matter by means of fungi, which grow in close contact with them.

Fig. 28. Parts of a young plant. *r*, root-hairs; *h*, hypocotyle, between the seed-leaves and the root; *c*, seed-leaves or cotyledons; *l*, true leaves.

The leaf.—The seed-leaves are commonly gorged with food, consisting of proteids (nitrogenous substances, like white of egg), fats, oils, sugar and starch. This food is mostly manufactured in the foliage leaves.

When starch is heated it separates into water and carbon dioxid (CO_2). Evidently it may be formed by causing these two substances to unite. This is just what the foliage leaf brings about. It is supplied with water by the activity of root and stem, and it absorbs carbon dioxid from the air. By utilizing the energy of the sunlight the leaf is able to break the bond of union between the carbon and the oxygen of the carbon dioxid, thus leaving the carbon free to combine with water and so to produce starch, and the oxygen free to escape into the air. The energy used in this process is set free again if the starch be burned, either by ordinary combustion or by the slower combustion that takes place in plant or animal cells. All elaborated foods, such as proteids, fats, oils and sugars, yield up their stored energy in the same way.

In order to make as much starch as possible, the leaf must expose the greatest possible surface to the sunlight and air, but in so doing it runs the risk of losing too much water by evaporation. To meet this difficulty, it has devices that enable it to increase or diminish evaporation (transpiration) according to its needs. Its surface is made waterproof by waxes, varnishes and resins, so that water can escape only at the pores or stomata that are thickly scattered (Fig. 30) over one or both of its surfaces,—as many as 3,500 per square inch in some instances. A section through a stomate is shown in Fig. 31, and a diagram of a stomate in Fig. 32. In the guard-cells, which surround the stomata, the plant possesses automatic devices of wonderful efficiency for regulating transpiration. When the

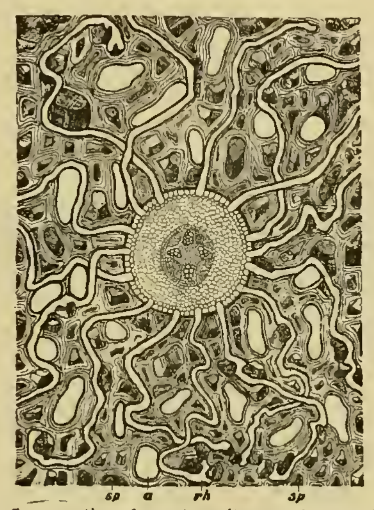

Fig. 29. Cross-section of a root, as it grows in the soil, showing the relations of the root-hairs (*rh*) to the soil particles (*sp*) and the air spaces (*a*); this soil is represented as containing the maximum amount of water compatible with good plant-growth.

water-supply is abundant, especially in the presence of sunlight, the guard-cells absorb water and expand. The pressure causes the walls that bound the pore or stomate to curve away from each other, thus causing the stomate to open. This is due to the fact that these inner walls are thicker than the outer walls. The effect is the same as would be produced on a rubber tube by thickening one side by cementing an extra strip of rubber on it. If such a tube be closed at one end while air or water is pumped in at the other, it will bend so that the thickened side becomes concave.

The absorption of the water by the guard-cells is aided in sunlight by the action of the chlorophyll grains which they contain; these produce sugar, which aids the cell in taking up water from the other cells of the epidermis that have no chlorophyll grains.

When, therefore, the water-supply is sufficient, and especially when sunlight, temperature and

Fig. 30. Stomates of geranium leaf.

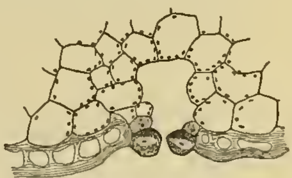

Fig. 31. Stomate of ivy, showing compound guard-cells.

other conditions are favorable for leaf activity, the stomata open and permit the leaf to absorb carbon dioxid. On the other hand, lack of water and unfavorable conditions cause them to close.

The stomata are usnally closed at night; hence it is then possible to fumigate plants with poisonous gases that would kill them if applied through the day. Closing at night prevents the stomata clog-

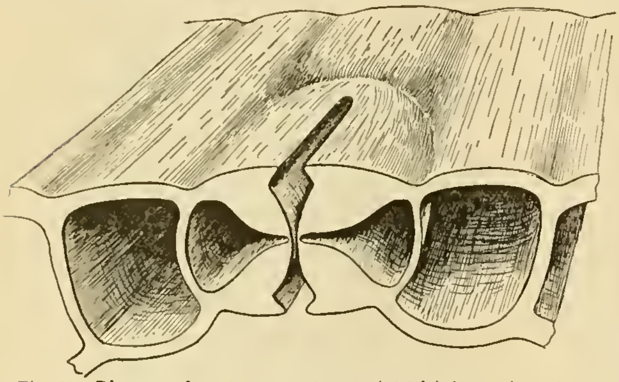

Fig. 32. Diagram of a stoma or stomate (of Iris) in section, showing guard-cells and neighboring cells of epidermis.

ging with dew. Water-proof materials, as well as hairy coverings of the leaf, protect the stomata from dew and rain. Leaves so protected appear silvery under water and do not become wet for a long time. If such protection is found on the lower side only, the stomata will be found on that side only. House plants should have the leaves washed occasionally to prevent the clogging of the stomata with dust. The devices by which desert plants check evaporation will be discussed later.

The carbon dioxid, passing through the stomata, comes directly into contact with the leaf-cells, which are sufficiently separated from each other to allow it to pass freely between them (Figs. 33, 34). The great absorptive surface which they expose is kept continually moist and is thus able to absorb with great rapidity, much as the moist lung surfaces absorb oxygen. The absorbed carbon dioxid passes into the cells and comes into contact with the green chlorophyll grains. The chlorophyll (leaf-green) in these bodies is divided into very minute drops (Fig. 35), thus giving it an enormous absorptive surface. At the same time that it takes up carbon dioxid it absorbs sunlight, and with the energy thus received decomposes the carbon dioxid

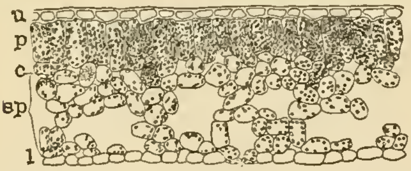

Fig. 33. Cross-section of ivy leaf, which grew in shade, and has only one layer of palisade-cells. *u*, upper epidermis; *p*, palisade cells; *c*, a crystal; *sp*, spongy parenchyma; *i*, intercellular space; *l*, lower epidermis. The plant here intended is the true or English ivy, *Hedera helix.*

and causes the carbon to unite with the water, thus forming sugar. This may be illustrated by the equation :

$$6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$$

Carbon dioxid — Water — Grape sugar — Oxygen

This equation, however, states merely the beginning and end of what is probably a long and complicated process. Oxygen is given off and may be seen arising in bubbles from water plants. Air that has been "vitiated" by animals may have its oxygen restored by green plants in sunlight. Aquaria are often maintained for long periods when a proper balance is struck between plant and animal life.

The process just described (photosynthesis) furnishes not only all the food, but practically all the fuel in the world. The leaf utilizes, that is, stores up, only about one-half of one per cent of the energy it receives in the form of sunshine. It makes use of the red and orange rays almost exclusively, and forms little or no starch in blue light. The rays that affect the photographic plate, therefore, have little part in photosynthesis, while the red and orange rays, so important in this connection, are the ones that also produce the greatest effect on the eye. A square meter of sunflower leaves is estimated to produce about 25 grams of starch in the 15 hours of sunlight of a summer day. This would use up the carbon dioxid contained in 50 cubic meters of air (a meter is nearly 40 inches); or, in other words, should the leaves take all their

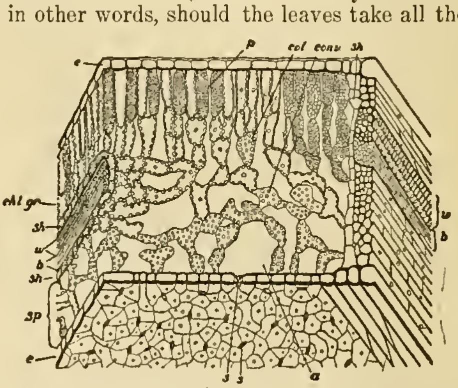

Fig. 34. Leaf of common wild yellow mustard; *e*, epidermis; *p*, palisade cells; *sp*, spongy parenchyma; *col*, collecting cells; *conv*, conveying cells; *sh*, conducting sheath of vein; *w*, woody tissue of vein; *b*, bast of vein; *s*, stoma; *a*, air-space; *chl. gr.*, chlorophyll granules.

carbon from the air directly above them, they would in a day consume all of it to a vertical height of about 165 feet.

The sugar formed in the chlorophyll grains is transformed, in great part at least, into starch, which makes its appearance in the form of glistening white bodies embedded within the substance of the grain. This starch mostly disappears during the night, being changed back into sugar, and conducted away into the stem and thence to the roots, flowers or other parts. Leaving the palisade cells of the leaf (Fig. 34 p.), it passes through the collecting cells (col.) into conveying cells (conv.), and on to the conducting sheath (sh.) of one of the veins, by which it passes through the leaf-stalk into the stem.

The evaporation of water is of great advantage to the plant, for it concentrates in the leaf the salts contained in the water. The leaf thus becomes the meeting place of air food and soil food. These two sorts of crude food combine to form elaborated food. The first step is probably the formation of sugar, which then, by combining with nitrogen, sulfur, phosphorus and other elements, forms proteids. These move from place to place, principally in the bast, and so reach the regions where they are needed.

The energy needed to elaborate food comes from the sunlight. The leaves have various devices to absorb all the sunlight possible. Some "follow the sun" all day long, thus facing eastward in the morning and westward at evening. At mid-day they are horizontal, except when the sunlight is excessive, in which case they assume the "profile position" with the edges pointing upward, thus avoiding injury due to too strong light. Many such leaves assume a "sleep position" at night by folding; they diminish thereby the loss of heat and avoid the precipitation of dew on the protected surfaces.

Most leaves have the power of turning toward the light, and so move out of the shadow of other leaves. Thus arise the beautiful "leaf-mosaics," e. g., of English ivy or of maple, in which no leaf unduly shades another. The usual arrangement of leaves on the stem is in regular vertical rows. The arrangement is known as phyllotaxy.

The stem.—The stem bears the leaves and furnishes them with a constant supply of water, which it conveys from the root. On placing a plant with its roots in diluted red ink or other colored solution, we can trace the colored solution up through the wood-cells in the root (Fig. 29), through the stem (Fig. 36), into the finest veins of the leaf. It is easily seen that the colored solution travels only in the wood-cells and not in the other cells of the stem. We usually find the wood-cells associated with bast-cells, forming together the fibro-vascular bundles (Figs. 21, 37). In dicotyledonous plants (e. g., squash, sunflower) these bundles form a circle near the outside of the stem; while in monocotyledonous plants (e. g., corn, lilies) they are scattered through the stem. [See page 9.]

The largest passages in the wood are called ducts, and in them the water travels faster than

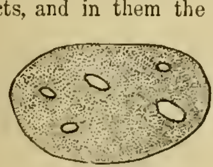

Fig. 35. A chlorophyll grain containing young starch grains. The dotted shading is to indicate the chlorophyll drops.

Fig. 36. Diagram of cross-section of squash stem. *str*, strengthening fibers.

in the other cells. They are formed by the breaking down of partitions, thus converting a long row of cells into a single continuous passage that may be as much as forty feet in length.

In the tracheïds—long, narrow, tapering cells—the water travels more slowly than in the ducts, being hindered by the frequent end walls. The markings seen on the walls of the wood-cells are pits or thin places in the walls, by means of which water passes more readily from one cell to another. The passage of air is prevented by a delicate membrane stretched across the pit.

The question may be asked, What causes the sap to rise? Various explanations have been

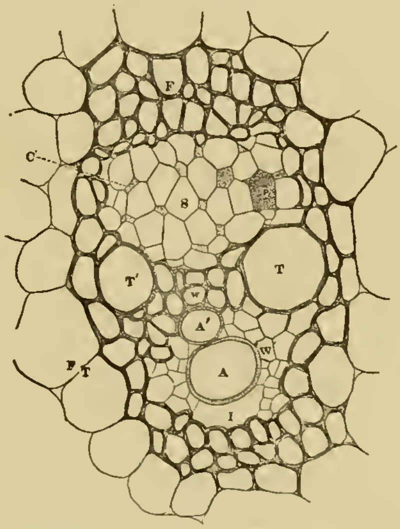

Fig. 37. Fibro-vascular bundle (cross-section) of Indian corn, much magnified. *a*, annular vessel; *a'*, annular or spiral vessel, *t'*, thick-walled vessels; *w*, tracheids or woody tissue; *f*, sheath of fibrous tissue surrounding the bundle; *ft*, fundamental tissue or pith; *s*, sieve tissue; *p*, sieve plate; *c*, companion cell; *i*, intercellular space, formed by tearing down of adjacent cells; *w'*, wood parenchyma.

advanced and proved unsatisfactory, such as capillarity, barometric pressure, action of air-bubbles and root-pressure (the action of the root in forcing water upward, as seen in the bleeding stumps of the grape-vine). The one at present most in favor is that the sap is drawn up by water-attracting substances in the leaves, just as the water is pulled away from the soil-particles by the root-hairs. This process is known as osmosis. Sugar is a substance that acts in this way. For example, the conversion of the stored starch of the maple into sugar, in the spring, causes a rapid rush of sap into the stem, even though no leaves are present. This theory is not satisfactory in all respects, especially when applied to the rise of sap in very tall trees.

Among the wood-cells are found short cells, wood-parenchyma, that remain alive long after the other cells are dead. One of their chief functions is to store starch and other foods that are conveyed to them by the medullary rays or silver grain. These consist of elongated cells that run at right angles to the course of the wood-cells; they serve to convey gases as well as food. Much elaborated food, especially proteids, is conveyed by the bast. Most proteids are unable to pass through cell-walls and so are able to move only in the large cells, or sieve-tubes of the bast, whose end walls or sieve plates are pierced with holes. The bast contains smaller cells known as companion cells and bast parenchyma which remain alive after the sieve cells are apparently dead; their function is not clearly understood.

In dicotyledonous plants, between the wood and the bast is found the cambium, an embryonic tissue that forms new cells whose growth causes the stem to thicken year by year. The inner part of this growth becomes wood, which adds an "annual ring." These rings are clearly marked, because the wood formed in the fall is denser and has smaller cells than that formed in the spring. The outer part of the new growth becomes bast, which wears away on the outside almost as fast as it forms within, and, in consequence, does not thicken much from year to year. Monocotyledonous stems have no cambium and do not grow thicker from year to year.

The cambium causes the cion to unite to the stock; it heals wounds, such as are made by pruning, by forming a tissue called callus. This sometimes produces new buds, whose growth compensates for the part cut away. At the tip of the stem the cambium does not form a complete ring but is confined to the fibro-vascular bundles. In trees and shrubs it gradually extends itself from one bundle to another, thus forming a complete ring. As soon as this is accomplished, it begins to form a complete ring of wood within and of bast without. In herbs no such complete ring is formed.

Outside the bast is found the rind or cortex, which is usually green, and, in consequence, manufactures starch. It also serves to convey starch. This is easily seen when it is cut away all around the tree, in the process of "ringing," whereupon the tissues below lose their starch. If the bast be cut through also, the supply of proteids is cut off and death soon ensues. As the stem grows older, layers of cork are formed in the rind. These cut off the tissues lying outside them, which soon die and so form bark. The very first layers of cork are formed on the extreme outside of the stem, and are interrupted at frequent intervals by breathing pores or lenticels.

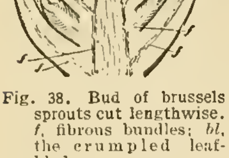

Fig. 38. Bud of brussels sprouts cut lengthwise. *f*, fibrous bundles; *bl*, the crumpled leaf-blade.

At the very tip of the stem is found embryonic tissue which continually forms new cells; this is called the growing point. Just back of this, new leaves arise as protuberances (Fig. 38). These rapidly grow larger and fold over in such a way as to protect the growing point from mechanical injuries as well as from drying. The various waxes, resins and furry coverings of buds are not for protection against cold, as popularly supposed, but for protection against drying.

The crowding of the young leaves at the growing point, forces them to take on a regular arrangement which largely determines the arrangement of the branches, since these arise from the point (axil) where the leaf is joined to the stem. Not all branches develop. Many that start cannot get sufficient light and soon die. This is known as "self-pruning," and is seen especially in forest trees, which produce lumber free from knots. Many buds do not even start to develop but remain dormant, often for many years, growing just enough to keep pace with the annual thickening of the tree. They may be traced back to the center of the tree, sometimes several feet long, but no thicker than a lead-pencil. New or adventitious buds may be formed; such buds, becoming crowded and distorting the grain of the wood, cause the appearance familiar in bird's-eye maple.

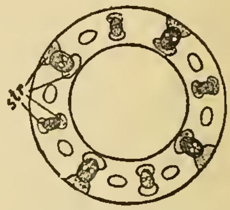

Fig. 39. Diagram showing the girder-like arrangement of strengthening tissues (*str*) in a bulrush. Scirpus.

The stem requires strengthening tissue in order to sustain the weight of its branches and the force of the wind. In the tree the accumulated wood serves every purpose, but in the herbaceous stem special strengthening tissue is formed, quite distinct from the wood. In parts of the stem that are lengthening, this tissue consists of collenchyma cells, whose walls, thickened at the corners only, have thin places by means of which food and water may be absorbed (Fig. 24). Their growth keeps pace with that of the stem, otherwise they would soon break and become useless. In older parts of the stem that have ceased lengthening, the mechanical cells, sclerenchyma, have walls equally thickened all around, except at the pits; when the thickening reaches a certain point the cells die, but their usefulness is not impaired thereby.

The distribution of mechanical tissue in the stem presents a wonderful example of useful arrangement to secure the highest degree of strength with the least expenditure of material. The principle of the girder and of the hollow cylinder is everywhere employed (Fig. 39) in leaf and stem. It results that a wheat stalk is a model of lightness and strength, and at the same time it is elastic enough to bend sufficiently in the wind. In the root (Fig. 29) the strengthening tissue forms strands in the center, known as cable construction, that enable it to resist pulling strains. Some stems economize material by climbing on walls, trees, or other supports. Some weave themselves in and out of the branches of other plants (blackberry), others form tendrils by modifying a branch (squash, grape), or a leaf (pea), or a leaf-stalk (clematis). The coiling of the tendril is due to a stimulus such that the contact side grows less rapidly than the opposite side. The tendril, and the tip of the stem as well, usually has a sweeping circular movement that assists in finding a support. The tendrils of the Boston ivy fasten themselves to walls; the roots of the English ivy answer the same purpose.

Plants which twine do so apparently under the influence of gravity, which causes one side to grow faster than another, so that the tip circles in the same direction as the hands of a watch, to the right, or with the sun (as in the hop), or in the opposite direction (as in the morning-glory). Such plants unwind and reverse their direction if placed upside down, and they will not twine on a horizontal or nearly horizontal support.

The flower.—When the work of root, stem and leaf has stored a sufficient surplus of food, the plant proceeds to flower. The century plant spends many years in this process; trees usually take four or five years or more; biennials, as the beet and turnip, require two, while annuals complete their preparation in a few days or weeks. The food is stored in roots, tubers, root-stocks, stems, or in modified leaves such as we find in bulbs. In the latter case, the fully formed miniature flowers can often be seen on cutting open the bulb.

Fig. 40. Flower of fuchsia in longitudinal section. The ovary is at *a*.

The flower is usually spoken of as a modified branch. In their early stages, flower-buds are so much like leaf-buds that they cannot be told apart. But the growing leaf-bud produces leaves that soon become separated by the elongation of the stem, while in the flower-bud they remain crowded together, and become modified into dissimilar structures.

The outermost set of these structures, the calyx (Fig. 14), consists of green, leaf-like sepals whose function is to protect the internal parts, much as the outer leaves of a bud protect the innermost. Next comes the corolla, consisting of petals, which are leaf-like except in color. Instead of chlorophyll they possess a number of pigments that are either held in solution in the cell sap or appear in solid form. These, by their combination, produce an endless variety of coloration. The appearance of white petals is due (like that of snow) to the presence of air.

The next set of organs, the stamens, often have a leaf-like basal part, while the upper part produces an anther, i. e., a structure consisting usually of four cavities filled with pollen-grains or microspores. At maturity these cavities open and discharge their pollen in the form of yellow dust. The innermost set of organs, known as the carpels, are often leaf-like, as, for example, in the pea-pod, whose texture, color and veining are essentially those of a leaf. It corresponds to a leaf folded lengthwise on the midrib, so as to bring the edges together. Along the united edges are borne the seeds. Such a carpel is called a simple pistil or ovary; when several are united, as usually is the case, the resulting structure is called a compound pistil or ovary. The term ovary is applied to the part that contains the seeds or ovules, while the term pistil includes also the style and stigma. The stigma is borne on the summit of the ovary, often on a stalk called the style, and consists of a sticky or hairy surface designed to catch and retain the pollen.

Inside the ovary are found the rudimentary seeds, or ovules (Fig. 40). An ovule usually has two coats, inside of which is a mass of tissue called the nucellus, containing a cavity called the embryo-sac, or macrospore. Inside of this are found one or more eggs.

Fig. 41. A branch of the style of oat, showing a pollen-grain pushing out a long tube (pollen-tube), which grows down toward the ovary (seed-case).

In order that the egg may develop, pollen must be brought to the stigma and there germinate (Fig. 41), sending out a long germ tube that makes its way down the style to the embryo-sac. A nucleus (Fig. 42, pn) makes its way from the pollen-tube through an opening that is formed at its end, and enters the embryo-sac, where it unites with the nucleus of the egg (e). This constitutes the act of fertilization, and the characters of both parents are thereby united in the nucleus so formed. This nucleus is called the fertilized egg. Since each of the fusing nuclei has the same number of chromosomes, the fertilized egg has twice as many, and this double number is found in all the cells of the plant that develop from the fertilized egg, until, in the mother-cells, that give rise to the pollen-grains and embryo-sac, the number is suddenly reduced to one-half.

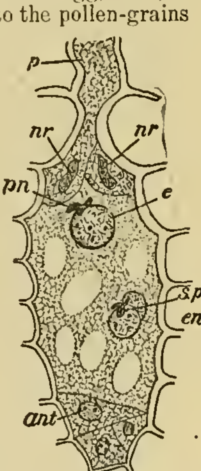

Fig. 42. Embryo-sac of a lily. Showing the union of the nucleus from the pollen-tube (*pn*), with the egg (*e*); the second pollen-tube nucleus (*spn*), unites with two endosperm pronuclei (*end*), which multiply and form the endosperm: antipodal cells (*ant*), nurse nuclei which help nourish the egg, etc., (*nr*), pollen-tube (*p*).

The fertilized egg soon begins to develop and eventually forms a tiny plant with rudimentary root, stem and leaf, as we find it in the seed. The coats of the seed develop from those of the ovule; sometimes the ovary wall or a part of it remains permanently attached to the seed. The endosperm of the seed comes from two endosperm nuclei (Fig. 42, end), which fuse with a nucleus from the pollen-tube (s pn). The endosperm may thus show the characters of both parents. In corn, in which the endosperm determines the color of the grain, an ear of yellow corn that receives pollen partly from yellow and partly from blue corn may show, on the same ear, both blue and yellow grains side by side.

Since pollen is easily injured by rain or dew, various devices exist for keeping it dry. The closing or drooping of flowers in rainy weather and at night, and numerous contrivances for shedding water, all serve to keep the pollen dry.

In a series of classical experiments, Darwin showed that self-pollination, or the placing of the pollen on the stigma of the plant that produced it, does not give as vigorous offspring as cross-pollination, or the transfer of pollen from another individual. In plants we find numerous devices to promote cross-pollination and to prevent self-pollination. It is common to find the stamens and pistils in separate flowers on the same plant (monœcious plants, as squash and corn), or produced on separate plants (diœcious plants, as the hop). When the organs are not thus separated they may mature at different times, or otherwise promote cross-pollination.

Pollen is carried from one flower to another through the agency of wind (as in corn), or water (as in many aquatics), or by insects. Whether the insects are attracted by the color or by the odor of flowers is to some extent still an open question.

The fruit.—The fruit is the ripe or ripening ovary, with its contents and any surrounding parts that remain attached to it. The first work of the fruit is to convey nourishment to the young seeds and protect them during their development. The great importance of the food supply is evident from the fierce struggle that takes place, not only between flowers and fruits on the same plant but between the developing seeds in the same fruit. Usually many fruits fall because of lack of nourishment, and this is aided by the grower, who thins the fruit to secure a few large ones rather than many small fruits. In a number of fruits many seeds in the ovary fail to develop from lack of sufficient food. In the majority of cases the plant gives its whole store of food to the fruit and then dies. The stalks of grain, for example, are almost completely emptied of nutriment during the ripening period, leaving the stalks dry and tasteless. This occurs even if the grain be cut before the seed is fully ripe. On reaching the seed the food is often transformed, as from starch to oil. During the ripening process many changes in the food substances occur, as when the acrid taste in apples gradually gives place to sweetness and agreeable flavor; and at the same time various gelatinous substances are produced that render the ripe fruit suitable for jelly-making. Such changes take place after the fruit is removed from the tree, as is illustrated by the familiar practice of allowing pears to ripen in drawers.

In order to insure abundant fruit, there must be vigorous and healthy development of foliage early in the season, followed later by a decrease in water supply and increase of light and heat. The tendency to produce wood instead of fruit is checked by decreasing the water supply, as evidenced in the practice of pruning or laying bare the roots, and breaking or notching the branches to increase productiveness.

An important function of the fruit is to scatter the seeds so that the plant may be reproduced in abundance. Some fruits float long distances on water, as the coconut; others, as the dandelion, develop wings, or parachutes, so that they may be carried far by the wind. Some stick to the rough coats of animals; others, by their pleasant taste and bright color, attract birds, which scatter the seeds.

Some seeds can germinate as soon as ripe, while others require long periods of rest before they germinate. A sufficient supply of water, warmth and air are necessary for germination. If these are not furnished the seed remains dormant, often retaining its vitality for many years.

General properties of plants.

Nutrition and respiration. —The formation of elaborated food has already been described. Such food is disposed of in three ways:

(1) It is oxidized or burned just as in the animal body, producing heat, chemical energy, and so on. In this process, called respiration, carbon dioxid is produced and given off to the air, to be again decomposed and built up into food. This food is burned in turn, forming more carbon dioxid; and so the process goes on in a never-ending cycle. It is evident that the chief object of producing food is to have energy stored in convenient form, so that it can be utilized whenever needed. The constructive work of the plant separates carbon from oxygen, which is given off into the air, and stores energy; the destructive work of the plant unites (burns) carbon with oxygen and sets energy free. The amount of energy set free may be estimated from the amount of carbon dioxid given off. When an organism has produced its own weight of carbon dioxid, it has set free sufficient energy to raise itself about 600 miles. Some bacteria give off twice their weight of carbon dioxid in 24 hours, while a man in the same time exhales about 1.2 per cent of his weight. Green plants consume much more carbon dioxid than they produce. The consumption of carbon dioxid stops at night, while its production goes steadily on. The amount produced is small, and a hundred plants in a room at night would not "vitiate" the air so much as a single candle.

When the supply of oxygen gives out, carbon dioxid continues to be produced for a time, at the expense of oxygen, which is in loose combination with the tissues. This is accompanied by the formation of alcohol. This process is known as intramolecular respiration. Respiration takes place in every living cell, since every such cell has need of energy to perform its work. In plants, each cell absorbs its oxygen for the most part from the air that enters the stomata, lenticels and cracks in the bark, and penetrates everywhere into the spaces between the cells.

(2) The food is used to build tissues, cell-walls and other parts.

(3) It is stored in various special storage organs, principally as starch, fats, oils and proteids. In the germination of seeds we can see very clearly that the stored food, before it can be used, must be digested just as in the animal body. Starch is changed to sugar and proteids are converted into

soluble form. This is accomplished by chemical substances called ferments, the presence of small quantities of which makes possible a large amount of chemical action. They are of the greatest importance in both constructive and destructive processes.

Plants without chlorophyll (saprophytes, living in decaying matter, and parasites, deriving nourishment from living organisms) are unable to make elaborated food. Some parasites that have chlorophyll, as mistletoe, have this power. Insectivorous plants secure an extra supply of nitrogenous food from the capture of insects. Plants of the pea family secure nitrogen from the air by means of bacteria living in their roots; this relation between two plants is known as symbiosis.

Growth.—Growth may be best illustrated by considering the growing tip of a stem. Here we may distinguish three stages:

(1) The formative region, where cells are constantly dividing and new organs are being formed.

(2) The elongating region, where the cells expand by absorbing large quantities of water. This comes next to the formative region.

(3) The maturing region, where the cells no longer expand but assume their characteristic form and markings.

In the first of these stages the cell is filled with protoplasm. As the absorption of water continues, drops are formed in the protoplasm; these coalesce to form a single large drop (vacuole) that occupies almost the entire cell. This condition persists in the later stages.

Growth depends very much on temperature, increasing rapidly up to about 30° C.; above this it diminishes. It depends, also, on an adequate supply of water, food and air. Light, especially the blue rays, generally checks the growth.

Movement.—Movement in plants may be produced by the contraction, or other movement, of the protoplasm, as in animals. It is usually due, however, to unequal growth of opposite sides of an organ (e. g., the opening and closing of flowers). The movements of the leaves of the sensitive plant and of clover are due to changes in the turgidity of cells.

Irritability.—Irritability is the power of responding to stimuli. When a leaf folds up at a touch, we say that the touch acts as a stimulus. The amount of energy needed to execute the movement is much greater than was imparted to the leaf by the act of touching it. The stimulus sets free stored energy, just as a touch on an electric button may explode a powder magazine. Among the stimuli to which plants respond may be mentioned light, gravity, heat, chemical substances, electricity, strains and contact. In general, the plant responds by bending toward or away from the source of stimulus or by changing the rate of growth.

Reproduction.—The process of fertilization in higher plants has already been described. This is called sexual reproduction, because it results from the union of two nuclei, a male and a female.

In addition, we find asexual reproduction, in which no such fusion takes place. The propagation of plants by cuttings, leaves, tubers, roots and bulbs furnishes familiar illustrations of this. Simple division, as in bacteria, or budding, as in yeast, are also methods of asexual reproduction. Asexual reproduction by means of specially modified single cells, called spores, is found in ferns, mosses, molds, bacteria and other plants.

In all plants, down to and including the mosses and liverworts, there is a regular alternation of sexual and asexual generations. A sexual generation (prothallium) arises from the asexual spore (e. g., of a fern) and bears sexual organs. After fertilization, the egg produces a plant that is called the asexual generation, because it produces no sexual organs, but only asexual spores, which, in turn, give rise to the sexual generation. In the fern, the sexual generation is of microscopic size, while the asexual (spore-bearing) generation is the familiar fern plant.

The environment of the plant.

The needs of the plant are like those of the animal, namely, water, food, light, air and warmth. The plant resorts to endless contrivances to secure a sufficiency of these, as well as to protect itself against an excess of any of them. It constantly adjusts itself to external conditions in order to make the most of its circumstances. Were it not able to do so it would soon perish. We may briefly consider the chief factors of the environment.

Water.—Nothing affects the plant more than the water-supply. The effect of dry conditions is best seen on desert plants, which show the following modifications: (1) Reduced surface secured by partial or total suppression of leaves, as in cacti. The discarding of leaves in winter is an adaptation to the dry conditions then obtaining. Even when there is water in the ground the roots cannot absorb it, because of the low temperature; (2) reduced evaporation secured by thicker epidermis, coverings of wax and of varnish; (3) reduced evaporation secured by rolling the leaf, as in grasses, or placing it in a permanently vertical position, as in iris; (4) storage of water in the thickened stem or leaf; (5) reduction in the number of stomata and sinking them in depressions; (6) hairy coverings of the leaves; (7) increased woody fiber; (8) smaller air-spaces; (9) longer palisade cells of the leaf.

Aquatic plants show the opposite characteristics, having large surfaces, thin epidermis, no waxes, resins or hairs, very little woody fiber, very large air-spaces, and poorly developed palisade cells in the leaf. Stomata occur only on the surfaces exposed to air, but are there numerous.

The size of every part of the plant is increased by an abundance of water. The large-celled spring wood is an illustration of this. The small-celled fall wood is formed under much drier conditions.

Growing plants in a saturated atmosphere produce curious modifications; a cactus may thus be made to produce leaf-like organs, and gorse produces leaves instead of thorns. On the other hand, a potato grown with a minimum amount of water, exposed to light, assumes a cactus-like habit, with no leaves and with very short internodes and thickened stems.

The water-supply directly influences the production of flowers and fruit. Aquatic plants cannot as a rule produce flowers under water. Land plants with abundant water-supply run to stem and leaf, and produce little fruit. Cutting off the water supply at the proper time greatly increases the production of fruit, and also makes it sweeter and of higher flavor. By irrigating properly, we may control both the quantity and quality of the crop. An excess of water soon kills the plant by suffocating the roots.

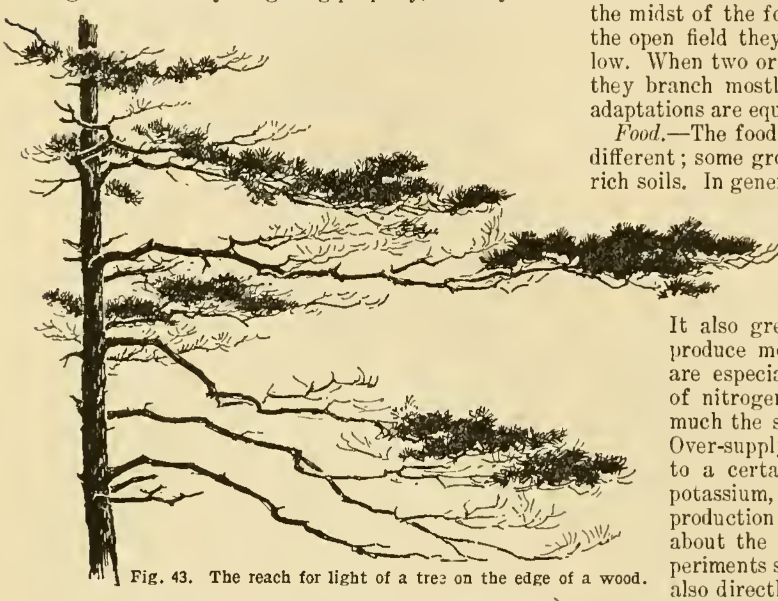

Fig. 43. The reach for light of a tree on the edge of a wood.

Light.—The effect of light on the plant is very similar to that of dryness, and in the case of desert plants the strong light increases the effects due to lack of water. Plants that prefer the sun are known as sun-plants (grasses), while those that can grow only in shade are known as shade-plants (ferns). The latter have longer, thinner leaves, usually of paler color. A similar difference may often be observed between exposed and shaded leaves on the same individual plant. The exposed leaves have thicker epidermis, longer palisade cells, smaller air-spaces and fewer stomata.

Both leaves and branches arrange themselves with reference to the direction of the light, and the same is true to a large extent of flowers. This is well illustrated by plants that grow near houses so that they are shaded on one side. A further illustration is the different arrangement of leaves on upright and on horizontal branches of the same plant. Excessive light produces "sunscald" and other bad effects. Some leaves avoid this danger by assuming a vertical position. On the other hand, absence of light produces marked effects. Chief of these is the pale color (etiolation) which is so noticeable in celery that has been blanched by being covered from the light, or in potatoes that have sprouted in darkness. The stem is usually weak and spindling, while the leaves, in dicotyledons at least, remain small; hairs and even prickles tend to disappear in darkness. With weak light the colors of flowers are much less brilliant, and the production of both flowers and fruit is seriously checked, even when there is sufficient food present for their formation.

The reach for light is well marked wherever plants are crowded. About the edge of a forest, the trees branch on the outward side (Fig. 43). In the midst of the forest they shoot straight up. In the open field they branch on all sides and remain low. When two or three trees grow close together, they branch mostly in opposite directions These adaptations are equally marked in bushes and herbs.

Food.—The food requirements of plants are very different; some grow best on poor soils, others on rich soils. In general, starving a plant causes it to flower and fruit more quickly but to produce a less abundant crop. Over-feeding creates a tendency to produce stem and leaf at the expense of fruit. It also greatly increases the tendency to produce monstrosities. Both these effects are especially produced by an over-supply of nitrogen. Abundance of water acts in much the same way as abundance of food. Over-supply of nitrogen may be corrected, to a certain extent, by the application of potassium, which tends to check the over-production of vegetative parts and bring about the development of fruit. Some experiments seem to indicate that phosphorus also directly favors fruit formation.

Lime is valuable not only as a food, but it helps to make other mineral food available. It hastens the decomposition of humus, sweetens sour soil and improves the texture of clay soils by its flocculating action. It also acts as an antidote to the poisonous action of magnesium, when the latter is present in large quantities. Some plants are found only where lime abounds, while others cannot tolerate it except in small amounts.

If any nutritive substance in the soil be reduced to a minimum, the effect on the plant is much the same as if all the nutritive substances were likewise reduced; this is known as the "law of the minimum." Consequently, the application of fertilizer containing an element deficient in the soil, may give results out of all proportion to its cost.

It is possible in water cultures to determine very closely the effect of excluding various necessary elements. For example, it is thus found that when iron is lacking, practically no chlorophyll is formed. The facts so gained have not as yet been applied to the soil to any great extent.

The root has a "selective action" in that it takes up from the soil certain elements, to the partial or total exclusion of others. Thus, from a solution of sodium nitrate, it takes nitric acid, leaving the sodium. A cereal crop takes from the soil only one-fourth as much potash and only half as much nitrogen as root crops. This is one reason why a suitable rotation of crops is necessary to preserve the productiveness of the soil.

The physical condition of the soil is just as important as the chemical. It is almost useless to apply fertilizers to poorly tilled land. The food supply of the soil can be unlocked and made available to the plant only by judicious tillage.

Heat.—As previously stated, the most favorable temperature for the growth of plants is about 30° Centigrade (86° Fahr.). If the temperature rises much above this point, growth stops, and if the rise continues, death ensues. On the other hand, if the temperature is lowered, growth ceases before the freezing point is reached. Some plants may be frozen with impunity provided they are allowed to thaw out slowly. Others are invariably killed by freezing.

Too great cold and too great heat have much the same effect on the plant as lack of water. The former prevents absorption by the roots; the latter causes water to evaporate from the leaves faster than it can be supplied. The habit of dropping their leaves on the approach of cold weather, which deciduous trees have, is therefore comparable to the action of desert plants in reducing their leaf surface.

In general, the plant that contains least water is most resistant to heat and cold. Dry seeds have been kept for a long time at the temperature of liquid hydrogen (—238° C., or —396° F.); when thawed they grew normally. Bacteria are much more quickly killed by moist than by dry heat. Frost does not injure buds in winter when they are comparatively dry; but in spring, when they are full of sap, it quickly kills them. The injurious action of frost is supposed to be largely due to the extraction of water from the cells by the formation of ice in the intercellular spaces. The air that normally occupies these spaces is thereby driven out, so that a frozen leaf, on thawing, resembles one in which the air of the intercellular spaces has been driven out by boiling. It is supposed that when the leaf is thawed slowly enough, the water is taken up again by the cells; but when it is thawed quickly, the water escapes by evaporation before it can be reabsorbed.

The action of frost may result in long splits in the trunks of trees, or in the killing of the ends of the branches, which soon blacken in consequence. The injured parts should be removed by pruning.

Air.—Every living cell must have a constant supply of oxygen in order to exist. The stem sometimes suffers by applications of tar which shuts out air. The roots commonly suffer and often are killed by being deprived of air. This happens when the soil is too wet or when a hard crust is allowed to form on the surface. For the same reason, paving sidewalks or covering the roots deeply with soil may be injurious. When the surface of the soil is loose and sufficiently dry, a circulation of air is kept up within the soil by constant changes in barometric pressure. When this is prevented the soil becomes sour and unfit for plants, and the chemical processes that make food available to the plant are checked. Roots may grow in running water, which constantly renews the supply of dissolved air. Some roots can live in mud, but they are supplied with air by way of the leaves and large air-passages in the stem; they are specially adapted to such environment. It is therefore of the utmost importance to maintain a loose, open texture of the soil by proper tillage, to ensure the health and vigor of most agricultural plants.

Wind.—The curiously gnarled and bent appearance of trees that are daily exposed to strong winds is familiar to all. In many cases all the branches on the windward side are killed. This is due to the drying effect of the wind, which may increase evaporation as much as twenty-fold. The mere mechanical effect of strong prevailing winds is often very marked. It is common to see trees with the tips of the branches permanently turned leeward, or with the heavy growth all on one side. Trees on mountain tops and near sea-coasts are often weirdly picturesque, from wind action.

The effect of wind in drying fruit blossoms is well known, as well as the mechanical damage to branches laden with ice and snow. For this reason the planting of windbreaks is often indispensable.

Environment and inheritance.—The facts just mentioned show how readily the plant responds to the influence of environment by altering its structure or functions. The way in which it responds is determined in each case by the qualities it has received from its ancestors. The form of the plant, therefore, depends on both these factors.

Some plants are plastic and easily modified by external influences; others are not so readily affected. The very remarkable alterations produced by insects, including the various kinds of galls, the "witches' brooms" produced by attacks of fungi, completely altering the habit of the plant, and the "green flowers" due to small insects, make us realize the great possibilities of external influences. The analysis of all these phenomena should enable us eventually to control them.

Literature.

The reader is referred to the following publications for further information: Lectures on the Physiology of Plants, J. Sachs; the two books, Power of Movement in Plants, and The Various Contrivances by Which Orchids are Fertilized by Insects, Charles Darwin; Text-book of Botany, E. Strasburger and others; The Physiology of Plants, W. Pfeffer; Lectures on the Physiology of Plants, S. H. Vines; Plant Geography, A. F. W. Schimper; Organography of Plants, K. Goebel; Comparative Anatomy of the Vegetable Organs of the Phanerogams and Ferns, A. de Bary; Plant Physiology, Paul Sorauer; Practical Text-book of Plant Physiology, D. T. MacDougal; An Introduction to Vegetable Physiology, J. R. Green; Text-book of Plant Physiology, G. J. Pierce; the two books, Disease in Plants, and The Oak, H. M. Ward; Natural History of Plants, Anton Kerner; The Great World's Farm, S. Gaye; The Soil, F. H. King. There are many good school and college texts that will aid the general reader.

RESPONSE OF PLANTS TO ARTIFICIAL LIGHTS

By *G. E. Stone*

Light constitutes one of the most important external factors affecting vegetation, and plays a prominent rôle in modifying the configuration of plants. Photosynthesis, or the assimilation of carbon, is one of the most fundamental processes in the vegetable kingdom, and is dependent on light. The activity of this process increases proportionally to light intensity.

Except in the polar regions, plants are exposed to the influence of light during only half their life period ; the other half is spent in darkness. So far as is known, plants do not assimilate carbon during bright moonlight nights, although sensitive appliances for determining light intensity are capable of registering the comparatively feeble illumination of even bright nights, which would tend to show that the minimum amount of light necessary for photosynthesis is comparatively strong. Photosynthesis takes place under the influence of electric and artificial lights, as has long been known, but the activity of the process depends on the intensity and the spectrum of the particular kind of light.

In glasshouse and other intensive cultures, it is important to know whether artificial lights of any kind can be used economically to supplement sunlight and thereby produce an earlier or better crop. It is also important to know what effect artificial lights have on plants in exhibition halls. This subject has been the theme of considerable experimenting, but little very practical agricultural result has yet been secured. In the winter, particularly in cloudy climates, artificial light may very likely come into prominence in the growing of some kinds of crops. The following account gives a brief survey of what has been accomplished.

Electric arc light.

Many experiments have been made relating to the influence of electric light on vegetation, more particularly with the stronger lamps, such as the arc light. The spectrum of the ordinary electric arc light is that of carbon, with a slight addition, in some cases, of the spectra of certain gases. It is especially rich in the rays of high intensity, lying in the ultra-violet or actinic part of the spectrum, beyond the range of vision. It is well known that electric light possesses more of the ultra-violet rays, with probably less of the orange rays, than sunlight; therefore it would not be expected that electric light would possess the same value to plants as sunlight, even if the intensity of each were the same, since the rays which are the most valuable for photosynthesis are those located in the yellow and orange bands of the spectrum. On the other hand, the highly refrangible or ultra-violet rays of the spectrum stimulate growth of a spindling nature, which would be undesirable to most crops.

Hervé-Mangon was one of the first to demonstrate that electric light was capable of producing chlorophyll in plants as well as inducing heliotropism, and as far back as 1869 Prillieux showed that electric light is capable of promoting assimilation.

The first recorded horticultural experiments with electric light were made by Dr. C. W. Siemens, an English physicist. He experimented with a variety of plants, such as strawberries, tomatoes, grapes and melons, and found that an arc light produced decided effects on the growth of these crops, sometimes producing beneficial, and, at other times, injurious effects. He ascertained very early in his experiments that a naked or unscreened light was injurious at short range, but that the interposition of a glass globe or ordinary window-pane prevented such injury. He demonstrated that an arc light could be placed over a greenhouse with good results, the glass in such cases screening off the injurious rays, and found that plants developed earlier under screened lights than otherwise. As a result of his experiments he became very sanguine that electric light could be used to advantage in horticulture, and he was the first to employ the term "electro-horticulture" to designate this new application of electrical energy. He showed that growth can be hastened by the addition of electric light to daylight, and that injury does not necessarily follow continuous light through the twenty-four hours ; that electric light often intensifies the green color of leaves, producing a deeper color in flowers and modifying the flavor of fruits. Siemans maintained that the addition of electric light enables plants to stand a higher temperature in a greenhouse.

At the time Siemens, in England, was conducting his experiments, Dehérain was making investigations in Paris along the same line. He attempted to grow plants by continuous electric light, that is, with no daylight whatsoever. He found, as Siemens did, that an unscreened light injured plants, although it promoted assimilation more effectively than a screened light. He found that barley, flax, chrysanthemums, pelargoniums, roses and others were severely injured after seven days of continuous exposure to electric light, and that this injury was manifested by the dropping off or turning black of the foliage. In the case of lilacs, when the leaves were screened or protected by the upper leaves, no injury took place. Plants which received sunlight by day and electric light by night were injured in the same manner, but to a less degree. He found that electric light was far inferior to bright sunlight in its effects on photosynthesis, and that electric light was particularly injurious to seedlings, as most of them died before forming leaves. Dehérain's conclusions are briefly as follows : Electric light contains rays harmful to vegetation. These, however, can be modified or eliminated by the use of transparent glass. It contains enough rays to maintain full-grown plants 2½ months, but is too weak to enable seedlings to reach maturity.

Among those in America who have experimented with electric light are L. H. Bailey, of Cornell University, and F. W. Rane, formerly of the West Virginia Experiment Station. Bailey made extensive experiments with the arc light, covering a period of four or five years. Rane, formerly Bailey's student, used the incandescent light. At first, Bailey employed a 2,000 candle-power unscreened arc lamp suspended inside his forcing-house, and this was kept running all night. He made his experiments in a forcing-house 60 feet long and 20 feet wide, this being divided by a partition. In one part of the house, plants were exposed to an electric light at night, in addition to the daylight which they received, while the plants in the other part of the house were grown under normal conditions, receiving daylight only. According to his experiments the general effect of the electric light was to hasten maturity, and the nearer the plants were to the light the greater was the acceleration, which was particularly marked in the case of crops like endive, spinach, cress and lettuce. He noticed a tendency for the plants to run to seed, and the leaves which developed near the light became small and curled. The amount of starch in the leaves of both the electric and the non-electric plants was the same, although the starch appeared to be more developed in those plants exposed to electric light. Lettuce plants within three feet of the lamp were killed outright soon after they came up, and the remaining plants were seriously injured, developing small, curled leaves. The farther away the plants were from the light, the more vigorous they appeared, but they were not so vigorous as those grown in sunlight.

Radish plants made strong bendings toward the electric light; their foliage curled and the injury was in direct proportion to the proximity of the lamp. Those plants located within three to six feet of the lamp were nearly dead in six weeks, while those fourteen feet away showed little injury. The normal crops during the same length of time made twice the development of those subject to the electric light. Chemical analysis proved that there was more ash in them, twice as much potash, and the chlorophyll was somewhat more than in the normal plants. Nitrogen, however, was the same in both cases, but more amide nitrogen had been changed into other forms than in the normal plants, and those grown under an electric light were richer in albumenoids. Dwarf peas blossomed and fruited earlier but yielded only four-sevenths as many seeds as those under normal conditions, while the plants were considerably shorter in growth. Bailey found that carrots showed the least injury from the effects of the arc light.

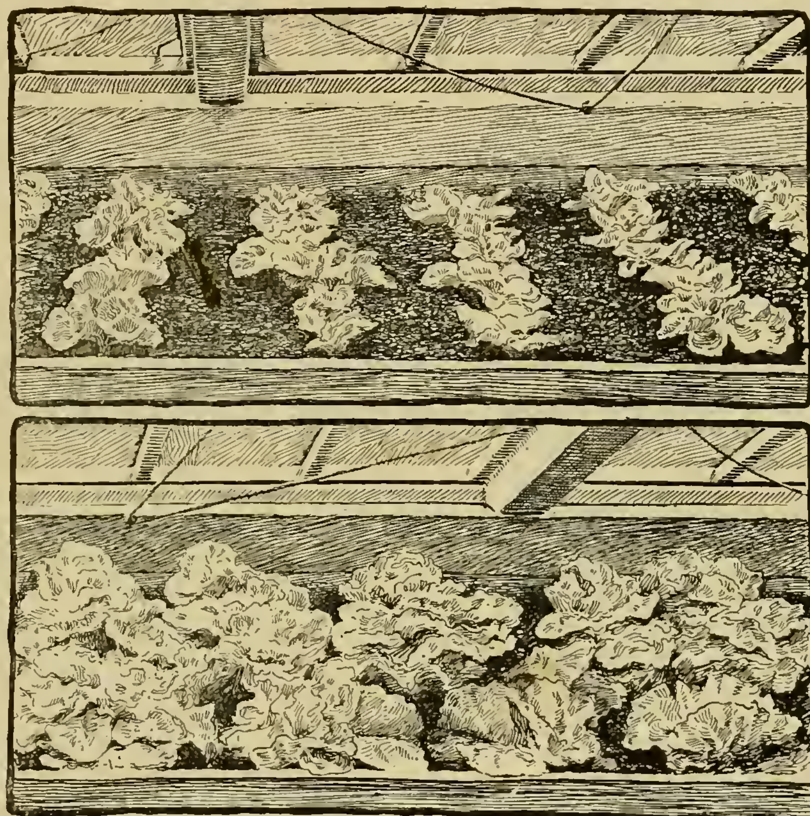

Fig. 44. Lettuce of the same age and variety grown under normal conditions of sunlight (above) and with naked electric arc light running part of the night in addition (below), five weeks after planting in permanent quarters. (Bailey.)

The experiments just described were all made with a naked arc light; but he further experimented on the effects of screening the arc light with glass, in which case he made use of opal globes. This screening eliminated many of the ill effects brought about by the naked arc light; while the loss in radishes from the use of the naked arc light was 45 to 65 per cent, with the screened light it averaged only 1 to 5 per cent. His results with lettuce were the most encouraging. This plant seemed able to adapt itself completely to screened light, while other plants, as before, showed a tendency to run quickly to seed.

He then attempted to operate his electric light for only half the night, with the result that the foliage of radishes was noticeably larger. Peas, on the other hand, showed small leaves and less fruit under these conditions.

The most favorable results, however, were secured in the case of lettuce, when the house was lighted only half the night (Fig. 44). At the end of three weeks the lettuce plants under the influence of electric light were fully 50 per cent in advance of those in the normal house, and the color and other characteristics of the plants were equally good. The lighted plants had received about 70½ hours of electric light during this period, and they were ready for the market one month later; but it was six weeks before the plants in the normal house were equally developed. This forcing required 161¾ hours of electric light, at a cost amounting to about $7. This experiment was repeated several times, with practically the same results. Further experiments showed that the injurious effects of electric light can be overcome by the interposition of glass, and good results were obtained by suspending a lamp surrounded by a globe. Plants that were injured by the naked arc light hung inside the house, were benefited by the same light hung above the roof. Experiments were also made with colored screens. The practical conclusions which Bailey drew from his researches are that lettuce can be profitably forced by the use of the electric light, and that probably many flowers can be similarly benefited.

Bailey's experiments with other market-garden crops and flowers under glass gave varying results which, on the whole, were not encouraging, the light in some cases not producing much modification, while in others modifying them in an undesirable way. Some of the unfavorable results which he noticed were a spindling growth, a bleaching of some of the leaves, disintegration of the cells and a collapse of the chlorophyll bodies; but these injuries are lessened or prevented by the interposition of clear glass, which cuts off the ultraviolet rays.

W. W. Rawson, a Boston market-gardener, has employed electric light for some years in connection with his lettuce business, and has reported beneficial results from the use of an arc light suspended over his houses.

Bonnier, of the University of Paris, has investigated extensively the effects of electric light on plants and has arrived at many interesting conclusions which are not at variance with those of other experimenters. He found that electric light contains more of the ultra-violet rays, which can be screened out or weakened by the use of thick glass, and that plants illuminated by screened electric light differed widely from those cultivated normally, as well as from those cultivated under an intermittent light,—twelve hours of darkness and twelve of light. According to his observations, plants grown entirely under electric light possessed much greater quantities of chlorophyll, and even the deeper-lying tissues not normally possessing chlorophyll were green. The axes of plants were also shorter than those grown under normal conditions, the leaves smaller and thicker and the flowers normally developed but more highly colored. The internal structure of such plants strongly resembled etiolated plants; that is, the mechanical tissues were not well differentiated. On the other hand, he found that plants exposed to discontinuous electric light showed some abnormal symptoms, but, in general, they possessed similar characteristics to plants grown in sunlight. It is thought that an uninterrupted duration of illumination is responsible for the deviation from the normal structure.

Bonnier made comparisons with plants grown in northern latitudes and those grown on the mountains of central Europe, and he maintains that the plants of northern latitudes possess less differentiation of structure than those in the mountains of central Europe, and that the same species of plants grown in continuous light resemble those which are found in the polar regions.

Electric incandescent light.

Rane experimented with incandescent light, the results of his work appearing in Bulletin No. 37 of the West Virginia Experiment Station. His results appear to be very similar to those secured by Bailey and others with the arc light.

The essential difference between the arc light and the incandescent light in this connection is that in the arc light the chemical or actinic rays are prominent, while in the incandescent light these are only slightly present. The spectrum of the incandescent light is that of carbon at low intensity, the luminous part of the lamp being cellulose; it is modified somewhat by the glass of the bulb. The incandescent light is much steadier than the arc, and it casts no sharp shadows; it is less expensive and requires almost no care. Rane found

(1) That the incandescent electric light has a marked effect on greenhouse plants.

(2) That the light appears to be beneficial for some plants grown for foliage, such as lettuce. The lettuce was earlier, weighed more and stood more erect.

(3) That flowering plants blossomed earlier and continued in bloom longer under the light.

(4) That the light influences some plants, such as spinach and endive, to run quickly to seed.

(5) That proper watering appears to be more important with radishes, beans and cuttings than improper watering plus the electric light.

(6) That the stronger the candle-power the more marked the results, other things being equal.

(7) That most plants tended toward a taller growth under the light.

Acetylene light.

The use of acetylene light for forcing plants has not yet had sufficient study to justify positive assertions regarding its value. Perhaps the most important investigations were those made at the Cornell Experiment Station in 1905 and 1906, and reported by John Craig, in the "Acetylene Journal" for September, 1906. The following discussion is an abstract from this report. (The full report, in bulletin form, to be made by the Cornell Station, is not published as this article is written):

The chief interest in the use of acetylene light for forcing plants, centers about the fact that in its composition it more nearly resembles sunlight than any other artificial illuminant in use. It is composed of the same colors and in very similar degrees of intensity. Münsterberg makes the following comparison of color values of acetylene and sun rays, allowing 1 to equal the value of each color of sunlight:

Sun	Acetylene
Red 1	1.03
Yellow 1	1.02
Green 1	.71
Blue 1	1.46
Violet 1	1.07

Indigo and orange are not given. The ultra-violet rays, the injurious factors in the case of electric light, are practically absent in acetylene, although blue and violet are equally strong.

In these experiments, acetylene was added to sunlight, being turned on after twilight. For comparison, the experiments were conducted in warm (60°–65°), medium (50°–55°), and cool (45°–50°) rooms. Lettuce, parsley and spinach were hastened; coleus increased in vigor; asparagus showed little effect; begonias gave increased growth, but delayed flowering period; *Cobæa scandens* produced 15 to 20 per cent more vine; ferns, leeks, onions and beets showed very little effect; radishes in the cool house in the dark days of autumn produced more than twice the root product, the time period was increased 62 per cent, and the maturing period shortened about 20 per cent; strawberries grew more vigorously and ripened fruit sixteen days earlier; peas and bush beans were benefited; pole beans produced a much heavier vegetative growth, but matured fruit later; cucumbers were apparently injured.

The results of the experiments may be briefly summarized. Comparing the results of the different vegetables, we find

(1) That with the exception of the cucumbers, all the forms had a decided increase of the foliage parts.

(2) That the time of fruit-maturing is variously affected, the strawberries and peas maturing earlier, the tomatoes and pole beans later, and the cucumbers and other forms practically unchanged.

(3) That there is, as a rule, an increase in the amount of fruit, also in size of individual fruits, the cucumber being the chief exception.

(4) That the chief beneficial effects of the light are to make up for deficiency of sunlight, to give, with few exceptions, stronger and more vigorous top growth, and to help overcome unfavorable conditions in certain other lines.

(5) That there seems to be a limit in rapidity of growth, beyond which plants cannot be forced at all proportional to the attendant expense. Just what conditions govern this limit or where the limit is in forcing-house plants, is as yet unknown.

Photosynthetic processes are completed to the point of starch-making; root systems increased in the main proportionately with top development.

Influence on blooming.—With three exceptions, all plants bloomed earlier under acetylene light than under sunlight. Some of the geranium plants bloomed twenty days earlier. The blooming of carnations was hastened, but the stems were elongated to an injurious extent. The growth of Easter lilies was increased and the flowering period hastened (Fig. 45).

Fig. 45. Lily grown only in sunlight, at the right; a plant of equal strength and age grown with acetylene light in addition to sunlight, at the left.

The influence on the quantity of the bloom was marked. In every case there was an increase, two or three times as many blossoms being produced in some plants. The effect on the duration of the bloom was somewhat contradictory. Cucumber flowers remained on the vines a shorter time. Lily and narcissus flowers lasted longer under the acetylene. Bulb plants came to maturity under acetylene light alone with no sunlight, and other plants made green foliage (Fig. 46).

General summary. — These preliminary tests gave marked results, but much more experimental work must be done. Ninety to ninety-five per cent of the plants experimented with responded favorably to the stimulus given by the acetylene light. There was no uniformity of results within a group of related plants. No striking detrimental results were observed except when plants were grown under optimum conditions.

Incandescent gaslight.

L. C. Corbett experimented with the Welsbach incandescent gaslight, the results of his work appearing as Bulletin No. 62, of the West Virginia Agricultural Experiment Station. These tests were of an economic rather than a scientific nature. In no case was the artificial light found to be a satisfactory substitute for daylight. But it is thought that, could the conditions of the plants in the dark chamber during the day be kept as nearly normal as are the conditions for plants exposed to the artificial light at night only, the results would be very different. A possible explanation of the stimulus following the use of the incandescent gaslight and the incandescent electric light as well, as gathered from these experiments, is from their richness in red and orange rays. A summary of the results of Corbett's work showed:

(1) The incandescent gaslight of the Welsbach burner was an active stimulus to plant growth when used at night to supplement daylight.

Fig. 46. Plants grown wholly by acetylene light, with no sunlight.

(2) Lettuce plants subjected to the influence of the incandescent gaslight at night were taller and heavier than plants of the same variety and seed-sowing grown in normal conditions.

(3) Lettuce and spinach subjected to the stimulating influence of the light grew faster and completed their growth in less time than plants of the same sorts from the same seed-sowing grown in normal conditions.

(4) No injurious effects resulted from the use of the incandescent gaslight.

(5) The stimulating influence of the light as indicated by the growth of plants used in various tests is shown by the order in which the sorts are named, the first being the most susceptible — spinach, cabbage, radish, lettuce, tomato.

(6) The range of the light was somewhat variable for the different crops. In general, the maximum growth was attained at twelve to sixteen feet from the light, while a perceptible increase was noted at twenty-four feet.

(7) Bloom record of tomatoes showed markedly earlier bloom in the light house,— eight days the least and eighteen days the greatest difference.

(8) In the case of radishes, top growth was stimulated, but evidently not markedly, at the expense of root. With sugar-beets, top growth was greatly stimulated, evidently at the expense of root growth.

(9) While the roots of beets grown in the normal house were larger than those in the light house, the sugar contents and the percentage of purity were markedly higher in the light-house grown plants.

(10) Spinach, lettuce and radishes all tended to make seed-stalks earlier under the light.

(11) Lettuce and spinach under the influence of the incandescent gaslight not only grew faster during the growing period, but the period was actually longer than for plants in the normal house.

The Cooper-Hewitt mercury vapor electric light.

C. P. Close, of the Delaware Experiment Station, endeavored to determine the effect of the Cooper-Hewitt mercury vapor electric light on plants. The results of his work were presented before the Society for Horticultural Science, at its second annual meeting, and are recorded in the proceedings of the society.

In conducting this test it was necessary to have an enclosed place practically light-tight, so as to exclude the daylight and allow the plants to have the artificial light only. This was provided by building in the greenhouse a "double-deck" bed, using the upper bed for plants in sunlight and the lower bed for those in artificial light. The lamps used were the Cooper-Hewitt 4-H pattern. These were suspended as nearly over the center of the bed as possible. Owing to variation in the electrical potential — from 100 to 125 volts — a constant intensity of light could not be maintained.

The light from these lamps is perfectly white, devoid of red rays. The candle-power of a 4-H lamp, or tube, is about 650, and the expense per candle-power is about one-eighth that of the candle-power of the incandescent electric light, and about three-fourths that of the arc light. The light is caused by the vapor of mercury in the tube becoming heated white hot as the electric current is passed through it. One end of the lamp-tube is positive, the other negative, and the vapor of mercury completes the circuit by connecting the two.

Tests were made with lettuce and radishes. Over the lettuce at first only one lamp was used, placed about sixteen inches from the soil. The growth was unsatisfactory because of the unfavorable temperature and atmospheric conditions of the bed, due to the tight enclosure, allowing no ventilation. The excess of moisture that accumulated in the atmosphere was a great hindrance. The plants received light only during the night. They partook of the nature of twining plants. The stems were long and produced leaves at intervals of two or three inches; and not being strong enough to support their weight, assumed a recumbent position. It was impossible to keep plants alive for any length of time when they were more than two or three feet beyond the end of the lamp-tube. The time for germination was the same as for seed sown in daylight. The formation of chlorophyll seemed to be perfectly normal. After a few weeks the plants came practically to a standstill. With two lamps, the results were but little more encouraging.

The results with radishes were practically the same. There was no fleshy root development, and the plants were long and weak. There was very little leaf-growth, although there was production of chlorophyll.

These experiments must be considered preliminary. They demonstrated that chlorophyll could be formed by this light, devoid of red rays. With improvement in the electrical apparatus better results are to be expected.

Influence of colored light on plants.

Investigations pertaining to the effects of the different rays of light on plants have been conducted for many years, although many of the earlier experiments are more or less faulty, since pure spectrum colors were not always employed, nor were the plants always subjected to the same degree or intensity of light.

Flammarion found in his experiments with sensitive plants that red light accelerated growth the most, this being followed by green, white and blue light, in the order named. His experiments were made in a small conservatory behind clear and colored glass, which, however, did not in all cases furnish strictly monochromatic light. Other observers have shown that plants grow more vigorously in orange rays and that they resemble those which grow in darkness, while those subject to blue light resemble plants grown in daylight. While orange light produces effects similar to those in plants grown in darkness,—that is, they develop small leaves and elongated internodes, resembling etiolated plants,—their leaves are green. On the other hand, blue light prevents the expansion of the cotyledons in some cases, and, since it does not induce photosynthesis, there is little need of their expanding.

The effect of orange light on the growth of fungi is similar to that brought about by darkness. For example, the aërial hyphæ of Pilobolus become greatly elongated when grown in darkness or in orange light. Blue light, however, induces irritable movements or heliotropic curvatures. Sachs found that the elimination of the ultra-violet rays has an effect on the production of flowers, causing a less luxuriant development of them. The accurate experiments of Englemann, Reinke and Timiriazeff have shown that photosynthesis in green plants reaches its maximum in the red and orange rays of the spectrum between the lines B and C. In the case of the red algæ, however, the region of maximum assimilation is somewhat different, since the greatest photosynthetic activity is shown between the yellow and green bands, while in the blue-green algæ this occurs between the orange and yellow. There is some reason to believe that such pigments as phycoerythrin, found in the red algæ, may possess some ecological significance, since the plant frequently grows at considerable depths in the ocean. The most active assimilation is caused in the purple bacteria in the infra red rays or those rays having wave lengths of 800 to 900 $\mu\mu$.

Some investigators have noted an injurious effect of the green rays on certain plants. This may be accounted for by unlike methods used in experimenting, although it is well known that different plants respond in a different way to the same light stimulus. Plants respond to the ultra-red and ultra violet rays, which are well known to make no impression on the retina; and the same may be held to be true in regard to other forms of radiant energy. It has been shown that electrical radiations characterized by wave lengths vastly longer than the last visible red rays are able to produce certain physiological effects on plants, but whether this will apply to the Röntgen and Becquerel rays has not been definitely proved.

There is little likelihood of monochromatic light being employed to advantage in growing crops, since plants are best adapted to mixed rays, such as occur in sunlight.

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THE STIMULATION OF PLANT GROWTH BY MEANS OF WEAK POISONS

By *Howard S. Reed*

That plant growth can be accelerated by the action of certain poisons has been known for some time. The method was at first practiced in laboratory cultures, but has now been applied successfully to plants growing in the field. Experiments indicate that the tillers of small farms and market-gardens would profit greatly by the practice of crop-stimulation; they will be able not only to raise larger and more succulent vegetables but to hasten the maturity of them.

In the practice of medicine it is well known that when small doses of poison (e. g., strychnine, alcohol, arsenic) are administered, a stimulation of some part of the body results. In a general way, the same principle has been noticed in the growth of plants. The application of gypsum, or land-plaster, while it undoubtedly sets free potash in the soil, has long been recognized as stimulating. The application of fungicides, as Bordeaux mixture, has been found beneficial: first, the mixture kills parasitic fungi; and, second, it stimulates the plants to more vigorous growth. Grapes and gooseberries sprayed with Bordeaux mixture were found to contain 1 to 2 per cent more sugar than the fruit from unsprayed but healthy plants.

Experiments with poisons.

Experiments in pure cultures have been conducted principally on the lowly plants, viz., the algæ and fungi. In 1897, Richards discovered the stimulating effects of zinc salts on the growth of the mold fungi. Ono, working in Japan, found that compounds of zinc, copper and iron, when present in very small quantities, exerted a stimulating effect on the growth of algæ. In this case he found that the stimulation was more manifest in the reproductive activity of the plants than in the growth in size of the individuals. Le Renard found that the greatest stimulation with mold fungi occurred in the presence of the best and most available food supply. As supplementary to this fact, we may mention that the presence of very small amounts of copper in distilled water is fatal to the growth of the roots of seedlings; while in the presence of food it would undoubtedly cause stimulation.

The writer has observed that seeds which have been soaked in very weak potassium bichromate solution to kill adhering germs, germinate in shorter time than those soaked in pure water. Miani found, too, that pollen-grains germinated better in water containing copper coins than in pure water. The effect of chemicals on seed germination has been studied by many investigators, under a variety of conditions, and the literature is rather extensive. With the exception of certain reagents, however, no definite general statements can be made regarding their action. Further work is needed to establish the principles on which action takes place. It is probable that the factors influencing germination differ fundamentally in certain respects from those affecting later growth. One need not expect, therefore, that germination will be stimulated by the same compounds that stimulate the growth of the adolescent plant.

Richards and his students have recently established the fact that stimulated plants work more economically than unstimulated plants, i. e., they attain to a given size and weight with a much smaller consumption of food material.

The results obtained from growing plants in pure culture are not all applicable to plants growing in the soil. Compounds of iron, manganese, fluorin, and iodin seem to promise most for practical agriculture. The best results have often been obtained by applying a mixture of two or more compounds.

Sulfate of iron (copperas) has often been the subject of experiment. Some experimenters reported favorable results, some unfavorable, and some inferred that it had no influence whatever. Its benefits varied according to the quantities used. Loew found that the application of 1 to 2 ounces of sulfate of iron per ton of soil resulted in a stimulating action, and Griffiths observed very good results when it was applied at the rate of 50 to 100 pounds per acre.

The advantage of applying two stimulating substances to the soil instead of one may be seen from the results of an experiment which Loew performed, using tobacco plants. The plants were grown in soil in pots, some were watered with dilute solutions of manganous sulfate and iron sulfate (0.3g $MnSO_4$ + 0.2g $FeSO_4$ in 100 cc. water), others with manganous sulfate or iron alone. The average height to which the plants attained in eleven weeks after the application of stimulants was as follows: When no stimulant was applied, 45 inches; when manganese and iron were both applied, 59 inches; when manganese alone was applied, 58 inches; when iron alone was applied, 55 inches. The average number of flowers and buds on the same plant was also distinctly greater on the plants that received two stimulants. Those that received both manganese and iron produced 63 flowers and buds; when manganese alone was applied there were 50; when iron only was applied there were 55, and on the control plants, none. It is thus shown that the application of stimulants not only produced larger plants, but hastened their period of blossoming. An additional point in favor of iron sulfate and manganous sulfate is their cheapness, since both salts can be applied directly in the raw, unpurified state.

Compounds of iodin have given marked stimulation to plant growth. However, since they are extremely poisonous to plants, they must be used in very small quantities. A top-dressing of iodid of potassium, applied at the rate of 50 pounds to the acre, injured wheat and barley. Suzuki found that such small quantities as one-third of an ounce per acre were sufficient to cause stimulation, and that four ounces per acre was amply sufficient. These small quantities were dissolved in water and sprinkled on the soil. This substance increased the weight of radishes 31 per cent over the yield on control plots.

The writer has tried the effect of some poisonous substances on the growth of potatoes. Although the results are far from complete, they indicate that magnesium carbonate, applied at the rate of 200 pounds per acre, and iron and manganous sulfate applied at the rate of 17 and 175 pounds per acre respectively, exert a stimulating action on the growth of potato tubers. The benefits of stimulation were shown not only in the increased yield of the tubers, but also in their improved quality. The action of the same poisonous compound is not always the same on different crops, just as the feeding of different crops must vary. The action will probably vary also on soils according to their content of acids or alkalies.

The application of small quantities of organic substances having a toxic effect at high concentrations is often beneficial, especially when applied to certain unproductive soils. Bulletin No. 28 of the Bureau of Soils of the United States Department of Agriculture describes the beneficial effects of tannic acid and of pyrogallol when applied in small quantities to an unproductive soil. The application of tannic acid at the rate of one part per million of soil increased the growth of wheat seedlings about 75 per cent. In another experiment, pyrogallol was added at the rate of 500 parts per million of soil. On soil so treated, the growth of wheat plants was twice that on the untreated soil. While it is not probable that the application of either of these last-named substances will be profitable for the commercial grower, it is shown that growth may be accelerated by a wide range of substances.

Etherization.

It may be in place to mention the action of anæsthetics on plant growth, since the anæsthetics behave as poisons if they are allowed to act for any length of time. The plants are inclosed in a tight compartment and exposed for a short time to the vapors of ether or chloroform. At the Government Botanical Garden in Dresden, lilacs treated with ether on October 19 produced blossoms November 8. Another season the etherized plants blossomed November 13. Etherization does not hasten the blooming period of lilacs if the period of rest is entirely completed before the anæsthetic is applied.

The practice of etherization is meeting with favor among the florists of France. In America it has been applied with success to the forcing of rhubarb and asparagus. Sandsten showed that chloroform and ether had an accelerating influence on seedlings, but they were injurious to narcissus.

Experiments made at the Cornell (N. Y.) Experiment Station gave interesting results. A Persian lilac, *Syringa vulgaris*, was placed in the forcing-house on November 24, after having been etherized for 24 hours. Within five days many leaf-buds were entirely open, and by December 11 the plant was in full leaf. The first flower-buds opened on December 6, and the plant was in full bloom on December 25, just 31 days after the beginning of the experiment. A check plant did not reach full bloom till six days later. When the plants were exposed to ether fumes for a longer period, more marked results were secured. A lilac etherized for 48 hours made a gain in coming to full flower of 8 days over the check plant; one etherized for 72 hours gained 10 days. *Astilbe Japonica* etherized for 24 hours, in one instance was in full bloom a month to five weeks before the check plant. Experiments with bulbs also showed favorable results from etherization (Fig. 47). Narcissus showed a gain varying from two days to three weeks in

Fig. 47. Narcissus etherized (at the right) and not etherized (at the left).

coming to full bloom, results contradictory to those secured by Sandsten. Two lots of *Lilium longiflorum* showed a decidedly taller growth, but no gain in the time at which first blossoms appeared. A third lot, which had been etherized for a longer time, showed a gain in both time and height. [A brief account of these Cornell Experiments, by J. Eaton Howitt, and Claude I. Lewis, appears in The Cornell Countryman, May, 1906; a bulletin of the work has not appeared as this article is written.]

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EFFECT OF ELECTRICITY ON PLANTS

By *G. E. Stone*

The relation that exists between electrical stimulation and plant growth has been a subject of much study, covering a great range of methods and conditions, and producing varied and conflicting results ; but the question has not yet had the careful and systematic study necessary to the formulation of rules for practical application. Much has been written on the subject, and the reader will find a few citations at the end of this article. It is here possible to give only a very general outline of the experimental methods that have been tried and the results.

Historical sketch of methods and results.

Investigations pertaining to the effects of electricity on plants have been made by various experimenters for 150 years or more. It might be supposed that electricity, which so universally manifests itself in nature, would under certain conditions be capable of acting as a stimulus to plants. That the roots of plants are susceptible to the influence of galvanic currents (galvanotropism) has been shown by the experiments of Elfving, Brunchorst and others ; and Hegler has shown that the aërial hyphæ of *Phycomyces nitens* are negatively electrotropic ; that is, they bend away from Hertz waves. It has also been known for some time, through the experiments of Kunkel and others, that electric currents exist in the plant itself. The cause of these currents has been attributed to minute streams of water passing through the plant. The experiments of Haake have shown that differences in the electrical potential in the plant are chiefly caused by metabolism and respiration.

The influence of current electricity on plants has received the most attention. Attention was first called to the influence of electricity on growing plants about the middle of the eighteenth century. The experiments made by Dr. Mainbray, of Edinburgh, in 1746, were among the first. He electrified two myrtles for a period of one month, and reported that not only was their growth accelerated but that they put forth blossoms, which was not true of myrtles not electrified. About the same time, Nollet, a distinguished French physicist, who had heard of Mainbray's experiments, took up the subject. He had previously been occupied with the phenomena connected with the behavior of fluids in capillary tubes, and Mainbray's experiments suggested to him the possibility of the increased growth in plants being due to the increase in the flow of sap brought about by electrical stimulation. His first experiments were made on various fruits, which after being weighed were electrified and then weighed again, and the result showed that electricity considerably accelerated evaporation. In 1747, Nollet experimented with two wooden pots filled with earth, in which were planted mustard seeds. One was treated daily with an electrical machine, the other being kept as a check. He found as a result of electrifying that germination was considerably increased, and in the course of a week or more the electrified plants were nine inches high, while the non-electrified ones were only three inches high. Nollet repeated the experiment a number of times with various plants, always obtaining the same result. He found, however, that the electrified plants were, as a rule, weaker than the non-electrified. Jallabert, in 1746, repeated Nollet's experiments on mustard and cress seeds, and obtained similar results. He also electrified bulbs of hyacinths, jonquils and narcissus placed on cakes of resin in glasses filled with water, the resin being connected with wires leading to a frictional machine. He found, as had Nollet, that the electrified ones gave off more moisture than the non-electrified ones, and also that the electrified plants grew more rapidly. Their leaves were larger and their flowers opened sooner than the ones not electrified.

Experiments were made about the same time also on bulbs planted in boxes, with similar results. In 1747, Boze electrified several different kinds of shrubs, the growth of which was accelerated. Similar results were obtained by Menon, in 1748. In 1771, Sigaud de la Fond experimented with bulbs, and found that when they were electrified they grew faster and formed more healthy plants.

De Lacepede, in 1779, found growth and germination invariably accelerated by the use of electricity. Marat, in 1782, experimented with lettuce and obtained positive results. Bertholon subsequently repeated the experiments of Nollet and obtained similar results, and he moreover made many observations in regard to the effects of electricity on the ripening of fruit, color of flowers, and the like. He was the first to attempt to apply electricity in a practical way in the growth of crops, and he even went so far as to recommend it as a panacea for all diseases caused by insects and fungi. Achard, De Saussure and Gardini likewise reported beneficial results from the use of electricity.

Gardini stretched iron wires over his garden at Turin for the purpose of experimenting with atmospheric electricity. After a short time the garden, which had been unusually prolific, began to fail, the plants became unfruitful and wilted. Ingenhousz and Schwankhard, in 1785, made experiments with plants cultivated in Leyden jars filled with water, and obtained negative results. The experiments were criticized by Duvarnier, who maintained that the methods employed were not satisfactory. Ingenhousz's negative results were confirmed by Sylvestre, Paets, Van Troostwyck and Krayenhoff. Ingenhousz and von Breda repeated Gardini's experiments with overhead wires across a garden, but both failed in observing any effect whatsoever on the plants. In 1768, Carmoy sowed grains of wheat in electrified tin vessels and found germination and growth accelerated. Rouland secured negative results with cress seeds planted on plates of cork in electrified porcelain vessels filled with water. D'Ormoy electrified mustard and lettuce seed for several days in moist earth and found their germination always accelerated. Bertholon enclosed seeds of turnip, endive and spinach in tin-foil and kept them constantly electrified for some days, after which they were sown. He found germination accelerated. Vassalli, in 1788, obtained beneficial results from treatment, and so did de Rozieres, who experimented with wheat, beans, rye, peas, radish, and others. De Rozieres maintained that not only was germination accelerated, but in all cases the electrified plants were larger, with longer roots and greener leaves. Humboldt believed that electricity exerted considerable influence on plant growth. On the other hand, Senebier was doubtful, while de Candolle was led to think by his experiments that electricity had very little effect on plants.

The various experiments which were made with electricity up to this time were made with static electricity. With the discovery of voltaric electricity, other methods of experimenting were employed.

From the year 1800, the suject of electricity and plant growth received little attention until 1844, when there was considerable interest manifested in the subject from the results of Forster's experiments. He endeavored to utilize the atmospheric electricity by stretching wires over a crop of barley, and found that growth was increased in a most extraordinary manner. In 1844, Ross made some experiments with galvanic currents which were described in the proceedings of the New York Farmers' Club. He planted a field of potatoes, at one end of which he buried a copper plate five feet in length and fourteen inches deep, connected with a wire to a zinc plate of the same size 200 feet away, at the opposite end of the row. According to Ross, potatoes grown on the treated row were two and one-half inches in diameter, while those grown on the untreated row in July were only one-half inch in diameter. Similar galvanic culture experiments have been made by Sheppard, Helmert, Fitchner and Söhne, Tschinkel, Holdefleiss, Maercker, Wollny and others. Sheppard employed copper and zinc plates two feet long and nine inches wide. These were connected with wires and buried in the soil nine feet apart, and a number of seeds of different kinds were sown in between them. He found that many of the seeds germinated poorly, and some of the plants eventually died, although the electrically stimulated turnip plants showed a greater development than the check plants. Helmert found in some instances that growth was accelerated; on the whole, however, he obtained negative results. Fitchner and Söhne secured positive results with buckwheat, summer wheat, peas, and certain other crops. The gain was 16 to 127 per cent. Tschinkel obtained a considerable acceleration in germination and growth. The electrified plants, he asserted, were much more robust. He attributed the beneficial effects of electricity to the decomposition of certain salts in the soil. Holdefleiss found both growth and germination to be accelerated. Maercker experimented with sugar-beets, and his experiments showed no differences between the treated and the untreated plants either in the weight or percentage of sugar. Some

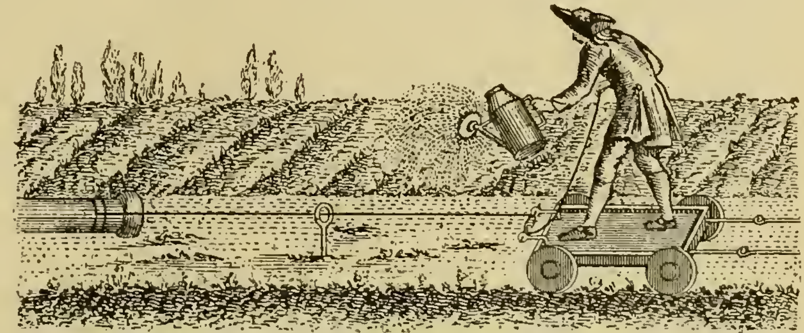


Fig. 48. An early plan for applying electrified water to plants (Bertholon, 1783). The man was to stand on an insulated mounted platform drawn by the two attachments at the right. The electric current was to be carried by a wire attached to the pot, and uncoiling at the operator's feet. (After Wollny.)

experiments were made by Wollny on a more extensive scale and in a very careful manner, with rye, beans, peas, potatoes, rape, beets and others, and in almost every instance he obtained negative results. Chemical analysis of the treated and untreated soil showed no difference in the amount of potash, ammonia, phosphoric acid and potassium nitrate, even when comparatively strong currents had been passed through it. Blondeau found that when seeds of peas, beans and wheat were treated one minute with a constant induction current, germination was hastened, and the electrified seed gave rise to stockier and greener plants. He also found that the fruit of the apple, pear and others ripened much earlier when subjected to electrical treatment.

Chodat employed static electricity, and found that the germination of the pea was accelerated, and that the electrically treated seedlings were longer and thinner, and their leaves somewhat smaller than normally grown plants. Paulin, who likewise used static electricity, obtained positive results. He placed his seeds inside a Leyden jar in which was suspended a copper wire connected with the conductor of a frictional machine. In order to get the best results, he found that the jar containing the seeds must be charged hourly, the length of time which this must be kept up depending entirely on the kind of seed employed. He maintained that electricity not only accelerates germination but that it is capable of awakening the dormant life in seeds.

Speschnew found germination greatly accelerated by the use of galvanic electricity. According to Speschnew, treated seeds germinated four or five days earlier than untreated seeds and possessed longer and stockier stems. Weakes applied electrified water to seed, which resulted in an accelerated germination and growth of seedlings. McLoud found, by the use of direct currents, that many seeds germinated earlier. The growth of the treated seeds, moreover, exceeded that of the normal.

Paulin erected poles in the middle of his experimental plots, which supported a collector composed of numerous copper wires. An insulated wire connected the collector with an iron wire buried in the soil. He asserted, as a result of his experiments, a gain of 33⅓ per cent in the production of potatoes. Jodro experimented in a similar way. However, he connected his collector, which was on a pole 35 feet high, to a wire attached to zinc plates in the soil. He obtained an average increase of 25 to 50 per cent, and in some instances nearly 100 per cent.

Maccagno's method was somewhat different from the preceding one. He attached wires directly to sixteen grape-vines and endeavored to pass the atmospheric electricity through the plant. Chemical analysis of the plants at the end of the season five months later showed only a slight difference in the normal and treated plants.

Aloi found that atmospheric electricity works favorably in the germination and growth of *Lactuca sativa*, *Zea Mays*, *Triticum sativum*, *Nicotiana Tabacum*, and *Faba vulgaris*. Celi employed static electricity. He asserted positive results by charging a wire provided with numerous small points, which were suspended over growing seedlings. Freda experimented in a similar way with Penicillium, but obtained negative results.

Lemström obtained favorable results with static electricity in a large number of cases, in which he used a large Holtz machine. The wire meshes were suspended over the plants which connected with the positive pole, the negative pole being connected with the ground. His experiments extended over a period of years, during which time he employed a larger number of plants than any of his predecessors and, on the whole, his experiments are the most trustworthy. He used a large variety of plants, some of which were favorably and others unfavorably stimulated. He demonstrated that strong charges were unfavorable, and arrived at the conclusion that electricity acts in an indirect way, and that ozone is produced by electrical discharges which have an influence on plants.

Atmospheric electricity.

Duhamel, in 1758, maintained that electricity may be concerned with those remarkable atmospheric changes which affect plants in so marked a manner. Similar ideas were entertained by Mann and Beccaria, who believed that after thunder-storms plants of all kinds grew with remarkable vigor. However, he attributed more marked effect to the constant but feeble electric conditions of the earth. Bertholon, in 1773, called attention to the influence of meteors and lightning on the germination of seeds and the growth of plants. He attributed the failure of the hop crop in 1787 to the comparatively small amount of lightning during that year. In fact, it has been believed for many years in Europe that there is some connection between thunder-storms and the behavior of plants. A common saying among the German peasants is that if a thunder-storm occurs during blooming time buckwheat will not set its fruit. Some years ago Lindley made measurements of plants during a thunder-storm and found no particular differences in their rate of growth, and Matthew thought to have disproved the notions about buckwheat.

Among farmers and others the idea has long been held that milk sours very rapidly during thunder-storms. There appears to be some foundation for this belief, although bacteriologists attempt to account for it by the occurrence of the warm and humid condition of the atmosphere which usually precedes thunder-storms. Our experiments on the influence of electricity on milk tend to show that the farmer's idea is well founded, at least in many instances, since a very slight charge of electricity given to milk increases the number of bacteria enormously in a very brief period of tme.

Review of the early work.

Taking into consideration the results of the various experiments which are embodied in the foregoing résumé, there would appear, notwithstanding the negative results, which, however, are considerably less than the positive ones, to be some reason for believing that electricity exerts an influence on plant growth. Many of the experiments giving positive results were notably crude, especially the earlier ones, and even many of the later ones are not detailed enough to allow of any reliable conclusions being drawn. In the greater majority of cases too few plants were used, faulty methods were employed, the seeds were usually sown in earth where no accurate means of determining the relative acceleration of germination was possible. In the utter absence of measurements of current strength and the growth of plants, the results based on mere superficial comparisons were of little more value than guesswork. In some of the more recent experiments, however, comparisons have been made of the treated and untreated plants by weighing, and in some instances chemical analysis, a very uncertain method, was resorted to. On the other hand, it should be borne in mind that it is easy to repeat some individual experiment that gives a positive result, and by introducing some slight variation in the methods employed, or modifying the strength of current, results of a quite different nature may be secured.

The most severe criticisms that can be brought against the various experiments pertain to the lack of sufficient data concerning the current strength employed; nor are there any data concerning the resistance or electrical potential from which the current strength might be calculated. The insufficient number of plants used and the lack of repetition of various experiments under the same conditions constitute serious objections. It would appear that individual variation as a factor was ignored in the majority of these experiments.

Since there is a limited range of current which accelerates growth, it is an easy matter to overstep the range and obtain negative results. This would seem to be the case in the very carefully conducted experiments of Wollny. The same criticism can be brought against Freda's experiments with Penicillium, in which case he obtained negative results. The writer is unable to find any indication of the potential employed in his experiments, but from his results it would appear that he was entirely out of range. If he had employed a potential of about fifty volts, different results would undoubtedly have been obtained, inasmuch as such has been the case with Monahan's experiments with Mucor and Phycomyces, which are equally delicate organisms.

Recent efforts and results.

The writer and some of his students have conducted for many years an extensive series of experiments dealing with the influence of current electricity on plants. Only a part of the results of these experiments has been published, and in giving a résumé of the subject of electricity and plant-growth, the writer will draw deductions from his various experiments representing data secured from the use of over 50,000 plants.

The experiments made by Kinney in 1896 showed considerable acceleration in the germination of seeds and growth of seedlings, and the idea that weak currents of electricity act as a stimulus was proved to be well founded. He experimented with static electricity and also with direct and alternating currents, all of which gave decidedly positive results. His experiments have been repeated by the writer and assistants, with similar results.

From experiments which the writer and his assistants have conducted for many years in large boxes charged with direct and alternating currents and atmospheric electricity, it has been shown that lettuce and radish crops are considerably accelerated in growth in all instances. The average percentage of gain in the electrically treated lettuce plants in all experiments, as compared with the normal, or untreated plants, was 34.81. The average percentage of gain of the electrically treated radish plants over the normal, or untreated, ones was 37.34. The radish roots showed a gain of 17.26 per cent, while the tops or leaves showed 42.90 per cent gain. The strength of current employed ranged from .05 to 1 milliampere. In these experiments a large variety of plants has been employed, with practically similar results.

Bacteria are greatly affected by electricity; they increase in numbers at a very marked ratio when stimulated. The process of fermentation by yeast is also greatly accelerated by the application of minute direct currents or by a single tiny spark from a frictional machine.

The range of currents acting favorably on growth is limited and may be represented as ranging from .005 to .55 milliamperes. Direct currents are not so stimulating in all cases as alternating currents, but static electricity stimulates very appreciably. In the many thousand seeds which have been used there is no evidence that electricity awakens life in dormant seeds. It always acts as a decided accelerator to germination and growth, but the germinating capacity is in no way affected.

Monahan has shown that charging air with static electricity constitutes an important stimulus to seeds and plants. Germination and growth in such instances are greatly accelerated. He employed a potential ranging from 50 to 175 volts, with most excellent results. A too high potential or a too strong current prevents growth, and if the current is increased sufficiently it is easy to kill plants. The maximum or death current is determined by the nature of the plant, as well as the conditions under which the plant is stimulated. On the other hand, too weak currents do not produce perceptible reactions. The optimum or best current the writer found to be about .22 milliamperes.

The connecting of copper and zinc electrodes placed in soil constitutes a very effective method, as well as one of the cheapest ways, of stimulating crops by electricity. Strips of copper and zinc one foot wide and four to six feet long connected with wires furnish a battery when placed in soil, which under certain conditions will generate an optimum current. The amount of current which these will produce depends, of course, on the size of the metal plates employed, together with the nature of the soil and other factors. A soil lacking in organic matter and plant-food will give less current than a richer soil. Plates six inches by three feet in some soils would give a current ranging from .02 to 1 milliampere when placed four feet apart, whereas, if these same plates were put in some of the highly manured Boston market-garden soils, they would generate ten to twenty times as much current in a tolerably dry soil, when placed farther apart. The amount of resistance in well-manured market-garden soils is extremely small, and it has been estimated that if a large house were provided with copper and zinc plates located at either end and these were connected with wires, a current could be generated sufficient to run a small incandescent lamp.

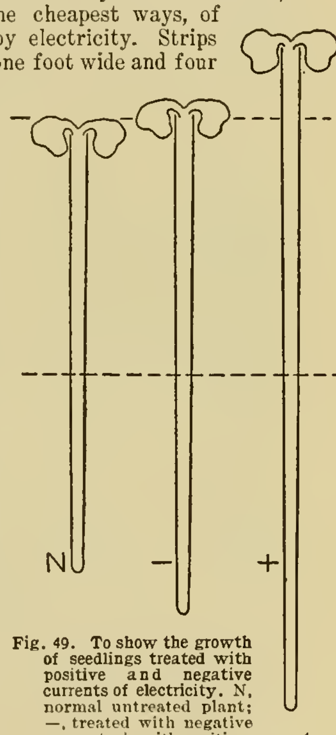


Fig. 49. To show the growth of seedlings treated with positive and negative currents of electricity. N, normal untreated plant; −, treated with negative current; +, with positive current.

General observations.

The extensive use of electricity in a commercial way has introduced factors which have a bearing on vegetation. The numerous high tension wires used for street lighting purposes frequently come into contact with beautiful shade trees and cause much injury. Such injury, however, is mainly of a local nature,—that is, trees are injured or burned only at the point of contact of the wires with a tree, and it can be positively stated that there are no authentic cases of alternating current wires killing large trees. The circumstances, however, might be different in the case of direct current lighting wires, providing sufficient grounding occurred; nevertheless, so-called direct current trolley wires have been known to kill large trees where certain conditions prevail. (Fig. 50.) There is also some evidence in support of the prevailing opinion that a certain leakage or grounding from a trolley system through a tree may cause its death in time without any material burning taking place. In such cases the tissues are over-stimulated, as it were, resulting in the possible disintegration of the protoplasm of the cells.

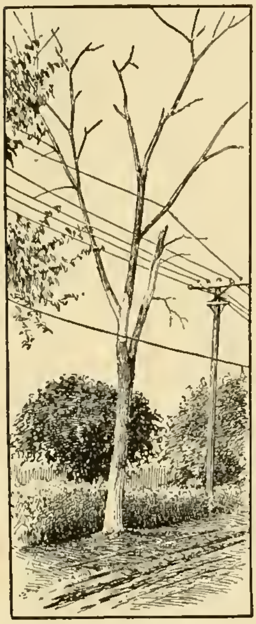


Fig. 50. Elm tree killed by a direct current from an electric railroad system.

There is much evidence in support of the idea that electricity plays an important rôle in nature. The air and earth are constantly charged with it, and vegetation, being in contact with both, is undoubtedly affected. Grandeau and others maintain that when plants are surrounded with wire netting they develop less in a given space of time than plants grown under similar conditions as regards light and other factors in a free atmosphere. The interpretation of this phenomenon is that wire screens modify the atmospheric potential to the detriment of the plant. Grandeau secured similar results by growing plants under chestnut trees, and he concluded that trees modify to a large extent the atmosphoric potential in their immediate neighborhood. Electrical experiments made for three years at the Massachusetts Agricultural College Experiment Station show that the electrical potential at corresponding heights in the free atmosphere and in an elm tree are identical during the season when no foliage is present. When, however, the foliage develops, the potential drops materially in the air surrounding the tree and remains in this condition until the leaves fall, at which time the potential becomes identical again. This is apparently a case of the foliage of a tree absorbing atmospheric electricity or screening it in the some way as does a glass structure. It may be interesting to note in this connection that there is no atmospheric electricity in greenhouses, but the effect of its absence on plants is not easily discernible, since there are too many other factors in greenhouses which modify the configuration of plants. The electrical potential records secured by the writer and his assistants under conifers, such as the Norway spruce, proved the potential to be similar most of the time to that of the earth and not of the air, as secured under deciduous trees, like the elm. Lemström was of the opinion that the numerous small pointed leaves common to conifers serve as points of discharge or accumulators of electricity. This theory has some foundation, since the apices of leaves of trees have been known to discharge electricity, and the electric potential of the air and earth may be more or less equalized by vegetation.

The phenomena underlying electrical stimulation are still imperfectly understood. There are many theories, however, in regard to its action. Nollet and Jallabert thought that the accelerated growth resulting from electrical stimulation was induced by the augmentation in the movements of the sap, and this view has been more recently held by Lemström. Fichtner, Söhne and Tschinkel maintain that electricity renders soluble certain constituents of the soil, as a result of which germination and growth are accelerated. On the other hand, Jodro attaches double significance to the action of soil currents, viz., a chemical and a mechanical action. Chemically it renders those constituents necessary for plant growth more soluble; mechanically it sets the particles of soil into a state of vibration which results in an increased rate of growth. It may be noted that both the chemical and mechanical theories fail to explain the results of stimulation of seeds not sown in soil.

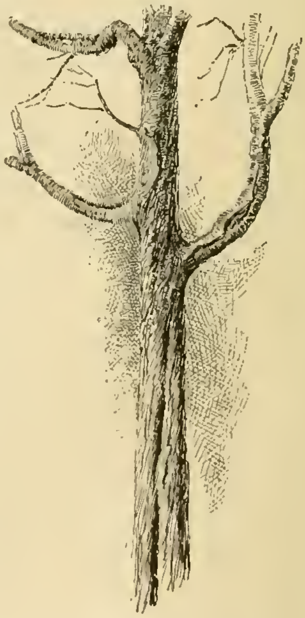


Fig. 51. To show the effect of earth discharge (lightning) through the tree, causing splitting of the trunk and limbs.

It is well known that feeble currents accelerate the movements of protoplasm, and the augmentative circulation theory has more to commend it than any of the others. Notwithstanding the considerable amount of accelerated growth manifesting itself as a result of electrical stimulation, the time is not yet opportune to apply this force very largely to the growth of crops, since the application of current electricity to crops has not been sufficiently tested on a large scale; neither has it been demonstrated that electrical stimulation would always prove advantageous to plants. There appears to be a tendency for electrically stimulated plants to develop a more spindling growth than those grown under ordinary conditions.

Fig. 52. To show the characteristic grooves on the trunk of an elm tree caused by a feeble stroke of lightning. (Compare with Fig. 51.)

Conclusions concerning the effect of current electricity on plants.

In conclusion, it may be stated that the application of electrical stimulation to crops is not as yet practicable, although undoubtedly in the future electricity will be more extensively employed in agriculture, and it is hoped that agriculturists will be able to make use of the enormous amount of electrical energy constantly stored in the atmosphere. From the work that has been done, the following very general conclusions may be drawn:

(1) Electricity exerts an appreciable influence on plants.

(2) Electrical stimulation gives rise to an accelerated germination and growth of plants, the foliage in some instances (radishes) being stimulated more than the roots.

(3) The strength of current inducing acceleration is confined to a narrow range.

(4) There is a minimum, optimum and maximum stimulus. The minimum current is equal to about .005 milliamperes, the optimum to about .22, and the maximum is determined entirely by conditions.

Literature.

Some of the literature pertaining to the influence of current electricity on plants is as follows: L. H. Bailey, Electricity and Plant Growth, Transactions, Massachusetts Horticultural Society, Part 1, pp. 54–79, 1894; Bertholon, De l'électricité des végétaux, Paris, 1783; De Candolle, Physiologie végétale, Tome 3, p. 1088; R. Chodat, Quelques effets de l'électricité statique sur la végétation, Laboratoire de botanique de l'université de Genève, Ser. I, Fasc V, p. 53–56; Bot. Cen. p. 92, Tome LV; Gardini, De influxu electrititatis atmosphæricæ in vegetantia dissertatio, 1784; L. Grandeau, De l'influence de l'électricité atmospherique sur la nutrition des végétaux, Ann. de Chim. et de Physiq., Ser. 5, XVI, 145–226, Feb., 1879; A. S. Kinney. Electro-germination, Bulletin No. 43, Hatch Experiment Station, Amherst, Mass., 1897; Selim Lemström, Electricity in Agriculture and Horticulture, Van Nostrand Company, New York City; J. Maccagno, Ueber den Einfluss der atmosphærischen Electricitat auf das Wachsthum des Weinstocks; Wollny, Forsch. Agricultur-physik, Vol. VI, p. 193, 1883; H. M. McLeod, The Effect of Current Electricity on Plant Growth, Transactions and Proceedings New Zealand Institute, XXV, 479–482, May, 1893, 1894; the same, Ibid XXVI, 463, 464; N. F. Monahan, The Influence of Atmospherical Electrical Potential on Plants, Sixteenth Annual Report, 1904, Hatch Experiment Station; G. E. Stone, Injuries to Shade Trees from Electricity, Bulletin No. 91, 1893, Hatch Exp. Sta.; G. E. Stone, The Influence of Current Electricity on Plant Growth, Sixteenth Annual Report, 1904, Hatch Exp. Sta.; Stone and Monahan, The Influence of Electrical Potential on the Growth of Plants, Seventeenth Annual Report, 1905, Hatch Exp. Sta.; E. Wollny, Forsch. Agricultur-physik, 1882, 1888; Ueber die Anwendung der Elektricitat bei der Pflanzenkultur, München, 1883; Geo. S. Hull, Electro-Horticulture, N. Y., 1898.

CHAPTER II

INSECTS AND DISEASES

INSECTS AND PLANT DISEASES are the plagues of the husbandman. Their incursions have been deplored from the earliest times, although plant diseases have not long been recognized except under the indefinite terms of blights and rusts and cankers and mildews. These pests and ailments have entailed endless human labor and have sacrificed numberless animals and crops; yet the net result has been the enforcing of a more vigorous and constructive agriculture.

The ailments of plants are constantly becoming more numerous and the knowledge connected with them more complex, owing to dissemination of the parasites into new regions, the increase of food supply due to new and more extended cultures, to changes in habits of parasites and hosts consequent on the disturbance of the normal equilibrium in nature. At the same time, however, the means of contending with these difficulties are increasing with phenomenal rapidity. Numbers of persons are now employed at public expense in the study of insects and diseases and in devising means of combating them. This is the guarantee of the future. In fact, our present-day agriculture would be impossible were it not for the entomologists and plant-pathologists. These persons have become as much a part of our modern needs as, in a related realm, have the physicians and sanitarians.

For the most part, the work of insects is at once recognizable ; but plant diseases are obscure as to cause, and it is only within the past fifty years that very careful study has been made of them. The special study of parasitic fungi, which cause many of the diseases of plants, is commonly dated from the work of M. J. Berkeley (1803–1889) in England about the middle of the century just passed. It is also astonishing that the life-histories of most of the common insects were not understood a century ago ; and there are numerous insects all about us whose life-cycles have never been worked out. A good part of our current, economic entomological study is devoted to discovering the main phases of the insects rather than to the adding of new facts and incidents. The subject of the intimate relationship of insects to each other, to weather, to food supplies, and to other factors of their environment, whereby their relative prevalence is largely determined, is yet practically an unexplored field ; yet it is in this ecological domain, rather than in merely destroying insects by what may be called mechanical means, that the greatest permanent progress in contention with insects is to be looked for.

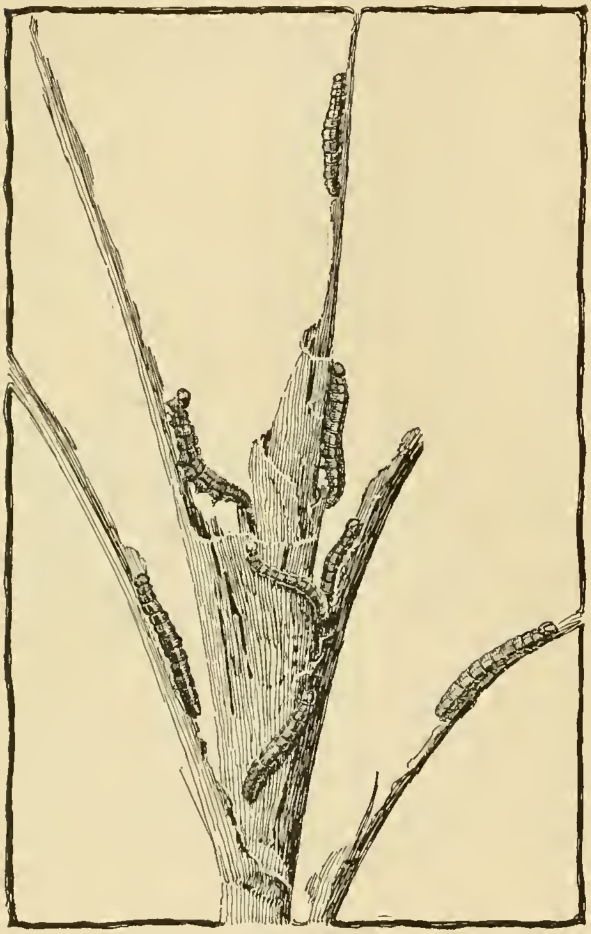


Fig. 53. Example of a biting or chewing insect. Army-worms eating up a stalk of corn.

The gradual growth of the idea that one plant may be parasitic on another and cause what may be called a disease, would be a subject of great attractiveness to one who is interested in human history. The idea is so recent that it should not be difficult to trace. A recent development of it is the discovery that there are germ diseases of plants as well as of animals, a history that is recorded by its literature in E. F. Smith's "Bacteria in Relation to Plant Diseases" (Carnegie Institution, 1905). Other classes of diseases are yet known only by their external manifestations. Of these, peach-yellows and other peach diseases are examples. What causes the mal-nutrition and what carries the disease are undetermined. No doubt many ailments of plants are physiological and organic,—using these words in their human-medicine sense—rather than due to germs or filamentous fungi. Plants have scarcely begun to be studied in respect to their intimate pathological processes and their response to sanitary or unsanitary environment. Very likely we await a new era in plant cultivation.

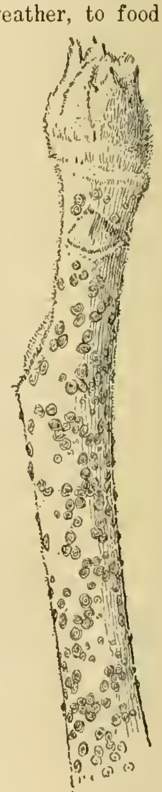


Fig. 54. Example of a sucking insect. San José scales (enlarged) attached to a twig and extracting the juices from it. Plant-lice are sucking insects; also the stink-bugs and their kin.

The plant diseases that are likely to be most clearly recognized by the general observer are those occasioned by the filamentous fungi. These low spore-bearing plants are related to the molds that appear on bread and decaying substances. It is impossible for one who has not studied these forms patiently under a microscope really to understand what they are. The ragged and spidery pictures of them that appear in the public prints convey little intelligence to the general reader. Perhaps Figs. 56, 57 and 58 will help to a vague understanding of what these parasitic fungi are, and how they work. These fungi are species of plants, without flowers or seeds or leaf-green or any of the parts and organs that we usually associate with plant forms. They have neither roots nor leaves, for they do not abstract mineral food from the soil nor construct organic food in the presence of sunlight. They live on organic compounds,—that is, on foods that have already been formed or organized by other plants or, through them, by animals. They run their vegetative root-like threads, or mycelium, into the food supply; and they propagate their kind by means of specialized cells known as spores. The injury they do to their host is of two kinds,—they appropriate food, and they impair the tissues by puncturing them or breaking them down and by plugging the vessels or natural openings.

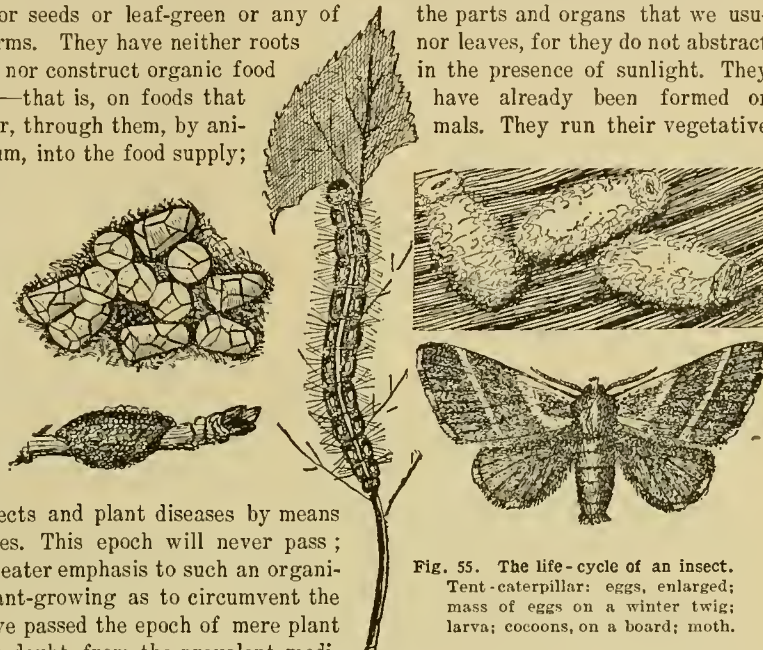


Fig. 55. The life-cycle of an insect. Tent-caterpillar: eggs, enlarged; mass of eggs on a winter twig; larva; cocoons, on a board; moth.

We are just now in the epoch of the control of insects and plant diseases by means of applications of substances. This epoch will never pass; but in time we shall give greater emphasis to such an organization of the business of plant-growing as to circumvent the difficulties. We seem to have passed the epoch of mere plant doctoring,—a suggestion, no doubt, from the prevalent medicine-habit in man—whereby we hope to kill the insect or cure the disease by putting some substance into the "circulation" of the plant; but the day of quacks has not gone by. It would seem to be needless to say to any person that he would better get expert professional advice, when he is in difficulty with insects or plant diseases, were it not for the fact that it is necessary to say it. Howbeit, the person to whom this needs to be said will not read this book, so that we may at once pass on to profitable matters.

Formulas.

The chemical materials used for destroying insects and plant diseases are very many, and they cannot be discussed in full here. The cultivator must keep himself posted by consulting the most recent publications of experiment stations and the United States Department of Agriculture. The materials used for seed diseases are mentioned on page 49; those employed in fumigating for insects, on page 45; soil diseases are also treated in Chapter XIII, Volume I. The main insects and diseases of the various crops are mentioned with the discussion of those crops in Part III. (See also pages 44, 45.)

Spraying materials are either insecticides (to kill insects), or fungicides (to kill fungi). The insecticides are, again, of two kinds,—poisons for chewing insects, and corroding astringent or oily compounds for sucking insects. Some of the leading materials are now mentioned:

Insecticides that kill by external contact.

Lime-Sulfur Wash (for dormant trees and bushes).— Lime, 15 pounds; sulfur, 15 to 20 pounds; (salt, 15 pounds, was formerly added, but does not appear to be necessary); water sufficient to bring the boiled product up to 50 gallons.

The lime and sulfur must be boiled or steamed. The mixture may be made by boiling in iron kettles. Heat the water before adding the lime and sulfur All the sulfur should be thoroughly reduced. Pour into the sprayer through a strainer and apply to the trees while warm.

Steaming is liked best by those who have tested both. The following method is recommended by Geo. E. Fisher, former San José Scale inspector for the Province of Ontario, Canada: "Steam is employed to dissolve the lump sulfur and cook the mixture. Provide yourself with eight barrels. Put one-quarter the full amount of sulfur and fresh stone lime in four barrels, with a proportionate amount of water. Turn the steam under a pressure of 80 to 100 pounds (15 to 20 pounds pressure works well) into these four barrels. When the water has boiled for a few minutes in these barrels, turn off the steam. It may then be turned on to four more barrels which have been prepared in the same manner as the first set. The full amount of lime and sulfur is then added to the first set of barrels slowly enough to prevent boiling over by the heat generated by the slaking lime. When the lime is all slaked, turn on the steam again for two or three hours or till the mixture is thoroughly cooked. It is quite possible to feed each barrel during the boiling process with a small stream of water, which will gradually fill the barrel without preventing the boiling. The mixture becomes quite thin during the boiling process, and when finished is of a deep orange color."

This is one of the popular and reliable remedies for San José scale.

Fig. 56. Spore-bearing stalks of a wilt fungus (*Acrostalagmus albus*). In this fungus the spores are borne in heads; some of the heads are ruptured at the right. (After Van Hook.)

Kerosene Emulsion.—Hard, soft or whale-oil soap, ½ pound; boiling soft water, 1 gallon; kerosene, 2 gallons.

Dissolve the soap in the water, add the kerosene and churn with a pump for 5 to 10 minutes. Dilute 4 to 10 times before applying. Use strong emulsion for all scale insects. For such insects as plant-lice, mealy-bugs, red spider, thrips, weaker preparations will prove effective. Cabbage-worms, currant-worms, and all insects which have soft bodies, can also be successfully treated. It is advisable to make the emulsion shortly before it is used. For San José scale, use 1 pound of whale-oil soap and dilute in proportion of one part to six of water. Especially effective in summer to kill the young and tender lice.

Miscible or "Soluble" Oils.—Recently various oils that emulsify readily when poured into water have been put on the market. Some persons have found them to be of great value and others report poor or indifferent results. Emulsified with twelve to fifteen times their quantity of water, they are applied to dormant trees for scale.

Distillate Spray.—In order to overcome some of the difficulties in the making and use of kerosene emulsion, California citrous growers are now using a mechanical mixture of a special distillate of petroleum and water. The mixture is prepared by a sort of churn propelled by a gasoline engine, and the same engine applies the spray. For scale insects and mites on citrous fruits.

Tobacco Water.—Prepared by placing tobacco leaves and stems in a water-tight vessel, and then covering them with hot water. Allow to stand several hours, dilute the liquor 3 to 5 times, and apply. For soft-bodied insects.

Whale-oil Soap.—On dormant trees for San José scale, dilute 2 pounds to 1 gallon water; for summer use on scale or aphis, 1 pound to 5 to 7 gallons. Dissolve in hot water if wanted quickly.

Insecticides designed for the insect to eat.

Paris Green.—Paris green, 1 pound; water, 75 to 250 gallons.

If this mixture is to be used on fruit trees, 1 pound of quicklime should be added. Repeated applications will injure most foliage, unless the lime is used. Paris green and Bordeaux mixture can be applied together with perfect safety. The action of neither is weakened, and the Paris green loses its caustic properties. Use at the rate of 4 to 12 ounces of the arsenite to 50 gallons of the mixture. It is sometimes used as strong as 1 pound to 50 gallons, but this is usually unsafe and generally unnecessary. This is the old and best known insecticide, used for potato-beetle, codling-moth, canker-worm, tent-caterpillar and very many other insects.

Arsenate of Lead.—See page 44.

White Arsenic.—White arsenic, being cheaper and of more constant strength than Paris green, is becoming increasingly popular as an insecticide. It may be safely used with Bordeaux mixture, or separately if directions as to its preparation are carefully followed; if, however, these are neglected, injury to foliage will result. It is unwise to use white arsenic without soda or lime. Methods numbers one and two are recommended as the least likely to cause injury.

(1) Arsenite of Soda for Bordeaux Mixture.—To a solution of 4 pounds salsoda crystals in 1 gallon of water, add 1 pound of white arsenic and boil until dissolved. Add water to replace any boiled away, so that 1 gallon of stock solution of arsenite of soda is the result. Use 1 pint of this stock solution to 50 gallons of Bordeaux.

(2) Arsenite of Lime.—(*a*) If used alone (not in connection with Bordeaux) white arsenic should be prepared thus:—To a solution of 1 pound of salsoda crystals in a gallon of water, add 1 pound of white arsenic and boil until dissolved. Then add 2 pounds of fresh slaked lime and boil 20 minutes. Add water to make 2 gallons of stock solution. Use 1 quart of this stock solution to 50 gallons of water.

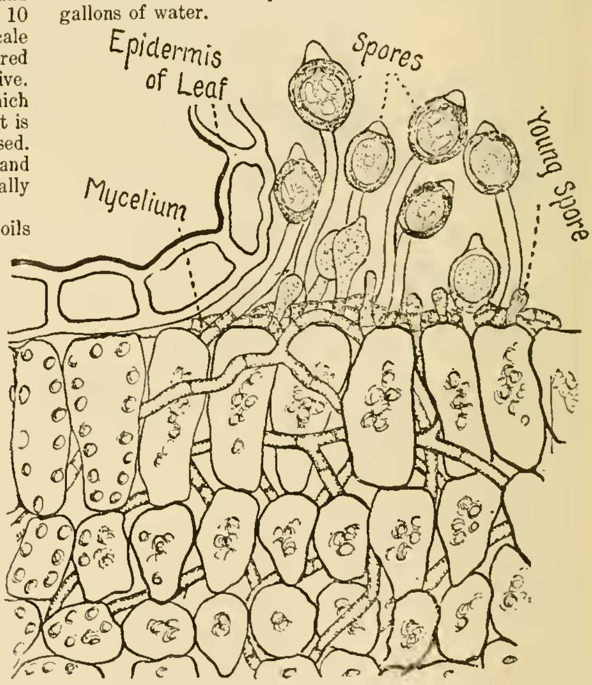


Fig. 57. How a fungus works in a leaf. Diagrammatic cross-section in a bean leaf affected by rust (*Uromyces appendiculatus*). The cells of the leaf-tissue contain the chlorophyll grains. The mycelium of the fungus is seen ramifying in the tissue. The spores are formed on the ends of mycelial threads, and as they grow the epidermis of the leaf is pushed up and broken. (After Whetzel.)

(*b*) Boil 1 pound of white arsenic in 2 gallons of water for one-half hour and use the solution while hot to slake 2 pounds of good, fresh quicklime. Add water to make 2 gallons of stock solution, and use 1 or 2 quarts of this to 50 gallons of water or Bordeaux mixture.

(*c*) Slake 2 pounds of good, fresh quicklime and add water to make 2 gallons of milk of lime. Add 1 pound of white arsenic and boil hard for forty minutes. Add water to bring the resulting compound up to 2 gallons. Use 1 or 2 quarts of this stock solution to 50 gallons of water or Bordeaux.

London Purple. — This is used in the same proportion as Paris green, but as it is more caustic it should be applied with two or three times its weight of lime, or with the Bordeaux mixture. The composition of London purple is variable, and unless good reasons exist for supposing that it contains as much arsenic as Paris green, use the latter poison. Do not use London purple on peach or plum trees unless considerable lime is added. Once much used.

Hellebore. — Fresh white hellebore, 1 ounce; water, 3 gallons.

Apply when thoroughly mixed. This poison is not so energetic as the arsenites, and may be used a short time before the sprayed parts mature. For insects which chew. Much used for currant-worms.

Fungicides.

The Bordeaux mixture, with variations in the proportion of water to suit the particular kind of plant and grade of development of the crop and of the disease, has become practically the universally used medium for spraying purposes. The standard formula is as follows: Copper sulfate, 3 to 6 pounds; quicklime, 4 pounds; water to make 50 gallons.

This solution is often used successfully at half strength on delicate foliage. The solution of copper sulfate is sometimes used without the lime on diseases of woody parts, such as apple canker and anthracnose of raspberry canes. In case of such use, the spraying must be done at a time before the foliation begins.

The Bordeaux mixture may be combined with Paris green and other arsenites, as explained under those heads on the preceding page, and thus destroy both insects and fungous diseases at the same time that the caustic or injurious effect of the arsenic is lessened.

There are many proportions in which the ingredients are combined to make Bordeaux mixture. The 6-4-50 formula is not now often used, as the amount of copper sulfate (or blue-stone) is greater than need be. The 3-4-50 formula is now much used.

Make stock solutions by dissolving 1 lb. sulfate to 1 gal. water in a barrel; and by dry-slaking the lime and then adding water till one gallon holds 1 lb. lime. Dilute these stock solutions before they are put together.

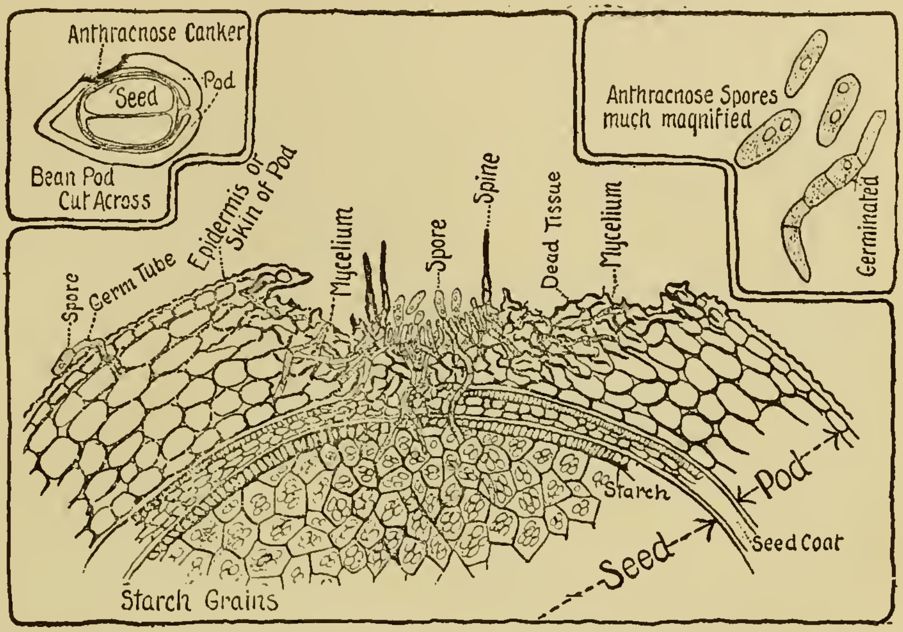


Fig. 58. How a fungus works in a bean pod. To the left above is a diagram of a section across a bean pod through an anthracnose canker. The large drawing below is a much enlarged view of a part of this same section. It is largely diagrammatic. It shows how the mycelial threads of the fungus may penetrate the seed-coat and enter the starchy tissue of the seed, there to remain dormant until the following season. On the left of the large drawing is shown a spore germinating and penetrating the epidermis. This germ-tube branches, spreads through the tissues of the pod and so gives rise to a new spot or canker. To the right above is shown a magnified view of some of the spores of the anthracnose fungus. One has germinated. (After Whetzel.)

There must be lime enough to kill the caustic action of the copper sulfate. This may be tested by dropping a solution of ferrocyanide of potassium on the surface of the Bordeaux mixture: if the drops turn brown or red, more lime should be added.

Ammoniacal Carbonate of Copper.—Copper carbonate, 5 ounces; ammonia (26° Beaumé), 3 pints; water, 45 gallons.

Make a paste of the copper carbonate with a little water. Dilute the ammonia with 7 or 8 volumes of water. Add the paste to the diluted ammonia and stir until dissolved. Add enough water to make 45 gallons. Allow it to settle and use only the clear blue liquid This mixture loses strength on standing. For fungous diseases.

Copper Sulfate Solution.—Copper sulfate, 1 pound; water, 15 to 25 gallons.

Dissolve the copper sulfate in the water. This should never be applied to foliage, but must be used before the buds break. For peaches and nectarines, use 25 gallons of water. For fungous diseases, but now largely supplanted by the Bordeaux mixture. A much weaker solution is recommended for trees in leaf.

Potassium Sulfid Solution.—Potassium sulfid (liver of sulfur), ½ to 1 ounce; water, 1 gallon.

This preparation loses its strength on standing, and should therefore be made immediately before using. Particularly valuable for surface mildews.

Maxwell Dust-Spray. — Fresh lime, 1 barrel; copper sulfate, 25 pounds; concentrated lye, 5 pounds; powdered sulfur, 25 pounds; Paris green, 6 pounds.

Spread lime in a large, shallow box, breaking into as small lumps as possible. Dissolve the copper sulfate in six gallons boiling water; also dissolve the lye in five gallons hot water. Keep separate. Sprinkle copper sulfate solution over the lime. Follow with lye water. If the lime does not all crumble to a dust, use clear water to finish. Screen the lime through a fine sieve, rub the sulfur through the sieve into the lime, add the Paris green and thoroughly mix both with lime. Lime should crumble to powder, not granules.

Copper sulfate water must be used hot, or the copper will recrystallize. Mixing should be done out-of-doors or in a separate building, as lime in slaking becomes very hot.

Missouri Experiment Station dust-spray. (To make 70 pounds of stock powder): —Copper sulfate, 4 pounds; quicklime, 4 pounds; water in which to dissolve copper sulfate, 2½ gallons; water in which to slake quicklime, 2½ gallons; air-slaked lime thoroughly sifted, 60 pounds.

Dissolve the copper sulfate and slake quicklime separately, each in 2½ gallons water. Pour at same time milk of lime and copper solution into a third vessel and stir thoroughly. Surplus water is then strained out and remaining wet material is thoroughly mixed with the 60 pounds of air-slaked lime. All lumps must be sifted out and the mixture must be perfectly dry. One pound each of sulfur and Paris green may be added.

The dust-sprays are useful where water is scarce or land is too rough or steep for the regular spraying machines.

MEANS OF CONTROLLING INSECTS

By *M. V. Slingerland*

Careful estimates indicate that the value of farm products now destroyed each year by insects in the United States aggregates the vast sum of $700,000,000, or more than the entire expenditures of the national government. Thus, one of the most serious problems that confront the American agriculturist is that of controlling the insect enemies of his crops. He is now menaced by nearly twice as many different kinds of insect pests as in 1850, and three or four times as many as a century ago. And the outlook is far from encouraging, for all the old pests will doubtless continue their ravages indefinitely, with "up" and "down" periods at uncertain intervals. Furthermore, the American agriculturist will have the best plants and animals the world produces, no matter whether he does thereby introduce other such destructive pests as the San José scale from China. There are still many insect pests in Europe, Asia, Australia, Africa and Mexico that are liable to be introduced at any time, and they may be much more destructive here than in their native home, where their enemies and surrounding conditions largely hold them in check. Thus, the unbroken ranks of the insect pests of a century ago will be constantly augmented by new kinds that are either disturbed by man in their wild haunts here (as the Colorado potato-beetle), or that come in naturally from adjoining countries (as the cotton boll-weevil from Mexico), or that are brought in by commerce from foreign lands (as the cattle horn-fly and over half of the other standard insect pests).

But the outlook is not really so gloomy, for the American agriculturists are well equipped with insecticidal batteries, and they are waging a most scientific and successful fight against insect enemies. Many millions of dollars are being spent annually in America by national and state governments and by individuals in fighting insects and in devising and testing new remedial measures; it is estimated that over $8,000,000 is expended each year in spraying apple trees for the codling-moth alone.

Natural checks.

In this warfare that man must wage against his insect foes, he should not forget that nature has provided active and often very effective insect-destroyers without which man could not grow crops, or even exist himself. Were it not for the many little enemies of plant-lice, these insignificant creatures with their wonderful powers of multiplication would soon overrun the earth, and destroy all vegetation, thus robbing man of his primary food supply. Among the forces of nature which thus aid man in his insect warfare may be mentioned strong winds, sudden changes of temperature in winter, rains, and forest and prairie fires. Then among the plants and animals there are some very efficient insect-destroyers. Bacteria and fungi often kill a large proportion of army-worms or chinch-bugs that are devastating crops. Many of the birds feed largely on insects and should be encouraged to stay on every farm, for they are among the most effective of nature's insect-destroyers.

But it is among their own kind, the insects, that insect pests find their most destructive foes. Vast numbers of insects, some so tiny that several of them can live inside an insect egg (codling-moth egg) not larger than a pin's head, are constantly preying on the insect enemies of man's crops. And these parasitic and predaceous insects are often very effective in aiding man in his strenuous warfare to protect his crops from insect pests. A little lady-bird beetle saved the citrous industry of California from destruction by a scale insect, and it would be impossible to grow wheat successfully in many sections of the United States were it not for the tiny insect parasites of the hessian fly.

Man is coming to realize more and more the value of these natural aids in his warfare against insect pests. In Hawaii and California, thousands of dollars are expended annually in searching for and importing from foreign lands beneficial insects to prey on insect pests, and some striking successes have been attained. Europe is now being searched for the natural enemies of the gypsy and brown-tail moths to aid in checking and finally controlling these serious pests.

Administrative control.

While these insecticides of nature are often very effective and finally accomplish their purpose, man can not wait but must usually resort to artificial insecticides to save his crops. For centuries man has been fighting insect enemies. The Greeks mixed hellebore with milk to kill flies, and the Romans required the inhabitants of infested regions to kill certain amounts of grasshoppers. In the middle ages the methods used for the destruction of insects were largely of a spiritual nature; priests marched around infested fields praying; anathemas were pronounced over grasshoppers; or the accused insects were summoned to appear in court and judgment was rendered in the form of an excommunication. Scarcely thirty years ago, two governors of states in America issued proclamations appointing days of fasting and prayer to stop the ravages of Rocky mountain locusts. It is only within the past quarter of a century that most of the modern scientific methods of controlling insect pests have been devised. Previously, American farmers resorted to hand-work or to simple mechanical devices, such as bands for canker-worms and codling-moth. The word "insecticide" was unknown half a century ago, and, according to the dictionaries when man kills an insect he is an insecticide, he may use an insecticide, and he also commits an insecticide. Usually, however, the word is restricted to some material or spray used by man to kill insects.

Fig. 59. A hopper-dozer at work in kafir corn. (Kansas Experiment Station Bulletin.)

We may classify the methods used against insect pests as: international, national, state, local or neighborhood and individual. The first three of these mostly comprise laws or commercial regulations, by the enforcement of which attempts are made to prevent the spread of insect pests from one country or state to another, and also to provide for the introduction of beneficial insects. Neighborhood and individual efforts usually aim at the immediate death of the insects either through the enforcement of municipal regulations, by the offering of prizes, by practicing better farm methods, or by the use of insecticidal batteries.

Laws or regulations are often necessary in insect warfare, but they must be supported by public opinion to be effective. Far-reaching and valuable results have been attained by international efforts in controlling insect pests by quarantine regulations and by the introduction of beneficial insects. Nations can scarcely overdo this kind of control work against injurious insects. Compulsory state legislation to control insect pests will often lack the necessary support of public opinion and hence be difficult to administer; attempts to annihilate the San José scale in Canada by the axe and fire were soon stopped by adverse public opinion. The state inspection laws to prevent the spread of insects by nurserymen have accomplished much good. Local authorities can do much to check the ravages of insects over limited areas by offering prizes or insisting that owners of infested premises shall use certain destructive measures or pay for having the authorities do it. A few neighbors can do much to mitigate the ravages of the hessian fly by combined action in using early trap strips of wheat and sowing as late as practicable.

And yet, after all has been said and done by international, national, state or local authorities to stay temporarily the inevitable spread of the world's injurious insect fauna, each individual who raises crops will often find himself face to face with the problem of fighting successfully some insect pest or the loss of his crop. Legislation and inspection or fumigation certificates are then of no avail. Usually his parasitic and predaceous insect friends are also too slow. A nation may profitably spend much money to introduce new insect friends; doubtless an extensive national quarantine would keep out some injurious insects for a time, and the state and local authorities can do much to check the spread of a pest; but in the end the brunt of the fight will fall on the individual whose crops are attacked.

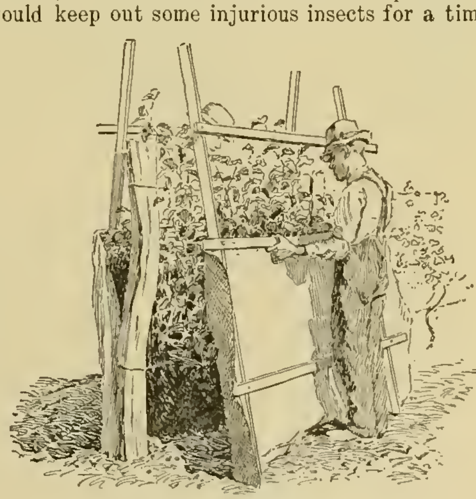


Fig. 60. A practicable and effective sticky shield for capturing adult grape leaf-hoppers in the spring.

The means which the individual may use in endeavoring to control his insect enemies are many and varied. They may be classed as mechanical methods, farm practices and the application of materials commonly called insecticides.

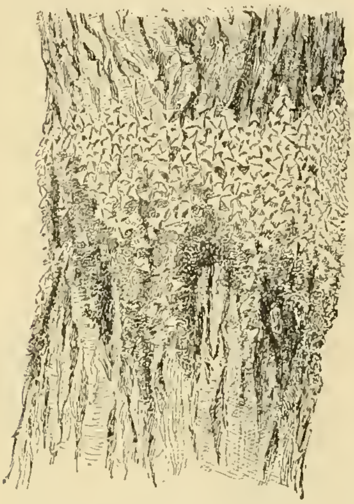


Fig. 61. Canker-worm moths stopped by sticky band in their progress up a tree.

Mechanical methods.

It is often practicable to hand-pick or dig out insect pests. This is largely practiced in countries where cheap labor is available. No cheaper and effective method has yet been found for combating borers and many pests (as cutworms and white grubs) working in gardens and on other small areas. Children have done very effective work in collecting eggs of tent-caterpillars and tussock-moths on shade trees. A box-like covering of wire-screen or mosquito-netting is often placed over hills of squashes, melons and cucumbers to protect them from the ravages of the striped beetle and stink-bug. Seed-beds of cabbages, radish beds and various choice or rare plants can be thus protected from insects at slight expense. Bushels of young grasshoppers and swarms of small leaf-hoppers are often collected on the western prairies by drawing large iron pans smeared with tar or containing kerosene, and called "hopper-dozers." (Fig. 59.) Thousands of grape leaf-hoppers can be collected on sticky shields held near while the vines are jarred. (Fig. 60.) Sticky bands have long been used effectively to prevent the wingless female moths of canker-worms ascending trees to lay their eggs. (Fig. 61.) For a quarter of a century before the advent of spraying, the principal means employed to reduce the numbers of the codling-moth were various kinds of cloth or hay-rope bands around the trunks of the trees to form more attractive places for the caterpillars to transform. Large numbers of the caterpillars gather under these bands, where they are easily killed. This effective banding method can now be used with profit to supplement the poison spray when a second brood of the insect occurs. Farmers often use the barrier method to prevent chinch-bugs, cutworms or army-worms from marching into other fields. Two furrows plowed together and a narrow strip of coal-tar poured along the ridge thus formed, effectively stop chinch-bugs. (Fig. 62.) To stop army-worms a deep furrow is plowed with the perpendicular side toward the field to be protected, and post-holes are then dug in the furrow at intervals of a rod or less. The caterpillars can not readily scale the furrow and so wander along it, finally dropping into the holes, where they can be killed with kerosene or crushed; bushels of the worms are often killed by this barrier method. Some insects may be jarred on sheets or into catchers. (Figs. 63, 64.)

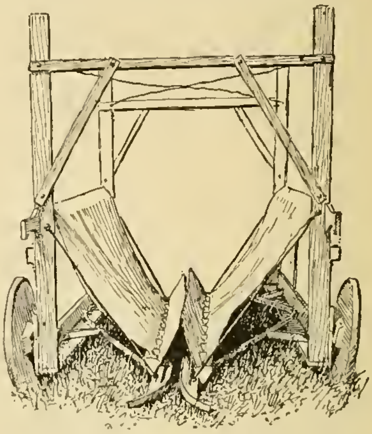


Fig. 63. An early type of beetle-catcher for vineyards, but now little used.

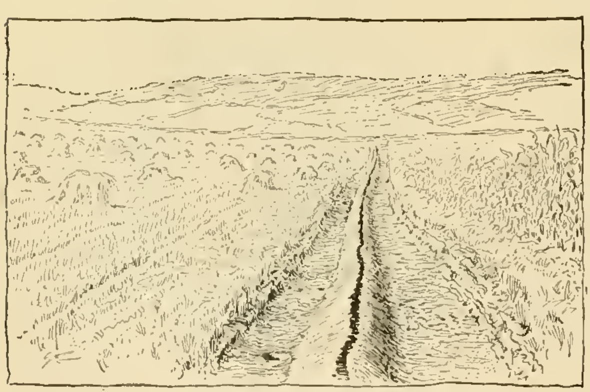


Fig. 62. Ridge formed by Marcy implement for protection against chinch-bugs. Post-holes are dug beside the ridge about fifty feet apart. This barrier is smooth and compact, and very little affected by the rain. The line of coal-tar along the top has been successful in all weather conditions. (Kansas Experiment Station Report, 1896–97.)

Farm practices.

The American farmer who grows field crops mostly, must depend largely on improved or different methods in growing his crops, or on what may be called farm practices, to prevent and control the ravages of insect pests. Often the horticulturist or gardener can also use these methods to good advantage.

Thorough and frequent cultivation, especially in early autumn, discourages and finally effectively controls wireworms and white grubs more than anything yet devised. One rarely sees a well-cultivated orchard seriously infested with canker-worms, as many of the pupæ in the soil are thus destroyed. A frequent rotation of the crops is one of the most effective methods of controlling insects which attack field crops, as corn, clover, wheat, potatoes and similar crops. The insects are starved out by finding their favorite food-plant replaced by some crop they do not like. Many field crops may suffer for a season or two

Fig. 64. Jarring peach tree for curculio.

from wireworms or white grubs if planted in fields, as pastures or old meadows, that have been in sod for several years and are the favorite breeding grounds of these pests. But thorough cultivation of such crops will soon discourage the insects.

Clean culture, or the destroying of weeds and clearing away of rubbish, will often help in the warfare against insect pests. Many insects find favorable hibernating quarters in rubbish, old stone walls, near-by clumps of bushes or forest lands. One fruit-grower has largely eliminated the plum curculio from his peach orchard by planting it away from such favorable hibernating quarters. The removal or burial of old cabbage stumps, old squash or cucumber vines, and other garden refuse, so as to leave the ground clean in the fall, will help much in controlling garden insects, like the cabbage, radish- and onion-maggots, cutworms, and other serious pests. Sometimes an attractive plant is used early in the season as a decoy, to be destroyed when it has served its purpose and become well infested with the pest. Then the main crop to be protected is planted later and often escapes serious infestation. A strip of mustard or early cabbages may be sown early in spring to attract the hibernated harlequin-bugs, which can then be killed with kerosene before the main crop of cabbage is put out. A strip of wheat sown in August will often attract a large proportion of the autumn brood of the hessian fly. This infested strip can then be plowed under in September, or just before the whole field is prepared for the main crop, which should be delayed in planting as long as local conditions will permit. This "farm practice" method of an early decoy strip and late planting will usually circumvent this serious wheat, barley and rye pest. Gardeners who grow cucurbitaceous vines sometimes plant a strip of early squashes along one side of the field and delay putting out the main crop, so as to attract many of the striped beetles, stink-bugs and borers to the decoy strip.

Fig. 65. A beetle, one of the chewing insects. Cucumber beetle (*Epitrix cucumeris*). Adult beetle much enlarged.

Extensive investigations have demonstrated that the cotton boll-weevil can be controlled only by cultural methods. Profitable crops of cotton can be grown in spite of the weevil by planting early-maturing varieties farther apart and earlier, by thorough cultivation, by plowing up and destroying all the old stalks in early autumn, and by a more liberal use of fertilizers—all these are "farm practices." By burning fruit-tree prunings before spring, the hibernating stage of several fruit pests, as plant-lice eggs and bud-moth larvæ, may be destroyed. The application of a little quick-acting commercial fertilizer will sometimes stimulate a plant to overcome or outgrow the onslaught of its insect enemies; but when used in practicable or fertilizing quantities, these fertilizers will not kill the insects.

It is an alluring thought that we may be able to develop insect-resisting varieties of many kinds of agricultural plants. The resistance of certain American native grape roots to the phylloxera plant-louse is proving to be the salvation of the grape industry in Europe. Promising efforts are now being made to develop a boll-weevil-resisting variety of cotton. Sometimes certain varieties of wheat seem to be resistant to the hessian fly.

Much can be done around farmhouses to reduce the numbers of house-flies and mosquitos. Put the horse manure in tight sheds so that flies can not breed, or spread it on the fields every two or three days in summer. Drain off or fill in low places where water stands continually or after showers, as such places breed "wigglers" or mosquito larvæ.

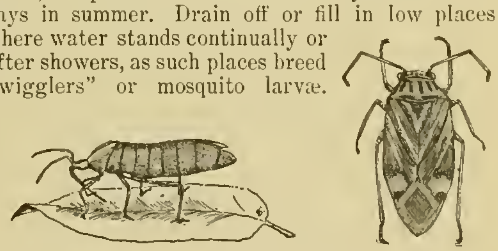


Fig. 66. Two examples of sucking insects, belonging to the group known to entomologists as the true bugs.

If the rain-barrel is also screened with wire netting, it will not become the breeding-place of thousands of mosquitos. House-flies may bring to human food the germs of typhoid fever on their feet or mouth-parts, and the only way one can get malaria is through the agency of certain kinds of mosquitos (Anopheles) that may have sucked the diseased blood from some malarial patient, which they then inject into the body of another when they "bite." (Vol. I, p. 297.)

Spraying and other insecticidal methods.

For a half century before 1875, the materials used by American farmers to kill insects consisted largely of whale-oil soap, hellebore, lime, tobacco, sulfur and salt. These materials were dusted or sprinkled or syringed on the plants. With the appearance and rapid march of the Colorado potato-beetle across the country from 1860 to 1870, there came into use Paris green poison, which was destined to revolutionize insecticidal methods. In 1872, it was suggested that a Paris green spray be applied on cotton plants for the cotton worm and on apple trees to kill canker-worms. Six years later it was found that the poison spray effectively checked the codling-moth, and this gave a new impetus to the warfare against insects, which has finally resulted in the modern formidable array of insecticide materials and elaborate machinery for their application.

The materials used as insecticides may be divided into three groups, based largely on the two different ways in which insects eat. Some insects, as caterpillars, potato-beetles, and many others, have their mouth-parts provided with strong jaws which enable them to bite off and swallow solid particles of their food-plants. (Figs. 53, 65.) Many other insects, of which the plant-lice, stink-bugs, scale-insects and mosquitos are familiar examples, have their mouth-parts drawn out into fine threads which are forced into the plant-tissues along a stiff, supporting beak ; such sucking insects are unable to eat solid particles and hence cannot be fed a poison sprayed on the surface, for they can suck only liquid food from the inner tissues of the plant-host. (Figs. 54, 66.) To kill biting or chewing insects, it is necessary only to apply a poison on the surface of the plant where they are going to feed. But each individual sucking insect and not a certain part of the plant must be hit with some material that will soak into its body and kill, or that may smother by covering the breathing holes along the sides of the body. The third method is fumigation.

Biting insects.—The insecticides used for killing biting insects consist mostly of poisons which have for their basis white arsenic. This substance can not be used alone, as it dissolves slowly, and this causes it to burn foliage severely. But it can be combined with salsoda and lime to form a cheap and effective poison spray. Boil 1 pound of arsenic and 2 pounds of salsoda in 4 quarts of water until dissolved ; then slake 2 pounds of stone lime with this solution, and add 2 gallons of water. Use about 1½ quarts of this stock mixture in 40 gallons of

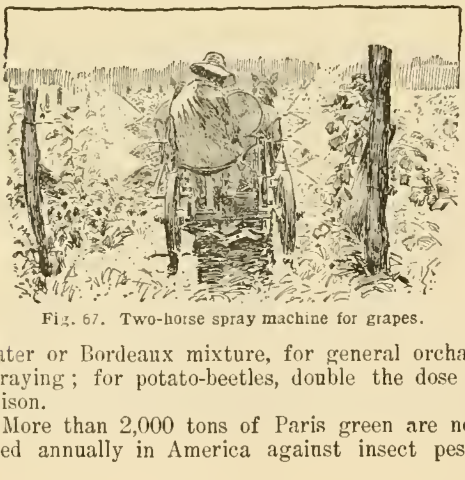


Fig. 67. Two-horse spray machine for grapes.

water or Bordeaux mixture, for general orchard spraying ; for potato-beetles, double the dose of poison.

More than 2,000 tons of Paris green are now used annually in America against insect pests. It is the standard poison spray, and is used at the rate of 1 pound in 100 gallons on orchards, except plum and peach, where only about half this amount is safe ; on potatoes it is used at least twice as strong.

The arsenite of copper or green arsenite is similar to Paris green.

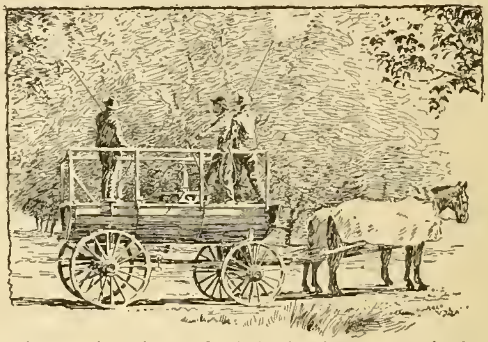


Fig. 68. Spraying outfit that will give good service in an apple orchard of forty to sixty acres.

The arsenate of lead, which was first used against the gypsy-moth in 1892, is coming into general use. It adheres better to the foliage and can be used very strong with safety, thus making it especially useful against certain insects like the elm leaf-beetle, codling-moth, plum curculio, rose-chafer, and grape root-worm. It is sold in a paste form, one pound of which contains only about half as much arsenic as Paris green, thus necessitating using twice as much of the arsenate of lead, or 2 to 4 pounds per 100 gallons for apple orchards and 4 pounds per 50 gallons in vineyards for grape root-worms.

Hellebore is still much used for currant-worms, but has been largely replaced by the Paris green spray.

Sucking insects.—The insecticides used for killing sucking insects are largely powders, oils or soaps, which kill by contact or when they hit the body of the insect.

Pyrethrum powder is often used for house-flies, but it is too expensive for general use in spraying.

Tobacco in various forms is largely used for fighting plant-lice in greenhouses, and sometimes as a spray outdoors or in "washes" or "dips" for domestic animals. Tobacco stems may be burned slowly, creating a killing smoke, or tobacco dust may be freely scattered over the plant, or decoctions and extracts may be sprayed on the plants.

Whale-oil and fish-oil soaps and various common soaps are effective insecticides for plant-lice, scale insects and many other sucking insects. Two pounds of soap dissolved in one gallon of water is the necessary strength for killing scale insects on dormant plants in winter, and one pound in four to six gallons will kill plant-lice and recently hatched scale insects.

Kerosene and crude petroleum are among the most effective materials for killing sucking insects. Sometimes they can be applied in a fine spray on dormant trees with little or no injury, but usually it is necessary to combine them with soap in an emulsion, which can then be diluted with water. The emulsion is made by dissolving ½ pound of soap in 1 gallon of hot water, then adding 2 gallons of the oil and thoroughly agitating the mixture into a stable emulsion. This should be diluted with 3 or

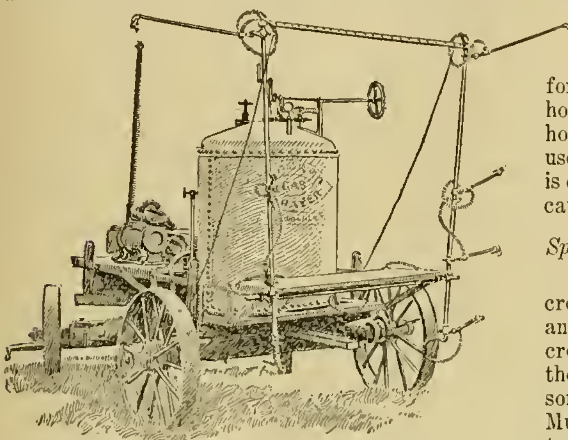


Fig. 69. Niagara carbonic acid gas sprayer.

4 parts of water for scale insects and with about twice as much water for plant-lice and other sucking insects. Pumps have been designed for combining the oils and water into a good mechanical emulsion, but usually the percentage of oil can not be satisfactorily controlled.

So-called soluble or miscible oils which quickly emulsify with water are now made and are very effective against scale insects.

A lime, salt and sulfur mixture (often without the salt) is a very effective and safe spray to use on dormant plants for the San José scale and the peach leaf-curl fungus. This "wash" is made by boiling for about an hour 15 pounds of flowers of sulfur and 20 pounds of stone lime in 50 gallons of water; by using about 6 pounds of caustic soda this "wash" can be made without boiling and is nearly as effective, but costs more.

Fumigation.

Both sucking and biting insects succumb to the fumes of carbon bisulphid or to hydrocyanic acid gas.

Carbon bisulphid is largely used in killing insects infesting stored grains or seeds. It is poured into shallow dishes set on top of the grain in tight bins, or it may be sprinkled over the grain. The fumes are heavier than air and sink all through the grain; as the fumes are explosive, no lights should be near. A little of the liquid poured on clothing stored during the summer will kill the destructive clothes moths. Cucurbitaceous vines have been covered with cloth and successfully treated for plant-lice with carbon bisulphid.

Hydrocyanic acid gas is generated by dissolving cyanide of potassium in sulfuric acid and water. It is used largely under tents by the citrous orchardists in California for scale insects, and by many nurserymen for fumigating their stock to kill San José scale and other injurious insects. Greenhouses, dwellings, cars and flouring mills have been fumigated successfully with this gas for the white-fly, household insects, and the flour-moth. The usual formula for fumigating everything but greenhouses is 1 ounce of cyanide of potassium, 2 ounces of commercial sulfuric acid, and 4 ounces of water for each 100 cubic feet of space; the fumigation should be continued for half an hour for nursery stock and several hours or all night in buildings or cars. For greenhouse fumigation, ½ to 1 ounce of the cyanide is used at night for each 1,000 cubic feet. This gas is exceedingly poisonous to persons when breathed, causing death instantly.

Spraying methods and machinery.

Many growers of fruits, potatoes and garden crops now include spraying as one of the regular and necessary "farm practices" to protect their crops from insect and fungous enemies. To spray the most successfully requires skill, practice and some knowledge of the enemies to be fought. Much energy and money is wasted every year in trying to kill sucking insects with poison sprays which they can not eat, or by uninterested laborers who hurry through the more or less disagreeable job. It is often necessary to success that we follow closely the detailed directions for making the sprays; for example, it is very essential that dilute and not concentrated mixtures of copper sulfate and lime be poured together in making Bordeaux mixture. Successful spraying is scientific and thus requires the services of faithful, trained men. Only the most thorough work with the best materials and machinery will accomplish the most paying results. To control successfully the San José scale, for example, each tiny scale not larger than a pin's head must be hit thoroughly with a powerful insecticide, thrown with force through fine nozzles so as to penetrate every crevice in the bark.

Machinery for the application of insecticides has developed from a bundle of twigs or a broom, through syringes and ill-adapted pumps, to a formidable array of powder-guns and pumps specially adapted to various conditions and crops. Insecticides and fungicides are now combined into a fine

Fig. 70. Spray rig with steam power pump.

dust that is blown into trees with powder-guns. This miscalled "dust-spray" is not so effective as the liquid sprays in orchards, as judged by present experiments, and is used mostly where water is scarce and the land is rough. For applying liquid sprays there are little atomizers holding a quart or two with which house plants, small gardens, or a few cattle may be sprayed. Next come the bucket pumps and knapsack sprayers, which will be found useful on most farms for spraying small areas or isolated trees in gardens. For several years barrel pumps were much used in all spraying operations, but now large tanks equipped with more powerful pumps in which the power is developed by horses, by steam or gasoline engines, by compressed air, or carbonic acid gas, are mostly used in spraying large areas of orchards, vineyards, potatoes and other crops. The horse-power pumps, in which the power is developed from the wheels by chain or eccentric attachments as the machine moves, give sufficient power to do satisfactory work only on potatoes and similar low field crops. A small compressed-air tank attached to these horse-power pumps greatly increases their efficiency for the spraying of small orchard trees and vineyards. The pumps using compressed air for power do very effective spraying of all kinds, but the necessary outfit of several spray tanks, an engine and an air-compressor are rather expensive. Steam spraying rigs are heavy but are easily managed, and furnish cheap and abundant power. Gasoline engines are lighter and are being much used instead of steam power. The tanks of compressed carbonic acid furnish ample, easily manipulated but slightly more expensive power than the engines. Some of the forms of spray rigs are shown in Figs. 67–71.

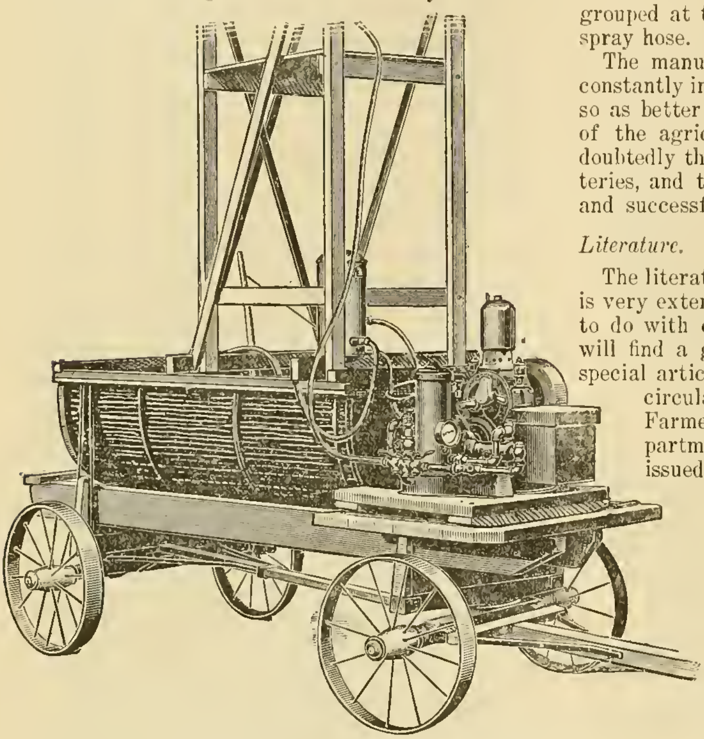


Fig. 71. A modern spray rig, with mounted gasoline engine.

Good nozzles are an essential part of spray pumps. Several types of spray nozzles are used. Some, like the cyclone and Vermorel nozzles, produce a very fine, funnel-shaped spray. In another type, like the McGowan, the spray is fan-shaped and can be thrown farther. The various modifications of the Vermorel type of nozzle are now most extensively used, often several nozzles being grouped at the end of a light rod attached to the spray hose.

The manufacturers of spraying apparatus are constantly improving and modifying their machines so as better to adapt them to the practical needs of the agriculturist. American farmers are undoubtedly the best equipped with insecticidal batteries, and they are putting up the most scientific and successful fight against their insect enemies.

Literature.

The literature on the means of controlling insects is very extensive and scattered, much of it having to do with controlling specific pests. The reader will find a great deal of interesting material in special articles in the yearbooks, in bulletins and circulars of the Bureau of Entomology and Farmers' Bulletins, of the United States Department of Agriculture, and in bulletins issued by the federal and state experiment stations of the various states. The following publications should also be consulted: Annual Reports and Bulletins issued by the State Entomologists of New York (Dr. E. P. Felt, Albany), Illinois (Prof. S. A. Forbes, Urbana) and Minnesota (Prof. F. L. Washburn, St. Anthony Park, St. Paul), and by the Government Entomologist (Dr. J. Fletcher) at Ottawa, Canada; Lodeman, Spraying of Plants, 1896; Johnson, Fumigation Methods, 1902; Smith, Economic Entomology, 1896; Weed, Insects and Insecticides, 1895; Sanderson, Insects Injurious to Staple Crops, 1902.

THE MEANS OF CONTROLLING PLANT DISEASES

By *Henry L. Bolley*

Almost every farm, garden and orchard crop is open to the attack or influence of one or more kinds of infectious disease. As farming, gardening, or fruit-producing districts age under cultivation, the soil ages, and the conditions and materials that are favorable to the development of disease accumulate. Each crop, or type of cultivated plant, unless properly handled, becomes more and more susceptible to disease, and is more liable to be attacked by disease-producers that are natural to the habits and growth conditions of that particular kind of crop.

Practically every known cultivated plant and crop, including hothouse-grown plants, vegetables, fruit and shade trees, grasses and cereals, is thus attacked and the yield and quality are often greatly reduced. It is to be expected that the warfare will continue.

Parts of the plant attacked.

Many plant diseases may be said to be systematic or constitutional in the same sense as observed in animal troubles. Though certain parts may be primarily the chief source of attack, as, for example, leaves in the case of rust, yet the effect on the physiology of the plant finally becomes general. All such diseases reduce the vitality of the plant body as a whole. The points of first injury are various, according to the kind of plant attacked and the nature of the organism which brings about the disease. There are "root diseases," "leaf diseases," "diseases of the stem" and "diseases of the fruiting parts," but, as indicated, these terms are so applied largely because the disease first appears on certain parts or is finally most destructive to these parts.

The destruction or damage depends largely on the part that is thus attacked, but also varies greatly according to the kind of organism that produces the disease, the period in the life of the crop when the disease appears, and almost directly according to the environment of weather and soil conditions.

The cause of disease and the effects produced.

The effects produced by disease on the individual plant and on a crop depend on the character of the plants attacked, the nature of the organism that causes the trouble and, as just indicated, on the life conditions, such as heat, light, moisture, fertility of soil, drainage, soil texture, and the like. Some diseases are of parasitic character and are directly infectious, as, for example, fire-blight of apple, wheat-smut, or wheat-rust. Others are imperfect parasites, or merely decay-producers, which become materially destructive only under special conditions of the soil or atmosphere. Some of these last-named types at times become exceedingly destructive, as in the case of numerous decay bacteria and molds on vegetation under conditions of excessive moisture. The work of the various damping-off fungi is a good example.

Some plant diseases are more or less local in action and temporary in results, depending on the character of the plant and the part attacked or on sudden changes in the weather. There are many others, such as plum-pocket, black-knot and potato-scab, that are perennial or persistent, year after year, dependent on special peculiarities of the life history of the organism that causes the trouble, peculiarities of the life of the plant attacked, on some method of cultivation and handling of the crop or soil, or on soil characters that allow of persistence from year to year in the soil; or, again, the disease may be transmitted on the parts of the plants that are necessary to continued yearly propagation.

These numerous peculiarities as to conditions, types of disease, modes of attack, differences in types of plant affected, and so on, allow us to contrive as to methods of combating or controlling crop diseases. Such features, closely studied, often make means of complete prevention possible. In some of the most destructive diseases of farm crops, such as potato-blight, stinking smut of wheat, and grape-rot, methods of prevention have been found quite practicable and have come into general use. One cannot estimate accurately the value of the results obtained, but the writer believes that from the smuts of cereal grains alone the people of the United States, through practices of seed disinfection, save annually in crop yields in values approximating \$20,000,000 to \$30,000,000. There are yet other plant diseases, such as wheat-rust and apple-blight, in which the natural conditions influencing their development are so complicated that means of prevention or control, as yet recommended, have given slight results.

In order to arrive at proper control or reasonably complete prevention of plant diseases, farmers and gardeners must study all characteristic features of the soil, climate, and conditions of plant growth, that affect the development of the individual plants or crops attacked, as well as those conditions that affect, further, or prevent the development of the disease. In this connection, it must be remembered that the development of disease in the crop is associated directly with the conditions that favor the propagation and distribution of the disease-engendering organisms. Therefore, close attention should be given to all features affecting the relationship of soil, air, seed and individual plants to crop development. All conditions should be sanitary.

Soil considerations.

In this connection the soil is a factor of great importance, and one should consider such features as texture, drainage, chemical nature, fertility and position, that is, the kind or type of soil and location of the field for the particular crop which it is intended to produce. It must be such as to furnish the properly balanced food supply for the crop or plant growth, so that there may be a regular proper growth and evenness of maturing. Soil drainage must be right, for it greatly affects many features and conditions that govern plant growth. It directly influences such features as soil texture, soil and atmospheric moisture, and temperature; and it has a particular bearing on the dissemination or distribution and life of plant diseases in the soil. Surface waters not only cause a souring of the soil and a general sickening of plant growth, but they also serve as a means of rapid distribution of the spores of disease from plant to plant and from soil area to soil area, until, in such soil diseases as cotton root-rot, potato-scab or flax-wilt, all flooded areas are quickly overrun or permeated by the disease-producing organism. Poorly drained farm lands not only directly distribute certain diseases but also, through evaporation, directly affect the air conditions, causing heavy fogs and dews. In the case of such diseases as the rusts of cereal grains, these conditions result in the greatest possible crop destruction. If soil drainage is not proper, it must be made so before one may hope for best results in the control of some of the plant diseases.

Treatment of the soil is a phase of work not evenly developed. There are numerous types of disease, especially those which find permanence in the soil, that may be controlled to a large degree through proper culture, rotation of crops, soil resting, and soil weathering. In certain types of troubles, chemical applications have been found to be efficacious. All such methods and treatments depend for their basis on the nature of the particular disease-producing organism. Proper crop rotation rests the land, keeps up an equable plant-food ration, and lessens the possibility of disease accumulation, because each plant disease is special in its wants and cannot increase in the absence of its host.

Fig. 72. Showing difference in growth of wheat from rusted and unrusted mother plants of the same crop (alternating). Seeds planted same day and plants same age.

Soil disinfection by means of chemical substances directly applied does not yet give great promise. The disease-producers are usually possessed of greater powers of resistance than the delicate roots of cultivated plants. Careful study of the soil constituents and physical condition often allows of soil treatment that is beneficial in reducing the effects of disease. Some diseases, such as potato-scab and flax-wilt, caused by soil fungi, are found to develop with much greater damage on markedly alkaline soils than on soils of neutrality. This is comparatively easy of correction through the use of barnyard manures, the growth of grasses, and the like. Soils of poor texture often result in such weak growths that ordinary infectious diseases become more destructive than under proper tillage. Such features must be remedied by proper methods of handling the soil preparatory to cropping. To this end, plowing and cultivating at the proper time aërate the soil, allow it to weather and become a large factor in destroying germs of disease that hold over in the soil from year to year. This, we are rapidly learning, is one of the real truths back of proper crop rotation. [Another discussion of this subject will be found in Vol. I, pages 450–453.]

Climatic conditions.

When considering possibilities of controlling plant diseases, the matter of prevailing climatic conditions, to which the crop must be subjected, is of much importance. It decides, primarily, whether or not one should attempt to produce the crop under question, and indicates what variety of the particular crop or type of plant should be selected. While prevailing climatic features cannot be directly controlled, one may often avoid the difficulties which they bring about. This matter of climate governs the time of planting, mode of harvest, the types of cultivation, and all such features. To escape the worst effects of disease on farm crops, one must take such features into consideration, avoiding, if possible, those types of work and methods which allow natural climatic conditions to favor disease development. For example, in the case of spraying to prevent diseases such as apple-scab and potato-blight, one must consider carefully the time when the work will prove most effective. This will depend almost wholly on the prevailing atmospheric and weather conditions, which account for the spread of the various types of disease-producing parasites and for their varying stages and destructiveness of development.

Seeds and seed treatment.

Of all the features of cropping which allow of direct effort toward controlling or avoiding disease, the seed is open to the easiest and most effective study. It is an old saying that the seed-time decides the harvest. It might as truly be said that the type of seed, how it is cared for and handled and prepared for the soil, decides what the harvest shall be. This is particularly true with types of plants that are subjected to certain crop diseases.

In handling the seed preparatory to the greatest possible control of plant disease, one should always have in mind a number of very important factors. The introduction of new varieties into standard cropping regions is often attended with troubles arising from disease introduction. Some varieties may not only prove worthless because of lack of disease-resisting powers, but also may often prove to be great disseminators of disease to the standard crop of the locality. This feature may be noticed in all types of plants, but is markedly noticeable among cereals with reference to rust, as in different varieties of oats and of wheat. For example, it is very probable that the introduction of winter varieties of wheat into noted spring-wheat areas is alone sufficient to account for the rapid disappear-

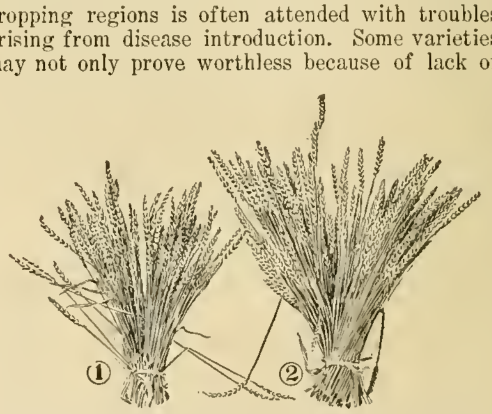


Fig. 73. Wheat from treated and untreated seed. Two bundles of wheat heads cut at the same distance from ground from two plots of wheat (the actual area two square feet). 1. From very smutty untreated seed; 76 per cent of smutty heads in this sample. 2. Grown from same seed but treated by the formaldehyde method to prevent smut.

ance of the spring crop, this result being brought about by rust which early developed on the winter crop and fell on the immature spring crop. For similar reasons, mixtures of varieties should be avoided when possible. This is especially true of cereals, but applies equally to fruit and vegetable culture. When attempting to control crop diseases, it is a matter of the greatest concern that in the crop there should be an evenness of development and maturing. One can often protect plants or crops of the same grade of growth or maturity, but it is difficult to avoid damage when there is no uniformity in these features.

Saving seed.—After purity of variety, there are no features of caring for the seed of greater importance than those which insure proper harvest, curing and storing. Aside from conditions that may cause weakened vitality of the seeds, there are many features of these processes that may introduce or multiply the chances of introducing infectious diseases. Each crop and its special diseases must be studied with these points in mind.

Vitality or initiative growth power in the seed or cion is of great importance. It is of much moment that the growth period from seed-time to maturity shall be as short as possible. This applies especially to annual crops. This initiative seed power can be gained and maintained only by persistent seed selection, cleaning and grading. With this point in mind, one selects to secure varieties and individual types which are the least susceptible to disease, cleans them thoroughly to free them from possible disease-bearing parts, and grades them to get rid of diseased seeds, those that are predisposed to disease and those that are not up to the standard of excellence. Note Figs. 72–74.

Treatment of seed.—Proper seed treatment presupposes a proper selection of seed, proper cleaning and grading. Seed thus prepared is then ready for treatment or disinfection. The theory of seed disinfection rests on the principle that some plant diseases, indeed many, are transmitted by way of the seed either to the soil or to the new plant directly by way of the embryo.

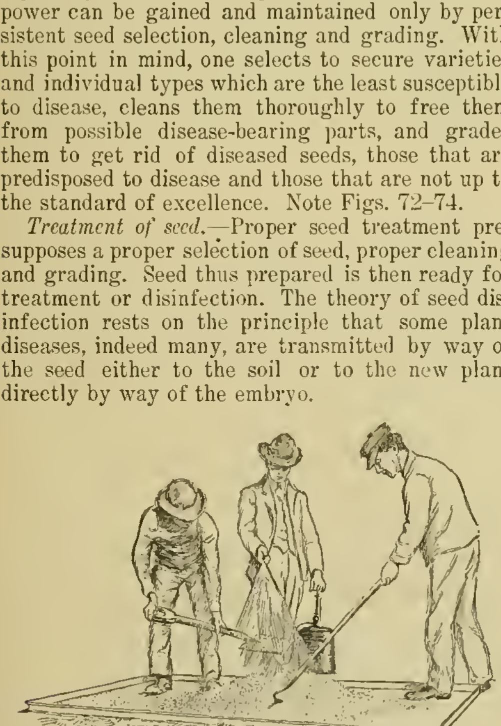


Fig. 74. Treating seed grain by spraying and shoveling, as practiced on large farms in the Northwest.

Taking up this feature of the question, it is necessary to consider just what diseases are to be prevented. Some are known to be directly transmissible by way of the seed, the embryo or germ layers being internally infected as in the case of flax-wilt or anthracnose of beans and loose smut of wheat. By far the greater number of diseases, such as the stinking smut of wheat and onions and numerous diseases of garden vegetables, including potato-scab and potato-rot, however, are easily transmitted to the ground and the new plant because of the presence of external spores, structures that are simply dusted on the seeds, and only await an opportunity to prey on the roots. (Fig. 75.) For all such diseases, seed disinfection is an

Fig. 75. Potato-scab growing on sugar-beets. This illustration is from the original experiment which proved that potato-scab fungus lives from year to year in the ground, and may attack other vegetables besides potatoes.

easy and direct remedy, and numerous formulas and washes or solutions suited for special diseases have been developed from time to time, among which may be named the following examples: Copper sulfate solution, corrosive sublimate solution, hot water treatment, and the formaldehyde treatments.

Usually the treatment demands that individual seeds shall be subjected thoroughly to the action of the disinfecting medium for a definite period of time. It is well to remember that, as in the case of serving medicine to persons, or administering washes to wounds, only certain strengths are suitable to particular cases. Therefore, the directions for using must be followed closely if prevention can be reasonably expected, the aim being to prevent the disease, and, at the same time, in no way to injure the growth from the seed. It is an interesting feature of seed disinfection that, whenever a proper treatment for prevention has been made, the yield may very greatly exceed that from the untreated seed of the same type, even though no particular disease is known to infest the seed. This may be readily accounted for by the fact that disinfection does away with many unknown or unobserved organisms on the seed that cause trouble to the young plant sufficient to be of great detriment to its growth, and yet not sufficient to give results that would ordinarily be characterized as disease. Thus, with seed properly treated by the formaldehyde method of disinfection, bacteria, yeasts, molds, all types of organisms which readily set up fermentations in the moistened seed, are disposed of, leaving the young plantlet to draw unmolested the full amount of food materials stored in the mother seed.

The following farm crops are grown with much greater advantage if the seed is first disinfected: Wheat, barley, oats, millet, grass seeds, flax seed and corn. The method of disinfection is now almost uniformly some modification of the formaldehyde treatment.

Formulas for seed treatment.—Only a few of the standard formulas for seed treatment may be noted here. The steps in different cases are very similar. Persons interested in some special method of seed treatment should consult their nearest experiment station officer interested in such work, or look up the matter in the general literature of the stations and the Department of Agriculture.

Hot water: Temperature and time of immersion vary according to kind of seeds and type of disease; especially recommended for stinking smut and the smuts of oats and barley; for stinking smut in wheat dip at 135° Fahr., for three to five minutes; for oat- or barley-smut, immerse at 133° Fahr., for fifteen minutes. (Consult bulletins of Indiana, Kansas, North Dakota, and other experiment stations.)

Corrosive sublimate solution: One ounce to six gallons of water; used successfully to treat potato tubers for destruction of spores of scab, rot and blight; immerse whole tubers for one and one-half hours. Plant on disease-free soil. This solution is also very effective against stinking smut of wheat. (See bulletins of North Dakota Experiment Station and others.)

Formaldehyde solution: The most economical and successful seed disinfectant; now in general use for all types of seed and all types of plant diseases. Especially recommended for prevention of smuts in cereal grains, wheat, oats, barley and millet, flax-wilt, onion-smut and potato-scab. Very effective in improving the first-growth powers of weak or moldy seeds, especially grass seed, corn, garden seeds, and the like. It prevents the early action of molds, damping-off fungi and other diseases. The strengths used on cereals and seeds is generally sixteen ounces of 40 per cent formaldehyde to forty gallons of water; for potato-scab, sixteen ounces to thirty gallons. It is used either as a spray or dip. (For special methods, consult experiment station literature.)

Sulfur and lime have often received high commendation for use in seed disinfection. The writer, after many trials, has been unable to find them of use against any fungus which attacks by way of seed or soil.

The growing crop or plant.

It is essential to take into consideration the growing plant or crop, noting the many features that have particular bearing on disease development or, at least, those that allow one to guard the crop against excessive destruction. Any feature of soil or environment which may chance to give an unfavorable growth period during the regular growing season may lay the crop open to serious damage. Thus, the drainage and character of the soil, as already said, and its cultivation may particularly affect the character of the crop with reference to its ability to develop in the presence of disease. The influence of drainage is always distinctly noticeable in its effects on the development of blights, wilts and rusts. For example, poorly drained areas in the great spring-wheat belt of the Northwest bring about heavy dew formations, and this results in extreme rust infection and consequent damage.

The matter of fertilization of the flowers by insects often plays a direct rôle in introducing new infection, as, for example, when bees and flies visit infected trees and carry infection from flower to flower and from tree to tree. This has been clearly demonstrated in pear- and apple-blight.

The application of fertilizers and barnyard manures may exert a direct influence on the development of plant disease. One often sees the ill-effects of the injudicious use of such agents. It need only be emphasized that an unbalanced food supply readily produces an irregular growth which may be open to the attack of many types of disease-producing agents, as, for example, rust of wheat in case of excessive use of nitrogenous fertilizers or barnyard manures. Weeds in many ways may be unfavorable in their effects on the growing plant, and directly favorable to destructive action of plant parasites on the crop. They draw away nourishment in time of drought and by keeping the crop befogged in times of dampness, as in the case of the rust parasites, they bring about profuse spore germination and infection. Certain weeds are also direct breeders of the parasites which prey on special cultivated crops. Clean culture, therefore, always has its direct merits.

The matter of considering the growth periods of the crop becomes one of actual necessity when preparing for the work of spraying for prevention. It determines the time of spraying and the strength of solution that may be used with success.

Spraying for prevention.

Spraying for the prevention of plant diseases has now become a fixed practice in the better agricultural regions throughout the world. It owes its existence to the simple fact that many of the special diseases which attack farm, garden and orchard crops are infectious by nature, and spread from plant to plant by means of small seed-like structures, called spores, which may be readily borne by the winds, water, insects or other agencies. When they fall on the growing plant, they begin to grow either by attacking the plant surface or by sending filaments into the internal structures. It has been found that certain solutions, applied at the proper time, cut short the lives of these spores and their developing growths, preventing injury to the plant on which they fall, or on which they are spreading. The aim of spraying is to cover all surfaces that are likely to be attacked, or on which spores are likely to fall, with a film of some chemical, either dry or in solution, that will prevent the germination of the spores and the development of the disease-producing organisms, and, at the same time, not injure the foliage and living tissues of the plant on which the spray falls. It is thus merely a matter of disinfection.

The time for spraying can be properly determined only by a close observation of the period at which the disease is spreading and by con-

Crab-apple in fruit. Indiana

Plate II. Orange tree in fruit. California

sidering the stage of leaf, flower or fruit development. Usually the earlier spraying is done on orchards and permanent plants, in order to destroy the first series of spores that may come from distant regions. Two or three, and in some cases four or five treatments are applied during the growing season for a like reason.

If spraying is done properly, one need not expect to see much indication of the diseases which are thus preventable in the sprayed crop. It is wholly a matter of prevention. Therefore, forethought must be exercised; for when the disease is once started, spraying, in most cases, will not prevent the particular plant sustaining injury, as in the case of a potato plant which has become attacked by blight. Proper spraying, however, will prevent the disease spreading from this plant to other plants,—indeed, will keep it confined to the parts of the plant already attacked. Even the individual plants that are once attacked are benefited because their future growths may continue uninterrupted. Spraying has become so universal that one need only cite a few diseases that are thus preventable. It must be remembered that, as each plant disease has a particular life-history and attacks its host-plant in a particular way, there are special reasons for modifying spraying processes to fit each crop and each peculiar disease; therefore, one who wishes to take up the work should consult proper authorities, or bulletins dealing directly with this phase of the question.

The following list of diseases that may be prevented by proper spraying is only an indication of the actual number: Apple ripe-rot, anthracnose, canker or bitter-rot, leaf-spot and scab; asparagus-rust; bean anthracnose; beet leaf-spot; celery-blight; cucumber damping-off, mildew and blight; gooseberry mildew; grape-rot and anthracnose; lemon-scab; lettuce leaf-rot, leaf-mold and mildew; melon mildew and anthracnose; olive-scab; orange-scab and mold; peach leaf-spot and scab; pear-scab and leaf-spot; plum-rot and shot-hole fungus; potato early blight, late blight, rot and mildew; raspberry anthrancnose; squash fruit-blight, rot and mildew; tomato anthracnose, leaf-blight and damping-off; violet mildew, mold and blight.

Sanitary prevention.

Since all of the plant diseases that affect field crops and plants generally, excepting those that are due to improper agricultural technique or particular chemical nature of the soil, may be looked on as essentially infectious, either directly from plant to plant or from soil to soil, one may put the whole matter on sanitary bases similar to those which apply to the prevention of diseases among animals and man. An ounce of prevention is worth a pound of cure. In the case of farm crops and garden plants, it is clearly true that a slight amount of energy placed to the credit of proper methods of prevention adds greatly to the crop returns. The chief methods of prevention that are usually practiced have been cited when we mention seed treatment and spraying. These strictly belong to this heading of sanitary prevention, but, as they have become matters of common practice, the writer wishes to call attention to the fact that there are other sanitary methods of avoiding diseases in farm and garden crops aside from these two. Much may be done to put the environments of the crop in sanitary condition, as the cleaning-up of the field after the previous crop, the elimination of diseased parts of permanent plants, trees and shrubs, the disinfection of bins, machinery, sacks, storehouses, elevators and all containers and contrivances that are to be handled in connection with the cultivation of the new crop. And, finally, the farmer should look to the breed, striving to procure breeds or strains that are resistant to the diseases that affect their race and variety.

In the case of crops that are annually attacked by diseases, an intelligent, concerted action on the part of the farmers throughout the country must, of necessity, have great bearing on the reduction of disease-producing influences. Every farmer knows that to grow potatoes year after year on the same patch of ground results in gradual reduction in yield and quality because of scab, rot, blight and wilt, and numerous apparent but unknown troubles. This is but an example of the accumulation of the infecting spores of such diseases in a particular area of soil or in the immediate neighborhood. There are probably none of the fungi producing known diseases, that are not able to survive the winter on the refuse of the preceding crop. We have numerous such examples: mildew of peas and beans, bacterial disease of cabbage, cotton root-rot, wilt of flax, stinking smut of wheat, the black smut of corn, potato-blight and potato-rot, apple-scab, apple canker, pear-blight, grape-rot, and so on. While some of these diseases are maintained from year to year on wild plants, the great majority of them gain their excess of development on the more tender abnormally developed agricultural plants. It has thus become one of the tenets of agriculture that the waste products of these, such as potato tops, waste fruit or vegetables, whatever they may be, should be eliminated as quickly as possible. This may be accomplished by gathering them carefully in heaps to be burned on the ground, or perhaps better by thorough composting. It has been said that thorough composting results in the destruction of most types of spores; yet, on the outside of all such manure piles and compost heaps it has been found that many of the diseases, such as the smuts and imperfect fungi, may even develop their spores in great quantities. The writer has known whole areas of virgin soil in North Dakota to be ruined for flax production through the use of poorly composted flax straw in barnyard manures.

Old-time gardeners have always believed in the elimination of weak and sickly plants. Greenhouse men of greatest success have always "rogued" all their beds. It will be clearly seen that, if such weakly and sickly plants are destroyed by fire, the chance of spreading disease is greatly lessened. In the case of perennial plants, trees and shrubs, there are many diseases for which proper pruning may largely lessen the possibilities of disease distribution. In the case of apple-blight, pear-blight, and many of the common fruit diseases, a persistent cutting back of the diseased parts and burning is sufficient largely to reduce the damage done by these very destructive diseases. Indeed, at present it seems the only effective means of controlling such diseases. In these cases which directly infect the internal tissues of the plants, the pruning to eliminate diseased parts must be done at a considerable distance below the actual place of disease in order that the disease may not continue below that point. One also keeps a disinfecting solution for the purpose of disinfecting his hands and tools, so that the disease may not be transferred from limb to limb. In the case of pear-blight, which may be taken as a good example of such troubles, the organism that occasions the blight may be transferred in the sticky juice that exudes from dying parts to other parts by any agency which comes in contact with the disease-bearing liquids and afterwards wounds or perforates delicate parts of other trees. A concerted action of the fruit-growers throughout the United States might readily reduce to a minimum the injury occasioned by this disease. In order to make such efforts effective, farmers interested in particular crops, whether of fruit, vegetables or cereals, will need to bring as much influence as possible to bear on their neighbors, and indeed on all persons concerned. It is only in concerted action that sanitary prevention can become of general benefit. When education along such lines is general, losses from disease will be reduced to a minimum.

A point in disease control which is often overlooked by many who are otherwise quite successful, is that of caring for the seeds after harvest. This especially applies to vegetables and cereal grains. All bins, machinery, granaries, storehouses and elevators should be kept thoroughly clean and, as nearly as possible, free from dust. The farmer who practically breeds and selects his own seed grain and plants for propagation, after once having procured a pure strain, need seldom take other precautions than those previously mentioned of eliminating the weak and inefficient plants and the like, providing he holds himself to cleanliness in regard to machinery and seed storage. It is easy to introduce such a disease as stinking smut of wheat, by allowing the machine which has previously threshed a smutty crop to come on the farm before it is properly cleaned. It is clearly evident that diseases of cereals and vegetables, including potatoes and smaller crops, can be transmitted readily in sacks and other containers. In most cases it is a simple matter to disinfect these containers at the time that the process of seed disinfection is being carried out.

Breeding and selection.

All of the above processes that have been mentioned for avoiding or controlling diseases have for their basis the assumption of the fact that we have a particular kind or strain of plant or crop that we wish to protect against disease. Controlling diseases of farm crops by means of breeding and selection has in view the supposition that those valuable strains of farm plants which we now possess, by proper breeding and selection may be increased in their efficiency of resisting disease without materially interfering with their economic value. Proper processes of breeding and selection, therefore, would presuppose the ability on the part of the breeder or selector to maintain, in his crop, its ability to produce quantity and quality and yet have the crop possess the added power of disease resistance. To accomplish this does not demand the effort of a scientific plant-breeder alone. It demands that the farmers gain that simple knowledge that enables them to recognize the plant or crop that does resist the prevailing diseases, and then that they should save the seed and propagate this crop to the exclusion of those types of plants or crops which are inefficient in this respect. New kinds are often secured by the process of crossing and breeding. This is usually the work of the expert or, at least, of men who have means and time to tend to the work. But new strains, so far as the actual crop is concerned, may be secured by straight selection of individual plants.

This line of work lately has been found to give results of enormous crop value. One has only to save the seed from the types that best serve the purposes, and persist in doing so to gain greatly in this respect. This is the newest field of work along the line of controlling plant diseases, but it is sufficiently past the experimental stage to allow one to assert with confidence that any farmer who will may thus greatly benefit himself and aid all mankind toward the elimination of plant diseases. For example, if we gain a type of wheat that does not produce on its leaves one-third as much rust as has been produced previously in that region on the common types of wheat, it is a self-evident fact that there will not be so much rust to be distributed to other fields. If, by careful and consistent selection of varieties and individual strains from the varieties, the farmer finally attains a crop of potatoes that is no longer open to the attack of potato-rot and potato-blight, it is a self-evident fact that his fields will not be distributers of the disease to other fields. It is too much to expect, perhaps, that this process will eliminate entirely some of the most destructive diseases, such as rust of wheat, rot of potatoes, blight of pear, root-rot of cotton, and wilt of flax, yet the results gained in this direction in the past ten years are such as to convince the most skeptical that herein lies a most effective means of reducing the destructive action of plant diseases. The process is so simple that any one may engage in it with success. Diseases weaken, mar, shrivel and lessen the produce from plants that are non-resistant. Mother plants that are resistant produce the more perfect products. It is from such that one should propagate the succeeding crops. It is but to put the "survival of the fittest" principle into direct action in crop production.

Literature.

The literature on plant diseases is voluminous. It is impossible here to cite monographs. References to these may be found in writings specially devoted to this subject. Many of the diseases that have to do with special crops are discussed or referred to under these crops. Most of the experiment stations and the United States Department of Agriculture have issued general and specific bulletins on plant diseases. The card catalogue of experiment station literature, issued by the United States Department of Agriculture, is especially helpful in this connection. A few important publications follow: Centralblatt fur Bacteriologie und Parasitenkunde; Cobb, Plant Diseases and Their Remedies, Department of Agriculture, New South Wales; Cooke, Rusts, Smut, Mildew and Mold; Cooke, Introduction to Study of Fungi; De Bary, Morphology and Biology of Fungi, translated by Garnsey and Balfour; Engler and Prantl, Die Naturlichen Pflanzenfamilien; Hartig, Pflanzenkrankheiten; Hartig, Diseases of Trees, translated by Sommerville and Ward; Journal of Mycology; Kuster, Pathologiche Pflanzenanatomie; Massee, British Fungus Flora; Revue Mycologique; Scribner, Fungus Diseases, Selby, Handbook, Diseases of Cultivated Plants, Ohio Agricultural Experiment Station Bulletin, No. 121; Smith, Diseases of Field and Garden Crops; Smith, Spread of Plant Diseases, see Massachusetts Horticultural Society Report, 1898; Sorauer, Pflanzenkrankheiten; Stone, Diseases of Crops, not Generally Supposed to be Caused by Fungi or Insects, Massachusetts Agricultural Experiment Station Report, 1905; Underwood, Moulds and Mushrooms; Von Tubeuf and Smith, Diseases of Plants; Ward, Diseases of Plants; Freeman, Minnesota Plant Diseases.

CHAPTER III

THE BREEDING OF PLANTS

INTEREST IN PLANT-BREEDING is now one of the dominant notes in American agriculture. We have tended to proceed along one line of progress at a time. The enriching of the soil has long been the most dominant note in agriculture. Of late years, the importance of tillage has been again very strongly emphasized, with some misapprehension, no doubt, of some of the real issues involved. In some periods, underdrainage has been especially advised. At present, the desire to breed adaptable kinds of plants has come strongly to the fore, following long years of insistence on the part of prophets here and there. This plant-breeding phase of our development is not likely to isolate itself, for we now have a body of investigators and teachers and of so many minds that all phases of agriculture are likely to receive somewhat coördinate attention.

The larger part of plant-breeding work is now centralizing about the experiment stations and the Department of Agriculture. This is characteristic of our time, for the institutions hold the leadership. In time, when agricultural affairs have readjusted themselves, leadership will again lie in good part in men engaged in commercial farming. There is every reason for supposing that plant-breeding should be a personal enterprise as well as an institutional enterprise.

These remarks do not lose sight of the fact that there are a few personal and isolated plant-breeders, standing out strongly and doing their work by methods of their own. In this class, Luther Burbank is preëminent. Burbank's work has been misjudged and sensationalized by reporters (a danger which just now threatens all work of this kind), until the public is in great error in its estimate of it. Mr. Burbank is experimenting with an unusual variety of plants in great numbers and under propitious natural conditions, with strongly personal methods and points of view. His place abounds in surprising and interesting results in the variation of plants. Some of the results will no doubt be of marked economic value. But his work is not occult, nor is it revolutionary. It will rank among the great efforts in the amelioration and adaptation of plants. It is calling attention to the fact that the intellectual interest in variation may be quite as much worth while as interest in the æsthetic or other companionship with plants.

The reader will now want a statement of what plant-breeding is: it is the producing of plants that are adapted to specific conditions or requirements. The mere production of something new, or unlike anything then existing, may have little merit or purpose, and it is not plant-breeding in the best sense. It will be seen, therefore, that the first step in plant-breeding is a definite purpose or ideal; one does not develop this ideal until he has a clear conception of his business.

The professional plant-breeders may be the persons to produce the larger and bolder races or groups; but it must lie with the individual farmer to adapt these things to his own place, or to be able to choose those that are already adapted, as it is also his part to determine what kinds of fertilizers he shall use or what kinds of crops he shall grow. Good farmers have always been plant-breeders: they have "selected the best" for seed; they have changed seed from place to place; they have exercised a shrewd discrimination in varieties and strains. The present phase of plant-breeding differs in attaching more importance to plant adaptations and in a better understanding of the principles underlying the practices. The good stockman does not use common stock for breeders; the good plantsman does not use common stock for breeders.

Every good farmer, then, is of necessity a plant-breeder. He knows the points and merits of his wheat or cotton, as the dog-fancier knows the points of his dogs. Knowing this, he will also know what improvements are needed to adapt the plants to his soil or climate or system of farming or markets. He will then set about it to secure these improvements by (1) looking for plants that most nearly approach the ideal or causing them to vary toward that ideal, (2) selecting seed from these plants, (3) repeating the process as long as he lives. The remainder of the work is detail.

This process may not produce any very striking or permanent new vegetable forms; but the efficiency of a personal business lies mostly in these smaller grades of differences. If a man is a seller of new plants, he may want plants with new names. For certain regions and certain purposes, also, wholly new kinds of things may be needed; but with the producing of these the individual farmer will not often concern himself. It is significant that some of the most important seed business of the present day rests on the sale of improved, selected or pedigreed seed of standard varieties. Every ambitious, careful and clear-headed farmer should now be able to produce superior seed-stock of his staple crop to sell for planting at good living prices. The public is now ready to believe that there are grades of quality in seed-stock of the common crops as there is in butter or cheese or liquors (some time we will also know that there are grades of quality in plain drinking-water).

The above advice rests on the principle that improvement is made by means of selection. This is the Darwinian principle. Selection, however, rests on variation. Why variations (or differences) arise, nobody really knows, although nearly everybody has an opinion. It is known, however, that variations accompany changes in soil, climate, methods of growing, and other changed conditions. Variation may also be induced or started off by crossing one plant with another, and such differences are likely to be marked. Some variations appear without any apparent reason, and they may be more or less stable from the first; they are "sports," or, as we now say, mutations (following the terminology of DeVries). These marked so-called "sudden" variations may reproduce remarkably true from seed. The recent evolution discussions have tended to divide variations into these two classes,—the small individual variations that do not reproduce or "come true" (and are therefore presumed to be of no permanent effect in the evolution of the type), and the variations, usually wider, that do "come true." We do not know, however, what are the ultimate origins or what the physiological differences. Divested of technical questions and controversial phases, the practical difference between mutations and other variations is one of definition,—the mutations come true, the others do not. The mutation theory controverts the older doctrine that variations may be augmented by selection until the differences become morphologically great, and until they also become "fixed" or able to reproduce themselves,—that is, that species originate by means of selection; but the mutation theory does not controvert the importance—but rather emphasizes it—of selection as an agent in the improvement of agricultural plants. Even if a mutation (or hereditable variation) appears, it may still be greatly improved in its minor features by careful selection.

The mathematical law of chance or probabilities applies to hybrids as well as to other numerical combinations. If a plant with three given characters, for example, were to be crossed with a plant of three contrasting characters, the law of probability would predict about how many of the offspring would have one combination of characters and how many would have another combination. The law might not be exemplified in any one plant, but it would very likely be apparent in the average of a number of plants; and the greater the number, the more regular the results, due to the subordination of exceptions. Mendel found that this law applies to characters that are united in crossing; if the law applies, it means that the characters or marks have an identity or individuality of their own, that they are carried over entire rather than as blends. In order to explain the application of the mathematical law of chance to hybridization, therefore, we suppose that characters are units and that they are represented directly in the germ-cell; and hereby arises the theory of the "purity of the germ-cell." That is to say, the mathematical law requires a biological hypothesis to explain why or how it works with animals and plants. Very many experiments have shown that the characters of parents reappear in offspring approximately in the given mathematical proportions; on the other hand, other experiments show a different or contradictory result. Some hybrids also are blends. A very complex body of speculation has been built up around the so-called Mendellian law, as there has been about other pronouncements in times present and past; how much of it is truth time only can tell. The Mendellian discussion has challenged our notions of hybridization and heredity and has modified the methods of experiment; but there is no indication that the Mendel law will enable us to produce new plants with certainty, as some of its early adherents predicted.

Plant-breeding societies.

This Editorial is written from the viewpoint of the farmer: the professional plant-breeder will take care of himself. The farmer needs help in this particular effort, as he needs it in other ways. The organization of breeding societies is one of the best means of spreading and unifying the work. A number of these societies are now in existence, indicating the interest in the subject and the grip that it has on practical men. Associations for plant-breeding are as necessary as societies for animal-breeding. As an illustration of the kind of effort that these organizations stand for, citations may be made from the literature of the Ohio Plant Breeders' Association: "The purposes of this association shall be to encourage the improvement of plants and to provide an official record for breeders who are giving special attention to this work." The rules for the registry of seed corn are as follows:

"Section I.—Eligibility.

"In order that a strain of corn may be eligible to registry with the Ohio Plant Breeders' Association, it is necessary that it trace directly and exclusively to remnants of ears that have ranked not lower than fourth in point of yield of grain, protein, starch or fat in a duplicate ear-row test of not less than twenty-five ears; and that each year's breeding or testing work shall have been conducted and recorded in accordance with the requirements of the Association.

"Section II.—Ohio Pedigreed Corn.

"Any corn which is the product of a cross between two ear remnants, one as sire and the other as dam, each of which has been selected as per Section I, shall be entitled to the name Ohio Pedigreed. The records shall show whether the cross was made by artificial or natural pollination.

"Section III.—Ohio Standard Corn.

"Eight or more registered ears, as per Section II, or ear remnants, as per Section I, may be merged by shelling and mixing together the grain from all, before planting. If this merged corn, or corn descended exclusively from it, shall, on the average, excel in yield of grain, protein, starch or fat per acre, each of three other varieties (including the one from which it has descended and a standard variety which shall be supplied by the council upon request), when tested upon not less than tenth-acre plots for three consecutive years, the owner of it shall be entitled to a certificate under the seal of the Association, setting forth the record numbers under which the work upon this corn has been recorded, together with a statement that it has filled the requirements of the association and is entitled to the name Ohio Standard. A fee of $10 shall be required for this certificate and copies of same shall be issued at 25 cents each to accompany any corn that traces directly and exclusively to this merging.

"Section IV.—Transfers.

"Transfers of grain, together with all breeding privileges, may be made at any time, but in order that the progeny of such grain may be eligible to registry with the Association, each transfer must be entered for registry with the Recording Secretary of the Association within three months of the time of transfer. A certificate of transfer shall then be issued under the seal of the Association showing the record numbers under which the work of the breeders upon this corn has been recorded. A fee of $1 shall be charged for each record of transfer."

How to cross plants.

One of the means of inducing variation, as already explained, is to cross one plant with another. By crossing, also, it may be possible to combine some of the attributes of two or more plants into one. The reader will want to know how crossing is accomplished.

For most farm purposes it is sufficient to grow the intended parents side by side, if they are wind- or insect-pollinated, and let the chance of crossing rest with natural agencies. The seeds are then taken from the most likely parents and sown separately. In the progeny, one may expect to find some plants to his liking or at least such as are suggestive for further experiment. Plants that are freely visited by bees, as the fruit trees, or those in which the sexes are in separate flowers, as maize and hemp and chestnuts and melons, are almost certain to be crossed by this method. If the stigma happens to receive pollen from its own flower or plant and also from another plant, the foreign pollen will usually accomplish the fecundation. No doubt a great many of our agricultural varieties have arisen from such natural and apparently promiscuous crossing.

If one wishes to make an exact experiment, however, he must transfer the pollen himself under conditions of control, both to ensure that crossing takes place and that the pollen is from a given parent. The manual operation of crossing is of four parts: (1) protecting the pistil from undesired pollen; (2) protecting the pollen; (3) applying the desired pollen; (4) protecting the ovary and fruit. The operator must first be familiar with the parts of the flower. If he has no teacher, he may secure this information from any of the school botanies: and Figs. 14 to 17 and 76 will aid him. In the succeeding pages he will find the flowers of the different crops displayed.

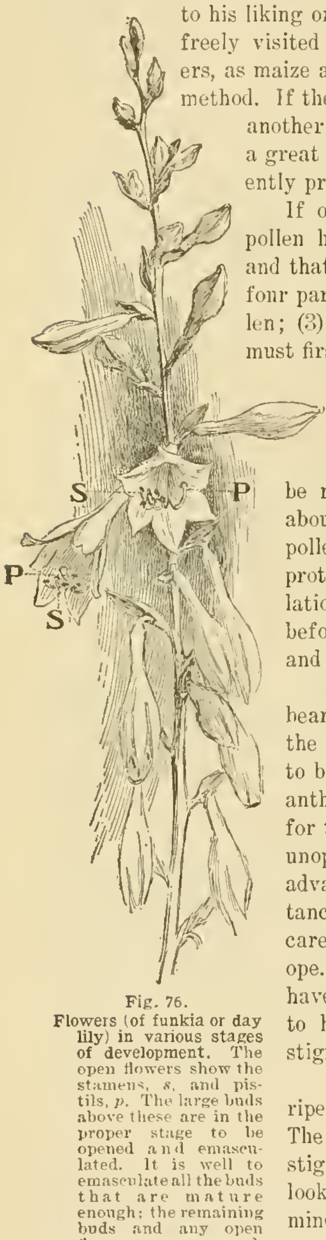


Fig. 76.
Flowers (of funkia or day lily) in various stages of development. The open flowers show the stamens, *s*, and pistils, *p*. The large buds above these are in the proper stage to be opened and emasculated. It is well to emasculate all the buds that are mature enough; the remaining buds and any open flowers are removed, and the emasculated ones covered with a bag.

(1) Protecting the stigma. If the flower contains stamens, the anthers must be removed before pollen is discharged. The discharge is likely to take place about as soon as the flower opens. The pistil must also be protected from foreign pollen. This means that the pistil must never be exposed to wind or insects. The protecting of the the pistil, then, is of two kinds,—removing the anthers (emasculation), covering the flower. Usually the bud is opened just before it is ready to burst, the anthers clipped off or broken off, and the flower covered securely with a thin paper or muslin bag.

(2) Protecting the pollen.—In the meantime the pollen-bearer has been looked after. It is safest to cover with a bag the flower or cluster of flowers from which pollen is to be taken, for insects may leave foreign pollen on the anthers. This precaution is not often taken, however, for the operator is careful to take his pollen only from unopened anthers. In some cases the pollen ripens in advance of the pistil, or it must be secured from a distance. It will usually retain vitality a few days if carefully dried (not heated) and kept dry in an envelope. Some species have short-lived pollen, and some have relatively long-lived pollen: it should be the aim to have it as fresh as possible, when applied to the stigma.

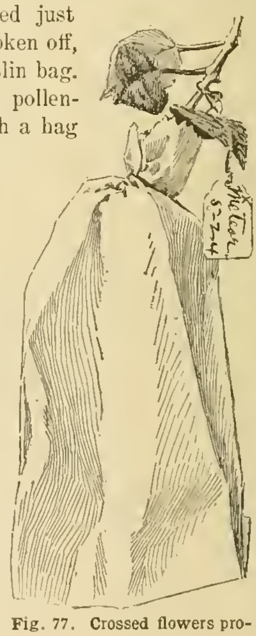


Fig. 77. Crossed flowers protected by a paper bag.

(3) Applying the pollen.—Usually the stigma is not ripe or "receptive" when the flower is emasculated. The flower is to remain covered, therefore, until the stigma is receptive. This epoch is determined by the looks of the stigma, a point to be accurately determined only by experience. The ripe stigma usually exudes a sticky or glistening covering, or it becomes rough and papillary. A hand lens will aid greatly in determining the proper time. A fresh ripe anther is crushed (if the pollen is taken fresh from the flower) on a knife-blade or thumb-nail, and some of the liberated pollen applied to the stigma by means of a needle-point or other small implement. The stigma is completely covered if possible. Then the bag is replaced.

(4) Protecting the forming fruit.—The bag is allowed to remain a few days, until all danger of further fecundation is removed. It is usually replaced by a mosquito-netting or tarlatan bag, in order to protect the fruit from insects or mechanical injury. This bag also aids in locating the fruit amongst

the foliage and it catches the fruit when it falls. When the cross is made, a label or tag is secured to the flower or branch to identify it.

It is seldom that all crosses "take." The proportion of successes depends somewhat on the skill of the operator and very largely on the kind of plant. Some plants cross very readily and some with great difficulty.

The seeds are now to be sown. The hybridizer always anticipates satisfaction with the results.

SOME OF THE PRINCIPLES OF PLANT-BREEDING

By *Herbert J. Webber*

We are inclined to think that plant-breeding is based on old and well-established laws. The fact is, however, that the fundamental principles of plant-breeding were not made known until the latter part of the eighteenth century. The sexuality of plants was established experimentally by Camerarius in 1691, and the first hybrid of which we have any record was made by Thomas Fairchild, an English gardener, in 1719, being a cross of the carnation with the sweet william. Hybrids were carefully studied by Koelreuter, but not from a practical breeding standpoint. Plant-breeding had its real beginning with the work of Thomas Andrew Knight, an eminent English plant physiologist, working in the early days of the nineteenth century. About the same time Van Mons, a Belgian horticulturist, also carried out experiments in a similar direction. A large part of our knowledge of plant-breeding has come down to us from these two investigators. Knight worked mainly in hybridization, and in 1806 said: "New varieties of every species of fruit will generally be better obtained by introducing the farina of one variety of pollen into the blossoms of another than by propagating from a single kind." Knight also enunciated what we may call the law of food supply, which is now generally recognized. This predicates that one of the principal factors which causes or induces variation in plants is an increase of food supply or a modification thereof. Van Mons worked mainly in selection, and it is interesting to note that his experiments were carried out primarily with pears. He preached the doctrine of continuous selection, and produced very many valuable varieties. Van Mons and Knight, therefore, were the exponents of the important factors of selection and hybridization in plant-improvement. It is probable that a large part of the success of Van Mons' work was due to the fact that pears are normally sterile to their own pollen, requiring cross-fertilization, and, therefore, many of his new varieties were probably hybrids. He was not aware of this fact, however, and it made no great difference in the establishment of the principle which has since proved to be so important.

In this country very valuable work was done in the improvement of plants and in discovering the principles of plant-breeding, by Carman, Pringle, Hovey, Ricketts, Rogers, and others, and in more recent years by Burbank, Hopkins, Hays, Bailey, and very many others.

The rediscovery of Mendel's now famous law by DeVries and Correns, in 1900, and the publication of DeVries' Mutation Theory in the same year, marked the beginning of a new era in plant-breeding. No matter what the final conclusions may be regarding Mendel's principles and the mutation theory, the general attention and investigation directed to plant-breeding as the result of these two theories will serve greatly to modify and extend our understanding of the general laws of breeding.

Classification of varieties.

To understand clearly the character of organisms with which we are dealing, we need careful definitions of the different groups of cultivated plants which are ordinarily known as varieties. We speak of varieties of wheat, corn, apples and pears, yet we know that these varieties differ from each other as natural groups. In order to distinguish clearly these differences, the writer has proposed the following classification of varieties into races, strains and clons:

Races are groups of cultivated plants which have well-marked differentiating characters, and propagate true to seed except for simple individual variations. The different groups of beans, peas, wheat, oats, corn, cotton, and the like, referred to commonly as varieties, are thus in a more restricted sense races. Boone County White, Leaming, Reid's Yellow Dent, and the like, would be recognized as races of field corn, and Turkey Red, Fulcaster, Fultz, and the like, as races of wheat.

Strains, the writer would recognize as groups of cultivated plants, derived from a race, which do not differ from the original of the race in visible taxonomic characters. When the breeder, by a careful selection of Blue Stem wheat, produces a sort of Blue Stem that differs from the original race only in the quality of yielding heavily, it would be called a strain of Blue Stem.

Clons are groups of cultivated plants, the different individuals of which are simply transplanted parts of the same individual, the reproduction being by the use of vegetative parts such as bulbs, tubers, buds, grafts, cuttings, runners, and the like. The various sorts of apples, potatoes, strawberries, chrysanthemums, and so on, commonly denominated varieties, in a more restricted sense would be clons. Clons of apples, pears, strawberries, potatoes, and the like, do not propagate true to seed, while this is one of the most important characters of races and strains of wheat, corn, and the like. The term variety would thus be used in a general sense, and would include races, strains and clons.

Factors of breeding.

Heredity.—The laws of heredity are of primary importance to the breeder. It is a general principle that ordinarily like begets like, but it is also true that like frequently gives rise to unlike. There are thus apparently two conflicting principles in plant-breeding. On the one hand, the breeder seeks to

Fig. 78. Individuality in cotton bolls. Smooth seeds above and fuzzy ones below, from four bolls of one hybrid plant.

produce variations in order to get new types as the foundations for improvement. On the other hand, when such a variation from or improvement on the normal type is secured, he then reverses the process and tries to establish heredity and reduce the amount of variation, so that the aphorism, "like begets like," will hold true.

In pedigree or grade breeding, and in breeding to produce new varieties, the importance of hereditary strength, prepotency or transmitting power, cannot be overestimated, as it is only by rendering this power very great that any new form can be brought to what is called a fixed type.

Unity of individual.—The unity of the individual is also an important factor in plant-breeding. If, for instance, the breeder is attempting to produce a seedless fruit, it is important that he discover the tendency to seedlessness in the entire individual. It would not be the correct policy for a breeder to select simply a single fruit which might accidentally be nearly seedless. He should examine a large number of fruits of different individual plants, and find a plant on which he can discover a general tendency toward seedlessness showing in all of the fruits produced. By selecting seed from such individuals, he may be able to find in time one such individual that would transmit to its progeny this tendency to produce few seeds.

While this is certainly generally true, there are some instances in which divisions of the individual are important. As an illustration may be mentioned the case of hybrids between a smooth- and a fuzzy-seeded cotton: when one is breeding to produce a smooth, black seed, it may be desirable to select a part of an individual. In this case the writer has found that very frequently a cotton hybrid of the above parentage will produce bolls that vary greatly in the amount of fuzziness on the seed, and that this variation does not seem to be limited to any part of the plant in particular, but seems to be a variation in certain branches or bolls (Fig. 78), and is thus a sort of bud variation. The writer's experiments have shown that by taking seed from certain bolls in which the seeds are nearly smooth and black, a much larger number of plants is produced the next year with smooth black seeds than are produced when bolls are selected in which the seeds have considerable fuzz, although the seed in both cases were borne on the same plant. This illustration shows that in some instances it is desirable to select a certain fraction or part of an individual which shows more clearly the character desired.

Variations.—It is well known that all plants vary. Plants differ from each other just as do men. Each plant has a facial expression, as it were, which marks it as distinct from any other plant of the same variety (Fig. 79). These slight fortuitous or individual variations are of the greatest value to the plant-breeder in connection with what may be termed pedigree breeding. By these variations alone, however, we would not expect to produce strikingly new varieties.

A second type of variation which is of value to the breeder is those known as "sports," or mutations (Fig. 80). These differ from individual variations only in degree. They are what may be termed large-type variations, and ordinarily reproduce true to seed. A very large number of our new races and varieties of cultivated plants are the results of such mutations or seedling sports. All vegetable-growers know that far the larger number of their new varieties are apparently produced suddenly. For instance, Livingston, who has bred a great many new varieties of the tomato, followed the practice of examining carefully his different plants for variations. Occasionally some striking new type differing from other varieties would be found. This was selected and used as the foundation stock for a new variety. Our good apples, pears, and peaches, have been found in many cases in fence-corners, and new varieties of wheat, cotton and other crops have resulted very largely from the selection of strikingly good plants which, because of their superior quality,

Fig. 79. Variation. Differences between tobacco plants, in size, shape of leaves, and also in time of maturing.

have attracted the attention of growers, and have been propagated. While many of these accidental discoveries are doubtless of hybrid origin, still it is probable that the majority are simply mutations or sports.

The third type of variation which is of importance to the plant-breeder is that produced by hybridization or crossing, and here we probably have the most prolific source of variations, and, therefore, the class of variation of the greatest importance and most consequence to the breeder It has come to be an established policy to combine the good qualities of two races into a single race by hybridization and selection.

Influence of environment.—It is a well-known fact that environment has a decided influence on the form and character of the plant. It is by no means certain, however, that these changes are of any value to the plant-breeder. It seems certain that those changes which are the consequence of environment purely are not hereditary. It is a well-known fact that if climbing or twining beans or viny cowpeas are transferred from a southern to a northern climate or from a lower to a higher altitude, they tend to produce a dwarfed type which will not show the twining or viny habit in such marked degree; and in order to secure bush types by selection, breeders have sometimes advocated the transferring of types to more northern latitudes or to higher altitudes, where the experiments may be made under conditions that naturally lead to the production of a lower bush type. It is doubtful, however, whether such a transfer would be of material aid. While it is recognized that such variations are produced as an influence of the environment, it is also known that, on the whole, those variations which are produced as an immediate influence of the environment are not hereditary. Individual variations and mutations are of greatest use to the plant-breeder. Without question, if the cowpea or bean were cultivated under southern conditions it would show individual variations in the degree in which it shows the climbing or twining habit. Even under southern conditions, certain individuals would doubtless show more of the bush type than others. It is believed by the writer that a bush type can be secured just as quickly under southern conditions by selecting from these lower and more bushy plants as it can by the same selection made in more northern localities or at higher altitudes.

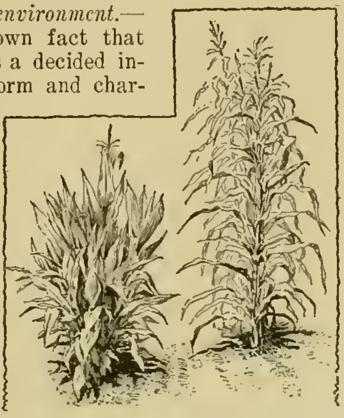


Fig. 80. Dwarf leafy sport or mutation of corn on left, which, when self-pollinated, reproduced original type. Mother parental types on right.

Location of breeding plots.

It is important to consider the conditions under which the breeding patch or plat should be grown. Some growers are inclined to locate their breeding patches in the garden and give the plants the very best possible care, thinking that this is the best means of determining which plants are superior. Animal-breeders also isolate their breeding stocks and give them every possible care and advantage. On the contrary, some plant-breeders assert that it is best to have the breeding patch located on soils which are most like those on which the general crop is to be grown. The writer has given this matter considerable thought, and he is strongly of the opinion that the most satisfactory method is to cultivate the breeding patch under the same conditions under which the ordinary crop is to be grown. Plants are fixed in one place, and are entirely dependent on the local soil conditions. If, therefore, the plant has been bred and adapted to one soil condition, it cannot be expected to give as good results under different soil conditions. If a variety is being bred for sterile soils, the selection should be conducted on similarly sterile soil in order to breed a race of individuals that are "gross feeders," as planters term it, and capable of deriving their nutriment from sterile soils and making a sturdy growth even under adverse conditions. If, for example, plants were being bred to adapt them to alkaline conditions, the breeding patch should not be placed in a sheltered, favored spot, where the soil does not contain alkali. The plants must be grown under alkaline conditions in order to discover, as a result of natural selection, those plants which do the best where the alkali is present, and thus guide us in the selection. The same would be true in breeding plants for arid regions. The plants should be cultivated in the arid region rather than in a moist region of heavy rainfall, or in a thoroughly irrigated patch.

In urging that the breeding patch be placed on the ordinary soils and cultivated under the conditions to which the crop is to be subjected, it is not intended to convey the idea that the breeding patch should not be given careful cultivation. Slipshod methods of cultivation should never receive encouragement. The breeding patch should be given thoroughly good cultivation; and such thoroughly good cultivation should also be used in the field when the crop is grown on a more extensive scale.

Necessity of a clearly defined ideal.

Careful breeders have found it very desirable and necessary to have a clearly defined ideal type which they are striving to produce. In the selections within the race it is necessary that the breeder have clearly in mind all of the characters of the race which he is breeding, and the writer thinks that all breeders should be recommended to draw up carefully a description of the type which they are breeding and the objects which they are attempting to obtain, otherwise it is difficult properly to limit the selections. All breeders know that in growing a large number of plants for selection, different types that appear very promising are likely to crop out here and there. We may be selecting for a certain type, and find in the row of plants which we are examining an individual that differs somewhat in its character but which seems to be of exceptional value. The temptation under such circumstances is to take this new plant and discard the old ideal. Many breeders have found that by taking such selections they have made serious mistakes, and lost the improvement already secured. Whenever a plant of different character springs up it is entirely an unknown quantity, and it may not transmit the desired characters; and, even if it should, they are different from the qualities of the ideal strain for which the selection was first started.

Control of parentage.

In plant-breeding, as in animal-breeding, the isolation of the parents is a very important consideration. It is necessary that we should know the character of both parents whenever this is possible. In breeding plants more attention is given ordinarily to the mother parent, and in very many instances the characters of the father parent are entirely neglected. Animal-breeders, on the contrary, give more attention to the characters of the male parent, and much improvement in ordinary herds has been accomplished by the introduction of improved blood through the male. In plant-breeding, it is desirable that the seed of the select individuals be planted in a field by themselves. This insures that only progeny of carefully selected plants will be planted near together, and thus no ordinary stock will enter as a contamination. One can be certain that each plant of the progeny is fertilized with pollen from another similarly good plant, or at least from a plant derived from good parentage. One difficulty, however, has been experienced by plant-breeders in planting continuously their selected stock in such isolated plots. If this method is continued year after year, it results in fairly close inbreeding, which in the case of plants frequently results in loss of vitality and vigor. In animal-breeding it is apparently the case that ordinarily there is no noticeable effect from close inbreeding, and many of the most famous animals have been produced as a result of the closest in-and-inbreeding. In plants, however, it is possible to secure much closer inbreeding than in the case of animals, as in many cases a plant can be fertilized with its own pollen.

Fig. 81. Loss of fertility in corn by inbreeding. Pile on left from cross-fertilized seed; on right from inbred or self-fertilized seed.

Within recent years much activity has been shown in the careful breeding and improvement of corn. The corn plant has been shown, as a result of experiments made by various investigators, as, for example, by the Illinois Experiment Station and the United States Department of Agriculture, to lose vitality very rapidly when self-fertilized. (Fig. 81.) Within three or four generations, by the most careful inbreeding, it is possible to reduce corn to almost total sterility. The general practice of corn-breeders who have been giving attention to the production of pedigree strains, is to plant the rows of corn from different select ears side by side, giving a row to each select ear, and each year selecting, from the progeny of those rows which give the largest yield, plants to continue further the selection. Planting these select ears together every year, therefore, means that they are more or less inbred, as the closest relatives are planted together in the same row. While in following this policy at first no effect was visible, corn-breeders are now finding in some cases an apparent decrease in yield, which seems to be traceable to the effect of inbreeding. It seems necessary for us, therefore, in corn and in other plants that are affected by inbreeding, to use methods that will avoid close inbreeding. The detrimental effect of inbreeding is largely limited to those plants which are normally cross-fertilized, this fact being strikingly brought out in Darwin's "Investigations on Cross- and Self-fertilization in the Vegetable Kingdom." Tobacco, wheat, and some other plants that are normally self-fertilized do not show this decrease in vigor as a result of inbreeding. Indeed, in such plants cross-fertilization ordinarily results in decreased vigor and should be avoided.

Principles of selection.

Selection is the principal factor of breeding, both in the improvement of races and in the production of new races or varieties. The keynote of selection is the choice of the best, and a factor of the highest importance is the examination of very large numbers in order to secure the maximum. Galton, writing on this subject, says: "One generation of 99-degree selection is seen to be more effective than two generations of the 90-degree selection, and to have about equal effect with the the 80-degree selection, carried on to perpetuity. Two generations of the 99-degree selection are more effective than four of the 95-degree, and than the perpetuity of the 90-degree." The use of degrees in representing the perfection in which a character is shown may not be possible, but it is possible for any breeder to examine large numbers and to find one or two plants which produce in the greatest degree the character desired. It is these plants that should be preserved as mother plants in starting the selection.

In the production of new races, it is of interest to us to know whether by pure selection we can lead plants to vary so greatly that they may be considered to have passed beyond the bounds of the race, and thereby the breeder to have established a new and distinct race. It is certain, of course, that, by careful observation and selection from any particular race, ultimately a new race may be produced. The question is whether the individual or individuals selected in producing the new race have not varied by mutation or seedsporting rather than being simply representative of the cumulative result of the selection of slight individual variations. The sugar-beet furnishes an interesting illustration in this direction. It will be remembered that Louis Vilmorin started the selection of sugar-beets for richness in sugar, between 1830 and 1840, selecting first by means of specific gravity, the method being to throw the beets into solutions of brine strong enough so that the great majority of them would float, the few which sank being of greater specific gravity and presumably of greater sugar content. Considerable improvement was produced by this method. About 1851 the method of chemical analysis was introduced to determine the exact sugar content. At this time the sugar content was found to vary from 7 to 14 per cent, and in the second generation of selection individuals with 21 per cent of sugar were found. The selection based on sugar content, using the beets highest in sugar content as mothers, has been continued regularly since that time, and the industry has come to rely entirely on careful selection for high sugar content. It would be expected that under these conditions the sugar content would have increased sufficiently so that the selected plants could be considered a different race or strain. Yet, after fifty years of selection, the highest sugar content found is only about 26 per cent, and this in a very few instances, seldom over 21 per cent being found. At the present time many thousand analyses are made every year, so that abundant opportunity is afforded to find individuals producing a high sugar content. On the contrary, when Vilmorin's work was started the determination of sugar content was by very laborious methods, and was limited to comparatively few individuals. It is not improbable that if Vilmorin had been able to make analyses of the sugar content in many thousands of roots he would have found certain individuals producing as high as 26 per cent. The inference from this illustration would be that the limitations of the variation within the race have not been surpassed as a result of selection. It may be argued, however, that in this case we are dealing with a physical impossiblity, as it is clearly evident that it would be impossible for a plant to produce a root containing a proportion of sugar beyond a certain percentage, and it is thus possible that 26 per cent, or thereabouts, represents the maximum.

It must be admitted that in many cases we have an apparently cumulative effect of selection, and it seems almost impossible to draw the line between improvements created by continuous selection of slight individual variations within the race or the selection of those plants which are mutations. In the case of the gooseberry, tomato and many other plants, the fruits have been increased in size gradually, until they are now four to eight times that of the original wild fruits. Much of this increase in size has of course been accompanied by hybridization between different wild species and different races of the same species which have been mixed together, yet it is a cumulative gain in size, as none of the wild types ever produce fruits nearly so large as those of the cultivated races that have been developed. Practically the entire development of the tomato has taken place within the memory of men now living, and in this case the development has not been accompanied by hybridization of different species but by the selection of different races within the species and the hybridization of these races. One of the experiments conducted by DeVries with corn is of interest in this connection. This experiment was undertaken for the purpose of increasing the number of rows of kernels on the ear. The corn used in the selection averaged twelve rows at the time the selection began. After seven generations of selections from ears which bore the largest number of rows, the mean was raised to twenty rows. In the first year of the selection the variation in number of rows ranged from 8 to 20. In the seventh generation of selection the variation in number of rows ranged from 12 to 28. This shows clearly the increase in the number of rows and the development of an apparently new race by simple selection. However, when the selection was discontinued the improvement or new character was soon lost.

The majority of new races produced as a result of selection are due, without much doubt, to the choice of mother plants showing marked variations which we would term mutations, and which are referred to by gardeners ordinarily as sports. In reviewing the history of cultivated varieties, one is surprised at the large number of varieties, which have had their origin in this way. Many of our apple, pear and peach varieties are simply accidental seedlings which have sprung up in fence-corners or door-yards, and a number of our wheat, tobacco and cotton varieties have been developed by selection from certain individual plants that have attracted attention because of the exhibition of superior qualities. It is probable that a large number of these accidental and selected varieties, particularly in the case of apples and pears, are really the results of accidental hybridization, and the same may be true of many wheat, corn and cotton varieties. Yet there are many cases in which the mutations or extreme variations cannot be traced back to hybridization. In the production of the Cupid sweet-peas, for example, the first small dwarf plant of this type was found growing in a row of the Emily Henderson, which is one of the normal climbing forms of the sweet-pea. At that time no other dwarf type of the sweet-pea was known, and this variation, therefore, cannot be accounted for as due to hybridization with some other dwarf form. It is impossible to account for these striking variations which sometimes occur, but it is important that all plant-breeders be on the lookout for the occurence of new types and variations of this sort.

The writer has been asked frequently whether it is possible to select a plant so highly that it will not revert to the original mother type. Experience would indicate that when the mother plant from which the selection is made is a true mutation, like the sweet-pea mentioned above, the type will maintain itself even after the selection has been discontinued, and indeed this is practically the only real criterion as to whether a new race has been produced. For example, in the case of the corn mentioned above as selected by De Vries, that in seven years had been increased from 12 to 20 in the number of rows to the ear, DeVries found that it required only about three years of cultivation without selection to fall again to the original average of 12 to 16 rows. In a case like this it would seem, therefore, that no distinctly new character had been added as a result of selection, but that the average of the race had been increased by the continuous selection under isolation, and that when the different individuals were allowed to breed together freely, without selection, the mean of the race, as a whole, was again quickly reëstablished.

Systematic methods of selection, or pedigree breeding.

Two distinct methods of selection are in use, which are termed (1) the nursery method, and (2) the field method. The nursery method, which was used first by Hallet about 1868, so far as the writer is informed, consists in cultivating each plant under the most favorable conditions possible for its best development. By this method, with wheat, for example, Hallet pursued the policy of planting the individuals in squares a foot apart, which would give the plant abundant opportunity for stooling, and also enable the investigator to distinguish clearly each individual plant. In more recent years this method has been strikingly emphasized by the work of Professor Hays, at the Minnesota Experiment Station, who, at the same time, has modified the principle somewhat into his centgener method (Fig. 82). In Professor Hays' method, the progeny of each plant, presumably about one hundred individuals, are grown together in a small plat or centgener, the individuals being planted four to six inches apart in the case of wheat and small grains.

Fig. 82. Centgeners of flax. Plats on right bred for seed production, thus short and very fruitful. Plats on left bred for fiber production, thus tall and less fruitful. (Notice difference in height is shown by difference in height of man's hand.)

The field method, which was emphasized by Rimpau about 1867, and has been used by many investigators, consists in selecting from plants grown under normal conditions. The argument for this method is that the plant will show what it will do and its true worth only when it is grown under the method of ordinary field culture. Both of these methods depend on progressive or cumulative selection, the building up and adding together of small improvements.

Breeders who are conducting careful experiments will find it necessary and desirable to use what may be termed statistical methods of judging their plants. While we are breeding possibly for one primary improvement, as, for example, increased yield, it is necessary, at the same time, that we should keep the product up to the standard

P. B. Form 41. No. 1a 3-1-12 COTTON—INDIVIDUAL NOTES. Year, 1903
Locality, Columbia SC Experimenter, H J Webber

Cotton—Individual Sheet.

Season.	Bolls.		Seed.			Lint.						Yield of Seed Cotton.	Per Cent of Lint.	Total Score.
V. Early, Early ✓, Medium, Late, V. Late.	V. Large, Large ✓, Medium, Small, V. Small.	Opening. V. Good ✓, Good, Medium, Poor.	Smooth ✓, Tufted, or Intermediate.	Size by Weight. 0.1 gr.	Covering. Excellent ✓, Good, Fair, Poor.	Length. 1½+ in.	Color. White	Very Fine, Fine ✓, Medium, Coarse.	Uniformity. Excellent ✓, Good, Fair, Poor.	Very ✓ Strong, Strong, Medium, Weak.	Drag. Very ✓ Strong, Strong, Medium, Weak.	305.9 gr.	33.1	
7	12					12		7	7	10		12	8	75

Bolls: No. 125; shape ovate blunt
No. locks 5; No. seeds to lock 8-10; weight 10 bolls seed cotton ....; No. of bolls open 40 on Oct 5

Resistance to—
Disease: Very resistant, resistant, medium, slight, none.
Storm: Very resistant, resistant, medium, slight, none.
Insect: Very resistant, resistant, medium, slight, none.

Basal Branches: No. 3; length 3 ft;
color ....; smooth, rough, hairy; horizontal, ascending ✓, nearly erect.

Flowers: Large, medium ✓, small; orange yellow, cream ✓, whitish; Pollen—orange, deep yellow, yellow, cream ✓, whitish; Petal spot—large, small, none ✓; deep red, red, pink, faint.

Leaves: Large, medium ✓, small; light or dark green; ...., parted, smooth, glaucous, pubescent ✓; Lobes—deep, medium, shallow; Type—Sea Island, upland ✓, intermediate.

Fruitfulness: Excellent, good, medium, light medium, poor.
Type Upland
Selected for Long Staple
Form of Plant Compact
Shape: Very good ✓, good, medium, poor.
Height 5½ ft.

A very excellent plant.
Select

Fig. 83. A score-card for cotton.

in other characteristics, namely, quality, disease-resistance, drought-resistance and the like, and that we see that all of the good qualities of the variety are retained. To do this properly necessitates the use of a score-card, on which each character of the plant which is important is given its relative weight or grade. By the use of such a score-card the breeder can judge each character separately, and by the adding up of the scoring get the rank of different plants in a comparative way (Fig. 83).

Fig. 84. A, Result of breeding from smallest grains; average head (after 4 years). B, result of breeding from the plumpest and heaviest grains; average head (after 4 years).

Test of transmitting power.

A factor of primary importance in all breeding work is the testing of what is termed the transmitting or centgener power. It is necessary for us to know that a certain plant, which, for example, gives a heavy yield, has the faculty of transmitting this tendency of producing heavy yield to its progeny (Fig. 84). It is frequently found that two select plants that are equally good so far as their yield is concerned will give progeny which, as a whole, differ greatly in this respect. In the progeny of one almost every plant may have inherited the desired quality, while in the progeny of the other only a few of the plants may show in any noticeable degree the inheritance of the quality. To determine the prepotency or transmitting power, it is necessary to grade carefully the progeny of each individual; and this is the primary reason for planting the progeny of different individuals in separate rows or separate plats, so that they may be examined easily. (Fig. 85.) It would seem to be an easy matter, when we plant the progeny of different plants in rows or small plats by themselves, to get the comparative yield, for example, of 100 plants, and from this to figure up the average percentage of the transmitting or centgener power. This matter, however, is very difficult in many cases. In corn, for example, certain individuals may stool and form suckers that have fairly good-sized ears. If the corn is planted thin enough on the ground these suckers will tend to increase the yield, and render the proper judgment of the transmitting power very difficult. It would seem at first thought that such suckering, if it increased the yield, would be desirable, and should be considered a favorable character in connection with the individual. However, if the soil is heavy enough to have allowed this suckering to give increased yield, it would have been possible on the same soil to have placed the plants closer, and, as seed is of little comparative value, it would be best to have a non-suckering type, and plant the corn as closely as the soil would properly permit. Again, it is almost impossible to get perfect stands, and a change in the stand may affect the yield. Very many difficulties and problems enter into the figuring out of this transmitting power, and it is obviously impossible to give directions for all cases. The breeder must study conditions and determine carefully what policy to pursue in each case.

The use of hybridization in plant-breeding.

Ever since the time of Knight, hybridization has been used extensively by plant-breeders, and it seems that this is the only sure means of forcing variations. Whenever it is possible to secure distinct species and races that can be hybridized, it is possible greatly to increase the variation in different directions, and thereby afford opportunity for greater selection than would otherwise be possible. Plant-breeders have come to understand that when desirable characters are exhibited by different species or races it is possible frequently, if not usually, to unite these characters in a hybrid if the work is done intelligently and on a large scale. (The writer uses the term hybrid here in a general sense, referring to any product of a cross when the parents were noticeably distinct from each other, whether the parents belong to different races, clons, varieties or species. It may be stated that this general or broad use of the term hybrid has become almost universal in recent years.) When plants of different races are crossed, as, for example, different races of wheat, corn or cotton, the hybrid usually comes nearly intermediate between the two parents in the first generation. And this is the case also when different fixed species are crossed. If, however, individuals belonging to unfixed races are crossed, there is usually a considerable variation in the first generation. This is well illustrated by the crossing of different clons of apples, pears, oranges, and the like, when the different so-called varieties are simply transplanted parts of the same

Fig. 85. Planting individual grains of flax and other cereals so that the individual growths of the plant may be watched and selection made from the very best. This machine allows a man to know exactly at what depth each is planted, so that each grain has an equal chance with the others.

individual seedling which have not been bred to a fixity of type. It is well known that if seeds of an apple variety be planted, the resulting plants exhibit many different variations in the first generation. The parents themselves, therefore, not being of fixed type, when they are hybridized they produce progeny which in the first generation is variable. An illustration is afforded in the crosses made by the writer of the trifoliate orange with the ordinary sweet orange, in which the hybrids of the first generation vary in fruit, foliage and branching qualities, so that almost every individual differs markedly from every other individual of the same combination. In the crossing of races which have been bred true to type, whether of the same or of different species, the first-generation hybrids, however, are nearly uniform in the characters presented, and in such instances it is necessary to secure a second generation of the hybrids in order to accomplish the breaking up of the characters and the production of a large number of variations. Ordinarily, therefore, desirable variations are looked for in the second generation. This, as has been explained above, is true only in the case of hybrids of species and races that are fixed in type.

(I) *Mendel's law of hybrids.*

The preceding discussion represents fairly well the general understanding of hybrids until about 1900, when DeVries and Correns rediscovered what is now termed "Mendel's law of hybrids." While Mendel's laws or principles may not be of great value from an economic standpoint, they have proved of the greatest scientific interest, and the general fundamental principles of the law or laws should be thoroughly understood by every practical breeder of plants. It has been known for many years that a splitting up and redistribution of parental characters occurs in hybrids, and it is on this fact largely that the practical application of hybridization in plant-breeding depended. Ordinarily, careful plant-breeders would plan to hybridize varieties or races having a definite combination of characters in view, as, for example, the combining of the fruit quality of one parent with the hardiness or drought-resistance of the other. Until Mendel's law was discovered, however, we had no understanding of why or how such a combination could be made, and it was necessary to experiment extensively in order to determine what could be accomplished.

Mendel's law includes several important features which must be thoroughly understood before its important bearings can be comprehended. One requisite for the application of the law is that the two parents shall possess certain characters that are opposed to each other. These two opposing qualities or characters are termed a "character-pair." As illustrations of such character-pairs, may be cited bearded and bald heads in wheat, sweet and starchy kernels in corn, fuzzy and smooth seeds in cotton, and stringy and stringless pods in beans. When parents possessing these opposed or contrasted characters are crossed, the hybrid contains a combination of the potentialities representing both characters, and the first-generation hybrid will thus show an intermediate form of the particular character under consideration in case the two characters are of equal strength or potency. If, however, as sometimes occurs, one of the characters is very strong or dominant, only this character will show in the first-generation hybrids, the other character remaining recessive or masked, although present. For example, in crossing a race of wheat having bald heads with a race having bearded heads, all of the first-generation hybrids, or at least the majority of them, will have bald heads, this character being strong or dominant over the bearded character. In some instances where the potentialities of these two characters appear to be of nearly equal strength or potency, the beards seem to be produced in the first-generation hybrids but are reduced in length, being intermediate between the bald and the bearded state. A number of intermediate cases of this kind were shown to the writer by Dr. C. E. Saunders, of the Canadian Experimental Farms. Frequently, in crossing flowers of different colors, the resulting hybrids will show a blend of the two colors, being light pink, for example, when the parents crossed are a white and a red. In other cases, however, one color or the other becomes the dominant character, and the first-generation hybrids show the color of one parent only.

The second important principle of Mendel's law is what is termed the purity of the germ-cell. It seems certain from the researches that have been conducted that, when the germ-cells of the first-generation hybrids are formed, the potentialities which represent the two different characters under consideration, and which were united by the hybridization, ordinarily segregate again in the cell divisions, which lead to the formation of the germ-cells, so that certain germ-cells include the potentiality of one only of the two characters. We have thus two kinds of germ-cells formed with respect to this one character-pair. Taking as an illustration a hybrid of wheat having bald heads with one having bearded heads, when the germ-cells were formed a segregation of the two potentialities representing the two opposed characters would take place, and we would have germ-cells of one kind containing the bald-head potentiality and of a second kind containing the bearded-head potentiality. This segregation, it must be understood, takes place in the formation of both the egg-cells and the sperm-cells or pollen-grains.

We thus see that the first generation of the hybrid when two such characters are combined contains two kinds of egg-cells and two kinds of sperm-cells, so far as this one character-pair is concerned.

The third important principle of Mendel's law is what is termed the law of probability, and explains what may be expected in plants of the second generation of such a hybrid. Remembering that we have formed in the first-generation hybrid, as explained above, two kinds of egg-cells and two kinds of sperm-cells with reference to the opposed characters, what would happen if the hybrid were bred with its own pollen; or, in the case of an animal, if it were bred with another hybrid of the same parentage? For the purpose of illustration, suppose that a hybrid of a bald wheat with a bearded wheat be fertilized with its own pollen and that 100 egg-cells be fertilized with 100 pollen-grains of the same hybrid. There are two kinds of egg-cells produced, some with potentialities of the bald wheat and some with potentialities of the bearded wheat, and the same is true of the pollen-grains. Taking the egg-cells and pollen-grains without selection, therefore, we would expect to have of the egg-cells 50 with bald potentialities and 50 with bearded potentialities. In the pollen-grains also we would expect to have 50 with bald potentialities and 50 with bearded potentialities. If these are brought together, allowing the law of chance to govern the union, the probability is that we would have 25 bald uniting with 25 bald; 25 bald uniting with 25 bearded; 25 bearded uniting with 25 bald, and 25 bearded uniting with 25 bearded. Representing the bald potentialities by B and the bearded potentialities by b, we have the following formulæ, which explain the probable unions graphically (and this is what is known as Mendel's law):—

One Hundred Egg-cells by One Hundred Sperm-cells.

25B × 25B = 25BB	(These do not contain potentialities of b, and will reproduce true.)
25B × 25b = 25Bb	(These are bybrids so far as this character-pair is concerned,—exactly the same as in the first generation, and contain potentialities of both B and b. These will not reproduce true to type, and will break up like second-generation bybrids.)
25b × 25B = 25bB	
25b × 25b = 25bb	(These do not contain the potentialities of B, and will reproduce true.)

"This formula for the hybrids," writes Bailey, "is Mendel's law. In words, it may be expressed as follows: Differentiating characters in plants reappear in their purity and in mathematical regularity in the second and succeeding hybrid offspring of these plants; the mathematical law is that each character separates in each of these generations in one-fourth of the progeny and thereafter remains true."

The above illustration will explain the law of segregation, and probable ratio of recombination when hybrids are inbred with their own pollen, and when only one pair of characters is considered. When an egg-cell with bald potentialities unites with a sperm-cell with bald potentialities, this gives rise to a pure germ-cell containing only bald potentialities, and the progeny in subsequent generations will breed true so far as this character is concerned. Also when the egg-cell with bearded potentialities unites with a sperm-cell with bearded potentialities, the result is a pure germ-cell containing only bearded potentialities, and the progeny would reproduce true, so far as this character is concerned, in subsequent generations. In the other two cases where, in fecundation, germs with bald potentialities unite with germs with bearded potentialities, giving the combinations Bb and bB, which amount to the same thing, we have in reality hybrids exactly the same as in the first generation, and the progeny from these in the next generation behave exactly the same as did the first-generation hybrids in the second generation. In such a case as this, where one of the characters, as the bald head, is strong and dominant, all combinations that contain the potentialities of this character, whether pure or mixed, show this character only. Thus, in the above table the 25bb would come with bearded heads, while the 75 of other combinations would have bald heads. To determine which of these 75 heads are the combination Bb, that is bald with bearded, and which BB, that is bald with bald, would require the growing of progeny, to determine which were reproduced true to type. The ratio of the combinations, it will be noticed, is 1BB to 2Bb to 1bb. While in certain hybrids of parents possessing two opposed parental characters this ratio of probabilities is not produced, if large numbers are used the ratio will be found in many cases with little deviation. A sufficiently large number of cases have now been carried out with various plants and animals to place the conclusion beyond question. We do not know, however, how many characters follow Mendel's law, and are not yet entirely certain whether those character-pairs that sometimes follow the law of segregation always follow it.

The individuals of the second generation which contain the potentialities of both characters of the pair, if self-fertilized or bred with similar individuals containing the potentialities of both characters, exhibit in the third generation exactly the same nature that first-generation hybrids exhibit in the second generation. The two potentialities are commingled in their cells, and to all intents and purposes they are exactly the same as first-generation hybrids. When such self-fertilized hybrids are grown they give again, in the third generation, the regular Mendelian proportion of 1BB to 2Bb to 1bb. Here the individuals containing only potentialities of one character, that is, BB and bb, would come true to these characters in succeeding generations, while those individuals containing the potentialities of both characters, Bb, would be expected to appear again in the fourth generation in similar proportions.

When we deal with more than one character-pair the matter becomes complicated, but will become clearer on careful study. If we combine with the above characters the character of hairy (H) and smooth (s) chaff in the head, and remember that the potentialities of these two characters in the hybrids segregate exactly as in the case of bald and bearded heads, we can foretell what will occur. In this case, the hairy chaff is the strong dominant character, as in the first-generation hybrids of hairy with smooth sorts the chaff is always or very generally hairy. We would thus represent these characters by H, for the hairy or dominant character, and s for the smooth or recessive character. In this character-pair we would expect a splitting and segregation to have occurred in the formation of the germ-cells of the first-generation hybrids, so that the hybrid plants of the second generation would exhibit these characters in Mendelian proportions, as in the characters described above. The progeny in the second generation would thus exhibit these characters in the following combinations and proportions: 1HH to 2Hs to 1ss. This probable proportion should hold rather constantly, either in small or large numbers of hybrids, though in large numbers it would probably be more accurately realized. The potentialities of the four characters, or two character-pairs, are commingled in the cells of the first-generation hybrid. When the egg-cells or pollen-grains are formed, however, a segregation of the potentialities of the two character-pairs occurs, but independent of each other. Each egg-cell or pollen-grain will receive only the potentiality of one character of a certain character-pair, but will, at the same time, receive potentialities of other characters belonging to other character-pairs. Considering the two character-pairs described, an egg-cell receiving the potentiality of the bald head (B) might contain the potentiality of either H or s, representing the characters of hairy or smooth chaff. These two character-pairs would thus give us egg-cells of four combinations, namely, BH, Bs, bH and bs.

In the formation of the pollen-grains the same combination occurs, so that with reference to the two character-pairs described, the pollen-grains that would be formed have the same combination of potentialities as the egg-cells, namely, BH, Bs, bH and bs. We thus have four kinds of egg-cells and four kinds of pollen-grains, so far as these two character-pairs are concerned. If these are brought together, sixteen combinations are possible as follows:

BHBH	BsBH	bHBH	bsBH
BHBs	BsBs	bHBs	bsBs
BHbH	BsbH	bHbH	bsbH
BHbs	Bsbs	bHbs	bsbs

Examining these combinations carefully, and cutting out the letters that occur twice, as the occurrence of the same potentiality in both egg-cell and and pollen-grain serves only to reproduce the same character, we have the following nine combinations, all of which are different: 1BH, 1Bs, 1bH, 1bs, 2BHs, 2BbH, 2Bbs, 2bHs and 4BbHs. In the illustration taken of the character-pair of bald and bearded heads, and the probable ratio of unions in second-generation hybrids, it was shown that out of 100 unions we should expect, by the law of chance, the ratio 25B to 50Bb to 25b. Now, considering the second character-pair, that is, the hairy and the smooth chaff, in connection with these same 100 unions, we would have the following as the probable combinations, according to the same law of chance:

25 B	50 Bb	25 b
25 B { 6¼ BH 12½ BHs 6¼ Bs	50 Bb { 12½ BbH 25 BbHs 12½ Bbs	25 b { 6¼ bH 12½ bHs 6¼ bs

These nine combinations are the same as the nine given above, only multiplied by 6¼ in each case. In each of the nine combinations when only one of the potentialities of the character is present, the progeny from such an individual from self-fertilized seed will come true to this character in all succeeding generations, as the potentiality of the opposed character has been eliminated. Thus, in the first combination, BH, representing the potentialities of the bald head and hairy chaff, if such a hybrid is fertilized with its own pollen, it will produce only progeny with bald head and hairy chaff. In the second combination, BHs, we have present the potentialities of the bald head of one character-pair and both the hairy and smooth chaff of the other character-pair. Self-fertilized progeny of this hybrid should all come bald, but some should have hairy chaff and some smooth chaff. In the third combination, Bs, we have simply the potentialities of the bald head and smooth chaff, and such a combination should give plants that will come true to type in later generations when self-fertilized. Similar conditions of purity or hybridity of the germ-cells can be figured out for each of the other six combinations.

If a third character were considered, the proportions of the combinations can be determined in exactly the same way. Each one of the above nine possible combinations would be again divided into three different unions in the same way as the three combinations of the one character-pair gave nine different combinations in the second character-pair. In the consideration of the three character-pairs there would thus be 27 different combinations of parental characters. And again in each ovary fecundated, when only one potentiality of each character-pair occurred, the opposing character potentiality being in each case eliminated, such a cell should give a plant that would reproduce its characters true to type. It is well known that almost any two different races or species that may be chosen for hybridization will ordinarily differ from each other in numerous characters. When there are a number of these opposing characters which form Mendelian character-pairs, the determination of the possible combinations by Mendel's formulæ becomes very complex and difficult to understand. It is only by taking a few well-marked character-pairs and carefully studying them that the segregation and new combinations according to Mendelian proportions can be followed and understood. Any character-pairs, following Mendel's law, would segregate as indicated above in the case of bald or bearded heads and smooth and hairy chaff of wheat. These characters with wheat have been investigated by Spillman, Hurst and others, and are known to follow very closely Mendelian proportions in their segregation. The same segregation takes place in the case of the bald and bearded barleys, smooth and fuzzy cottons, sweet and starchy kernels in corn, and many other opposed characters in plants.

It is by no means probable that all characters follow Mendel's law of segregation and recombination, and secondary characters in practical work need be given no attention. The knowledge of Mendel's principles may not change greatly the practical methods of breeding which have been followed for a number of years, but they give us a more thorough comprehension of what we are doing, and also greater surety that certain combinations of parental characters can be secured.

(2) *The use and fixation of intermediate or blended types.*

The principle of the purity of the germ-cell, if strictly applied, would not recognize as possible the fixation into a race reproducing true to type of an intermediate hybrid, that is, one in which two characters of a certain pair are blended. Yet practical work shows that such a fixation certainly can be secured. In very many hybrids of plants cultivated for their flowers, intermediate colors have been bred to stability, showing that the inheritance is blended. The writer has been attempting to fix a hybrid of Black Mexican sweet corn having blue-black kernels, with Stowell's Evergreen, which has a nearly white kernel, into a race of light blue-violet color, and strictly intermediate in this respect between the two parental varieties. Ordinarily, the color of these hybrids breaks up in Mendelian proportions, but neither color can be considered to be dominant in the true sense of the word. In practically all cases when the potentialities of the two characters are mixed in the same egg-cell, the coloration is intermediate rather than like one or the other of the parent varieties. The writer has uniformly selected the seed of such intermediate light blue-violet kernels for planting, and has kept the patch completely isolated. After four years of such selection, a type that produces nearly uniformly light blue colored kernels has been produced. There are still many reversions to the coloration of either parent, but these are growing fewer and the type is becoming fixed into a stable race, reproducing itself true to seed. Halsted, of the New Jersey Experiment Station, has produced such an intermediate colored race by the hybridization of Black Mexican with the Egyptian, and has already secured a new race which is practically fixed in its intermediate color. The writer thinks that in this and in a great many other cases it is possible by careful selection of plants showing the intermediate type to breed new races that exhibit a blend of characters, and such blends are frequently of great value.

The work that has been carried out by the writer in the Department of Agriculture in the breeding of citrous fruits very clearly indicates that valuable intermediates may sometimes be secured. The writer, in conjunction with Mr. Walter T. Swingle, hybridized the hardy, cold-resistant trifoliate orange (*Citrus trifoliata*) with several varieties of the tender sweet orange, and as a result at least five different varieties of hardy oranges or citranges have been produced (Fig. 86). These hybrids are nearly intermediate between the two parents, having the characters in the first generation nearly blended. The leaves are trifolioliate, but are much larger than the leaves of the ordinary trifoliate orange tree, and show a tendency to drop off, the lateral leaflets producing an unifolioliate leaf. The trifoliate orange is deciduous, while the sweet orange is evergreen. The hybrids are semi-deciduous, holding a large share of their leaves through the winter. In hardiness they also seem to be intermediate, being much more cold-resistant than the ordinary orange, but not so hardy as the trifoliate orange. They are sufficiently hardy so that they doubtless may be grown with safety as far north as South Carolina, or 300 to 400 miles north of the present orange region. Some of the fruits produced are as large as the ordinary orange, but the majority are very nearly intermediate in size. They are very variable, however, in the first generation. At least five of the fruits that have been produced are juicy and valuable. It is not probable that they would be reproduced true to seed, but orange varieties are clons, and the different types will, of course, be normally reproduced by buds or grafts, so that from a practical standpoint it does not matter whether or not they would reproduce true through the seed. In the second generation it is probable that these different characters would split up, possibly according to Mendel's law, and it is likely that still more valuable varieties will be secured when a second generation has been grown.

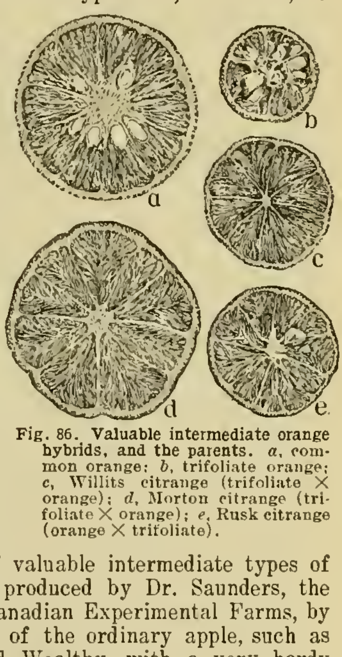


Fig. 86. Valuable intermediate orange hybrids, and the parents. *a*, common orange; *b*, trifoliate orange; *c*, Willits citrange (trifoliate × orange); *d*, Morton citrange (trifoliate × orange); *e*, Rusk citrange (orange × trifoliate).

Similar groups of valuable intermediate types of fruits have been produced by Dr. Saunders, the Director of the Canadian Experimental Farms, by crossing varieties of the ordinary apple, such as the Pewaukee and Wealthy, with a very hardy cold-resistant crab (*Pyrus baccata*). Dr. Saunders has produced already numerous hardy intermediate types which bid fair to be of very great economic value.

(3) *The combination of different parental characters not blended.*

The greatest value of hybridization in the production of new varieties lies probably in the possibility of combining in the new race certain valuable characters of different races or species. This principle breeders have long recognized, but it cannot be too clearly borne in mind. The work which the writer has carried out in the Department of Agriculture, in the production of long-staple varieties of upland cotton, forms an interesting illustration in point. Ordinary upland cotton, which is grown all over the interior cotton regions of the South, produces a short fiber averaging about one inch in length. In the eastern part of South Carolina, southern Georgia and northern Florida, sea island cotton is grown. This cotton

Fig. 87. Selection. Results of rogueing in a verbena seed-field.

has a fiber $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in length. Ordinary upland cotton has an average value of eight or nine cents per pound, while this longer staple sea island cotton is ordinarily worth twenty to thirty cents per pound. Other things being equal, a longer-fibered cotton is always more valuable than a short staple, and were it possible to secure the same yield it would be far better to grow long-staple cotton altogether. The sea island or long-staple cotton, however, has a small three-locked boll which opens very poorly, and is difficult to pick, and yields much less than does upland cotton. Upland cotton, on the contrary, produces large rounded bolls, which open wide and are easy to pick, and yields much more heavily than the other. Sea island cotton has a smooth black seed, so that roller gins can be used in separating the seed and fiber, and this is an important consideration with long-staple cotton, as the saw-gin tears and breaks the fiber. With the short-staple or upland cottons the seed is covered with a short close fuzz, and they are uniformly ginned on saw-gins. The tearing of the fiber which necessarily results to a considerable extent, does not matter greatly with a fiber of this short length. If longer stapled varieties are desired they should have smooth, black seed, so that a roller gin can be used. The writer undertook experiments in the hybridization of these two kinds of cotton, in the hope of producing a new race, which would inherit, on the one hand, the large bolls, tendency to yield heavily, and adaptability to upland regions, of the short-staple or upland cotton, and, on the other hand, the long, fine and strong lint and black seed of the sea island cotton. The first-generation hybrids were found to be nearly uniform and showed little breaking up of characters of the two parents. In the second generation, however, all manners of types were formed, exhibiting the characters of the two parents in very different degrees. Out of several thousand second-generation hybrids several individuals were selected which showed almost exactly the combination of characters which it was desired to produce. These hybrids were self-fertilized the next year, and each one was planted in an isolated patch in order that it would be fertilized only with pollen of related progeny. In each generation since, only those plants have been selected for seed which come the nearest to the original type, and now, after five generations of selection, two or three of the types have been bred to a practical state of fixity, showing the possibility of combining in a hybrid valuable characters from distinct parents.

(4) *Fixation of hybrids.*

When different types have been crossed and hybrids secured which possess the characters desired, it is necessary that careful methods of selection and breeding be followed in order to secure finally a type that will transmit its qualities. The great majority of such hybrids when first produced will not reproduce true to type. The policy followed by the writer in the cotton experiment above referred to, will usually serve as a good guide in the fixation of any hybrid. If self-fertile, the hybrids should be fertilized with their own pollen in order not to introduce any new hereditary tendencies unless it is found that such fertilization too greatly reduces the vigor. In cotton, self-fertilization has been found not to decrease the vigor of the plants, and the same is true of wheat, tobacco, oats, and plants that are normally self-fertilized to some extent. In the case of corn, as it has been found that the inbreeding of a plant with its own pollen results in a great deterioration in vigor, it is the best policy to cross the desired hybrid with another hybrid having the same characters. The seed of such select hybrid plants should then be planted in isolated places, so that the plants will not be crossed with the pollen of either parent or other varieties. When the progeny of these select hybrids reach a point where their characters become visible it may be desirable to weed out the undesirable plants that are off type, in order that the plants which most nearly resemble the type desired will be fertilized with pollen from similar plants. In the writer's cotton experiments, the seed of each individual selected plant of the second generation was planted in a small isolated plot of about one acre. As soon as the plants began to show their characters and it could be recognized that certain ones had inherited the desired qualities, the fields were carefully searched and all plants not true to type were pulled up, leaving only a few good plants of the right type. (Fig. 88.) This insured that all of the later bolls formed would be fertilized with pollen from similar plants of good type. Each subsequent generation, the select plants should be grown in isolated plots and seed selected only from those plants which have reproduced the ideal type for which the breeder is working.

The time required to secure fixed types is variable, but in wheat and cotton, when careful experiments have been carried out and recorded, the indications are that four to six generations are ordinarily required to reach a fixed stage. This does not mean, of course, that all variation is prevented, but that the hybrids have been bred to the same type as nearly as is the case in any ordinary race or variety.

Selection of vegetative parts.

No consideration of the methods of plant-breeding would be complete without a mention of the improvements which can be produced by what may be termed the selection of vegetative parts. While, in general, all buds of a plant are practically the same, as is shown by the fact that buds taken from the Baldwin apple almost uniformly produce Baldwin apples, yet there is considerable variation frequently in the product from different buds, and

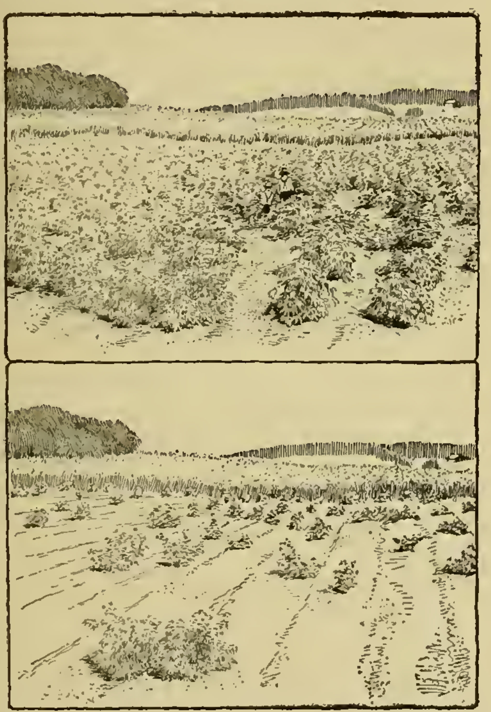


Fig. 88. The rogueing, or removing of undesirable plants. These are cotton-fields. The upper picture shows men at work pulling out the plants that are not wanted; the lower picture shows a field after rogueing has been completed.

it is well known that we have a class of variations which we have come to call bud-sports or bud-variations. In violets, for example, the propagation is normally by slips that are developed from different buds. These slips when grown into plants frequently show considerable difference, and Dr. B. T. Galloway and Mr. P. H. Dorsett, of the Department of Agriculture, have demonstrated that, by the selection of slips from plants which are very productive, the yield in the number of flowers to the plant can be increased considerably. In the case of the orange, seedling trees are almost always very thorny, yet certain branches may show a tendency to be more nearly thornless, and by the selection of buds from such branches the thorny character of almost all the standard varieties has been reduced. By the systematic selection of vegetative parts, such as buds, slips, suckers, and the like, in many cases very important improvements could doubtless be secured, and the plant-breeder should have a thorough understanding of this method of improvement. In hybrids of mixed parentage frequently a bud on one side of a plant will sport, showing different tendencies, and many of our new varieties of roses, chrysanthemums and carnations have been produced by the selection of such bud-sports. Many standard varieties of carnations have produced bud-variations that have proved valuable; the Lawson has given rise to the Red Lawson and White Lawson. The Enchantress has produced the Pink Enchantress and White Enchantress. The practice of exercising care in choice of chrysanthemum or carnation cuttings and of cions for fruit trees is therefore seen to rest on rational reasons.

The variations in the character of the seed from different bolls in the case of hybrid cottons, referred to on page 58, are bud-variations of this sort which, as pointed out there, may be of value to the breeder even in cotton which is propagated by seed. In the study of cotton, the writer has found similar bud-variations showing in the lint characters of hybrids. In quite a number of instances, certain bolls have been found which produced much longer lint than other bolls on the same plant, and similar variations in strength and uniformity of length have been observed. Experiments indicate that such variations, which are doubtless to be classed as bud-variations, are transmitted in considerable degree. This being the case even in seed-propagated plants, it becomes desirable to observe and search for bud-variations.

Literature.

The principal general works are: Bailey, Plant-Breeding, 4th edition, 1906, The Macmillan Co., New York; Fruwirth, Die Zuchtung der Landwirtschafllichen Kulturpflanzen, Berlin, 1904-06. The following are a few of the most important general papers: Production et fixation des variétés dans les végétaux, E. A. Carriere, Paris, 1865; Die Pflanzenmischlinge, W. O. Focke, Berlin, 1881; A Selection from the Physiological and Horticultural Papers of Thomas Andrew Knight, published in the Transactions of the Royal and Horticultural Societies, London, 1841; Hybrids and Their Utilization in Plant-Breeding, W. T. Swingle and H. J. Webber, Yearbook, United States Department of Agriculture, 1897; Sur la production et la fixation des variétés dans les plantes d'ornement, Jean Baptiste Verlot, Paris, 1865; The Improvement of Plants by Selection, H. J. Webber, Yearbook, United States Department of Agriculture, 1898; Hybrid Conference Report, Journal Royal Horticultural Society, Vol. XXIV, April, 1900; Survival of the Unlike, Bailey; Proceedings, International Conference on Plant-Breeding and Hybridization, New York Horticultural Soc. Memoirs, Vol. I, 1902; Proceedings of American Breeders' Association, Vols. I and II, Washington, D. C., 1905 and 1906; Breeding Animals and Plants, W. M. Hays, St. Anthony Park, Minnesota. Bailey's Plant-Breeding contains a very extended list of papers and books.

CHAPTER IV

PLANT INTRODUCTION

By DAVID FAIRCHILD

THERE IS NEED OF A MORE EXTENDED CROP FLORA. We are prone to look on the agriculture of this country as in a finished state, when, in fact, even the pioneer work has barely been done. The farmers have spread marvelously over the land. They have tried corn and wheat in nearly every great area where water is to be found; they have planted potatoes from one corner of the country to the other, and have set out apple and pear trees wherever they have gone; they have found out the value of such a forage plant as alfalfa, which was a great crop in South America before the farmers of this country heard of its existence. They have done the best that could be done with the materials at their disposal; but, when the land was too moist to grow potatoes, they left it alone; regions in which corn and wheat failed because of the drought, they have given a wide berth; and they have allowed good farming land in New England to grow up in weeds because it was in too small areas to grow wheat or corn in competition with the great fields of the West. Rich alluvial fields in the Carolinas, which have easy water connection with New York, they have abandoned for a similar reason. One thing that farmers need is new crops,—grains that will grow on dry land where wheat fails, higher-priced crops for the abandoned New England farms, new and valuable plants for rice lands.

Early efforts at plant introduction.

Farmers are searching for these new plants and are willing to spend millions of dollars in testing them, but until recently there has been no organization to aid them in getting the necessary plants with which to experiment.

Their needs have long attracted the attention of the government, and when, in 1838, Congress made its first appropriation in aid of agriculture, this appropriation was in the form of a grant of one township of land in southern Florida to Doctor Henry Perrine, former American Consul in Campeche, for the purpose of encouraging the introduction and the cultivation of tropical plants in the United States. In 1838, Mr. Ellsworth, Commissioner of Patents, made the following appeal to Congress:

"Our citizens who are led by business or pleasure into foreign countries, and especially the officers of our navy and others in public employment abroad, would feel a pride in making collections of valuable plants and seeds if they could be sure of seeing the fruits of their labors accrue to the benefit of the nation at large. But, hitherto, they have had no means of distributing, to any extent, the valuable productions of other climates which patriotism or curiosity has led them to introduce into our country. To a great extent, they have perished on their hands for want of some means of imparting to the public the benefit they had designed to confer. Those who have not considered the subject in its wide details are very imperfectly qualified to judge of its importance."

In 1839, Mr. Ellsworth believed still more strongly in the work of plant introduction, for he remarks:

"The diplomatic corps of the United States residing abroad have been solicited to aid in procuring valuable seeds, and the officers of the navy, with the appropriation of the honorable Secretary of that department, have been requested to convey to the Patent Office, for distribution, such seeds as may be offered. In many cases no charges will be made for seeds. If small expenses do arise they can be reimbursed by appropriations from the patent fund, daily accumulating, and consecrated especially to the promotion of the arts and sciences.

"The cheerfulness with which the diplomatic corps and the officers of the navy have received the request of this office justify sanguine anticipations from this new undertaking."

In 1840, the work of plant introduction, coupled with that of gathering statistics on agriculture, called for the first stated expenditure by the Commissioner of Patents for agriculture. The amount was only \$451.58, but it was the beginning of an expenditure by the government that has increased in sixty-five years to over \$6,000,000.

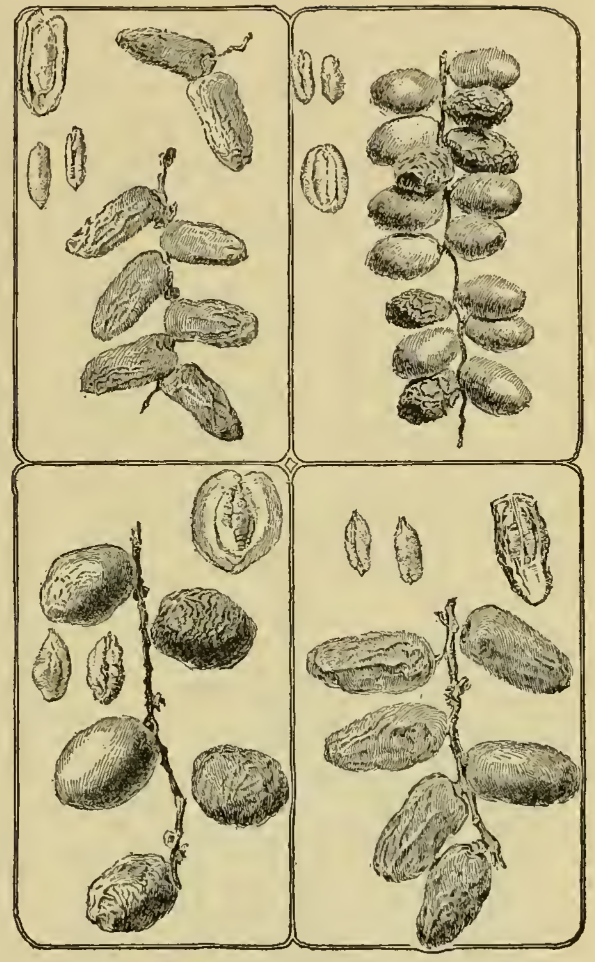


Fig. 89. Four types of Tunisian dates, showing the variation in this fruit.

The first government work in agriculture was to introduce new plants, but of this early work, no doubt much of it important to the country, only traces or legends remain. Few records of the various introductions are to be found, and hardly a trace of where they were planted. Mr. Ellsworth's idea was good, but the experience of the past seven years has shown where the weakness lay. The seeds and plants collected by those in the diplomatic service were not gathered by trained men who knew the agricultural needs of the country, but were, in the great majority of cases, gathered by men who saw in a new plant some useful quality, without having the training necessary to find out whether it was capable of being adapted to our quite different conditions of labor, or to know in what part of the country it should be tried. An immense amount of valuable introduction work was done later by Mr. Saunders, who, for many years, had charge of the gardens and grounds of the Department of Agriculture, but no connected record of it exists. In 1870, the government made a notable introduction of cions of Russian apples.

The work of persons not connected with government departments should not be forgotten. Nurserymen and seedsmen have long been in the habit of introducing interesting plants from many countries. Many times they have introduced plants in advance of the popular necessity for them, and the introductions have disappeared, to be introduced again later. Many citizens, from Washington down, have been influential in introducing plants. In later years the work of the late Professor Budd, of Iowa, and the late Charles Gibb, of Quebec, in introducing Russian fruits should not be overlooked, for they were pioneers in the modern movement.

The organization of plant-introduction work and some of its problems.

It was not until 1897 that this great work of finding, getting, importing, and sending out new plants was put on a scientific basis and the Section of Seed and Plant Introduction made an integral part of the Department of Agriculture. The organization of the Office as it now stands owes its smoothly working machinery to the painstaking efforts of Mr. Adrian J. Pieters, who has put into the work years of study and thought, and who, together with the writer, has general charge today. This Office has almost constantly had agricultural explorers and collectors in the field, and has worked out a system that takes care of every plant sent in and of every seed distributed, and it is on a basis of accurate coöperation with the experiment stations and farmers all over the country. Every one of the more than 19,000 specimens that have been sent in by agricultural explorers, by friends of the work or by correspondents, or that have been purchased abroad, has been put on permanent record and then sent out to some one who was especially interested in it; and, as far as possible, each introduction has been followed up and the result recorded. Over 120,000 cards record the distributions, and thousands of reports now on file form a most valuable historical record of the systematic plant introductions of the past eight years. The aim of the work has been preeminently a practical one, and the introductions have been made to meet some demand either of an experiment station or of a plant-breeder, or to carry out the idea of some one of the explorers who saw in a foreign plant industry the possibility of its utilization in this country. The work of early years failed in doing the great good that it was capable of because it was not systematic, because no adequate records were kept, and because the public were not alive to its great possibilities. Today the interest in new plants is so much greater than it was twenty years ago that large numbers of the really suggestive applications from private experimenters cannot be met by the Office for lack of funds.

A very brief sketch of some of the interesting problems that are on the program of the Office will illustrate the opening vista of plant introduction as a government enterprise. The largest collection of date varieties ever made is now growing in gardens in Arizona and California (Figs. 89, 90). The largest collection of tropical mangoes in the world is in greenhouses or already in the hands of experimenters in Florida, Porto Rico and Hawaii. Thousands of the Japanese matting rush plants, from which the valuable Japanese matting is made, of which this country imports several million dollars' worth every year, are being grown in South Carolina. A new and valuable salad plant from Japan, the udo (Fig. 13), is being grown from Maine to Florida. The superior varieties of French bur artichoke have been introduced for trial in the trucking region of the South. The berseem, the greatest of annual winter forage crops from the Nile valley, is now being grown experimentally in the new irrigated regions of the Southwest (Fig. 91). Kafir corns from the uplands of Abyssinia, the east coast of Africa and India are being tested in Kansas and other places in the West. New varieties of alfalfa, the one from Turkestan, the other from Arabia, are both attracting the attention of alfalfa-growers in those sections where alfalfa is the great forage crop. In Alaska a newly found variety of oat, from northern Finland, is proving superior to all others. Before these lines are printed the sisal industry of Yucatan will have been given a start in Porto Rico through the assistance of the organization that the Office of Plant Introduction has built up. At the request of the State Experiment Station of North Carolina, peanuts have been gathered from all over the world for the use of breeding experimenters in the South. Pentzia, an interesting fodder plant of the "karroo," has been sent to one of the barren islands of the Hawaiian group for trial. The Hanna, a pedigreed barley

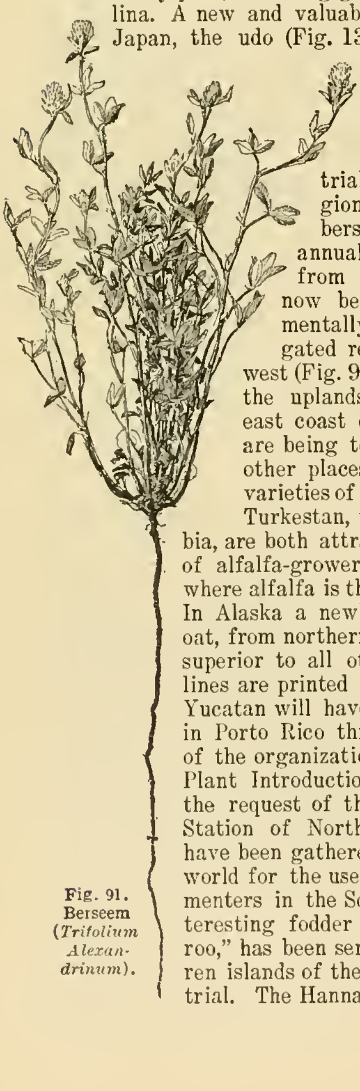


Fig. 91. Berseem (*Trifolium Alexandrinum*).

Fig. 90. Egyptian date palm in fruit at Indio, California. Imported by Department of Agriculture in 1889.

variety from Moravia, is now being given a practical test by the brewers in St. Louis and California, and its uniform character and good yields on the Pacific coast have aleady led to its cultivation on a large scale. A new root crop from Porto Rico, the yautia (Figs. 114, 115, page 105, Vol. I), prominently brought forward by Mr. Barrett, now of this Office, is to be practically tried in northern Florida and the Carolinas, in both of which places it has proved its ability to grow. The plant from which Japan makes her papers of unexcelled quality is growing in the plant-introduction garden in California (Fig. 92). The wood-oil tree of the Yang-tse valley has been imported from Han Kow, and there are on hand in California hundreds of plants with which to make the first trials of this interesting oil-producing plant, the product of which is imported into America in increasing quantities every year to be used for varnish and imitation rubber manufacturing purposes. The hardy bamboos of the Orient have been imported, and, as far as the funds of the Office have allowed, these have been placed at several places in the South where the old "canebrakes," which are growths of a commercially worthless species of bamboo, indicate that the valuable kind from Japan may be expected to grow successfully. Answering an appeal from the rice-planters of the Carolinas, whose plantations have been devastated by a very serious disease, rices of the type of the famous Carolina Golden have been imported from the Orient, Africa, the West Indies and Italy, with the hope of finding one that will resist the disease. This hope has not yet been fulfilled, although there is one variety at least that has some promise of being useful in the rice-fields of the region. An early introduction of one of the agricultural explorers was the fenugreek, a plant the seeds of which, when ground, form the body of most of the condition powders so much used by raisers of fat-stock show animals; and although the manufacturers of these condition powders still import their seed from abroad, the Californians

Fig. 92. The Mitsumata paper plant of Japan. A plantation in the hills. (*Edgeworthia Gardneri.*)

have learned that fenugreek is one of their best cover-crops, as it stands up especially well and can be plowed under easily.

One of the most far-reaching in its possibilities of all the introductions of the Office is the drought-resistant durum wheats, which yield crops where all ordinary wheats fail for lack of water. Largely through Mr. M. A. Carleton's effort, this grain, unknown on American grain markets seven years ago, is now grown in such quantities that in 1905 the United States exported 6,000,000 bushels of it. Another introduction was the Japanese Kiushu rice, which was in part responsible for the great development of the Texas and Louisiana rice-fields and which is now planted on one-half the rice area of these states.

These problems, chosen from among the many engaging the attention of the Department specialists, should give an idea of the way in which this branch of the government is affecting the agriculture of the country.

Other interesting or important food plants that the Office is introducing or disseminating are shown in Figs. 93 to 99. These are products of well-known species and need not be further described here.

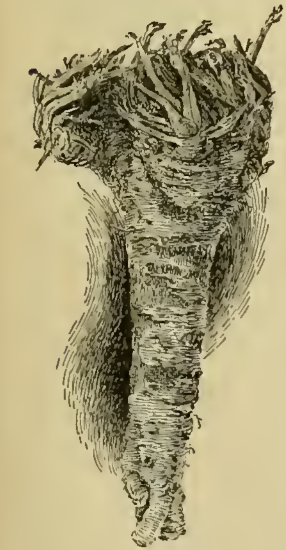


Fig. 93. The Bohemian horse-radish or Maliner kren. Root grown at Edgewater Park, N. J., from introduced root-cuttings from Malin, Bohemia.

A feature of the introductions that deserves especially to be mentioned, since it is growing rapidly in importance, is the getting of material for those engaged in breeding new races of plants. In order to break up a species it is often necessary to cross it with some nearly related species, and such near relatives are often wild plants or forms that are not to be found in this country. It is one of the pleasant parts of the work to secure a plant from the ends of the earth that some breeder may incorporate it into a new hybrid of value. The citrange of Messrs. Swingle and Webber would not have been made had not an ornamental, the *Citrus trifoliata*, been introduced from Japan; the interesting tobacco crosses that Mr. Shamel has made owe their origin in part to the fact that he had Sumatra seed to work with; the interesting series of hybrid cottons that Dr. Webber has been working with are the results of cross-pollinations between the American and Egyptian cottons. To help Mr. Swingle in his work on the pistachio-nut, which may prove a new nut industry for California, the Office is searching for a Chinese species that will resist cold, a species native in Afghanistan that will resist alkali, the mastick and terebinth of southern Europe, and a native Texan species that Mr. Swingle thinks will be valuable for use as stocks. The problem of the introduction of the tropical mangosteen of the Dutch East Indies is being worked out by Mr. Oliver, the expert propagator of the Department, chiefly through the use of as many of the nearly related species of the genus Garcinia as can be brought together. There are over sixty species in this tropical genus, and, as fifteen of these bear edible fruits, it would be

Fig. 94. English Broad bean (*Vicia Faba*) as grown in America. Pods ready for the table.

strange if at least one should not be available as a stock or of worth for breeding purposes. The successful introduction of this, the most valuable of East Indian fruits, probably hangs on the utilizing of some of these other and more vigorous species of Garcinia.

Most fortunately for the Office, the possibilities of plant-introduction work appealed at the outset most strongly to the practical mind of a past master in the art of travel, who for over forty years has wandered almost constantly over the world,—Mr. Barbour Lathrop, of Chicago. Seeing such widely different crops in the many lands that he visited, his unusual foresight saw in the work of plant introduction a great wealth-creating power, and, convinced of the good he could do for his country by aiding its progress, he spent the greater part of his time and energy during the years of 1896, 1898-99, 1901-02, and 1903 in making, at his own expense, a tour of reconnaissance of the world in the interest of the Office of Plant Introduction. He took the writer with him as his agricultural explorer, and established correspondents in most of the principal points of plant interest in the world. This list of correspondents is one of the great assets of the Office, enabling it to secure quickly from any region the seeds or plants desired for hosts of experiments which the Office is pressed by private experimenters to take up. In the course of these six years of travel a mass of material was imported from all parts of the world, aggregating at least 1,200 different selected things that seemed worthy of trial in America. Many of these are now forming subjects of study and experiment in different parts of the country and have been alluded to under the successes achieved or the problems now being worked out by the Department specialists.

Fig. 95. The Hungarian paprika as grown by Dr. R. H. True in South Carolina. Until this was taken up by the Bureau of Plant Industry all the paprika used in America was imported from Austro-Hungary and other European countries.

The profession of agricultural exploration has been originated and developed by the Office of Plant Introduction. The first explorer, Mr. N. E. Hansen, made an extended trip through Russia and the steppes of Siberia in search of hardy fruits and drought-resistant forage plants, the result being the introduction of the Turkestan alfalfa plants. Mr. W. T. Swingle, on two separate trips, explored the oases of the Sahara for the best sorts of date palms, and unearthed a host of new and interesting forage and fruit plants in Algeria, with many of which various experimenters are now at work; he studied and perfected the best method of sending over the caprifying insect that has since made Smyra fig culture a success in California, and started investigations of the pistachio industry in Sicily and Asia Minor, besides calling the attention of olive-growers to the dry-land olive culture of Tunis. Mr. C. S. Scofield spent a summer in Algeria collecting the seeds of a lot of promising leguminous plants that are now attracting interest as new fodder plants in California. At the same time he secured the best of the Kabili fig varieties that are now growing in the same state. The two Russian expeditions of Mr. M. A. Carleton were made in search of cereals that would resist the rust and the extreme droughts of the great western plains, and the tons of seed wheat that were distributed as the result of his trips have led to the establishment of the durum wheat industry in the Dakotas, Nebraska and Kansas, and that is now attracting the attention of the Californians as a possible solution of their serious wheat problem. Mr. E. A. Bessey made a journey through the Caucasus after hardy grapes and cherries, and went into Turkestan for sand-binding plants and alfalfas. Dr. S. A. Knapp was sent twice to the Orient to study the rice varieties of those great rice-growing countries, and introduced among other things the Kiushu rice that has been referred to. Mr. T. H. Kearney has made two explorations of the north coast of Africa, the first to select strains of the best Egyptian cotton (Figs. 100, 101), the second to make a collection of the many important dates that grow in the oases of southern Tunis. He has given the first account by a trained agriculturist of the date-palm industry written on the ground at the time of ripening of the fruit. Mr. O. W. Barrett, during the time he was stationed at Porto Rico, was sent to other of the West Indian islands, and he has introduced a number of valuable plants into the tropical territory there, notably varieties of the cacao and the yautia, the root crop already mentioned, the arracacha of Venezuela and others. The discovery by Mr. P. H. Rolfs that the vanilla can be fruited in Florida led to his recent trip to Mexico to study the vanilla industry of eastern Mexico,

Fig. 96. The prickly pear or Tuna (*Opuntia Ficus-Indica*), as sold on the streets and in the fancy fruit stores of this country.

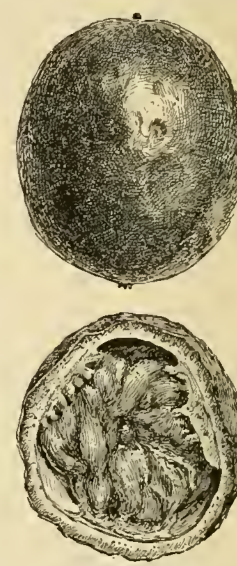


Fig. 97. The passion fruit (*Passiflora edulis*), one of the commonest products in the Natal market and which in Australia and New Zealand is a popular table fruit.

and resulted in the importation of a number of varieties of this valuable plant to serve as experimental material for his researches. Mr. Rolfs also

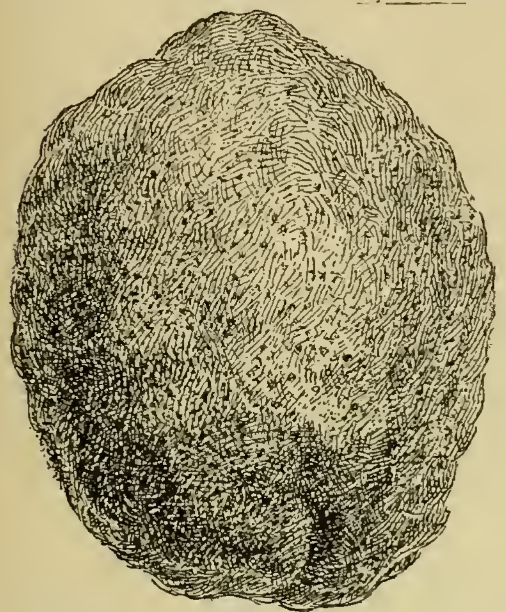


Fig. 98. The true Corsican citron. An American-grown fruit from the only paying plantation of this fruit yet established in America, that of Dr. Westlake, of Los Angeles. The cions were secured for the Division of Pomology by David Fairchild, his first piece of plant-introduction work.

made a trip to Jamaica to study the cassava industry, and there made a collection of cassava varieties which is now established in Florida.

A short investigation of the Alpine trial gardens of Austria was made last summer by Mr. Edgar Brown, who also secured for trial the Ladino clover of the irrigated valley of the Po. At the present time Mr. Frank N. Meyer, agricultural explorer of the Office, is in northern China, and from this region he is sending, week by week, cions and seeds of hardy fruits, vegetables, nuts, grains and ornamental plants that may be expected to have an important bearing on the agricultural industries of the Atlantic and middle western states.

The government responsibility in plant introduction.

It will be evident from what has been said that the aims of this Office are not at all identical with those of such a wonderful botanic garden as that of Kew, Berlin, or New York. It does not maintain a collection of living plants, whether of practical value or not, but its funds are spent in importing for the use of experimenters throughout the country material with which they can work. Scarcely a day passes without some request being received for seed which is not carried by any seedsman in the country. A potato-breeder in Vermont wants the new *Solanum Commersonii* from the wet lands in Uruguay to hybridize with the ordinary potato; a settler in southern Texas wants to try bamboos on the Rio Grande; the representative of a land-development company on the Sacramento wants to plant the Egyptian horse-bean for a green-manure crop; the Experiment Station of Hawaii wants wine-grape varieties introduced into the islands; and the director of the Alaska Experiment Station asks for North Swedish grains and vegetables for the Klondyke.

The government enterprise of plant introduction should not interfere with the private seed trade, but, on the contrary, benefit it, for its object is to create a demand which the seedsmen will supply. Seedsmen have kept on their catalogues for years certain species for which the demand is so small that it does not pay to handle them, and yet some of them are worthy of wide cultivation in this country. Government plant introduction brings these to public attention. Had the work of introducing new fa.m and garden plants been a profitable one, there would certainly be in this and other countries commercial firms with their collectors in all parts of the globe, as there are rug- and tea-importers; yet it is safe to say that there is no private concern in America that would undertake to get at moderate expense the Manchurian millet through fields of which the Japanese soldiers marched in the recent Russo-Japanese war, nor would it have thought it profitable to supply the Canadian wheat experimenter with the early-ripening wheat from the Ladoga sea from which one of the best wheats for the Northwest has been originated.

Experimental work is expensive, and it is only when the first stages in the experiment have been

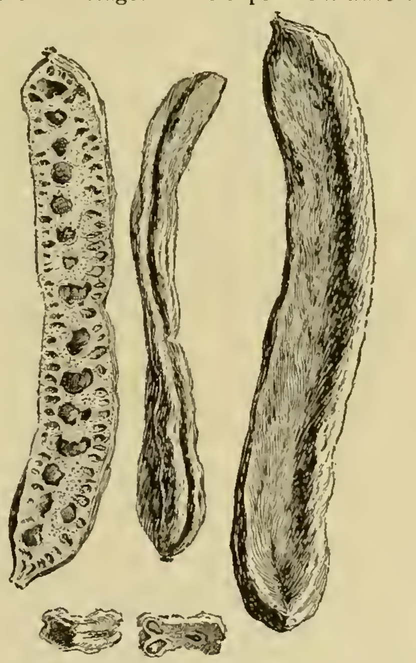


Fig. 99. The Carob bean, or St. John's Bread, of the Mediterranean. Pod of a fodder-producing tree. (*Ceratonia Siliqua.*)

passed—when a demand has grown up for the seeds—that there is money in keeping in stock a supply for this demand. Understanding this point fully, the work of the Office of Plant Introduction is planned to cease as soon as experiments have shown the money-making value of a crop—as soon, in other words, as the seed firms decide that it is to their advantage to take it up.

There is another great reason why the plant introduction of a country should be in the hands of the government. This lies in the danger of the introduction of noxious weeds, insect pests and fungous parasites. This idea is quite distinct from that of a quarantine affecting all private introductions. The damage wrought by fungous and insect pests in Europe has been so great that practically prohibitive quarantines have been placed against the introduction of foreign plants in Italy and Greece; and in this respect these countries have been followed by the Argentine. The result has been that the potato-growers of Greece have seen their potato varieties deteriorate without being able to get a change of seed, and in Argentine the pressure to get new things was so great that seeds were imported clandestinely in large quantities, and the law has had to be repealed. The doors had been shut to private introduction and yet no provision was made for the government to meet the legitimate demand of the people for foreign plants.

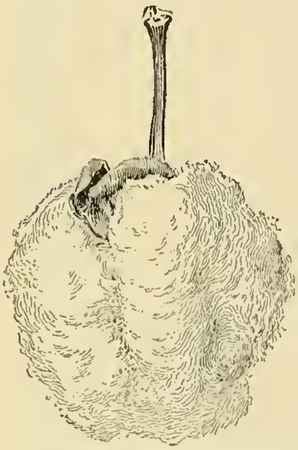


Fig. 100. The Ashmuni Egyptian cotton used by Dr. Webber in his hybridizing experiments. It has a long staple.

Fig. 101. The common upland cotton of America.

In bringing a new plant into a country, with all we now know of plant diseases, it would be a calamity to introduce its particular disease with it, yet, unless done with the greatest care and under the supervision of experts who know how to inspect, disinfect and fumigate, this is almost sure to occur. Two important plant industries which the Department is now at work on, the mango and the pistachio, could be seriously injured by injudicious private introductions that would almost surely bring in the destructive mango weevil of Java and a dangerous pistachio bud-borer from Sicily, pests that are now unknown here.

The possibilities of plant introduction.

The possibilities of organized plant introduction are almost unlimited. Enough has already been done in this country to attract the attention of other nations which had not hitherto realized its importance; and the time is not far off when the interchange of plants between countries will assume proportions that are now not dreamed of even by the most enthusiastic believer in the work, and the building up of new plant industries in a country will one day rank with the greatest of national duties.

The rate at which new plants arrive today is such that the inventory of accessions in the Office in the last two years comprises over 7,000 entries, while in the three years preceding, only 4,000 new things were brought in by the Office; altogether, since 1898, over 19,000 selected seeds or plants have entered.

It is not intended to give here even a partial list of the introductions of the Office of Seed and Plant Introduction and Distribution, but only to mention some of the species whose names do not appear in former cyclopedias of horticulture or agriculture.

Agropyron cristatum, J. Gaert. Gramineæ. From Walujka Experiment Station (in the dry steppes about 50 miles east of Rovnaya, south of Saratof on Volga river), Russia. Received through Prof. N. E. Hansen, May 25, 1898. Native dry steppe grass. Seed from plants cultivated one year. Director Bogdan, of the Walujka Station, regards this species promising for cultivation.

Andropogon rufus, Kunth. Jaragua. Gramineæ. From Matto Grosso Province, Brazil. Presented by the Brazilian minister, Hon. J. F. de Assis-Brasil, December 1, 1900. A native fodder grass called by the Portuguese *provisorio*. Described by Mr. Assis-Brasil in his book on Brazilian agriculture.

Angelica sylvestris, Linn. Umbelliferæ. From Naples, Italy. Received through Mr. W. T. Swingle, May, 1899. Said to have a much more fleshy leaf and stalk than the ordinary Angelica (*Archangelica officinalis*). Of this latter plant Vilmorin says: "The stems and leaf-stalks are eaten preserved with sugar. The leaves are also used as a vegetable in some parts of Europe. The root, which is splendidly shaped, is employed in medicine. It is sometimes called 'The Root of the Holy Ghost.' The seeds enter into the composition of various liquors." By some, the candied angelica is preferred to citron.

Arracachia esculenta, D. C. (*A. xanthorrhiza* Bancr.). Arracacha. Umbelliferæ. From Jamaica. Received through Messrs. Lathrop and Fairchild from the Hope Botanical Gardens, Kingston. A carrot-like vegetable much used in tropical and subtropical South America, especially in Venezuela, where it is called *apio*. The roots are propagated by subdivision, and the culture is much like that given to celery, though no blanching is necessary. Successfully introduced into Porto Rico. In South America generally eaten in soups, but said to be best when fried.

Astragalus falcatus, Lam. Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. A species native to the Caucasus. It should be tried as a forage plant in the Rocky mountain region.

Astrebla pectinata, F. Muell. Mitchell grass. Gramineæ. From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900. This is one of the famous Mitchell grasses and is regarded by some as the best of all native grasses, both for its drought-enduring qualities and for its fattening properties.

Blennodia lasiocarpa, F. Muell. Hairy-podded Cress. Cruciferæ. Annual, 1 to 1½ feet high, covered with pubescence. Pod hairy. Peculiar to the Darling river, sandy plains near the Murray river, and generally over the arid plains of Australia. Makes its growth during the hottest part of the year. Valuable for forage. Reference: Forage Plants of Australia, p. 4. Introduced by J. H. Maiden, Sydney Botanic Garden, March 1, 1904.

Cæsalpinia brevifolia, Baill. Algarobillo. Leguminosæ. From Santiago, Chile. Received through Messrs. Lathrop and Fairchild, July, 1899. A desert shrub from the region about Huasco, growing where often no rains fall for an entire year. The shrub produces an abundance of small pods that are remarkably rich in tannin. The industry of their export has been very profitable in Huasco, and it has been proposed to cultivate the shrub in other sections of Chile. At present only wild plants furnish the pods of commerce. This is a shrub eminently suited to Californian desert conditions, and should be tested in Arizona as well. It may be expected to bear fruit in four years. The seeds should be taken from the pods, carefully sown in the open ground, and covered with about three-fourths of an inch of soil. Care should be exercised to give them only a little water. The plants could be potted and transplanted, but the better way would be to try a few in the open ground. This is worthy of serious attention. The amount of tannin borne by the pods is very great, and it is said that they contain a valuable coloring matter as well.

Cæsalpinia coriaria, Willd. Divi-divi. Leguminosæ. From France. Received through Mr. W. T. Swingle, March, 1899. A small leguminous tree 20 to 30 feet high, from the West Indies to Brazil. The pods contain a high percentage of tannin and are largely exported to Europe. The tree thrives only on the seashore or in salt marshes. For trial along the Florida coast and in the tropical possessions.

Capparis inermis, Forsk. Spineless Caper. Capparideæ. From France. Received through Mr. W. T. Swingle, March, 1899. *Caprier sans épine*, an improved variety of the caper. The buds are much easier to gather than those of the ordinary spiny sort. This variety is said to come true from seed.

Carica heterophylla, Poep. and Endl. Jarrilla. Passifloraceæ. From Celaya, Mexico. Presented by Prof. Felix Foëx. Received December 10, 1900. A curious fruit, being drunk as one would swallow a raw egg, and not eaten. The name is Jarrilla, or "little pitcher," because it is shaped like a pitcher and is always full of water. The water contained in it is fresh and slightly acid, resembling lemon juice. When the fruit is taken from the plant it acquires in a few days a bitter taste, something like lemon peel, but without its aroma. The plant is a perennial, half climber, and grows wild on the hills around Celaya.

Centaurea Jacea, Linn. "Jacée des prés." "Chevalon." Meadow Knapweed. Compositæ. From France. Received through Mr. W. T. Swingle, December, 1898. Perennial; a plant for aftermath in elevated meadows, suitable to enter into natural and artificial mixtures. Its presence among the herbage is considered an indication of good quality. The stem and leaves contain a yellow coloring matter. Under this name several species and varieties closely related to it and having nearly the same qualities are frequently confounded in commerce and cultivation.

Chloris virgata, Sw. Rhodes Grass. Gramineæ. From Cape Town, South Africa. Received through Messrs. Lathrop and Fairchild, May 6, 1903. A species of pasture grass that, although scattered widely through the tropics of both hemispheres (according to the books), has probably not before been brought into culture. Mr. Cecil Rhodes had the seed of this plant collected several years ago and sown in large patches on his place near Cape Town, called "Groote Schur." The grass has done well there, forming heavy sods of a good herbage. This does not seem to be a drought-resistant form; at least, it is not able to withstand very severe dry weather. However, a grass which has attracted the attention of so keen a cultivator as Mr. Rhodes and is meeting with favorable comment from many practical men at the Cape deserves a thorough trial in America.

Diplachne fusca, Beauv. Swamp Grass. Gramineæ. From Coolabah, New South Wales. Presented by Mr. R. W. Peacock, August 3, 1900. This annual grass grows plentifully in damp and swampy places and is worth cultivating on low-lying waste lands. It makes desirable hay and ensilage. The plant produces an abundance of seeds which ripen late in the winter.

Eucommia ulmoides, Oliver. Trochodendraceæ. From London, England. Purchased from Messrs. James Veitch & Sons, Ltd., November 25, 1904. At one time much spoken of as a possible new source of rubber. Its leaves contain a substance similar to India rubber, but as yet no large quantity has been experimented with. For experimental plantings in the South. China.

Eutrema hederæfolia, Franch & Sav. Dry-land wasabi. Cruciferæ. From Yokohama, Japan. Presented by Mr. H. Suzuki, of the Yokohama Nursery Company, through Mr. David Fairchild. Received April 18, 1904. This dry-land wasabi, or Japanese horse-radish, is said to grow well in shade, but, being native of the central part of Japan, might not resist our climate. It seems much easier of cultivation than the ordinary wasabi (*Eutrema Wasabi*), though it will take some years before it grows to the size of ordinary wasabi roots; but, as the leaves have a very good flavor, it is said to be eaten by the natives as one of the best kinds of spice. Wild; not in cultivation yet.

Eutrema Wasabi, Maxim. Japanese horse-radish. Cruciferæ. (Fig. 102.) From Yokohama, Japan. Presented by Messrs. Lathrop and Fairchild. Received December 7, 1903. The wasabi takes the same place in Japan that the horseradish does in America, furnishing, when served at the table, a delicate, light green condiment, with a sharp, agreeable, pungent flavor, in some respects superior to horse-radish. The plant is cultivated in mountain valleys, in springy land where there is an abundant supply of moisture. Half shade is given. The method of cultivation is described in Bulletin No. 42, Bureau of Plant Industry, Department of Agriculture.

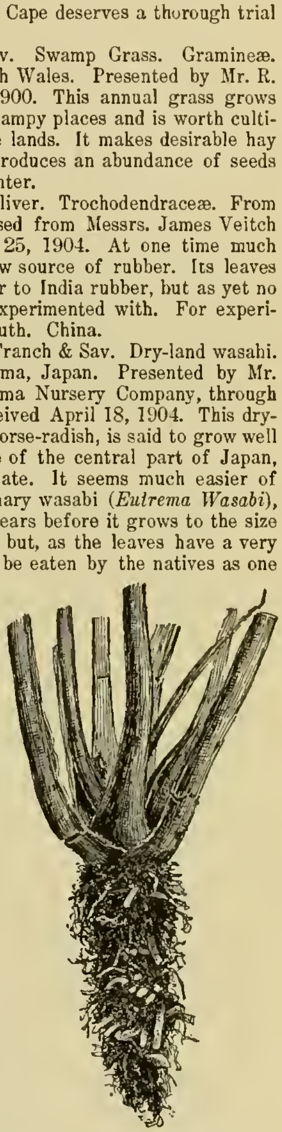


Fig. 102. Japanese horse-radish or wasabi (*Eutrema Wasabi*). Served with every fish dinner in Japan.

Festuca pabularis, Sodiro. Gramineæ. From Quito, Ecuador. Presented by Mr. Luis Sodiro, S. J., a botanist and student of Ecuador agriculture, through Mr. David Fairchild. Received May 25, 1904. Mr. Sodiro remarks that this is one of the most remarkable forage grasses of the mountain region of Ecuador. It is likely to prove of value in certain parts of this country.

Garcinia Celebica, Linn. Guttiferæ. From Buitenzorg, Java, Dutch East Indies. Received from Dr. Treub, September 28, 1904. Designed for use as a stock on which to graft the mangosteen, or for breeding purposes.

Garcinia Cochinchinensis, Choisy. Guttiferæ. From

Durban, Natal. Received through Messrs. Lathrop and Fairchild, November 9, 1904. This tree is a more vigorous one, and easier to adapt to cultivation than *G. Mangostana*, the true mangosteen. It is also a heavier bearer, and it is valuable in connection with experiments on the cultivation of the mangosteen in Porto Rico and Hawaii. The fruit is of a golden yellow color, one-seeded, with characteristic agreeable acid-flavored pulp.

Ilex Paraguensis, A. St. Hil. Paraguay tea. Maté. Ilicineæ. From France. Received through Mr. W. T. Swingle, March, 1899. The leaves of this shrub or small tree are extensively used in South American countries as a substitute for tea. This is a small tree reaching the height of 15 or 20 feet, which grows all through southern South America. The leaves are prepared by drying and roasting; but instead of being handled separately, as in preparing Chinese tea, large branches are dried by a wood fire and then placed on the hard floor and beaten with sticks until the dry leaves fall off. These leaves are then used in much the same way as ordinary tea. It is used as a beverage by millions of people in South America and is used as medicine to a small extent. The tree is not cultivated in South America, but there are said to be numerous and extensive forests where it is the predominating species.

Lotus uliginosus, Schkuhr. Bird's-foot trefoil. Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. Perennial; a very good plant for meadows and damp woods, demanding more humidity than *L. corniculatus;* taller and gives more fodder; succeeds well in the shade, in peat bogs, heaths and acid marshes, not calcareous; has been suggested for the formation of artificial prairies and is very suitable for mixtures for meadows and natural pastures. This lotus is a little more prolific in its seeds than *L. corniculatus.* It may be sown from March to May and even in autumn.

Medicago falcata, Linn. Medic. Leguminosæ. From Walujka, Russia. Received through Prof. N. E. Hansen, May, 1898. Regarded by Director Bogdan, of the Walujka Experiment Station, as a promising fodder plant for dry steppes, where it is found native at Walujka.

Medicago sativa, Linn. Turkestan alfalfa. Leguminosæ. A Turkestan variety or strain of the ordinary lucerne or alfalfa, introduced by Prof. N. E. Hansen, in 1898, and has proved a distinct success, more particularly in those regions subjected to severe drought, and on soils impregnated with alkali. Its resistance to severe cold has not been so satisfactorily proved as its hardiness under conditions of drought and alkali. Professor Hansen secured seed of this variety from Bokhara, Samarkand, Tashkend, Sairam, 150 miles north of Merke, in the Kirghiz Tartar steppes, and from Kuldja, China, Djarkent and Kopal. This variety, as well as other drought-resistant forms introduced from Algiers and Arabia, is likely to play an important rôle in alfalfa cultivation in this country.

Melilotus macrostachys, Pomel. Melilot. Leguminosæ. This species of melilot, native to Algeria, differs from most of the sweet clovers in having no pronounced odor. In consequence of this it is readily eaten by cattle. It has succeeded very well at the Experiment Station at Rouïba, where it attains a height of 3 to 6 feet.

Melinis minutiflora, Beauv. Molasses grass. Gramineæ. From Brazil. Presented by Senhor I. Nery da Fonseca, of Pernambuco. This is said to be the finest pasture grass in Brazil. Should be tried in Florida.

Miscanthus condensatus. (?). Gramineæ. From Yokohama, Japan. Presented by Mr. H. Suzuki, of the Yokohama Nursery Company. Received March 9, 1904. In the native region where this plant is grown, its leaves remain green all through the year, and the cattle are fed on it. It should be cut while young, before it reaches its full growth, as the stem gets hard if left too long. Young stems can be cut from time to time throughout nearly the entire year, but a few stems on each clump should always be left, as it sometimes dies if cut too severely. It is difficult to get seed of this plant, as the stems are constantly cut by the villagers. It seldom seeds. The roots, however, can be secured in any quantity.

Myoporum deserti, A. Cunn. Sweet-fruited myoporum. Myoporaceæ. Erect shrub, 3 to 4 feet high, with linear leaves 1 to 2 inches long. Said by some to be poisonous when in fruit. Others state that it is a good forage plant. Found principally in the interior of all the colonies of Australia. (See Forage Plants of Australia, p. 40.) Introduced by J. H. Maiden, Sydney Botanic Garden, March 1, 1904.

Nephelium lappaceum, L. Rambutan. Sapindaceæ. Presented by Dr. Treub, Buitenzorg, Java, through Mr. David Fairchild. Received March 31, 1905. This species and *Nephelium mutabile*, Blume, known as the "capoelasan," produce fruits far superior to the litchi in lusciousness. The fruits differ from that of the litchi in having distinct long protuberances from the fruit-skin which make them resemble superficially well-developed "cedar apples," though much darker in color. They are two of the showiest and most delicious fruits cultivated in Java, and should have been introduced long ago into the West Indies.

Ononis avellana, Pomel. Ononis. Leguminosæ. This is said by Doctor Trabut to be a good green-manure for heavy soils. It is found only in Algeria, where it occurs in few localities on clay hills.

Oxalis crenata., Jacq. Oca. Geraniaceæ Yellow variety. From France. Received through Mr. W. T. Swingle, February 13, 1899. The oca of western South America, where it is much appreciated as a vegetable. It is a perennial plant, but cultivated as an annual. Its tubers, which resemble potatoes, are acid when fresh, but after exposure to the sun become floury and sweet. When dried for several weeks, they become wrinkled and taste something like dried figs. In this condition known as *calli.* For directions for planting, see Vilmorin's Vegetable Garden.

Panicum molle, Sw. Para grass. Gramineæ. From Jamaica. Received through Messrs. Lathrop and Fairchild, March, 1899. A tropical hay and pasture grass, introduced before 1899 by private individuals, adapted to cultivation on rich muck or swampy soils. Propagated mostly by root division. Has proved profitable in southern Texas, and is being experimented with throughout the South. An exceedingly vigorous grower, and a very succulent-stemmed species.

Paspalum digitaria, C. Muell. Gramineæ. From Cape Town, South Africa. Presented by Prof. P. MacOwan, Government Botanist, through Messrs. Lathrop and Fairchild. Received May 6, 1903. Seed of a grass which, according to Professor MacOwan, is promising for moist bottom land. It will not endure cold weather, but is suited to subtropical conditions.

Pentzia virgata. Less. Karoobosch. Compositæ. From Ward No. 3, Jansenville, South Africa. Received through Messrs. Lathrop and Fairchild, May 2, 1904. A low-growing, spreading bushy composite, which layers naturally when the tips of its branches arch over and touch the ground. In the eastern provinces of Cape Colony, where rains occur in summer, but where long, severe droughts are frequent, this Pentzia is one of the most valuable of all the Karro plants for fodder purposes. It is especially good for sheep and goats, which eat it down almost to the ground. Though tested unsuccessfully in Australia, the plant is of such great value that it deserves a thorough trial in America and should be used in experiments on the dry lands in Hawaii and in southern California. It has grown and fruited for several years at Berkeley, California, where it was introduced previous to 1904.

Phaseolus viridissimus, Tenore. Gram. Leguminosæ. From Athens, Greece. Received through Mr. D. G. Fairchild May 9, 1901. One of the smallest and most delicate beans in the world. The beans are not much larger than grains of rice and are of a deep green color. They are said to be most delicious when cooked alone or with rice in the national Greek dish called *pilaff*. Their culture in Greece is restricted and the beans are considered a great delicacy. Prof. Th. de Heldreich, of Athens University, called attention to this species, of which he has made a special study. Probably a variety of the gram of India (*Phaseolus Mungo*). Has proved of value for cultivation on barren soils in the South.

Phleum Boehmeri, Wibel. Boehmer's timothy. Gramineæ. From the experiment grounds of the agricultural academy, Moscow, Russia. Received through Mr. M. A. Carleton, March, 1899. A promising grass for dry regions.

Pistacia vera, Linn. Pistachio or Pistache. Anacardiaceæ. The introduction of the pistache into California promises to be a success, inasmuch as trees of this species have already fruited well at Niles, California. The work of introduction has been largely in the hands of Mr. Swingle, and the best varieties have been secured from Sicily; the hardiest stocks have been collected by Mr. Swingle from Asia Minor and Italy, and still hardier species than these are being sought for by the Office in Northern and Central China and Persia. The advantages of this pistache industry, from which the delicious table nut used extensively in the Levant is secured, is that the plants will be likely to grow and bear well in localities where the almond has proved a failure, owing to the late spring frosts. The nut furnishes the flavoring extract known by the same name, and is also a most delicate table nut when roasted and salted.

Poa mulalensis, H. B. & K. Gramineæ. From Quito, Ecuador. Presented by Mr. Luis Sodiro, S. J., through Mr. David Fairchild. Received May 25, 1904. Mr. Sodiro remarks that this is one of the most remarkable forage grasses of the mountain regions of his country.

Polygala butyracea. Polygala. Polygalaceæ. From Paris, France. Received May 8, 1900. Presented by A. Godefroy-Lebeuf. This plant produces a vegetable butter. It will grow in summer in the hot sections of California and Florida, and as the plants can be grown as annuals it will probably prove successful.

Polygonum Weyrichii, F. Schmidt. Polygonaceæ. A species apparently having all the good qualities of *Polygonum Sachalinense*, but with leaves more tender and branches not so woody as in the latter species, which forms the latter's chief objection. This species was discovered by the Russian physician Dr. Weyrich. It came originally from Sachalin island, and was introduced by Mr. M. A. Carleton. It has been grown at the Imperial Botanic Gardens of St. Petersburg.

Portulacaria afra, Jacq. Portulaceæ. From Durban, Natal. Received through Messrs. Lathrop and Fairchild, November 9, 1904. A native South African shrub, or small tree, with succulent shoots which are said to be keenly relished by live-stock. The plant is reported to grow on dry, waste places without requiring attention. The cuttings take root easily, and the plant may even be propagated from the leaves. This species will probably thrive only in a frostless region. It grows on hot, rocky slopes, preferably of a doleritic nature, and is now being grown for trial on the dry islands of the Hawaiian group. Trials in Arizona showed it susceptible to the low temperatures there.

Quercus cornea, Lour. Oak. Cupuliferæ. (Fig. 118, Vol. I.) From Hongkong, China. Presented by Mr. S. T. Dunn, Superintendent of the Botanical and Afforestation Department, through Mr. David Fairchild. Received April 27, 1904. An evergreen oak, said to be very showy and ornamental as grown on the island of Hongkong. It bears acorns with as hard shells as those of the hickory-nut, and kernels almost as sweet as the sweetest Spanish chestnut. These acorns are sold in the markets of Canton and Hongkong by the ton, and are keenly relished not only by the Japanese, but by Europeans. Although difficult to predict how hardy this species will be in America, it is worthy of trial in all regions where citrous fruits can be grown.

Solanum Commersonii, Dunal. Aquatic potato. Solanaceæ. (Fig. 103.) Introduced from Marseilles, France. Secured through Dr. E. Heckel by Mr. David Fairchild. Received January 2, 1904. The so-called "aquatic potato" of Uruguay. This species is being experimented with by Dr. Heckel, of Marseilles, who is breeding it with the ordinary potato, and finds that it gives successive crops on the same soil without the necessity of replanting. It also gives abundant foliage, which he thinks may be used for green forage. He further points out that, in his opinion, the bitter flavor of the skin will protect the potatoes against the depredations of subterranean enemies. The special point to be emphasized in connection with this new species, however, is its possible immunity from the potato diseases. One difficulty in its culture consists in the necessity of carefully working over the soil to a depth of 15 cm., because the tubers are deeply buried in it. It flowers abundantly, beginning in June and ending in September, the flowers having a perfume similar to that of jasmine. Their odor on a hot day is perceptible for several meters. Planting takes place in southern France by means of whole or cut tubers in April, and the harvest is in October. Hybrids of this species with *Solanum tuberosum* have been made by Burbank, who introduced it previous to 1904. Dr. Heckel's experiments are reported on in the Revue Horticole, No. 581, December, 1902, p. 200; Contribution à L'Etude Botanique de Solanum tuberiferes, par M. Edouard Heckel, a separate publication. Doubt has been expressed regarding the authenticity of the advertized hybrids of this species. Promising for experiment.

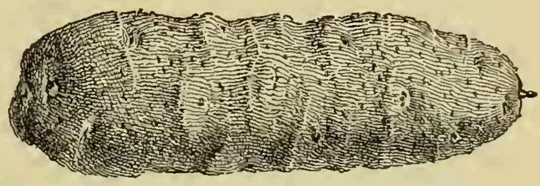


Fig. 103. Aquatic potato (*Solanum Commersonii*). Specimen grown at Santa Rosa, Cal., by Luther Burbank. (Reduced.)

Sporobolus Lindleyi (S. pallidus), Lindl. Gramineæ. A slender-growing perennial grass. Grows on rich soil, and is much relished by all kinds of stock. All colonies except Tasmania. Introduced by J. H. Maiden, Sydney Botanic Garden, March 1, 1904.

Trifolium Alexandrinum, Linn. Egyptian Clover, or Berseem. Leguminosæ. (Fig. 91.) Berseem is the principal winter fodder crop of Egypt. It is an annual, very rapidly growing clover, adapted to irrigated conditions in countries having a mild winter climate. It seems to be injured by intense summer heat, which causes it to run to seed prematurely, and it is killed by temperatures below 25° F., in winter. It requires a large quantity of water, and makes an exceedingly vigorous growth when these conditions are met. As many as five cuttings of excellent fodder are taken from a single seeding in Egypt. The trials in America have not been successful, but experience seems to indicate that these trials have been made without a due regard for the requirements of the plant. Successful plots have been grown and seeded in the widely separated regions of Galveston, Texas; Phoenix, Arizona, and Mecca, California; and it is thought that this plant will find a permanent place in the Southwest as an annual winter fodder plant for irrigated regions. It is a wonderful soil-enricher, and may find a place in the orchards of

California. The introductions of this plant are due to the efforts of Mr. Barbour Lathrop and Mr. David Fairchild.

Trifolium Johnstoni. Uganda clover. Leguminosæ. Introduced from Uganda, East Africa. Received through Mr. David Fairchild, from Mr. R. N. Lyne, Director of Agriculture, Zanzibar, East Africa, January 30, 1904. According to Mr. Lyne, this is the Uganda clover, a distinct species which may be of value for breeding experiments of this country. It forms a part of the luxuriant pasturage of the high plateau of Uganda, which, although in the tropics, has a comparatively mild climate.

Trigonella corniculata, Linn. Small fenugreek. Leguminosæ. This species, which has the same strong odor as fenugreek, from which it differs, however, in having very much smaller pods and seeds, grows very vigorously at the Experiment Station at Rouïba, where it attains a height of 3 to 5 feet. It could not be used for feeding milch cows, as the strong odor would make the milk unsalable. It is used, however, for fattening stock and as a green-manure. It is said to resist drought very well.

Trigonella gladiata, Stev. Trigonella. Leguminosæ. This plant also resembles fenugreek in odor. It has been cultivated with some success at the Experiment Station at Rouïba.

Trichinium nobile, Lindl. Yellow hairy spikes. Amarantaceæ. Stout perennial herb, not easily affected by drought. Affords a rich succulent herbage even in very dry weather, of which stock are very fond. Interior of New South Wales and South Australia and Victoria. Reference: "Forage Plants of Australia," p. 85. Introduced by J. H. Maiden, Sydney Botanical Garden, March 1, 1904.

Trichinium obovatum, Gaudich. Silver bush. Amarantaceæ. An erect undershrub 1½ to 4 feet. Flower-spikes globular. Has remarkable drought-enduring qualities. Will grow in the driest of soils when once fairly established. Valuable as a forage plant. Arid interior of all Australian colonies. Introduced by J. H. Maiden, Sydney Botanical Garden, March 1, 1904.

Ulex nanus, Forsk. Dwarf Furze. Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. A much smaller species than *Ulex Europæus.* It is of spreading habit and thrives in moist situations, even in swampy places, where the other species would not grow. It might prove of use as a winter soiling crop in regions inclined to be barren, but its utility is likely to be local.

Ullucus tuberosus, Caldas. Ulluco. Chenopodiaceæ. The ulluco of the Peruvians is grown on the Sierras, 3,000 feet above sea-level. The tubers are considered very nutritious by the common people and are eaten by them mixed with salt meat. Although the tubers are much smaller than the potato, they are worthy of consideration for breeding purposes. Various distinct varieties exist in Peru. Introduced by Mr. Fairchild in 1899.

Vicia angustifolia, Clos. Vetch. "Vesce á feuille étroite" (narrow-leaved vetch). Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898.

Vicia biennis, Linn. Biennial vetch. "Vesce bisannuelle." Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. Biennial and perennial, hardy, very large species, yields much fodder, demands the support of some other plant with firm, erect stalk; very scanty in seeds.

Vicia calcarata, Desf. Vetch. Leguminosæ. This vetch is native to the Mediterranean region. The seed of this particular sort was secured at Boghar, in Algeria, where the climate is very dry. This is one of the species introduced into culture by Dr. Trabut.

Vicia Ervilia, Willd. Leguminosæ. From Canné, Crete. Received through Mr. D. G. Fairchild, May 17, 1901. Orobus. A forage plant very largely cultivated in the island of Crete. It is sown like any ordinary vetch, and the seeds are fed to the oxen and cattle.

Vicia fulgens, Battaud. Scarlet vetch. Leguminosæ. An Algerian vetch with handsome red flowers. It is an annual and grows with extraordinary vigor, reaching a height of 6 to 8 feet and yielding an abundance of excellent forage. Doctor Trabut reports that it yields forty tons of green fodder to the acre.

Vicia hirta, Balb. Vetch. Leguminosæ. This plant, which is usually considered to be a hairy form of *Vicia lutea,* occurs very commonly in Algeria and has been introduced into cultivation by Doctor Trabut. It reaches a height of 16 to 18 inches at the experiment station at Rouïba.

Vicia Narbonensis, Linn. Narbonne vetch. "Vesce de Narbonne." Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. Annual; very vigorous and very early, remarkable in its stalks, its foliage and its general appearance, which recalls that of a small bean, but earlier. To be sown early in spring in the North. In more temperate climates than ours (latitude of Paris) it may and even should be sown in autumn. This species has been confounded for some time with *V. macrocarpa,* and sold under that name. It is generally sown alone, but it may be found advantageous to have it enter mixtures for green cutting, which are to be sown early in spring, or to mix it with oats or rye or some other cereal grass.

Vicia sepium, Linn. Hedge vetch. Leguminosæ. From France. Received through Mr. W. T. Swingle, December, 1898. Perennial. A common plant (in France) along borders and paths in the woods; it prefers shade and moisture, but succeeds equally well in good wholesome and even dry soils. Seeds scarce.

Xanthosoma atrovirens, C. Koch & Bouché. Yautias or Taniers. Araceæ. Varieties of this common tropical American food plant and its two very closely related species, *X. sagittæfolium,* Schott, and an undescribed species, have been introduced into the southern states from Porto Rico. The yield is about 8 to 15 tons of edible tubers per acre; and in quality these are equal or superior in many respects to potatoes. This is thought by some to be the oldest crop in the world and the only one which never produces seeds. About fifty varieties were cultivated in the western hemisphere at the time of the discovery of America by Columbus. It deserves to become a staple vegetable for export from the tropics and temperate regions. (See Bulletin No. 6, Porto Rico Experiment Station. Barrett.)

Literature.

There is a large amount of information on plant introduction scattered through the periodicals to which reference cannot be made here; the following are the most important books:

Charles Pickering, Chronological History of Plants; Man's Record of His Own Existence Illustrated Through Their Names, Uses and Companionship, Boston, 1879; Paillieux et Bois, Le Potager d'un Curieux, Paris; Baron Ferd von Mueller, Select Extra-Tropical Plants Readily Eligible for Industrial Culture or Naturalization, 9th Edition, Robert S. Brain, Government Printer, Melbourne, 1895, pp. 654; Inventories Nos. 1 to 10, inclusive, of foreign seeds and plants imported by the Section of Seed and Plant Introduction, and later by the Office of Seed and Plant Introduction and Distribution, comprising 841 pages in all; appearing as bulletins of the United States Department of Agriculture. Von Mueller's is the only comprehensive work on the subject, and it is a pity that the work is difficult to secure.

CHAPTER V

CROP MANAGEMENT

HOW TO ORGANIZE A FARM BUSINESS so that it shall be profitable and otherwise satisfactory is the fundamental problem in agriculture. It is to be feared that in the past generation we have placed relatively too much emphasis on information; and, in fact, this danger has not yet passed. This is a consequence of the remarkable discoveries of recent years and the rapid diffusion of facts. The best farmer is not the one who knows the most "science," but the one who is best able to organize the facts and the business into a harmonious system or plan. The principles that underlie such organization are now beginning to be apprehended, and we think we see the possibilities of a sound farm philosophy, with wise generalizations from the mass of rapidly accumulating facts and practices. Farm management will be a fertile subject for writers in the years to come.

Fig. 104. Crop labor, as often performed in Europe. Drawn from life, in Bavaria.

The basis of farm organization is the cropping plan or the crop management. On this project or scheme rests the maintenance of fertility and consequently of productiveness, the subsistence of livestock, the economy of labor, the type of business. The crop management must be considered in reference to the entire layout and design of the farm enterprise. In the article following this Editorial it is so discussed in the approximate proportion that the author thinks it should hold. The article covers some of the ground that is specialized in Vol. I, but what repetition there is will distinguish the points that probably need special emphasis.

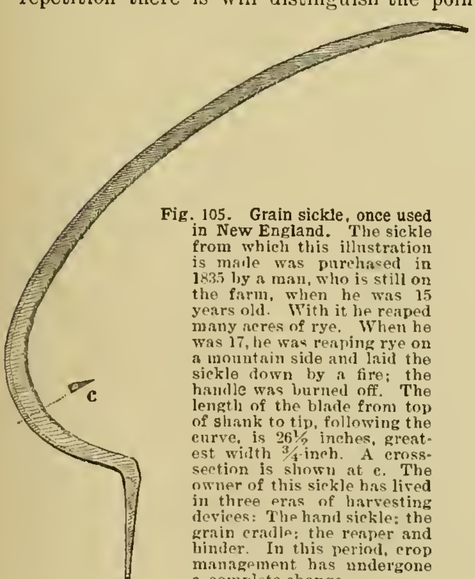


Fig. 105. Grain sickle, once used in New England. The sickle from which this illustration is made was purchased in 1835 by a man, who is still on the farm, when he was 15 years old. With it he reaped many acres of rye. When he was 17, he was reaping rye on a mountain side and laid the sickle down by a fire; the handle was burned off. The length of the blade from top of shank to tip, following the curve, is 26½ inches, greatest width ¾-inch. A cross-section is shown at c. The owner of this sickle has lived in three eras of harvesting devices: The hand sickle; the grain cradle; the reaper and binder. In this period, crop management has undergone a complete change.

The rotation of crops.

Crop management is a scheme, not a lot of practices. An important part of it is the rotating or alternating of crops on given areas. This phase of the subject may now be given a general treatment, inasmuch as it is not fully treated as to underlying reasons in other articles.

All crop management, and crop rotation in particular, has been greatly changed by the introduction of machinery. Larger areas of cereal crops can now be grown because of the use of the self-binder as compared with the cradle and sickle. Larger areas can also be handled in intertilled crops, and those that require much heavy labor in the harvesting. Pictures of some of the old American tools will contrast this fact (Figs. 104 to 119) by suggesting some of the kinds of devices that were formerly in use and the former state of invention in farm machinery.

On the other hand, the present scarcity of acceptable farm labor is tending to reduce the area of crops that require much care. Wherever grass is a foundation crop, the tendency is to grow less of the tilled crops.

The term "rotation of crops" is used to designate a system of recurring succession of plants covering a regular period of years, and maintained on alternating fields of the farm. Its purpose is primarily to increase the productiveness of the various crops by conserving the fertility of the soil and eliminating weeds, pests and crop diseases. All farmers practice rotation to some extent, but usually it is imperfect and unplanned. In most parts of the northern states it is common practice to have oats follow corn, and wheat follow oats. Such indefinite practices are perhaps to be called modes or systems of cropping rather than crop rotations. The real rotation of crops is a more purposeful and orderly procedure; in grass-growing and cereal-growing countries it assumes alternations of grain crops, grass crops, intertilled crops. It would be better if all writers used the term rotation of crops to designate only well-laid systems or courses.

Fig. 106. Rake and cradle still used in parts of Germany.

Definite rotation is usually a practice of old and well-settled countries, where the virgin fertility of the soil has been somewhat depleted and crop enemies are numerous. In most new countries, the husbandry is at first haphazard and unscientific. The land is exploited. Fertility is seemingly exhaustless and little attention is given to conserving it. The land is robbed, and the robber moves on. But when the land must be used over and over again, century by century, the farmer looks to the future and lays out a plan that will cause his land to increase in value. The rotation and diversification of crops are subjects of increasing importance in North America.

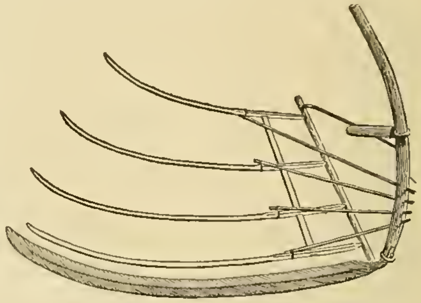


Fig. 107. The present-day grain cradle, used for small areas and rough lands.

These remarks are well illustrated in the depletion of lands once devoted to tobacco and cotton. Wheat production constantly moves westward. George Washington wrote to Arthur Young, in England, as follows, in 1787: "Before I undertake to give the information you request, respecting the arrangements of farms in this neighbourhood, &c., I must observe that there is, perhaps, scarcely any part of America, where farming has been less attended to than in this State [Virginia]. The cultivation of tobacco has been almost the sole object with men of landed property, and consequently a regular course of crops have never been in view. The general custom has been, first to raise a crop of Indian corn (maize) which, according to the mode of cultivation, is a good preparation for wheat; then a crop of wheat; after which the ground is respited (except from weeds, and every trash that can contribute to its foulness) for about eighteen months; and so on, alternately, without any dressing, till the land is exhausted; when it is turned out, without being sown with grass-seeds, or reeds, or any method taken to restore it; and another piece is ruined in the same manner. No more cattle is raised than can be supported by lowland meadows, swamps, &c. and the tops and blades of Indian corn; as very few persons have attended to sowing grasses, and connecting cattle with their crops. The Indian corn is the chief support of the labourers and horses. Our lands, as I mentioned in my first letter to you, were originally very good; but use, and abuse, have made them quite otherwise.

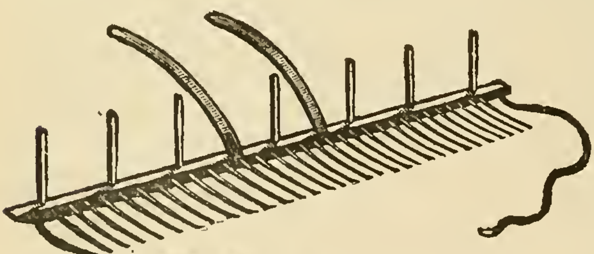


Fig. 108. "The improved horse-rake," 1821.

"The above is the mode of cultivation which has been generally pursued here, but the system of husbandry which has been found so beneficial in England, and which must be greatly promoted by your valuable Annals, is now gaining ground. There are several (among which I may class myself), who are endeavouring to get into your regular and systematic course of cropping, as fast as the nature of the business will admit; so that

I hope in the course of a few years, we shall make a more respectable figure as farmers than we have hitherto done."

Fallowing.

A significant part of Washington's letter is the statement that land was "respited" for eighteen months. He meant that the land was allowed to lie idle or fallow. It is an old notion that land "rests" when allowed to go wholly uncropped; and, in fact, it is true that the succeeding crops may be better for the fallow, but in most instances equally good results can be secured by other means and without the loss of a year's crop. The fallow was a regular part of early rotation practices. Fallowing was employed by the Jews, Greeks and Romans. It is common in many large parts of Russia and other countries to-day.

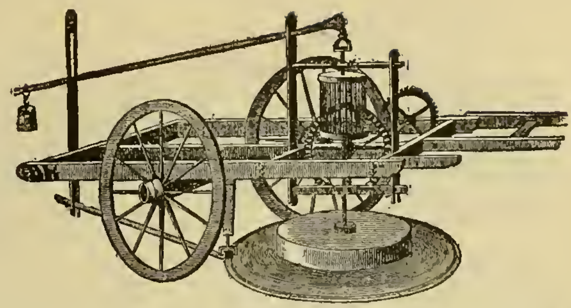


Fig. 109. "The mowing machine," 1823. Invented and patented by Jeremiah Bailey, Chester county, Pa. "It has been extensively used and approved of during the last season. . . . It is understood that it will mow ten acres per day." The cutting is done by a horizontal revolving circular scythe, working against a whetstone.

In special cases and in regions of insufficient rainfall, fallowing is still an allowable practice; but in general it belongs to a rude and unresourceful type of agriculture. In most of the humid regions of this country the practice, if employed at all, is diminished to "summer fallowing," whereby the period of idleness is reduced to a minimum. The summer fallow was formerly often employed in order to fit the land for wheat. The land was kept in more or less clean and free tillage from spring till fall, without crop, for the purpose of destroying weeds and of putting it in good condition of preparation. With improved tillage implements and well-planned rotations, these special results usually can be secured without resort to fallow.

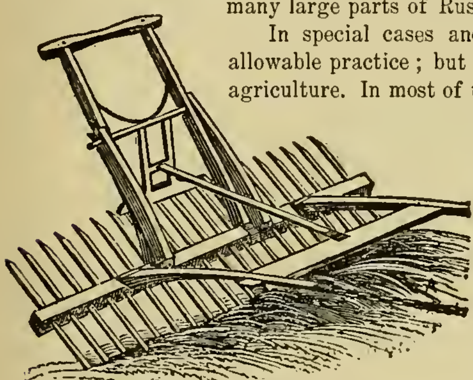


Fig. 110. Revolving hay-rake as pictured in 1846. "This implement, with a horse, man and a boy, will rake from fifteen to twenty-five acres per day. It can be used to good advantage even on quite rough ground." Price, $7.50 to $9.00.

Why rotations are useful.

There is no dispute as to the value of rotation of crops. The only differences of opinion are in respect to its feasibility in particular cases and the merits and demerits of the different courses. Many experiments have reënforced common experience as to the importance of rotation, particularly in recuperating old lands. Experiments made at Rothamsted are perhaps the most conclusive, because of the long period. Wheat has been grown without rotation for sixty-six years and other crops for varying periods. No method of fertilizing potatoes or clover kept up the yield without rotation. Rotation alone did not fully maintain the yield of any crop, but the combination of manure or fertilizers with rotation increased it. At the Louisiana Experiment Station (to cite only one more illustration), it was found, as a result of eleven years' work with a three-course rotation (first year corn, second year oats followed by cowpeas, third year cotton), that the yield increased from 12 to 25 per cent even without the application of manure. In another part of the same experiment, manure was applied and the

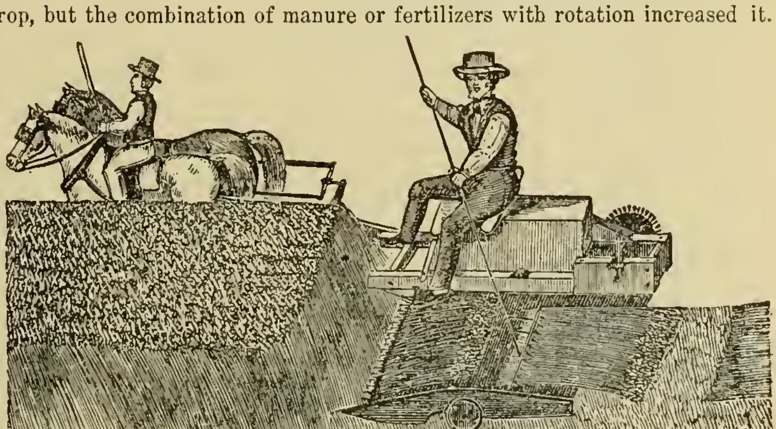


Fig. 111. Hussey's reaping-machine; from a print of 1852.

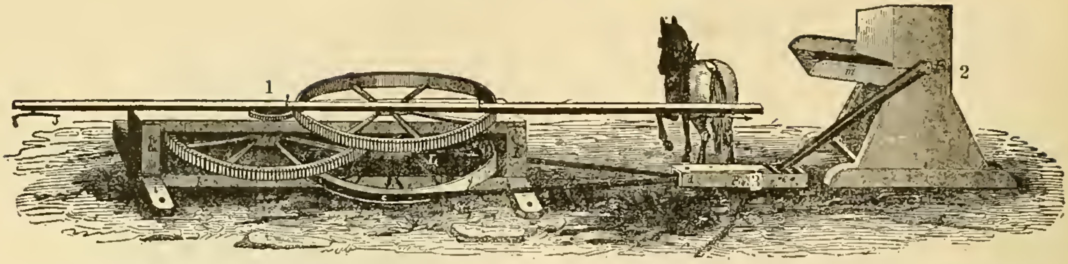


Fig. 112. A threshing device as pictured in 1845 (Warren's horse-power and thresher). "The machines may be placed as follows, viz.: The horse-power, Fig. 1, and the pulley-box, Fig. 3, outside the barn, and the threshing machine, Fig. 2, inside any convenient distance, say about 4 feet."

general increase in yield was 400 to 500 per cent. This shows that a plain rotation is itself capable of increasing yield, but that a greater increase is to be expected by a combination of rotation and manuring.

The first rotation-farming to gain wide attention in North America seems to have been the so-called Norfolk system. This was chiefly a four-crop rotation employed on the light lands of Norfolk, England, and which had grown up during a long course of years. A century and more ago this system was explained by writers and thereby became widely known, the more so because at that time the American agricultural literature was drawn chiefly from English sources. An account of "the Improvements made in the County of Norfolk" comprised the larger part of Jared Eliot's "Fourth Essay upon Field Husbandry," published at Killingworth, Connecticut, in 1753. The exact rotation itself—comprising roots, barley, clover, wheat, in various combinations—was of less importance to the American colonies than the fact that attention was called to the value of rotation-farming in general. At the same epoch another system of farming practice was also coming in from English sources. This was the clean-tillage system introduced by the epoch-making experiments of Jethro Tull. Between the discussions of the Tull "new husbandry" and the Norfolk rotations, agricultural practices were challenged and overhauled in the new country.

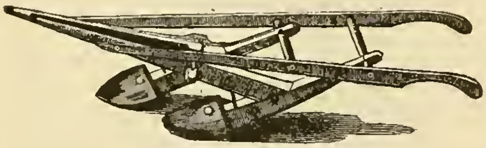


Fig. 113. The double-shovel plow in 1820, used until very recently.

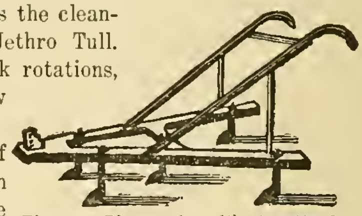


Fig. 114. Picture of a cultivator attending an advertisement in "American Farmer," 1821. The advertisement also says that "persons transmitting the cash for any of the following articles, will be carefully put up and shipped to any part of the United States: Clover, Timothy and other grasses and garden seeds warranted of good quality."

One of the early explanations of the good results of rotation of crops was the doctrine that some plants exhaust the soil of certain materials which are not needed by other plants; therefore the value of rotation depended on securing such a combination of crops as would in time utilize all the elements of the soil. There is, of course, some truth in this teaching, but we now know that the question is by no means one of so-called exhaustion alone.

Another explanation was found in the theory that roots excrete certain substances that are noxious to the plants excreting them and innocuous or even beneficial to other plants. The excretory theory was taught early in the past century by the renowned Swiss botanist, Pyramus de Candolle. It was no doubt a suggestion from the animal kingdom. This theory was practically given up before the middle of the past century. Yet it is most interesting to find recent experiments in England on the growing of grass in orchards leading to the suggestion that one plant may exert some influence on the soil deleterious to another plant. It is suggested that this influence, however, is biological rather than chemical—in some way, perhaps, concerned with the little-understood germ life of the soil. Recent publications by the United States Department of Agriculture (Bureau of Soils) state that root excretions are probably very intimately associated with soil productivity, that much of the value of manurial substances lies in the cleansing of the soil of these toxic excreta, and that the value of

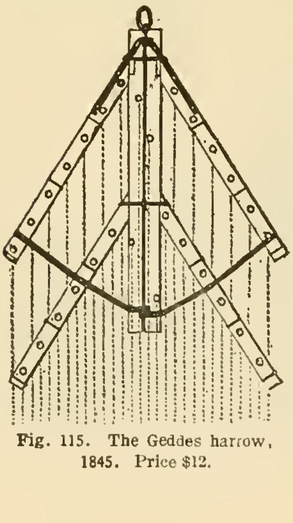


Fig. 115. The Geddes harrow, 1845. Price $12.

rotation of plants is determined largely by the presence or absence of such excreta.

Some of the reasons why rotation-farming is considered to be advantageous (under present teaching) may now be mentioned.

Fig. 116. "The irrigator," pictured in 1823. "This machine is calculated to water meadow-grounds, cotton and provision land, and with a boy and horse, ought to water one or two acres per day, according to the distance of the river from the field." "No. 1, The Cask; 2, The Axle; 3, Felloes; 4, Bung; 5, Plug holes at both ends; 6, Seat for the boy."

(1) One crop tends to correct the faults of another crop. The continuous growing of one crop usually results in the injuring of the soil in some respect; a rotation tends to overcome and eliminate such effects. It evens up and works out the inequalities. The general average of many or several kinds of treatment is better than the effects of one treatment.

(2) Plants differ considerably in the proportions of the kinds of foods that they take from the soil. In rotations, the different plants make the maximum of their draft on the soil at different times in the year, thereby allowing the progress of the seasons to even up the inequalities.

(3) By a judicious choice of crops, different plant-food materials may be incorporated in the soil in available condition, through the decay of the parts plowed under or left in the ground. The most marked benefit of this kind probably comes from incorporation of nitrogen compounds through the use of leguminous plants. These plants have the power, by means of their root nodules, of fixing the free atmospheric nitrogen of the soil; and the new compounds are turned back to the soil in condition to be utilized by plants that do not have the power to appropriate the nitrogen of the air. Since nitrogen is the most expensive and usually the most easily lost of the plant-food elements that the farmer has to buy, this rôle of the leguminous plants is most important. It is significant that most of the early rotations, developing before rational explanations of them could be given, comprised some legume.

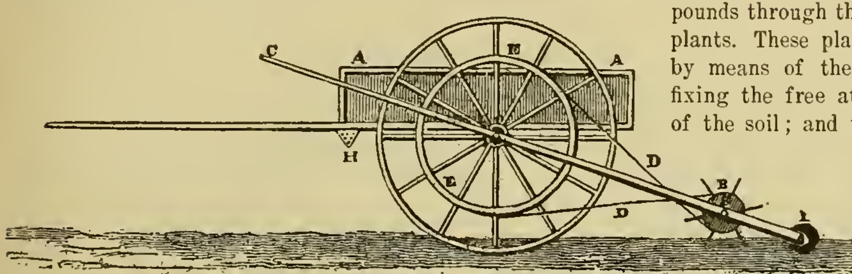


Fig. 117. Woodside's machine for harrowing, sowing and rolling, 1833. The seeder or sieve is at H; harrow at B; roller at I. "From the above it will be perceived that I can of a truth affirm, that I can sit in the front of my cart, under a canvas covering, sow the grain, harrow and roll it in, without exposure to the sun, leaving the ground without any impression of the horses' feet, my own feet, or the cart wheels."

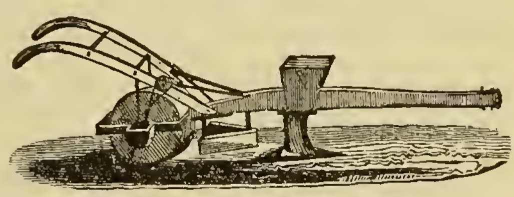


Fig. 118. Bachelder's corn-planter, as illustrated in 1846. "The seed is put into the hopper above the beam, and as the planter moves along, the share below opens the furrow; the corn is then dropped by arms moved by a crank."

(4) Some plants have the power, more than others, to utilize the content of the subsoil. Such plants may not only make less proportionate draft on the upper soil, but by their decay may add to the richness of such soil. It has been determined, for example, that lupines are able to take more food from the subsoil than oats. Most of the legumes have similar power, largely because of their deep-rooting habit; and this affords additional explanation of the good results accruing from the use of such plants in the rotation.

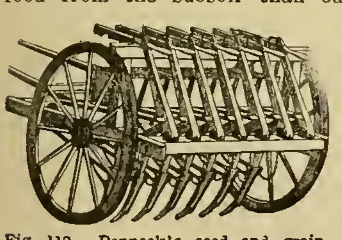


Fig. 119. Pennock's seed and grain planter, from a picture of 1846. "This machine will plant wheat, rye, Indian corn, oats, peas, beans, rutabagas and turnips; and can be regulated to drop any required quantity on an acre."

(5) A rotation of crops can be so planned as to maintain the supply of humus in the soil. This humus, coming from the decay of organic matter, adds to the plant-food content of the soil and, what is usually more important, exerts a great influence in securing a proper physical texture of the land. The Bureau of Soils recently asserts that the chief value of humus is to cleanse the soil of toxic excreta. The humus is chiefly supplied by the grass crops and clover crops in the rotation. The practice of "green-manuring" rests chiefly on the need of supplying humus. Green-manure crops are those that

are grown for the special purpose of being turned under, root and top, and are not usually a definite part of the rotation; but, so far as it goes, the root-and-stubble part of similar crops employed in the rotation answers the same purpose.

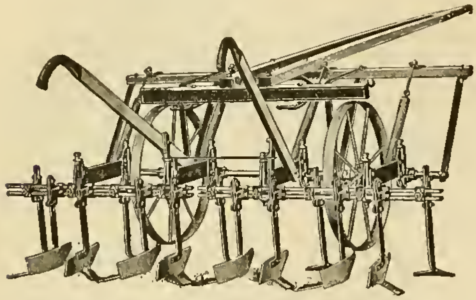


Fig. 120. Four-row beet cultivator of today.

(6) Well-considered rotation schemes reduce the necessity of excessive use of concentrated or chemical fertilizers. On the other hand, they may utilize such fertilizers to greater advantage than do the continuous-cropping schemes, as has been shown by the Ohio Experiment Station.

(7) A good rotation provides for the making of farm manures, because it grows crops for the feeding of live-stock. As a general practice, it is better to market the hay and straw crops in the form of animals or animal products than to put them on the market directly; for the farmer not only has the opportunity to make an extra profit by an extra process, but he gains the manure with which to maintain the fertility of his lands. He raises the crop to feed his stock to secure manure to raise a better crop. In the maintaining of fertility, the live-stock farmer has the great advantage of the horticulturist or other special farmer, for the latter must resort to special practices or special purchases in order to maintain the producing power of his land.

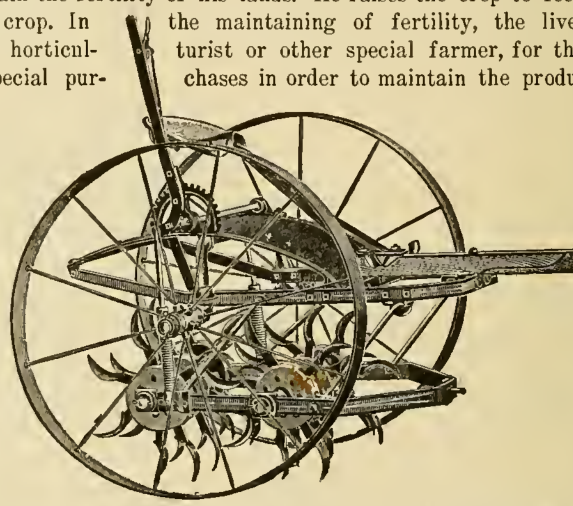


Fig. 121. Stubble digger, to fit land for a succeeding crop, 1906.

(8) Rotation is a cleaning process. Certain weeds follow certain crops. Chess and cockle are common weeds in old wheat-lands. The life-cycle of these plants is so similar to that of wheat that they thrive with the wheat; and the seeds may not be removed from wheat-seed in the ordinary cleaning process. These weeds are soon eliminated by the grass-course in the rotation, or by some clean-tillage course. Most weeds are eradicated in the course of a good rotation; in fact, a rotation cannot be considered to be good unless it holds the weeds in check. With crops which are not grown as a part of a rotation, as rice, it is sometimes necessary to interject another crop for a year or two in order to clean the land.

Insects and plant diseases follow certain crops. There are no insects or diseases that follow all crops. Therefore a rotation cleans the fields of many of these troubles and pests. Nearly all continuous-cropping schemes run into these difficulties sooner or later. A short and sharp rotation, for example, is the best means of contending with wire-worms. It is not uncommon sometimes to find onions failing year after year in the best onion regions. The trouble is likely to be due to pests or diseases. Two or three years of celery or other crop may clean up the difficulty. The horticulturist is particularly liable to suffer from insects and plant diseases, especially if he is an orchardist, because he cannot well practice a definite rotation. The larger part of the spraying devices and materials are devised to meet the necessities of the horticulturist.

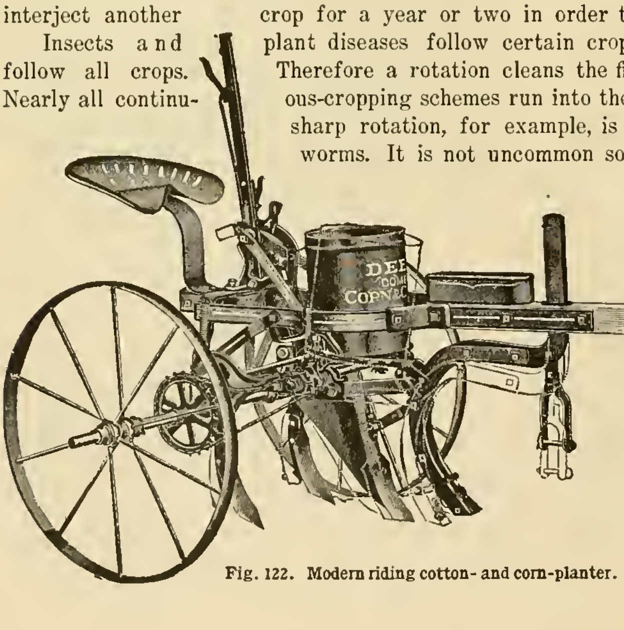


Fig. 122. Modern riding cotton- and corn-planter.

(9) A rotation allows the farmer to meet the needs of the staple markets by providing a continuous and predictable output.

(10) Rotation-farming develops a continuous and consecutive plan of business. It maintains the continuity of farm labor, and reduces the economic and social difficulties that arise from the employing of many men at one time and few men at another time.

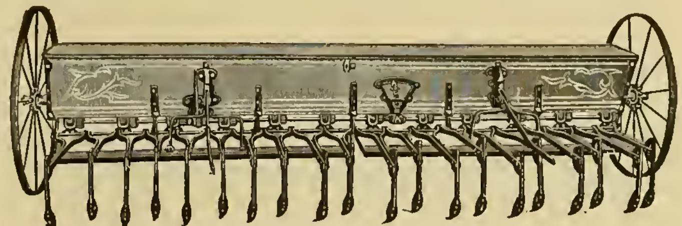


Fig. 123. A modern 11-foot seeder.

Rotation practices.

Just what rotation scheme shall be adopted in any case must depend on many local and special considerations. What some of these considerations are may be briefly discussed.

(*a*) The rotation must adapt itself to the farmer's business—to the support of live-stock if he is a dairyman or stock-farmer, to the demands of the grain trade if he is a grain-farmer, to the cotton market if he is in a cotton region.

(*b*) It must adapt itself to the soil and the fertility problem. Often the chief purpose of a rotation is to recuperate worn and depleted lands. In such case, the frequent recurrence of leguminous humous crops is preëminently desirable.

(*c*) The fertilizer question often modifies the rotation — whether manure can be purchased cheaply and in abundance or whether it must be made on the place.

(*d*) The kind of soil and the climate may dictate the rotation.

(*e*) The labor supply has an important bearing on the character of the rotation-course. The farmer must be careful to plan to keep the number of plowings and the amount of cultivating within the limits of his capabilities.

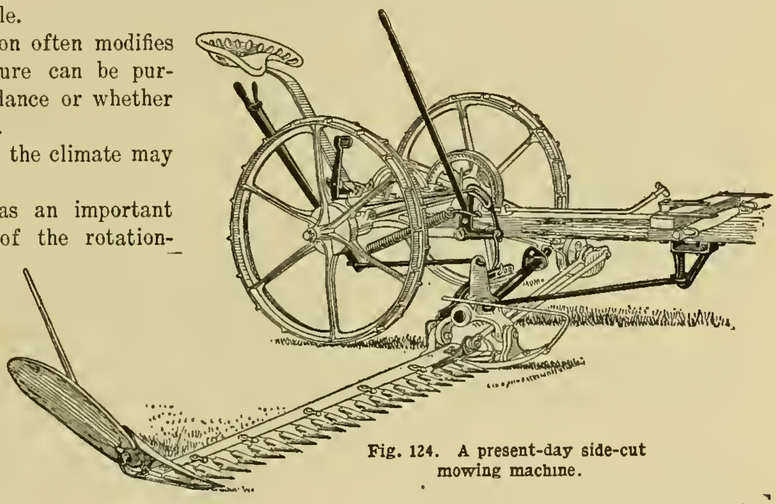


Fig. 124. A present-day side-cut mowing machine.

(*f*) The size of the farm, and whether land can be rented for pasturage, are also determinants. It is not profitable to grow the cereals and some other crops on small areas; in fact, rotation-farming is chiefly successful with large-area crops.

(*g*) In the future more than in the past, the rotation must be planned with reference to the species of plants that will best serve one another, or produce the best interrelationship results.

(*h*) The rotation must consider in what condition one crop will leave the soil for the succeeding crop, and how one crop can be seeded with another crop. One reason why wheat is still so generally grown in the East is because it is a good "seeding crop"; grass and clover are seeded with it, and it therefore often makes a rotation practicable. In some parts of the East, rye takes the place of winter-wheat in the rotation course. Every careful farmer soon comes to know that a certain tilth or condition of soil may be expected to result from certain crops. Thus buckwheat has a marked effect on hard-pan soils, leaving them mellow and ash-like. The explanation of this action of buckwheat is unknown. Potato-growers who have hard land like to grow buckwheat as a preparation for potatoes, although buckwheat is rarely a regular part of a rotation. Winter-wheat commonly follows oats, for the reason that the oats are harvested

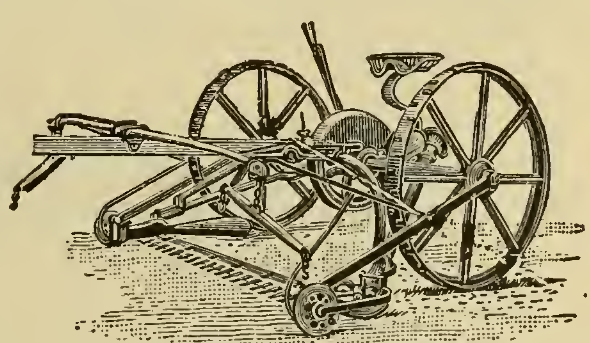


Fig. 125. A present-day center-cut mowing machine

early enough to allow the sowing of wheat in the fall. However, barley is considered to be a better preparation crop for wheat, as it comes off the land earlier and does not deplete the moisture content of the soil so much; it therefore usually allows the making of a better seed-bed for the wheat.

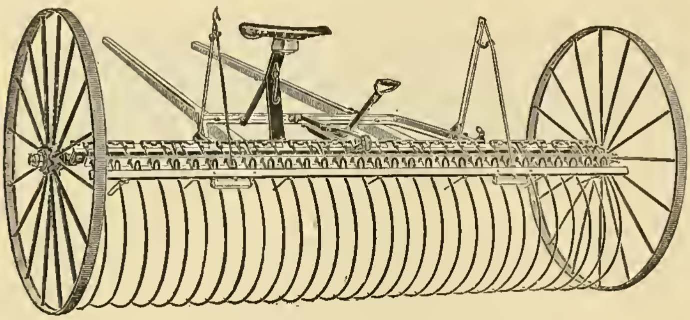


Fig. 126. The common form of spring-tooth hay-rake.

It must be remembered that the rotation is not confined to a single field. If a perfect system is practiced, there must be as many equal fields concerned in the rotation as there are years in the course, so that every crop is grown on some part of the farm every year. The farm is therefore laid off into shifts or blocks. It is unusual, however, that a farm is sufficiently uniform in surface and soil to allow of such a perfect arrangement, and consequently the output of the various crops varies from year to year. Of course, it is not expected that the entire farm is to be laid under a rotation system. Parts of it will be needed for gardens, orchards, woods, permanent pasture, and for special crops.

Not all the crops of the farm are adapted to rotation. The cereal and hay crops are most adaptable. Cotton ordinarily is not a part of a rotation scheme; and this is one reason why cotton-lands so soon become "exhausted." The adopting of a short and good rotation, in which cotton would be the pivot crop, would no doubt add immeasurably to the wealth of the southern states. Some crops occupy the land for a series of years and therefore do not often become parts in a rotation. Of such is alfalfa, now largely grown in the West and rapidly working its way into the East. But even this crop will probably tend more and more to occupy a place in rotation courses; and in the South (and even in other regions) this may be enforced in order to overcome disease affecting the plant.

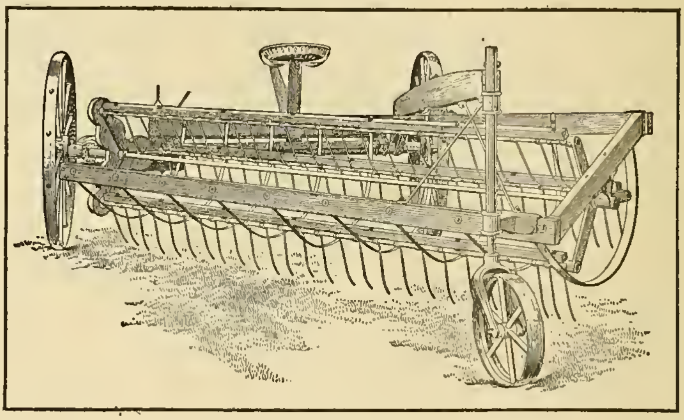


Fig. 127. Side-delivery rake of recent make.

Usually a rotation contains at least one "money-crop," that finds a direct and ready market; one clean-tilled crop; one hay or straw crop; one leguminous crop. Formerly the manure was applied mostly to one crop in the rotation, but the tendency now seems to be to distribute the application of some kind of fertilizer throughout the various years of the course. Some crops, however, may receive the coarse manure, others the fine or rotted manure, and others the chemical fertilizer. It is now thought that there is advantage in rotation of fertilizers. In the Norfolk system, manure is usually applied heavily with the root-course. Grass crops follow clean-tilled or "exhaustion crops." Pasturing eliminates the weeds of tillage, compacts the land following tillage-practice, and provides manure in the droppings of the animals.

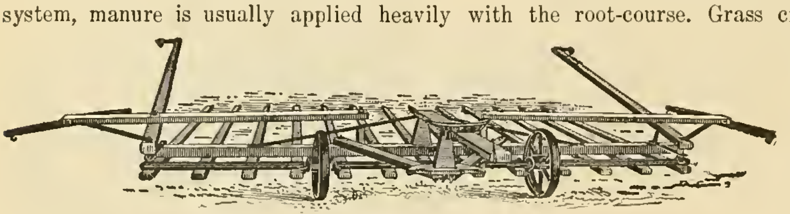


Fig. 128. A truss-frame sweep hay-rake.

The leguminous rotation crops most used in North America are red clover and cowpeas. The clover is adapted to the humid North, cowpeas to the South. The use of the cowpea supplies the missing link in the rotation for the South and makes humus; it adds nitrogen, obviating the necessity of depending on chemical fertilizers alone, which has been such an undesirable practice in the South. Velvet bean and beggar-weed are special leguminous crops sometimes employed in the extreme South.

Nearly all special crops can be grown without rotation, because the market value of their products is so high that the grower can afford to resort to extra manuring and other expensive practices in order to keep the land in good heart. This is the chief reason for the excessive use of stable-manure in market-gardening, a use which usually far exceeds the needs of the crops in mere plant-food. When the land is not too high-priced, it is a practice with gardeners to "rest" part of the land now and then in clover. Orchards do not lend themselves readily to rotation, although peaches generally do not follow peaches directly nor apples follow apples. In order to supply the humus to these lands and at the same time to secure the benefits of tillage, the practice of cover-cropping has lately come into practice. This is

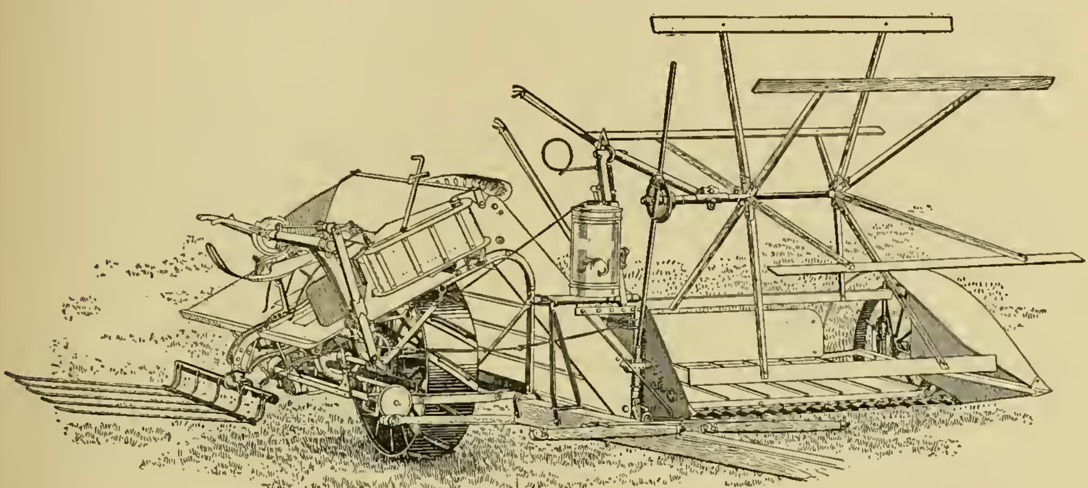


Fig. 129. The modern reaper and binder.

the use of some quick-growing crop that can be sown in midsummer or later, after tillage is completed; usually this is plowed under early the following spring. Acceptable cover-crops are crimson clover, vetches, peas, rye and sometimes buckwheat, rape or cereals.

In what Year each field was cropped with.	Suppose the six columns six fields, twenty Acres in each, shews six Sorts of Crops, to follow each other in Rotation, four of which are charged to this Account, but the two Clover crops go to maintain the Cattle and are charged to them.						Natural grass to accommodate this Farm	Meadow to accommodate this Farm
	A 20 acres	B 20 acres	C 20 acres	D 20 acres	E 20 acres	F 20 acres	G 20 acres	H 10 acres
1785	Wheat	Oats	Turnips	Barley	Clover grass	Clover hay	Grass	Meadow
1786	Oats	Turnips	Barley	Clover grass	Clover hay	Wheat	Grass	Meadow
1787	Turnips	Barley	Clover grass	Clover hay	Wheat	Oats	Grass	Meadow
1788	Barley	Clover grass	Clover hay	Wheat	Oats	Turnips	Grass	Meadow
1789	Clover grass	Clover hay	Wheat	Oats	Turnips	Barley	Grass	Meadow
1790	Clover hay	Wheat	Oats	Turnips	Barley	Clover grass	Grass	Meadow
The year of our Lord	£ 568 Total Produce of this Field in six years.	£ 568 Total Produce of this Field in six years.	£ 568 Total Produce of this Field in six years.	£ 568 Total Produce of this Field in six years.	£ 568 Total Produce of this Field in six years.	£ 568 Total Produce of this Field in six years.	This Field is charged to the Account of the Cattle fold.	This Field is charged to the Account of the Cattlefold, etc.

A contrast of rotations (to be compared with those on succeeding pages). Tabular view of "a regular Succession of Crops in Rotation," as proposed by Varlo in "A New System of Husbandry," Philadelphia, 1785. This is part of a farm scheme for a property of 150 acres, to be stocked with horses, cattle, hogs and sheep. Counting all labor and other outlay, Varlo estimates an annual expense for the six years of £265 16s., and an annual profit of £402 4s.

FARM MANAGEMENT

By *A. M. Teneyck*

Farm management is the application to personal farming of all the facts, principles and sciences related to agriculture. It includes the conducting or organizing of the farm, not only as regards present success and profits, but also with reference to the future fertility of the land. It is the crowning study in agricultural practice. A knowledge of the natural sciences and good judgment as to their applications, and skill in producing large crops and fine herds are important factors, but proper executive management of the farm and the farming business is the essential feature which largely determines success.

The discussion of many subjects may properly be included in a treatise on farm management. The proper consideration of this subject is a study of the farming business in all its wide variations of class, character and place, and it is possible in a short article to discuss briefly only some of the important phases of the subject.

The subject of crop management and rotations is likely to have strong local color, depending on the region in which the writer lives; but the nature of the problem is similar everywhere and many of the principles can be elucidated by any system. It is probably needless to say that this article is written from the prairie-states point of view.

Laying out the fields.

The first essential in introducing a definite system of soil management and crop rotation is that the farm be laid out uniformly in fields of nearly equal area. So far as possible the division lines of the several fields should follow the natural division lines of the land, which separate quarter-sections, sections, eighties, forties and so on. The size of the fields will be determined largely by the size of the farm and the kinds and number of crops. Often the average farm is cut up into many small fields, irregular in size and shape, while with large farms sometimes the fields are very irregular in size, some being very large and others small, making a regular system of crop rotation impossible. Figs. 130 to 133 illustrate practical plans for laying out the fields, and also show how the fields of a badly managed farm may be rearranged and made more uniform in size and shape, thus making it possible to rotate crops in a systematic way and to prescribe some definite system of maintaining the soil fertility. When possible, the fields should be laid out in rectangular form, with the longer distance extending east and west in order to give the crop as much protection as possible from the sun and wind. Small grain drilled east and west breaks the force of prevailing southern and northern winds more than the grain drilled north and south; also, the shading of one row by another seems to be of some benefit to the crop. The writer has observed that wheat drilled north and south rusted and blighted worse than that drilled east and west, and it is often remarked by farmers that larger yields of wheat may be secured by planting in drills east and west, than by drilling north and south. Also with corn, in dry, hot climates, there is an advantage in rowing east and west when the corn is planted in drill rows, as is the practice through a great part of the West and South, because the greater shading of the ground, when the corn is planted in this way, prevents to some extent the excessive heating and drying of the soil.

In some instances, as on sloping land, it may be advisable to lay out the fields with the longer distance extending north and south, in order that the tillage and cultivation of the crop may be across the slope, rather than up and down the slope, and other factors may make it desirable to lay out irregularly formed fields; but as a rule the practice should be to follow natural division lines of the land in dividing the farm into fields.

The sketches and diagrams and the discussion refer particularly to the laying out of new farms, or the rearrangement of farms that have not been improved to any extent, but many of the suggested features may be adapted successfully to the remodeling of old farms.

Roads, lanes, fences, shade trees, drains and irrigation ditches.

The plans for rotating crops proposed in this article call for the gradual fencing of a new farm, by which the expense may be distributed over several years at no serious inconvenience to the farming operations. The purpose is each year to fence the pasture, that being made a part of the crop rotation system. In this way an eight-year rotation on eight fields, in which a field is seeded to grasses each year and another grass field is broken up, will require eight years to fence the farm. It is not desirable to have too many permanent division fences between the several fields. Rather, the field division fences may be made temporary and easily movable. A permanent fence is a nuisance in the tilling of the land and the cultivation of the crop; it makes a harbor for weeds and throws good fertile soil out of use for cropping. However, it is not the purpose of this article to discuss the fence question. [See Vol. I, Chap. VII.]

From the plans already mentioned it is clear that, so far as possible, all roads and lanes that are necessary in getting to and from the several fields should follow the natural division lines of the land. In laying out new fields and in building permanent fences, this rule should be observed also. This is an element of handiness in measuring the area of fields, in keeping records, and in having an easy and accurate means of describing and locating each field in a farm. Permanent lanes with permanent fences should be established, leading from the barns and building site to the center of the farm, and from thence to the pasture and to every field that is included in the regular crop rotation system. By such an arrangement the live-stock may be sent to pasture without a driver, and if properly treated the cows will be at the bars in the evening when the farmer is ready to milk them. In certain sections of the country it is very important, and often necessary, to plant hedges and shade trees for the purpose of protection against wind and storms. Usually it is not desirable to have many hedges around the fields; and, although shade trees are necessary in the pasture, it is not best to distribute them over the field, but to have a group of trees in one corner or in some spot which takes little of the tillable land and does not interfere with the farming operations.

As regards drainage and irrigation ditches, the natural lay of the land will determine largely where they must be placed. In every well-regulated

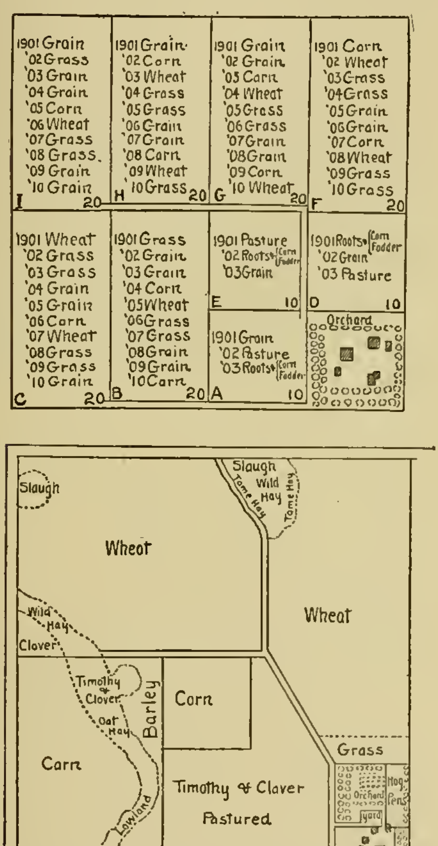


Fig. 130. Plan of farm before (below) and after (above) laying out into regular fields; also plan for rotation of crops. (Figs. 130–133 by Professor Wilson of Minnesota.)

farm a careful survey should be made and a thorough system of drainage established, so that the surface water may be readily removed from the yards and fields and carried to the natural drainage channels, and not left where it may damage the land and growing crops and form cesspools for the breeding of diseases. It is desirable in some sections of the country to build artificial ponds and lakes for catching the drainage water. Such places should not be made the wallows for cattle and swine, but should be surrounded with dry, grassy banks and kept clean and wholesome, otherwise they may become the breeding places for injurious germs and thus the source of disease.

A map of the farm.

An outline map of the farm is valuable and handy. It may often save steps in the directing of workmen and others to different parts of the farm. On a very large farm a map is almost a necessity. By means of a set of outline maps, very condensed records of the cropping of the different fields on the farm may be kept each year. The map should be large enough to note not only the crops growing on each field, but the dates of planting and harvesting, yield per acre, date of plowing, and other records of importance. A better plan still is to have a map small enough to be bound in book form, introducing with each map several blank pages on which the notes relating to each field may be written. Such maps may be readily printed at small expense from a zinc etching prepared from an original inked line drawing.

The several figures and diagrams here shown illustrate what is meant by the map of the farm. It is simply an outline drawing showing the division of the farm into fields, the location and plan of the building site, the location of lanes and roads, and the natural features which need notice, such as the groves, streams, draws, and the like. A careful survey of the farm will have to be made in order to locate properly the points and objects which need to be noted on the map. The map should be drawn accurately on a small scale, an inch to 50 or 100 feet. Almost any bright boy or girl, having exact measurements and distances and the area of the fields, with a little help can draw a map of this kind.

Soil management.

In the management of the farm, the handling of the soil is of the greatest importance. It is impossible to grow good crops on the same field year after year, except by thorough tillage and cultivation, the addition of fertilizers and the proper rotation of crops in order to maintain the fertility of the land. It has been truly said that "tillage is manure" to the crop. The plant-food of the soil is largely in an unavailable condition, and is made available for the use of plants only by the action of physical and chemical agencies. The presence of air and moisture is necessary that decomposition and chemical change may take place, by which the insoluble and unavailable plant-food elements are made soluble and available to the plants. Thus, tillage and cultivation, by aërating and pulverizing the soil, and by the conservation of soil moisture, make favorable conditions for the development of bacteria, hastening the processes of decomposition and chemical change which make the plant-food available.

Simple tillage, however, will not maintain the fertility of the soil. It becomes necessary finally to replace the plant-food, exhausted by the continuous growing of crops, with the application of manure or chemical fertilizers or by the rotation of crops, in which the legume crops, such as alfalfa and clover, are introduced in order to restore again the humus and nitrogen. When land has been farmed a long time in wheat or corn, it finally ceases to produce profitable crops. The soil is not necessarily exhausted in fertility, but by a long period of continuous cropping with one crop the diseases and insects which prey on the crop have accumulated in the soil, and the organic matter and humus and nitrogen have become more or less exhausted. The land is really "wheat sick" or "corn sick," as the case may be; what it needs more than anything else is a rotation of crops, which shall include legumes and grasses, by which the organic matter, exhausted by continuous cultivation and cropping with one crop, may be restored.

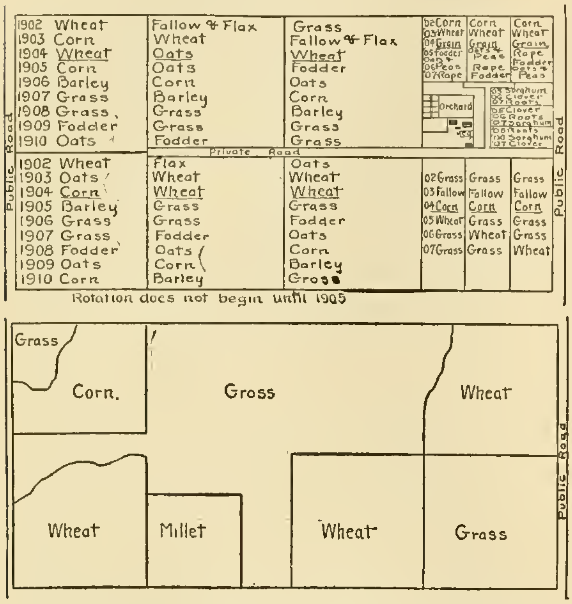


Fig. 131. Plan of farm before (below) and after (above) laying out into regular fields; also plan for systematic rotation of crops.

Grass is a soil-protector, a soil-renewer and a soil-builder. Covering the land with grass is nature's way of restoring to old, worn-out land the fertility and good tilth characteristic of virgin soil. The true grasses do not add nitrogen to the soil, as do clover, alfalfa and other legume crops, yet the grasses are, in a sense, nitrogen-gatherers, in that the nitrogen of the soil is collected and stored up in their roots. Thus, grasses prevent the waste of nitrogen and other plant-food elements and serve to protect the soil and to maintain its fertility. By their extensive and deep-penetrating root systems, many grasses also tend to break up and deepen the soil, gathering and storing plant-food in the roots and thus actually increasing the available plant-food content.

The legume crops, such as clover and alfalfa, not only accomplish all that grasses may accomplish, as described above, but also actually increase the total and available supply of nitrogen in the soil. By means of the bacteria which grow on the roots of legume plants, free nitrogen taken from the air in the soil is made available for the use of the plant, and not only may large yields of forage rich in nitrogen and protein be taken from land planted with legume crops, but by the great root-growth and the accumulation of humus by these crops the nitrogen of the soil is actually increased. Moreover, perennial legumes, such as clover and alfalfa, are very deep feeders; thus a part of the mineral elements of plant-food required by these crops is taken from depths in the soil below the feeding-ground of ordinary crops, and by the large root-growth in the surface soil there may be accumulated a supply of the mineral elements of plant-food which gradually becomes available, as the roots decay, to crops which follow the legume crops.

When the wild prairie is first broken, the soil is mellow, moist and rich, producing abundant crops. After a few years of continuous grain-cropping and cultivation, the physical condition of the soil changes—the soil-grains become finer, the soil becomes more compact and heavier to handle; it dries out quicker than it used to, and often turns over in hard clods and lumps when plowed. The perfect tilth and freedom from clods, so characteristic of virgin soils, is always more or less completely restored when land has been laid down to grass for a sufficient length of time.

Rotation of crops.

In order to maintain soil fertility, and at the same time to make the greatest profit in farming, a practicable and scientific rotation of crops should include the following:

(1) Grasses and perennial legumes.

(2) Pasture, with an addition of manure one or two years previous to breaking the sod.

(3) Intertilled crops.

(4) Small grain crops, with green-manuring crops planted in the stubble after harvest.

For a self-sustaining farm, small grain crops must be grown. Often they are the greatest money-making crops; hence they must be given a prominent place in the general crop rotation system. Intertilled crops are often the money-making items of the farm, also, and they are useful in a rotation plan in order that the land may be cleared of weeds. Especially is this true in a locality where small grain is the main crop. Cultivation also conserves the soil moisture and develops the fertility of the soil.

Pasture must be had on every farm carrying live-stock, and it is essential that it be made part of the regular crop rotation. Many soils become too light and mellow by continuous cropping and need the trampling of stock to firm them. Much more grass can be produced on tillable lands when the pastures are kept fresh and new, and the increase of fertility and improvement of soil texture result in larger crops of corn and grain when the meadow or pasture is broken and planted again to these crops. In some sections of the United States permanent pastures develop the best sod, and on many farms certain fields may be kept more profitably in grass than in any other crop; but such fields will not enter into the regular crop rotation system.

A convenient and desirable time to manure land is while it is being used as meadow or pasture. If the manure is applied a year or so before breaking, it will stimulate the growth of grass and cause a greater production of hay or pasture. Meanwhile, the soil is enriched by an increased root-growth and the formation of more humus. Besides these beneficial results, some plant-food will be supplied by the manuring for the use of the first crop that is grown on the breaking, at a time when available plant-food is much needed, because the larger part of the fertility in new breaking is in an unavailable condition and cannot be used readily by the new crop.

Soils in which the organic matter and humus are deficient may be improved in fertility and texture by green-manuring. A cheap and practical method of green-manuring is to plant a crop adapted to this purpose (the annual legume crops, such as cowpeas, soybeans, field-peas and vetches being preferred) in the grain stubble immediately after harvest. The method at the Kansas Experiment Station is to follow the binder directly with the drill; thus, when the harvest is finished the field has been replanted. Cowpeas, rape or sorghum seeded in this way usually make a good stand and an excellent growth, and furnish forage or pasture, or the crop may be plowed down for green-manure or left as a winter cover.

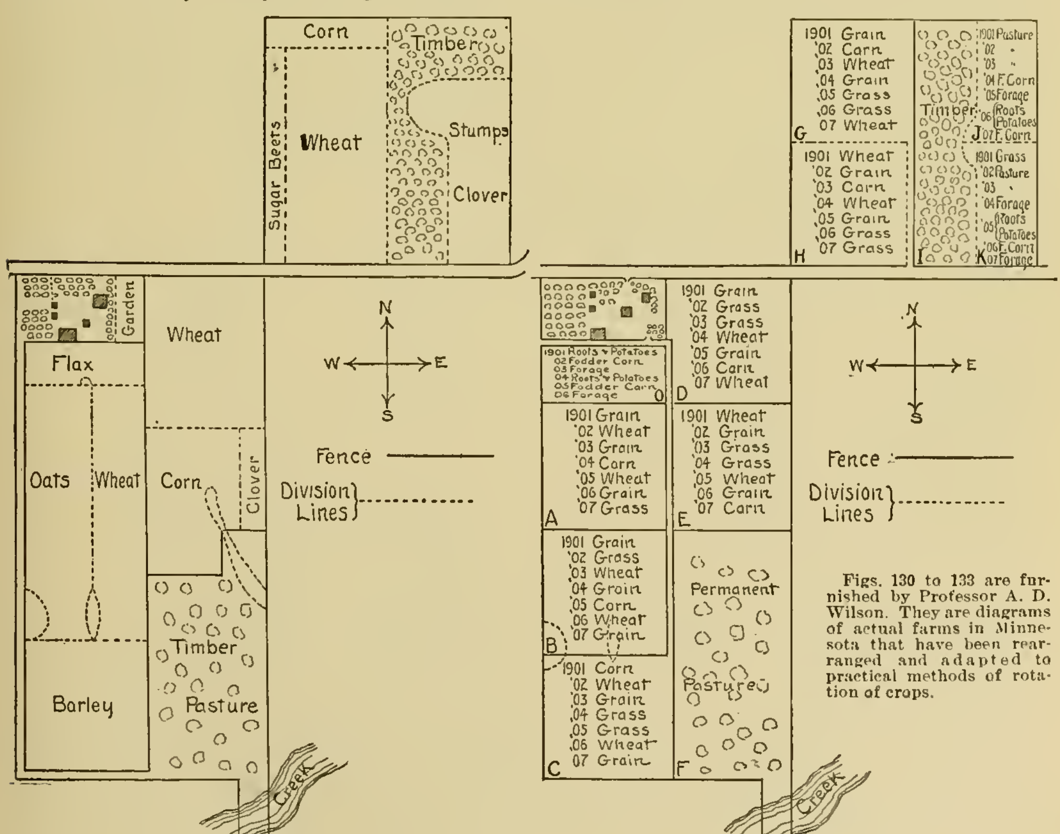
It is necessary, in carrying out permanent plans for crop rotation, to have fields of nearly equal area, in order to grow about the same acreage of the several crops each year, thus making it possible to keep a certain number of live-stock, and from year to year to have regularity and uniformity in the farming business.

In order to demonstrate the working of practical systems of crop rotation, as outlined, assume for illustration a farm of 160 acres, divided into eight equal fields, as shown in the diagrams:

Rotation Plan No. 1.

The farm plan, showing crops on all fields for one year.

Legumes and forage	Wheat
Wheat	Wheat
Wheat plus legumes	Pasture (manured)
Spring grains (seed to grass)	Grass and clover



Figs. 130 to 133 are furnished by Professor A. D. Wilson. They are diagrams of actual farms in Minnesota that have been rearranged and adapted to practical methods of rotation of crops.

Fig. 132. Plan of farm before (left) and after (right) laying out into regular fields; also plan for systematic rotation of crops.

Rotation plan, or order of crops on each field.

First year . . . . Grass and clover.
Second year . . . Pasture (manured).
Third year . . . Wheat.
Fourth year . . . Wheat.
Fifth year . . . . Legumes and forage.
Sixth year. . . . Wheat.
Seventh year. . . Wheat plus legumes.
Eighth year . . . Spring grains (seed to grass).

It will be observed that the crops growing on the eight fields each year are the same as the "order of crops on each field" in eight years. By carrying out successfully the above plan of rotation on a 160-acre farm, the farmer will raise each year 80 acres of wheat, 40 acres of grass and clover (20 of which may be used for pasture), 20 acres of small grains other than wheat, and 20 acres of forage crops, part at least consisting of annual legume crops. Each year 20 acres of grass land is given a dressing of manure, and a 20-acre field in wheat is renewed in fertility by a crop of cowpeas or other green-manuring crop planted after the wheat is harvested. Meanwhile, once in eight years the whole farm will have been seeded to grass and clover, each field remaining in grass two years.

This rotation is adapted to a wheat-growing country, and the money crop, wheat, is grown on one-half of the farm each year, while the other half of the farm is kept in crops that have a more or less renovating effect on the land, and which may be turned into money indirectly by feeding them to live-stock on the farm. In a corn country, corn may be substituted for wheat in the above rotation.

If this system of rotation does not leave the land in grass long enough, the farm may be divided and the following systems of rotation practiced on each division of four fields for eight years, when the systems may be interchanged, the first taking the place of the second, and the second of the first:

No. 1 A.

Rotation plan, or order of crops on each field.

First year . . . . . . Grass.
Second year . . . . . Grass.
Third year. . . . . . Pasture plus manure.
Fourth year . . . . . Pasture plus manure.
Fifth year . . . . . . Wheat.
Sixth year . . . . . . Wheat.
Seventh year. . . . . Wheat.
Eighth year . . . . . Wheat.

No. 1 B.

Rotation plan, or order of crops on each field.

First year . . . Legumes and forage.
Second year . . Legumes and forage.
Third year. . . Wheat.
Fourth year . . Wheat.
Fifth year . . . Wheat.
Sixth year . . . Wheat plus legumes.
Seventh year . . Spring grains.
Eighth year . . Spring grains (seed to grass).

It will be observed that this is really a double eight-year rotation, or, in fact, a sixteen-year rotation; that is, keeping each of the fields in grass four years at a time requires that one field be seeded to grass every two years and that one grass field be plowed every two years and planted again to wheat, requiring sixteen years before the whole farm shall have received a rotation with grass.

Rotation Plan No. 2.

The farm plan, showing crops on all fields for one year.

Corn	Corn
Corn	Small grains (seed to alfalfa in fall).
Alfalfa (manured)	Alfalfa
Alfalfa (manured)	Alfalfa

Rotation plan, or order of crops on each field.

First year . . . Alfalfa.
Second year . . Alfalfa.
Third year . . . Alfalfa plus manure.
Fourth year . . Alfalfa plus manure.
Fifth year . . . Corn.
Sixth year . . . Corn.
Seventh year . . Corn.
Eighth year . . Small grains (seed to alfalfa in fall).

If the above plan keeps too much land in alfalfa, the farm may be divided and the following systems of rotation practiced on each division of four fields for eight years, when the systems may be interchanged, the first taking the place of the second, and the second of the first:

No. 2 A.

Rotation plan, or order of crops on each field.

First year . . . . Alfalfa.
Second year . . . . . . Alfalfa.
Third year. . . . . . . Alfalfa plus manure.
Fourth year . . . . . . Alfalfa plus manure.
Fifth year . . . . Corn.
Sixth year . . . . Corn.
Seventh year . . . . . . Corn.
Eighth year . . . . . . Corn.

No. 2 B.

Rotation plan, or order of crops on each field.

First year . . . Legumes and forage.
Second year . . Legumes and forage.
Third year. . . Corn.
Fourth year . . Corn.
Fifth year . . . Corn plus manure.
Sixth year . . . Corn plus manure.
Seventh year. . Spring grains.
Eighth year . . Spring grains (seed to alfalfa).

It may be desirable to grow grass as well as alfalfa on the same farm in order to supply pasture for cattle and hay for horses and other stock. If this is so, then the alfalfa rotation plan may be slightly changed and a third system introduced, making a double eight-year or a sixteen-year rotation, as follows:

No. 2 C.

Rotation plan, or order of crops on each field.

First year . . . Alfalfa.
Second year . . Alfalfa.
Third year . . . Alfalfa plus manure.
Fourth year . . Alfalfa plus manure.
Fifth year . . . Corn.
Sixth year . . . Corn.
Seventh year . . Small grains.
Eighth year . . Small grains (seed to grass).

No. 2 D.

Rotation plan, or order of crops on each field.

First year . . . Grass.
Second year . . Grass.
Third year . . . Pasture plus manure.
Fourth year . . Pasture plus manure.
Fifth year . . . Corn.
Sixth year . . . Corn.
Seventh year . . Small grains.
Eighth year . . Small grains (seed to alfalfa).

The rotation will not ordinarily be perfected until the end of the third year, as most of the farms are growing corn and small grain almost exclusively.

This rotation of crops is well adapted only to a grain-farm that carries much live-stock. It will be observed that four fields, or one-half of the farm, is always in alfalfa or grass, but occasionally there may be only one field in alfalfa and three in grass, or vice versa; this is the result of the arrangement by which the seeding and breaking of grass and alfalfa sod is made to come in alternate years in order to distribute the work evenly from year to year. There will always be two fields of corn and two fields of small grain, although, if it were preferable, corn or some other crop might be grown instead of small grain, on one of these fields each year previous to the year in which the land is seeded down, and not interfere at all with the regular system of rotation.

A Rotation on Eight Fields with Alfalfa, Grass, Corn and Small Grain, being an Exhibit of Rotation Plans Nos. 2 C and 2 D.

Year	Field 1	Field 2	Field 3	Field 4	Field 5	Field 6	Field 7	Field 8
1906 . . .	Small grain (S A)	Corn	Corn	Corn	Small grain (S G)	Corn	Corn	Corn
1907 . . .	Alfalfa	Small grain	Corn	Corn (M)	Grass meadow	Small grain (S G)	Corn	Corn
1908 . . .	Alfalfa	Small grain (S A)	Corn	Corn	Grass meadow (M)	Grass meadow	Small grain	Corn
1909 . . .	Alfalfa (M)	Alfalfa	Small grain	Corn	Meadow or pasture (B)	Grass meadow	Small grain (S G)	Corn
1910 . . .	Alfalfa (B)	Alfalfa	Small grain (S A)	Corn	Corn	Meadow or pasture (M)	Grass meadow	Small grain
1911 . . .	Corn	Alfalfa (M)	Alfalfa	Small grain	Corn	Meadow or pasture (B)	Grass meadow	Small grain (S G)
1912 . . .	Corn	Alfalfa (B)	Alfalfa	Small grain (S A)	Small grain	Corn	Meadow or pasture (M)	Grass meadow
1913 . . .	Small grain	Corn	Alfalfa (M)	Alfalfa	Small grain (S A)	Corn	Meadow or pasture (B)	Grass meadow
1914 . . .	Small grain (S G)	Corn	Alfalfa (B)	Alfalfa	Alfalfa	Small grain	Corn	Meadow or pasture (M)
1915 . . .	Grass meadow	Small grain	Corn	Alfalfa (M)	Alfalfa	Small grain (S A)	Corn	Meadow or pasture (B)
1916 . . .	Grass meadow	Small grain (S G)	Corn	Alfalfa (B)	Alfalfa (M)	Alfalfa	Small grain	Corn
1917 . . .	Meadow or pasture (M)	Grass meadow	Small grain	Corn	Alfalfa (B)	Alfalfa	Small grain (S A)	Corn
1918 . . .	Meadow or pasture (B)	Grass meadow	Small grain (S G)	Corn	Corn	Alfalfa (M)	Alfalfa	Small grain
1919 . . .	Corn	Meadow or pasture (M)	Grass meadow	Small grain	Corn	Alfalfa (B)	Alfalfa	Small grain (S A)
1920 . . .	Corn	Meadow or pasture (B)	Grass meadow	Small grain (S G)	Small grain	Corn	Alfalfa (M)	Alfalfa
1921 . . .	Small grain	Corn	Meadow or pasture (M)	Grass meadow	Small grain (S G)	Corn	Alfalfa (B)	Alfalfa
1922 . . .	Small grain (S A)	Corn	Meadow or pasture (B)	Grass meadow	Grass meadow	Small grain	Corn	Alfalfa (M)
1923 . . .	Alfalfa	Small grain	Corn	Meadow or pasture (M)	Grass meadow	Small grain (S G)	Corn	Alfalfa (B)
1924 . . .	Alfalfa	Small grain (S A)	Corn	Meadow or pasture (B)	Meadow or pasture (M)	Grass meadow	Small grain	Corn

(M)=Manured. (B)=Break sod either in fall or spring. (S A)=Seed to alfalfa; this may be done in the fall and a catch of alfalfa secured without losing a crop. (S G)=Seed to grass, which may be done in the fall in the West and South, and in the spring with the grain in the central and eastern states.

With this plan of rotation practiced successfully, each of the eight fields in the farm will have been in alfalfa four years and in grass four years at the end of sixteen years of cropping, and in this period the entire farm will have been manured twice. Meanwhile four fields should have produced, each year, large crops of corn and grain. There is little question that a farm thus managed may be even more fertile at the end of the sixteen years than it was at the beginning.

ROTATION PLAN NO. 3.

The farm plan, showing crops on all fields for one year.

Grass	Corn
Pasture (manured)	Small grain
Corn plus legumes	Wheat (seed to grass)

Rotation plan, or order of crops on each field.

First year . . . . . . Grass.
Second year . . . . . Pasture (manured).
Third year . . . . . . Corn plus legumes.
Fourth year . . . . . Corn.
Fifth year . . . . . . Small grain.
Sixth year . . . . . . Wheat (seed to grass).

The above is a six-year rotation and cannot be well adapted to eight fields; it is given to show how crops may be arranged for a smaller number of fields.

ROTATION PLAN NO. 4. A SIXTEEN-YEAR ROTATION WITH ALFALFA, SMALL GRAIN AND CORN ON FOUR FIELDS.

YEAR	Field A	Field B	Field C	Field D
1906 * . .	Small grain (S)	Corn	Corn (M)	Corn
1907 . .	Alfalfa (M)	Small grain (CC)	Corn	Corn
1908 . .	Alfalfa	Corn (M)	Small grain (CC)	Corn
1909 . .	Alfalfa	Corn	Corn (M)	Small grain (CC)
1910 . .	Alfalfa (B)	Small grain (S)	Corn	Corn (M)
1911 . .	Corn	Alfalfa (M)	Small grain (CC)	Corn
1912 . .	Corn	Alfalfa	Corn (M)	Small grain (CC)
1913 . .	Small grain (CC)	Alfalfa	Corn	Corn (M)
1914 . .	Corn (M)	Alfalfa (B)	Small grain (S)	Corn
1915 . .	Corn	Corn	Alfalfa (M)	Small grain (CC)
1916 . .	Small grain (CC).	Corn	Alfalfa	Corn (M)
1917 . .	Corn (M)	Small grain (CC)	Alfalfa	Corn
1918 . .	Corn	Corn (M)	Alfalfa (B)	Small grain (S)
1919 . .	Small grain (CC)	Corn	Corn	Alfalfa (M)
1920 . .	Corn (M)	Small grain (CC)	Corn	Alfalfa
1921 . .	Corn	Corn (M)	Small grain (CC)	Alfalfa
1922 . .	Small grain (S)	Corn	Corn (M)	Alfalfa (B)
1923 † . .	Alfalfa (M)	Small grain (CC)	Corn	Corn

*It is assumed that this farm has been cropped largely with corn and small grains and has received little rotation of crops. No alfalfa is growing on the farm in 1906, when field "A" is seeded. The rotation really begins in 1907.

† Observe that this is a repetition of 1907 crops: viz., this rotation is repeated every sixteen years, each of the four fields having received a rotation of four years in alfalfa.

(S)=Seed to alfalfa in fall. (B)=Break alfalfa sod. (This should be done in the spring when the new catch of alfalfa by fall seeding is assured.) (CC)=Catch-crop, or green-manuring crop, planted in the stubble after the small grain is harvested. (M)=A dressing of barnyard manure applied in the fall and winter on alfalfa as a surface dressing, or on corn-stubble land and plowed under previous to planting the following crop of corn.

This plan of rotation is more readily understood in this way: It is really a three-year rotation on three fields, one of the four fields being kept continually in alfalfa, as shown in the plan. The order of the rotation on each field is corn, followed by corn, followed by small grain. Thus, two fields of corn, one of small grain and one of alfalfa are grown on the farm each year. At the end of four years the field in alfalfa, which has not been included in the three-year rotation, is plowed and planted to corn the succeeding season, while one of the three fields which has been in the regular rotation is seeded to alfalfa and comes out of the regular three-year rotation plan, remaining in alfalfa for four years, when this field is plowed and planted to corn and becomes one of the fields in the three-year rotation series; then another field that has been seeded to alfalfa is thrown out of the regular rotation system, and so on. It will be observed that such a plan may be followed with five fields, six fields, or, in fact, any number of fields. With four fields, by the method described, one-fourth of the farm is kept continually in alfalfa. With five fields, one-fifth of the farm would be in alfalfa each year, and it would take twenty years for the alfalfa rotation to be carried out on all the fields. With three fields, one-third of the farm would be in alfalfa all the time and the rotation system would be completed in twelve years.

Manure and fertilizers.

There is no waste on the farm which is so wanton and inexcusable as the too common waste of stable and barnyard manure. It is true that it is necessary to have well-drained yards, yet a side-hill barnyard may result in a great loss of the soluble elements of the manure unless provision is made for spreading the drainage from such yards over meadows or pastures. Also, in an open barnyard a liberal use of straw or other absorbents will often save in manure much more than the value of the bedding.

Probably the most economical method of handling manure is to haul it directly to the fields as fast as it is made and spread it at once. This is practicable in the handling of stable manure, but not with manure in open yards and sheds. However, if barnyard manure is exposed in open yards, the sooner it can be removed to the fields after the winter's feeding the better. The manure from the stable should not be thrown out under the eaves of the barn to leach; neither should it be thrown in large piles and allowed to fire, as is so often done. It is a good plan to feed cattle and other stock under sheds simply for the purpose of better preserving the manure.

The manure-spreader is a useful implement, and when the manure is handled regularly as made and spread in the fields, the spreader may be used very profitably on the farm that carries much live-stock. On the small farm, or on the farm in which the practice is to haul the manure out at intervals and turn all hands to the work for a time, the spreader cannot be used so advantageously. There is little question, however, but that in the spreading of large quantities of manure each year a good spreader will soon pay for itself, not only in the saving of labor but in the more even spreading of the manure, thus giving more uniform results and making the manure cover more land. The manure should be put on the grass land when grass is used in the regular order of rotation, as described above. [For a discussion of the economy of the manure-spreader, see Vol. I, Chap. VI, page 215; also page 499.]

Manure should be spread thinly, the purpose being to cover a large area of land with a relatively small quantity, rather than to give a very heavy dressing to a smaller area. When the manure is spread thinly, over a large area, the crop on the land may get all the value of the manure and no harm be done; but when spread thickly, especially when plowed under, the crops may not make full use of the manure, and often there is danger, especially in dry seasons, that the crop may be injured or destroyed by "burning out" of the soil. This means that the heavy coat of manure breaks the capillary connection between the soil and the subsoil, cutting off the supply of water and in a period of drought the crop suffers. The purpose and methods of green-manuring have already been discussed under crop management and rotation on preceding pages.

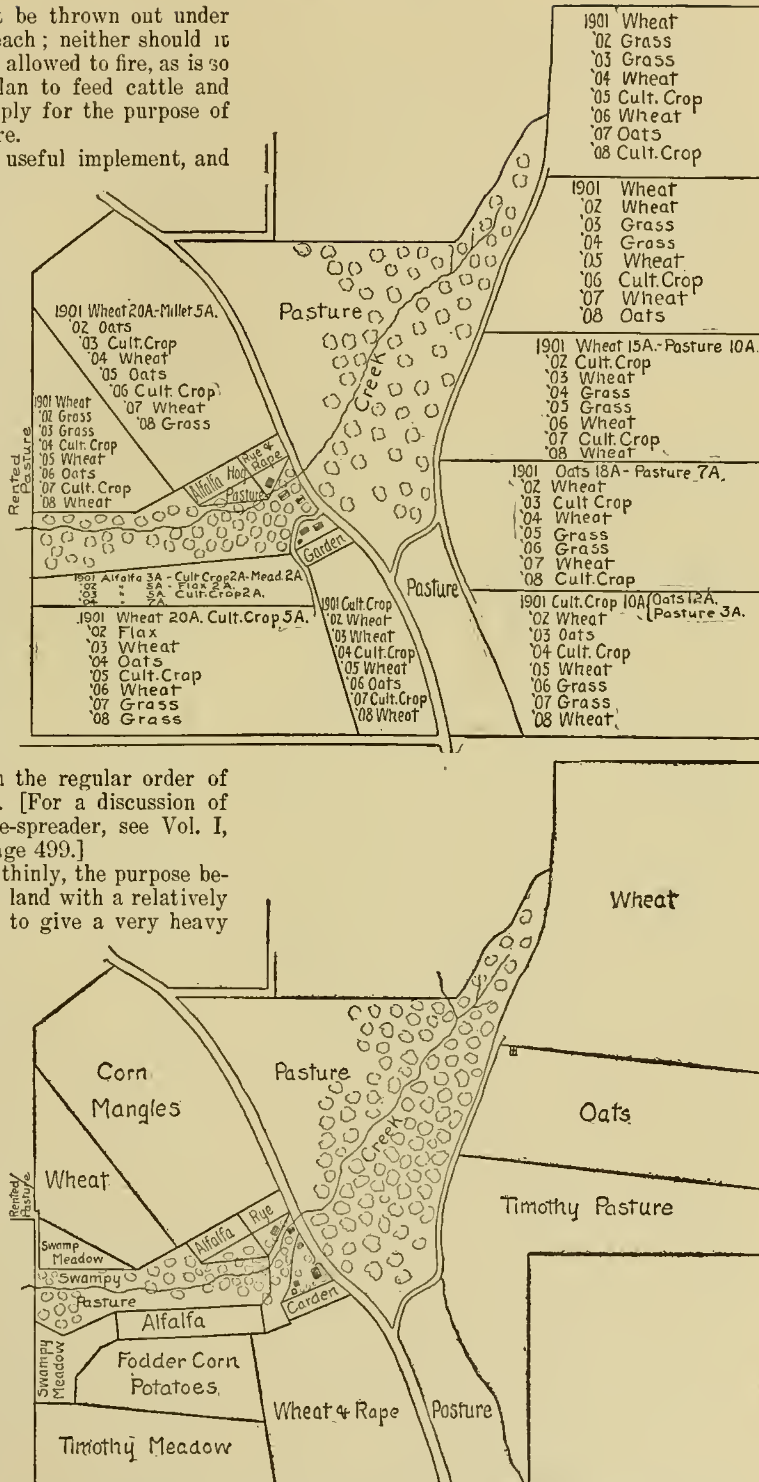


Fig. 133. Plan of farm before (below) and after (above) laying out into regular fields: also plan for systematic rotation of crops.

Crop practices.

Details cannot be given here of the planting, culture, harvesting, storing and marketing of the several staple farm crops. In general, successful farming depends on doing everything at the right time and in the right way. After a crop has been grown it should not be lost or allowed to become damaged by a little carelessness in handling or storing, through the negligence of the farmer. The quality of wheat and other grain often is injured seriously by harvesting too late, by leaving in the shock too long, by wetting or heating in the stack because of careless stacking, and by threshing and storing damp grain, resulting in bin-burning and other evils. Often wheat that might have graded No. 1 or No. 2, grades No. 3 and No. 4, or is rejected, simply because of the neglect in taking proper care of it. Much of the wheat sold grades low because of being mixed, or not pure in type. Farmers should grow well-bred, pure types of grains. Much of the corn which farmers sell grades as mixed because it is not pure in color. Pure white or pure yellow corn of the same quality as mixed corn will often sell for two or three cents more per bushel. The subject of crop breeding is now attracting great attention. It pays to breed and grow pure varieties of crops as well as of livestock.

The writer believes that farmers should store and hold their grain and not sell so largely at harvest time. This practice throws a surplus of grain on the market, which usually results in low prices and less profits to the farmer, and perhaps not always greater profits to the dealer. Grain may be stored and kept for a time in small quantities with less loss to the growers than to the dealers when the same grain is bought and stored in large quantities. This is especially true with corn, much of which is sold in the fall and early winter, too damp to keep well when stored in large quantities. It is true also of wheat and other grain that, when hauled from the threshing machine, it may be too damp to store in large elevators. There is a risk to the dealers in handling such grain, hence the low prices. Also, doubtless, there is a tendency on the part of the dealers to make as low prices as possible when the farmer sells the bulk of his crop. Some farmers are obliged to sell as soon as the crop has been harvested or threshed, needing the money and having perhaps no suitable storage room. But this is a hand-to-mouth method of living and farming, and the thrifty, experienced farmer will make himself independent of such conditions.

From the results of several trials at different experiment stations, it appears that the shrinkage of grain put into the bin in good condition is very slight, and corn put into the crib in the fall, fairly well cured and dry, will not lose over ten per cent in weight during the four or five winter months, the shrinkage usually being much less proportionately than the rise in price. Also, as sold in the fall, ten to fifteen per cent greater weight per bushel of ear corn is required by dealers than is required in the winter or spring.

The farmer should watch the market and sell at the highest prices. A good seller is usually a successful farmer. Farmers should give more attention to the marketing of their products in this day of trusts and combinations. They should coöperate and protect their interests in maintaining fair prices for their products. But let us urge that every farmer, by his own efforts as well as by coöperation, seek first to prepare for the market a prime article, which on its own merit will bring the highest price.

Literature.

There has been little published on farm management as such, though various phases of the subject have received much separate treatment. Such books as The Fertility of the Land, by Roberts; The Soil, by King; Cereals in America, by Hunt; Grasses, by Shaw, treat more or less on the subject of farm management. Somewhat fuller accounts will be found in Agricultural Economics, by Henry C. Taylor; Physics of Agriculture, F. H. King (chapter on Farm Mechanics); Chapters in History of Agriculture, T. F. Hunt. The most specific information will be found in the two bulletins, An Example of Model Farming, and Farm Management Investigations, by W. J. Spillman, United States Department of Agriculture; Successful Farming, by William Rennie, Sr., published by Wm. Rennie's Sons, Toronto. For farm bookkeeping: The Farmer's Business Handbook, I. P. Roberts, The Macmillan Co.; The Model Farm Record, Minnick, Bliss & Co., Chicago; Farm Account Book and Farm Record, E. A. Boehne & Sons, Hansen, Nebraska; Practical Bookkeeping for Farmers, published by H. G. Phelps, Bozeman, Mont. The importance of study of this subject is being recognized, and the future will find available much helpful farm-management literature.

THE TRIENNIAL CROP ROTATION SYSTEM

By *Hugh N. Starnes*

After the red-clay lands of the southern cotton-belt have been protected from erosion by terracing (Vol. I, page 402), experience has proved that a simple three-year crop rotation will rapidly restore their original fertility without materially deranging existing conditions or interrupting the continuous production of the three principal staples of that section—cotton, corn and oats. The two factors which simplify the process are (1) the retentive clay subsoil and (2) the rapid growth and effective service (both chemical and mechanical) of the cowpea. This valuable legume, in the space of 90 days, not only stores in the soil, through its decaying roots and stubble, a large quantity of vegetable matter for subsequent conversion into humus, and transfers from the atmosphere a considerable supply of immediately available nitrogen, but it also "pays its own way" while so doing. In principle, the process is of course not new, but its adoption as a practice is recent and by no means universal, as yet, though making rapid headway, particularly in Georgia.

Details of the system.

In brief, the details of the process are as follows: An equal farm area is devoted to each of the three staple crops. The best third is planted in cotton, the next best in corn and the poorest third in fall oats. The three areas need not be all in one body; indeed, it is seldom found possible, at the start, so to locate them. After the oats are harvested in June, the stubble is turned under and the area sowed broadcast with cowpeas, which are later cut and converted into either hay or ensilage, leaving only the roots and stubble to be turned under, since there would be no economy in utilizing a feeding material for a fertilizer at forage prices. The cowpea area is planted the second season in cotton, and the former cotton area is put in corn, while oats occupy the previous corn plat. With the corn, cowpeas are also generally planted, either in the drill after the corn is waist-high or upward, or sowed broadcast on "laying by," thus introducing a legume or nitrogen-gatherer into the rotation two years in three. The rotation is invariably (1) corn (with peas) after cotton, (2) oats and peas after corn, and (3) cotton after oats and peas—the grossest feeding crop, cotton, thus following the nitrogen-gatherer, the cowpea. The result, after two or three complete rotations, is an impressive increase in yield all around. Each crop, however, is, when planted, given its own specific fertilization, the formulas for which in the South are well-established standards.

Results.

At the end of the first rotation, that is to say in the fourth year, when the area first planted in cotton is again occupied by that crop, the increase in yield is always marked and frequently surprising (100 per cent is by no means uncommon); and the poorer the land originally the more likely is the percentage to be attained. For example, an initial yield of one-third of a bale, or 500 pounds of seed cotton per acre (the average output), often reaches two-thirds of a bale or 1,000 pounds of seed cotton, after the first rotation; one bale, or 1,500 pounds of seed cotton, after the second rotation ; and one and one-third bales, or 2,000 pounds of seed cotton, after the third rotation. Here uniform increase seems to stop. Given a sufficient supply of moisture there would be, theoretically, no limit to the increase in yield, since the mechanical condition of the soil would be steadily improving under its enlarging content of humus, which would of course render possible a corresponding increase in the application of commercial fertilizers for each staple. As the water-supply, however, is a most erratic factor, it is found in practice that after the third rotation (or tenth year), the yield fluctuates considerably, yet seldom falls short of one and one-third bales as a minimum and frequently, in more propitious seasons, attains a maximum of one and three-fourths to two bales per acre, in which there is a most satisfactory profit.

The increase in the yield of the other two staple crops is neither so uniform nor so large, relatively, as the increase for cotton, yet it is nevertheless very obvious.

When the available supply of lot manure, usually limited in the South, is distributed broadcast over the poorer spots, or "galls," in order to bring their fertility up to the average of the surrounding area, a terraced cotton-farm, subjected to the "triennial rotation" for ten or twelve years, presents a high type of progress, and becomes, with little cost or inconvenience, an impressive and profitable object lesson, and one that is fortunately placed each year more and more in evidence. The general adoption of the system throughout the entire cotton-belt is unquestionably assured.

EXAMPLES OF CROP ROTATION SYSTEMS IN CANADA, UNITED STATES, AND ELSEWHERE

By *S. Fraser*

The list following includes the most common rotations employed in America, in Great Britain and parts of the continent, and some in other lands. The effort is not to make a complete list of all crop rotations in use : this would be useless, if indeed not impossible. The more common ones that have come under the writer's notice, and that will serve to show the importance generally attached to crop rotation in the farm management scheme, are given. The same rotation may be in use in many states, but it is given in one place, only where some special significance attaches. The rotations given under any state or province, for this reason, may not be the ones in general use ; the latter will be found elsewhere on the list. In most cases, however, the rotation or rotations are the ones most generally accepted. A few states have been omitted, as it has been impossible for the writer to secure any authentic record of rotations in use. These rotations are made as a matter of record, not for recommendation ; nor is it to be understood that the persons cited as authorities necessarily recommend them, nor have they furnished them all. These records cannot fail to be suggestive to the reader.

1. Canada

Ontario. (G. E. Day.) Ontario Agricultural College Report, 1905.

4-course : 1, Rutabagas, mangels, potatoes, corn, barley, oats or peas ; 2, fall-sown wheat, or spring-sown oats or barley, and seeded to timothy and clover ; 3, meadow ; 4, meadow or pasture.

A modification of the above in use at Ontario Agricultural College is :

8-course : 1, Roots, corn or potatoes ; 2, fall-sown wheat, or spring-sown oats or barley, with four pounds of timothy and eight pounds of red clover per acre, and sometimes a little alsike clover; 3, meadow ; 4, dwarf essex rape, land plowed and cultivated until June, rape sown and grazed ; 5, barley, oats or peas (spring-sown); 6, fall-sown wheat, or spring-sown oats or barley, with four pounds of timothy, eight pounds of red clover and five to eight pounds of a mixture of orchard-grass, meadow fescue and tall oat-grass. The addition of the three latter grasses has proved of considerable value for pasture, enabling more stock to be carried per acre than on timothy and clover alone; 7, meadow; 8, pasture or meadow, cut once and then grazed, it being usually arranged to have the area in pasture so that it may be grazed with the rape. When stock have access to both grass and rape at all times, better results are secured than from either alone. This land is manured and fall-plowed for the succeeding root crop.

J. H. Grisdale, Experimental Farms Report, 1905, pp. 77–89:

3-course: 1, Oats; land plowed twice in previous fall, oats sown in spring and ten pounds of clover and ten pounds of timothy; 2, clover hay, manured in fall; 3, timothy hay or mixed clover and timothy.

3-course: 1, Oats; land plowed twice in previous fall, and twelve pounds of timothy sown with oats; 2, timothy hay, land manured; 3, timothy hay.

3-course. Primarily for feeding hogs: 1, Roots, turnips, carrots, mangels, sugar-beets; sugar mangels are grown, part being pastured by hogs; of these, mangels and sugar-beets were preferred by the hogs; 2, grain (oats, etc., with peas), used for soiling or the peas pastured when ripe. Alfalfa or some other pasture crop is sown with the grain crop; 3, hogs pastured on alfalfa or other crop, land manured and fall-plowed ready for the root crop.

3-course. Suitable for farmer having considerable rough pasture and desiring to keep considerable stock. Roots might be grown in place of some of the corn: 1, Corn, land manured and plowed the previous fall, depth of plowing about five inches. The land is again fall-plowed when the corn is cut; 2, grain, oats or barley spring-sown, with ten pounds of red clover, one pound of alsike clover, five pounds of timothy; 3, hay, mown twice, and manured and fall-plowed for succeeding corn crop.

3-course: 1, Corn, land manured the previous fall and winter and plowed in spring; 2, grain; oats or barley, spring-sown, with ten pounds of red clover, one pound of alsike clover, five pounds of alfalfa, five pounds of timothy seed per acre; 3, pasture. Thus far, pasturing the land, instead of mowing as in the previous rotation, has not been so remunerative.

4-course: 1, Roots; 2, grain (oats), land being fall-plowed if possible and ten pounds of red clover, one pound of alsike, ten pounds of timothy sown with the oats; 3, meadow, mown twice; 4, meadow, mown twice, land manured and fall-plowed.

4-course. For a sheep-farm: 1, Roots, areas of the following crops being grown to furnish a succession: White turnips, cabbage, rutabagas or swedes, kohlrabi, thousand-headed kale, rape, mangels, etc.; 2, grain, oats or barley, used for soiling or for grain as circumstances dictate. The following seeds are sown with the grain: Alfalfa, red clover, alsike clover, awnless brome and timothy; 3, meadow, mown once, the aftermath being devoted to pasture for newly weaned lambs; 4, pasture, manured in the fall and plowed for the succeeding root crop.

5-course: 1, Oats, with clover and timothy among; 2, meadow; 3, meadow, plowed twice in the fall and left ridged for winter; 4, oats, with ten pounds of red clover per acre as a cover and green-manuring crop, land manured in winter; 5, corn; land spring-plowed for the corn and fall-plowed after its removal if possible.

5-course: 1, Oats, with ten pounds of red clover, one pound of alsike clover, and five pounds of timothy per acre; 2, meadow, manured in the fall and winter; 3, corn or roots, land spring-plowed; 4, oats, with clover and timothy as before; 5, meadow, and land fall-plowed for succeeding oat crop.

6-course: 1, Oats, land fall-plowed, and ten pounds of red clover sown with the oats and allowed to grow until late fall, when it is plowed under; 2, oats or barley, with eight pounds of red clover and ten pounds of timothy per acre; 3, clover hay, mown twice and last aftermath not grazed; 4, mixed hay, land manured; 5, timothy hay; 6, timothy hay, land fall-plowed.

If straight timothy hay is desired all the time, no clover need be sown; such a course is not so profitable for general farming.

II. United States

Alabama. (J. F. Duggar.) Rotation not often attempted.

1, Corn with cowpeas between; 2, small grain, usually oats, with cowpeas; 3, cotton; 4, cotton or corn as before.

1, Cotton; 2, cotton; 3, cotton; 4, oats with cowpeas. (Wilcox county.)

Arkansas. Cotton continuously on bottom-land.

1, Corn; 2, cotton; 3, oats with cowpeas.

California. (E. J. Wickson.) Rotation not general, in fact, generally avoided. Grain crops are sometimes grown after beans or alfalfa. Watermelons, tomatoes, etc., are followed by grain. Grain and pasture are alternated.

1, Corn; 2, wheat; 3, oats. (Napa county.)

2-course: 1, Barley; 2, fallow. (Monterey county, etc.)

2-course: 1, Wheat; 2, fallow. (San Joaquin county, etc.)

1, Corn, for silage; 2, oats, for hay. (Sonoma county.)

Considerable multiple cropping is done on irrigated land.

Colorado. (W. H. Olin.) No general use of rotations.

1, Grain; 2–4, alfalfa, cut two or three times per year; 5–7, roots, potatoes, sugar-beets, etc.

1, Peas; 2, potatoes; 3, wheat; 4, fallow.

1, Potatoes; 2, wheat; 3, potatoes; 4, wheat; 5, alfalfa, one to several years.

Potato-growing sections. 8-course: 1, Potatoes; 2, potatoes; 3, wheat; 4, barley or oats and seeded to alfalfa; 5, 6, 7, 8, alfalfa, manured before plowing under for potatoes.

Connecticut. (L. A. Clinton.) Rotation common.

1, Corn, manured, cut for silage, and rye sown among for cover-crop and plowed under; 2, corn

Plate III. Harvester and binder at work. Indiana

cut for silage and rye sown in fall; 3, rye, and seeded to timothy and clover; 4, timothy and clover mown and retained as long as possible.

Tobacco continuously. (Hartford county.)

1, Corn, with rye as cover-crop; 2, rye plowed under and tobacco planted; 3, grass for one or more years. (Litchfield county.)

1, Tobacco; 2, tobacco; 3, corn; 4, tobacco; 5, clover. (Tolland county.)

Delaware. (A. T. Neale.) Rotations in general use.

Most common one, now in use over one hundred years: 1, Corn; 2, oats or potatoes; 3, wheat seeded with timothy and clover; 4, hay retained as long as considered profitable.

1, Corn, with crimson clover seeded in it; 2, crimson clover cut for seed and a volunteer crop allowed to grow until August, then plowed under and seeded to wheat; 3, wheat seeded with timothy and clover; 4 and 5, hay, or 4 hay; 5, pasture.

Dairy-farm. 1, Corn cut for silage, with crimson clover seeded in July; 2, crimson clover cut for hay in May, followed by corn cut for silage, with a late variety of crimson clover sown in it; 3, crimson clover cut for hay and land seeded to cowpeas cut for hay, and land seeded to wheat in September; 4, wheat and land seeded to timothy and clover; 5, hay; or the latter crop may be omitted if desired. A very successful rotation.

Florida. (C. M. Conner.) Rotation not largely practiced.

3-course: 1, Corn; 2, cotton; 3, velvet beans or cowpeas.

(G. K. Holmes) 1, Cotton; 2, corn with peanuts (Madison county).

1, Corn; 2, cotton; 3, corn; 4, cotton; 5, oats (Jackson county).

Multiple cropping is often practiced; thus, the following crops are often grown on the same land in one year: Cabbages, beans and hay; melons, sweet-potatoes and turnips; melons, sweet-potatoes and perhaps peas; two crops of hay and cabbage; cabbage, beans and hay; vegetables, followed by rice; corn, or cotton, followed by beggarweed (for hay in corn-fields but not in cotton-fields); tobacco, followed by Irish or sweet-potatoes, peas, turnips, etc.

A crop of hay is generally grown after all early cultivated crops.

Georgia. (R. J. Redding.) Rotation not common. See Alabama.

6-course: 1, Cotton; 2, cotton; 3, cotton; 4, oats with cowpeas; 5, corn with cowpeas; 6, oats or small grains with cowpeas. (Baldwin county.) Considered only as a compromise, with all the advantage in favor of the cotton.

3-course: 1, Corn, with cowpeas; 2, oats, with cowpeas; 3, cotton. Recommended by Georgia Experiment Station. On thin land it is recommended to extend it to a 4-course, as follows: 1, Corn, with cowpeas; 2, oats or wheat, with cowpeas; 3, oats or wheat, with cowpeas; 4, cotton.

Frequently two or three crops are grown on the same land in one year; thus, small grains, as oats, sweet-potatoes, potatoes, corn, cotton, cowpeas, millet, peanuts, sorghum hay, cabbage, watermelons, follow one another, and three crops are secured by growing these after a crop of oats or wheat.

Idaho. (H. T. French.) Rotation practiced to considerable extent.

7-course for irrigated land: 1-4, Alfalfa for four years; 5, wheat; 6, oats; 7, barley, seeded to alfalfa.

Northern part of state. 3 years: 1, Wheat; 2, wheat, oats or barley; 3, bare fallow.

5 or 6 years: 1, Wheat; 2, oats; 3, barley, seeded with timothy and clover; 4 and 5, timothy and clover.

Illinois. (C. G. Hopkins.) For the corn-belt:

Most common rotation: Corn for two or three years, followed by oats for one year. Sometimes clover is seeded with the oats and plowed under the next spring for corn.

4-course: 1, Corn, with cowpeas, soybeans or clover as a catch-crop, sown at last cultivation; 2, oats, with wheat seeded in fall; 3, wheat, clover seeded in spring; 4, clover, first crop used for hay, second for seed or grazed.

For the wheat-belt:

5-course: 1, Corn; 2, corn; 3, oats, with clover and timothy seeded; 4, meadow; 5, pasture.

4-course: 1, Corn; 2, oats; 3, wheat; 4, cowpeas or soybeans.

3-course: 1, Wheat, with cowpeas or soybeans as a catch-crop; 2, corn, with cowpeas or soybeans as a catch-crop; 3, cowpeas or soybeans.

Some multiple cropping is done, as: Rape in corn; cowpeas after rye or wheat; corn after strawberries; millet after winter rye, which has been used as pasture until June; millet, turnips or rape after early potatoes, etc.

Indiana. (A. T. Wiancko.) Rotation generally practiced.

The 3-course is most common: 1, Corn; 2, wheat; 3, clover, used either as hay or for seed production.

N. W. Indiana: 1, Corn; 2, oats; 3, clover.

4-course: 1, Corn; 2, oats; 3, wheat; 4, clover.

E. and S. Indiana: 1, Corn; 2, wheat; 3, clover; 4, grass.

2-course: 1, Wheat; 2, clover, fertilizers being applied to the wheat.

Iowa.

1, Corn; 2, oats; 3–5, grass and clover.

1, Corn; 2, oats; 3, clover.

1, Corn; 2, corn; 3, oats; 4 and 5, hay for two or more years. (Common.)

Kansas. (A. M. Ten Eyck.) Rotation not general.

Northeastern Kansas: 1, Corn; 2, wheat, oats or other small grains, and seed to clover and grass; 3–5, clover and grass.

Southeastern Kansas: 1, Corn; 2, oats; 3, wheat. For others, see article on Farm Management, page 90, by Professor Ten Eyck.

1, Kafir corn; 2, rye; 3, corn; 4, millet.

1, Kafir corn ; 2, corn.
1, Kafir corn ; 2, corn ; 3, sorghum.
Kafir corn is grown as a catch-crop after wheat.

Kentucky. (J. N. Harper.)
1, Kentucky blue-grass for several years, hemp for several years, corn two years, wheat, cowpeas, wheat, clover two years, timothy and Kentucky blue-grass ; grass land manured ; fertilizer applied to hemp and corn.

Tobacco, two years ; corn, three years ; wheat, two years ; clover, two years ; timothy and Kentucky blue-grass, the latter remaining for several years.

Tobacco ; corn, with peas ; wheat ; cowpeas ; wheat ; corn, two years ; oats ; cowpeas ; rye ; corn ; wheat ; clover ; timothy ; Kentucky blue-grass.

1, Corn ; 2, rye ; 3, clover ; 4, clover. (Clark county.)

1, Tobacco ; 2, rye ; 3, clover. (Grant county.)

1, Tobacco ; 2, wheat ; 3, clover. (Graves county, etc.)

1, Corn ; 2, tobacco ; 3, wheat ; 4 and 5, clover. (Christian county.)

Multiple cropping is practiced, as : Potatoes, followed by sweet corn, beans, corn, turnips, cabbage ; onions with cabbage ; rye and millet, soybeans, clover, cowpeas being sown with rape ; corn and small grains, with cowpeas, clover, etc.

Louisiana. (F. H. Burnette.)
2-course : 1, Cotton ; 2, corn with cowpeas.

Rice-growing : Rice for two years ; one year rest, with no crop.

Sugar-growing : Cane for three years ; corn with cowpeas.

In use in 1850 and maintained until the land became unproductive : 1, Cotton ; 2, cotton ; 3, corn.

Some multiple cropping is practiced. See Florida and Georgia.

Maine. (W. D. Hurd.) Rotation not general.
1, Potatoes ; 2, corn, manured, cut for silage ; 3, oats, seeded with grass and clover ; 4 and 5, hay.

Potato-growers' rotation : 1, Potatoes ; 2, oats or spring-wheat ; 3, grass and clover.

1, Oats ; 2 and 3, clover ; 4, potatoes. This requires but one plowing in four years, viz., that for the potatoes.

Maryland. (W. T. L. Taliaferro.) Rotation commonly practiced. General farming.

Very common : 1, Corn ; 2, wheat or oats ; 3, wheat, with grass and clover, stubble pastured ; 4, mixed hay cut once, second crop grazed ; 5, timothy cut once, second crop grazed.

1, Corn ; 2, wheat, followed by some rapid-growing cowpea ; 3, cowpeas plowed under and seeded to wheat with grass and clover ; 4 and 5, hay and pasture.

1, Corn with crimson clover between rows ; 2, crimson clover plowed under and corn planted ; 3, wheat ; 4, winter oats ; 5 and 6, timothy.

1, Corn ; 2, wheat ; 3, clover, pastured.

1, Tobacco ; 2, wheat with clover ; 3, clover grazed. Often the clover fails when sown so frequently, and the third course is largely weeds.

See Tennessee.

1, Corn, with cowpeas between the rows and crimson clover sown at last cultivation ; 2, clover plowed under and cowpeas put in for hay or silage ; 3, wheat, with timothy and clover ; 4 and 5, hay.

Massachusetts. (Wm. P. Brooks.) Rotation generally practiced.

Dairy-farming, 5-course, soil medium loam, good: 1, Corn, manured for grain ; 2, corn, manured, cut for silage and grass and clover sown in the corn ; 3, grass and clover mown twice ; 4, grass and clover, sometimes fertilized and mown twice ; 5, grass and clover, usually fertilized and mown twice.

5-course. Heavy loams. Good: 1, Corn, manured ; 2, oats, with grass and clover seeds ; 3, 4, 5, grass and clover, usually mown twice and fertilized the last two years.

5-course. Light soil. Fair : 1, Corn, manured, for silage ; 2, corn, manured, for grain ; 3, rye, with grass and clover seeds ; 4 and 5, hay cut twice a year and fertilized.

Potato-growing, 5-course. Medium to light soils. Good : 1, Potatoes fertilized ; 2, corn, for silage, manured ; 3, oats, cut for hay, and seeded to grass and clover ; 4 and 5, hay, cut twice a year and fertilized.

3-course. Light soils. Poor : 1, Potatoes with fertilizers ; 2, winter rye ; 3, clover.

4-course. Light soils : 1, Corn manured ; 2, potatoes with fertilizers ; 3, rye ; 4, clover.

1, Corn ; 2, oats ; 3, rye ; 4 and 5, grass and clover. (Hampden county.)

In Buckland : 1, Corn, manured ; 2, oats manured, and land laid to grass, which was allowed to grow until the yield dropped to 1,500 pounds per acre. First crop usually 2 tons per acre.

In Shelburne, on one of the best farms : 1, Corn on a grass sward, manured; 2, spring-wheat, laid down to grass or sometimes rye ; then oats, or oats and peas ; then wheat, with grass ; grass remaining for five years.

In Deerfield : 1, Corn, manured ; 2, spring-wheat, or wheat and oats, or rye with southern clover ; 3, clover, then plowed again.

Sometimes an early crop of hay is followed by millet, barley or winter squash ; green rye by corn, oats or millet ; oat hay by barley.

Coleman in Fourth Report of Agriculture, Mass., 1841, says that rotation is limited.

Michigan.
1, Corn ; 2, rye ; 3, clover. (Gratiot county.)

1, Corn ; 2, rye ; 3, rye ; 4 and 5, clover. (Allegan county.)

Minnesota. (A. D. Wilson.)
3-course for dairy sections : 1, Grain, as oats, etc.; 2, clover ; 3, corn.

5-course : 1, Wheat, seeded to grass and clover ; 2, meadow; 3, pasture; 4, grain, usually oats; 5, corn, manured at eight tons per acre.

Grain-growing. 7-course : 1, Corn ; 2, wheat and seed to grass ; 3 and 4, grass ; 5, 6, 7, grain crops with clover or rape among the grain, on at least one occasion, and plowed under as green-manure.

4-course : 1, Corn ; 2, peas ; 3, barley ; 4, clover.

5-course : 1, Wheat ; 2, clover and timothy, mown ; 3, meadow ; 4, oats ; 5, mangels or potatoes.

1, Wheat ; 2, wheat ; 3, oats ; 4, wheat ; 5, flax.

1, Corn ; 2, wheat ; 3, wheat ; 4, oats.

1, Barley ; 2, barley ; 3 and 4, clover.

1, Barley ; 2, corn ; 3, oats ; 4, corn ; 5, wheat. Last four poor.

Mississippi.

1, Cotton, with annual vetch in winter, continuously.

1, Corn and cowpeas continuously.

2-course : 1, Oats and cowpeas ; 2, cotton.

2-course : 1, Corn and cowpeas ; 2, cotton.

3-course : 1, Cotton ; 2, corn and cowpeas ; 3, oats and cowpeas.

3-course. Poor : 1, Cotton ; 2, cotton ; 3, corn (poor).

Missouri. (M. F. Miller.) Systematic rotation not largely followed.

Common rotation on black loam : Corn for one to five years, followed by oats or wheat, seeded with timothy and clover (left for two or three years).

Stony loam : 1, Corn ; 2, corn ; 3, wheat ; 4, clover or clover and timothy, in which case the timothy may again be cut the fourth year.

Montana. (A. Atkinson.)

6-course : 1, Wheat ; 2, clover ; 3, oats ; 4, sugar-beets ; 5, barley ; 6. peas.

3-course : 1, Wheat and barley ; 2, clover ; 3, roots and peas.

Most common one : 1, Barley ; 2, clover ; 3, clover ; 4, oats or wheat ; 5, wheat.

New Hampshire. (F. W. Taylor.) Few definite systems in use.

Dairying, clay loams. 6-course. Good : 1, Corn ; 2, corn ; 3, oats and peas, with grass and clover seeds ; 4, 5, 6, hay or pasture.

Loams. 7-course. Good : 1, Corn ; 2, corn ; 3, potatoes ; 4, oats and peas ; 5, 6, 7, clover and timothy for hay or pasture.

8-course : 1, Corn ; 2, potatoes ; 3, barley seeded with clover and grasses ; 4, clover hay ; 5–8, grasses, used for hay or pasture.

Upland light loam, used by Prof. J. W. Sanborn, Gilmanton, N. H.: 1, Corn ; 2, oats and peas ; 3, clover ; 4, potatoes ; 5, Hungarian (millet) ; 6, 7, timothy (hay) ; 8, pasture.

New Jersey. (E. B. Voorhees.) General farming.

Medium clay loam. 4-course : 1, Corn ; 2, oats ; 3, wheat ; 4, timothy and clover.

Heavy clay loam. 5-course : 1, Corn ; 2, oats ; 3, 4, 5, hay.

Same. 4-course : 1, Corn ; 2, wheat ; 3, 4, hay.

Loam. 4-course : 1, Corn ; 2, potatoes ; 3, wheat ; 4, hay, timothy and clover.

3-course : 1, Potatoes ; 2, wheat ; 3, clover. Has been used by T. B. Terry, Ohio, for several years, but he is abandoning it now, since a clover crop every third year is too frequent.

Sandy loam. 4-course : 1, Corn ; 2, tomatoes ; 3, white potatoes (early) ; 4, clover.

Light sandy loam. 4-course : 1, Corn ; 2, sweet-potatoes ; 3, rye ; 4, clover.

Dairying. Clay loam. 3-course : 1, Corn (cut for silage) ; 2, rye ; 3, timothy and clover.

Medium loam. 3 years : 1, Corn (cut for silage) ; 2, oats and peas, followed by millet or cowpeas ; 3, rye.

New York.

Gravel loam : 1, Potatoes, with rye sown in fall ; 2, rye, with clover sown in spring and plowed under for potatoes. No manure or fertilizers used. Successful for past twelve years.

3-course : 1, Beans ; 2, wheat ; 3, clover.

4-course : 1, Potatoes or corn ; 2, beans ; 3, wheat and sown to clover ; 4, clover cut for hay.

4-course : 1, Wheat, manured and seeded to clover ; 2, clover hay ; 3, potatoes, cabbage or corn ; 4, oats.

5-course : 1, Corn, manured ; 2, oats ; 3, rye, manured, with grass seeds ; 4 and 5, grass and clover hay.

Heavy loams, 4 crops in three years : 1, Rye or oats, with clover ; 2, clover, cut once, land plowed and sown to buckwheat ; 3, potatoes.

3-course : 1, Corn ; 2, wheat or oats ; 3, timothy and clover for hay.

4-course : 1, Rye, seeded to clover, etc. ; 2, clover and timothy ; 3, corn or potatoes ; 4, oats or barley.

4-course : 1, Wheat, manured, seeded to clover and timothy ; 2, clover and timothy (hay), manured before plowing ; 3, corn or oats ; 4, barley or beans.

Clay, 6-course : 1, Corn ; 2, oats ; 3–5, hay ; 6, pasture.

5-course : 1, Beans, cattle beets or cabbage ; 2, oats, with timothy and clover ; 3, meadow ; 4, meadow ; 5, pasture.

Cornell University 4-course. Very successful for over thirty years. Dairy-farm, with one-third of area in permanent pasture. Clay loam : 1, Corn (manured), cut for silage ; 2, oats ; 3, wheat (manured), and timothy and clover sown ; 4, meadow, cut twice.

Dairy-farm : 1, Corn, cut for silage ; 2, oats and peas ; 3–5, grass and clover. (Delaware county.)

1, Strawberries planted ; 2, strawberries harvested in June, land plowed and sown to rutabagas, followed by rye, which is plowed under the next spring for strawberries.

1, Corn ; 2, cabbage ; 3, peas, followed by buckwheat ; 4, oats ; 5, wheat, with grass seeds ; 6, meadow.

Used in western part of Long Island, mentioned by General Washington in 1790 : 1, Indian corn on clay, manured in the hill or scattering the dung broadcast ; 2, oats or flax ; 3, wheat, with what manure can be spared, seeded with 4 to 6 pounds of clover and a quart of timothy; 4, meadow, left down three to six years.

For dairy-farm, soil gravel loam; 33 per cent of the land permanent pasture, the remainder cropped as follows: 1, Corn, manured, cut for silage, clover to be sown at last cultivation; 2, land manured, plowed and sown to peas for canning; land disked after peas come off and sown to clover, which is grazed in fall; 3, land plowed, sown to barley or oats with alfalfa, grain crop cut for hay; 4, 5, 6, alfalfa, mown three times a year and manure applied in fifth and sixth years; 7, corn, cut for silage, with clover sown; 8, clover mown twice and manured in fall, or oats; 9, potatoes, beans, sugar-beets or cabbage; 10, wheat, manured, with grass and clover seeds; 11, clover and grass, mown twice; 12, pasture. Some straw or other material will need to be purchased for bedding. Part of the alfalfa will be mown green for soiling the cattle. Surplus hay may be sold, also peas, potatoes, wheat, to furnish cash to buy concentrates.

North Carolina. (C. K. McClelland.)

Cotton-growing districts:

2 years: 1, Cotton, followed by crimson clover; 2, corn with cowpeas.

3 years: 1, Cotton, followed by crimson clover; 2, corn; 3, wheat, followed by cowpeas.

3 years. Cotton and grain: 1, Rye, wheat or oats; 2, cotton; 3, corn. A poor rotation, no legumes included.

3 years. Cotton and grain: 1, Cotton; 2, corn with cowpeas; 3, wheat, followed by cowpeas. Better than one above.

Tobacco-growing districts. 2 years: 1, Tobacco; 2, wheat, followed by cowpeas.

4 years: 1, Clover; 2, corn with cowpeas; 3, tobacco; 4, wheat seeded to clover.

Grain-growing. 2 years: 1, Corn with cowpeas, latter not harvested; 2, wheat, followed by cowpeas or crimson clover.

Corn and potatoes: 1, Corn with cowpeas, followed by rye; 2, Irish potatoes, followed by vetch or crimson clover.

Corn and potatoes. 4 years: 1, Corn with cowpeas; 2, oats with red clover; 3, clover; 4, Irish potatoes.

Forage. 5 years: 1, Corn; 2, oats with red clover; 3, clover; 4, cowpeas for seed or hay; 5, wheat.

1, Cotton; 2, corn; 3, peanuts.

1, Corn with cowpeas or crimson clover; 2, peanuts; 3, oats with cowpeas; 4, peanuts.

1, Corn with cowpeas; 2, peanuts; 3, cotton; 4, cotton.

North Dakota. (J. H. Shepperd.) Rotations not settled.

1, Wheat; 2, flax; 3, oats; 4, barley; 5, fallow. (Benson county.)

1, 2, Flax; 3, 4, small grain (Ramsey county.)

1, Corn; 2, flax; 3, wheat; 4, oats. (Cass county.)

1, Wheat; 2, wheat; 3, flax; 4, wheat; 5, oats. (Grand Forks county.)

Ohio.

1, Tobacco; 2, wheat; 3 and 4, grass and clover. Also, 1, Corn; 2, beardless barley; 3–6, alfalfa. (J. E. Wing.)

3-course: 1, Tobacco; 2, wheat; 3, clover.

3-course: 1, Corn, manured; 2, wheat; 3, clover.

4-course: 1, Corn; 2, soybeans or cowpeas; 3, wheat; 4, clover.

5-course: 1, Corn; 2, oats; 3, wheat; 4 and 5, timothy and clover.

T. B. Terry's 3-course: 1, Potatoes; 2, wheat; 3, clover. Has been considerably used in England. (See Bavaria, p. 107.) This rotation "keeps the land moving." It repeats clover every third year and thereby becomes a great rejuvenator of the land.

Oklahoma. (F. C. Burtis.) Rotation not general.

3-course: 1, Corn; 2, oats; 3, wheat and cowpeas.

5-course: 1, Castor-beans; 2, kafir corn; 3, cotton; 4, oats; 5, wheat and soybeans.

1, Corn; 2, kafir corn; 3, sorghum. (Greer county.)

Wheat and kafir corn the same year continuously.

Kafir corn continuously.

Oregon. (James Withycombe.) Many practice rotation.

Dairying: 1, Corn, cut for silage and wheat drilled in between rows; 2, wheat; 3, clover; 4, clover; 5, wheat.

2-course: 1, Barley or oats; 2, vetch.

1, Wheat; 2, oats; 3, corn or fallow. (Marion county.)

1, Wheat; 2, oats; 3, oats; 4, grass and clover.

Pennsylvania. (G. C. Watson.) Rotation common and long practiced.

Clay loam: 1, Corn; 2 oats; 3, wheat or rye; 4, clover and timothy for one or two years.

5-course: 1, Corn; 2, tobacco; 3, wheat; 4, wheat; 5, clover and timothy.

5-course: 1, Potatoes; 2, oats; 3, wheat; 4, wheat; 5 clover and timothy.

4-course: 1, Tobacco; 2, oats; 3, wheat; 4, meadow. (Clinton county.)

Gravelly soils: 1, Corn; 2, oats; 3, clover; 4, oats; 5, clover and timothy.

Gravelly soils: 1, Corn; 2, oats; 3, rye, clover and timothy; clover and timothy are left down as long as desirable, frequently two or three years, the second and subsequent crops being largely timothy.

John Beale Bordley, on the rotation of crops, 1792, Philadelphia, Pa.:

Old English: 1, Fallow; 2, wheat; 3, peas or beans; 4, barley. Maintained on half the farm for ten or twenty years, the other half being in grass, then vice versa.

New English (suggested): 1, Barley; 2, clover; 3, wheat; 4, clover: 5, peas, beans or turnips.

Old American systems: 1, Maize; 2, wheat or rye; 3, rubbish pasture.

1, Maize; 2, naked fallow; 3, wheat; 4, rubbish pasture.

Yields of wheat six to eight bushels per acre.

Suggested systems: 1, Maize; 2, wheat or barley; 3, clover; 4, rye or winter barley; 5 and 6, clover.

1, Maize; 2, beans; 3, barley; 4, clover; 5, wheat; 6, clover for one or two years.

Montgomery county, 5-course. In use over one hundred years: 1, Corn on sod, limed and plowed in fall or spring; 2, oats; 3, wheat with timothy sown in fall and red clover in spring; 4, clover and timothy mown; 5, pasture.

The old York and Lancaster rotation is similar to the above, but the grass is left down longer.

A successful rotation long practiced in parts: 1, Wheat; 2, rye; 3, clover; 4, wheat; 5, corn; 6, oats; 7, wheat; 8, clover.

Porto Rico. (D. W. May.) Rotation not general in the island.

Low land: Sugar-cane for three to eight years, and then Para grass cut and sold.

A better rotation would be: Sugar-cane, rotated with cowpeas or alfalfa, the latter being fed and the manure returned to the soil.

Rhode Island. (H. J. Wheeler.)

3-course: 1, Winter rye, with clover sown in spring; 2, clover hay; 3, potatoes.

4-course: 1, Winter rye, with red clover sown in spring; 2, clover hay; 3, maize on clover sod; 4, potatoes.

5-course: 1, Rye, seeded with grasses and clover; 2, hay; 3, hay; 4, corn; 5, potatoes.

6-course: 1, Corn, on grass sod; 2, potatoes; 3, winter rye, seeded to red clover, timothy and redtop; 4–6, grass. When the land is poor it is better to begin the rotation with rye.

Market-garden: 1, Sweet corn (Cory), followed by beans, with clover sown at last cultivation as a cover-crop; or beans followed by corn (Crosby), with clover as cover-crop; 2, clover plowed under, tomatoes planted and rye sown as cover-crop in fall; 3, potatoes (early), followed by cabbage, or early cabbage followed by carrots; 4, spinach, followed by celery, followed by spinach again, or transplanted lettuce followed by celery.

South Dakota. (J. S. Cole.) Rotation not general.

In northern and western parts of state: Corn, potatoes or other intertilled crop, followed by wheat.

In southern and eastern parts of state: Barley or oats grown instead of wheat.

South Dakota Experiment Station. The following is a list of twenty-four rotations which are now, and have been, on trial for the past ten years: 1, Flax; 2, barley; 3, millet; 4, wheat; 5, corn.—1, Wheat; 2, oats; 3, peas (fed off by stock); 4, wheat; 5, roots.—1, Oats; 2, wheat; 3, fallow; 4, wheat; 5, corn.—1, Wheat; 2, barley; 3, peas, plowed under for manure; 4, wheat; 5, corn.—1, Wheat; 2, oats; 3, corn; 4, flax; 5, millet, fed off by stock.—1, Wheat; 2, barley; 3, peas; 4, wheat; 5, corn, fed off by stock.—1, Wheat; 2, corn; 3, wheat; 4, oats.—1, Wheat; 2, corn; 3, oats; 4, millet.—1, Wheat; 2, corn, land manured; 3, wheat; 4, oats.—1, Wheat; 2, corn; 3, oats.—1, Oats; 2, fallow; 3, wheat.—1, Barley; 2, millet; 3, wheat.—1, Barley; 2, peas; 3, wheat.—1, Wheat; 2, wheat; 3, fallow.—1, Wheat; 2, wheat; 3, corn.—1, Wheat; 2, fallow.—1, Wheat; 2, corn. —1, Wheat; 2, vetch.—Wheat continuously, no manure.—Wheat continuously, manured every five years.—Wheat continuously, manured every three years.—Wheat continuously, manured every year. —1, Wheat, seeded to awnless brome-grass; 2, brome-grass; 3, brome-grass; 4, flax; 5, wheat; 6, corn.—1, Wheat, seeded to awnless brome-grass; 2, brome-grass; 3, brome-grass; 4, wheat; 5, corn.—(For details of these rotations, see South Dakota Bulletins, Nos. 79, 98, and Yearbook, United States Department of Agriculture, 1903, pp. 447–452.)

Tennessee. (H. A. Morgan.)

1, Wheat and cowpeas. (Same rotation is used year after year)

2-course: 1, Wheat and cowpeas; 2, corn.

4-course: 1, Wheat seeded to clover; 2 and 3, clover; 4, corn.

1, Cotton; 2, corn with cowpeas sown in it; 3, oats followed by cowpeas the same year.

1, Corn; 2, wheat; 3, grass for two to three years.

5-course: 1, Cowpeas, followed by rye (plowed under the following spring); 2, cowpeas; 3, corn; 4, wheat; 5, clover or cowpeas.

1, Wheat; 2, clover; 3, clover (pastured); 4, wheat, peas; 5, corn (peas planted in the corn); 6, oats followed by cowpeas.

Common dairy-farm rotation: 1, Corn or sorghum or corn and sorghum; 2, wheat, seeded to clover; 3, clover.

Utah. (W. M. Jardine.) Rotation little considered in the state.

Sandy loam, 5-course: 1, Sugar-beets; 2, peas and oats for forage; 3, sugar-beets; 4, oats, seeded to alfalfa; 5, alfalfa, two crops mown, third plowed under.

1. Corn (manured); 2 sugar-beets; 3, peas for forage; 4, sugar-beets; 5, wheat, preferably followed by alfalfa, making a six- or seven-year course.

Virginia. Rotations long established.

1, Irish potatoes (2 crops); 2, sweet-potatoes; 3, sweet-potatoes; 4, corn. (Accomac county.)

1, Potatoes followed by corn; 2, oats, followed by cowpeas.

1, Corn; 2, wheat; 3, clover; 4, wheat; 5, oats or pasture.

1, Corn; 2, wheat or oats; 3, wheat; 4, hay for two to nine years.

In use in 1800, and previously (Farmers' Register, Va.): 1, Corn; 2, wheat or oats; 3, land allowed to grow weeds, which were grazed.

On poorer land: 1, Corn; 2, natural cover of weeds, either grazed or burned off.

4-course, along James river, A. D., 1800: 1, Corn or oats; 2, wheat and clover; 3, clover grown as green-manure and plowed under; 4, wheat.

1, Tobacco; 2, wheat; 3 and 4, clover.

1, Tobacco; 2, wheat.

1, Corn with cowpeas or crimson clover sown among; 2, peanuts.

1, Corn with cowpeas; 2, peanuts; 3, cotton; 4, cotton.

1, Corn (soiling crop); 2, oats or other grain; 3–5, hay and pasture.

Colonel Taylor's rotation, about one hundred years ago: 1, Corn; 2, wheat and clover; 3 and 4, clover, neither mown nor grazed. His idea was that this was necessary to prevent depletion of the soil.

The Eastern Shore rotation consisted of three crops in two years: 1, Maize; 2, oats, followed by Magothy Bay beans (also called partridge peas) which were plowed under.

West Virginia.

Buckwheat up to 6 years without change. (Preston county.)

1, Buckwheat; 2, wheat; 3 and 4, grass and clover. (Marshall county, etc.)

1, Buckwheat; 2, corn; 3, wheat. (Tucker county.)

Wisconsin.

1, Buckwheat; 2, rye; 3 and 4, grass and clover. (Juneau county).

1, Potatoes; 2, potatoes; 3, buckwheat; 4, rye; 5, corn. (Juneau county.)

1, Potatoes; 2 and 3, grain; 4 and 5, grass and clover. (Waupaca, etc., counties.)

1, Potatoes; 2, corn; 3, potatoes; 4 and 5, grass and clover.

1, Potatoes; 2, wheat; 3 and 4, clover.

1, Corn; 2–4, tobacco.

Wyoming. (B. C. Buffum.) Rotations not generally used.

1, Oats on sod; 2, potatoes; 3, wheat, seeded to alfalfa; 4 to 9, alfalfa.

2-course: 1, Field peas, harvested or pastured by lambs; 2, grain.

1, Legume, either peas for one-year crop or alfalfa for three to five years; 2, roots, either turnips or beets for stock or potatoes for sale; 3, grain.

III. Great Britain

3-course: 1, Wheat; 2, beans; 3, fallow. In use before the Roman invasion, and in some places as late as 1870.

Norfolk 4-course. Introduced by Lord Townsend in 1730 on his Norfolk estates. Soil sandy and poor: 1, Turnips, fed on the land by sheep; 2, barley with clover seeds; 3, clover hay; 4, wheat. Mutton, wheat and barley are the products sold. This course is expensive in labor, and it has been found to be impossible to grow clover so frequently as once in four years on many soils.

Suffolk: 1, Turnips; 2, barley; 3, rye-grass and clover; 4, peas; 5, barley.

Light calcareous soils:

1, Turnips; 2, barley; 3, peas; 4, wheat; 5, turnips; 6, roots; 7, barley; 8, sainfoin for ten or more years. (Alfalfa is sometimes used instead.)

1, Peas; 2, oats; 3, turnips; 4, barley with grass and clover seeds; 5, meadow.

Peaty soils: 1, Turnips or cabbage; 2, oats; 3, turnips or cabbage; 4, oats; 5, clover; 6, wheat. (Everything fed to stock except wheat.)

1, Potatoes (sold for seed); 2, oats; 3, turnips or cabbage; 4, turnips or cabbage; 5, oats, with grass and clover seed; 6, meadow. (Everything fed to stock except potatoes.)

Heavy peaty land: 1, Cabbage; 2, oats; 3, beans or clover; 4, wheat; 5, cabbage or mangels for feed; 6, oats.

Light soils: 1, Turnips; 2, barley; 3, 4, 5, clover and rye-grass; 6, peas; 7, rye; 8, wheat.

Common Hertfordshire system: 1, Turnips; 2, barley; 3, clover; 4, wheat; 5, peas or oats.

Sir Mordaunt Martin's course one hundred years ago: 1, Turnips; 2, barley; 3, clover; 4, wheat; 5, potatoes, mangels or vetches; 6, turnips; 7, barley; 8, trefoil and rye-grass; 9, peas; 10, potatoes, mangels or vetches.

1, Turnips; 2, barley; 3 and 4, grass and clover; 5, vetches; 6, wheat.

Heavy loam: 1, Beans or oats; 2, turnips; 3, barley; 4, clover or winter vetches; 5, wheat; 6, turnips or mangels; 7, barley with grass and clover; 8, grass and clover for three or more years.

Old system: 1, Oats; 2, beans; 3, wheat; 4, grass and weeds for four or five years.

1, Oats; 2, turnips; 3, barley with grass seeds; 4–6, grass and clover.

1, Peas; 2, barley; 3, clover; 4, wheat; 5, turnips; 6, barley, with grass seeds; 7–10, grass and clover.

Clay: 1, Fallow; 2, wheat or barley; 3, peas or beans.

1, Fallow; 2, wheat; 3, clover; 4, oats.

In use over one hundred years ago: 1, Fallow; 2, wheat; 3, oats; 4, fallow; 5, wheat.

Another method: 1, Fallow; 2, wheat; 3, clover; 4, clover; 5, wheat or other grain.

1, Fallow or roots, manured; 2, oats with grass seeds; 3, pasture; 4, oats; 5, beans, manured; 6, wheat.

The Rothamsted course is: 1, Rutabaga; 2, barley; 3, beans or clover; 4, wheat.

Ayrshire, Scotland.

1, Oats; 2, oats; 3, meadow; 4–7, meadow or pasture.

Clover-sick land: 1, Turnips; 2, barley; 3, grass seeds for one or two years; 4, wheat; 5, barley or oats; 6, peas; 7, wheat.

1, Turnips or potatoes; 2, barley; 3, clover; 4, wheat; 5, turnips or mangels; 6, barley; 7, vetches or beans; 8, wheat.

Midlands of England.

6-course: 1, Wheat; 2, barley; 3, roots; 4, oats; 5, clover and grasses mown; 6, pasture. Wheat is grown before barley to ensure a more uniform sample of the latter. Grain and stock are sold.

1, Turnips; 2, barley; 3, barley; 4, clover, grazed until May and then allowed to mature seed; 5, wheat; 6, oats.

1, Turnips; 2, barley; 3, peas; 4, fallow or intertilled crop; 5, wheat; 6, oats.

Common North England and Scotch.

5-course: 1, Wheat or oats; 2, turnips and potatoes, part in each; 3, barley or oats; 4, clover and grass mown; 5, pasture. This permits heavy cropping and there is but one intertilled crop in five; labor bill comparatively light.

Scotch (Lothians) 5-course. Land rented high: 1, Oats; 2, potatoes or beans; 3, wheat; 4, turnips; 5, wheat or barley; 6, clover or grass.

Scotch 7-course used in the north of Scotland: 1, Oats; 2, barley; 3, turnips; 4, oats; 5, 6, 7, clover and grass. Practically all of the crops are fed to the stock. Sometimes the oats are made into oatmeal.

Aberdeenshire, Scotland, 1762:

The Aberdeen rotation: 1, Bere; 2, oats; 3, oats. Long practiced.

The East Lothian: 1, Summer fallow, manured; 2, barley; 3, oats; 4, peas; 5, wheat.

The Carse: 1, Summer fallow and peas; 2, wheat; 3, barley; 4, oats.

The Norfolk 4-course was also used.

Scotland, A. D., 1900, W. S. Ferguson, Picstonhill, Perth; farm, 1,000 acres: 1, Oats; 2, turnips; 3, barley; 4, potatoes; 5, wheat; 6, grass for one or two years.

George Bell, Errol, Perth: 1, Wheat; 2, turnips; 3, barley or oats with grass and clover; 4, meadow; 5 and 6, pasture; 7, oats; 8, potatoes.

W. F. Bell, Dundee, farm, 2,000 acres. His rotation is: 1, Oats; 2, potatoes; 3, wheat; 4, turnips; 5, oats; 6 and 7, grass, cut green and sold. For the past one hundred years all crops have been sold off the farm in Dundee, and manure hauled back, the grass going to cow-keepers. The farm is as productive as ever.

Cunningham, of Delachy, Aberdour. Area, 593 acres. Half the farm is in grass, the remainder is cropped as follows: 1, Potatoes; 2, wheat; 3, turnips; 4, barley; 5, hay; 6, oats. Cattle and sheep are bred and sold fat. None are bought for fattening.

IV. Other Rotations

Europe. Used by beet-growers, 1900.

3-course: 1, Oats (manured); 2, beets; 3, wheat.

3-course: 1, Oats; 2, beets (manured); 3, wheat.

4-course: 1, Wheat; 2, beets (manured); 3, barley or oats; 4, clover.

4-course: 1, Wheat; 2, clover; 3, rye, or oats; 4, beets (manured).

Ireland. Flax-growing regions. In use in 1906.

4-course: 1, Oats; 2, potatoes, mangels or turnips; 3, oats, barley or flax; 4, rye-grass and clover. By changes in 2 and 3, this can be made 8-course, flax being grown once in eight years.

Bavaria. (Schubert, 1700–1800.)

1, Potatoes; 2, barley; 3, clover; 4, wheat. The land became clover-sick under this system. This was later found to be true by Lawes and Gilbert, Rothamsted, England, in the Norfolk four-course of roots, barley, clover, wheat; and still more recently by Terry, in Ohio, in his rotation of wheat, clover and potatoes.

Belgium. Flax-growing districts. In use 1906.

7-course: 1, Rye; 2, oats; 3, clover; 4, barley or rye; 5, potatoes; 6, barley, wheat or rye; 7, flax. Clover or carrot seed is often sown with the flax. The rotation is often extended to an 8-, 9- or 10-course, but practically none of the land is seeded for pasture.

France.

1750. Main crop woad: 1, Wheat; 2, millet; 3, woad; 4, grass, allowed to remain several years; sometimes two successive crops of woad were taken.

For saffron, A. D. 1750, eighteen to twenty years rotation, the statement being made that it could not be grown at closer intervals. The crop takes four years to mature: 1, Land fallowed and frequently plowed; 2–6, saffron, one crop; 7, oats, and seeded to sainfoin; 8–16, sainfoin cut for hay; 17, grapes for several years or barley; 18, wheat; and then land fallowed as before.

1750. Main crop teasel: 1, Land manured, fall- and spring-plowed and sown to wheat or rye in fall, teasel seed sown with it or in spring; 2 and 3, teasel, takes two years to mature.

1750–1760. Main crop flax: 1, Fallow; 2, fallow; 3, flax; 4, grass for several years.

1, Maize or turnips; 2, beans; 3, flax; 4, grass for several years.

1, Flax or hemp; 2, turnips or other roots; 3, wheat or barley; 4, clover or alfalfa for several years.

1, Beans; 2, carrots; 3, wheat or barley; 4, alfalfa or clover for several years.

Normandy and Guienne, 1750:

2-course: 1, Wheat; 2, fallow.

2-course: 1, Wheat; 2, clover.

2-course: 1, Wheat; 2, maize, land manured.

3-course: 1, Wheat; 2, clover, sown on wheat; stubble irrigated and grazed by sheep in winter and spring, irrigated again later and mown for hay; 3, land plowed and sown to kidney beans or millet.

Patullo's rotation for rich land: 1, Fallow, manured, sown to wheat in fall; 2, wheat; 3, oats or barley; 4, wheat.

1760. Patullo's rotation for light land. Land cleared, fallowed, manured and wheat sown in fall; 1, Wheat, stubble plowed and sown to turnips; 2, peas, followed by turnips as a catch-crop; 3, barley, and seeded with clover; 4, clover (hay) manured; 5, clover (hay); 6, clover grazed and plowed in fall; 7, barley; 8, wheat.

Angoumois, 1760: 1, Meslin of barley, oats, wheat, peas, etc., cut green; 2, maize; 3, wheat; 4, barley or oats or a mixture of same; 5, fallow.

1, Maize; 2, wheat; 3, maize, barley or oats; 4, wheat or fallow.

1760, 5-course: 1, Maize; 2, potatoes; 3, wheat; 4, clover, mown; 5, clover pasture, for one or more years.

1, Turnips, carrots, potatoes fed to stock; 2, wheat or barley; 3, alfalfa for several years.

Normandy and Brittany, 1760: 1, Oats; 2, gorse or whin for several years, cut for stock and bruised.

11 years: 1, oats, sown thinly and sainfoin; 2–10, sainfoin, mown; 11, wheat or rye.

Bayeux. 1760. Ten years, good: 1, Buckwheat, sown end of June, land manured, followed by wheat; 2, wheat; 3, oats or barley; 4, peas, vetches or turnips, and sown to wheat in fall; 5, wheat; 6, oats and clover seed; 7–10, clover, pastured.

Holland. Flax-growing district near Rotterdam. In use 1906.

7-course: 1, Rye or wheat; 2, beets or oats, manured; 3, flax, the land having been previously manured with liquid manure; 4, beans or clover; 5, potatoes; 6, rye or oats; 7, clover. The rotation is not so strictly adhered to as formerly, owing to various economic conditions, largely scarcity of labor. Land is rented at about fifteen dollars per acre, per annum.

Italy. Old rotations. A. D., 1500–1600.

1, Millet; 2, wheat.

Brescia: 1, Flax and millet; 2, maize; 3, wheat; 4, pasture for a long time.

Brescia: 1, Wheat; 2, clover; 3, flax and millet; 4, maize; 5, pasture for several years.

Venice.

C. Tarello, 1566, suggested the following 4-course and was granted a royalty thereon, same to be paid by any person using the rotation:

1, Fallow (manured); 2, grain; 3, clover and grass; 4, clover and grass.

Russia. (I. M. Rubinow, United States Bureau of Statistics, Bulletin No. 42, p. 53.) There is little systematic rotation of crops in practice.

The most primitive system in vogue, and the one largely used both in European Russia and Siberia, is to clear the land from the forest and sow to wheat or rye, which are grown continuously until the yield is reduced to almost nothing, when the land is abandoned for 10, 15 or even 30 years.

A more advanced system is the "three-field," consisting of: 1, Winter rye; 2, spring-wheat; 3, fallow; or, 1, winter rye; 2, oats; 3, fallow.

In some regions, the introduction of potatoes, sugar-beets, maize, tobacco and sown grasses has led to their use in the system instead of the fallow.

Egypt.

3-course on reclaimed irrigated alkali land: 1, Samar (*Cyperus lævigatus*, a reed); 2, rice; 3, cotton.

1, Samar; 2, cotton; 3, maize.

India, in general.

The rotation of crops is well understood and is generally practiced with more or less system. Voelcker states that the same fields have grown the same crops on much the same system as at present for centuries; it is averred, too, that, by rotation and fallows, the land receives the necessary change of cropping and the "rest" from cultivation which prevents its going down in quality (p. 36, Indian Agriculture). A remarkable feature is the frequent use of legumes and the sowing of mixtures of crops together, the same to be harvested at different times. For example:

Juar or millet (*Sorghum vulgare*) and arhar or pigeon pea (*Cajanus Indicus*) are sown in alternate rows like corn and cowpeas in the southern states, a grain and a leguminous crop being secured from the land in one year.

Cotton and arhar, or

Cotton and juar (millet) sown together are often more profitable than cotton alone.

Wheat and gram or chick-pea (*Cicer arietinum*).

Wheat and mustard.

Wheat, barley and gram (*Cicer arietinum*).

Wheat, barley, gram and rape.

(From Report on the Improvement of Indian Agriculture, J. A. Voelcker, pp. 234, 235.)

The following crops are placed in the order in which they would ripen and be cut; two or more of them are often sown together.

Rape, sveti-sorse, mustard, lentil, linseed, native peas (*Pisum arvense*), khesari (*Lathyrus sativus*), wheat, barley and gram or chick-pea. (From Handbook of Indian Agriculture, p. 266, N. G. Mukerji.)

Rice is grown continuously on flooded land.

Indigo (a legume) is frequently grown continuously on the same land.

Bengal.

Main crop sugar. Four crops in two years. Preparation: Jungle cleared in March to May and sown to aus paddy or maize, which is harvested in September; then potatoes: 1, Potatoes, harvested in February and sugar-cane planted; 2, sugar-cane, harvested in February and followed by either cowpeas, dhaincha (*Sesbania aculeata*), sunn hemp (*Crotolaria juncea*) or indigo, to be succeeded by potatoes, gram (*Sorghum vulgare*) or pulse, preferably kurthi (*Dolichos biflorus*).

High and light soils. Nine crops in five years: 1, Aus paddy (May to September), followed by a pulse or oilseed crop or the two mixed together (October to March); 2, jute (April to September); followed by a pulse or oilseed crop or the two mixed together (October to March); 3, aus paddy (May to September), followed by potatoes (October to February); 4, sugar-cane (February to February); 5, aus paddy (May to September), followed by a pulse crop (October to March). (Handbook of Indian Agriculture, p. 367, N. G. Mukerji.)

For low and light soils. Eight crops in five years: 1, Maize, sown in April, til (*Sesamum Indicum*), and barley, sown in September; 2, sugar-cane, sown in February; 3, sunn hemp and jute, sown in March, and mustard and country-peas (as distinguished from European or American peas), sown in October; 4, aman paddy, sown in June; 5, cucurbitaceous catch-crop, sown in January, and aman paddy, sown in June.

For high and heavy land. Eight crops in six years: 1, Sugar-cane, sown January to February; 2, buhri cotton (if virgin soil), or (if old tilth) arhar or pigeon-pea (*Cajanus Indicus*), sown in May; 3, jute, sown in April; linseed and gram (chick-pea), sown in October; 4, maize, sown in April; linseed or kalai (*Phaseolus radiatus*), sown in October; 5, aus paddy, sown in May; cowpeas, sown in September; 6, fallow, also used as a cattle run, on which the cattle graze and are fed.

For low and heavy soils. Six crops in five years: 1, Aman paddy, sown in June, and a cucurbitaceous catch-crop, sown in January; 2, aman paddy, sown in June; 3, jute, sown in March, kalai (*Phaseolus radiatus*), musuri or lentils (*Ervum lens*), khesari (*Lathyrus sativus*) and linseed, sown in October; 4, aman paddy or a sugar-cane that can withstand water; 5, fallow. (Consult the Handbook of Indian Agriculture, p. 368, by N. G. Mukerji, Calcutta.)

Burdwan division, India.

Dearh land (sandy soils near rivers). A six-year rotation, furnishing ten crops and one year fallow. Good rotation, recommended for such conditions: 1, Aus paddy (an early-maturing, rather coarse rice), followed by a pulse or oilseed crop, or the two mixed together; 2, jute, followed by a pulse or oilseed crop or the two mixed together; 3, aus paddy, followed by sugar-cane; 4, sugar-cane, followed by aus paddy; 5, potatoes, followed by aus paddy; 6, bare fallow.

2-course: 1, Aus paddy; 2, wheat or barley.

Dacca.

3-course: 1, Potatoes; 2, rice or jute; 3, chilies (*Capsicum frutescens*).

2-course: 1, Jute; 2, tobacco or a pulse (leguminous) crop.

Lohardaga. On uplands.

4-course: 1, Millet; 2, rice; 3, pulse; 4, millet, followed by an oilseed or pulse crop.

Palamau.

3-course: 1, Cotton; 2, gingelly (oilseed); 3, Kodo (millet, *Paspalum scrobiculatum*).

6-course: 1, Maize or millet; 2, wheat; 3, wheat; 4, wheat; 5, legume; 6, legume. (Voelcker, Indian Agriculture, p. 235.)

Northwest provinces of India.

4-course: 1, Indigo; 2, barley and peas: 3, fallow; 4, wheat.

4-course: 1, Millet; 2, fallow (green crop plowed in); 3, wheat or other winter cereal; 4, millet.

2-course: 1, Maize, with carrots between the rows; 2, if rainfall is heavy, gram or chick-pea (*Cicer arietinum*), poppy, mustard or safflower.

2-course: 1, Maize, with carrots; 2, wheat or barley.

Punjab.

Three crops a year: Wheat or barley harvested in March, followed by melons, harvested and land fitted by July and sown to maize. (Handbook of Indian Agriculture, Mukerji, p. 257.)

4-course, with main crop sugar-cane: 1, Dhaincha (*Sesbania aculeata*), sunn hemp (*Crotalaria juncea*), or cowpeas (*Vigna Catjang*), cut when in bloom (August), and potatoes planted in October; 2, potatoes, harvested in February and sugar-cane planted; 3, sugar-cane, harvested in February, and land sown to arhar (pigeon-pea, *Cajanus Indicus*) or aus paddy and then to potatoes; 4, potatoes, harvested and sugar-cane planted.

4-course on dry (barani) land. Two years fallow, two of crops: 1, Fallow; 2, wheat and gram; 3, chari (fodder juar, *Sorghum vulgare*); 4, fallow.

5-course on rich land: 1, Cotton; 2, senji (a millet); 3, sugar-cane; 4, maize; 5, wheat.

4-course: 1, Wheat or barley, with gram (chick-pea) and oil seeds; 2, juár (sorghum) or bájra, with pulses; 3, fallow; 4, fallow. (J. A. Voelcker, Report on Indian Agriculture, p. 235.)

Bombay.

Gujarat: 1, Cotton; 2, wheat or juar (sorghum); 3, gram (chick-pea) or other legume.

Mahim: 1 and 2, Betel vine (*Piper Betel*); 3, ginger (*Zingiber officinale*); 4, sugar-cane; 5 and 6, plantain (*Musa sapientum*); 7, rice.

Surat: 1, Sunn hemp (*Crotalaria juncea*), plowed in, followed by sugar-cane; 2, sugar-cane; 3, rice, with arhar (*Cajanus Indicus*) or other legume; 4, legume.

Konkan, on hill land: 1, Nágli; 2, warai; 3, niger seed (*Guizotia Abyssinica*); 4 to 9, fallow. (J. A. Voelcker, Improvement of Indian Agriculture, p. 235.)

Literature.

In addition to works mentioned in the text, consult the Yearbook, United States Department of Agriculture, Washington, D. C., 1902, pp. 519–532, for modern American systems. The Complete Farmer, London, England, five editions between 1767 and 1807, contains many examples of rotations in use in Europe previous to and at this period. The writings of Sinclair and Arthur Young contain many examples of rotations in use in Europe, and the Journals of the Royal Agricultural Society of England and the Highland and Agricultural Society of Scotland contain frequent reference to this topic. The reports of the Boards of Agriculture of some of the eastern states contain articles on this subject. Current agricultural books give some attention to rotations.

A systematic rotation of crops is more commonly practised in Great Britain, Ireland and other countries of northern and central Europe and in the eastern parts of the United States and Canada, than elsewhere. The subject has received but little attention in Australia, and practically none in Alaska, Philippine Islands, Central and South America and the greater parts of Africa and Asia. This note will guide the reader where to look for literature.

WEEDS, AND THE MANAGEMENT OF THEM

Weeds are plants that are not wanted. They are of two general kinds, — those that inhabit waste or unoccupied areas, and those that invade cropped lands and compete with the plants that the husbandman grows. Certain species of plants are by nature adapted to occupy such places or to engage in such competition, and these particular plants are commonly known as weeds; but weediness is not characterized by species but by habits and adaptabilities. Any plant may be a weed at times. Buckwheat or rye is a weed when it volunteers in other crops and becomes a nuisance. Elm-tree seedlings may be pestiferous. When any crop is too thick, there is competition among fellows, and the weaker and useless ones are weeds to the better ones. It has been said that the worst weed in a corn-field is corn.

Fig. 134. Pigweed, lambs-quarter (*Chenopodium album*).

All plants are contending for a place in which to live and to spread their kind. They all are invading new fields. The more successful their invasion, the more inimical they are to other plants. They overrun, and we call them weeds. The weed plants are therefore virile and persistent types. They are weeds because of one or all of these attributes: (1) They are adapted to a wide range of conditions; (2) many of them have a life-cycle similar to that of some cultivated plant; (3) they are tenacious of life; (4) they produce seeds or other propagating parts in abundance; (5) they have means of disseminating the seeds or parts, either by natural agencies or by resembling crop seeds so closely in size or weight that they cannot be readily separated.

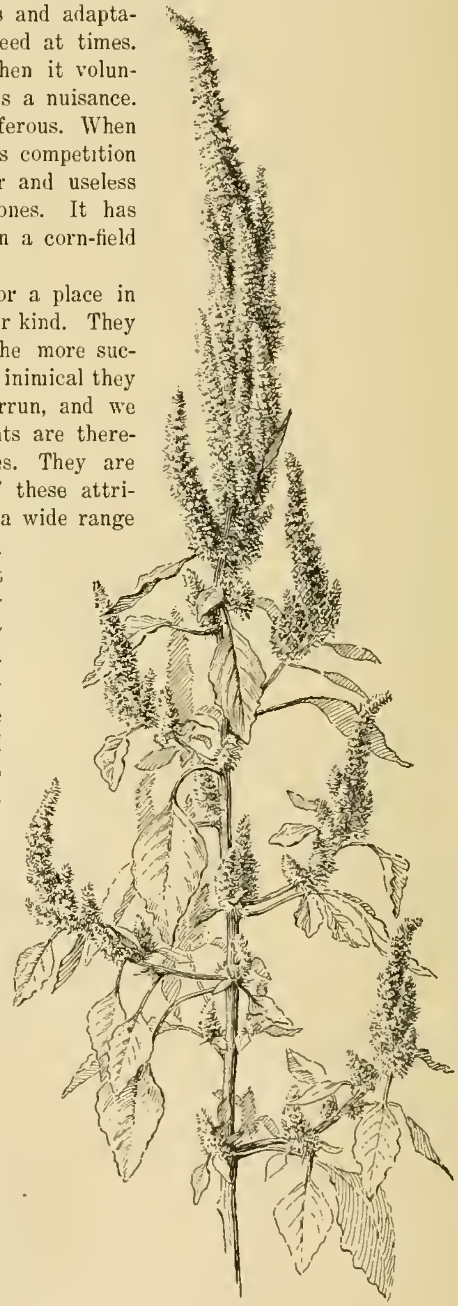


Fig. 135. Redroot or pigweed (*Amarantus chlorostachys*).

All this sounds very simple, but it is a fact that we really do not know just why some of the weeds follow certain crops or how they injure the crops. More than once the editorials in these volumes have suggested that there may be relationships between plants that have been past finding out. On the face of it, it seems plain enough that weeds reduce the yields in crops by competing for water and food. We think we know that this is often the case.

These discussions at once suggest the one means of dealing with weeds, — the working out of such a system of crop management that they find the least opportunity to gain a foothold. It is commonly advised that the farmer do this and do that to destroy weeds — always putting the emphasis on the word destroy; but while it may be useful to prevent wild carrot from seeding, it is much more to the point not to have wild carrot. Much of the current advice on the destruction of weeds is of small value, for the farmer has little time or opportunity to hunt out the different species and then laboriously to prevent them from seeding or to spud them out at a certain season of the year, or to practice other very special methods. The fundamental thing is to apprehend the fact that certain weeds follow certain crops and certain methods of farming.

Crop management, therefore, necessarily involves weed management. A weed-infested farm is not merely a shiftless farm in the sense of being untidy, but it is a poorly farmed farm. Some of the fundamental means of preventing weeds are: good rotation courses; clean tillage; cleaning up of waste places in which weeds breed; care in the choice of clean seed; care to see that the manure does not carry seeds; alertness to recognize new weeds when they begin to invade the neighborhood. This means that the farmer should endeavor to determine why he is possessed of certain weeds: this discovered, he can then proceed to treat the question rationally.

Fig. 137. Stick-tight or beggar-tick (*Bidens frondosa*).

There are, of course, special methods for certain weeds and certain conditions. Summer-fallowing is a means of cleaning fields of weeds, but it is usually necessary for this purpose only in new lands or those that have been improperly handled. Pasturing with sheep is another special method. Spraying with poisons will despatch some kinds of weeds. Mowing at certain times of the year will dispense with others. Burning the fields is often useful. In meadows and lawns, it is often possible to eliminate weeds by fertilizing and re-seeding the invaded parts, for usually the weeds do not run out the grass, but the weeds invade because the sod is poor.

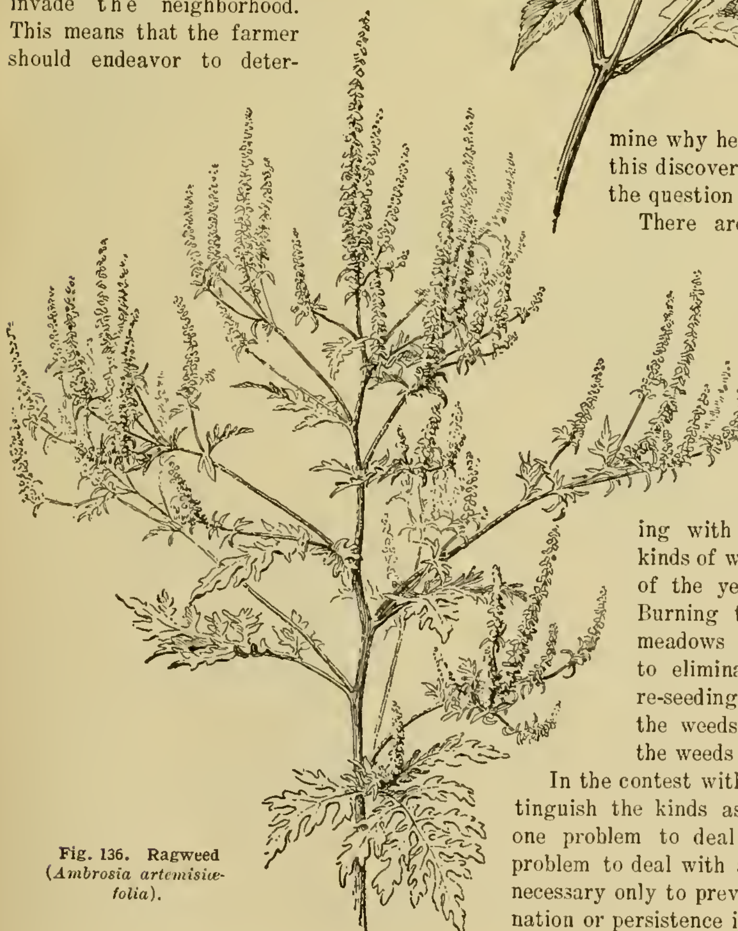


Fig. 136. Ragweed (*Ambrosia artemisiæfolia*).

In the contest with weeds, the farmer should distinguish the kinds as to duration. It is obviously one problem to deal with perennials and another problem to deal with annuals. In the annuals, it is necessary only to prevent seeding, so far as dissemination or persistence is concerned. In perennials, it may be necessary to destroy or crowd out the entire plant, root and all. In grass lands, the annuals perish as a matter of course; or, if they do not, it is because the grass is poor. The annual weeds follow tilled crops; among such are the pigweeds, purslane, chess, ragweed. The perennials that follow cultivated crops are mostly such as have rootstocks or other underground parts that are carried by the tools; as bindweed, quack-grass and nut-grass. The weeds of dooryards are mostly perennial or, at least, biennial, as docks, burdock, plantains, self-heal, round-leaved mallow. In the accompanying pictures, Figs. 134 to 148 show annuals; Figs. 149 to 154 biennials; Figs. 155 to 171 perennials.

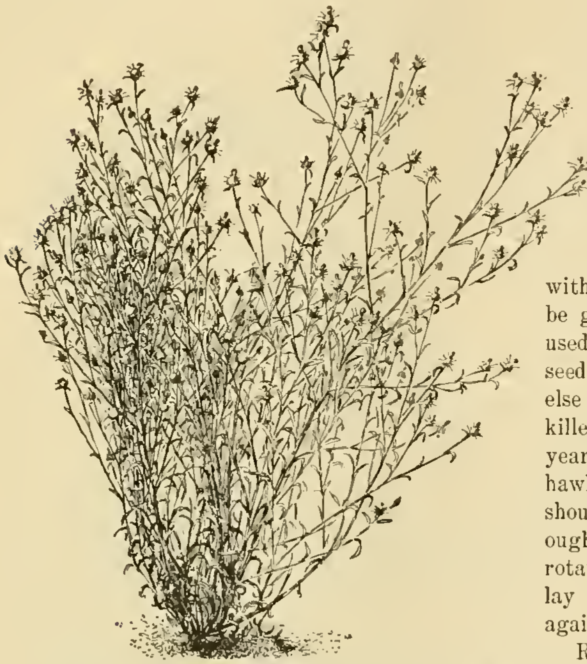


Fig. 138. Napa thistle or tocalote (*Centaurea Melitensis*). Naturalized in California.

Whenever any area becomes badly infested with weeds, it is safe to assume that the place should be given a radical change of treatment. Areas long used for garden are likely to become very weedy: seed down the place and make the garden somewhere else for a time. A patch of Canada thistles can be killed by seeding down heavily and mowing for a few years. Meadows badly infested with carrot, daisy or hawkweed (paint-brush or hieracium), or dandelion should be broken up, thoroughly tilled and put in rotation until it is safe to lay them down to grass again.

Fig. 139. Seed top of the Shepherd's Purse (*Capsella Bursa-pastoris*).

Roadsides and waste places should be kept clean. Most states or localities have laws to compel property owners to mow the roadsides. It is probable that these weedy roadsides are less real menace to farming lands than is popularly supposed; but the laws should be enforced, nevertheless, for the effect of attractive roadsides in elevating public taste is everywhere worth consideration.

It would not be right to leave the impression that all weedy fields are necessarily poorly managed fields. In humid climates it is usually better that ground be bearing plants than that it be idle. Nature covers all the waste and raw places; and nature knows. If land is to go fallow for any reason, it may be very good practice to let the weeds grow, with the purpose of plowing them down for humus. The carcass of a weed may make just as good humus as that of a plant in good standing. Weeds in orchards may make good cover-crops; although this does not mean that other plants may not make better ones.

Fig. 140. Purslane or pusley (*Portulaca oleracea*).

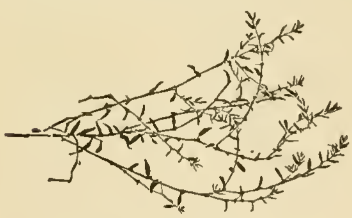


Fig. 141. Spray of knotweed (*Polygonum aviculare*).

Fig. 142. Chickweed, a winter annual. (*Stellaria media*).

The kinds of plants that are known as weeds are legion, but the really important or belligerent kinds in any community will usually not exceed two dozen. They are mostly homely plants, but this does not in the least interfere with their efficiency as weeds. A description of the kinds of weeds would scarcely be worth the while in this Cyclopedia, where every inch of space is needed for the most significant matters. The pictures will identify a few of the old friends.

Of course, everybody deplores weeds. They always have. They probably will continue to deplore them even after this Cyclopedia is printed. But it would be an interesting question if some one were

Fig. 143. Charlock, one of the mustards (*Brassica arvensis*).

Fig. 144. Corn Cockle (*Lychnis*, or *Agrostemma*, *Githago*). Thrives mostly in wheat fields.

Fig. 145. Mayweed.

Fig. 146. Mayweed (*Anthemis Cotula*). From a California specimen.

Fig. 147. Prickly lettuce (*Lactuca Scariola*). Annual or biennial.

Fig. 148. Milk thistle (*Silybum Marianum*). A naturalized weed in California; annual or biennial.

Fig. 149. Evening primrose in seed (*Œnothera biennis*).

Fig. 150. Wild carrot. (*Daucus Carota*).

Fig. 151. Bull or pasture thistle (*Cnicus lanceolatus*).

to ask to what state our agriculture would probably have attained at this time if it had not been for weeds. There is no danger, however, that we shall cease to be taught.

Fig. 152. Burdock (*Lappa major*).

Poisonous plants.

Certain plants are poisonous either when eaten or when handled. The most deadly of the poisonous plants are some of the mushrooms (which see, in Part III), and the water parsnip (Fig. 167) and poison hemlock (Fig. 168). The last two are rank-smelling, strong herbs, members of the parsnip family (*Umbelliferæ*), inhabiting wet places. V. K. Chesnut in "Thirty Poisonous Plants of the United States" (Farmers' Bulletin No. 86, United States Department of Agriculture), writes as follows: The musquash-root, or water hemlock (*Cicuta maculata*) "is one of the most poisonous native plants in the United States, being rapidly fatal to both man and animals. The roots are especially dangerous, because the taste, being aromatic and to some people suggesting that of horse-radish, parsnips, artichokes, or sweet cicely, is apt to lead children to eat them when they are found forced out of the soil by washing, freezing, or other causes in early spring." The poison hemlock (*Conium maculatum*) contains "the well-known volatile alkaloid, coniñe, which is found in the seeds, and, especially at flowering time, in the leaves. The root is nearly harmless in March, April and May, but is dangerous afterwards, especially during the first year of its growth. The poison hemlock is the most generally known poisonous plant historically, it being, without much doubt, the plant administered by the Greeks to Socrates and other state prisoners. Recent cases of poisoning have arisen accidentally from eating the seed for that of anise, the leaves for parsley, or the roots for parsnips; also, from blowing whistles made from the hollow stems. It has recently been shown that some of the anise seed in both foreign and domestic markets is contaminated with hemlock seeds, but it is not known whether serious consequences have resulted therefrom." The only other poisonous plants or weeds that need be mentioned here are two or three species of the sumac genus: *Rhus Toxicodendron*, the poison ivy (Fig. 169); *R. diversiloba*, the poison oak of the Pacific coast (Fig. 170); *R. venenata*, the poison sumac (Fig. 171), an attractive bush growing in swamps. These are poisonous to the touch to many persons. It is enough for the present purpose merely to identify them by means of pictures. Poisoning by ivy and sumac is treated with a solution of sugar of lead (poisonous if taken internally), in 50 to 75 per cent alcohol. Add the sugar of lead "until no more will easily dissolve. The milky fluid should then be well rubbed into the affected skin, and the operation repeated several times during the course of a few days." There are a number of plants that are poisonous to live-stock, and these will be treated in Vol. III; and there are others that have medicinal qualities, and these are mentioned in Part III of the present volume.

Fig. 153. Mullein (*Verbascum Thapsus*).

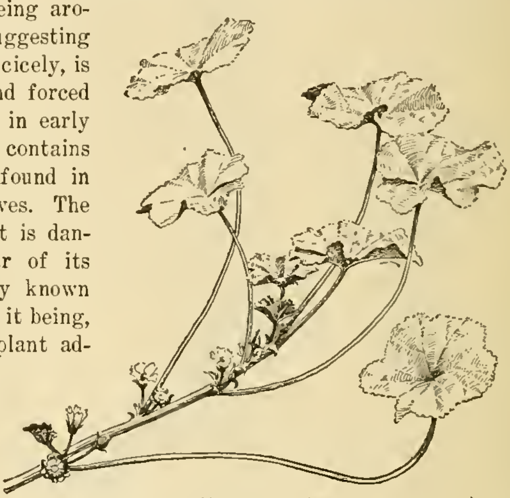


Fig. 154. Mallow or "Cheeses" (*Malva rotundifolia*). Biennial or perennial.

Fig. 155. Bindweed (*Convolvulus arvensis*).

CHEMICAL WEED-KILLERS OR HERBICIDES

By *L. R. Jones*

The use of chemicals as herbicides offers no specific cure-all against weeds. Cultivation, short rotations, watchfulness against the introduction and scattering of weed seeds, are all of more fundamental importance than chemicals in combating weeds. There are, however, various cases in which chemicals intelligently used are more expeditious and economical than any other means for weed-killing. A practical difficulty is so to use the herbicide as to kill the obnoxious plants without working permanent injury to the soil or to neighboring cultivated plants. This difficulty limits the chief usefulness of chemicals as weed-killers to the following cases:

(1) When an especially obnoxious weed, as poison ivy, occurs in a limited locality and is to be destroyed regardless of consequences to soil or neighboring plants.

(2) When the aim is to render the soil permanently sterile, as in roadways, tennis courts, and the like.

(3) When the weed plant, as orange hawkweed and mustard, is much more sensitive than the associated useful plants to the action of some herbicide.

Chemicals useful as herbicides.

Any soluble chemical, even including the various commercial fertilizers, if used in sufficient amount, will kill plants. Some act directly and quickly as poisons, e. g., arsenic and carbolic acid; others, such as salt, have little or no direct poisonous effect but kill the plants primarily by drawing the water from the tender foliage, or by holding the moisture of the soil so that it cannot be absorbed by the roots. It is important in this connection to note that in either case the herbicide is most effective on young plants that are in active growth. Effectiveness in one or the other of these ways, together with cheapness and convenience of application, are the things to determine choice among the various compounds available. Without attempting to list all of these, we include those whose worth has been best established by trial.

Salt (sodium chlorid) is probably more commonly used than any other compound, chiefly because of cheapness and handiness. Its action depends almost wholly on the withdrawal and retention of moisture from the plant, therefore it should be applied dry or in strong solution; and it is most effective in hot, dry weather. Salt can be used in any weed-killing operation, but it is most valuable on roadways and like surfaces and for certain lawn weeds.

Blue vitriol (copper sulfate).—This is more powerful in herbicidal action than salt, but its cost prohibits its general use. For most purposes it is best used in solution, 2 to 10 per cent being effective. It is often used on gravel walks and similar surfaces, but salt will generally be found cheaper and arsenical poisons more effective. Its chief value is against charlock, as noted on page 117.

Kerosene.—This and other coal-oil products will kill plants. Because of handiness it is frequently used, but it is weak in efficiency, and relatively more costly than any other chemical here listed. A pint of crude carbolic acid will do better service than two gallons of kerosene, and costs much less. When crude petroleum is available at very low price it is commended.

Carbolic acid.—This is one of the quickest and most valuable herbicides. The crude acid is relatively cheap. It is not quite equal to the arsenical poisons for penetrating the soil or in lasting effects, but it is often preferable because of cost or convenience. It does not corrode metals, hence, may be applied with any can or pump. An effective method is to squirt the strong acid from an ordinary oil can on the roots or crown of individual weeds. If it

Fig. 157. Heads of orange hawkweed.

Fig. 156. The orange hawkweed, or paint-brush (*Hieracium aurantiacum*). This plant originated from the runner shown at the lower right-hand corner. The two young runners at the left have already taken root and will soon give rise in turn to new plants. (Adapted from Vermont Experiment Station.)

Fig. 159. Quack-grass (*Agropyrum repens*).

Fig. 158. Goldenrod or solidago.

Fig. 160. Milkweed (*Asclepias Cornuti*).

Fig. 162. Narrow-leaved dock (*Rumex crispus*).

Fig. 166. Buttercup (*Ranunculus acris*).

Fig. 161. Canada thistle (*Cnicus arvensis*).

Fig. 163. Broad-leaved dock (*Rumex obtusifolius*).

Fig. 167. Water hemlock (*Cicuta maculata*). A similar species, also poisonous, grows from Idaho westward.

Fig. 164. Toad-flax (*Linaria vulgaris*).

Fig. 165. Yarrow

is to be sprayed or sprinkled broadcast on the foliage or ground, it should be diluted with 15 to 30 parts of water, and this mixture agitated frequently during use.

Sulfuric acid (oil of vitriol).—This, of course, is

Fig. 168. Poison hemlock (*Conium maculatum*).

destructive to everything it touches. It can be applied in the crown or about the roots of coarse or especially hardy plants, provided the user is willing to kill the adjacent vegetation, also. In general, carbolic acid will be preferred, partly because sulfuric acid can be handled only in glass vessels.

Caustic soda.—A strong solution of this makes a cheap and effective herbicide, commended especially for pouring on soil where it is desired to destroy poison ivy or other deep-rooted or woody plants. Of course, soil so treated will be rendered sterile for some time, but the soda will gradually leach away. Like salt, this is most effective if applied in hot, dry weather.

Arsenical compounds.—One or another of the soluble arsenical compounds form the most effective herbicides known. These form the basis of all or nearly all of the various proprietary "herbicides" or "weed-killers." Such compounds are handled by leading horticultural supply houses, and, so far as the writer has tested them, are highly efficient. The only reason for seeking elsewhere is their high price. Soluble arsenical poisons as a rule can be bought considerably cheaper in the drug trade and are similar in action. The simplest to employ is arsenate of soda. This needs only to be dissolved in water for use, at the rate of 1 pound in 3 to 9 gallons of water. White arsenic is still cheaper, but according to Schutt's formula, which the writer has used, it must be combined with sal soda, which is somewhat bothersome. (White arsenic, 1 pound; washing soda, 2 pounds; water, 3 to 9 gallons.) An important characteristic of these arsenical poisons is that they endure for a long time and do not readily wash or leach away. For this reason they are the most useful herbicides to use on roadways and other plain surfaces, as explained below.

More specific directions for use.

Any of the above chemicals will kill any plant if applied directly to it in sufficient amount. In addition to the more general advice included in the above account, the following specific directions are adapted to special cases.

Gravel roadways, gutters, tennis courts and like surfaces can be kept free from weedy growths by the application of any of the above. If salt is used it should be scattered freely in the dry form. Caution is necessary where it is liable to be washed on to lawns, lest it damage the grass borders. Carbolic acid or arsenical poisons are preferable, being both less liable to wash and more enduring in their action. One quart of crude carbolic acid in 8 gallons of water, or one pound of either arsenical compound mentioned above in a like amount of water, will suffice to cover a square rod or more of surface; and one, or, at most, two applications per year, will be sufficient.

Charlock, known also as kale or wild mustard (*Brassica arvensis*, Fig. 143), is easily destroyed in oat-, wheat-, or other grain-fields by spraying with a solution of 1 pound of copper sulfate in 4 to 6 gallons of water (2 to 3 per cent solution). A force pump should be used, supplied with fine nozzles. The treatment is most effectively made when the grain is 3 to 6 inches tall,

Fig. 169. Common poison ivy (*Rhus Toxicodendron*). Climbing or trailing.

since at this stage the large charlock leaves spreading above the grain are easily covered by the spray. One barrel or less of the solution (30 to 50 gallons) suffices to cover an acre and destroy the charlock, and this amount causes little or no damage to the grain. This same treatment is reported to be more or less effective against a variety of other common grain-field weeds. The

Fig. 170. Pacific Coast poison oak (*Rhus diversiloba*). A trailing or climbing plant.

wild turnip (*Brassica campestris*) and some allied cruciferous weeds are less easily killed because the spray does not adhere to their smooth leaves.

Experiments by the Cornell Station gave the following general conclusions: Wild mustard growing with cereals or peas can be destroyed with a solution of copper sulfate, without injury to the crop. A 3 per cent solution (about 10 pounds to the barrel, or 40 gallons of water), at the rate of 40 to 50 gallons per acre, gives very satisfactory results.

The following notes on the effect of the copper sulfate solution on different plants are from observations and reports from various sources:

"Plants reported killed by copper sulfate solutions: wild mustard, wild radish, wild barley, penny-grass (if young), shepherd's-purse, wild buckwheat, lamb's-quarters, ragweed, sow-thistle, hemp-nettle, bindweed, dock, dodder.

"Plants reported severely injured: curly dock, black bindweed, dandelion, sow-thistle and senecio.

"Plants reported as not injured: wild rose, poppies, pigweed, spurge, corn-flower, field-thistles, chamomile, couch-grass, bent-grass and horsetails.

"Crops that may safely be sprayed: all cereals, as wheat, rye, barley and corn; the grasses; peas; sugar-beets.

"Crops that are killed or severely injured by the copper sulfate solution: beans, potatoes, turnips, rape."

Lawn weeds.—Orange hawkweed (*Hieracium aurantiacum*, Fig. 156–7), chickweed (*Stellaria media*, Fig. 142), and some other of the shallow-rooted succulent weeds of lawns and grasslands can be combated more effectively by the use of salt than by any other chemical. Fine, dry salt should be applied on a bright, hot summer day (late June or early July best), broadcasting it so as to cover all plants uniformly, since it kills chiefly by drawing water from the leaves. One to four quarts of salt can be used per square rod, with little or no permanent injury to the grass if on a strong soil in the northeastern states. Since the effect varies with local conditions, advance trials should be made on a small scale. Following the application, the dead weeds should be raked out and a liberal application of grass seed made.

Poison ivy and similar woody-rooted pests can be eradicated by cutting off the tops in hot, dry weather in midsummer and pouring a saturated solution of caustic soda about the roots. The arsenical solutions mentioned above can be used, but are generally objectionable because they render the soil sterile for so long a period thereafter.

Literature.

For more extended discussion the reader should consult: Bolley, The Destruction of Weeds in Cereal Crops by the Use of Chemicals Sprayed on the Foliage, Proc. Soc. Prom. Agri. Sci. XX, 107 (1899); Jones and Orton, The Orange Hawkweed or Paint-brush, Vermont Experiment Station, Bulletin No. 56 (1897); Killing Weeds with Chemicals, Vermont Experiment Station, Report XII, 182 (1899); Report XIII, 282 (1900); Shutt, Canada Experimental Farms, Bulletin No. 28 (1897); Report for 1899,

Fig. 171. Poison sumac (*Rhus venenata*).

page 194; Voelcker, The Destruction of Charlock, Journal Royal Agricultural Society, England, 3 Series, X, 767 (1899). This last gives an excellent summary of results in England. Stone, Cornell University Experiment Station, Bulletin No. 216, 1904.

CHAPTER VI

GROWING PLANTS UNDER COVER

HOUSES IN WHICH PLANTS MAY BE GROWN have come to be one of the necessities of agriculture. Until recently, these houses have been chiefly glass structures used for the so-called horticultural crops; but various slat-covered sheds have been devised to protect crops and plants in the extreme South from sudden periods of cold, and now the cloth-covered house has begun to come into somewhat extensive use, not only for horticultural plants but for plants that are customarily grown as field crops. The demand for certain high-class products the entire year has made it necessary to protect plants from heat and sun and storms in summer as well as from cold and snow in the winter, and the cloth house is often substituted in summer for the hot and uncongenial whitewashed glass house. Moreover, it is now found that certain field crops, of which some kinds of tobacco are examples, actually thrive better and produce a better product when protected from the sun. Hereby has also arisen a new subject in agriculture,— the study of the effect of shade on plants. With the ever-increasing niceties of agriculture, protection to plants in summer will assume added importance.

All this means that we are constantly pressed by the necessity of growing plants under conditions of control; and this control now runs the round of the year. The gardeners have long practiced such control, and they have carried the cultivation of plants to its greatest perfection. These ideas are now working out into general field conditions, demanding a new kind of crop management. The general subject of plant-growing under cover is scarcely germane to the present work. It is discussed in its many relations in the Cyclopedia of American Horticulture. Two phases of it may be considered to be within the scope of this volume,—the growing of plants under shade (the subject will be referred to again under Tobacco in Part III), and the making of glass houses for the cultivation of vegetable-garden crops. Figs. 172 to 178 illustrate some of the new practices; see, also, page 100, Vol. I. In addition to these phases, it may be worth while to add to the chapter some advice to the farm-wife on the growing of plants in windows.

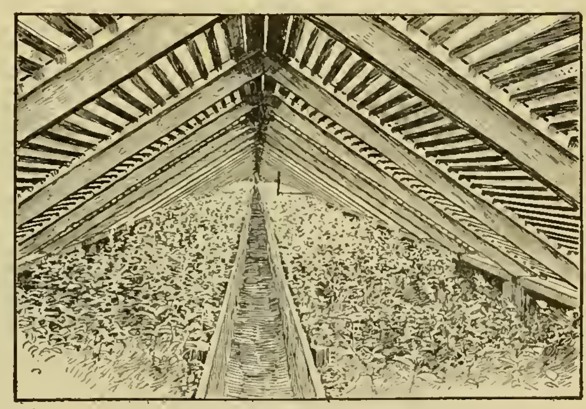


Fig. 172. A lath-covered nursery house, in which young camellias are grown.

THE SHADING OF PLANTS

By *B. M. Duggar*

The shading of plants is a relative expression. It is qualitative and means simply reduced light intensity. As used by horticulturists, shading has reference most frequently to half or partial shade, or to the growth of plants under some form of improvised screen. The extremes of shading are great; and properly to circumscribe the subject we must consider all plants exposed to grades of a light intensity between bright diffused light, as one extreme, and the darkness of cellars and caves, as the other extreme.

Shading is a distinct phase of horticultural work, and it has its physiological, or fundamental, side. Such quantitative physiological work as has been done relates, for the most part, to absolute shading, or darkness, and an insignificant amount of accurate physiological data have to do with half or partial shade, which latter is more important horticulturally. The physiological work is not yet so helpful as it might be, but some of the general principles modifying form, size and quality of plants in shade or darkness enable us better to direct half-shade operations, and better to interpret the results that may be secured. The subject offers an interesting field of investigation.

A general discussion of shading involves the following considerations:

I. The Plant.
 (a) Direct effect on the plant.
 (b) Indirect effect on the plant through environment.
 (c) Kinds of plants with which the operation of shading may be employed.

II. The Screen Mechanism.
 Laths and boards, cloth screens, plant covers.

The plant.

(a) *Direct effect.*—It must be borne in mind that plants are very differently adapted to light intensities. Some plants to a large degree are independent of light conditions. Certain small fungi grow equally well in total darkness or in strong diffused light. The common mushroom, so far as the production of the fruit, or mushroom proper, is concerned, is uninfluenced by light, except in so far as light affects temperature and, thereby, evaporation. Among common green plants there are shade-loving and sun-loving species. In the shade of certain trees, no green plant may live constantly. In the deepest gorge the densest ferns may grow, and on the exposed cliff a grass or a heavy vine may find its suitable home.

In considering the direct physiological effects of shading on plants, we may note the effect on

(1) Color: Etiolation or blanching.
(2) The form and size of the plant.
(3) The minute structure, i. e., on the elements of the framework which have to do with texture and succulence.
(4) The bulk of the plant, by reducing or modifying the products of growth.
(5) The checking of nitrogen assimilation and albuminoidal synthesis.
(6) Modification of the acid content, as well as the content of soluble carbohydrates.
(7) The aromatic content in the plant juices, and other minor metabolic modifications affecting the quality of the product.
(8) The development of flowers, fruits and seeds.

(1) The effect on color is considerable. The intensity of the light will usually directly affect the chlorophyll development. In darkness most plants are soon etiolated, or blanched, and many are much affected in half-shade. The production of brilliant color is also less under diminished light. In garden products blanching may add directly only to the appearance or tenderness, freshness or crispness; it is in its indirect relation to other modifications discussed below that it is most important.

(2) The ordinary green plant shows, with the exclusion of light, either partial or complete, an elongation of the main axis accompanied by some suppression of branches. This is of little practical advantage. Plants with restricted stems, and consequently with basal or truly "radical" leaves, usually show an elongation of the petiole with reduction of the leaf-blade. This effect is of practical value when the plant has been grown previously under full light, and has accumulated in root and stem an abundant supply of nutriment. A crop in point is rhubarb when grown by the "new culture" method; and celery is somewhat similarly influenced in addition to the blanching effect.

(3) The diminished development of tough fiber in etiolated plants has been known since the time of Sir Humphrey Davy, and even earlier. The reduction is largely in the amount of mechanical or supporting tissues. This effect is an advantage when succulence is a chief concern. It is true of the crops mentioned in the preceding paragraph, and it may also be of interest in growing certain salads.

(4) The dry weight of certain shaded plants is less than of plants under normal light intensity, and this probably is due largely to the lessened chlorophyll activity. In this connection, however, it is important to remember the specific light relations of the plant. It is asserted that under favorable conditions of temperature and moisture the common evening primrose (*Œnothera biennis*), a sun-plant, has the power to fix in direct sunlight

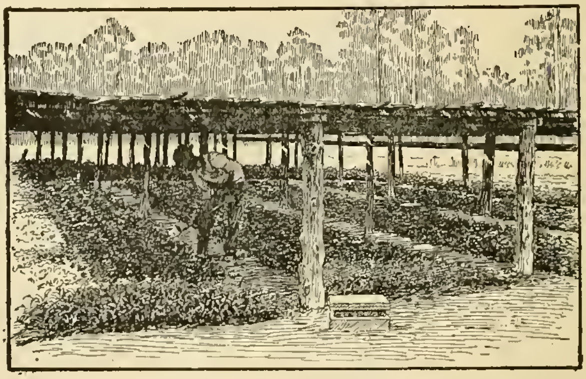


Fig. 173. A tea nursery in South Carolina. (C. U. Shepard.)

about three times as much CO_2 as in ordinary diffused light. The common polypody (*Polypodium vulgare*), on the other hand, has shown a more energetic assimilative (photosynthetic) activity in diffused light than in direct sunlight. This doubtless would be true for the ginseng. Indeed, it may be said that shading is an antidote for ills with one species, while with another it may prove a bane. Varieties may likewise show diverse sun relations. It is therefore of comparatively little value to make shading tests with only two or three of many diverse varieties of a cultivated plant, the extremes of whose light relations have been merely assumed.

(5) In ordinary green plants light seems to be

Fig. 174. Raising tea under shelter in South Carolina.

essential to nitrogen assimilation. Just what intensity of light may be the optimum for this particular function is not known, and there are doubtless complex relations to be considered. At any rate, the proteid content is usually less in shaded plants.

(6) It has been held that there is an increase in the acid content of shaded plants. This may be relative. A certain amount of acid lends quality and flavor, while an increase without gain in sugar may be decidedly objectionable. In shading strawberries with cheese-cloth it has been shown that there is an actual reduction in the acid content. The acidity, however, is more marked in taste, and this because of a marked reduction of sugar. The reduction of the sugar content, as well as of certain other carbohydrates in fruits, seems to be general under such cultural conditions.

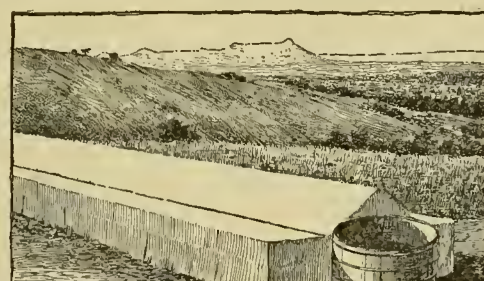


Fig. 175. Muslin-covered plant house. Hawaii Experiment Station.

(7) The aromatic products may not be very important as animal nutrients, but they are physiologically essential, and represent almost the sole value of economic plants used as condiments. In 1838, De Candolle called attention to the diminished production of savors and odors in shaded plants. It was found later that plants removed from southern latitudes to the latitude of Scandinavia during the two months of maximum sunshine in the latter region, showed an increase in the development of aromatic products. Indeed, it has long been suggested that many fruit-bearing plants containing objectionable flavors might be benefited by etiolation.

(8) In total darkness very few plants will develop normal flowers or fruit, even when grown from bulbs or other storage organs, and a general effect of etiolation is usually apparent in the reduction of fruiting, while increased or continuous illumination often hastens flowering or fruitage, or may lengthen the flowering period. However, when there is only partial shading it is quite possible that the size of succulent fruits may be increased, and the time of ripening hastened, for the moisture and temperature factors under half-shade will play important rôles. It has been found, for instance, that under cheese-cloth several varieties of strawberries bear a larger fruit; and that lettuce runs earlier to seed.

(b) *Indirect effect through the environment.*—The practice of shading may modify the factors of the environment in a variety of ways; and each of these factors is important in the life relations of the plant. The purpose, of course, is primarily the modified light effect, yet frequently the effect on other factors is much more important. Aside from reducing the light, shading is important in the relations of the plant in order

(1) To regulate humidity.
(2) To conserve soil water.
(3) To mitigate or equalize temperature.
(4) To give partial protection from wind.
(5) To maintain better physical condition of the soil.

(1) In wet periods, shaded plants may have no advantages, certainly none so far as the humidity is concerned; but in dry weather the humidity is reported as more regular under partial shade. This relation is important in dry regions. It is a mistake to assume that

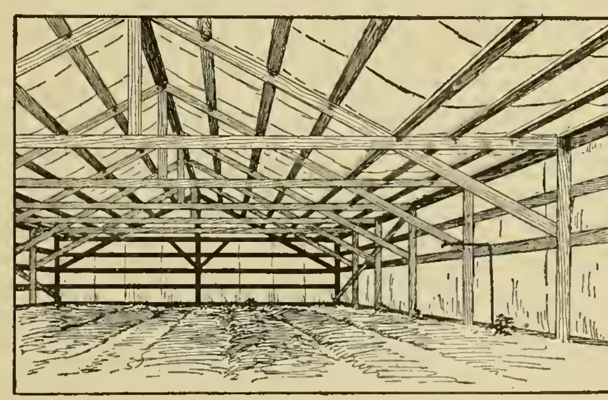


Fig. 176. Interior construction of house shown in Fig. 175.

because of greater humidity plants will always be more subject to fungous diseases. The relation of plants to fungous diseases is complex, and the general vigor of the plant is usually of more importance than any single environmental factor.

(2) The evaporation of water from the soil is unquestionably less under the covers used in shading, and this has been experimentally demonstrated time and again. The extent of the benefit would necessarily be determined by the dryness of the season or the region.

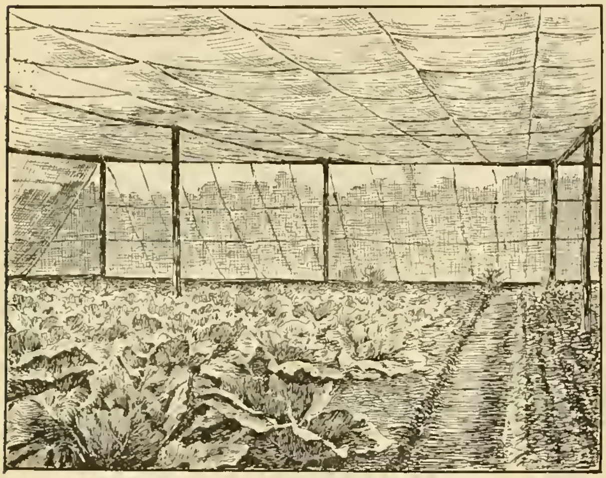


Fig. 177. Cheese-cloth shelter for vegetables.

(3) Extremes of temperature are somewhat mitigated by shading. Radiation from the soil is prevented to a considerable extent, and the light that does enter carries with it heat, much of which is absorbed. The minimum temperature under cover devices will always lag behind the minimum of the external air. Experiments in the North in early summer in moist seasons have shown a desirable increase in the temperature under cloth cover. Other experiments in July and August, when the amount of sunshine is much greater, have shown a slightly lessened temperature under cover, yet a greater uniformity. Repeated experiments in the South, however, show that by shading a very desirable equalization of temperatures is effected. In the famous market-garden and floricultural region of France, east of Toulon, many crops are grown throughout the winter under the protection of half-shade. The temperature thus secured is sufficient for the maintenance of growth in the semi-hardy flowers and vegetables.

(4) Shading devices are not wholly unimportant from a consideration of the wind relation. There is, in the first place, a lessening of the mechanical injuries, and, in the second place, the prevention of desiccation or excessive loss of water at times when the water content should be conserved.

(5) Under cover the soil does not bake so readily and is more or less constantly in excellent workable condition.

Shading devices may have an important bearing on all the above environmental factors, but, of course, it would be absurd to use such devices merely for the regulation of some of these, such as the conservation of soil moisture or the maintenance of a good physical condition of the soil.

(c) *Kinds of plants to shade.*—Shading is applicable to celery, rhubarb and tobacco under a variety of conditions, and may be employed for cauliflower, lettuce, asparagus and probably some other crops,—these all being plants commonly cultivated throughout the country. It is particularly applicable in pineapple-culture in Florida, and it has been shown to be undesirable in citrous culture in the same state. In addition, shading must be practiced to a certain extent in the cultivation of those greenhouse or floricultural plants whose native habitats are beneath the shade of the forests in subtropical or tropical regions. Among such plants are some species of ferns, palms, selaginella, anthurium, caladium, certain orchids and many others. Indeed, in the case of ornamental plants, a knowledge of the habitat will generally indicate the procedure to be used in their propagation with reference to light. Moreover, in some cases it will be necessary in drier regions to propagate under half-shade plants whose native habitats are more moist. Under the severe sunshine of the Sahara, shading is practiced on a large scale, for the garden cultures are beneath the palms of the oases. In other lands, tea may be grown in forest glades.

The screen mechanism.

Lath screen.—The materials to be used in the construction of the shading screens will depend on local conditions and prices. One of the earliest forms of screening was a lattice composed of separate lath screens supported on scantling at the height desired. Such screens are still in use where tropical plants are being propagated. The lath screen is durable but, of course, is expensive in most regions.

A desirable lath shed for half-shade work, suitable in the cultivation of pineapples or tobacco, may be made as follows:

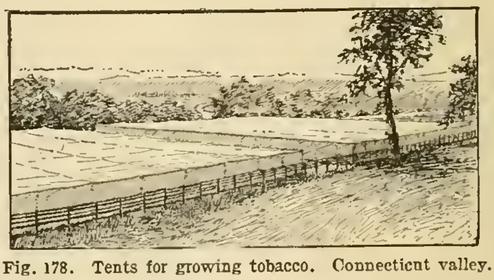


Fig. 178. Tents for growing tobacco. Connecticut valley.

Posts of 2 x 4-inch or 3 x 3-inch pine are placed nine or ten feet apart the short way and fourteen feet apart the long way. For solidity these may be set about one foot in the soil. Boards sixteen feet long are nailed across the long way and spliced at the posts, forming the joists of the structure. Stringers, 1 x 3 inches, are then nailed across the boards, the stringers in turn supporting plastering laths, nailed about one inch apart. The shed may be of any height desired, but for ease in cultivation it should be at least seven feet high.

Cloth screen.— In recent times, the cheese-cloth screen has come into very general use in tent-making on a large scale. The screens may be either open or closed at the sides, and the height will vary according to the crop and the cultivation to be given. Details of the cost of such screens per acre are available. When 2 x 4 scantlings are used for posts and good support is given overhead by means of scantling and stout wire, the materials and labor have been variously estimated at $300 to $350 per acre the first year. The lighter grades of cheese-cloth, which are preferable for most cultures, cannot well be used a second season; nevertheless, the cost for the second and subsequent years will be materially lessened. Heavier grades of cloth may be used in some cases. Cloth is now manufactured in sixteen and one-half-foot breadths for this purpose. "Domestic" is sometimes to be recommended; for small, more resistant covers, such as for coldframes, this material may be treated with linseed oil.

A good shelter-tent for tobacco, and, consequently, one suitable for almost any shade-crop, may be constructed as follows:

Posts of pine, chestnut, locust or other durable wood, eleven feet long are placed two feet in the ground and sixteen and one-half feet apart each way. Sixteen-and-one-half-foot stringers, 2 x 4 inches, nailed at the top of the posts, run one way, and across the other way are stretched No. 9 cable wires, stapled to each post and secured at the borders of the field by stakes placed six to nine feet beyond the tent borders and connected by a baseboard. Two lines of smaller wire (No. 12) are placed between and parallel to the heavy cables, hence, five and one-half feet apart. The lighter wire may also be run along the stringers and baseboard, over which wire may be wrapped the selvage of the cloth when stapled. G. B. cloth of a special width (sixteen and one-half feet) may be employed in this construction, or a heavier grade if it is hoped to use the cloth through a second year. G. B. cloth is somewhat heavier than cheese-cloth. At the two open sides twelve-foot cloth may be employed. When the shade is desired for only a part of the growing season this construction may be considerably simplified by reducing the height of the shed, the size of timbers, and the like.

Shelter-tents in the form of propagating-houses could be used advantageously in those sections in which the winters are mild, but where some form of shed is essential.

Small frames covered with cloth for coldframe purposes should be painted with raw linseed oil if imperviousness and durability are desired.

Miscellaneous screens.— In some regions, mattings may be cheaply prepared from plant products. In the far South palmetto leaves have been used successfully, and straws of various kinds have been employed in countries where labor is cheap. In the Riviera section of France and Italy a very common species of heath, *Erica arborea,* is valuable for this purpose. Its uniform height after a few years of growth, the slender yet dense branches, and its lightness, render it very efficient and remarkably cheap. Bamboo has been employed where it is sufficiently common.

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GLASSHOUSES FOR VEGETABLE CROPS

By *L. R. Taft*

For many years gardeners made use of coldframes and hotbeds for the starting of vegetable plants in the spring, and for the forcing of lettuce and radishes, to get them on the market before they could be produced in the open air. A demand soon sprang up for a great variety of other vegetables, and it was found that, if they could be produced throughout the winter months, the prices they would bring would be sufficiently remunerative to make their culture very profitable. This has led to the erection of numerous forms of vegetable forcing-houses, and some of the ranges are so extensive as to cover several acres. Some of the larger houses are several hundred feet in length and fifty to one hundred feet in width, and are so arranged as to permit teams to be driven through to bring in soil and manure; and horses are often used for plowing and working the ground. The modern vegetable forcing-house makes it possible to produce crops of all kinds of vegetables with comparatively little risk, and with far less labor and expense than was possible with hotbeds or coldframes or with the form of greenhouses used in the early days.

The business of growing vegetable plants either for sale or home use has assumed large proportions. In some cases, the houses that have been used for the growing of vegetables or flowers are used for this purpose, while in others special houses are used. Although not necessary, it will be convenient to have raised benches in houses to be used for this purpose, at least enough to serve as seed-beds, otherwise the vegetable houses will answer very well. Less care is required in the construction of houses to be used exclusively for the starting of plants in the spring. The roof covering of small houses can be of hotbed sash, and the houses can be heated by means of flues.

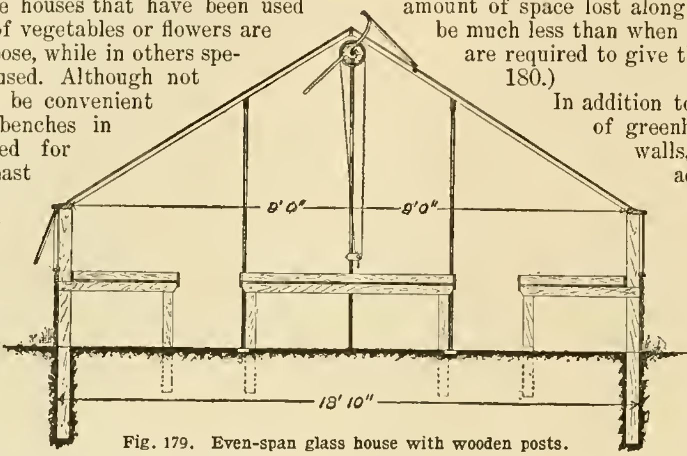

Fig. 179. Even-span glass house with wooden posts.

Types of houses.

The forcing-houses in use thirty years ago, and which are occasionally found today, were about ten feet in width, with wooden walls and the roof covered with a row of hotbed sash on each side of the ridge. They were commonly heated with a flue. The width of the houses was gradually increased to about twenty feet. (Fig. 179.) The walls were either of posts covered with a double thickness of boards, or there was a row of glass one to two feet in width under the plates to furnish light and ventilation. In addition to the two benches about four feet wide found in narrow houses, these contained a bed or bench through the center about eight feet wide. While some of the houses of this size were heated with flues, hot water was more commonly used, although in large ranges steam was generally preferred. This width and style of house gives good satisfaction, and even today will be found very well suited to the purpose if only one or two small houses are required.

The modern vegetable forcing-houses are more commonly constructed of widths varying from twenty-six to fifty or more feet, as it has been found that better crops can be grown in the wide houses and there will be less waste room. By building the houses where there is a slight gradual slope of the land toward the south, it is possible to erect a house forty or fifty feet in width without having the ridge excessively high, while the amount of space lost along the south wall will be much less than when three to five houses are required to give the same area. (Fig. 180.)


Fig. 180. A side-hill greenhouse.

In addition to the ordinary form of greenhouse with vertical walls, a style that will add eight to ten feet to the available width of the house, without greatly increasing the cost of construction or of heating, is built with a sort of hip-roof; that is, instead of having vertical walls, the plates are supported by means of iron posts and the side walls stand at an angle so that at the ground the walls are three to five feet outside of the plates on each side of the house.

If the houses are not sufficiently large to make it worth while to drive in at the ends with compost, there should be either ventilators or movable sash in the side walls that can be taken out so that soil can be thrown in.

The most common form of roof for vegetable-houses is the even span, with the houses running either east and west or north and south. The three-quarter-span houses, with the long slope either to the south or to the north, are also much used. In the former case, the north wall is usually somewhat higher than the south, but if the long slope is to the north the walls are of the same height. It is possible to build a house fifty or more feet in width under a single roof by placing it on a gentle slope. As much as five-sixths of the roof may then be in the south slope.

The framework.

There is considerable variety in the methods of construction used for vegetable-houses, as indicated in Figs. 179–183. In some cases, posts of cedar, or some other durable timber, are set at intervals of six feet so as to stand five or six feet above ground. They are then covered to the height of two or three feet with sheathing and siding, with a double thickness of building-paper between. A sill is placed on this and the space up to the plate is filled in with sash-bars and glass. Another method is to build a wall of concrete to the height of two feet. In this, two-inch gas-pipes are set at intervals of five feet. These support the plate, and the space between the plate and the concrete is occupied by glass. In other cases, angle or flat bar iron is used for the posts, to the upper ends of which iron rafters are fastened.

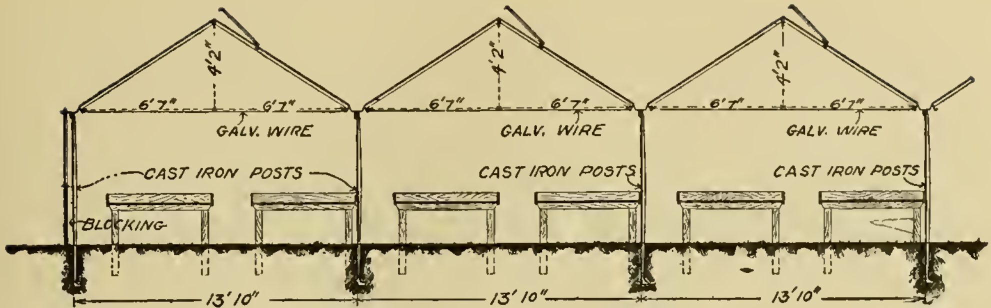

Fig. 181. Ridge- and furrow-houses with iron gutters.

When several houses are built with common gutters between the adjacent houses, if they are used for the same classes of crops, a row of posts to support the gutters will be all that is required. (Fig. 181.) Although less commonly used for vegetables than for flowers, what is known as the ridge-and-furrow style of construction has much merit, especially for tomatoes and cucumbers. As now constructed these establishments are made up of several narrow houses, with a width of sixteen to twenty-four feet, and at least six feet in height to the gutters. As there is nothing but posts under all except the outside walls, it practically makes one wide house. There is less trouble from the shadows of the gutters than in most narrow houses, as the walks are located where the deepest shadows fall.

The roof.

For the construction of the roof of a greenhouse there is no material equal to southern cypress that is free from sap-wood. If soaked in oil and the joints put together in white lead, a cypress greenhouse will last for many years when kept properly painted. Although iron rafters and purlins make possible the use of lighter sash-bars (Fig. 182), a great majority of vegetable-houses are built without rafters, the framework of the roof being formed of cypress sash-bars that run from the plates to the ridge. These are two to two and a half inches deep and about one and one-eighth inches wide, according to the size of the glass and the distance between the supports. The plates may be either of wood, beveled so that the water will run off, or formed into a gutter to carry the water to a drain; or various forms of iron plates and gutters may be used. The iron gutters are of course more durable, but the houses are harder to heat and with some kinds the ends of the sash-bars decay sooner than with wooden gutters and plates.

Ventilating.

Ample means should be provided for the ventilation of vegetable-houses. This can be secured by means of a row of ventilating sash at the ridge and another row beneath the plates, which should have a width of two to three feet. They should be supplied with some of the modern ventilating machinery that will permit of opening stretches of one hundred feet at a time.

Glass.

The glass most commonly used is sixteen by twenty to twenty-four inches, double strength, and of "B" quality, although "A" glass is better. For small houses it answers fairly well if it has a width of twelve to fourteen inches. The putty used for bedding the glass should be mixed with about ten per cent of white lead. In laying the glass, it should be lapped about one-eighth of an inch. As the lower edge of each pane will be raised from the sash-bars the thickness of the glass, a sufficient amount of putty should be placed on the rabbets to fill this space before the glass is laid. Care should be taken to select the panes so as to make tight joints where they lap, and they should be held in place by zinc shoe-nails, using four to six according to the size of the panes. The double-pointed glazing tacks also answer well for holding the lower corners of the panes in place. No putty should be used on top of the glass and all surplus should be scraped off, care being taken to fill all of the cracks. In addition to soaking the sash-bars in oil, and giving them a coat of paint after they are in place but before the glazing is done, the roof should receive a final painting after the glass is in place, care being taken to "draw" the putty wherever it shows. It is economy to repaint every five years.

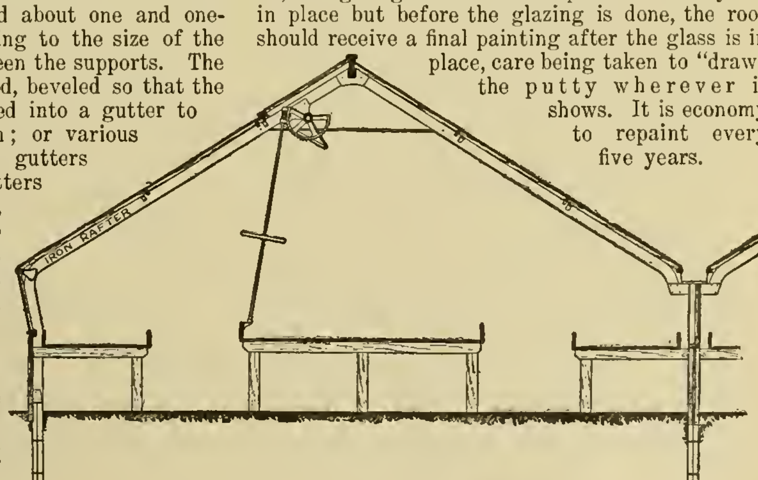

Fig. 182. Even-span greenhouse with iron rafters.

Benches and beds.

In the narrow houses it has been customary to have raised benches three or four feet in width along the walls, with one or more others six or eight feet in width in the middle of the houses, the walks being eighteen to twenty-four inches in width between the benches, or the walks placed along the walls, and all of the benches have a width of seven or eight feet. In some cases, the gutters are supported by means of arches so as to permit the placing of walks under the gutters, where the space is less useful than in the center of the houses. The raised benches are often built entirely of wood, or with wooden bottoms and some less destructible materials such as gas-pipe or cement for the supports. In some cases, cement has been used with good satisfaction for constructing the bottoms of raised benches. The practice is becoming more common in the construction of houses designed entirely for vegetable forcing, to do away with raised benches. Sometimes the ground is handled exactly as in a garden, all of the ground being covered with the crop with the exception of a narrow space every fifteen or twenty feet for use when watering or ventilating. It is more common, however, to keep the surface soil a foot or more above the level of the walks. This certainly helps in the drainage of the soil. If the soil is inclined to be heavy, it is an excellent plan to sink the walks or to fill up the beds so as to make the surface at least eighteen inches above the walks. The soil can be held in place by cement walls that need not be more than two inches thick at the top. If drain tiles are run about a foot below the surface, either across or lengthwise of the beds, it will aid both in the drainage and the aëration of the soil. Even better results can be secured by running one of the heating pipes in a tile once in five feet in the width of the house. This sometimes hastens development 10 to 25 per cent.

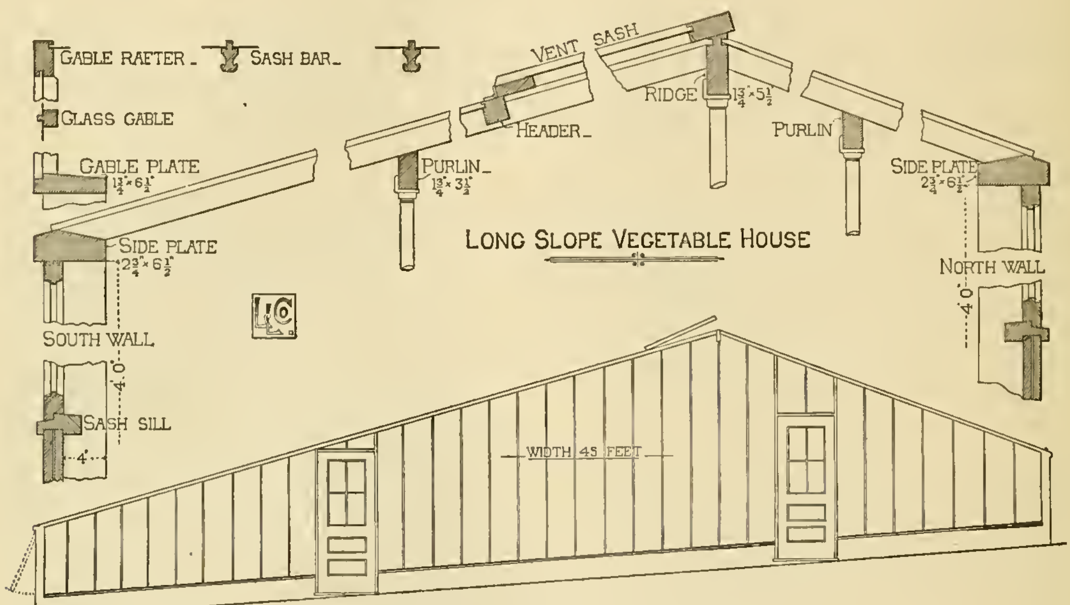

Fig. 183. Details of construction of a long-slope greenhouse.

Heating by means of flues.

Various methods are used for heating vegetable houses and all have their merits under certain conditions. The old-fashioned flue answers very well for small houses in sections where wood can be obtained cheaply for fuel, but it is not very reliable in the colder climates, except after severe cold weather is over. A brick furnace is constructed at one end of the house, with a length of three to five feet according to the length of the wood. An opening can be left at one end near the bottom to serve for a draft, and a tile or iron smoke-pipe should lead from near the top of the other end, with a slight ascent, to a smoke-stack at the farther end of the house. There should be a door for putting in the fuel in the end or top of the furnace. In addition to the increased danger from fire when a flue is used, these furnaces give more or less trouble with smoke and do not work well when the flue is more than fifty feet long. For use in fire hotbeds, which are really low and narrow greenhouses used for starting lettuce and similar crops in the spring, a flue with a tile running through the soil at the depth of a foot answers very well.

Heating with hot water.

For greenhouses with less than 5,000 square feet of glass, a hot water heating system will be more satisfactory than either a flue or steam system, as, although it will cost nearly 50 per cent more to install, it will be more economical in fuel and will require less attention than a steam-heating plant, besides giving a more regular heat if run without a regular night fireman.

In a hot-water system the water is heated in a boiler and then carried through the houses in a series of pipes. The circulation is due to the fact that cold water is heavier than hot water, and as one end of the circuit of pipes is attached to the bottom, while the other is connected with the top of the boiler, the heavy cold water in the greenhouse flows back in the pipes and pushes the light hot water out at the top to flow off into the system to take its place. A great variety of hot-water boilers, of both cast- and wrought-iron, are made for greenhouse heating. The cast-iron boilers are to be preferred for small plants, but there are a number of tubular boilers that are made for hot-water heating that answer very well. An ordinary tubular steam boiler will also be found very satisfactory for hot-water heating, although if a tubular boiler is to be constructed for the purpose it would be better to have tubes also in the top of the boiler.

Four-inch cast-iron pipe was formerly used for hot-water heating, but two-inch wrought-iron pipe is now more commonly used for the coils, and the same size will answer for the flow pipes in houses less than 100 feet in length. In determining the amount of pipe to be used in a greenhouse, it will be safe under ordinary conditions to use one square foot of pipe for three square feet of glass, when a temperature of 60° is desired, or for four square feet of glass if 50° will suffice. All of the glass in the roof, sides and ends of the house should be computed, and it will be safe also to consider the exposed woodwork as equivalent to 20 per cent as much glass.

After determining how many feet of radiation will be required in the house, the size and number of flow pipes should be determined. As a rule, two-inch pipes can be used in houses 50 feet in length if they are not more than 20 feet wide, but they should not be used to carry more than 200 square feet of radiation, including that in the main itself. While a larger number might be used in short houses, when the boiler is some distance below the coils, the circulation will be more even when not more than two two-inch returns are supplied by a two-inch flow pipe. A two and one-half-inch flow pipe will ordinarily handle 400 square feet of radiation, including its own surface. Unless the houses are rather long, it will be best not to use flow pipes within the houses larger than two and one-half inches.

It is an easy matter to adjust the radiation in a greenhouse. If a house is 20 feet wide and 100 feet long, and has two feet of glass in each of the side walls, it will require about 1,000 feet of radiating surface to heat it to a temperature of 60° in zero weather, provided the house is reasonably well built and is not too much exposed to strong winds. From the above, it will be seen that three two-and-one-half-inch flow pipes should be used. These will supply 225 square feet of radiation, while twelve two-inch returns will supply the remainder of the radiation required. In addition to the data given above, one merely needs to know that a two and one-half-inch pipe has .75 of a square foot of surface, while a two-inch pipe has .621 of a square foot for each foot in length.

In arranging the pipes, it will ordinarily be well to place the return pipes on the walls and under the benches, or in the walks when beds are used. The flow pipes may also be under the benches, provided the returns are above the level of the heater; but a better circulation can generally be secured if there is one flow pipe placed on each of the plates. When more than two flows are required and are not placed under the benches, one or two may be carried on the center posts two to four feet below the ridge, and, in wide houses, one can be on each row of purlin posts. In all systems of heating, the return pipes should be given a fall of one inch in ten or fifteen feet to allow the air to escape. The flow pipes give the best circulation when they also are given a slight fall, but they can run uphill with but little loss of circulation. If the downhill system is used, it will not be necessary to use air-valves, provided the pipe which connects the system with the expansion tank leads from the highest part of the main flow pipe. It will also be well to place a valve on each of the flow pipes to the different houses so that the circulation of the water can be regulated. If the lower ends of the returns are higher than the top of the boiler, there will be little difficulty in securing a good circulation, even though the flow pipes are on the same level. By giving the flow pipes considerable elevation, a fairly good circulation can be secured even when the returns are only slightly above the bottom of the boiler.

The above applies to what is known as the open-tank system. This will always be most satisfactory for small ranges, but by the use of a closed system, the water, which with an open tank seldom has an average temperature of more than 160°, can be raised above the boiling point. This makes it possible to use fewer and smaller heating pipes, thus reducing the cost of installing the plant; but it is less economical of fuel, requires greater care, and may become somewhat dangerous.

Steam heating.

In a general way, much that has been said regarding hot-water heating plants applies to steam-heating. Both wrought- and cast-iron boilers are used, the latter being rather more expensive and lasting but little longer than tubular boilers that are well cared for. The ordinary return tubular boilers seem well adapted to the heating of greenhouses containing more than 5,000 square feet of glass. Aside from the steam boiler fittings, there is but little difference in the arrangement of a hot-water and a steam-heating plant except that the pipes used for the latter are much smaller and the air-valves are placed at the lower end of each coil. In a general way, it can be said that the number of one-inch steam-pipes required to heat a greenhouse will be about the same as the number of two-inch pipes when hot water is used. In all except very small houses, it will be better to use one and one-fourth-inch steam-pipes for the returns. The flow

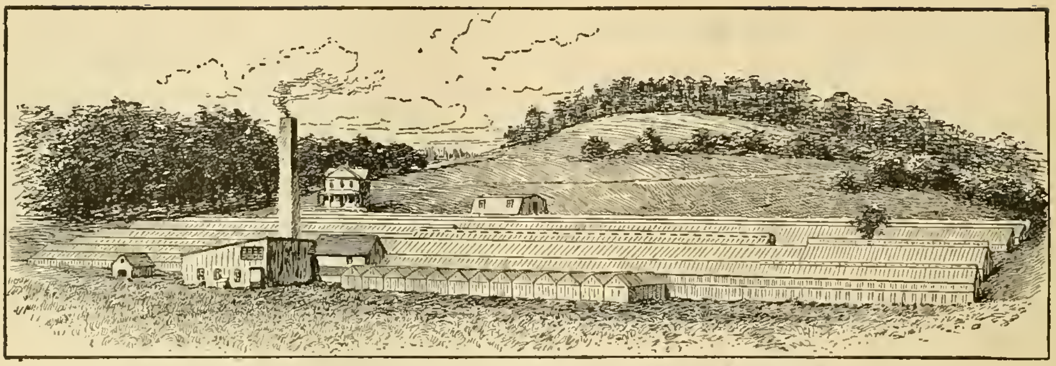

Fig. 184. A modern floricultural establishment. (Pierce Bros., Waltham, Mass.)

pipes also can be much smaller than with hot water, a two and one-half-inch pipe being amply large for a house 20 by 100 feet.

Two methods are commonly used for arranging the steam heating pipes in greenhouses. In one, the flow-pipe is carried to the farther end of the house where it is joined by means of branch pipes to the coils, which are distributed about the same as with hot water. The other way is to connect the flow pipes with the coils at the end nearest the boiler. Each of the coils may be provided with a return pipe for the drip, or all of the coils may be connected at the farther end of the house with one pipe which serves as a common return pipe for the series.

Literature.

Greenhouse Construction and Greenhouse Management (two books), L. R. Taft, Orange Judd Co., New York. For chapters on the building and care of greenhouses, see also Gardening for Pleasure, Peter Henderson ; Success in Market Gardening, W. W. Rawson ; Vegetable Gardening, S. B. Green; Vegetables Under Glass, Henry A. Dreer. The Forcing-Book, L. H. Bailey. All recent garden books are likely to offer good advice. Recent years have seen great changes in methods of constructing glass houses for both vegetable gardening and floriculture under glass. The reader will need to consult the current horticultural periodicals to keep in touch with the progress. The tendency is toward very wide houses of simple construction. Some of the newer forms are shown in Figs. 184–188, as well as in the pictures on preceding pages. Fig. 184 is redrawn from a print in The Florist's Exchange.

PLANTS IN RESIDENCE WINDOWS

By *Charles E. Hunn*

There is no one way to grow plants in windows, since there are so many kinds of plants to be considered ; but it will be worth while to give the farmer's wife advice. There is no intention of covering the general question of window-gardening in this article ; that will be found in many special books and articles. It is purposed only to mention the four or five main causes of success and failure, omitting all details of the culture of special plants.

General cultural requirements.

Soils that will grow a good corn crop, will, with the addition of manure and sand, generally grow good crops of flowers. But for the best results, a made soil is preferable. This soil may have for a base any good garden soil or the soil next under the sod of an old pasture, to which may be added well-rotted manure, leaf-mold and sand. The proportion of the latter to the former will depend somewhat on the kinds of roots the plants have ; whether strong, stiff roots, capable of pushing through the soil, or fine, fibrous roots that require mellow, easily penetrated soil.

As to the kinds of manure to use, preference should be given to well-rotted cow manure, as this is a cool, slowly available plant-food. Horse manure is of value, but heats and soon loses its value as plant-food. Sheep manure, poultry manure and the commercial fertilizers are best used in the liquid form, dissolved in water, and are of value as a stimulant after the plants have filled the pots with roots. There are no rigid rules as to the make-up of soils, and plants may thrive in a vari-

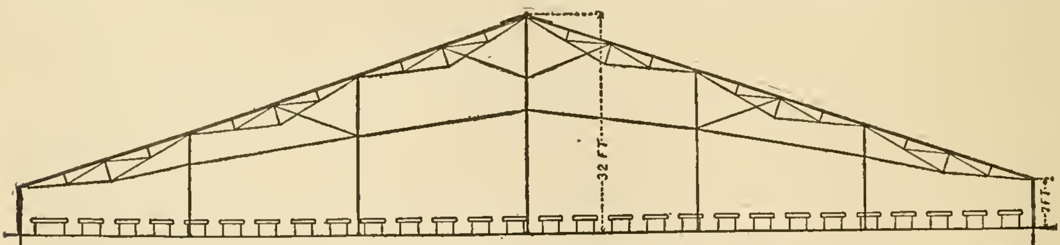

Fig. 185. Modern greenhouse construction. Design of even-span house, 150 feet wide. (King Construction Company.)

ety of mixtures of soils. With a larger number of plants a mixture of three parts loam, one part each of well-rotted manure, sand and leaf-mold, or woods dirt, will prove satisfactory.

Having in mind the fact that the growing of plants in a room through the winter is an unnatural process, every care should be taken to make all conditions favorable for plant growth. The most important point in house-culture of plants is to have ample drainage in the box. The necessarily dry atmosphere of the living-room soon dries out the soil and frequent waterings are necessary; but if there is imperfect drainage there may be water standing around the roots of the plant when the top soil needs moisture. With but few exceptions, such as callas and cyperus or umbrella plant, water is decidedly injurious to plants and facilities for the escape of excessive water should be furnished, leaving only moisture. When one has facilities, window-boxes should be used rather than shelves or ledges, setting the potted plants in the box and filling in around the pots with moss or sifted coal-ashes. This prevents the soil drying out, keeps the roots cool, and saves in the watering.

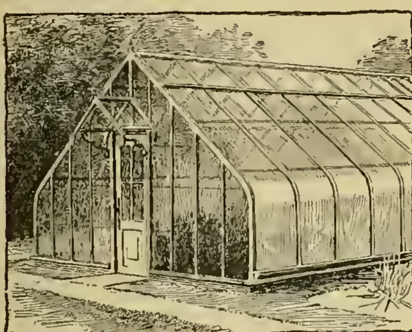

Fig. 186. House without eaves. The glass at the shoulder or plate is bent, and the glass extends nearly to the ground.

Kinds to grow.

A prime cause of failure in raising house plants is a poor choice of the kinds. The practiced grower usually has a rather small range, such as experience has taught him will thrive under his conditions. The choice of the plants, therefore, is of the greatest importance. In this age of furnace-warmed and gas-lighted houses, the range of plants that may be successfully grown in a dwelling-house, to a certain extent, is limited; yet a good choice remains if one is willing to give the attention that the plants require and will use good judgment as to temperature and moisture. The so-called "foliage plants"—those grown for their graceful or colored foliage rather than for their flowers—are, perhaps, the easiest to manage. Having no flowers or buds to be injured by water, they may be sprayed or washed as often as required; and, needing no change in the temperature to develop flowers, they may be grown together without difficulty; and, as many of them can be grown from seed, they may be had cheaply. Choosing a list of six plants of this character, we could start with *Dracæna indivisa*, a graceful, narrow-leaved, erect-growing plant with a drooping leaf habit. Another good choice would be *Grevillea robusta*, or silk-oak, a rapid-growing plant of erect habit and graceful, finely-cut, dark green foliage. For a drooping plant, nothing is better than *Asparagus Sprengeri*, a rapid grower and a plant that lends itself to almost any treatment, training along the windows, held upright, or hanging in a natural way. The Boston fern, or some of the more graceful types of the same species, are entirely satisfactory. A small Date palm, *Phœnix reclinata*, and either a Kentia or an Areca palm, will finish the list, giving one a range of upright, spreading and drooping plants, all requiring practically the same general treatment.

The Dracæna, Grevillea and Asparagus may readily be grown from seed, plants from seed sown in early summer growing to good size by winter. The other three plants may be purchased at reasonable prices. The common rubber plant (*Ficus elastica*) should not be omitted from the foliage plants. When young and vigorous, it is attractive.

Among the flowering plants that submit to house treatment, the geranium is perhaps the most popular, and a well-grown plant in full bloom speaks of very careful treatment. The objections to this plant are the tendency to grow leggy or spindling, having a bare stalk with a few leaves at the top, and the habit of turning its leaves toward the light and becoming one-sided. Begonias, both the ornamental-leaved and the flowering type, may be grown to fine specimen plants if given care. Primroses grown from seed sown in May, or purchased in November, should bloom profusely through the winter. Cyclamen grown from seed sown in January make fine little plants by the following winter. A few careful growers with exceptional facilities and the knack of making plants thrive, succeed with a wide range of plants; but one who has only a limited experience and but little time to devote to plants should attempt to grow but few, if any, of the plants most difficult of culture.

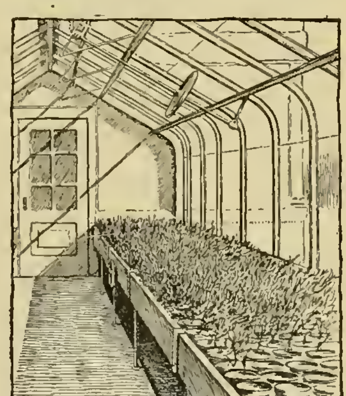

Fig. 187. Eaveless house, interior view

Window-gardens are never complete without a show of spring-flowering bulbs. These take the place of plants that have bloomed through the winter and have become unsightly, thus allowing one to have his windows full and, at the same time, to have a change of blooms. Hyacinths, narcissi and freesias are perhaps the best to grow. The first two, if potted in October or November and set away in a cool, dark place to form roots, will be fit to put into the windows in six to eight weeks, or may be allowed to remain cool until wanted later. The freesias may be placed in the window as soon as potted, but will give better satisfaction if grown cool for a month before being set in the window. The freesia bulbs may be saved after blooming for the next winter. The hyacinth and narcissus bulbs do not furnish satisfactory bloom the second year, but, if planted out, will grow and bloom for several years.

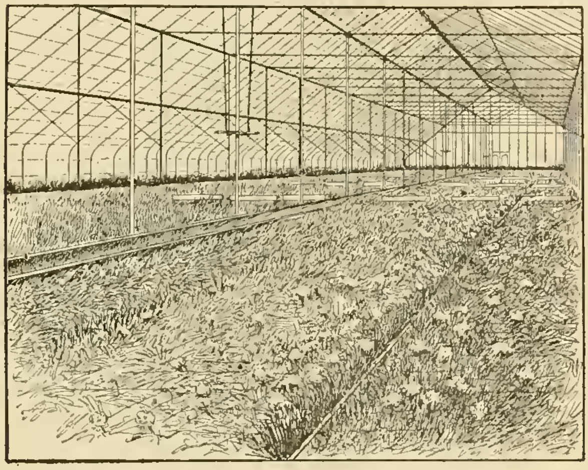

Fig. 188. Interior of one of the great modern glasshouses. There are no eaves. (F. R. Pierson Company.)

Window-boxes.

A very satisfactory type of window-gardening is the window-box made to set into the window ledge or supported in front of the window. By means of such a box, which should be at least six inches deep and ten inches wide, a more even condition of moisture and a more abundant supply of plant-food may be had and consequently a larger range of plants may be grown. Climbing as well as drooping vines, such as parlor or German ivy, *Asparagus plumosus*, *Lygodium scandens* or climbing fern, or maurandia, all rapid growers, may be trained along the windows. The last mentioned vine, maurandia, has, added to its attractive leaves, a profusion of light blue flowers produced through the entire season. Of drooping vines, perhaps the best is the *Asparagus Sprengeri*, followed by wandering jew, saxifrage, and Kenilworth ivy. Geraniums, begonias, in fact all plants recommended for house-culture may be grown to advantage in such a box, and as spring advances the seeds of such annuals as sweet alyssum, candytuft, lobelia and mignonette may be sown along the edge, thus renewing the plants and changing the character of the box from a winter to a spring collection of plants. It often happens that one or more plants in such a window-box fail to make a satisfactory growth, in which case their places may be filled by pots of bulbs that are ready to be brought into flower, or the whole box may be changed into a bulb bed with very little trouble. One more point in favor of these boxes is the fact that, if they contain no climbing vines, or if such vines are not attached to the walls, the boxes may easily be moved from an exposed window and protected through severe weather.

Pests and diseases.

Red-spider and green fly are the two pests that are most commonly found on house plants. The former is a very minute mite, hardly visible to the naked eye, but whose presence is easily known by the gray appearance of the under side of the leaves, and when the spider is abundant by a fine cobweb covering both sides of the leaf. This insect lives only in a dry atmosphere and if attention is given to spraying and washing the foliage, there is very little danger of its obtaining a foothold. The green fly may be destroyed by fumigation with tobacco or by dusting fine tobacco over the plants.

Insects of minor importance are, mealy bugs, whose presence is known by a cottony appearance in the axils of the beans, and several species of scale which infest palms, ferns, and other plants. For the mealy bug, lay the plant on its side and spray forcefully with clear water; or dip the plant in strong soapsuds and after a few moments clean it with clear water. The scale may be destroyed by spraying the leaves with soapsuds, or, in severe cases, with a solution of whale-oil soap (one pound to five gallons of water). Soon after this treatment the plant must be cleansed with clear water.

House-plants often show a sickly appearance, and from some cause or other fail to thrive. If the leaves turn yellow and fall, one of two things is the cause,—imperfect drainage and consequent sour soil, or neglect in watering and consequent drying up of the sap in the plant: very rarely can the wilted, yellowing leaves be saved. The trouble may be rectified and the plant recover.

Another disease, due to sudden changes in temperature, is mildew. It is revealed by a whitish or grayish appearance of both sides of the leaves, causing them to fall. The treatment is to dust the plants with flowers of sulphur or spray with sulfate of potassium (one-half ounce dissolved in two gallons of water).

Literature.

Some American books are: Anders, House Plants as Sanitary Agents; Julius J. Heinrich, The Window Flower Garden; Eben E. Rexford, Home Floriculture; E. S. Rand, Jr., Window Gardener; Daisy Eyebright (Mrs. S. O. Johnson), Every Woman Her Own Flower Gardener; Edwin A. Johnson, Winter Greeneries at Home; N. Jonsson Rose, Window and Parlor Gardening; Henry T. Williams, Window Gardening; Lizzie Page Hillhouse, House Plants and How to Succeed with Them.

CHAPTER VII

SEEDING, PLANTING AND YIELDS

FIELD CROPS ARE PROPAGATED chiefly by means of seeds, rather than by means of cuttings or other special parts. Moreover, the seed-propagation is of the easiest and simplest kind, adaptable to wholesale methods. There is no necessity for the employing of grafting or other very special practices. For these reasons, the subject of propagation of plants is usually considered to belong to that phase of agriculture known as horticulture.

A very few of the field crops are propagated by asexual parts or cuttings of them, as white potato, sweet-potato, sugar-cane, cassava, chicory. Whenever cutting-propagated plants are raised from seeds, the seedlings are likely to vary greatly, so greatly, in fact, that seed propagation may be employed with such plants for the purpose of securing new varieties. The white or Irish potato is a good example; and as this species seeds relatively freely and seedlings are easily grown, the number of varieties is very large. The sweet-potato and sugar-cane seed so rarely, at least in this country, that this means of securing new varieties is practically little employed, and reliance must be had on variation through asexual parts. The reason why seeds give such uncertain results in cutting-propagated plants, as potatoes, apples, grapes, strawberries, is because there has been no seed-selection to make them "come true." In the seed-propagated plants, as the cereal grains and garden vegetables, selection has been practiced so long and so carefully that the tendency to vary has been largely bred out. The tendency of seeds to give variable offspring is greatly increased, as a general thing, by crossing, whereby different elements or tendencies are combined.

Fig. 189. Seed storage room.

Quality in seeds.

The merits of good agricultural seeds lie in the following characteristics:

They are "strong," or able to produce vigorous normal plants;
They are free of disease;
They are of the proper variety or strain;
The sample carries no impurities or adulterations.

Whether seeds are strong depends in part on the vigor or strength of the plants that produced them, in part on their age, in part on the way in which they were grown, and in part on the way in which they have been handled and kept. Tables of longevity,—that is, of the number of years that seeds retain their germinating power,—are of some value in determining whether seeds of a given age are likely to be good. Such a table, compiled from various sources, for some of the field crops is given below. Such tables present only averages, however, and are likely to be of more use as information than as advice. Many conditions influence the longevity of a seed. When well ripened and kept in a dry cool aërated storehouse, the viability may be retained longer for some seeds than the figures indicate. The

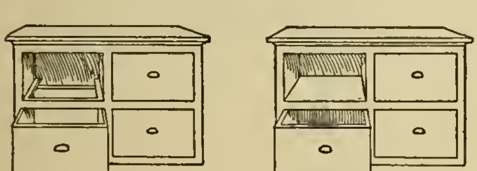

Fig. 190. Poor and good cabinets. In the chest on the left, rats and mice pass readily from one drawer to the other. In the one on the right, this is impossible because of solid partition between drawers. (Cornell Reading-Course Bulletin.)

tables usually represent extreme average longevity. The vigor of the seed—as expressed in crop-producing power—may decline long before it ceases to retain life. Fresh seed is therefore safest; although certain seeds of the melon family are said to produce better crops when a year old.

Longevity of Certain Seeds.

The asterisk (*) denotes that the seeds had not all lost their germinating power at the termination of the number of years recorded.

	Average years	Extreme years		Average years	Extreme years
Barley	3		Mustard	3	10
Bean	3	8	Oats	3	
Beets	6	10	Orchard-grass	2	
Buckwheat	2		Parsnip	2	4
Cabbage	5	10	Peanut	1	1
Carrot, with the spines	4 or 5	10*	Peas	3	8
Carrot, without the spines	4 or 5	10*	Pumpkin	5	9
Chicory	8	10*	Rape	5	
Chick-pea	3	8	Rye	2	
Clover	3		Soybean	2	6
Flax	2		Squash	6	10*
Hop	2	4	Timothy	2	
Lentil	4	9	Turnip	5	10*
Maize	2	4	Wheat	2	7*
Millet	2				

Haberlandt's Figures of Longevity (Quoted in Johnson's "How Crops Grow").

Percentage of seeds that germinated in 1861 from the years

	1850	1851	1854	1855	1857	1858	1859	1860
Barley	0	0	24	0	48	33	92	89
Maize	0	not tried	76	56	not tried	77	100	97
Oats	60	0	56	48	72	32	80	96
Rye	0	0	0	0	0	0	48	100
Wheat	0	0	8	4	73	60	84	96

Experience and experiment have determined certain seed standards. The following standards of purity and germination in seeds are recommended by the Department of Agriculture: "The term *purity*, the percentage of which is reckoned by weight, denotes freedom from foreign matter, such as chaff, dirt, or seeds of other plants, but it has no reference to the genuineness of the variety, which is called by seedsmen purity of stock. The percentage of *germination* is reckoned by count from a sample freed from foreign matter, a seed being considered as having germinated when the rootlet, or radicle, has pushed through the seed-coat. It is not to be understood from these standards that the real value of a quantity of seed is dependent wholly upon the number of pure germinable seeds it contains. The ancestry of the seed and its trueness to type are factors of primary importance in determining seed value, especially in the case of vegetables. These points, however, are very difficult, if not impossible, to determine at the time of purchase, while the purity and germination are easily ascertained and are very essential points. The germination standards are based upon tests conducted between moist blotters in a germinating chamber. Such tests usually give a little higher result than those made in soil. For the best results in blotter tests of lettuce and beets the seed should first be soaked in water for from four to six hours."

Fig. 191. Millet's seed-sower.

The following table showing percentages of the purity and the germination of leading agricultural seeds of high grade is prepared for this book by J. W. T. Duvel, of the Seed Laboratory of the United States Department of Agriculture. These figures represent what may be considered a high average for such seeds, but not the maximum, even of commercial seeds. While the figures are only tentative and subject to change, it should be stated that they are the result of all the information available at the present time, including nearly fifty thousand germination tests conducted in the seed laboratory of the Department of Agriculture.

Percentage of Purity and of Germination of High-Grade Seed.

Seed	Purity Per cent	Germination Per cent	Seed	Purity Per cent	Germination Per cent
Alfalfa	99	95	Millet, common	99	90
Asparagus	99	85	Millet, hog	99	90
Barley	99	98	Millet, pearl	99	90
Beans	99	98	Mustard	99	95
Beet, garden	99	*150	Oats	99	96
Beggarweed	99	90	Okra	99	80
Bermuda-grass	98	90	Onion	99	96
Blue-grass, Canada	95	85	Orchard-grass	95	90
Blue-grass, Kentucky	95	85	Parsley	99	80
Brome, awnless	90	90	Parsnip	98	85
Buckwheat	99	96	Peas	99	98
Cabbage	99	95	Pumpkin	99	96
Caraway	98	90	Radish	99	97
Carrot	98	85	Rape	99	96
Cauliflower	99	85	Red-top	96	90
Celery	98	85	Rice	99	95
Clover, alsike	98	95	Rye	99	96
Clover, crimson	98	97	Rye-grass, Italian	98	90
Clover, red	98	95	Rye-grass, English	98	90
Clover, sweet	98	90	Salsify	98	85
Clover, white	96	90	Sainfoin	99	95
Collard	99	95	Sorghum	98	95
Corn, field	99	99	Soybean	99	95
Corn, sweet	99	94	Spinach	99	90
Cotton	99	90	Spurry	99	90
Cowpea	99	95	Squash	99	96
Cress	99	90	Sugar-beet (large balls)	99	*175
Cucumber	99	96	Sugar-beet (small balls)	99	*150
Eggplant	99	90	Sunflower	99	90
Endive	99	85	Sweet-pea	99	90
Fescue, meadow	98	90	Teosinte	99	90
Fescue, sheep's	96	85	Timothy	99	96
Flax	99	95	Tomato	99	94
Hemp	99	90	Tobacco	99	90
Kafir	99	97	Turnip	99	98
Kale	99	95	Velvet bean	99	90
Lettuce	99	98	Velvet grass (hulled)	97	85
Melon, musk	99	96	Vetch	99	93
Melon, water	99	96	Wheat	99	98

*Each beet fruit, or "ball," is likely to contain two to seven seeds. The numbers given in the table represent the number of sprouts from one hundred balls.

The seed-bed.

The character of the seed-bed, or the ground in which the seed is planted, has very much to do with the success of the crop. A vigorous start is a long step toward a good crop. Such a start contributes to early continuous growth, the plant has "constitution" to withstand adverse conditions, it may be able to overcome insects or plant diseases or to recover from the attacks of them. The fit preparation of land has for its object the making of a good seed-bed, the increasing of the pasturage for roots, the physical and chemical amelioration of the soil. If the seed germinates freely, it must be in close contact with a firmly settled soil. This means that the soil must be finely broken and evenly surfaced. Many implements are now manufactured to aid in putting the finish on the seed-bed, as smoothing harrows and special forms of cultivators. After the crop is well up, the seed-bed

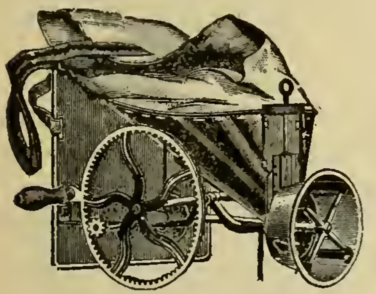

Fig. 192. Hand broadcast seeder.

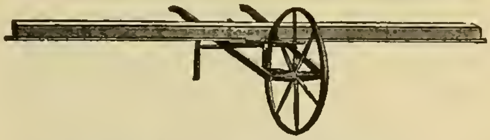

Fig. 193. A wheelbarrow grass-seeder.

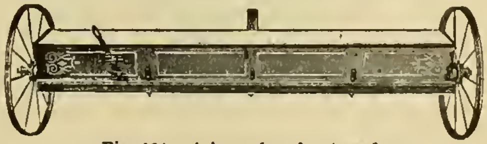

Fig. 194. A horse broadcast seeder.

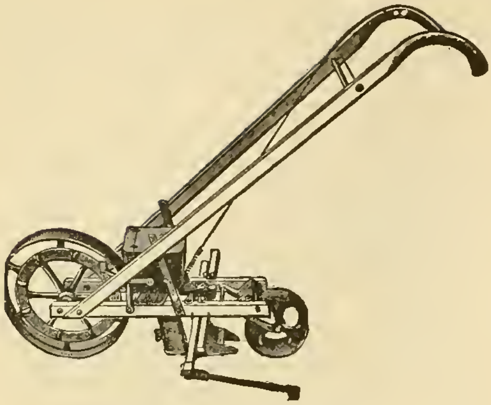

Fig. 195. A hand seed-drill.

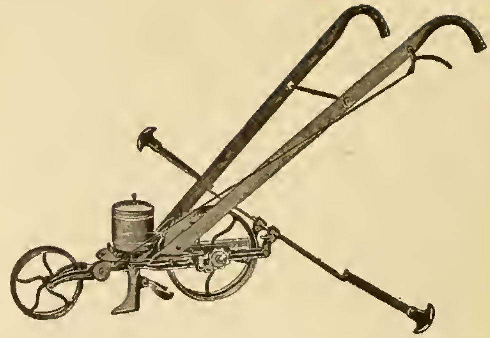

Fig. 196. Another model of garden seeder.

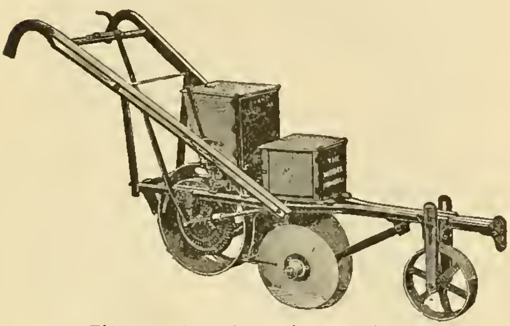

Fig. 197. A one-horse disk corn-planter.

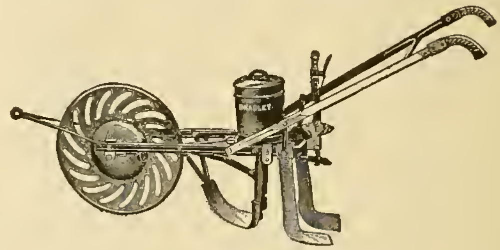

Fig. 198. A one-horse corn-drill.

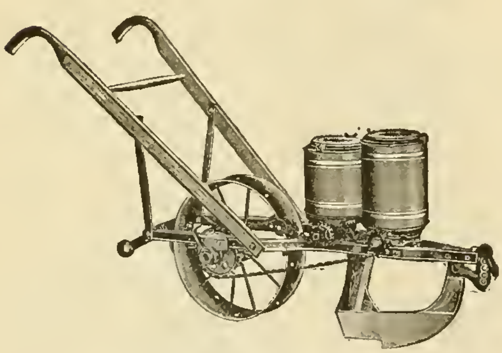

Fig. 199. A one-horse double planter, planting corn and cowpeas at one operation.

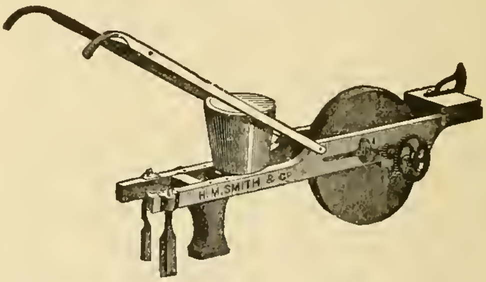

Fig. 200. A one-horse corn-planter.

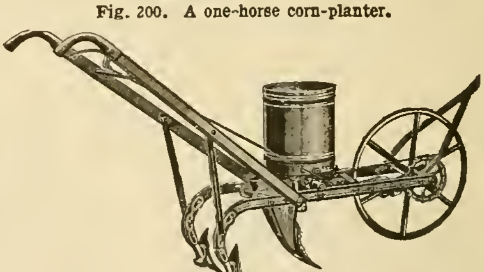

Fig. 201. One-horse combined cotton- and corn-planter.

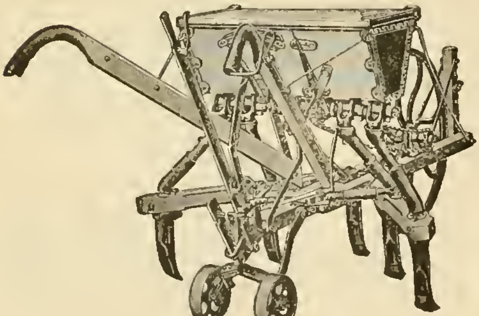

Fig. 202. A five-hoe grain-drill.

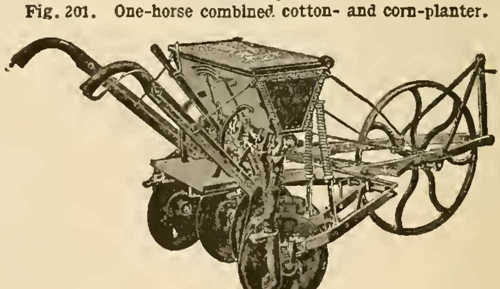

Fig. 203. A five-disk grain-drill.

is broken up by subsequent tillage; or if the crop is not tilled, as the cereal grains, the seed-bed disappears by the action of the elements and the natural settling together of the soil. The seed-bed is therefore only an epoch in the care of the field.

The comminuting tillage tools leave the ground loose and more or less open. In this loose earth the seed is readily incorporated. But the earth may be too loose to promote the best germination. In such cases the roller is used to compact the earth. The soil-grains are then settled about the seeds, and the subsurface moisture passes up from grain to grain or through the small cavities, and supplies the seed. This moisture is on its way toward evaporation into the air; therefore it is well to break up the compact surface by tillage, as soon as the plants are well established, in order to prevent the further loss of moisture, particularly if it is the case of a spring-sown crop. The common practice of tramping on the row in making garden hereby finds explanation; and it is probable that the custom of spatting the hill with the hoe in the steadfast old days when we planted corn by hand, had other merit than merely to mark the spot where we had dropped five kernels from a bed-ticking bag.

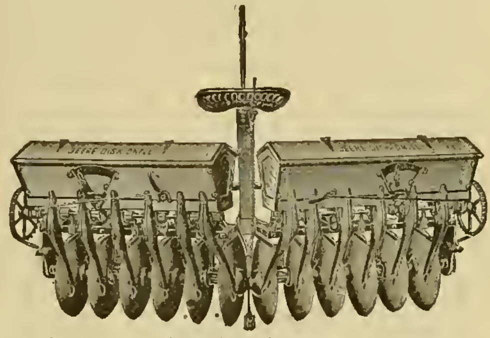

Fig. 204. Combined disk-drill and force-feed seeder.

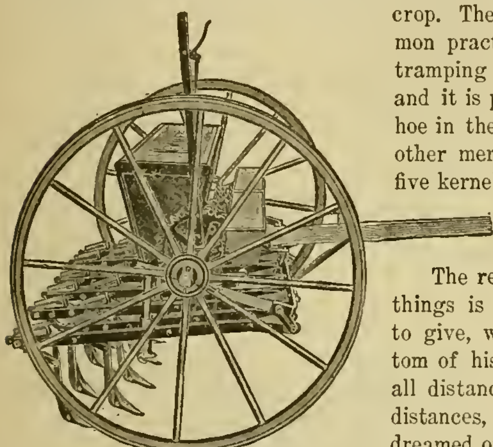

Fig. 205. A six-foot seeder, with grass seed attachment.

The quantity to sow.

The reader will want to know how much seed of the various things is required for an acre. This information was once easy to give, when fields were small and every one followed the custom of his father or his neighbor. But now we plant in hills at all distances, or drills at all distances, or semi-broadcast at no distances, and we grow crops for more purposes than were ever dreamed of in the old philosophy. The tables, therefore, represent either averages or extremes, and the person who is looking for precise direction is likely not to find it, and he is told that it all depends on conditions, and as likely as not he does not know what the conditions are. However, a table has been compiled from good sources, and the reader is referred, for further information, to the articles on the special crops comprising the major part of this book; from these sources the reader should be able to derive some help.

Quantity of Seed Per Acre.

Alfalfa (broadcast)	20–25 lbs.	Carrots (for stock)	4–6 lbs.
Alfalfa (drilled)	15–20 lbs.	Cassava	By cuttings
Artichoke, Jerusalem	6–8 bus.	Chick-pea	30–50 lbs.
Barley	8–10 pks.	Chicory (and by cuttings)	1–1½ lbs.
Barley and peas	1–2 bus. each	Clover, alsike (alone, for forage)	8–15 lbs.
Bean, field (small varieties)	2–3 pks.	Clover, alsike (on wheat or rye in spring)	4–6 lbs.
Bean, field (large varieties)	5–6 pks.	Clover, Egyptian or berseem	½–1 bu.
Beet	4–6 lbs.	Clover, Japan (lespedeza)	12 lbs.
Beggarweed (for forage)	5–6 lbs.	Clover, Mammoth	12–15 lbs.
Beggarweed (for hay)	8–10 lbs.	Clover, red (alone, for forage)	16 lbs.
Bent-grass	1–2 bus.	Clover, red (on small grain in spring)	8–14 lbs.
Berseem	½–1 bus.	Clover, sweet (melilotus)	2 pks.
Blue-grass	25 lbs. (pure)	Clover, white	10–12 lbs.
Brome-grass (alone, for hay)	12–15 lbs.	Clover, yellow (for seed)	3–5 lbs.
Brome-grass (alone, for pasture)	15–20 lbs.	Clover, yellow (in mixture)	1 lb.
Brome-grass (in mixture)	2–5 lbs.	Corn	6 qts.–1 bus.
Broom-corn	3 pks.	Corn (for silage)	9–11 qts.
Broom-corn (for seed)	1 pk.	Cotton	1–3 bus.
Buckwheat	3–5 pks.	Cowpea	1–1½ bus.
Bur-clover	12 lbs.		
Cabbage	¾–1 lb.		

QUANTITY OF SEED PER ACRE, *continued*

Cowpea (in drill, with corn)	½–1 bu.
Cowpea (for seed)	3 pks.
Crimson clover	12–15 lbs.
Durra. See Kafir and Milo.	
Field-pea, (small varieties)	2½ bus.
Field-pea, (large varieties)	3–3½ bus.
Flax (for seed)	2–3 pks.
Flax (for fiber)	1½–2 bus.
Guinea-grass	Root cuttings
Hemp (broadcast)	3½–4 pks.
Hungarian grass (hay)	2 pks.
Hungarian grass (seed)	1 pk.
Johnson-grass	1–1½ bus.
Kafir (drills)	3–6 lbs.
Kafir (for fodder)	10–12 lbs.
Kale	2–4 lbs.
Kohlrabi	4–5 lbs.
Lespedeza	12 lbs.
Lupine	1½–2 bus.
Mangels	5–8 lbs.
Meadow fescue	12–15 lbs.
Millet, barnyard (drills)	1–2 pks.
Millet, foxtail (drills)	2–3 pks.
Millet, German (seed)	1 pk.
Millet, Aino (drills)	2–3 pks.
Millet, Pearl (for soiling)	4 lbs.
Millet, Pearl (for hay)	8–10 lbs.
Millet, Proso or Panicle (drills)	2–3 pks.
Milo	5 lbs.
Oat-grass, tall	30 lbs.
Oats	2–3 bus.
Oats and peas	oats 2 bus.; peas ½ bu.
Orchard-grass	12–15 lbs. (pure)
Para-grass	Cuttings
Parsnips	4–8 lbs.
Popcorn	3 lbs.
Potato (Irish) average	10–14 bus.
Potato, cut to 1 or 2 eyes	6–9 bus.
Potato, recommended by many for best yields	15–20 bus.
Pumpkin	4 lbs.
Rape (in drills)	2–4 lbs.
Rape (broadcast)	4–8 lbs.
Red-top (recleaned)	12–15 lbs.
Rescue grass	30–40 lbs.
Rice	1–3 bus.
Rutabaga	3–5 lbs.
Rye (early)	3–4 pks.
Rye (late)	6–8 pks.
Rye (forage)	3–4 bus.
Rye-grass	2–3 bus.
Sainfoin (shelled seed)	40 lbs.
Sand lucern (broadcast)	15 lbs.
Serradella (alone, in drills)	40–50 lbs.
Sheep's fescue	2½–3 bus.
Sorghum (forage, broadcast)	1½–2 bus.
Sorghum (for seed or syrup)	2–5 lbs.
Sorghum, saccharine (for silage or soiling, drills)	6 lbs.–½ bu.
Sorghum and peas	3–4 pks. each
Soybean (drills)	2–3 pks.
Soybean (broadcast)	1–1½ bus.
Spurry	6–8 qts.
Spurry (for seed)	4 qts.
Sugar-beets	15–20 lbs.
Sugar-cane	4 tons of cane
Sunflower	10–15 lbs.
Sweet clover	2–4 pks.
Sweet-potato	1½–4 bus.
Teasel	1–1½ pks.
Teosinte	1–3 lbs.
Timothy	15–25 lbs.
Timothy and clover	timothy 10 lbs.; clover 4 lbs.
Tobacco	1 tablespoonful to 100 sq. yds. to set out 6 acres.
Turnip (broadcast)	2–4 lbs.
Turnip (drills)	1 lb.
Turnip (hybrid)	3–5 lbs.
Velvet bean	1–4 pks.
Vetch, hairy (drilled)	1 bu. + 1 bu. small grain
Vetch, hairy (broadcast)	1½ bus. + 1 bu. small grain
Vetch, kidney	18–22 lbs.
Vetch, spring	⅝ pks. + 1 bu. small grain
Wheat	6–9 pks.

Permanent meadows:

Timothy	12 lbs.	20–24 lbs. per acre.
Red clover	4 lbs.	
Alsike	2 lbs.	

Timothy	16 lbs.
Red-top	16 lbs.
Red clover	4 lbs.

Red-top	13 lbs.
Orchard-grass	18 lbs.
Meadow fescue	9 lbs.
Red clover	4 lbs.

Tall oat-grass	28 lbs.
Red clover	8 lbs.

Timothy	8 lbs.
Red clover	4 lbs.
Alsike	2 lbs.
Kentucky blue-grass	2 lbs.
Red-top	2 lbs.

Orchard-grass	10 lbs.
Red-top (recleaned)	5 lbs.
Red-top (in chaff)	12 lbs.
Tall meadow oat-grass	12 lbs.
Red clover	8 lbs.
Alsike clover	4 lbs.

Permanent pastures:

Timothy	3 lbs.
Orchard-grass	2 lbs.
Red-top	2 lbs.
Kentucky blue-grass	2 lbs.
Italian rye-grass	1 lb.
Meadow fescue	2 lbs.
Red clover	4 lbs.
White clover	2 lbs.

Kentucky blue-grass	8 lbs.
White clover	4 lbs.
Perennial rye-grass.	9 lbs.
Red fescue	3 lbs.
Red-top	8 lbs.

Red-top	14 lbs.	Wet pasture.
Alsike	8 lbs.	
Creeping bent	6 lbs.	
Perennial rye-grass.	12 lbs.	

Red fescue	20 lbs.	Light sandy soil.
Red-top	10 lbs.	
Kentucky blue-grass	8 lbs.	
White clover	2 lbs.	

Timothy, red-top, Kentucky blue-grass and red clover, equal parts, 8 to 20 pounds per acre of the mixture.

Storing of seeds.

The first requisite to the keeping of seeds is to have them well grown, from strong and healthy parents. The second requisite is to have them well cured, or free from mold and damp. Usually it is best to thresh before storing, for there is less danger from damp and from vermin, and the seeds occupy less space. The room should be dry and devoid of great extremes in temperature. Very low temperature is less inimical than very high temperature. Moist seeds are less able to withstand extremes of temperature than dry seeds. Ordinary winter temperatures in a secure loft are harmless. In large quantities seeds are usually best stored in bags. (Fig. 189.) In all cases, it is well to keep the bags or boxes tied or shut, to avoid currents of air and thereby avoid either too much dampness or too great drying, and to exclude vermin. Most nests of drawers allow runways for mice. Fig. 190 illustrates poor and good construction. Peas and beans and maize are specially liable to injury by weevils when in storage. Bisulfid of carbon may be poured into the receptacle on the seeds. It quickly volatilizes and destroys all animal life if the receptacle is immediately closed tight. A teaspoonful is sufficient for eight or ten quarts of seed in a very tight box or drawer. Carbon bisulfid is very inflammable and care should be exercised to avoid the danger of an explosion. It should never be handled freely in rooms containing fires of any kind. It is a thin liquid, volatilizing at low temperatures; therefore the receptacles containing it should be tightly sealed. Hydrocyanic acid gas (made by pouring sulfuric acid on pieces of cyanide of potassium) may be used to destroy insects when they infest whole rooms or buildings. This gas is exceedingly poisonous, however, and it should be used only by those who have had experience. (See page 45.)

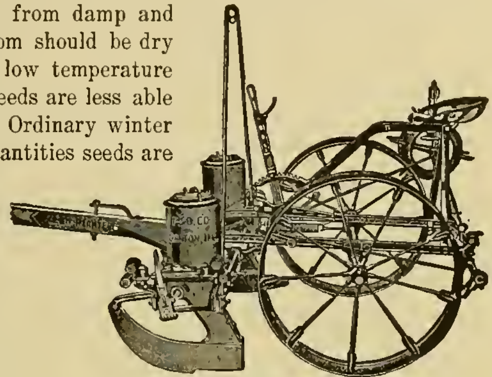

Fig. 206. A corn-planter.

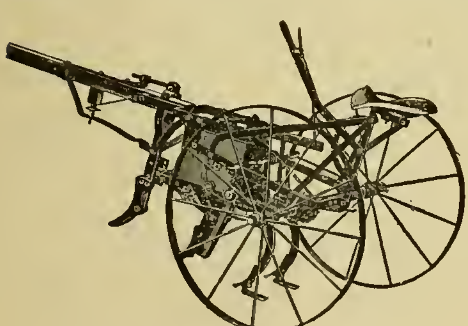

Fig. 207. Riding cotton- and corn-planter.

Planting calendar.

In the great expanse of North America, it is impossible to give in any brief space a very useful list of dates for the planting of the various field crops. The subject is one that demands careful and prolonged study, however. It needs to be approached from the point of view of phenology, and to be related to farm-practice questions. (See discussion of Phenology on pages 532 and 533, Volume I.) To be of much service, such records should be averages of several years. The farmer, long accustomed to a locality, depends less on the calendar than on the general state of the weather and the "signs" of the season. It is an old custom to plant corn when the oak leaves are the size of a squirrel's ear. In order to systematize their business and to establish a fixed point to which men may work, some large planters set a formal date on which they plant certain crops year after year. The season, however, properly determines the date of planting. The forwardness of grass and trees, the condition of the soil, the type of crop succession, all indicate season of planting. As a suggestion to the uninstructed planter, the average or usual dates of planting have been secured from careful persons in several parts of the country, and these dates are given on the following pages for what they may be worth to the reader. These records will be suggestive to the beginner, to whom any fixed points or standards, of whatever kind, are valuable in enabling him to plan his work. As he becomes experienced, the fixed and formal epochs will have less significance to him. In a restricted region, it is possible to give advice by months. Once books called "calendars" were popular, particularly with gardeners; but these are inapplicable to continental areas.

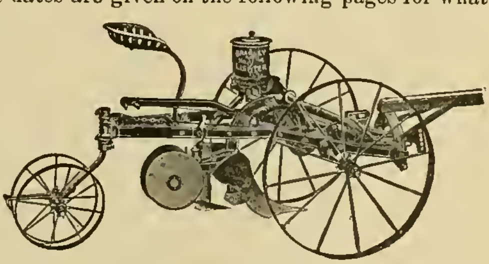

Fig. 208. A sulky lister, for planting corn.

USUAL PLANTING DATES

	Maritime Provinces	*Quebec	New England	Central New York	Georgia and Alabama	Indiana (Lafayette)
Alfalfa	May 10–July	May	May–July	May–Aug 15	Feb. 20–Mar., Oct.	April–August
Artichoke	. . . . . .	May	. . . . . .	May, June	March	. . . . . .
Asparagus	. . . . . .	May	April	. . . . . .	Feb., Mr., Nov. 20–Dec. 10	April 15
Barley	May	May, June	April, May	April, May 15	Sept. 20–Oct.	April 1
Beans	June 1–15	May 15–30	May	May 15–Jn. 25	April–June	May 20
Broom-corn	. . . . . .	May 15–30	May 15–25	. . . . . .	April, May	May 20
Buckwheat	June	May–July	June 1–20	June 15–July 5	March 15–30	June 1
Cabbage	May 1–15	Hotbed April	Mar.–June 15	May	Jan.–March ‡	Apr. 10–June 1
Carrot	May	May	May	May	Mar. 20–April	April 15
Clover	May	May	Mr. 15–Sept. 1	March–Aug.	Mar., Sr., Oct.	Feb.–April
Cotton	. . . . . .	. . . . . .	. . . . . .	. . . . . .	Mr. 20–May 15	. . . . . .
Cowpea	. . . . . .	. . . . . .	May 15–June 1	May 15–Ju. 25	May–Aug. 1	May 15–25
Field-pea	May	May	Mar. 15–May	April–June	Feb., April	April 1
Flax †	May	May	. . . . . .	. . . . . .	. . . . . .	. . . . . .
Kafir corn	. . . . . .	. . . . . .	. . . . . .	May	April–June	May 20
Kohlrabi	. . . . . .	Hotbed April	April	May	March	April 15
Lespedeza	. . . . . .	. . . . . .	. . . . . .	. . . . . .	March 1–15	. . . . . .
Lupine	. . . . . .	May	April–May 12	May	March	. . . . . .
Maize	May 20–June 1	May, June	May 10–Ju. 10	May	March–July 1	May 1–20
Mangels	May 1–20	May	Apr. 15–My. 20	May	Mar., Aug. 1	May 1–20
Melilotus	. . . . . .	May	July	March–Sept.	Feb., March	. . . . . .
Millet	June	May–July	May 10–Ju. 20	May 15–Jy. 10	April–July	June 1
Oats	May	May, June	April	April	Feb., March, Sept.–Nov.	Mr. 15–Apr. 10
Parsnip	May	May	April, May	May	Mr. 25–Apr. 25	April 25–30
Peanut	. . . . . .	. . . . . .	. . . . . .	. . . . . .	May, June	. . . . . .
Potato	May 15–June 1	May	Apr. 15–My. 10	March–July 5	Feb. 15–Mar., July 1–10	April–June
Pumpkin	June 1	May 15–30	May 5–31	May	May	May 15
Rape	June	May–July	April	May–July	March, Oct.	May–July
Rice	. . . . . .	. . . . . .	. . . . . .	. . . . . .	March–May	. . . . . .
Rutabaga	. . . . . .	May, June	June 5–30	May, June	July	April 20–25
Rye	May	May or Sept.	Apr., My., Sept.	August–Oct.	Mr., Sr.–Nov.	Sept. 20–Oct. 10
Sainfoin	. . . . . .	. . . . . .	. . . . . .	. . . . . .	Sept., Oct.	. . . . . .
Sorghum	. . . . . .	. . . . . .	May 10–30	May 15–Ju. 25	Mar. 15–June	May 20–31
Soybean	. . . . . .	. . . . . .	May	May, June	April 10–June	May 15–25
Squash	May 10–June 1	May 15–30	May 15–Ju. 15	May, June	April 5–30	May 1–10
Sugar-beet	May 15	May	. . . . . .	May	. . . . . .	May 1–20
Sugar-cane	. . . . . .	. . . . . .	. . . . . .	. . . . . .	Mar. 21–Apr. 5	. . . . . .
Sweet-potato	. . . . . .	May	. . . . . .	. . . . . .	May 1–July ‡	May 10–15
Timothy	May	May	Apr. 15–My. 15, Aug.–Oct.	March–Sept.	March–Oct.	Sept., Oct.
Tobacco	. . . . . .	Hotbed Apr., plant June 1	May 20–Jn. 15	Seed-bed Mar., Apr., June 1	May	. . . . . .
Turnip	May 15–Jn. 30	May–July	April, May, July, August	May–July	Feb.–Apr. 25, July 1–10	May–August
Vetch	May	May, June	July	May–August	Feb. 25–Mr. 10, Sept., Oct.	April 1
Wheat	May	May	April	April–Sept.	Oct., Nov.	Sept. 20–Oct. 10

Mr.=March; My.=May; Ju.=June; Jy.=July; Sr.=September.
† For others, see article on flax.
*District of Quebec; District of Montreal about twelve days earlier.
‡ Transplanting.

USUAL PLANTING DATES, continued

Wisconsin	Manitoba	Missouri (Columbia)	Oklahoma	New Mexico	Colorado	‡ Montana
April 10–July 1	May 15–June 1	Apr. 15–My. 15, Aug. 15–Sr. 15	Mr. 15–May 15 Aug. 15–Oct. 1	March, April, Aug. 15–Oct. 1	Mar. 15–Apr. 20	Apr. 15–My. 10
May, June	May 18	April 1–30	. . . . . .	. . . . . .	April	. . . . . .
. . . .	Shoots May 6	Mr. 20–May 1	. . . . . .	. . . . . .	April	May 15
April 10–25	May 10–25	Mr. 20–Apr. 10	Feb. 15–Mr. 15	. . . . . .	March 15–30	May 5
May 10–30	June 11	April 15–mid-summer	. . . . . .	. . . . . .	May 15–June 1	May 20
. . . .	. . . . . .	May 10–25	Apr. 1–May 15	April, May	May 15	April 10
June 20–July 10	May 1	Not grown	. . . . . .	. . . . . .	June 15–July	. . . . . .
Tr. May 15–30	April 25	Mr. 15–Jly. 15	Apr. 1–June 1	. . . . . .	April 15	May 20
April 25–May 15	May 7–16	Mr. 20–Apr. 15	. . . . . .	. . . . . .	April 1–15	May 1
April 15–May 10	May 15–June 1	Feb. 1–Apr. 1	. . . . . .	. . . . . .	Mar. 15–Apr. 20	May 10
. . . .	. . . . . .	June 1–10	Apr. 15–My. 15	. . . . . .	. . . . . .	. . . . . .
May 20–31	June 11	June 1–July 10	May 15–Jy. 15	Spring & sum.	June 15	. . . . . .
April 20–30	May 4–8	Mar. 1–Apr. 1	March 1	March–June	April 1	May 1
. . . .	May 16–Ju. 15	. . . . . .	. . . . . .	. . . . . .	. . . . . .	April 10
. . . .	. . . . . .	May 1–25	April 1–July 1	March–June	May 15	April 10
. . . .	. . . . . .	Mar. 1–Apr. 30	. . . . . .	. . . . . .	April 15	. . . . . .
. . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
. . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	Mar. 15–April	. . . . . .
May 15–30	May 21–June 1	May 1–25	Mr. 15–Ju. 15	April, May	May 15	May 12
May 1–15	May 16	May 5	April 1–May 1	May, June	April 15	May 1
April 15–30	. . . . . .	April, May	. . . . . .	. . . . . .	. . . . . .	. . . . . .
May 20–July	May 1–8	June, July	Mar. 1–June 1	June, July	. . . . . .	May 15
April 10–30	May 10–20	March 15–31	Feb. 15–Mr. 15	Feb.–July	Mar. 15–Apr. 15	May 10
. . . .	April 10	Mar. 1–Apr. 1	. . . . . .	. . . . . .	April 1–10	May 10
. . . .	. . . . . .	Apr. 15–May 1	Apr. 15–Ju. 15	. . . . . .	. . . . . .	. . . . . .
May 1–June 30	May 18	Mr. 15–Apr. 30	Feb. 15–Mr. 15, June 15–Jy. 15	April–May †	May 20–Ju. 10	May 25
May 10–30	June 7	May 1–June 1	April 1–May 1	. . . . . .	May 25	May 20
May 1–August 1	Apr. 20–Jy. 1*	March–May	Feb. 15–Apr. 1	. . . . . .	April, May	Up to July 10
. . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
May 1–30	May, June	May 25	April 1–May 1	. . . . . .	March–June	May 5
Aug. 25–Sept. 10	Apr. 10–My. 10	Sept., October	Aug. 15–Nov. 15	Jan.–July, Sept., Oct.	Mar. 15., Apr. 1, Sept. 15	Apr. 1–May 10
May 10–20	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
May 15–30	May 21–Ju. 1	May 1–25	Mar. 1–Aug. 1	March–June	May 20	May 10
May 10–30	June 11	June 1–July 10	May 15–Jy. 15	. . . . . .	. . . . . .	. . . . . .
May 20–June 10	June 7	May 1–June 1	Apr. 1–May 15	. . . . . .	May 20	May 20
May 1–30	May 16	May 5	. . . . . .	. . . . . .	Mr. 15–Apr. 15	May 1
. . . .	. . . . . .	May 1–25	. . . . . .	. . . . . .	May 20	. . . . . .
. . . .	. . . . . .	My. 15–Ju. 15	April 1–May 1	. . . . . .	. . . . . .	. . . . . .
April–Sept.	May 15–June 1	April, Sept.	. . . . . .	. . . . . .	Mr. 15–Apr. 15	May 10
Tr. May 1–June 1	. . . . . .	May 1–25	. . . . . .	. . . . . .	. . . . . .	. . . . . .
May 1–20	May 16–21	March–August	Jy. 15–Aug. 31	. . . . . .	March–June	May 5
April 20–30	May 15–June 1	April, August	. . . . . .	. . . . . .	September	. . . . . .
April–August	Apr. 10–My. 10	Sr. 15–Oct. 30	Sr. 10–Nov. 30	Jan.–April 15, Sept. 1–Oct. 15	Mr. 15–Apr. 15	May 1

* If there is enough moisture. † Grown only at high elevations.

‡ For irrigated crops; for non-irrigated crops, as soon after March 25 as conditions allow.

USUAL PLANTING DATES, continued

	* Arizona (Phœnix)	Nevada	California	Oregon	Washington	Alaska
Alfalfa	Jan., Feb., Sr. 20-Nov. 10	March–August	October–Feb.	March–May 15	Apr. 20–My. 15	. . . . . .
Artichoke . . .	. . . . . .	. . . . . .	Dec.–March	March–May 15	April 1–May 1	. . . . . .
Asparagus . . .	Jan.–March, Oct., Nov.	. . . . . .	Dec., January	March–May 15	Mr. 10–May 15	. . . . . .
Barley	Sept.–March 1	April	Dec.–March	Mar.–May 15, Oct.–Dec.	April 20	May 1–15
Beans	Mar.–Apr. 15, Aug. 15-Sr. 15	May 20	April, May	March–May 15	Apr. 25–My. 25	. . . . . .
Broom-corn . . .	. . . . . .	Apr. 20–My. 20	April, May	May 15–June 1	May 10–20	. . . . . .
Buckwheat . . .	. . . . . .	May 1–10	May	March–May 15	May 10–20	May 10
Cabbage	Tr. Jan., Feb., Sr. 15, Oct. 20	May 15	Sept.–April	Mar.–May 15, Oct.–Dec.	Mar. 15–Apr. 1 (under glass)	. . . . . .
Carrot	Jan., Feb., Aug. 20-Oct. 15	May 15	Sept.–April	March–May 15	Apr. 15–My. 15	May 1
Clover	. . . . . .	March, April	April, May, Oct.–Feb.	Mar.–May 15, Oct.–Dec.	Mr., Apr., Sept.	April 1
Cotton	April	. . . . . .	April, May †	. . . . . .	. . . . . .	. . . . . .
Cowpea	April–August	. . . . . .	April, May	. . . . . .	. . . . . .	. . . . . .
Field-pea	Jan., Feb., Aug. 20-Nov. 20	April, May	Sept.–May	March–May 15	Mr. 15–May 15	April 15
Flax**	. . . . . .	May 1–20 (not grown)	Dec.–April	March–May 15	May 1–15	May 1
Kafir corn . . .	. . . . . .	Apr. 20–My. 10 (not grown)	April–June	March–May 15	May 1	. . . . . .
Kohlrabi	April–June	May 15	Dec.–April	March–May 15	May 15–Apr. 1 (under glass)	Tr. June 1
Lespedeza . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
Lupine	. . . . . .	. . . . . .	October–Feb.	March–May 15	Apr. 15–May 1	. . . . . .
Maize	Feb. 20–Mr. 15, Jy. 10–Aug. 5	Apr. 20–My. 20	April, May	March–May 15	May 1–15	. . . . . .
Mangels	. . . . . .	Apr. 15–My. 15	October–June	March–May 15	April 1–June 1	April 15
Melilotus	. . . . . .	. . . . . .	. . . . . .	March–May 15	March–May	. . . . . .
Millet	August	Early April	April, May	May 15–June 1	. . . . . .	. . . . . .
Oats	October–Dec.	Early April	Dec.–April	March–May 15, Oct.–Dec.	April 10	Apr. 20–My. 15
Parsnip	. . . . . .	May 15	April, May	March–May 15	April 1–May 1	April 15
Peanut	. . . . . .	. . . . . .	April, May	. . . . . .	. . . . . .	. . . . . .
Potato	Jan. 15-Feb. 15, Aug. 20–Sr. 10	Apr. 15–My. 15	Sept.–May	March–May 15	April 1–May 1	May 1
Pumpkin	March–June	May 10	April, May	May 15–June 1	May 1–15	. . . . . .
Rape	. . . . . .	Early April (not grown)	. . . . . .	March–August	April 1–June 1	May 1
Rice	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .
Rutabaga . . .	. . . . . .	May 1–10	Sept.–April	March–May 15	May 1–June 1	Apr. 15–My. 15
Rye	. . . . . .	Feb.–April, Sept.–Nov.	Dec.–Feb.	March–May 15, Oct.–Dec.	Mr., Apr., Sept.	Winter, July Spring, May 1
Sainfoin	. . . . . .	. . . . . .	. . . . . .	March–May 15	. . . . . .	. . . . . .
Sorghum	May, June	Apr. 20–My. 10	April–June	March–May 15	May 1–15	. . . . . .
Soybean	. . . . . .	. . . . . .	Feb.–April	May 15–June 1	April 1	. . . . . .
Squash	Mr., Ju., Aug.	May 20	April, May	May 15–June 1	May 1–20	. . . . . .
Sugar-beet . . .	Jan. 15–Feb. 28, Sr. 20–Oct. 10	Apr. 20–My. 10	January–May	March–May 15	May 1	. . . . . .
Sugar-cane . . .	. . . . . .	. . . . . .	. . . . . .	. . . . . .	May 1–15	. . . . . .
Sweet-potato . .	March–May	. . . . . .	May	. . . . . .	May 1–15	. . . . . .
Timothy	. . . . . .	March, April	April, May ‡	October–Dec.	Mr., Apr., Sept.	. . . . . .
Tobacco	. . . . . .	. . . . . .	Sept.–May	March–May 15	March 20 (under glass)	. . . . . .
Turnip	Jan., Feb., Aug.–Oct.	May 15	Sept.–May	March–May 15, Oct.–Dec.	April–June	April–July 31
Vetch	. . . . . .	. . . . . .	Sept.–Feb.	March–May 15, Oct.–Dec.	April–Sept.	. . . . . .
Wheat	. . . . . .	Early April	Dec.–March	March–May 15, Oct.–Dec.	Feb.–April, Aug., Sept.	Winter, July Spring, May 1

* From Bull. No. 48, Part III, Arizona Agricultural Experiment Station.

** See article on flax.

† No commercial product.

‡ Grown only in extreme northern part.

Seed machinery.

Seed-sowing is one epoch in crop practice. Whatever modifies the crop management of a farm also modifies the methods or purposes of seeding. In Chapter V it was shown that crop management has been profoundly influenced by the invention of machinery. Some of this invention, also, has been modified and directed by changes in crop management. The same remarks may be made with special force in reference to the seed-sowing phase of the work. In seeding and harvesting machinery we have made great progress. Figs. 191–208, and also Figs. 117–119 and 122, 123, illustrate some of the progress in seeding machinery, and at the same time exhibit most of the mechanical principles that have been applied for putting seeds into the ground. The number of different patterns and styles of machines is very great. Every largely grown crop has its own range of planters or seeders.

PRACTICAL ADVICE ON SEED-TESTING

By *E. Brown* and *F. H. Hillman*

The quality of agricultural seeds, especially of forage crops, has been given much more attention in Europe than in America. European countries have seed control in various forms, with over one hundred seed-control stations, some of them with an international reputation. We have developed a system by means of which commercial fertilizers are sold under guaranteed analyses, and a large part of the work of some of our state agricultural experiment stations is given to making these chemical analyses; but comparatively little attention has been given to the quality of seeds. No seeds sold in this country are guaranteed as to purity and germination, and but few experiment stations have facilities for seed-testing. The United States Department of Agriculture and some of the agricultural experiment stations, however, have done much to show the importance of good seeds. Publications have been issued calling attention to the quality of various kinds of seeds on the market, and samples have been tested for the information of the senders.

Large quantities of low-grade screenings, especially of clover and alfalfa, are imported annually to be mixed with better seeds and sold as medium and low grades. Besides dirt and dead seed, these screenings contain large quantities of weed seeds.

Beal has shown (Bot. Gaz., August, 1905, "The Vitality of Seeds") that the seeds of many common weeds grow after having been buried in the ground for twenty-five years. Among these are pigweed, black mustard, shepherd's purse, peppergrass, evening primrose, smartweed, purslane, curled dock, pigeon-grass, chickweed and mayweed. The purchaser of low-grade seed is fouling his land with weeds which may appear for years afterward, whenever the conditions are right for their germination. Farmers make the mistake of thinking that there is not so much difference in quality as in price, while as a matter of fact the good seed in the low grades costs often many times as much per pound as the good seed in the best grades.

Fig. 209. Tripod magnifier.

Testing for purity.

Everyone buying seeds should have some kind of a lens with which to examine them. The form shown in Fig. 209, costing twenty-five to fifty cents, is satisfactory. By spreading grass or clover seed thinly on a sheet of white paper and looking at it carefully with a lens, it is easy to detect the presence of any considerable amount of weed seeds or chaff. The seeds used as adulterants are much more difficult to distinguish, and in all cases of suspected adulteration samples of the seed should be sent for examination to the state agricultural experiment station or to the Seed Laboratory of the United States Department of Agriculture. All seed should be practically free from weed seeds and chaff, and contain no adulterants. Clover and alfalfa should be bright and contain no brown seeds or dodder seed.

Testing for germination.

All the quick-germinating seeds, such as clover, timothy and grain, can be easily tested for germination by any one with the simple tester shown in Fig. 210. Mix the seed thoroughly and count out 100 or 200 seeds just as they come, making no selection except to discard any weed seeds. Put them between a fold of canton flannel or some similar cloth that has been washed in boiling water, taking care not to let the seeds touch one another. Lay the cloth on a plate, moisten it well but do not saturate it, cover with another plate and keep at a temperature of about 70° F. Every day count and take out the sprouted seeds. In four to ten days all of the good seeds will have sprouted, and the percentage of seed that will grow is known.

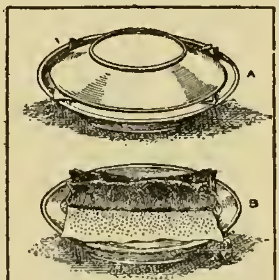

Fig. 210. A simple home-made seed-tester. See pp. 280, 281.

Some of the grass seeds are more difficult to test, requiring more exact conditions and an alternating temperature. In all cases where seeds do not germinate well in the simple tester shown, it is best to send them away to be tested before discarding them.

Adulteration.

Several of our most important forage crop seeds are frequently adulterated with seeds costing one-third to one-half the price of those with which they are mixed. Red clover, alfalfa, Kentucky blue-grass and orchard-grass seed are the principal ones affected. The seed of yellow trefoil is imported in

Fig. 211. "Seeds" or perigynia of species of carex, sedge plants that are sometimes found in grass seed.

large quantities from Germany to be used as an adulterant of red clover and alfalfa. It is a low-growing, leguminous plant not cultivated in the United States and of no value where red clover or alfalfa will grow. Bur-clover seed, which is combed out of South American wool, is also imported from Germany and mixed with alfalfa seed. English and Italian rye-grass and meadow fescue seed are frequently mixed with orchard-grass seed in varying proportions. Canada blue-grass seed, although used to some extent in this country, is imported in large quantities from Canada, to be mixed with, or sold as Kentucky blue-grass seed. All of these seeds used as adulterants resemble so closely the seeds with which they are mixed that they are difficult to distinguish. In the following discussion, enlarged pictures are given of the true seed, in order that the examiner may distinguish adulterants. The sedges frequently occur with grasses but are not used as adulterants. Some of the seeds or fruits are shown in Fig. 211.

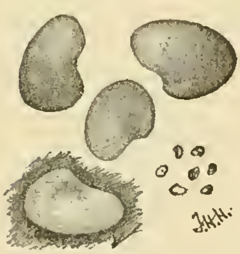

Fig. 212. Red clover.

Fig. 213. Alsike clover.

Farm seeds and adulterants.

Red clover (*Trifolium pratense*). Fig. 212. Fresh, well-matured seed is plump and has a slight luster. The color is clear yellow, violet or variegated. Old seed loses these colors, which are replaced by dull brown. Artificial polishing produces a high luster but does not redeem the original colors. Shriveled screenings are thin owing to the poorly developed embryo, and dull greenish or brown. Well-developed seeds are somewhat triangular, rounded and have a broad notch at the scar. Samples of commercial seed exhibit considerable difference in the average size of the seeds.

Alsike clover (*Trifolium hybridum*). Fig. 213. Seeds smaller than in red clover, averaging somewhat larger than white clover seed. Fresh seed has little if any luster, but the olive to dark green color is bright, and the mottled surface exhibited by many of the seeds is distinct. Old seed loses its green color and becomes dull brown, the mottling becoming indistinct or disappearing. Such seed is not readily distinguishable from old white clover seed.

Crimson clover (*Trifolium incarnatum*). Fig. 214. Crimson clover seed is readily distinguished from that of the other clovers by the large size, oval and more rounded form of the individual seeds. Fresh seed is reddish pink and has a pronounced luster. A dull reddish brown replaces these in old seed. There is considerable variation in the size of seeds in commercial samples.

Alfalfa or lucerne (*Medicago sativa*). Fig. 215. Fresh, well-matured seed has a clear greenish yellow color but no distinct luster. Its greenish color readily distinguishes it from the seed of the cultivated true clovers. Individual seeds vary considerably in form, since several are produced in each spiral pod. They are angular, oval-oblong or kidney-shaped and usually have a light stripe on each side.

Fig. 214. Crimson clover.

Fig. 215. Alfalfa seed.

Yellow trefoil (*Medicago lupulina*). Fig. 216. This seed is largely used as an adulterant of red clover and alfalfa, and to some extent in alsike and crimson clovers. Individual seeds are practically the same size as those of red clover and alfalfa, but larger than alsike seed and smaller than average crimson clover seeds. The admixture of 35 to 45 per cent of this seed in red clover seed gives the latter in bulk a greenish tinge. It lightens the general color of alsike seed, but does not materially change that of alfalfa or crimson clover seed. Its detection is readily accomplished by examining individual seeds with a lens. The seeds are produced singly in the pod and so are fairly constant in form.

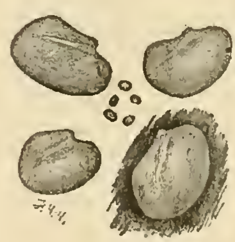

Fig. 216. Yellow trefoil, an adulterant.

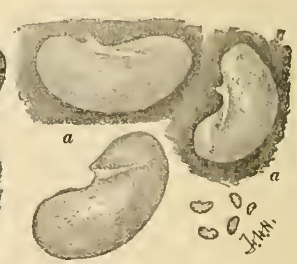

Fig. 217. Bur-clover, an adulterant.

They are oval, with the scar notch near the smaller end with a prominent projection beside it. A light stripe on each side usually extends from the scar toward the broader end of the seed. These seeds

Fig. 218. Timothy.

Fig. 219. Orchard-grass.

are faintly greenish yellow, becoming reddish brown in age.

Red clover seed (Fig. 212) is distinguished by its lighter yellow or violet colors, its triangular form, broad scar notch and the absence of a projection at the scar. Alfalfa seed (Fig. 215) is distinguished by its more angular, oblong or kidney form, only the latter having a projection beside the nearly central scar. The contrast in form is even more pronounced in alsike and crimson clover seeds. (Figs. 213, 214.)

Bur-clover (*Medicago Arabica*, aa; *Medicago denticulata*, b). Fig. 217. These kinds are used as an adulterant of alfalfa seed. *Medicago Arabica* seeds are mostly kidney-shaped, the scar being nearer one end than in alfalfa, a distinct projection beside it. Fresh seeds are light yellow. The large seeds are larger than alfalfa seeds and are readily distinguished from them, the smaller being distinguished only with difficulty. *Medicago denticulata* seeds are mostly larger than alfalfa seeds, oblong-kidney-shaped, the scar notch prominent near the center and the projection slight or wanting. Most of these seeds are distinguishable from the others. They are commonly darker than the seeds of *Medicago Arabica*.

Timothy (*Phleum pratense*). Fig. 218. This seed has a characteristic appearance and is readily rec-

Fig. 220. Meadow fescue.

Fig. 221. Red-top.

ognized. It is not subject to adulteration, but is often an impurity of alsike seed, sometimes of red clover seed. The seed may either bear the hull (a a) or be free from it (b b). The presence of the hull gives fresh, well-cured seed a bright, silvery white appearance. The dull, oval seeds free from the hull are darker.

Orchard-grass (*Dactylis glomerata*). Fig. 219. This seed appears mostly in the hull. In this form it is straw-colored or darker. Individual seeds are triangular in section, being sharply angled along the back, tapering toward the ends, the apex awn-pointed. Viewed from the angled back or front they are curved to one side (a). The surface may be smooth or somewhat hairy, the back hairy toward the apex. The rachilla segment is slender, terete and slightly curved. Seeds rest on the front face (a) or oblique sides (b b) on a level surface.

Meadow fescue (*Festuca elatior*). Fig. 220. This seed in the hull is dark straw-colored or light brown. Individual seeds are somewhat boat-shaped, tapering to the ends, often frayed at the thin, papery apex. The inner face (a) is flattened and concave, the back rounded, not angled; seeds resting on the front or back on a level surface. The rachilla segment is slender, terete, straight, distinctly expanded at the apex, important in distinguishing this seed.

Red-top (*Agrostis alba*). Fig. 221. Seeds minute, mostly in the hull (a a), or in the "chaffy" grades largely surrounded by the outer chaff (b). In the

Fig. 222. Kentucky blue-grass.

Fig. 223. Canada blue-grass.

"fancy" grade the seed, practically all in the inner hull, is very light gray; individual seeds spindle-shaped, slightly angled on the back, the edges of the hull separated on the inner face, exposing the grain. "Chaffy" seeds, covered by the outer hull, are longer, lance-shaped and bear a part of the flower stemlet. Such seed is darker colored and much lighter in weight than the "fancy." "Extra" or "fancy cleaned" seed consists largely of this outer chaff devoid of seed.

Kentucky blue-grass (*Poa pratensis*). Fig. 222. Bulk seed is light brown and well-cleaned seed is free from chaff. Individual seeds are in the hull, which is lance-shaped, tapering to each end, broadest at the middle and triangular in cross-section, the back of the seed being sharply angled. The intermediate nerves of the hull, one along the center of each oblique half of the back, are plainly evident under a lens as broad ridges (a a). These are important in distinguishing this seed. The edges of the hull are separated along the inner face (b). The free grain of the seed (c) is lance-shaped, wine-colored and grooved on one side. Commercial seed is usually rubbed free of the hairs on the angles of the hull and the frail apexes are usually more or less torn.

Canada blue-grass (*Poa compressa*). Fig. 223. This seed in bulk is usually somewhat lighter colored than Kentucky blue-grass. Individual seeds are very similar to the latter, hence this seed is used successfully as an adulterant. The apex of the seed is less sharply pointed and often flares somewhat, becoming rounded (c). The seed usually is widest a little above the middle (a). The intermediate nerves (b) are very indistinct. The presence of Canada blue-grass seed as an adulterant can be determined only by the use of a lens.

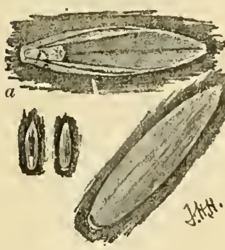

Fig. 224. English rye-grass.

PERENNIAL OR ENGLISH RYE-GRASS (*Lolium perenne*). Fig. 224. The seed is so similar to that of meadow fescue that it is distinguished with difficulty. The distinguishing mark lies in the rachilla segment (a) which is flattened externally and gradually broadens toward the apex, which is scarcely expanded.

ITALIAN RYE-GRASS (*Lolium Italicum*). Fig. 225. The seed is similar to that of perennial rye-gasss, with the exception that most of the seeds bear a slender awn at the apex. The rachilla segment is somewhat intermediate in form between that of perennial rye-grass and that of meadow fescue, but usually distinguishes the rye-grass from the fescue.

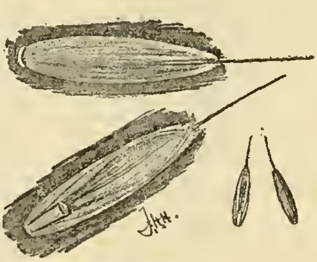

Fig. 225. Italian rye-grass.

Both kinds of rye-grass seed are used as adulterants of orchard-grass seed. Their flatter form and the awn of Italian rye-grass readily distinguish them from the angular, curved seeds of orchard-grass.

GROWING SEED CROPS

By *W. W. Tracy*

The requisities for growing farm seed of the best quality are, (1) a field free of weed seeds or plants; (2) the use of pure stock seed of desirable strain; (3) so to harvest the crop as to secure a clean, bright sample of high vitality; (4) the careful use of machines for threshing and cleaning the seed. The way the machines are used is quite as important as their structure. Often one person will secure a poor sample of seed when another, by a wiser use of the same machines, will get an extra-fine sample from a similar lot of seed.

The business of growing seed crops on the farm may be considered under three general divisions, according to the direct purposes for which the seeds are grown: (1) The growing of seeds, usually of cereal and forage crops, to be sold on the market by sample, as are other farm crops; (2) the growing of seeds, chiefly of garden vegetables, on contract with seedsmen; (3) the growing and breeding of improved strains of seeds to be used on the farm, with the sale, perhaps, of the surplus.

(1) *Growing cereal and forage-crop seeds for the general market.*

The crops grown specifically for seed in the past have been chiefly the grasses and clovers, the only special effort being to secure pure seed unmixed with weed seeds; but of recent years there has been increased attention to growing seed not only of grasses and clover but of cereals, corn and other crops of selected strains that are adapted to special soils and uses. Certain sections are especially adapted to the growing of certain kinds of seeds. For example, millet seed can be grown best in the southern states, clover and wheat in more northern sections, and field corn in the central states.

The methods vary with the kinds of seed and the places where they are grown. Usually timothy is cut, bound into bundles, cured, and then threshed, being cleaned in ordinary farm mills with special screens. Orchard-grass is harvested in much the same way. Kentucky blue-grass is harvested by strippers, which strip the seed from the standing stalks. The gathered seed is allowed to cure in windrows, on hard earth floors or in open sheds, and is there threshed and cleaned. Clover is generally cut with the mower, allowed to cure in windrows or bunches in the field, and is then threshed in special machines or hullers. With the exception of the stripper or comber used in gathering blue-grass, red-top and a few other kinds, and possibly of some fingers to be attached to the cutting-bars of mowing machines for cutting clover and peas, no special machines are necessary. Specially constructed machines for hulling clover are desirable, but in sections where clover seed can be grown profitably, threshers with such machines usually move from farm to farm. The final cleaning for market is done by farm mills, of which there are many forms that do good work.

(2) *Growing vegetable seed crops on contract.*

To many farmers, seed-growing for a widely advertised firm is more attractive than growing ordinary farm crops; and a seed crop which can be sold only to the contractor and cannot be used or frittered away has advantages for one who rents on "crop-share rental," so that such contracts are eagerly sought, with the exception of biennial plants, as onions, which are usually grown on special seed farms. Seedsmen secure most of their stock of vegetable seed by contracting with farmers to plant a certain area and deliver the entire seed product at an agreed price. The seedsman furnishes the stock seed, the farmer only undertaking to grow and harvest the crop so as to secure a good clean sample, the seedsman being responsible for the quality of the stock. Although a single seedsman, but one of the largest of the more than five hundred in the country, annually contracts with farmers for the product of 20,000 to 30,000 acres of vegetable seed crops, yet a very small proportion of the farmers of the country can easily produce all the seed needed, and a slight over-production results in a surplus and a consequent reduction in the contract prices that seedsmen are willing to offer, so that generally a seed crop is not especially profitable.

One who has soil and climatic conditions especially adapted to the growing of some particular vegetable, and who is familiar with its culture, but who is situated where he cannot handle profitably the ordinary farm product, can frequently grow seed to advantage. The cultural requirements of a seed crop are not different from those of a crop for market except in the harvesting and curing of the seed, and these features are not especially laborious or expensive. Careful attention and the doing of the work at the proper time are the real essentials. Sweet corn, peas and beans are grown and the seed harvested and cured in the same way and at no greater expense than is required for a crop of the grain, except that it is more important to gather, cure and handle these in such a way as to secure a bright sample and to avoid mixing in seed from other crops. The yields that may be expected vary greatly with different varieties, but generally are a little less than those of field sorts. The prices paid are usually somewhat higher, so that the seed crops are often more profitable than the grain crops.

With tomatoes, cucumbers, melons and other pulpy fruits, the fruits are allowed to ripen and the early-maturing ones to get a little over-ripe but not soft, so that the bulk of the crop can be gathered in one to three pickings. The fruit is crushed by passing through rollers, and the seeds are separated from the skins and coarse pulp in a slowly-revolving cylinder of wire netting of such size as to allow the seed and fine pulp to pass through, while the skin and coarse pulp pass out at the end. The cylinder is set at an angle and revolves slowly so that the seed will all be shaken out into a vat or into a simple board-lined pit in the ground, and only the coarse pulp pass out at the open end of the cylinder. The seed and liquid pulp is then allowed to ferment for a few days, care being taken that there is no water or rain added while fermenting. As soon as the mass is sufficiently soured so that the seed will slip clear of the pulp (2 to 10 days, according to temperature), it is separated and washed by passing it through a trough or sluice box of slowly-moving water. The seed settles to the bottom to be removed by perforated scoops, while the pulp floats off and away. The seed is then rapidly dried by spreading very thinly and stirring. If the seed is allowed to stand in a mass when wet, it will speedily be discolored or rot and become worthless for seedsmen.

The cost of separating and curing the seed after the fruit is gathered is much less than one would suppose, and with the best conveniences need not exceed five to ten cents a pound, according to variety. Very little special machinery is required in vegetable seed-growing, and most of this can be constructed on the farm.

In Fig. 226 is shown a side view of a horse-power machine for seeding cucumbers, melons, summer squashes, tomatoes and other pulpy crops. The cut shows the machine ready for work, except that the reel is shown without the wire netting with which it should be covered. This netting should be of stout wire and of one-half-inch mesh, or a little larger. The reel is about three and one-half feet in diameter and six feet long. Its upper

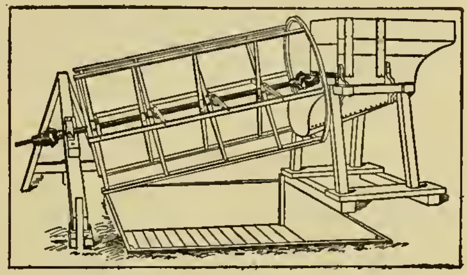

Fig. 226. Machine for seeding pulpy vegetables. The netting about the cyclinder is omitted.

end is formed of two common bent felloes of buggy wheels, bolted together so as to break joints; the lower end has no rim except the selvage edge of the piece of wire netting. The reel is built on a shaft connected with the trundling rod from the power and the shaft of the roller by knuckle joints. These allow the reel to be given any desired inclination by raising or lowering the journal block in the jack which supports the lower end. The vat is simply a hole in the ground lined with boards so as to keep dirt out of the seeds but allow the juice to soak away into the soil. In practice the vat should be made deeper than is shown and have guard boards to prevent the seeds and juice flying from the reel out on the ground. It will be necessary to set the machine where there will be no danger of rain or other water soaking or running into the vat. In Fig. 227 the same machine is

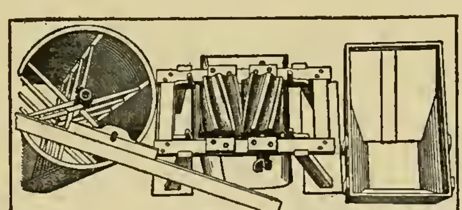

Fig. 227. Detail of seeder shown in Fig. 226.

shown with the hopper and reel taken off, and the frame tipped forward to show the rollers as if we were looking down on them. The rollers should be made of hard wood, and are about sixteen inches long and twelve inches in diameter, having eight grooves about three inches wide and one and one-half inches deep, cut with a spiral of one cog. The teeth or cogs are about one and one-half inches wide and would be better if faced with strap iron. The rollers might be made of soft wood and the teeth faced with iron, but they would be much inferior to those of hard wood. The bolts which secure the journal block, in which the left-hand roller turns, should move in slots in the frame so that the rollers can be set different distances

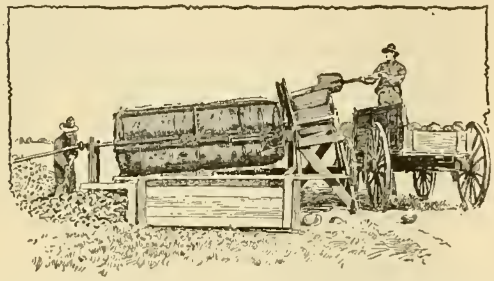

Fig. 228. Machine for separating watermelon seed.

apart. For cucumbers, tomatoes and watermelons, it will be found best to set the rollers as close as possible without injuring the seeds; but as open as possible and still turn, for summer squash and muskmelons. The frame is made of 4 x 4, and may be of pine. Fig. 228 illustrates the machine in action. In Fig. 229 is pictured a table on which cucumbers may be seeded.

(3) *Growing and breeding seed crops for home use.*

It has been clearly demonstrated that it is possible to increase the product per acre of the average farm up to 40 per cent simply by the use of improved strains of seed developed on the farm itself, at the cost of a little well-directed effort on the part of the farmer. There is no more effective way of increasing the money profit of the farm and the attractiveness of farming as an occupation, particularly to alert-minded young men, than through wise efforts in the improvement of the quality of the seed to be used.

A most important factor controlling the profit of any crop is uniformity in the plants. With most crops, the profit would be greatly increased if each plant were only equal in quantity and quality of yield to that of the best one-third of them. Superlative individuals rarely add to the value of a crop, while markedly inferior ones always detract from it.

The character and potentiality of every plant grown directly from seed seems to be fixed and inherent in the seed itself, and is made up of a balanced sum of potentialities and limitations inherited in different degrees from each of its ancestors for an indefinite number of generations. There is a difference in the degree to which plants have the power of transmitting their individual characteristics to their descendants, or in their prepotency, and we can be sure as to the potential character of the seed only in proportion as we know the character and prepotent power of its ancestors. It may not be possible to know this fully, but we can accomplish much by a wise system of plant selection and breeding. A somewhat full discussion of this subject is given in Chapter III and under a number of the individual crops, so that it is necessary here to give only a few general directions. Study your plant and settle on the exact type which would be most practically desirable, and write out as full and complete description of its characteristics as possible. With the description in hand, select one to ten or more plants, which most fully accord with it, avoiding those of phenomenal excellence in some particulars at the cost of deficiencies in others. Save the seed of each selected plant separately, even if the plants themselves cannot be distinguished from each other, and plant that of each selected individual by itself, though all may be side by side in a single block. When the plants mature, go over the different lots, that is, the plants grown from the seed of each of the selected individual plants, and reject those lots in which the plants show the greatest variations, even if in so doing you reject a few plants of superlative merit. Select the two or three lots in which the plants most uniformly accord with the description, and from these lots select plants to repeat the process. The object is to secure a fixed type of plants that are uniformly of the desired type, rather than superlative individual plants. The remainder of the seed from the best lots can be used for a general crop.

Fig. 229. Table on which cucumbers may be seeded. The fruit is emptied on the table and halved by being pushed against the set blade, and the seeds then scraped into barrels as shown.

The essentials for success in seed-breeding are (1) a clear conception of the exact type of plant wanted; (2) a carefully written out description of that type and very rigid adherence to it in all selections; (3) saving and planting separately the seed of each selected plant; (4) continuing to select from generation to generation from the product of the selected plants those that are most uniformly of the desired type. In some cases, where such crops as garden peas, beans or sweet corn, which have some feeding value, have been grown, farmers often come into possession of seed that has been rejected by seedsmen as unfit for their use, and plant it as a field crop, making no effort to have the seed pure and unmixed. Such stock speedily degenerates and can be sold only at a reduced price or when the regular supply has failed. Quite a proportion of the tomato seed used in this country comes from canning factories, being washed out from the waste of the tables where the fruit is prepared for canning, or from lots of fruit that is over-ripe, or that used for catsup. If saved from equally good fruit, such seed is as good as that from fields grown especially for seed, but usually it comes from a mixture of fruit of different sorts and qualities and is of very poor quality.

THE GROWING AND TRANSPLANTING OF FIELD-CROP PLANTS

By *L. C. Corbett*

From a cultural standpoint, field, as well as truck crops, may be divided into two groups: (1) those that are propagated from seed planted where the crop is to mature, and (2) those grown from seed planted under special environment for the purpose of producing plants which may be transferred to the field when the soil and temperature conditions have become congenial. The objects sought by the use of specially prepared seed-beds are to lengthen the season for plants requiring a long period for maturing, to bring plants to maturity out of their natural season and to increase the supply of planting material from plants requiring special methods of propagation.

Among the crops which are handled extensively in artificially prepared seed-beds, are the following: cabbage (page 221), onions, beets, sweet-potatoes (page 613), celery, tobacco (page 639), tomatoes, peppers, and, to a less extent, sugar-cane (page 599) and cassava (page 227), the last two being crops which are grown by transplanting, although no special seed-bed is usually employed for starting the plants. With each of the crops mentioned, the peculiar nature of the plant, the time and method of transplanting it to the open, as well as its resistance to cold, determine to a large extent the type of seed-bed in which the young plants are grown.

Advice on specific crops.

Cabbage.—Plants for the early crop of cabbage at the South are grown from seeds sown in the open in September, for transplanting to the field in December; while at the North seeds are sown either in coldframes in September, and wintered under cover, to be transplanted to the open early in the spring, or they are sown in the greenhouse or hotbed from January to March and grown in a low temperature with plenty of air in order that the plants may be of suitable size for transplanting to the open in April or May.

Onions.—In the case of onions of the Bermuda type, the common practice in Texas is to sow the seed in September or October in a carefully graded and well-enriched bed, which can be irrigated and the young plants kept growing vigorously up to the time to transplant them to the field in December. At the North onions are handled in a different way. All the onions which are transplanted for field purposes are grown either in coldframes or hotbeds, the seed being sown early in February or March and the young plants placed in the open after the soil has become thoroughly warm and in a high state of cultivation.

Beets are less extensively transplanted than the two crops just mentioned, but in some localities they are sown in coldframes in the fall to be transplanted to the field early the following February or March.

Celery.—While celery is cultivated very extensively in certain parts of California, Ohio, Michigan, New York and Florida, plants are usually started in plant-beds in the open. For some of the extremely early crops at the North, it is necessary to bring the plants on in the greenhouse or hotbed, but for the main crop it is sufficient to sow the seed in the open in specially prepared beds, the seed being scattered in rows or broadcasted, and in some cases transplanted before it is finally set in the field. Ordinarily, however, on an extensive scale, the plant-bed is simply sheared or gone over with a light mowing machine before transplanting in order to reduce the top surface. Then, with a special digging machine, the plants are lifted. They are usually set in the field by hand.

Commercial production of plants for transplanting purposes.

Beside the methods of producing field-crop plants already suggested, which are usually practiced by the proprietor of the market-garden or truck-farm, there are those who plan to meet the inevitable losses and failures which annually befall a greater or less number of those engaged in the field culture of transplanted plants. Large and distinctive enterprises of this character now exist near both Baltimore, Md., and Charleston, S. C. The managers of these industries maintain extensive seed-beds

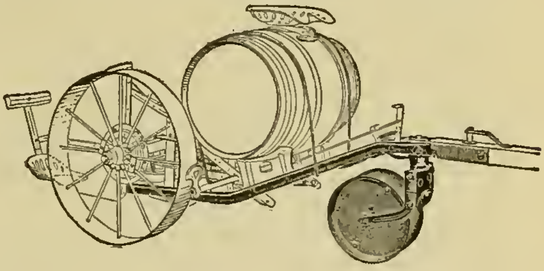

Fig. 230. A transplanting machine. The two men who handle the plants sit behind.

both in the open and under glass in order that they may be prepared to meet the demand for plants for the garden or truck-farm at all seasons and in any quantity. One firm operating a business of this character annually devotes four to five acres to cabbage plants, four to six acres to celery, and large areas to tomatoes, beets, peppers and asparagus, beside some two acres under glass devoted to the propagation of ornamental bedding plants. These firms do exclusively wholesale business and, while well known in the trade, are little known to the public outside of truck-farming districts. One of the plant producers located in an especially favored locality on the south Atlantic coast, conducts a business which enables him to supply cabbage plants in carload lots. This grower six years ago, was able to meet the demand for cabbage plants from sixty pounds of seed sown on two acres. At the present time he uses over one ton of seed on about seventy acres of land. Extensive growers are able to produce plants under favorable conditions at very low cost, and in many localities it has come to be the practice of the growers to depend on the "plant men" for their annual supply, often as a question of economy.

Transplanting machinery (Figs. 230, 843, 871).

Sweet-potatoes, tomatoes and tobacco are the crops most extensively planted by machinery at the present time. The feasibility of handling cabbage by machinery is attracting the attention of growers, because of the difficulty of securing sufficient hand labor to transplant the extensive acreage of this crop now grown in the trucking region of the Atlantic coast. Up to the present, however, the work of transplanting the immense numbers of cabbage plants annually produced has all been done by hand, as is also the case with onions and beets which have been subjected to this type of cultivation. It is probable that a machine-transplanter will never be adapted to the growing of beets or onions because of the limited space between the individual plants, and the proximity of the rows in which they are set; but where the space between the individual plants is eighteen inches, and the distance between the rows sufficient to allow of cultivation by horse-power, as in the case of cabbage, sweet-potatoes, tobacco, tomatoes and peppers, it is perfectly feasible to use a machine to assist in transplanting these crops.

Truck-growing has reached the point where it is necessary to take advantage of every opportunity to reduce the cost of production. The use of the mechanical transplanter is one of the factors which is bound to play an important part in reducing the cost of producing cabbage. It will undoubtedly do for cabbage what it has already done for sweet-potatoes and tobacco. Celery, while grown at sufficient distance between the rows to admit of using a transplanter, is set so closely in the rows that it is probable that it will never be feasible to use this implement for transplanting the crop. In fact, many of the plants which require special attention at transplanting time and are more or less exacting in regard to handling will always have to be transplanted by hand. It should be perfectly feasible to handle sugar-cane and cassava with the transplanting-machines.

LEGAL WEIGHTS OF AGRICULTURAL PRODUCTS

I. United States.—Adapted from Circular No. 10 of Bureau of Standards, Department of Commerce and Labor, issued April 15, 1905.

"These tables show the weights in pounds per bushel legally established for various products by the several states and (for customs purposes) by Congress. The lack of agreement between the weights thus locally established is greatly to be regretted; they are published here exactly as they appear in the statutes. The local weights for the more common commodities, such as wheat, corn, and oats, are fairly uniform, but even these do not agree with the weights of Standard United States bushel measures of the respective products. In many cases, moreover, in which the weight of the bushel is fixed by law, purchase and sale are also permitted by capacity measures, which deliver quantities differing from those based on the legal weights." Since these figures were compiled, Indian and Oklahoma territories have been combined, and it is not known to what extent the figures now apply in the new state.

List of products for which legal weights have been fixed in but one or two states:

Apple seeds, 40 pounds (Rhode Island and Tennessee).
Beggarweed seed, 62 pounds (Florida).
Blackberries, 32 pounds (Iowa); 48 pounds (Tennessee); dried, 28 pounds (Tennessee).
Blueberries, 42 pounds (Minnesota).
Bromus inermis, 14 pounds (North Dakota).
Cabbage, 50 pounds (Tennessee).
Canary seed, 60 pounds (Tennessee).
Cantaloupe melon, 50 pounds (Tennessee).
Cherries, 40 pounds (Iowa); with stems, 56 pounds (Tennessee); without stems, 64 pounds (Tennessee).
Chestnuts, 50 pounds (Tennessee); 57 pounds (Virginia).
Chufa, 54 pounds (Florida).
Cotton seed, staple, 42 pounds (South Carolina).
Cucumbers, 48 pounds (Missouri and Tennessee); 50 pounds (Wisconsin).
Currants, 40 pounds (Iowa and Minnesota).
Feed, 50 pounds (Massachusetts).
Grapes, 40 pounds (Iowa); with stems, 48 pounds (Tennessee); without stems, 60 pounds (Tennessee).
Guavas, 54 pounds (Florida).
Hickory nuts, 50 pounds (Tennessee).
Hominy, 60 pounds (Ohio); 62 pounds (Tennessee).
Horseradish, 50 pounds (Tennessee).
Italian rye-grass seed, 20 pounds (Tennessee).
Johnson-grass, 28 pounds (Arkansas).
Kafir, 56 pounds (Kansas).
Kale, 30 pounds (Tennessee).
Land-plaster, 100 pounds (Tennessee).
Meal (?), 46 pounds (Alabama; unbolted, 48 pounds (Alabama).
Middlings, fine, 40 pounds (Indiana); coarse middlings, 30 pounds (Indiana).
Millet, Japanese barnyard, 35 pounds (Massachusetts).
Mustard, 30 pounds (Tennessee).
Plums, 40 pounds (Florida); 64 pounds (Tennessee).
Plums, dried, 28 pounds (Michigan).
Popcorn, 70 pounds (Indiana and Tennessee); in the ear, 42 pounds (Ohio).
Prunes, dried, 28 pounds (Idaho); green, 45 pounds (Idaho).
Quinces, 48 pounds (Florida, Iowa, and Tennessee).
Rape seed, 50 pounds (Wisconsin).
Raspberries, 32 pounds (Kansas); 48 pounds (Tennessee).
Rhubarb, 50 pounds (Tennessee).
Sage, 4 pounds (Tennessee).
Salads, 30 pounds (Tennessee).
Sand, 130 pounds (Iowa).
Spelt or Spiltz, 40 pounds (North Dakota); 45 pounds (South Dakota).
Spinach, 30 pounds (Tennessee).
Strawberries, 32 pounds (Iowa); 48 pounds (Tennessee).
Sugar-cane seed, 57 pounds (New Jersey).
Velvet-grass seed, 7 pounds (Tennessee).
Walnuts, 50 pounds (Tennessee).

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL.

	Apples			Beans									Corn				Corn meal			Cotton seed		
	Apples*	Dried apples	Barley	Beans*	Castor-beans (shelled)	Beets	Blue-grass seed	Bran*	Broom-corn seed	Buckwheat	Carrots	Clover seed	Corn*	Corn in ear, husked	Corn in ear, unhusked	Shelled corn	Corn meal*	Corn meal, bolted	Corn meal, unbolted	Cotton seed*	Sea-island cotton seed	Upland cotton seed
United States	. .	. .	48	. .	50	. .	. .	. .	. .	42	. .	. .	56	. .	. .	. .	48	. .	. .	. .	. .	. .
Alabama	. .	24	47	60	. .	. .	. .	. .	. .	. .	. .	. .	. .	70	75	56	. .	. .	. .	32	. .	. .
Arizona	. .	. .	45	[a]55	. .	. .	. .	. .	. .	. .	. .	. .	54	. .	. .	. .	. .	. .	. .	. .	. .	. .
Arkansas	[b]50	24	48	[a]60	. .	. .	14	20	48	52	. .	60	. .	70	74	56	48	. .	. .	33⅓	. .	. .
California	. .	. .	50	. .	. .	. .	. .	. .	. .	40	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Colorado	. .	. .	48	60	. .	. .	14	. .	. .	52	. .	60	. .	70	. .	. .	50	. .	. .	. .	. .	. .
Connecticut	48	25	48	60	. .	[c]60	. .	20	. .	48	50	60	. .	. .	. .	. .	50	. .	. .	. .	44	30
Delaware	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	44	48	. .	. .	. .
Dist. Col.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Florida	[b]48	24	48	[d]60	48	. .	. .	20	. .	. .	. .	. .	. .	. .	70	56	48	. .	. .	32	46	. .
Georgia	. .	24	47	[e]60	. .	. .	14	[f]20	. .	52	. .	60	. .	70	. .	56	48	. .	. .	30	. .	. .
Hawaii	. .	. .	48	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Idaho	[b]45	28	48	. .	. .	. .	. .	. .	. .	42	. .	60	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Illinois	. .	24	48	[c]60	46	. .	14	20	. .	52	. .	60	. .	70	. .	56	48	. .	. .	. .	. .	. .
Indian Ter.	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Indiana	. .	25	48	60	46	. .	14	. .	. .	50	. .	60	. .	(g)	. .	56	50	. .	. .	. .	. .	. .
Iowa	48	24	48	60	46	. .	14	20	30	52	. .	60	. .	[h]70	. .	56	. .	. .	. .	. .	. .	. .
Kansas	[b]48	24	[illegible]	60	46	. .	[i]14	20	. .	50	. .	60	. .	[j]70	. .	. .	50	. .	. .	. .	. .	. .
Kentucky	. .	24	47	[c]60	*45	. .	14	20	. .	56	. .	60	[k]70	. .	. .	56	50	. .	. .	. .	. .	. .
Louisiana	. .	. .	48	. .	. .	. .	. .	. .	. .	. .	. .	. .	56	. .	. .	. .	. .	. .	. .	. .	. .	. .
Maine	44	. .	48	60	. .	60	. .	. .	. .	48	50	. .	56	. .	. .	. .	[o]50	. .	. .	. .	. .	. .
Maryland	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Massachusetts	48	25	48	[l]60	. .	. .	. .	20	. .	48	50	60	. .	. .	. .	[m]50	50	. .	. .	. .	44	30
Michigan	48	22	48	60	46	. .	14	. .	. .	48	. .	60	. .	[h]70	. .	56	50	. .	. .	. .	. .	. .
Minnesota	[b]50	28	48	60	. .	50	14	. .	57	50	45	60	. .	70	. .	56	. .	. .	. .	. .	. .	. .
Mississippi	. .	26	48	[e]60	46	. .	14	20	. .	48	. .	60	. .	72	. .	56	48	44	48	32	. .	. .
Missouri	48	24	48	[n]60	46	. .	14	20	. .	52	50	60	. .	. .	70	56	50	. .	. .	33	. .	. .
Montana	45	. .	48	60	. .	50	14	20	. .	52	50	60	. .	70	. .	56	50	. .	. .	. .	. .	. .
Nebraska	. .	24	48	[e]60	46	. .	14	20	. .	52	. .	60	. .	70	. .	56	50	. .	. .	. .	. .	. .
Nevada	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
N. Hampshire	. .	. .	. .	62	. .	. .	. .	. .	. .	. .	. .	. .	56	. .	. .	. .	50	. .	. .	. .	. .	. .
New Jersey	50	25	48	60	. .	. .	. .	. .	. .	50	. .	64	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
New Mexico	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
New York	48	25	48	60	. .	. .	. .	20	. .	48	50	60	. .	. .	. .	. .	50	. .	. .	. .	44	30
North Carolina	. .	. .	48	. .	. .	. .	. .	. .	. .	50	. .	60	. .	. .	. .	. .	. .	46	48	30	. .	. .
North Dakota	50	. .	48	60	. .	60	. .	20	30	42	. .	60	. .	70	. .	56	. .	. .	. .	. .	. .	. .
Ohio	50	24	48	60	. .	56	. .	. .	. .	50	50	60	. .	68	. .	56	. .	. .	. .	. .	. .	. .
Oklahoma	. .	. .	48	60	. .	60	. .	20	30	42	. .	60	. .	70	. .	56	. .	. .	. .	. .	. .	. .
Oregon	45	28	46	. .	. .	. .	. .	. .	. .	42	. .	60	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Pennsylvania	. .	. .	47	. .	. .	. .	. .	. .	. .	48	. .	60	58	. .	. .	. .	. .	. .	. .	. .	. .	. .
Rhode Island	48	25	48	60	46	50	. .	20	. .	48	50	60	. .	70	. .	56	50	. .	. .	. .	44	30
South Carolina	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	[p]48	46	48	30	(q)	. .
South Dakota	. .	. .	48	60	. .	60	. .	20	30	42	. .	60	. .	70	. .	56	. .	. .	. .	. .	. .	. .
Tennessee	[b]50	24	48	[nr]60	46	50	14	20	42	50	50	[s]60	. .	70	[t]74	56	. .	50	48	28	. .	. .
Texas	45	28	48	[e]60	. .	. .	. .	20	. .	42	. .	60	. .	70	72	56	. .	. .	. .	32	. .	. .
Utah	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Vermont	46	. .	48	62	. .	60	. .	. .	. .	48	50	60	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Virginia	. .	28	48	[e]60	. .	. .	14	. .	. .	52	. .	60	. .	70	. .	56	50	. .	. .	32	. .	. .
Washington	[b]45	28	48	. .	. .	. .	. .	. .	. .	42	. .	60	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
West Virginia	. .	25	48	60	. .	. .	. .	. .	. .	52	. .	60	56	. .	. .	. .	. .	. .	. .	. .	. .	. .
Wisconsin	50	25	48	60	. .	50	. .	20	. .	50	50	60	. .	. .	. .	. .	50	. .	. .	. .	44	30
Wyoming	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .

* Not defined.
[a] Small white beans, 60 lbs.
[b] Green apples.
[c] Sugar-beets and mangels.
[d] Shelled beans, 60 lbs.; velvet beans, 78 lbs.
[e] White beans.
[f] Wheat bran.
[g] Corn in ear, 70 lbs. until Dec. 1 next after grown; 68 lbs. thereafter.
[h] In the cob.
[i] English blue-grass, 22 lbs.; native, 44 lbs.
[j] Indian corn in ear.
[k] Corn in ear, Nov. 1 to May 1, 70 lbs.; 68 lbs., May 1 to Nov. 1.
[l] Soybeans, 58 lbs.
[m] Cracked corn.
[n] Green unshelled beans, 30 lbs.
[o] Indian corn meal.
[p] Standard weight bushel corn meal, bolted or unbolted, 48 lbs.
[q] Matured.
[r] Dried beans.
[s] Red and white.
[t] Green unshelled corn, 100 lbs.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL, continued.

	Cranberries	Flaxseed (linseed)	Gooseberries	(Plastering) hair	Hemp seed	Herd's-grass	Hungarian-grass seed	Indian corn, or maize	Lime: Lime*	Lime: Unslacked lime	Malt	Millet	Oats	Onions: Onions*	Onions: Onion sets	Orchard-grass seed	Osage orange seed	Parsnips	Dried peaches, unpeeled	Peanuts	Pears*
United States	..	56	..	..	..	..	..	..	..	..	34	..	32	..	..	..	..	..	..	..	..
Alabama	..	..	..	..	..	..	..	..	..	..	..	..	32	..	..	..	..	..	33	..	..
Arizona	..	..	..	..	..	..	..	..	..	..	..	..	32	..	..	..	..	..	..	..	..
Arkansas	..	56	..	..	..	..	..	..	..	..	..	50	32	57	..	..	..	..	33	..	..
California	..	..	..	..	..	..	..	52	..	..	..	..	32	..	..	..	..	..	..	..	..
Colorado	..	..	..	..	44	..	..	56	80	..	..	..	32	57	..	..	..	..	..	..	..
Connecticut	..	55	..	..	..	45	..	56	70	..	..	..	32	52	..	..	..	45	33	..	..
Delaware	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	..	..	..	..
Dist. Col.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Florida	..	..	..	..	..	..	..	..	..	..	..	50	32	56	..	..	..	..	..	22	60
Georgia	..	56	..	8	44	..	..	..	..	80	..	..	32	57	..	..	..	..	33	..	..
Hawaii	..	..	..	..	..	..	..	56	..	..	..	..	32	..	..	..	..	..	..	..	..
Idaho	..	56	..	..	..	..	..	56	..	..	..	..	36	..	..	..	..	..	28	..	[l]45
Illinois	..	56	..	8	44	..	..	..	..	80	38	..	32	57	..	..	..	..	33	..	..
Indian Ter.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Indiana	33	..	..	..	44	..	..	..	..	..	[a]35	50	32	48	..	14	33	55	33	..	..
Iowa	..	56	40	..	44	..	50	..	80	..	..	50	32	57	..	..	32	..	33	..	..
Kansas	..	56	..	[b]8	44	..	50	[c]56	..	80	32	50	32	57	..	..	..	..	33	..	..
Kentucky	..	56	..	8	44	..	50	..	..	35	..	50	[c]32	57	[d]36	14	..	..	..	..	..
Louisiana	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Maine	..	..	..	11	..	45	..	..	..	..	..	..	[e]32	52	..	..	..	45	..	..	..
Maryland	..	..	..	..	..	..	..	..	..	..	..	..	26	..	..	..	..	..	..	..	..
Massachusetts	..	55	..	..	..	45	..	[c]56	70	..	..	..	32	52	..	..	..	..	..	..	..
Michigan	40	56	..	..	44	..	50	..	70	..	..	50	32	54	..	14	33	..	..	..	..
Minnesota	36	..	40	[b]8	50	..	48	..	80	..	..	48	32	52	..	14	..	42	..	..	..
Mississippi	..	56	..	..	44	..	50	..	..	80	38	50	32	57	..	..	..	..	..	..	..
Missouri	..	56	..	..	44	..	48	..	..	..	38	50	32	57	[f]28	14	36	44	..	..	48
Montana	..	56	..	..	44	..	50	..	..	80	30	..	32	57	..	..	..	50	..	..	45
Nebraska	..	56	..	8	44	..	50	..	..	80	30	50	32	57	25	..	32	..	..	..	..
Nevada	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
N. Hampshire	..	..	..	..	..	..	..	..	..	..	..	..	32	..	..	..	..	..	..	..	..
New Jersey	..	55	..	..	..	..	..	56	..	..	..	..	30	57	..	..	..	..	..	..	..
New Mexico	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New York	..	55	..	..	..	45	..	56	70	..	..	..	32	57	..	..	..	..	..	..	..
North Carolina	..	55	..	..	..	..	..	56	..	..	..	..	32	..	..	..	..	..	..	22	..
North Dakota	..	56	..	..	..	..	..	..	80	..	..	50	32	52	..	..	..	..	..	..	..
Ohio	..	56	..	..	44	..	50	..	70	..	34	50	32	55	..	..	..	..	..	..	..
Oklahoma	..	56	..	..	..	..	..	..	80	..	..	..	32	52	..	..	..	..	..	..	..
Oregon	..	..	..	..	..	..	..	56	..	..	..	..	32	..	..	..	..	..	..	..	45
Pennsylvania	..	..	..	..	..	..	..	56	..	..	..	..	32	50	..	..	..	..	..	..	..
Rhode Island	..	56	..	..	44	..	50	..	70	..	38	50	32	50	..	..	..	50	..	..	..
South Carolina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
South Dakota	..	56	..	..	..	..	..	..	80	..	..	..	32	52	..	..	..	..	..	..	..
Tennessee	..	56	48	8	44	..	48	..	(g)	80	..	[h]50	32	[i]56	[j]28	14	33	50	..	23	[k]56
Texas	..	56	..	..	44	..	48	..	..	..	..	50	32	57	..	..	..	..	..	..	..
Utah	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Vermont	..	..	..	..	..	45	..	56	..	..	..	..	32	52	..	..	..	..	..	..	..
Virginia	..	56	..	8	44	12	48	..	..	80	38	50	30	57	28	14	34	..	32	22	..
Washington	..	56	..	..	..	..	..	56	..	..	..	..	32	..	..	..	..	..	..	..	[l]45
West Virginia	..	56	..	..	..	..	..	..	..	..	..	..	32	..	..	..	..	..	..	..	..
Wisconsin	..	56	..	8	44	..	48	56	70	80	34	50	32	57	..	..	..	44	..	..	..
Wyoming	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

*Not defined.
[a] Malt rye.
[b] Unwashed plastering hair, 8 lbs.; washed, 4 lbs.
[c] Shelled.
[d] Bottom onion sets.
[e] Strike measure.
[f] Top onion sets.
[g] Slacked lime, 40 lbs.
[h] German Missouri and Tennessee millet seed.
[i] Matured onions.
[j] Button onion sets, 32 lbs.
[k] Matured pears, 56 lbs.; dried pears, 26 lbs.
[l] Green.

LEGAL WEIGHTS (IN POUNDS) PER BUSHEL, continued.

	Peas			Potatoes									Salt							Turnips		
	Ground peas	Green peas, unshelled	Peas*	Potatoes*	Sweet-potatoes	White potatoes	Red-top	Rough rice	Rice corn	Rutabagas	Rye meal	Rye	Salt*	Fine salt	Coarse salt	Shorts*	Sorghum seed	Tomatoes	Timothy seed	Turnips*	Common English turnips	Wheat
United States	..	..	60	60	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Alabama	..	..	60	..	55	60	..	..	..	..	..	56	..	..	..	..	..	..	..	55	..	60
Arizona	..	..	..	..	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Arkansas	..	..	60	60	50	..	14	..	..	..	..	56	50	..	..	..	50	..	60	57	..	60
California	..	..	..	..	..	..	..	..	..	..	..	54	..	..	..	..	..	..	..	..	..	60
Colorado	..	..	..	60	..	..	..	..	..	..	..	56	80	..	..	..	..	..	45	..	..	60
Connecticut	..	..	60	60	54	60	..	45	..	60	50	56	..	50	70	20	..	..	..	..	50	60
Delaware	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	60
Dist. Col.	..	..	..	60	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Florida	..	..	..	..	60	60	..	..	..	..	..	56	60	..	..	..	56	..	..	54	..	60
Georgia	25	..	60	..	55	60	..	43	..	..	..	56	..	..	..	..	..	..	45	55	..	60
Hawaii	..	..	..	..	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Idaho	..	..	..	60	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Illinois	..	..	..	..	50	60	..	..	..	..	..	56	..	55	50	..	..	..	45	55	..	60
Indian Ter.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Indiana	..	..	..	60	55	..	..	..	..	..	..	56	50	..	..	..	..	..	45	55	..	60
Iowa	..	..	..	60	46	..	..	..	..	..	..	56	50	..	..	..	[a]30	..	45	..	..	60
Kansas	..	..	..	60	50	..	..	..	56	..	..	56	50	..	..	..	56	..	45	55	..	60
Kentucky	24	..	60	60	55	60	..	..	..	..	..	56	50	55	..	..	..	..	45	60	..	60
Louisiana	..	..	..	..	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Maine	..	..	60	60	..	..	..	..	..	60	50	50	..	60	70	..	..	..	..	..	50	60
Maryland	..	..	..	56	..	..	..	..	..	..	..	..	..	..	..	..	..	60	..	..	..	..
Massachusetts	..	..	60	60	54	..	..	45	..	..	50	56	..	50	70	20	..	..	45	..	..	60
Michigan	..	..	60	..	56	60	[b]14	..	..	..	..	56	56	..	..	..	..	..	45	58	..	60
Minnesota	..	..	60	..	55	60	[b]14	..	..	52	..	56	..	..	..	..	57	..	45	..	..	60
Mississippi	24	..	60	..	60	60	..	..	..	..	..	56	50	..	..	..	42	..	45	55	..	60
Missouri	..	56	[c]60	..	56	60	[b]14	..	..	50	..	56	50	..	..	..	42	45	45	..	42	60
Montana	..	..	60	60	..	..	..	..	..	..	..	56	50	..	..	..	..	..	45	50	..	60
Nebraska	..	..	60	..	50	60	..	..	..	..	..	56	50	..	..	..	30	..	45	55	..	60
Nevada	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
N. Hampshire	..	..	60	60	..	..	..	..	..	..	50	56	..	..	..	..	..	..	..	..	..	60
New Jersey	..	..	60	..	54	60	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
New Mexico	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
New York	..	..	60	..	54	60	..	45	..	..	50	56	..	56	70	20	..	..	45	..	..	60
North Carolina	..	..	60	..	..	..	..	44	..	..	..	56	..	..	..	..	..	..	..	..	..	60
North Dakota	..	..	60	..	46	60	..	..	..	..	..	56	80	..	..	..	..	..	45	60	..	60
Ohio	..	..	60	..	50	60	..	..	..	..	..	56	..	..	..	..	..	56	45	60	..	60
Oklahoma	..	..	60	..	46	60	..	..	..	..	..	56	80	..	..	..	..	..	42	60	..	60
Oregon	..	..	..	60	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
Pennsylvania	..	..	..	56	..	..	..	..	..	..	..	56	..	[f]62	85	..	..	..	..	..	..	60
Rhode Island	..	..	[c]60	..	54	60	..	..	..	..	50	56	..	50	70	20	..	56	45	50	..	60
South Carolina	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
South Dakota	..	..	60	..	46	60	..	..	..	..	..	56	80	..	..	..	..	..	42	60	..	60
Tennessee	..	30	60	..	50	60	[b]14	..	..	..	..	56	50	..	..	..	50	56	45	50	..	60
Texas	..	..	..	..	55	60	..	..	..	..	..	56	50	..	..	..	..	55	45	55	..	60
Utah	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Vermont	..	..	60	60	..	..	..	..	..	..	..	56	70	..	..	..	..	..	45	60	..	[e]60
Virginia	..	..	[d]60	..	56	56	12	..	..	..	..	56	50	..	..	..	..	..	45	55	..	60
Washington	..	..	..	60	..	..	..	..	..	..	..	56	..	..	..	..	..	..	..	..	..	60
West Virginia	..	..	..	60	..	..	..	..	..	..	..	56	..	..	..	..	..	..	45	..	..	60
Wisconsin	..	..	60	..	54	60	..	45	..	56	50	56	..	50	70	20	..	..	45	42	..	60
Wyoming	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

[a] Sorghum saccharatum seed.
[b] Seed.
[c] Including split peas.
[d] Black-eyed peas.
[e] Indian wheat, 46 lbs.
[f] Ground salt, 70 lbs.

II. Canada.—Section 90 of the Inspection and Sale Act of the Department of Agriculture for the Dominion of Canada, dealing with the legal weights of farm products, reads as follows:

"In contracts for the sale and delivery of any of the undermentioned articles a bushel shall be determined by weighing, unless a bushel by measure is specially agreed upon, and the weight equivalent to a bushel shall, except as hereinafter provided, be as follows:

	Pounds
Barley	48
Buckwheat	48
Flaxseed	56
Indian corn	56
Oats	34
Pease	60
Rye	56
Wheat	60

Section 337 reads as follows:

"In contracts for the sale and delivery of any of the undermentioned articles the bushel shall be determined by weighing, unless a bushel by measure is specially agreed upon, and the weight equivalent to a bushel shall be as follows:

	Pounds
Beans	60
Beets	60
Blue-grass seed	14
Carrots	60
Castor-beans	40
Clover seed	60
Hemp seed	44
Malt	36
Onions	50
Parsnips	60
Potatoes	60
Timothy seed	48
Turnips	60

"In the province of Quebec when potatoes are sold or offered for sale by the bag, the bag shall contain at least 80 pounds."

Fruit packages.

Sub-section I, Section 325: The minimum legal limit of apple barrel is a barrel having a dimension of not less than twenty-six inches and one-quarter between the heads, inside measure, and a head diameter of seventeen inches and a middle diameter of eighteen inches and one-half, representing as nearly as possible ninety-six quarts.

Sub-section 3, Section 325: "When apples are packed in Canada for export, for sale by the box, they shall be packed in good strong boxes, of seasoned wood, the inside dimensions of which shall not be less than ten inches in depth, eleven inches in width and twenty inches in length, representing as nearly as possible two thousand two hundred cubic inches."

Sub-section 2, Section 326, of the Inspection and Sale Act, dealing with fruit baskets, now (May, 1907) reads as follows:

"2. Every basket of fruit offered for sale in Canada unless stamped on the side plainly in black letters at least three-quarters of an inch deep and wide, with the word 'Quart' in full, preceded with the minimum number of quarts, omitting fractions, which the basket will hold when level-full, shall contain, when level-full, one or other of the following quantities:

"(*a*) Fifteen quarts or more.

"(*b*) Eleven quarts, and be five and three-fourths inches deep perpendicularly, eighteen and three-fourths inches in length and eight inches in width at the top of the basket, sixteen and three-fourths inches in length and six and seven-eighths inches in width at the bottom of the basket, as nearly exactly as practicable, all measurements to be inside of the veneer proper, and not to include the top band.

"(*c*) Six quarts, and be four and one-half inches deep perpendicularly, fifteen and three-eighths inches in length and seven inches in width at the top of the basket, thirteen and one-half inches in length and five and seven-eighths inches in width at the bottom of the basket, as nearly exactly as practicable, all measurements to be inside of the veneer proper, and not to include the top band: Provided that the Governor in Council may by proclamation exempt any province from the operation of this section.

"(*d*) Two and two-fifths quarts, as nearly exactly as practicable."

YIELDS OF FARM CROPS.

The yields of farm crops in any given locality are influenced by a multitude of factors,—seed, weather, soil preparation and management, care, harvesting, and the like. Any effort, therefore, to tabulate yields of widely grown crops must be considered as suggestive and provisional rather than definite and constant. Yet, when an extensive area is considered, as a continent, a fairly accurate determination can be arrived at, and the effort will be of value in measuring up the adaptabilities and possibilities of any area for a given crop grown in that region.

In the tables that follow, the average and best yields of the more important field crops of the United States and Canada, as reported by good observers in several parts of the continent, are recorded. In some cases census figures have been available; in others, the reporter has had to determine the yields for his state or province from such figures and estimates as he was able to secure. It is not improbable, therefore, that some error has been made in certain cases, especially in reporting the best yields. If the best yields, as reported in these tables, have any significance, it is to show what has been accomplished, and, therefore, what can be accomplished again, even though in special cases the best reported yields may seem to be very exceptional. Unfortunately, the average yields of all crops are greatly lowered from the average yields attained by successful and painstaking growers by the small yields of the careless and indifferent growers, and the small figures of poor crop years. Hence, no progressive farmer will be satisfied to attain merely the average.

YIELDS OF FARM CROPS

As reported for this volume by observers in several parts of the continent.

	Quebec	New York		North Carolina		Alabama	
	Average	Average	Best	Average	Best	Average	Best
Alfalfa	3 tons	2.3 tons	7 tons	1.7 tons	5 tons	3.5 tons	7 tons
Barley	25 bushels	23.9 bus.	50 bushels	10 bushels	25 bushels	12 bushels	45 bushels
Beans, field	20 bushels	10.5 bus.	45 bushels	10 bushels	....	....	....
Broom-corn	....	565 lbs.	1,000 lbs.	455 lbs.	....	400 lbs.	600 lbs.
Buckwheat	25 bushels	16.9 bus.	40 bushels	10 bushels	30 bushels	....	....
Cabbage	12 tons	10 tons	*40 tons	100 crates	200 crates	5 tons	10 tons
Carrots	12 tons	10 tons	20 tons	....	....	....	....
Clover	2 tons	1.1 tons	4 tons	1–2 tons	3 tons	2 tons	3 tons
Cotton	....	....	....	½ bale	2 bales	†200 lbs.	1,000 lbs.
Cowpeas	....	....	....	10 bushels 1.5 tons	30 bushels 5 tons	10 bushels	30 bushels
Field-pea	25 bushels	17.1 bus.	45 bushels	1–2 tons	....	....	....
Flax	15 bushels	8.5 bus.	15 bushels	....	....	....	....
Kohlrabi	....	....	....	....	....	....	....
Lespedeza	....	....	....	1.25 tons	2 tons	....	2 tons
Maize	25 bushels	32 bushels	100 bus.	13 bushels	100 bus.	14 bushels	75 bushels
Mangels	20 tons	24 tons	40 tons	....	....	....	....
Melilotus	....	....	....	2 tons	....	2 tons	3.5 tons
Millet	....	1.7 tons	5 tons	1.5 tons	4 tons	1 ton	3 tons
Oats	35 bushels	32 bushels	80 bushels	10 bushels	50 bushels	15 bushels	70 bushels
Parsnips	....	335 bus.	1,000 bus.	....	....	....	....
Potatoes	150 bus.	79 bushels	500 bus.	70 bushels	....	60 bushels	300 bus.
Pumpkin	....	....	....	....	....	....	....
Rape	20 tons	....	....	....	....	....	....
Rice	....	....	....	360 lbs.	....	12 bushels	30 bushels
Rutabaga	10 tons	14 tons	30 tons	100 bus.	....	....	....
Rye	15 bushels	16 bushels	35 bushels	5.5 bus.	20 bushels	7 bushels	20 bushels
Sorghum	....	....	....	5–6 tons	10 tons	2.5 tons	7 tons
Soybean	....	....	....	12 bushels 1.7 tons	40 bushels 4 tons	15 bushels 1.7 tons	25 bushels 4 tons
Sugar-beets	15 tons	7.8 tons	30 tons	....	....	....	....
Sugar-cane	....	....	....	7–8 tons	12 tons	‡200	‡600
Sweet-potatoes	....	119 bus.	200 bus.	85 bushels	....	80 bushels	400 bus.
Timothy	2 tons	1.1 tons	4 tons	1–2 tons	4 tons	....	....
Tobacco	1,000 lbs.	1,155 lbs.	....	650 lbs.	....	500 lbs.	1,000 lbs.
Turnips	10 tons	12 tons	28 tons	100 bus.	....	....	....
Vetch	2 tons	....	....	1–2 tons	3 tons	1.5 tons	3 tons
Wheat	15 bushels	18.9 bus.	60 bushels	7–8 bus.	30 bushels	8 bushels	30 bushels

* Including varieties grown for stock-feeding. † Lint. ‡ Gallons of syrup.

YIELDS OF FARM CROPS, continued

As reported for this volume by observers in several parts of the continent.

	Indiana		Wisconsin		Manitoba		Eastern Texas	
	Average	Best	Average	Best	Average	Best	Average	Best
Alfalfa	3-4 tons	6 tons	3 tons	6 tons	3 tons	4 tons	3 tons	7 tons
Barley	25 bushels	40 bushels	30 bushels	65 bushels	30 bushels	75 bushels	. . . .	. . . .
Beans, field . .	. . . .	. . . .	18 bushels	30 bushels	. . . .	. . . .	150 bus.	200 bus.
Broom-corn . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Buckwheat . .	. . . .	. . . .	15 bushels	35 bushels	. . . .	. . . .	. . . .	. . . .
Cabbage . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	4,000 lbs.	6,000 lbs.
Carrots	. . . .	. . . .	10 tons	18 tons	300 bus.	800 bus.	9,000 lbs.	12,000 lbs.
Clover	1.5 tons	2.5 tons	3 bus. seed 1.5 tons	5 bus. seed 4 tons	2 tons	4 tons	. . . .	. . . .
Cotton	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	⅓ bale	2 bales
Cowpeas . . .	18 bushels	30 bushels	8 bushels	15 bushels	. . . .	. . . .	1.5 tons	3 tons
Field-pea . . .	. . . .	. . . .	10 bushels	25 bushels	40 bushels	65 bushels	40 bushels	60 bushels
Flax	. . . .	. . . .	13 bushels	25 bushels	18 bushels	. . . .	. . . .	. . . .
Kohlrabi . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	1,200 lbs.	2,000 lbs.
Lespedeza . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Maize	40 bushels	100 bus.	41 bushels	100 bus.	. . . .	. . . .	30 bushels	90 bushels
Mangels . . .	18 tons	25 tons	25 tons	60 tons	800 bus.	1,200 bus.	5 tons	6 tons
Melilotus . . .	. . . .	. . . .	2.5 tons	4 tons	. . . .	. . . .	. . . .	. . . .
Millet	1.7 tons	4 tons	30 bus. seed 2 tons	65 bus. seed 4 tons	2 tons	4 tons	1 ton	2 tons
Oats	30 bushels	80 bushels	36 bushels	97 bushels	40 bushels	110 bus.	35 bushels	85 bushels
Parsnips . . .	. . . .	. . . .	8 tons	15 tons	300 bus.	600 bus.	9,000 lbs.	12,000 lbs.
Potatoes . . .	100 bus.	200 bus.	92 bushels	400 bus.	300 bus.	800 bus.	60 bushels	150 bus.
Pumpkin . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	6 tons	8 tons
Rape	. . . .	. . . .	15 tons	35 tons	10 tons	. . . .	. . . .	. . . .
Rice	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	50 bushels	100 bus.
Rutabaga . . .	. . . .	. . . .	12 tons	40 tons	500 bus.	1,000 bus.	6 tons	8 tons
Rye	14 bushels	*50 bushels	16 bushels	40 bushels	20 bushels	40 bushels	. . . .	. . . .
Sorghum . . .	9 tons	15 tons	15 bus. seed 8 tons	25 bus. seed 15 tons	. . . .	. . . .	2.5 tons	6 tons
Soybean . . .	20 bushels	35 bushels	15 bushels	35 bushels	. . . .	. . . .	. . . .	. . . .
Sugar-beets . .	14 tons	20 tons	12 tons	30 tons	300 bus.	800 bus.	4 tons	6 tons
Sugar-cane . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	25 tons	40 tons
Sweet-potatoes.	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	100 bus.	400 bus.
Timothy . . .	1.5 tons	2 tons	1.5 tons	3.5 tons	1.5 tons	4 tons	. . . .	. . . .
Tobacco . . .	. . . .	. . . .	1,280 lbs.	1,800 lbs.	. . . .	. . . .	800 lbs.	1,200 lbs.
Turnips	. . . .	. . . .	10 tons	35 tons	600 bus.	1,100 bus.	6 tons	8 tons
Vetch	. . . .	. . . .	†8 tons	†12 tons	2 tons	3 tons	. . . .	. . . .
Wheat	14 bushels	45 bushels	12 bushels	35 bushels	27 bushels	56 bushels	12 bushels	48 bushels

* Winter rye. † Green feed.

YIELDS OF FARM CROPS, continued

As reported for this volume by observers in several parts of the continent.

	New Mexico		Wyoming		Washington		British Columbia
	Average	Best	Average	Best	Average	Best	Range
Alfalfa	3 tons	7 tons	3 tons	8.5 tons	‡6 tons	‡10 tons	. . . .
Barley	40 bushels	70 bushels	35 bushels	. . . .	29.7 bus.	80 bushels	35 bushels to 105 bushels
Beans, field . .	600 lbs.	1,000 lbs.	. . . .	. . . .	13 bushels	. . . .	15 bushels to 25 bushels
Broom-corn . .	. . . .	. . . .	. . . .	. . . .	3,000 lbs.	. . . .	. . . .
Buckwheat . .	. . . .	. . . .	. . . .	. . . .	19.4 bus.	. . . .	13 bushels to 41 bushels
Cabbage . . .	. . . .	. . . .	. . . .	16,150 lbs.	2,855 heads	. . . .	3 tons to 25 tons
Carrots	. . . .	. . . .	12,000 lbs.	21,107 lbs.	476 bus.	. . . .	4 tons to 85 tons
Clover	. . . .	. . . .	. . . .	. . . .	2.2 tons	5 tons	1.5 tons to 4.5 tons
Cotton	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Cowpeas . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Field-pea . . .	. . . .	. . . .	18 bushels	34.7 bus.	26 bushels	. . . .	25 bushels to 106 bushels
Flax	. . . .	. . . .	. . . .	16 bushels	5.7 bus.	. . . .	. . . .
Kohlrabi . . .	. . . .	. . . .	. . . .	15,475 lbs.	. . . .	. . . .	10 tons to 16 tons
Lespedeza . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Maize	22 bushels	60 bushels	. . . .	. . . .	21 bushels	40 bushels	**10 tons to 45 tons
Mangels . . .	. . . .	. . . .	. . . .	. . . .	600 bus.	. . . .	13 tons to 50 tons
Melilotus . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Millet	. . . .	. . . .	. . . .	. . . .	1.5 tons	. . . .	1 ton to 6 tons
Oats	35 bushels	85 bushels	40 bushels	137 bus.	42 bushels	150 bus.	35 bushels to 125 bushels
Parsnips . . .	. . . .	. . . .	. . . .	8,200 lbs.	377 bus.	. . . .	. . . .
Potatoes . . .	. . . .	. . . .	75 bushels	972 bus.	142 bus.	500 bus.	8 tons to 28.5 tons
Pumpkin . . .	. . . .	. . . .	. . . .	. . . .	1,384 pumpkins	. . . .	. . . .
Rape	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Rice	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Rutabaga . . .	. . . .	. . . .	15 tons	. . . .	. . . .	. . . .	20 tons to 63 tons
Rye	. . . .	. . . .	18 bushels	34 bushels	14.6 bus.	. . . .	15 bushels to 32 bushels
Sorghum . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Soybean . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	4.5 tons
Sugar-beets . .	11.5 tons	19.5 tons	10 tons	28.7 tons	3.3 tons	§ 18 tons	6 tons to 23 tons
Sugar-cane . .	. . . .	. . . .	. . . .	. . . .	2.9 tons	. . . .	. . . .
Sweet-potatoes .	10,000 lbs.	18,000 lbs.	. . . .	. . . .	90 bushels	. . . .	. . . .
Timothy . . .	. . . .	. . . .	1.5 tons	. . . .	3.7 tons 1.5 tons	irrigated dry land	2 tons to 5.5 tons
Tobacco . . .	. . . .	. . . .	. . . .	. . . .	236 lbs.	. . . .	. . . .
Turnip	. . . .	. . . .	. . . .	40 tons	. . . .	. . . .	. . . .
Vetch	. . . .	. . . .	. . . .	. . . .	3 tons	. . . .	. . . .
Wheat	30 bushels	63 bushels	25.5 bus.	*50 bushels †78 bushels	25 bushels	100 bus.	11 bushels to 43 bushels

* Field culture.
† Garden culture.
‡ Under irrigation. On dry land, 2.5 tons and 4 tons, respectively.
§ Under irrigation.
** For silage.

PART II

THE MANUFACTURE OF CROP PRODUCTS

Every important crop affords material for one or more manufuctured products. These products are of several classes or kinds, as: Preserved products for use as food for men or live-stock; construction products, as lumber, in which the plant material is merely put in shape or form for use, without change in its structure; extracted or expressed products, as wines; ground or pulverized products, as flour; transformed structural products, in which the identity of the original materials is lost, as in woven goods, paper. It would be interesting to make a list of the manufactured or manipulated products of the plants described in this book, beginning with the meal made from the alfalfa plant and ending with the flour and other products of the wheat grain. If the list were at all complete, the number would be astonishingly large and would impress the reader with his great dependence on the common crops of the fields.

For the most part, the manufacturing of crop products is not agriculture. This manufacture is delegated to other persons who make it their exclusive business. The farmer, however, is closely governed in many cases by the necessities of the manufacturer. In fact, the need of manufactured goods has had a tremendous influence on agricultural practice, dictating the kinds of crops to grow in great regions, the varieties, the methods of growing them, the season at which they shall be delivered, the methods of harvesting and of marketing. It is clearly not the concern of a work of the nature of this Cyclopedia to discuss in any completeness the manufacture of crop products, for farming properly ends at the factory door. Certain manufacturing processes, however, are home industries, or they may be local and practically coöperative, and are therefore nearly or quite within the sphere of this book. Such processes are the various forms of preserving crop products for human consumption, and the making of juices and beverages. It is proposed, therefore, briefly to discuss some of these familiar subjects to aid the housekeeper and also to give information on some of the commercial relations of these industries.

With the increase of population, the utilization of secondary or waste products in manufacture becomes more marked and important. In time, a use must be found for everything, and everything must be saved. This is well illustrated in wood products, paper now being made from kinds and sizes of trees that were passed by a few years ago, and lumber being sawn from small and crooked stuff that not long ago was left in the forest to be burned. A closer economy of materials will, of course, augment the influence of manufacture on crop production.

In the old days, every good farm establishment conducted much of its own manufacture. It did its own weaving of cotton, flax or wool. It tanned its own hides. It "put down" its own meats. In many cases it made its own meal or flour. The manufacture moved to the village and finally to the city and remote from the farm. There is every reason to expect that manufacture is to return to the farm, perhaps not of the staple articles above mentioned, but of many secondary products that must be saved or that need to be added to the necessities of living. Every good farm will be equipped with light power, which will be utilized in the saving of labor and in manipulating crop products. Neighborhood manufacture is returning, particularly in dairy regions; this introduces new methods of coöperation, and produces social as well as economic results.

Unfortunately, there seem to have been few studies of these subjects in this country from the agricultural point of view. The literature is of two kinds,—the purely domestic writing, largely of the recipe-book order; and the technical writing for the use of manufacturers or students of the scientific principles involved in the manufacture. We shall find, however, that these subjects have close relation to farm management and to crop-growing. It is impossible, for example, to find adequate advice on the growing of crops for canning factories. The field or farming phases of these subjects are in need of study.

Plate IV. Canning factory scene in the Delaware country. Loads of peas. Ships in the background

CHAPTER VIII

PRESERVED PRODUCTS

NEW METHODS OF MANUFACTURE have greatly extended the importance of canning and of other methods of preserving, and have widened their influence on crop production. These methods have been largely in the way of perfecting machinery to take the place of hand-labor in preparing the products, making the cans or receptacles, and in cooking or sterilizing. The modern art and practice of canning are said to have begun with Nicholas Appert, in France, toward the close of the eighteenth century. It was about 1810, however, before the method became prominent, at least in England, whence Appert had received financial assistance for his work. Within ten years thereafter, Ezra Daggett and his son-in-law, Thomas Kensett, introduced into New York the method of hermetically sealing perishable products. Later they secured a patent for an improvement in the art of preserving. Nearly or quite contemporaneously, Charles Mitchell introduced the method into Boston, entering the employment of William Underwood, who established the firm of William Underwood and Company, in 1822. The canning of fruits, vegetables and meat products spread slowly for many years, but great impetus was given it by the gold-fever exodus, in 1849 (creating demand for compactly preserved food), later by the Civil War, and thereafter by the rapid growth of cities and the dependence on the market. At first the scientific principles involved were not understood, but they have now been explained by the studies of Tyndall, Pasteur and many others. The underlying principle is sterilization,—the killing of the germs that cause change and decay,—and the hermetical sealing to prevent contamination.

The canning industry has experienced very great extension in this country, gradually moving westward with the development of diversified agriculture. The Central West has now become the principal packing section for certain leading goods. This is marked in the westward extension of corn packing. In 1906, Iowa held first place in the output of canned corn, with 1,593,000 cases of two dozen cans each. Pumpkins, peas and other general field crops are heavily packed in the upper Mississippi valley states. The output in different years is likely to fluctuate greatly, however, as between localities or regions.

The great importance of the various industries that preserve crop products, or extract their juices is shown by the following figures from the Twelfth Census (for 1900):

	Number establishments	Total capital	Land	Buildings	Machinery, tools and implements	Cash and sundries
Fruits and vegetables, canning and preserving . . .	1,808	$27,743,067	$2,702,470	$4,517,008	$4,797,719	$15,725,870
Vinegar and cider	1,152	6,187,728	708,857	1,410,215	1,956,010	2,112,646

Later statistics, from the Statistical Abstract for 1906, give figures as follows for canning and preserving fruits and vegetables:

Census year	Number establishments	Capital	Wage-earners		Cost of material	Value of product
			Average number	Total wages		
1880	411	$8,247,488	31,905	$2,679,960	$12,051,293	$17,599,576
1890	886	15,315,185	49,762	4,651,317	18,665,163	29,862,416
1900	1,813	27,795,621	37,189	8,251,471	37,382,541	56,427,412
1905	2,261	47,629,497	39,988	10,428,521	51,582,460	78,142,022

This class of products figures heavily in the exports of the United States, as shown in the following exhibit.

DOMESTIC EXPORTS. YEARS ENDED JUNE 30. (Statistical Abstract, 1906).

	Cider		Canned fruit	Malt		Total wines	Vegetables canned	Vinegar	
	Gallons	Dollars	Dollars	Bushels	Dollars	Dollars	Dollars	Gallons	Dollars
1897	637,672	77,695	1,686,723	289,543	177,292	698,714	408,840	93,969	11,572
1898	465,873	60,063	1,624,741	406,702	287,473	728,749	386,039	108,657	12,939
1899	490,803	64,500	2,330,715	453,038	324,145	676,330	555,691	107,317	13,488
1900	483,367	64,283	3,127,278	296,742	215,198	625,592	603,288	115,372	12,583
1901	462,048	61,132	3,006,109	357,947	250,099	504,573	528,914	83,780	13,231
1902	121,006	21,869	1,195,635	401,375	266,894	450,325	560,612	95,675	19,754
1903	598,119	84,084	1,739,571	347,147	252,801	315,176	597,759	103,417	18,072
1904	714,476	103,314	2,637,002	438,580	315,676	436,693	719,580	132,450	19,192
1905	394,723	61,204	2,541,025	487,158	342,851	383,457	580,048	111,994	17,158
1906	344,117	53,577	2,348,064	881,523	598,453	351,550	658,739	92,027	16,266

The literature of canning and preserving is scattered in bulletins of a few agricultural colleges and stations, the national Department of Agriculture, the trade journals, proceedings of societies, in the agricultural press and a few books. The writers in this chapter suggest the following titles: H. W. Conn, Bacteria, Yeasts and Molds in the Home; Mrs. Sarah T. Rorer, Canning and Preserving; Hester M. Poole, Fruits: How to Use Them; Fletcher Berry, Fruit Recipes; Gesine Lemcke, Preserving and Pickling. Farmers' Bulletins: No. 93, Mary Hinman Abel, Sugar as Food; No. 203, Maria Parloa, Canned Fruits, Preserves and Jellies; No. 183, Andrew Boss, Meat on the Farm. Cornell Reading-Course for Farmers' Wives, Bulletin No. 20, Series IV, Canning and Preserving.

Following are a few of the technical publications on this subject: Art and Science of Canning, published by Canner and Dried Fruit Packer, Chicago; E. W. Duckwall, Canning and Preserving of Food Products, with Bacteriological Technique, Aspinwall, Pa.; C. A. Shinkle, American Commercial Methods of Manufacturing Pickles, Preserves and Canned Goods, Canyon City, Colo.; Science and Experiment as Applied to Canning, published by The Sprague Canning Machinery Company, Chicago (1902); papers by W. Lyman Underwood and S. C. Prescott, entitled Microörganisms and Sterilization in the Canning Industries, Technology Quarterly, Vol. X, No. 1, and Vol. XI, No. 1, Boston (1896, 1897).

The mutual relations of canning factories and farming are very intimate, one dictating to some extent the methods of the other. These relations have probably developed as far in California as elsewhere, and a brief account of them may serve to express the nature of the problems and progress involved, as well as to supply information of a certain region.

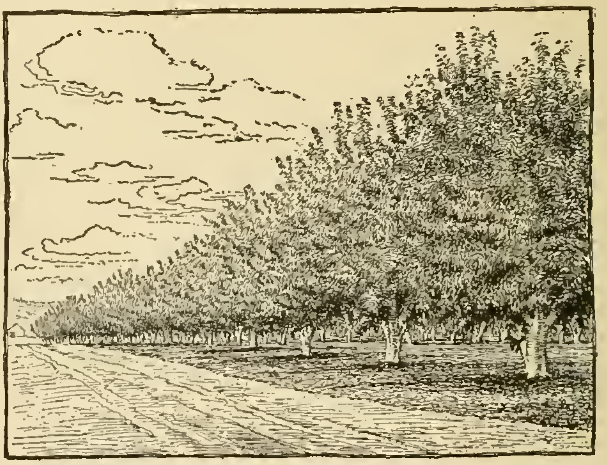

Fig. 231. Cherry orchard, the fruit used largely for canning.

CANNING INDUSTRY IN CALIFORNIA

By *C. H. Bentley*

Owing to the wide variation in soil and climate, there is great divergence in the canning products and the canning industry in the states of the Pacific coast and Rocky mountains.

California, having a climate favoring the widest range of products and a location best suited for marketing them, has shown the largest development in this industry. With the rapid increase in fruit crops throughout the state, large tracts of land have been set out without regard to any particular market. Nearly every fruit-growing community in turn has found it difficult, if not impossible, to market the crop in the fresh condition. The local cannery, often started on a semi-coöperative plan by growers and other interested parties, has been a natural though rarely successful development. When operated on a strictly business-like basis, it has given reasonably good returns to the owners. In some cases, the canner has grown his own fruit, but he has usually bought from year to year according to the crop and market conditions, or has entered into a term contract with growers for a period of years to buy fruit of a size, quality and condition suitable for canning, at an agreed price or scale of prices. Through such term contracts the canner has exercised a beneficial influence. It has been to his interest to see that only the most improved varieties of fruit are grown ; that the orchard is properly pruned, plowed, cultivated and protected against pests of every kind ; that the crop is thinned when necessary and that it is harvested properly. Operating under such contracts, orchardists have been brought to see the benefit of intelligent and business-like farming. Information from the best authorities, relating to preferred varieties of fruits, methods of cultivation, pruning and fighting of pests, harvesting and the like, has been distributed to the growers through the agency of the canners, and the latter have frequently pioneered some suggestion of the State College of Agriculture or of the United States Department of Agriculture, looking to improved conditions of horticulture.

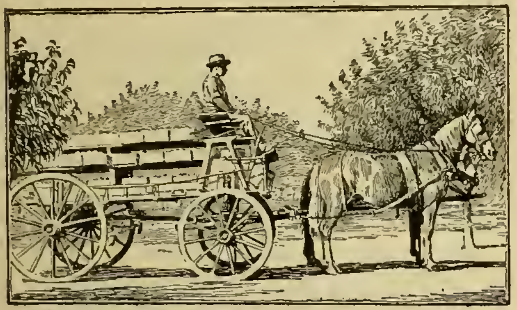

Fig. 232. Hauling peaches to the cannery. Penuryn, Placer county, California.

In the growing of vegetables, canners have appeared even more prominently in bettering the conditions surrounding the growth of canning products. From the very limited acreage of asparagus grown for the local produce trade, has developed a great industry, thousands of acres now being grown for the exclusive purpose of canning. When this industry was threatened by the parasitic rust, canners were the first to propose and contribute to a fund handled by the College of Agriculture of the University of California in making scientific investigation, which promises to be of lasting benefit. Similar conditions have arisen in connection with the growing of peas, tomatoes and string beans. Sweet corn has not been grown to good advantage in California, and practically none has been canned. The worm which almost invariably appears in each ear of corn has made it impossible for canners to operate with any profit. The past season, through means provided by the canning interest, the College of Agriculture has had the opportunity of experimenting on several hundred acres of corn. While the results have not seemed to justify development in this business, a distinct advance has been made.

The season begins in March with the canning of asparagus, the better packs being made in the peculiar peaty soil found in a few favored localities. Fig. 233 shows a small part of an asparagus

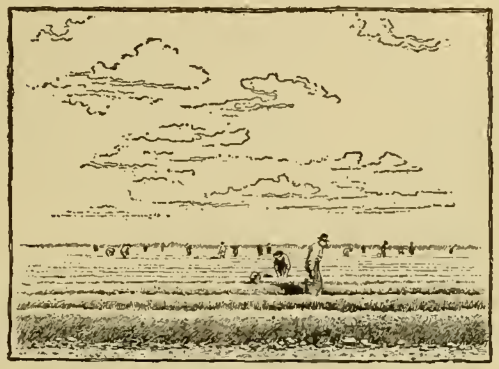

Fig. 233. Cutting asparagus for canning.

field of 1,000 acres grown exclusively for canning purposes. The light loose soil is built up over the root crowns to a considerable depth, so that the shoots can grow without resistance during the time of harvesting. During the height of the season the entire acreage must be cut daily, as the asparagus is not allowed to grow above the surface, and each spear is cut as rapidly as the point is exposed to the air. In this way, the white asparagus, so much preferred, is secured. If exposed, the point turns first to a purple then to a green color.

Sugar peas are handled extensively under what is known as the "viner system," the vines being mown at the harvest time and hauled in hayricks to the cannery, which is located close to the field where the peas are grown. The vines are put into viners or threshers, as indicated in Fig. 234. This method is in general use throughout the country and is not peculiar to California.

Tomatoes are contracted for delivery in early

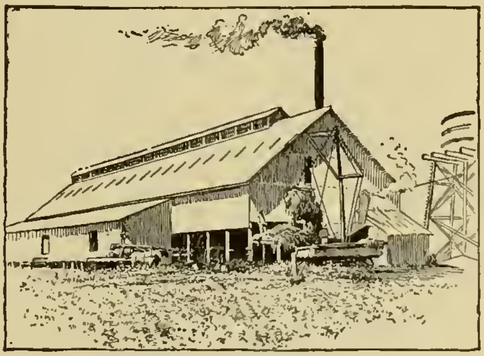

Fig. 234. Pea-field, viner and cannery.

September after the rush of the fruit season. They are usually safe from frost until the middle of November. Frequent crops of fifteen tons to the acre are secured. Fig. 235 shows tomato vines during the month of July. These vines were planted in May. Fig. 236 shows the tomato field at the time of harvesting, when the vines cover the ground. As no rains are expected in California until the very end of September, there is no necessity for the use of trellises.

The beginning of the canning industry in California was made in 1860. In 1863 the total pack was about 7,000 cases. It has increased as follows:

1870	36,000 cases
1875	61,000 cases
1880	221,000 cases
1885	615,000 cases
1890	1,495,000 cases
1895	1,639,000 cases
1900	2,775,000 cases
1905	3,800,000 cases

By reason of the diversity of soil and climate, the canneries are scattered throughout the state, specializing more and more so as to handle products where they are grown to the best advantage.

The above table gives the duration of the canning season by varieties. The heavy black line indicates when the season is at its height. This table also gives a list of the more important varieties used in canning, although it is to be noted that artichokes, baked beans, lima beans, beets, cabbage, carrots, cauliflower, celery, corn, onions, parsnips, potatoes, pumpkin, spinach, sprouts, squash and turnips are packed in considerable quantities. In addition to the varieties of fruits mentioned, it should be noted that crab-apples, figs, lemons, logan-berries and oranges are also used in the preparation of jams, jellies and preserves.

Duration of the California Canning Season—By Kinds or Varieties

Showing Earliest and Latest Day's Packing for Period of 42 Consecutive Years in San Francisco

Explanation: ═══ entire season. ▬ heavy period.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Asparagus				6		12						
Strawberries					8					23		
Peas					13	21						
Gooseberries						19						
Cherries, red					29		2					
Cherries, white					29							
Currants						6	28					
String Beans						13						
Blackberries						19			4			
Apricots						21		25				
Green Gages							19		18			
Egg Plums							20		23			
White Free Peaches							22			15		
Yellow Free Peaches							23			17		
Nectarines							24		6			
Pears							25		26			
Yellow Cling Peaches							29			12		
Golden Drops								7	5			
White Cling Peaches								10		9		
Damson Plums								20		23		
Tomatoes								23			16	
Grapes									4		30	
Quinces									14		10	
All varieties, entire season				6								1

It is safe to say that the canneries in California are using the product of 15,000 acres bearing fruit and 10,000 acres bearing vegetables. The canned asparagus, apricots, peaches, pears and plums are shipped to all the open markets in the world and are regarded as superior. The cheaper staples, as peas and tomatoes, are marketed usually on the Pacific coast, as the cost of transportation limits the sale of such products as are generally produced throughout the country. With berries and apples, California enjoys no advantage over other localities, and for a like reason these products are, under normal conditions, sold in Pacific coast territory. Other vegetables, such as potatoes and

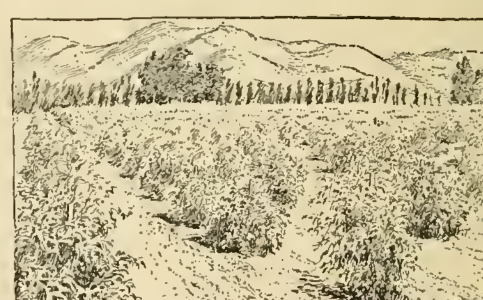

Fig. 235. Tomato-field in July. At the time of harvesting the vines will have covered the ground. California.

cauliflower, are distributed largely in logging, mining and construction camps, and in cold and remote regions where fresh supplies cannot be secured.

It is generally thought that the industry will not show the rapid growth in the future that it has in the past, for the reason that communities formerly dependent on canned goods for their supplies of fruits and vegetables, are now in many cases growing, and even canning, their own products. In other cases, with the improved shipping facilities and extension of railway lines, comparatively remote communities are now able to receive apples, citrous fruits and vegetables in safety throughout the winter. The constant improvement in the quality of dried fruits and their relative cheapness has had the tendency to reduce the volume of business on the cheaper grades of canned fruits. On the other hand, the demand for the better grades shows gratifying increase, and the development of new markets offsets the falling off of others.

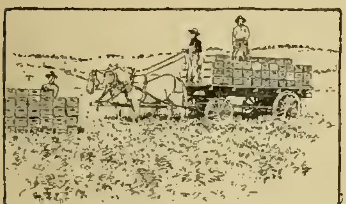

Fig. 236. Harvesting tomatoes in California. The vines cover the ground.

HOME PRESERVING AND CANNING

By *Anna Barrows*

Primitive man early discovered that dried foods are more easily transported from place to place and have better keeping qualities than when fresh; and that the salt of sea-water and the smoke of the camp-fire have further preservative influence. Generations ago housekeepers found out that dense substances would keep longer than those that were watery, so they packed cooked meat in its own fat, and made preserves rich with honey, or sugar, and savory with spices. The air-tight tin can and glass jar, sterilization and cold-storage, have done much in solving one of the most complicated problems of modern civilization, but all the possibilities have not yet been fully investigated.

The efficiency of all ancient processes of food preservation is explained by the later knowledge of the habits of microörganisms. Failure in canning and preserving is usually due to lack of knowledge of these subjects. The essential points are these: Bacteria do not thrive in substances containing less than 25 per cent of water, such as preserves or jellies thick with sugar; they are destroyed by heat; they do not flourish in the presence of acids, alcohol, salt, spices, or the substances deposited by smoke. Foods containing little nitrogenous matter are less liable to the attack of bacteria; therefore bacteria are less troublesome in the preservation of fruits than of fish and meats.

Molds and ferments or yeasts are the common enemies of preserves, jellies and the like. (Figs. 237, 238.) These growths usually are killed in a few minutes at the temperature of boiling water, 212° Fahr. A lower degree of heat continued for a longer period — half an hour or more — is often as effectual and less detrimental to the flavor and texture of the fruit. The spores, or undeveloped organisms, resist heat that would be fatal to those fully grown, so in laboratories or canning factories steam, under pressure, is used to secure a temperature much higher than 212° Fahr., and thus wholly to sterilize the food. Here the housekeeper cannot compete with the factories, and must practice intermittent sterilization as was done long before the existence and habits of these microörganisms were known. The material to be sterilized is heated to the boiling point and kept there for half an hour on three or more successive days. Between these scaldings it is left at an ordinary temperature, that the spores may germinate and become active organisms. These are then killed by the next heating, and after the final boiling the exclusion of air prevents the entrance of others.

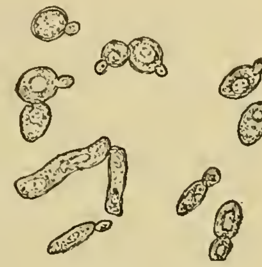

Fig. 237. Forms of yeasts of different kinds.

It is essential that everything exposed to the air, filled as it is with "germs," should be sterilized before it comes in direct or indirect contact with the food to be preserved. Fruits are constantly exposed while growing, or in market, and their skins harbor vast numbers of microörganisms; hence they must be thoroughly washed. The removal of skins from peaches, tomatoes and like products by scalding has more than one beneficial effect. If pared fruit must stand before cooking, it should be dropped into water with lemon juice or vinegar in it, to prevent the discoloration probably due to the action of a ferment.

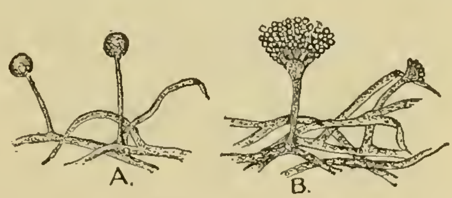

Fig. 238. Molds. A, Mucor, showing sporangia bearing spores; B, Pencillium, showing conidiophore bearing spores.

The room in which such work is to be done should be as clean as the operating-room of a hospital. All possible dust should be removed with a damp cloth. Every utensil should be boiled ten minutes or more, and kept in the water till it is to be used. The jars had better be filled over the stove where the air is sterilized by heat and steam, rather than by an open window, where dust-laden air can come in contact with them.

We have become so accustomed to certain flavors in pickles and preserves that we forget that they are used primarily for their preservative effects and that they may retard digestion as much as the newer preservatives, the use of which is so justly condemned.

In her "Frugal Housewife," published in 1830, Mrs. Lydia Maria Child says, "Economical people will seldom use preserves, except for sickness. They are unhealthy, expensive and useless to those who are well." To a modern student of dietetics it seems singular to give the sick anything unsuitable for the well, but certain pharmaceutical values were ascribed to "conserves" in the early days of their manufacture. Thomas Tusser, who died in 1580, author of "Five Hundreth Pointes of Good Housekeeping" has this to say in their favor:

> "Good housewife provides, ere a sickness do come,
> Of sundry good things in her home to have some;
> Conserves of barbary, quinces and such,
> With sirops, that easeth the sickly so much."

The thorough sterilization of such articles is in their favor, and the value of sugar as a food is now recognized.

Dr. Robert Hutchison makes this statement regarding homemade jam: "The acids of the fruit, aided by the high temperature employed in the course of preparation, bring about the conversion of a considerable proportion of the cane-sugar into the invert form. Homemade jam is boiled for a longer time than the commercial article and consequently contains more invert and less cane-sugar than the latter. The larger the proportion of cane-sugar which has been inverted, the less likely is the jam to interfere with digestion."

In a discussion of preserves and preserving, a number of preparations may be considered. It is but a step beyond the making of ordinary preserves to the preparation of candied, glacé or crystallized fruits. Preserves also naturally merge into fruit butters, jams, jellies and marmalades, some fruits being better adapted to one form than to another. These terms are often used interchangeably and vary in their application according to locality These several preparations will here be considered in order.

Preserves.

This type of sweet should not be served as freely as the ordinary canned fruits in which there is less sugar and more water, but there is no objection to its use in moderation. The fruit is cooked in thick syrup, and more thoroughly than for canning. The denser the syrup the better the fruit will keep its shape, but when there is a tendency to jelly or caramelize, more water must be added. The proportion of sugar and water for the syrup must vary according to the juiciness of the fruit. For preserves, three-fourths to one pound of sugar is allowed for each pound of fruit. At the begining the syrup may consist of twice as much sugar as water, for average fruits. A few pieces are put into the kettle at once, that each may be surrounded by the thick, hot syrup. As soon as these sections of fruit are cooked, in many cases becoming somewhat transparent, they are removed to the jars, and more are put into the syrup. More water or sugar is added as needed. At the end, the remaining syrup is used to fill the jars containing the fruit, and often forms a firm clear jelly in which the fruit is imbedded.

Strawberries, stoned cherries, and any fruit likely to lose form and flavor if cooked, are sometimes sprinkled with sugar and the syrup thus formed is scalded and poured hot over the uncooked fruit placed in the jars. If the syrup is then scalded two or three days in succession and poured over the fruit again, there is little danger of fermentation.

Preserves will keep in jars that are not air-tight, but they should have much the same protection as jellies. The texture of each lot of fruit should be carefully observed, since varieties of the same fruit, and any one variety at different stages of growth, may produce a marked difference in the product. Hard fruits, as quinces, some pears and apples, may be improved by steaming until tender before cooking in the syrup. When any fruit is to be preserved whole, the center must be as thoroughly sterilized as the outside, which must be accomplished by slow, gentle cooking, otherwise the surface will be broken and unsightly. There is a certain transparent appearance when the syrup has penetrated throughout.

Candied fruit.

This is to be classed with candies rather than with fruits, since the sugar predominates. Among the fruits most commonly subjected to this treatment are apricots, cherries, peaches and pineapples. The fruit is preserved in a thick syrup, then drained, cooled, dried and rolled in sugar. The time given to each process depends on the texture of the fruit and the size of the pieces. Experiments in this country have been hurried too much to produce as satisfactory results as are obtained in France. One of our consuls has given this report on the methods pursued there: "Some of the denser fruits, as citron, are soaked first in sea-water. All are carefully sorted as to size and degree of ripeness, and stones and parings are removed. The fruit is then plunged into boiling water and drained, thus removing much of the juice. If this process is too long continued the fruit is overcooked or left too woody, but if the juices are not extracted sufficiently, less sugar is absorbed and there is more danger of fermentation later. Experience is the only guide."

Syrups of different densities must be provided for different fruits,—the softer the fruit the denser the syrup required. The fruit, after thorough draining, is soaked in the syrup for a time before heating. When a cloudy appearance in the transparent syrup indicates the beginning of fermentation, the vessel containing syrup and fruit is heated to 212° Fahr. The process of soaking in syrup takes about six weeks, and the mass is heated about three times during the period. After this, the fruit may be crystallized by cooling slowly to about 90° Fahr., which causes the thick syrup that covers it to granulate. Or it may be glazed by dipping in a thick syrup and drying rapidly in the open air. The syrup remaining is worked up into various confections. Housekeepers frequently use up their orange and lemon skins in this way, and keep them in salt water until enough accumulate to make it worth while to prepare them. The salted skins are first boiled in fresh water to remove the salt and make them tender, then they are cooked in the syrup. Sweet flag and ginger roots should be cooked in several waters, to remove the too intense flavor before they are candied. The yellow plum tomatoes make a fair substitute for figs, if treated in this way. In all cases care must be taken not to cook the fruit at too high temperature or to dry it too much.

Fruit butter.

Fruit butters seem to be of Dutch or German origin. They are smooth pastes made by long-continued stirring. They are given their name from being used as or in place of butter. Sometimes several fruits are combined. Skins and seeds are removed, but the mass is not sifted. Sugar may or may not be used. The apple butter of Pennsylvania and Ohio is closely akin to the cider apple sauce of New England, but is usually a smoother paste.

To make apple butter, sweet cider is boiled down one-half, then pared and cored apples are put in it. There should be rather more apple than cider, but if too thick add more cider; if too thin add more apples. Stir with a wooden paddle till a rich, dark color and the desired consistency are secured. Further evaporation may be secured by putting the butter in stone jars in a slow oven. Spice may be added for variety, or when the apples are of inferior flavor. The better the apples and the more care given to every detail, the better will be the result. This product has had a market value, but is used mainly for home consumption, always ready as a relish for any meal. Apple-butter "frolics" once ranked with corn-huskings among the autumn festivities. (Fig. 239.)

Jam.

Jam is the general English term for any fruit conserve. The origin of the word seems evident, but it is also traced to words meaning to congeal or thicken. Jams are usually made from the smaller fruits and berries, which may be jammed or mashed without previous cooking and which do not require the straining and longer process involved in jellies, marmalades or fruit butter. The fruit is cleaned, put into the kettle and jammed with a wooden masher as it heats, enough juice flowing out at once to prevent burning. Since no water is added, less time is required for evaporation, and in most cases cooking for half an hour is enough before the sugar is put in; then cooking should continue five or ten minutes more. As commonly known, jams are seldom as firm as jellies and marmalades. Similar compounds are sometimes called fruit purées.

Currants, if clean and thoroughly mashed, may be combined with an equal amount of sugar, and will keep without cooking if packed in sealed jars, their natural acid being enough to repel bacteria.

Marmalade.

"After a good dinner, left Mrs. Hunt and my wife making a marmalett of quinces," says Mr. Pepys in his Diary, November 2, 1663; so marmalade is no new product. The derivation of the word shows that the quince was probably the first fruit used in this way. Its modern form is usually made from acid and semi-bitter fruits, and has a texture between the fruit butter or jam and jellies. The fleshy fruits with much pulp are desirable for this purpose, and those too ripe to keep their shape if preserved whole may be used.

Some fruits may yield material for both jelly and marmalade. The cleaned fruit is cooked, with water enough to prevent burning, until soft. The clear juice is then drained off for jelly, and the pulp while still warm is sifted through coarse cheese-cloth (or a hair sieve, a purée strainer, or potato ricer) for marmalade. To avoid burning, the fruit pulp may then be cooked until thick before adding sugar, which is generally used in a smaller proportion than for jelly. Fruit lacking flavor may be improved by moderate use of spice.

Firm, solid marmalade, cut in strips and rolled in sugar, may form an agreeable addition to a box of homemade candy. In England, experiments have been tried of packing fruit pulp, cooked with sugar, in brick form, when it will keep indefinitely

Fig. 239. Making apple butter. (Adapted from "Rural New-Yorker.")

in a wrapping of waxed paper. For use, these fruit bricks may be reduced with water as desired.

Jelly.

The ideal jelly is transparent, of uniform consistency throughout, firm enough to come from the glass in one mass and retain its shape, but with a quivering texture which divides readily and without any approach to gumminess. Some fruits are not adapted to jelly-making, though ambitious housewives, wishing to display a great variety, attempt to utilize all kinds of fruits. This effort is often the cause of failure to secure perfect jellies. Good results may be obtained from combination of fruits, one giving consistency, another flavor.

Just what the changes are that take place in the transformation of hard fruits into sparkling jellies does not appear to be fully settled by the chemists. Referring to the group of carbohydrates known as "pectin bodies," or "pectose," Dr. Robert Hutchison says, "These are the substances which give to fruits their power of forming jellies when boiled, and little is known of their exact chemical nature, but they appear to be converted into a special kind of sugar when digested (pentose), which is at least partly assimilable by the body." At present the general opinion seems to be that the pectose, insoluble in unripe fruits, under the influence of a ferment-like body called pectase, which is present in ripening fruits, or of acids and heat, becomes pectin, a soluble substance which stiffens the juices and produces the compound we know as jelly. As Miss Parloa says, "Pectin is at its best when the fruit is just ripe or a little before. If the juice ferments, or the cooking of the jelly is continued too long, the pectin undergoes a change, and loses its power of gelatinizing."

By continued evaporation of certain fruit juices containing much pectin, jelly may be made without addition of sugar. Currant jelly may be made by combining the warm juice and warm sugar without further cooking, placing the glasses where sunlight will do the remainder.

The effect of a damp season may be seen in jellies. There appears to be less of the jellying property, more boiling is needed to evaporate moisture, and there will be more shrinkage of the jelly in the glass afterwards.

The apple may be used to illustrate the general process of jelly-making, since that contains a large proportion of the pectosic principle, and having a less distinctive flavor of its own may be combined with more expensive fruits, as the pineapple, to produce satisfactory results. A good supply of jellies may be secured from different varieties of apples alone, the different kinds ranging from the pale color of the Porter to the deep red of some winter varieties, with flavors as unlike as the shades of color. The fruit is cleaned, quartered and cooked in water until soft, but no longer. The average proportion is one quart of water to two quarts of apples, but this varies with the juiciness of the apples. The cooked fruit must drain without pressure. One simple old-fashioned way to accomplish this is to spread a square of cheese-cloth over a large agate or earthen pan, pour the hot fruit into this, tie the opposite corners of the cloth together, and hang over a strong stick placed across two chairs so the juice will drip into the pan. Better than chairs and stick is a strong bird-cage hook in the wall over the kitchen table; or the cheese-cloth may be laid over a hair sieve which is set in a pan. The frame of the sieve will raise the fruit out of the juice. The cloth should always be moistened before the fruit is put in it.

Jelly-making is seldom as successful in damp weather as on a clear, bright day, for evaporation is slower. Sugar is peculiarly affected by the weather and, though in less degree, some of the same difficulties attend jelly-making as the manufacture of candy. On a clear, windy day evaporation is rapid and less boiling is required. In midsummer, bacteria are so active on some of the hot, muggy days, that it is almost impossible to make everything sterile.

The juice must be measured and boiled rapidly in a shallow kettle. It is often more satisfactory to boil lots of one or two quarts than in larger quantities. The process is hastened by heating in the oven for ten minutes the nearly equal weight of sugar, while the juice is boiling on the top of the stove. When the sugar will hiss as it meets the liquid, it is put in, stirred till blended, and the whole boiled for about ten minutes more. Careful skimming at intervals is essential to secure a clear jelly, for if the froth once boils in, the jelly, even if strained afterwards, will never be quite clear. The time and the general appearance of the jelly tell us when to stop. If uncertain, single drops on a cold surface will show the consistency.

Strain the jelly quickly through a new wire strainer into a pitcher and pour from that into the final receptacle. Tumblers are generally preferred, giving a good form for the table, but tin covers are undesirable. When the jelly is cold and firm, melted paraffine may be poured over till one-fourth inch thick. One thinner layer may be allowed to cool, and then the remainder poured on will cover any cracks. Papers dipped in alcohol or brandy, laid directly on the jelly, will prevent mold, but a layer of absorbent cotton or batting is an additional safeguard, and strong paper may be pasted over all.

Jellies crystallize because of excess of sugar or too hard boiling. A temperature even 2° higher will make the color darker, and cause a loss of flavor in the jelly.

Fruit syrup.

Jellies that do not stiffen properly, and any surplus syrup from preserves, should be bottled for future use as the foundation of many desserts, such as gelatine or custard puddings, ice creams, and the like. Often several odd lots of fruit juice may be combined for a summer beverage. Occasionally it has been found more convenient to can the fruit juice and make jelly at another time.

Fruit syrups seem to be slowly taking the place of the homemade wines by which our great-grandmothers set such store. W. M. Williams, in his "Chemistry of Cookery" says,

"We shamefully neglect the best of all food in eating and drinking so little fruit. As regards cooked fruit, I say jam for the million, jelly for the luxurious, and juice for all. With these in abundance the abolition of alcoholic drinks will follow as a necessary result of natural nausea." Yet much of the fruit syrup which has been used in "temperance drinks" was composed of artificial colors and flavors, with hardly a trace of the fruits whose names they bore. Under the new pure food laws these will not be allowed to pass for the real article.

Homemade preserves for market.

Notwithstanding the consolidation of industries, there is a constant demand for high-grade homemade preserves at prices as high as for other fine hand-work. Every detail must be looked after to secure perfection. The price-list of any first-class grocery in our large cities mentions certain "specialties" of Miss ——— or Mrs. ——— at fifty cents per quart-jar and upward. Even at the lowest figure, a woman may earn more money at home than she can save from city wages, but she must control her conditions to secure a regular income in this way. Much cheap jelly has been made from poor fruit sweetened with glucose and flavored artificially, while in some sections of the country fruit rotted on the ground.

There are many combinations of fruits possible which would be more attractive to customers than some of the usual articles. Such are pears cooked in grape-juice, currants with raspberries, barberries with wild apples. Insipid fruits are improved by combination with raisins, lemon-peel or spices. Ground spices are easily added and are not objectionable in a dark marmalade or ketchup. Whole spices may be tied loosely in a bag, and cooked in water from which syrup is to be made, while, in some cases, oils and essences are preferred to either whole or ground spice.

Economies of preserving.

There are many women who would do better to employ some country friend to provide them with a supply of canned fruits, jellies and the like, than to do it for themselves if they must buy all the fruit. Whether for ourselves or for sale, much discretion is necessary to adapt the fruit at hand to the many varieties in preserves. We can seldom raise or buy perfect fruit, therefore it must be sorted carefully. To preserve whole, select that of uniform medium size and good shape. From abnormal sizes and imperfect shapes parts may be cut to preserve, and the remainder used for marmalades and the like, with the fully ripe fruit which would not keep its shape to cook whole. Clean skins and cores, undersized fruit and inferior parts will yield ample material for jellies and fruit syrups. This is the method we follow when cooking meats: the large, tender, sections for roasts and steaks, the smaller pieces of clear muscle for stews, the bones and tough parts for soups.

To keep its shape, fruit must be cooked slowly, a few pieces at a time in syrup; for other preparations it is better to add the sugar later.

When a single variety of fruit must be the main dependence, it should appear in as many forms as possible, and with different flavors. Peaches, for example, may be cooked whole, or in halves, or in slices, with little sugar or much, with cracked pits for the flavor, or in spiced vinegar, or made into marmalade.

About one pound of fruit will be required for each pint-jar of preserve, and this pound will measure roughly, one quart before cooking. Thus, a woman may estimate the number of jars to be secured from a given quantity of fruit. In this way she can decide whether to buy fruit and prepare it for herself, to pay some one else for skilled hand labor, or to depend on the factories.

Evaporating.

[The home evaporating of fruits under eastern conditions is described on pages 174 to 177. A note may be inserted here on the sun-drying of fruit in dry regions. There is practically no evaporating in California as it is understood at the East or in the moist-air sections of Oregon and Washington. Evaporating machines and houses are practically unknown as home devices, although they are used in connection with large canneries for the purpose of saving fruit which is a little too ripe for the canning process. Not less than nine-tenths of all the dried fruit produced in California is cured by sunshine in the open air; and by wise use of sulfur fumes immediately after cutting discoloration is prevented, so that California sun-dried fruit sells as "evaporated." Thirty years ago many evaporators were erected to apply the Alden and other pioneer processes, but they were all abandoned as soon as the proper, sun-drying process was developed. Since then repeated attempts have been made to introduce various styles of evaporators, without success, because no artificial drying agency is so cheap as sunshine acting under the very dry summer air and practical absence of rains. Consult Chapter XXXV, Wickson "California Fruits," 3d edition; also bulletins of Oregon and Washington Experiment Stations.—*Editor.*]

Canning.

Although in some respects a simpler process than those already described, the discussion of canning has been left until the last because it is a later discovery.

When fruits and vegetables are freed from bacteria and packed in air-tight cans, little or no preservative material need be combined with them. Hence, canned fruits, being in a more natural form and more dilute than jams and preserves, are considered to be more digestible than such preparations dense with sugar.

Acid materials, as rhubarb or cranberries, may be canned without cooking. The cut pieces are put in glass jars, the spaces filled with fresh cold water, and the jars sealed. Thus the sour juices act something like vinegar as a preservative.

Usually, however, sterilization by heat is essential. The fresher and cleaner the article to be canned, the more certain we are of securing complete sterilization. Overripe fruit, or that exposed in dusty markets, may harbor bacteria not easily destroyed at the boiling-point. Here the home canner cannot compete with the factory, as there it is possible through steam under pressure to secure a higher temperature.

Firm fruits may be stewed or steamed and then packed in jars. The softer fruits may be steamed in thin syrup or, better still to preserve their form and flavor, put in jars and set in a pan of water in the oven or in a steamer to cook and then be filled with thin syrup. Before sealing, a spoon should be put down between jar and fruit to let out all air-bubbles.

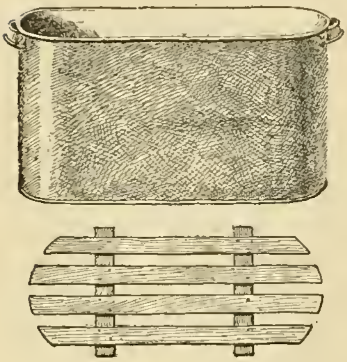

Fig. 240. Common wash-boiler and slats for heating cans preparatory to sealing.

The pressure of the atmosphere on the surface of the preserving kettle causes some variation in the density of syrup, however the sugar and water were proportioned at first. When canning acid fruits, the syrup used to fill the jars may be made of equal measures of sugar and water, while, for sweet fruits, the sugar may be reduced.

The canning of vegetables is usually considered a more difficult process under ordinary conditions than that of canning fruits. With due precautions as to cleanliness and a long period of cooking in the jars placed in a steam cooker or wash-boiler (Fig. 240), many housekeepers are as successful with vegetables as with fruits.

Some vegetables are more subject to fermentation than others. Where the skin is cut, as in sweet corn, there is greater opportunity for bacterial action. String beans may well be parboiled in salted water before putting into the jars, where the cooking process must be continued two or three hours. Tomatoes are less liable to spoil if thoroughly skimmed while cooking. When they have proved most troublesome to housekeepers, it appears that they have not been cooked long enough for the center of the tomato to be raised to the boiling point.

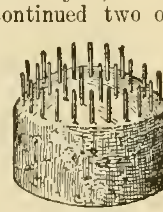

Fig. 241. Fruit pricker. Made by thrusting needles through cork.

The country housekeeper who can bring perfect fruits and vegetables from her garden directly into the preserving kettle and air-tight can will have little trouble with "germs"; but the city woman who must secure raw materials through many middlemen would better depend on reliable canneries for her main supply.

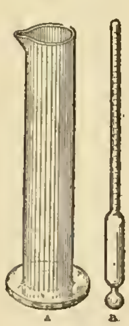

Fig 242. Glass cylinder (A) and syrup gage (B) (Figs. 241–244, Farmers' Bulletin No. 203).

Utensils.

While excellent results have been accomplished by many housekeepers with very poor appliances, any one who is to make preserves as a business needs the best utensils, not the most expensive, but those best adapted to the purpose. Everything should be of shape and substance easy to handle, not readily affected by acids, and affording little hiding-place for molds and ferments.

Scales give greater accuracy than measures. A silver-plated fruit-knife with sharp edge is best for paring and coring, or steel knives, if used, should be kept bright. Wooden, enamel, or silver spoons should be used, never tin or iron.

Fig. 243. Wire basket for scalding the fruits.

The old porcelain-lined iron kettles transmitted moderate heat with little danger of burning the contents. There are brown earthenware kettles, raised from the stove by short legs or a metal rim, that are useful when slow evaporation is essential, as for marmalades or ketchups. Agate-ware kettles are light, easy to lift, and clean, and with asbestos or a metal trivet underneath do not burn readily. There should be several of different sizes, and new ones are desirable since fruit acids often remove stains which cannot be scoured off,—and that does not improve the hue of a jelly. Broad rather than deep kettles should be chosen, since evaporation is thus hastened, and whole fruits should be cooked in shallow layers.

Fig. 244. A wooden masher for jam.

A wire basket is a great help in scalding fruit to remove skins. A wire spoon or bright skimmer is needed occasionally. Enamel strainers and colanders are convenient. A wooden masher is best for jam. Fruit-presses, cherry-stoners, and the like are required when large quantities are to be prepared. For accurate results, a thermometer and syrup gage are as essential as any other tools. Never try to fill many jars without a large-mouthed tin funnel. Strong linen cheese-cloth strainers and a flannel bag are necessary for jellies. To protect tables from stains and make it easy to clear up afterward, cover with several layers of paper, those on top being clean brown paper.

Jars.

To hold different quantities of fruit and, later, to serve a family of varying size, the jars should be of all sizes, half-pint, pint, quart and two-quart. Better pay a few cents more than to get jars with imperfect edge, sure to result in cut fingers, or with blisters of glass inside that will break and mingle with the contents of the jar, or with letters and trade-marks in the way of complete sterilization. The best covers are those of glass held in place by a metal spring fastened about the neck of the jar. When a glass top is fastened in a metal rim it is impossible to keep it perfectly clean.

New rubber rings should be provided each year, though a few of those left over may be usable. Sometimes two rings should be used, they are so thin. Wide-mouthed bottles may be tightly corked and covered with a cement of rosin and beeswax. Bottles are suitable for the fruit syrups, but the self-sealing ones are best. For all purposes, even for jellies, air-tight jars with glass covers have many advantages. Sterilization is as necessary for jelly tumblers as for jars. After jars are filled properly, they should be labeled and dated. Printed labels already gummed may be bought at low rates, so there is no excuse for indistinct or untidy labels.

The closet where filled jars are kept should be light, dry and easy to keep clean. For the first

Fig. 245. *Amanita muscaria.* A poisonous white-spored agaric.

month, watch all jars, and, if there is any indication of fermentation, open, scald, and use at once.

Summary.

This is no place for detailed recipes, since those may be found in cook-books and bulletins. The essential points in all canning, jelly-making, preserving and pickling may be given in few words : The article to be preserved and everything to come in contact with it must be sterilized, and then the air must be kept from it. Constant watchfulness and absolute cleanliness are the only magic arts employed. The housekeeper of today must not forget the traditions and experience of past generations, but even in these every-day processes she must apply also the results of the experiments of modern scientists. Though many of these processes have passed out from the home, there is still a place for the homemade preserves which have a distinct quality and with which no factory goods can compete.

Preserving and preparing mushrooms. (By B. M. Duggar.)

In the preservation of mushrooms the processes may be either by drying or canning. By both processes some of the flavor of the mushroom is lost, but, nevertheless, the product is an important article of commerce, and commands a price averaging, perhaps, half that of the fresh mushrooms. A discussion of edible native mushrooms will be found on page 474. Figs. 245–247 show some of the mushrooms to be avoided.

Drying.—The simpler method is by drying, and this is commonly used by the peasantry of Europe for the preservation of such common forms as *Boletus edulis* (*Steinpilz cèpe*), *Agaricus campestris* (the common mushroom), and, in addition, several species which are used primarily for soups and stews. The method is, however, applicable to a large number of fleshy species. The method which is recognized as giving the best results consists in thoroughly cleaning the fungi and then immersing them for a moment in boiling water which is slightly acidulated with vinegar or lemon juice. It is asserted that the acidulation prevents, to some extent, the darkening of the mushrooms, yet the addition of acid is not a universal custom. Taken from the boiling water, the mushrooms, if small, are frequently strung on threads and hung in the sun or over the stove. Large specimens should be sliced. When dried in quantity, it is unquestionably desirable to desiccate more promptly by placing the material in a slow oven (a temperature of 90° to 100° C., or 194° to 212° Fahr.) or it may be disposed over wire netting suspended over a stove or oven. When dry they are frequently hung in sacks, or merely as strung, in a dry room where peppers, dried apples, and other such products are preserved. For commercial purposes, however, they may be immediately placed in glasses or tins, well closed or sealed. In moist weather much moisture may be taken up, if exposed, and molding will

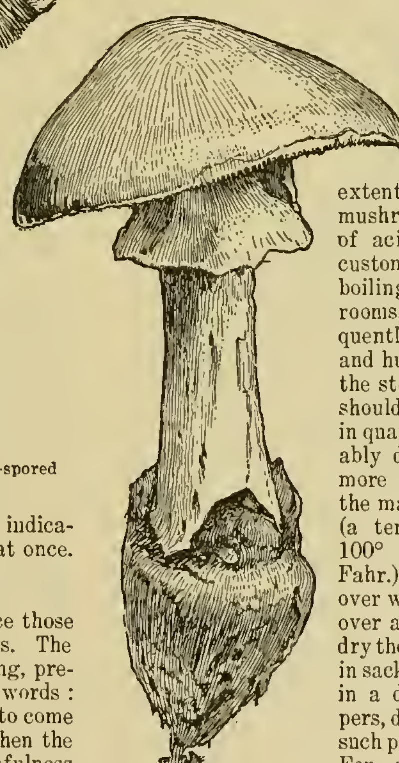

Fig. 246. *Amanita phalloides.* A deadly poisonous, white-spored agaric. Showing cap, stem, ring and cup-like volva with a free, prominent limb.

more readily result. All mushroom growers will find the drying process of value in order to make use of portions of the stems and of mushrooms rather too far advanced for the demands of the best markets. They may then, moreover, be reduced to powder, by passing through an ordinary grinder, and this powder is in considerable demand for sauces and as seasoning.

The canning of mushrooms in liquid, according to many methods which have been published, involves

Fig. 247. *Boletus felleus*, the bitter boletus of doubtful reputation.

blanching by means of a solution containing alum and bisulphite of soda. An effective home method, preserving the flavor fairly well, is this: Peel and throw into boiling water, containing for each gallon three ounces of salt and the juice of two lemons. After five minutes, put into clean pint-jars and cover with a brine containing per gallon from one to two ounces of salt and a little lemon-juice. They are then brought gradually to the boiling-point and boiled for about fifteen minutes.

Preserving in butter, an expensive but common process, is somewhat as follows: Clean and peel as usual and place for a few minutes in cold water, acidulated with vinegar or lemon-juice. Dry with a clean cloth, and use for each quart of mushrooms three ounces of butter, a small teaspoonful of salt, a little pepper and the juice of one lemon. Melt the butter in a stewpan, add the mushrooms and the seasonings; cook slowly until nearly dry, shaking to prevent sticking. Then put into jars and fill with melted butter. Heat in boiling water for ten minutes, close the top, cool gradually and seal.

Mushroom ketchup is commonly made as follows: Clean, cut into slices and dispose in layers one-half inch thick in an earthen dish, sprinkle with salt, and repeat until the dish is full. Place in the refrigerator or a cool place for at least two days. Then crush and strain the product through a cloth. Boil the liquid in a porcelain-lined kettle, adding for each quart one-fourth ounce allspice, one-half ounce ginger root, one dozen cloves and several blades of mace. Boil fifteen minutes, strain through flannel into sterile bottles, cork and dip into sealing wax. Or, in the spring, omit the ginger, and add instead, at the time of maceration in refrigerator, to each two pounds of fresh mushrooms about three ounces of fresh walnut husks, finely chopped. Again, gelatine may be added prior to the last boiling, and the product may be used as a jelly, when it is not desired to keep it for a long period of time and to avoid bottling.

Pickled mushrooms may be readily prepared, but they are not greatly esteemed.

THE COMMERCIAL CANNING INDUSTRY

By *Samuel C. Prescott*

Canning is so called because the food material, either animal or vegetable, is "packed" in metal or glass containers, hermetically sealed and sterilized or "cooked" by the application of heat. The containers, commonly spoken of as "cans," are generally made of tin plate, although, for certain kind of foods, glass jars are sometimes used. The process is capable of very wide application, as all kinds of foods, except those eaten only in the raw condition, may be preserved in this way, and thus the abundance of one season or one locality may be made available at another place or time.

The general object of the process is apparent from the foregoing, but it may be stated that the main problem is to prevent decomposition or spoiling, changes induced in foods by the activity of various kinds of microörganisms which ferment or putrefy the foods, giving rise to products of harmful or undesirable character and rendering the food unfit for use.

From a sanitary point of view, canned foods, if properly prepared, are of the highest value, as they are free from bacteria. This fact, combined with their convenience and the ease with which they may be transported, has led to an enormous manufacture and consumption of these very satisfactory food products. In this article the canning of vegetable foods only will be considered.

Methods of sterilization.

Sterilization of the can and its contents is effected by one of the following methods: (1) water bath, (2) chemical bath, (3) steam under pressure in strong chests or kettles frequently called "retorts." Figs. 248 and 249 show sterilizing or cooking apparatus.

(1) The water bath. As its name implies, sterilization by this means consists in boiling the cans or jars for a single period or discontinuously, a

temperature of 100° Centigrade (212° F.) being thereby obtained.

(2) The chemical bath. This consists of a strong solution of some salt, generally calcium chlorid, because of its great solubility. The boiling point of the solution being much higher than that of water, higher temperatures may be reached by its use than with the ordinary water bath, and consequently a shorter time is required to bring about sterilization. This method was first employed in this country about 1863, but was not a success because the cans of that time were not strong enough to withstand the pressure generated within. The method of use is the same as with the water bath, i. e., the filled cans are boiled for a certain definite period.

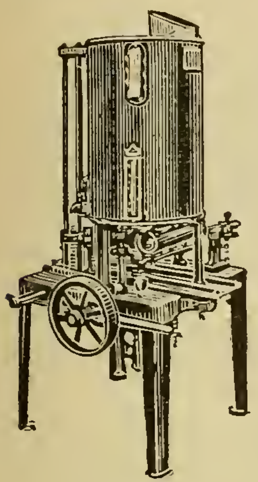

Fig. 248.
A commercial corn cooker.

(3) Steam under pressure. This method of sterilization was introduced about 1870. The temperature in this case may be varied by control of steam pressure. The steam being confined in the retorts, of course the pressure is equal within and without the cans; thus, unless the outside pressure is removed suddenly, the strain on the cans is not great and loss from bursting is small. Most of the modern cans, however, are sufficiently strong to withstand sudden changes without injury.

There are two modifications of the retort, known as the "wet retort" and the "dry retort." In the former, the kettle is filled with water and steam under pressure blown in, so that the boiling-point of the water is much raised owing to the increased pressure. These kettles are generally cylindrical and are placed in a vertical position, with a heavy lid on the upper end. When in use, this lid is fastened down by means of heavy bolts. The kettles are generally provided with three valves,—an intake valve for steam at the bottom, an outlet for water at the bottom and an exhaust valve for steam in the lid. Although spoken of as a "wet retort," it can be used without water in the same way as a "dry retort." In the "dry retort," the steam under pressure is blown in, directly replacing the air and coming directly into contact with the cans.

The Portland type of retort consists of a heavy iron chest, about cubical in shape. One side of the cube is the door, which is hinged and fastens by bolts. With the exception of the door the retort is cast all in one piece, the door forming a separate casting.

Both types of retorts are provided with thermometers and pressure gages. In the use of retorts of either kind it is essential that a current of steam under pressure be passed continuously, this "circulation" being effected by leaving the exhaust valve slightly open. The temperature may be kept constant by regulating the amount of steam entering the retort and the amount of the exhaust.

As already mentioned, this method is most efficient in its action on the resistant spores of bacteria, consequently is the safest method to employ in the preparation of canned goods. It is necessary, however, to avoid excessive heating, as damage to the foods may be done in this way. One result of over-cooking is to produce discoloration of the food substance, a defect which sometimes interferes with the commercial value of the article. Temperatures above 120° C. (248° F.) are rarely used, the best temperature for any material being determined directly by experiment.

In sterilization of canned foods, it is necessary that the whole contents of the can be subjected to the required temperature for a period of time long enough to destroy all germs whether spore-producing or not. This period of time can be determined accurately only by experimental tests. It is of equal importance to know the length of time necessary for the required heat to penetrate to the center of the cans, this time varying very much with different materials, owing to their different conductivity for heat. Liquids are, in general, good conductors, while solid or semi-solid substances conduct but poorly. Knowledge on this point is absolutely essential in order to prescribe a satisfactory process.

The vacuum.

It is customary in the preparation of canned foods to have a partial vacuum in each can, and

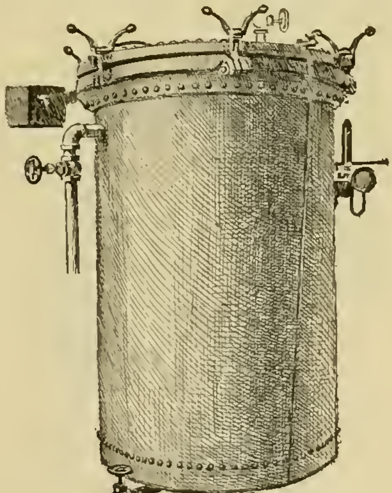

Fig. 249. Improved steel process kettle, manufactured to hold 800, 1,000 and 1,200 two-pound cans.

for many years it was thought that this vacuum was the principal factor in keeping the goods. While this is untrue, it is desirable to have the vacuum as it allows a means of inspection of the cans. The vacuum is indicated by the concavity of the ends of the cans and should always be present in sound cans. If, however, putrefaction or fermentative changes take place, in which gases are produced, the ends bulge out, owing to the pressure of the gas within, and so may be easily detected. Even in case no swelling of the cans takes place, skilful inspectors can distinguish between good and bad cans by the sound when the cans are struck on the ends. The vacuum is generally produced by filling the cans with the material in a hot condition and sealing them immediately. When water-bath sterilization is employed, the cans are sometimes unsealed or punched while hot and the steam allowed to escape, the aperture being closed again at once.

Principles involved in canning specific crops.

In the canning of fresh vegetables, the raw materials are substances high in their percentage of water and relatively high in carbohydrates, but relatively low in proteid matter. Because of differences in texture and composition, no hard and fast rules of procedure can be laid down. The details of the processes for various kinds of canned goods cannot be given here, but the general principles involved in the different classes may be mentioned.

In the preparation and preservation of all kinds of canned goods the necessity for cleanliness is evident, since the entire operation is one in which the aim is to prevent bacterial action. Although in the final process absolute sterilization is to be brought about, the length of time necessary to produce this end may be much shortened if care is

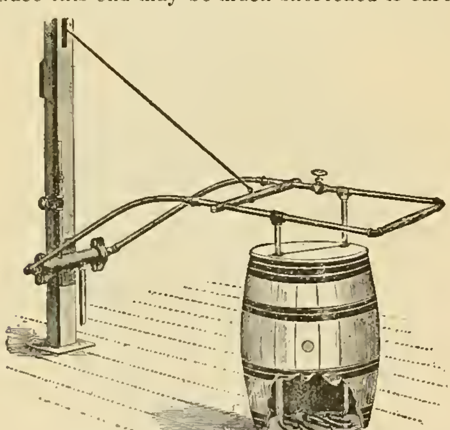

Fig. 250. A steam apple-butter cooker.

taken to exclude the organisms from external sources. Owing to the preponderance of carbohydrates, fermentations taking place are most likely to give rise to acids, lactic acid, probably, being the one most frequently found. Putrefactive fermentations sometimes occur, especially in those vegetables having considerable nitrogenous substances, as beans, peas and asparagus.

Asparagus is packed in large quantities in California and the middle Atlantic states. After placing the stems in the cans, a dilute salt solution is added in sufficient amount to fill the cans. Unless the freshly cut plant is used, a poor product is obtained, as, on standing, it rapidly becomes withered and tough. If not sufficiently "processed" it

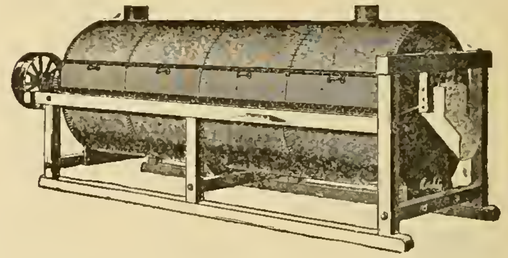

Fig. 251. Whirlpool blancher for use in canning factories.

undergoes fermentation, losing color and assuming a rather bitter, acid taste. If too highly heated, it is darkened and has an overcooked taste.

Peas.— In packing peas, the peas are first removed from the pods by a machine, either a "viner" or a "podder." In construction the "viner" consists of a large hollow cylinder, enclosing a wire cylinder, within which a paddle wheel revolves rapidly. The vines are fed in at one end of the cylinder, and as they are struck by the paddles the pods are burst open and the peas dislodged, the bruised vines being delivered at the other end of the cylinder. The peas and fragments of leaves, pods and the like, fall on a broad endless rubber belt which travels up an inclined plane, where separation by gravity takes place, the peas rolling down into a trough while the lighter impurities are carried away by the belt.

In the "podder" the mechanism is still simpler. Instead of passing the whole vines into the machine, the pods are picked off by hand and these are fed into the machine through a hopper. The removal of the peas from the pods is effected in the same way as in the viner, and the peas and pods delivered by chutes.

From a bacteriological point of view, the latter process is the more desirable, as it leaves the peas clean and dry, while in the case of the "viner" they become wet and sticky with the juice of the bruised vines, and consequently more or less contaminated with dirt and dust.

After grading, i. e., separation by sieves into peas of different sizes, and further removal of fragments and poor peas, washing and blanching or scalding takes place. In this process much of the adherent dust and other contamination is removed, and the peas pass to the "filler" where they are delivered into cans, then to the "briner," where a boiling hot solution of sugar and salt is added. The cans are then sealed and are ready for the final cooking process or sterilization. This is done by steam under pressure, the length of time being determined by the age and quality of the peas. The temperature and time given varies with different manufacturers, ranging from 230° to 240° for thirty to forty minutes.

The fermentations which are likely to take place in case of insufficient sterilization are numerous. There may be the formation of acids—lactic, acetic, and butyric particularly—with formation of gas; acid production (lactic) without gas formation; or putrefactive fermentation. The fermentations vary with the conditions and in many cases are due probably to mixed infection, thereby giving a large variety of products. These fermentations often take place rapidly, and are generally favored by a temperature of 35° to 40° C. (95° to 104° F.). These rapid actions are generally accompanied by evolution of gases, sometimes the pressure of the gases generated being sufficient to burst the cans. In other cases, the action is very slow and but a small amount of gas is produced.

The sweating of green peas when allowed to stand in boxes has been studied to some extent by Underwood and the writer. Rapid fermentation takes place with the formation of acids and a slimy layer envelops the peas. Because of this action, peas should never be allowed to stand over night or for any length of time before being sterilized. The bacteria causing these fermentations have been studied by Prescott and Underwood.

Beans.—The canning of green beans or string beans is done in much the same way as the canning of peas. Baked beans, however, being somewhat denser and more resistant to the penetration of heat, require somewhat longer cooking in order thoroughly to sterilize. They are generally packed together with pork or with the addition of some sauce, as tomato.

Sweet corn is canned in immense amount in the United States. The corn is cut from the cobs by a machine, mixed with water and a little "brine," and heated in a "cooker," in which it reaches a temperature of about 80° C. (176° F.). Sugar is added in small amount and the heated corn is filled into cans and sealed immediately. The sterilization is done by steam under pressure of thirteen to fifteen pounds, and the time required for sterilization varies with the consistency, percentage of

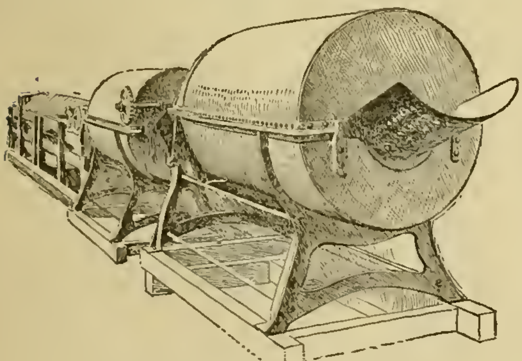

Fig. 252. Peach peelers for canning factory.

water, starch and the like, variations of fifty to seventy-five minutes being found in different factories. Sweet corn undergoes fermentative changes even more rapidly than do peas, because of its high percentage of sugar, and especially from the fact that the kernels are broken, thus allowing direct access of bacteria to the saccharine juices. Unless means were taken to prevent it, fermentation would take place in a short time. An extended study of this fermentation has been made by W. L. Underwood and the writer. Several species of bacteria were discovered in cans of "sour" corn, some of these being able to resist five hours' boiling without being destroyed. Further investigation showed the source of these germs to be

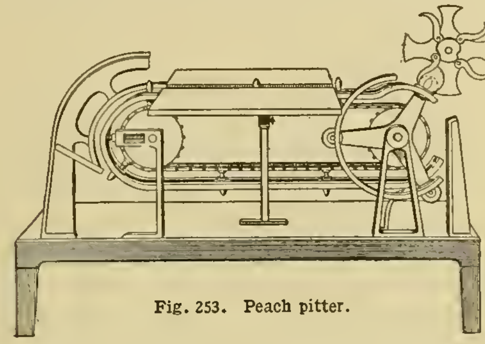

Fig. 253. Peach pitter.

the ears of corn. Bacteriological examination of healthy ears of fresh corn revealed the presence of germs on the kernels beneath the husks. These bacteria give characteristic reactions with nutrient media, and produce rapid fermentation of sugars, giving rise mainly to lactic acid, but also to forms of butyric and acetic acid. Sterilized sweet corn was converted in a few hours to a mass with strong acid reaction and sour taste. The most favorable temperature is 36° to 40° C.

The effect of the various steps in the canning process was also investigated. In the "cooker" many bacteria are destroyed, the more resistant ones, however, remaining uninjured. Two-pound cans which were given a heating at 120° C. (248° F.) for thirty minutes were found to contain living bacteria, and cans so treated frequently become much disturbed within a few days. On the other hand, if the heating process is continued for a sufficiently long time all bacteria are destroyed. The reason for the necessity of the long period of heating is the low conducting power for heat of the corn. Experiments made with maximum registering thermometers showed the time necessary for the temperature applied to record at the center of two-pound cans, as follows:

Temperature applied,—

	Temperature recorded			
Min. Time	235° F.	240° F.	245° F.	250° F.
40 . . .	226	233	234	237
45 . . .	227.8	234.5	236.5	240.5
50 . . .	229	236	239	244
55 . . .	231	237.4	241	247.5
60 . . .	233	239	243	250
65 . . .	235	240	245	250
70 . . .	235	240	245	250
75 . . .	235	240	245	250

This is strikingly confirmed in a practical way by the fact that souring, in many cases, is found only at the center of the cans, and in a majority of cases the fermentation probably begins at that point.

The use of mild antiseptics has also been of frequent occurrence in the packing of corn, the object being not only to prevent development of bacteria, but primarily to render the corn white in color. Excessive heating gives a slightly brownish coloration to the corn, which has been counteracted to some extent by the use of sodium sulfite and similar compounds. The use of antiseptics or bleachers of any kind is not free from objection, as, even if the amount is so small as to be uninjurious to health, the flavor of the article may be somewhat affected.

Tomatoes.—In the canning of tomatoes, the fruit is first scalded to make easier the removal of the skins. The peeled and properly prepared pulp is then put into the cans by means of a machine which may serve both as a preliminary heater and as a filler. The preliminary heating is of advantage as it saves time in the final heating or sterilization process. As with other vegetables, the cans are generally capped by use of a machine, when the canning operations are conducted on a large scale.

As tomatoes are more watery than corn, they may be more readily heated through and hence do not require so long a sterilization process. They are, however, extremely liable to fermentative changes if the heating is not thoroughly done.

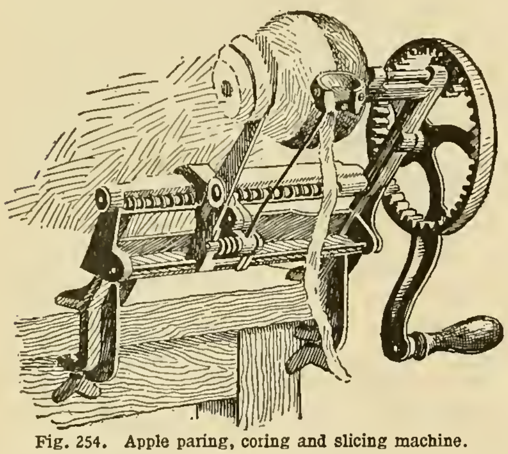

Fig. 254. Apple paring, coring and slicing machine.

Other kinds of vegetables are prepared in similar ways. It is essential to take into consideration only the physical character of the food and the changes it undergoes on heating to modify the process to suit an individual case.

Fruit-packing.

The packing of fruits is in general accompanied by less danger of spoilage than with vegetables, owing to the presence of natural acids and to the greater water content and resulting higher conductivity. As in the case of vegetables, specialized machinery has been devised for the carrying out of certain processes. A good example of this is in the peach peelers and pitters. Small stone-fruits are packed whole, i. e., without removal of the pits. A syrup of cane-sugar and water is added to supply liquid.

The sterilization may be carried out in retorts, or an open water bath may be employed, in which case the temperature does not get above 100° C. (212° F.). The spoiling of fruits is of a different character from that found in vegetables, as in the former case the sugar is most frequently fermented to alcohol and carbon dioxid. Trouble from this source is relatively rare, however.

Extent of the canning industry.

The canning of fruits and vegetables has shown an interesting tendency toward centralization in those localities especially adapted for the growth of special kinds of materials. Baltimore, the most eminent canning center, is perhaps an exception to this, as here are packed annually enormous amounts of pineapples as well as other southern fruits.

New York state lead, in 1899, in canning corn, apples and pears, and also packs large amounts of beans and peas. A second corn-canning area is found in Maine, the only one of importance in New England, and a third of greater extent in the central states of Iowa, Illinois and Indiana.

Tomato-packing is perhaps the most widely distributed of these special branches of the industry, and in this line Maryland stands in first place, followed by New Jersey, and then by Indiana, California and Delaware. The tomato may perhaps be regarded as the most typical canned fruit. In 1906, there were 9,074,965 cases of this fruit packed, aggregating over 200,000,000 cans of three pounds each.

The industry, as has been said, is one which has had a rapid growth in this country, and with care and strict adherence to making quality a first consideration, is bound to increase to still greater proportions. This fact is made evident by a study of the Census figures showing the increase from 1889 to 1899 in the five leading canning states for tomatoes and corn. The figures refer to the number of cases of twenty-four cans each :

TOMATOES.

	1899	1889
United States	8,905,833	2,942,440
Maryland	2,793,522	671,333
New Jersey	1,080,059	516,701
Indiana	878,791	194,150
California	796,080	234,020
Delaware	763,836	191,797

CORN.

	1899	1889
United States	6,365,967	1,726,096
New York	1,341,352	272,925
Illinois	1,082,196	200,750
Iowa	995,713	70,100
Maryland	852,859	400,104*
Maine	715,211	505,362†

* Including Virginia. † Including Vermont.

The pack (cases) of peas for 1899 was as follows in the five leading states :

United States	2,738,251
Maryland	758,431
New York	751,535
Wisconsin	490,296
Indiana	209,154
Delaware	101,038

In 1899, fourteen states packed 94.6 per cent of the tomatoes and 92.3 per cent of the corn for the United States. Maryland alone packed 31.4 per cent of the total pack of tomatoes, and Maryland, New Jersey and Indiana, 53.4 per cent. New York alone produced 21.1 per cent of the total can of corn, while New York, Illinois, Iowa, Maryland and Maine produced 78.3 per cent.

For further detailed statistics the reader is referred to the reports of the Bureau of the Census.

For Canada, in 1891, there were sixty establishments engaged in fruit and vegetable canning, with a total capital of $571,520, employing 2,304 persons, paying $523,151 for materials, and turning out a product valued at $929,778. In 1901, there were fifty-eight establishments, with a total capital of $2,004,915, employing 4,640 persons, paying $1,571,681 for materials, and turning out a product valued at $2,831,742.

HOME-MADE PICKLES AND KETCHUP

By *Anna Barrows*

There is but slight difference between acid fruits preserved with sugar and spice (spiced currants for example), and the sweet pickles in which vinegar is added to supply lack of acid in the fruit, or to make a preserve more acceptable to serve with meats.

The average proportion for sweet pickles is one-half pint of vinegar, one-half to one pound of sugar, one ounce of mixed spice, to two pounds of fruit. Because of the uncertain quality of ingredients this is subject to variation; some vinegar is so strong that it should be diluted with water; brown sugar is often preferred and sweet fruits require less sugar.

Vinegar is a product of bacterial action, but after the acetic acid, which is its most important principle, is formed, it protects anything placed in it from change. Thus it is used often for a temporary preservative of vegetables, such as pickled beets or turnips for salads. Cider vinegar is usually preferred. Spices are a further protection against ferments and mold. Vinegar has also the power of softening the cellulose of green vegetables, and thus renders some most unpromising substances acceptable as condimental food; the hard green cucumber and tomato, melon rind, string beans and the like, are thus made usable. It is a question whether, now when we can bring fresh fruit from all the world, we are wiser to retain some of these, or to discard them as we have the rose-haws, which our fore-mothers used to preserve.

Some of these materials keep better and lose objectionable flavor if they are first soaked in brine. Some are so hard that they should be stewed in weak vinegar before scalding in the syrup. Ripe fruits are oftener treated to intermittent sterilization. The ordinary sour pickles are prepared in the same general way, omitting the sugar. The green cucumbers, and the like, frequently are packed in salt as fast as they grow, and the final preparation with vinegar and spices is left until they are needed for use. Sauer kraut is cabbage prepared with salt, but not enough to prevent fermentation, so that there is some acid formed which softens the cellular tissues of the cabbage.

It is difficult to retain a fresh green color in pickles that have been long salted. It has been secured by scalding the pickles and vinegar in a brass kettle, but this is dangerous. Grape leaves, or others rich in chlorophyll, placed in the jar sometimes aid in producing the desired color.

To make pickles more crisp, old recipes often recommend the addition of one tablespoonful of powdered alum to the gallon. This may not be seriously harmful, but it may well be omitted. The best way is to make the pickles more quickly, so that color and crispness are not lost, instead of packing in dry salt which extracts their juice and makes it necessary to soak them for a long time to remove salt and restore water. Soak small cucumbers in salt water over night, then drain and pour hot spiced vinegar over them and leave for several weeks. The flavors of the different jars may be varied, onion in one, dill in another, and mixed spice in another. A horseradish leaf on top of a jar of pickles is thought to retard mold.

Ketchup and like preparations.

Ketchup, catchup, or catsup, is "a spiced condiment for meats" which is not mentioned in our earlier dictionaries. Yet it is probably of very ancient origin,—a form of the East Indian "kitjap" from which these names are evidently derived. Dr. William Kitchiner, in his "Cook's Oracle" published in 1838, gives recipes for mushroom, walnut and oyster "catchups." The cook-books give many formulas for appetizers of similar nature, many of them doubtless of similar origin: "India relish," "chowchow," "chutney," "picalilli," "chilli sauce," appear with many variations. These bear much the same relation to pickles that jams and marmalades bear to preserves; some are strained, others are not, but all are fluid.

Almost any fruit or vegetable pulp may be used as the basis for these preparations, and this is supplemented by additions of salt, sugar, vinegar and spices. Tomato is perhaps more generally used than any other foundation, but apples, gooseberries, grapes and plums may be prepared in the same way. Imperfect tomatoes and those not fully ripe may be used in this way to advantage. After cooking and straining, the seasonings are added to the ketchup, and then it is cooked down to a consistency as thick as will pour easily. The brilliant color which has been seen in some tomato ketchups is plainly artificial. Small bottles are best, since after opening, anything of this nature is liable to mold, unless it contains strong preservatives. Olive oil is sometimes used on top of fruit syrups and ketchups to keep out air. When the bottle is opened, the oil may be removed by a swab of cotton or soft paper.

EVAPORATING AS A HOME INDUSTRY IN EASTERN UNITED STATES

By *G. F. Warren*

In the past twenty-five years great progress has been made in each of the three methods of preserving fruit: drying or evaporating, canning or preserving, and extracting the juice. Canning for market has largely passed into the hands of firms that operate expensive canneries and make this their business. Evaporation has also passed through a period of great development from the old methods of drying in the sun. But while it has progressed to so great an extent, it still remains as a home industry in the East. Perhaps it is because the equipment of a good evaporator lies within the means of a farmer, while the equipment of a canning factory is very expensive. The Twelfth Census report gives the total product of evaporated fruit in 1899 as 144,-804,638 pounds. A large part of this represents the product of the farmers' home evaporators.

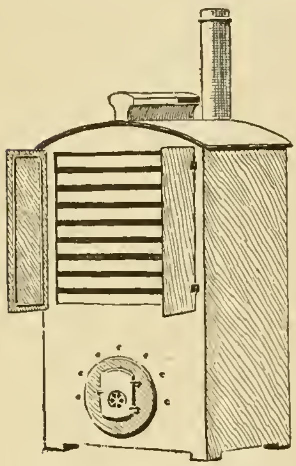

Fig. 255. A cabinet evaporator.

The evaporator furnishes a profitable outlet for fruit that is undesirable for market purposes. It not only makes such fruit a source of profit, but keeps it from the market where it would compete with good fruit and lower the price. In years of low prices, the entire crop can be evaporated and held for better prices. Not all of the fruit evaporated is of poor quality. In some regions, fruits are grown primarily for evaporation. In Wayne county, New York, nearly half of the apple-growers regularly evaporate all their crop or sell it to neighbors for that purpose.

Extent of the industry.

Apples, pears, raspberries, peaches, plums, cherries, quinces, huckleberries, currants, peas, corn, potatoes, pumpkins, and other crops are evaporated to some extent in the East. The apple-evaporating is by far the most important. The following table gives the average amounts of dried apples exported and shows the increase in these amounts:

Annual average	Pounds	Value	Price
1864–1870	1,067,920	$114,681	$0.107
1871–1880	4,632,460	289,986	.063
1881–1890	13,305,098	773,508	.058
1891–1900	19,368,301	1,088,104	.056
1901–1904	32,980,363	1,968,808	.059

The center of the apple-evaporating industry is Wayne county, New York. This county undoubtedly produces more evaporated apples than any state outside of New York, except perhaps California. In 1902, this county evaporated over 3,000,000 bushels of apples, producing about 20,000,000 pounds of dried stock. The average for the past five years (1900–05) has been about 15,000,000 pounds. Over 70 per cent of the total crop is evaporated. This evaporation is nearly all done by the farmers who grow the fruit or by their neighbors. The evaporators are almost as characteristic of the farms as are the barns in a dairy region. Evaporating is also done in the villages. The methods described in this article are founded on New York experience. (See page 165.)

Sun drying.

Until about 1870, sun drying, or drying over the kitchen stove, were the only methods used. Probably, the beginning of the evaporating industry was with the invention of the Lippy fruit-drier, in 1865. It was about fifteen years later before the evaporator largely replaced the sun-drying method. Many farmers still dry fruit in the sun, but in the East large quantities are not often so dried by one person. The sun-drying is ordinarily done on racks, made of lath placed about one-fourth inch apart and covered with cloth or paper, or made of thin lumber. Slices of apples are sometimes strung on strings and hung in the sun to dry.

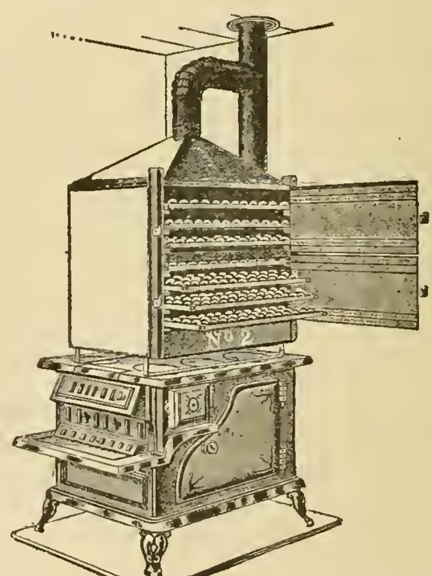

Fig. 256. Fruit evaporator adapted to kitchen stove.

Evaporation gives a much better looking product, that is more palatable and more digestible, and that consequently brings a much higher price. At the date of this writing (February 1906) the best quality of evaporated apples is quoted in New York City at eleven and one-half cents per pound, while the best sun-dried stock is quoted at seven cents.

The poorest grades are quoted at seven cents for evaporated and five cents for sun-dried. Other fruits show similar differences. Not only is the sun-dried product less valuable than the evaporated, but the process is slow and inconvenient. The fruit must be protected from showers and dew. In rainy weather, it is almost impossible to get it dry without having it damaged.

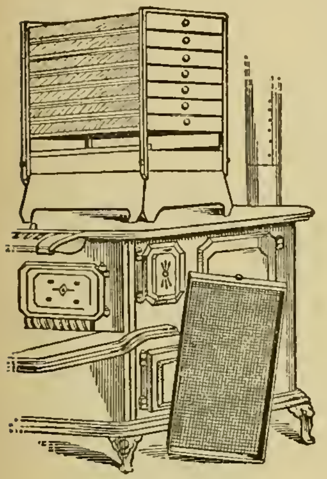

Fig. 257. A fruit drier set on an ordinary cook-stove.

Artificial evaporation.

In the process of evaporating, two distinct methods are followed: one, by means of air heated by stoves or furnaces and then made to circulate through the drying fruit; the other, an indirect system, by means of steam-pipes that pass through the evaporator. The latter system has not yet been generally employed, but it has many points in its favor and seems likely to replace the direct-heating system in large evaporators.

There are three general types of construction of the direct-heating system: the cabinet, the kiln, and the tower or flue.

Cabinet evaporators.— The cabinet evaporators usually consist of a series of drawers with screen bottoms, placed above a furnace or stove so that the hot air passes up through the fruit. Sometimes the floor under the lower screen is solid, with openings at the sides. The hot air strikes this floor, is divided into two currents that pass up on the sides, then over the fruit to the center of the evaporator and out at the top. Fig. 255 shows an evaporator of this type. In these evaporators, the fresh fruit is usually placed in the upper drawer. When that on the lower screen is sufficiently dried, it is removed and each screen is lowered one space, making room for a new screen in the top space. Usually there are two series of drawers carrying twenty to twenty-five screens, which are one to four feet square, according to the size of the evaporator.

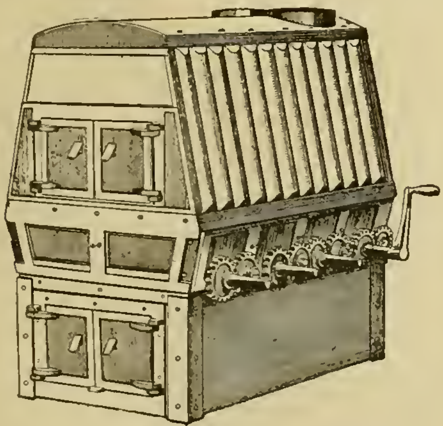

Fig. 258. Fruit evaporator and furnace.

There are many sizes and styles of these cabinet evaporators. Some are small enough to stand on the kitchen stove (Figs. 256, 257), cost three to five dollars, and have a capacity of one to four pecks per day. Fig. 258 shows one of a larger size, made of galvanized iron and provided with its own furnace. This has twenty 12 x 24-inch screens, and has a capacity of four to five bushels per day.

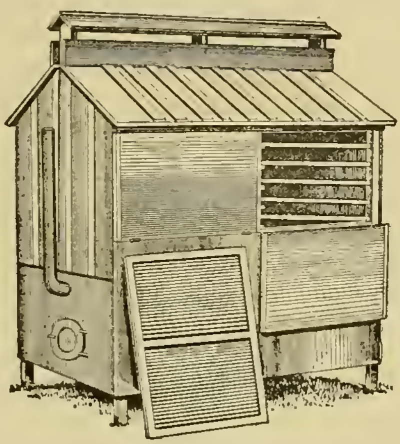

Fig. 259. A simple portable evaporator, provided with its own heater.

Larger evaporators constructed by farmers usually consist of a wooden building on a brick basement, in which the furnace or stove is placed. The stove pipe is carried around the basement so as to get the full benefit of the heat. These usually have two compartments, each of which has room for ten to twelve screens that are about four feet square.

Another form of cabinet evaporator sometimes used is made with doors at the front and at the back, and is much larger, so that there is room for six to ten screens on one plane. Each newly filled screen is put in at the highest level, and as it goes in it pushes the preceding one toward the back. When the first one reaches the back, it is put in the next lower level and started toward the front again. The screens are thus run back and forth till they come out at the lowest level when the fruit is sufficiently dried.

Because of their cheapness and simplicity, the cabinet evaporators are very popular with beginners and with small growers. The smaller ones are well adapted to evaporating for home nse.

Kiln evaporators.—The kiln evaporator is simply a room with a slatted floor, underneath which air-pipes or smoke-pipes from a stove or furnace are conducted. The buildings are usually constructed with double walls or with some other device for retaining the heat. The drying floor is placed about nine to twelve feet above the floor of the furnace room. It is made of slats of hard wood that are about one inch wide on top and one-half inch wide at the bottom, so that they have cracks one-eighth to one-fourth inch wide. The cracks are larger on the lower side, so as to prevent clogging. On such a floor, hops, apples, pears, raspberries, and the like are evaporated. Fig. 260 shows such a kiln filled with apples. This kiln is the common size in New York, 20 x 20 feet, and will evaporate one hundred bushels of apples per day, or more if run all night. In this evaporator, two men had charge of the furnace and of six kilns that were evaporating 400 bushels per day. Fig. 261 gives the outside view of a five-kiln evaporator of this type. It shows the ventilator at the ridge, where the hot air escapes after passing over the fruit.

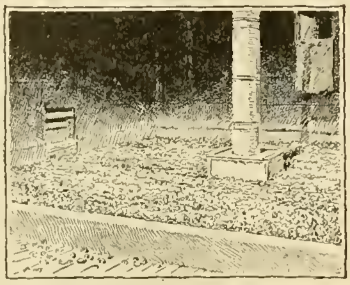

Fig. 260. A kiln of evaporating apples.

This system is open to the objection that the fruit must be shoveled over from time to time to insure uniform drying. If not skillfully done, some will be too dry while other parts will not be dry enough. The handling itself is likely to damage some fruits. However, a skilled man overcomes these objections. The system has some very decided advantages over the tower system. Kilns are cheaper to build, are less likely to take fire, and require much less labor to operate. In some neighborhoods the tower evaporators are now being replaced by the kiln system for evaporating apples.

Tower or flue evaporators.—The tower evaporators are the commonest ones in New York, where apple-evaporating has become such a great industry. They consist of a chimney-like structure of wood or brick extending from the basement of the building to a point higher than the roof. A stove or furnace in the basement furnishes hot air that passes through the tower.

Fig. 261. A five-kiln evaporator.

The tower is usually three to four feet square and is provided with an endless chain or other lifting device on which the screens may be placed. The screens of fresh apples are placed in the tower at the first floor. By means of the lifting device, the entire charge can be lifted by one operation, so that the screens gradually rise as more are added at the bottom. The screens of evaporated fruit are removed on the second floor. In some forms there is a double shaft, so arranged that the screens are carried up to the top and down again in the other side of the shaft, so that they may be removed on the first floor. It will be seen that in the former case the fresh fruit is placed directly in the hottest part of the shaft, so that the vapor and steam from this pass through the fruit that is partly dried, while in the cabinet evaporators it is placed in the coolest part and comes to the hottest part as the drying nears completion. There is some dispute as to which of these methods is the more desirable, but the latter seems to be so.

In Fig. 262 is shown an evaporator with three brick towers. Each of these towers has a capacity of twenty-five trays, each forty-nine inches square. Such a plant will evaporate about fifty bushels of apples or 1,600 quarts of raspberries per day for each tower.

Handling the crop.

If the entire crop of an orchard is to be evaporated, the apples are shaken from the trees. They are cored, pared and sliced by machinery. Before slicing, they are inspected by a "trimmer," who removes any remaining skin, core or decayed places. Before evaporating, the apples are placed in the fumes of burning sulfur for a few minutes for the purpose of bleaching.

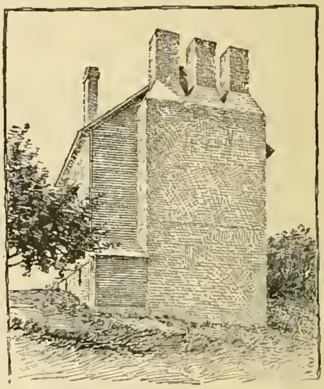

Fig. 262. Three-stack evaporator (coal-shed on left) in Wayne county, New York.

With a one-tower evaporator, fifty to sixty bushels can be evaporated in one day by one parer, two trimmers, one slicer, and one man to tend the evaporator,—five persons, four of whom may be women and children. If kilns and self-feeding slicers are used, the labor may be much reduced. The average cost per bushel of evaporating is eleven to fifteen cents. A bushel (50 pounds) of apples produces five to eight pounds of dried stock. The early apples produce less than the winter varieties. There is also much difference between different varieties of the same season. If properly dried, the average is six and one-fourth to seven pounds.

Apples that are not suitable for drying are chopped and evaporated without paring or coring, and are sold as "chops." The cores and skins are also dried, and are sold for the manufacture of jellies and wines.

Raspberry evaporating.

One of the other important evaporated fruits is the raspberry. Usually only the black varieties are dried. There is not much demand for red ones, and they are so tender as to require more careful handling and give less dried stock per quart. For evaporating, the berries are sometimes hand-picked and are sometimes "batted." In the latter method of harvesting, the picker carries a frame covered with cloth and so arranged that the berries that strike against it are caught at the bottom. The vines are pulled in with a hook and are hit with a bat, so that the berries fall into the box at the bottom. The process of evaporation is much like that for apples, except that no sulfur is needed, and that, if a kiln is used, the floor is usually covered with muslin cloth. It requires about three to four quarts (four to five pounds) of berries to give one pound of dried berries.

Literature.

Bulletin No. 100, Cornell Experiment Station, and Farmers' Bulletin No. 213, Department of Agriculture, discuss different types of evaporators in detail and describe the methods of raising and evaporating raspberries (Fig. 256 is adapted from the latter); Bulletins Nos. 226, 229 of the Cornell Station give statistics and some discussion of apple-evaporating in New York; Yearbook, United States Department of Agriculture, 1898, p. 309; Farmers' Bulletin No. 291, Evaporation of Apples, H. P. Gould, from which Fig. 259 is taken.

CHAPTER IX

JUICES AND LIQUORS

WITH THE PERFECTING OF MECHANICAL METHODS, and the consequent cost of installing apparatus, the manufacture of beverages has practically ceased to be a home industry, although cider is still sometimes made on the farm. The business of making juices and liquors is still very closely associated with land culture, however, inasmuch as the products are made from fresh and perishable materials that cannot be transported great distances or kept for any length of time. From being an incidental business, using only the cull or inferior fruit, these industries have now developed to such an extent as to take the entire product of whole farms, the crops being grown for the express purpose of supplying the manufactories. It is probable that the making of fruit juices of many kinds will very largely increase, affording a staple means of finding a market for large areas of crop produce.

The extent of this group of industries is already very large, as the following statistics indicate:

United States Census Figures for 1900.

	Pickles, preserves and sauces	Vinegar and cider
Number establishments	474	1,152
Capital	$10,656,854	$6,187,728
Number salaried officials, clerks, etc.	1,845	456
Salaries	$1,652,051	$391,541
Cost of materials	$12,422,432	$3,272,565
Value of products	$21,507,046	$6,454,524

Figures for Vinegar and Cider. (From Statistical Abstract.)

Census year	Number establishments	Capital	Wage-earners		Cost of material	Value of product
			Average number	Total wages		
1880	306	$2,151,766	1,257	$413,451	$1,888,173	$3,418,038
1890	694	5,858,395	2,637	720,681	3,268,455	6,649,300
1900	613	5,629,930	1,557	652,077	3,134,313	5,931,692
1905	568	7,519,853	1,528	725,148	3,852,233	7,265,469

The total number of wine-making establishments in the United States in 1900 was 359, of which by far the larger part (236) were small establishments owned by individuals rather than firms or incorporated companies. The total value of the product for that year was $6,547,310, of which $3,937,871 was the value of the California product. New York was second with a product valued at $942,548, and Ohio third with $801,684 ; New Jersey, North Carolina and Missouri follow in the order given. The gallons of Domestic Wines consumed (not including exports) are as follows for a series of years :

1900	26,242,492	1904	37,538,799
1901	24,008,380	1905	29,369,408
1902	44,743,815	1906	39,847,044
1903	32,634,293		

GRAPE AND OTHER FRUIT JUICES

By *A. M. Loomis*

Grape and other fruit juices have become, of recent years, articles of commercial importance; their manufacture is recognized as a noteworthy industry; and the sale of fruit for this purpose is of sufficient volume to be an influential factor in establishing the market price. Grape juice is now manufactured and sold as a beverage, for its nutritive and tonic value in sickness, and for its use for flavoring other foods and drinks. Other fruit juices are sold largely for their uses as flavors, particularly to the soda-fountain, baking and confectionary trades. The amount of grape juice made probably exceeds many times the amount of all other fruit juices, although of recent years there has appeared in the markets an unfermented apple juice and an unfermented orange juice in considerable quantities.

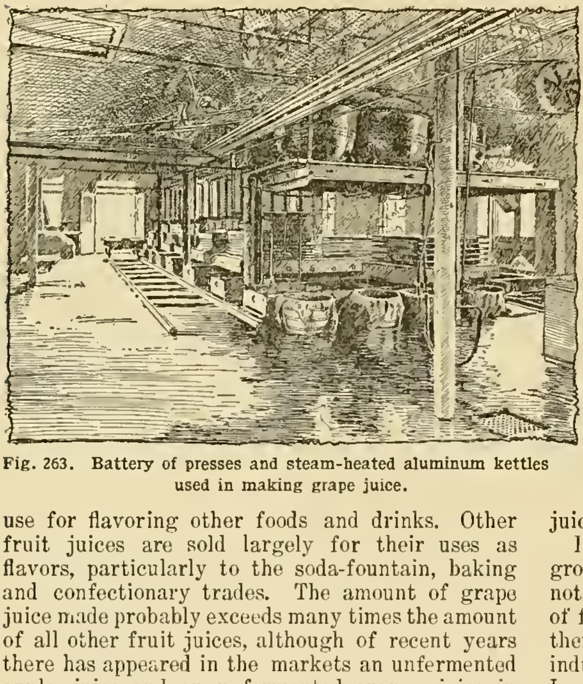

Fig. 263. Battery of presses and steam-heated aluminum kettles used in making grape juice.

Distribution and extent of the industry.

The greatest manufacture of fruit juices in the East is in New York state, and in the West in California. The manufacture of apple juice, properly so-called, being a different product from cider, in that it contains no product of fermentation and no alcoholic content, is being practiced in increasing measure in several sections, particularly in the western New York apple-belt and some other apple-growing sections. Orange juice is put up in California on a somewhat extensive scale.

The manufacture of grape juice grew up as a commercial enterprise entirely apart from the wine industry, contrary to the general impression that the wine industry is the parent of the grape-juice business. It can be said to have had its beginning at Vineland, N. J., with Dr. Thomas B. Welch. In 1869, Dr. Welch put up a few bottles of grape juice for use at the communion table of the Vineland church of which he was a member, and each succeeding year found a larger demand for his product. It was made in the kitchen of his own home. Sugar was used for preservation; but even in the earliest days it was seen that much sugar destroyed the more delicate flavors of the juice, and its use was gradually lessened until later methods of perfect sterilization make its use unnecessary with grapes of ordinary quality. When the vineyard interests of Vineland and the surrounding sections of New Jersey began to fail, the Welch business, then grown to fair-sized proportions, was moved to Chautauqua county, N. Y., and the factory of the Welch Grape Juice Company was established at Westfield.

Prior to the removal of Welch to Westfield, in about 1890, other persons, in a more or less experimental way, had begun to make grape juice in that section, and today there are several large factories other than the Welch factory located there. Notable among these experimenters was M. B. Gleason, of Ripley, who evolved a secret process. W. H. Bigelow, of Dunkirk, N. Y., was another pioneer, producing a staple unfermented juice by a secret process as early as 1892.

In other states, of recent years the industry has grown. In Ohio, there are two or three factories, notably the one at Sandusky, which gets its supply of fruit from the Kelley island group. In Michigan there are several factories, and in New Jersey the industry still exists on a small scale at Vineland. In Georgia there is a small grape-growing area, and the manufacture of unfermented juice is practiced. In California, since 1900, several factories have started, and one or two companies have been in the business for over twenty years. The extreme sweetness of the California grapes, which are of the European varieties and much different in flavor from those grown in the more northern climates, makes the juice from them very unlike that made and sold in the eastern factories.

The total production of unfermented grape juice for the year ended December 31, 1906, for the United States, is estimated at 1,000,000 to 1,200,000 gallons. Of this, the western New York section produced over 750,000 gallons.

Principles involved in making fruit juices.

The making of fruit juices is an outgrowth of the preserving industry. Preserving, as commonly known, is a process of saturating a fruit pulp during cooking, or a partial drying process, so thoroughly with common (cane) sugar that by the action of the sugar alone decay is prevented and the fruit held in palatable condition for months, even years. The art of canning is based on another principle, that of destroying by excessive heat the ferment-producing organisms, in which process sugar is often used to secure a palatable product, its preservative effects being a secondary consideration. The fruit juices sold for soda-fountain and flavoring purposes are thickened and preserved, in large measure, by the liberal use of cane-sugar, and are more in the nature of syrups than of fruit juices.

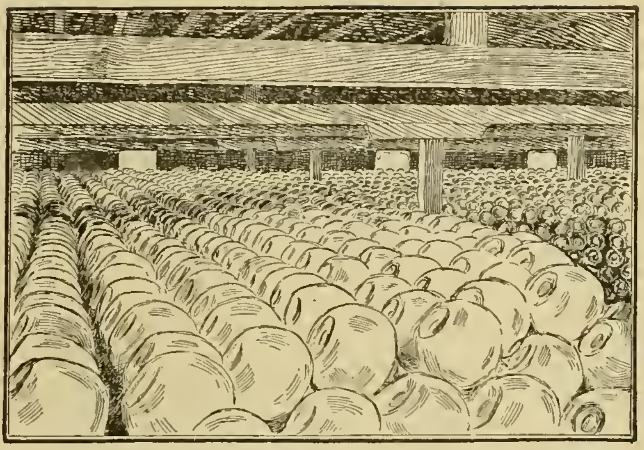

Fig. 265. Empty storage carboys for grape juice.

As might be inferred from the above, the first attempts to manufacture fruit juice products utilized a considerable quantity of sugar; so, today, many manufacturers are using sugar in larger or smaller quantities, and the home maker of grape juice usually finds it convenient and an insurance against "spoiling," which is but fermentation, also to use sugar in considerable quantity. Sugar does not destroy the basic flavor of the juice, and with some varieties of grapes, or even with the best grapes in cold wet seasons, when the sugar content of the juice is low, its use is essential to produce a palatable product; but with perfect sterilization this is entirely unnecessary, and its use has an effect on the medicinal value of the juice, and covers up and obliterates the more delicate flavors and aroma which are preserved by the more scientific and careful methods of manufacture without sugar.

The manufacture of grape juice, and also both apple juice and orange juice, as sold for beverages, is based on the principle of sterilization and perfect cleanliness, not preservation by sugar or otherwise. Grape juice, as marketed today, is an undiluted, unadulterated and unpreserved product. It is the pure juice of the grape, sterilized as it comes from the fruit, put up in sterile bottles, handled only in sterilized machinery, and sold to the consumer, still contained in sealed and sterilized smaller bottles. The ordinary housewife can duplicate this process in her own kitchen with very little trouble by the observance of the one rule, namely, perfect sterilization of everything that comes in contact with the juice, and the application of such a degree of heat to the fruit and the juice as will keep it perfectly sterilized at all stages of the process. The commercial product is allowed to stand in its first containing vessels, after being drawn from the presses, for at least three months to settle, and is then drawn away from the sediment, which formerly was thrown away but is now a valuable by-product. In the kitchen this settling must be provided for, if best results are to be secured. A second sterilization is necessary when the juice is changed from the settling vessel to the smaller bottles.

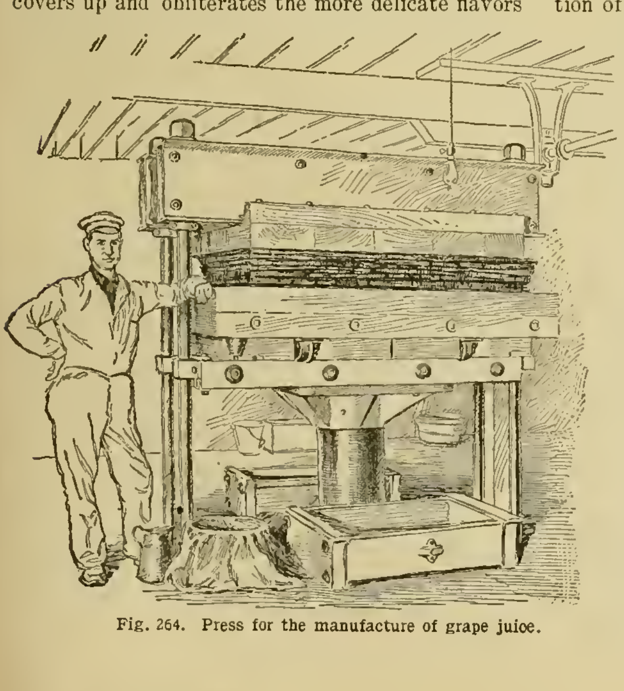

Fig. 264. Press for the manufacture of grape juice.

Details of the processes.

Fruit juices, other than grape and apple juice, are made by cooking fresh fruit, pressing it and adding sugar to the juice, and cooking or evaporating it down to a consistency of thick cream, in which condition preservation is not difficult. This product is used for flavoring in the manufacture of confectionary and baked goods, and as the flavoring part of the commonly sold soda-fountain beverages. Apple juice is made by pressing apples as for cider but using a better grade of apples, and following by an immediate sterilization and bottling of the product. The sterilization prevents fermentation and the product is a pure apple juice. Orange juice is put up in the same way.

The manufacture of grape juice begins with the picking of fully ripe grapes, of good quality. In vineyards that are free from rot, "run of vineyard" grapes are used, but they are allowed to remain on the vines and mature some weeks after picking for commercial purposes has begun in other vineyards. The grapes are taken to the factories in picking crates, holding forty to sixty pounds each, and taken by an elevator to an upper story and passed through a stemmer. The stems contain a large proportion of tannin, and if kept with the grapes will affect the flavor of the juice. After being stemmed, the grapes are placed in aluminum steam-heated kettles (Fig. 263), large enough to hold fifteen hundred to two thousand pounds each, and gently heated, not boiled. Care is taken at this point, as in every application of heat to the grape and its products, not to allow too high temperature. If the temperature at any time reaches the boiling point, a "burned taste" is caused. The color comes from the pigment cells of the skin, and can be varied by the amount of heat and pressure used. At the first heating, not more than 100° Fahr. is used. The seeds do not lose their vitality in this heating process. The minimum heat used in most factories in this stage is 80° Fahr., although what is known as the "light juice" is made in some factories by pressing before any heat is applied, thus leaving the pigment cells in the skin undisturbed. The heated mass of juice, pulp, seeds and skins is then placed in power presses, usually hydraulic, where it is subjected to great pressure. (Figs. 263, 264.) The juice again goes to the heating kettles, where it is heated to at least 180° Fahr., this being the lowest point of sterilization. Heating above this point spoils flavor, and it is the aim of the manufacturer to maintain a steady temperature at this point until the storage in the five-gallon carboys is completed and the juice sealed in these receptacles. (Figs. 265, 266.) Here it stands three months before being put into the smaller bottles for the wholesale and retail trade.

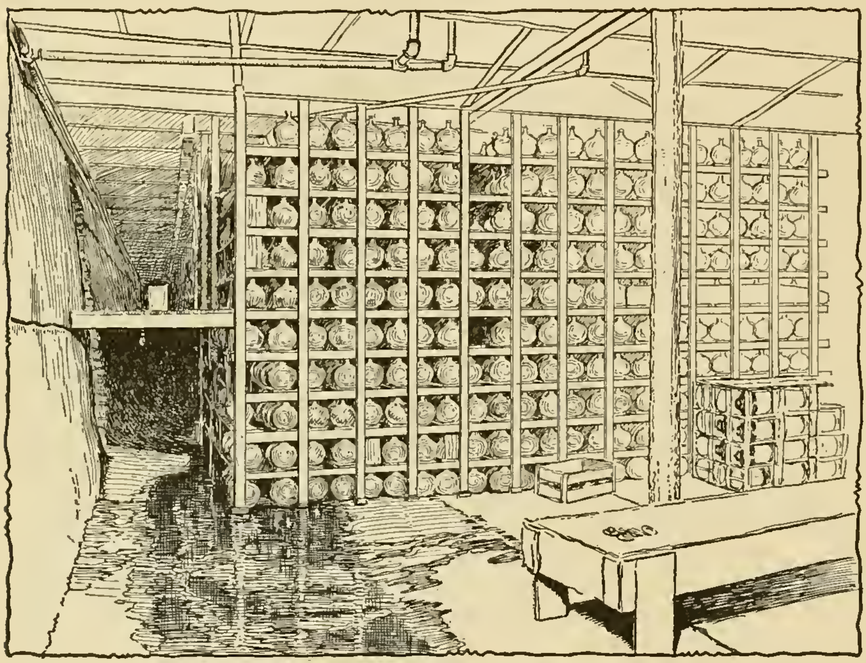

Fig. 266. Storage of grape juice in five-gallon carboys.

It is generally figured that eleven to thirteen pounds of grapes are used in making one gallon of unfermented grape juice. The amount varies with the season, the soil of the vineyard, the quality and ripeness of the grape and also with the variety.

By-products.

A sediment is deposited in the storage carboys. The juice is carefully decanted and the sediment dried out and sold. It is largely cream of tartar and is used for the preparation of the purified or commercial cream of tartar. The juice is resterilized, and rebottled in the pint, quart, or gallon bottle of commerce; it is then labeled, packed and shipped.

Pomace.—Another by-product is pomace, which has a fertilizer value but is more largely sold to distilleries, where from it is made a grape brandy containing a high grade of alcohol. The use of the pomace from which to make denatured alcohol is anticipated as an enterprise which legislation may make possible. This pomace is composed of the skins, pulp and seeds left after the juice is expressed.

Uses of grape juice.

The use of grape juice as a beverage is becoming very common, as the sale of 1,250,000 gallons during the current year will indicate. It has a very important use, also, in the hospital and sick room as a tonic and nutrient. There is every reason to expect greater popularity for it. The juice, subjected to chemical analysis, shows the following composition:

	In 100 parts, grape juice
Albuminoid and nitrogenous matters	1.7
Sugar, gum, etc.	18.05
Mineral substances	1.7
Water	75 to 80

The food value of the grape is greater than that of any other fruit in popular consumption. This superior nutrient quality is due to a larger content of sugar, gluten, mineral salts and fruit acids, together with a lesser quantity of water, than so great a content of nutrients generally affords, especially in the fruits. Grape-sugar (of the grape) is the chief nutritive constituent. The particular advantage which grape-sugar possesess over all other types of sugar is the ease of its assimilation. Grape-sugar, unlike other sugars, is naturally in the state to which all other carbohydrates must be reduced by preliminary digestion before they are ready to be absorbed by the system. This physical property rests on the fact that its constituent elements are in looser chemical combination, and therefore the greater part of the sugar passes into the circulation unchanged. The grape is unusually rich in albuminoids. It also contains a very fair percentage of vegetable fats.

Literature.

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WINE, CIDER AND VINEGAR

By *Samuel C. Prescott*

These beverages are prepared from the sugar-containing juices of fruits by means of the alcoholic fermentation produced by microörganisms known as yeasts. The fermented juice of grapes is known as "wine," while that produced from apples is "cider." Technically, they are very similar. Fermented pear juice is known as pear cider or "perry." The juices of certain fruits or vegetable bodies other than grapes may result in the formation of special kinds of so-called "wines," as "elder-blow wine," "rhubarb wine," and the like. These are produced, however, only on a very small domestic scale, and have no importance commercially.

The alcoholic fermentation.

The alcoholic fermentation, which is the basic process on which the preparation of cider and wine depends, is a chemical change induced in sugar solutions by the activity of a group of microörganisms technically known as the *Saccharomycetes*, and commonly spoken of as "yeasts." Of these there are a large number of species, but the ones of industrial importance, so far as their utilization is concerned, fall, in general, into two more or less distinct types. One of these, the *Saccharomyces cerevisiæ* type, includes the yeasts employed technically in brewing, fermentation preceding distillation, as in the manufacture of spirits and of whisky, and in the preparation of compressed yeasts or other yeasts for bakery or domestic purposes. The second type, the *Saccharomyces ellipsoideus*, is used in the fermentation of wine and cider, champagne, and in the fermentation for distillation of brandy. All these organisms are widespread in nature, the *Saccharomyces ellipsoideus* being found especially on the surfaces of ripe fruits and in the soil of orchards and vineyards.

The chemical change induced by these organisms consists in the breaking up of sugar into alcohol and carbon dioxid, the latter, a gaseous product, escaping for the most part, unless special effort is made to confine it or absorb it in the fermented liquid itself. Chemically, the change may be expressed by the equation

$$\underbrace{C_6H_{12}O_6}_{\text{Grape-sugar}} = \underbrace{2C_2H_5OH}_{\text{Alcohol}} + \underbrace{2CO_2}_{\text{Carbon dioxid}}$$

This equation, while expressing the change theoretically, is not absolutely exact, as small quantities of other products, generally called the by-products, are also formed. These include glycerin, succinic acid and traces of other acids and ethers.

Since the fruit juices in general contain considerable amounts of sugar, these are especially susceptible to the alcoholic fermentation, and require only that the organisms resident on the surfaces of the fruits be brought in contact with the juice in order that the change may take place. This is generally accomplished by crushing or grinding the fruits, and in this way the yeasts, together with other organisms which may also be present on the fruits, come into intimate contact with the sugary juice.

If the desired organisms are predominant, the fermentation is likely to proceed normally and give a good product. If, on the other hand, organisms of less desirable types gain the ascendency, the fermentation may result in a wine or cider which is bitter, turbid, or in other ways abnormal and unsatisfactory. This may be prevented in a great measure by introducing into the freshly expressed juice a pure culture of a desirable yeast, and thereby artificially making certain that the proper type of organism is in a suitable excess. The fermentation may thus be controlled in a way analogous to the control of brewing operations by the use of a pure culture of yeast.

The course of the fermentation is somewhat as follows: After the crushing of the fruit, pressure is applied and a juice, more or less colored, according to the kind of fruit, is obtained. In wine-making, this is known as the must; in cider-making, it is sweet cider. This juice may be nearly clear, or it may be rather turbid, and contains, besides the sugar, some acid, the natural acid of the fruit, ethers, salts and other soluble matters.

The alcoholic fermentation proceeds most rapidly at a temperature of about 25° to 26° C. (77–79° F.), or a few degrees above the ordinary temperature, and is retarded by cold and entirely prevented if the temperature is sufficiently high. With ordinary temperatures, the first twenty-four hours after the juice is expressed sees but little apparent change. During this period, however, the yeast cells are multiplying rapidly and the turbidity of the solution increases. Then a change, beginning slowly but increasing rapidly, takes place; small bubbles of gas rise to the surface, and flecks of foam are formed. Finally the solution seems to be undergoing a mild "working" or ebullition (hence the name fermentation, from *fervere*, to boil), and the fermentation is at its height.

The solution is now changed in taste as well as appearance. The sweetness largely gives place to a mild stinging taste as alcohol is formed. Gradually the "working" ceases, as the sugar is used up or the alcohol becomes sufficiently large in amount to inhibit further action by the yeast. The yeast settles to the bottom of the liquid and the fermentation, except for a slow change, the after-fermentation, which persists for several days after the active period of change, comes to a stop. The solution thus acted on cannot be further changed by the same organism, but may be again fermented by the acetic bacteria. [See *Vinegar*, p. 183.] Generally, not over 10 per cent of alcohol may be produced by yeast, and the ordinary ciders and wines contain less than this amount.

I. The Manufacture of Wine

The preparation of wine on a small scale has been practiced in this country since its settlement. It is, however, only about one hundred years ago that the first systematic attempt at grape-culture for wine-making was made in North America (except in California, which was not then a part of the United States). The first really successful attempt was made at Cincinnati, in 1825, by Nicholas Longworth, who planted a vineyard with cuttings of the Catawba grape, a native vine taking its name from the Catawba river in North Carolina. Owing to fungous diseases, the industry had to be abandoned at Cincinnati about 1865, but meantime it had been taken up in other parts of Ohio, and in New York and Missouri.

In California, wine-making has been conducted successfully for more than a hundred years. The introduction of foreign vines, which were not successfully cultivated elsewhere, was here immediately successful, and, from the first attempt to grow these vines at the Catholic missions in 1771, the industry has developed, until now California produces more than four times as much wine as all the remainder of the country combined.

The making of wine is a process requiring very great care and watchfulness. From the moment the juice is expressed until the product is ready for the market the wine must be treated with scrupulous care. After the expressing of the juice the first fermentation proceeds in vats or barrels, after which the wine is "racked" into bottles, where the finishing and the after-fermentation take place. Deep-seated chemical changes, resulting in the formation of ethers, or substances giving the pleasant aroma and flavor to wines, are brought about during this period, which may be of long duration. In most instances these changes proceed very slowly, so that wine must be several years old before it reaches the highest quality. Attempts have been made to imitate this aging, with its interaction of alcohol, acids and ethers, by the use of electricity and other agencies, but the naturally ripened product is unapproachable in real delicacy of flavor and aroma.

While the principle underlying the manufacture of wine is very simple and easily comprehended, the actual process is one which requires years of detailed study to master, owing to the effect which minute variations in the quality of the grapes, or in the environmental conditions, may exert.

Classification of wines.

Wines may be divided (1) according to color into red and white; (2) according to the amount of unchanged sugar left in them at the end of the fermentation process, into "sweet" and "dry"; (3) according to the presence or absence of carbon dioxid held in solution under pressure, into "sparkling" or "effervescing," and "still" wines.

Red wines are made from grapes with dark-colored skins. The skins are allowed to remain in the fermenting mass, and the alcohol as it is formed dissolves out the red coloring matter. White vines are usually made from light-colored grapes and the skins are carefully eliminated.

Sweet wines are those still containing a considerable amount of sugar after the fermentation is at an end, while on the other hand, those which are fermented out, or have the sugar exhausted in the final fermentation, are called "dry." It is thus possible to have red or white wines which may be either sweet or dry, still or sparkling, and the number of types or varieties is very large, including champagnes, clarets, Sauternes, Rhine wines, Burgundies, sherries, Madeiras and ports. Many of the kinds are named for the province or locality in which they originated.

Champagnes are effervescing wines, so called from the province in France where they were first manufactured. In addition to being made from the finest grapes, and fermented and handled with the greatest care, champagnes usually have added to them a *cuvée* made from sugar, water, cordials and the like (generally each maker has his secret formula), and subjected, in strong bottles, to a final fermentation in which the gas formed is absorbed under great pressure, so that on opening the bottle a marked effervescence results. They are classed as sweet, dry and extra dry.

Clarets are dry red wines, originating in the region of Bordeaux, while Sauternes are dry white wines. The Rhine wines are dry and usually white, although sometimes red. Sherries, named from Xeres, Spain, are "fortified" wines; that is, they have added to them some alcohol in excess of that produced by fermentation in order to prevent deterioration. This treatment is not uncommon with sweet wines.

II. Cider

The production of cider is fundamentally like that of wine, the fermentation being of the same character. Cider-making, however, is not so extensively a commercial enterprise as is wine-making. A certain amount of bottled cider, "champagne cider," and the like, is to be found in the market, however.

In cider-making, much depends on the character of the fruit used. Not all kinds of apples are equally well adapted to cider-making. Varieties like the russet and crab, which are apparently high in tannins, appear to be best adapted for this purpose. Many other varieties will produce excellent cider, however.

For the preparation of good cider, the fruit should be mature, clean and free from bruises or decayed spots. These spots always contain cells of molds which may exert an unfavorable influence on the fermentation or by their own fermentative action give rise to undesirable products. According to some authorities, the fruit should be allowed to remain on the trees as long as possible, and then piled up for a sufficient time to allow a sweating process to take place. This is supposed to cause uniformity and completeness of ripening.

The fruit is next ground or crushed and the pulp reduced to a fine state of division, in order that the cells may give up their burdens of saccharine juice. Pressure is then applied to this mass of pomace, as it is called, and the more or less colored sweet cider or juice is thus secured. The color depends to a great extent on the time during which the pulp is exposed to the air before pressing, as certain components of the fruit become oxidized through the agency of oxidase enzymes in the cells, and turn brownish in color.

The pressing was formerly, and in some parts of the country still is accomplished with alternating layers of pomace and straw to give firmness to the "cheese," and to allow a more ready exit for the juice. Racks for holding the pomace, and press cloths of a fairly coarse material are now more generally used, and are to be preferred, as the straw is likely to impart a musty taste to the cider.

After pressing out the sweet cider, it is generally allowed to undergo a spontaneous fermentation in a moderately cool place. In domestic operations the fermentation is carried out in barrels. After the first violent fermentation is over, the barrels may be tightly bunged and the slight secondary fermentation allowed to take place without further attention, except to keep the temperature fairly low. If the cider is to be bottled, it should be done after the primary fermentation is at an end, but before the secondary fermentation is complete, so that some of the carbon dioxid may be retained by the cider. "Champagne cider" is prepared in this way, with the addition of some brandy and more sugar, so that the secondary fermentation may be considerable in amount.

Apple juice generally contains 10 to 14 per cent of sugar. If less than 10 per cent is present, a cider with good keeping quality cannot generally be made, unless, of course, the cider be "fortified."

The cider should be protected from direct contact with air, otherwise acetic fermentation will take place and vinegar will result.

Sometimes for the preparation of specially fine cider, sugar and raisins are added, and the solntion clarified by isinglass or catechu, in order that the color may not be changed on exposure to air.

Cider, like wine, is subject to a number of troubles or "diseases" caused by invading or undesirable organisms, due oftentimes to poor fruit and uncleanly conditions. As in wine-making, to obtain a really excellent product requires good raw material and scrupulous care and attention to cleanliness.

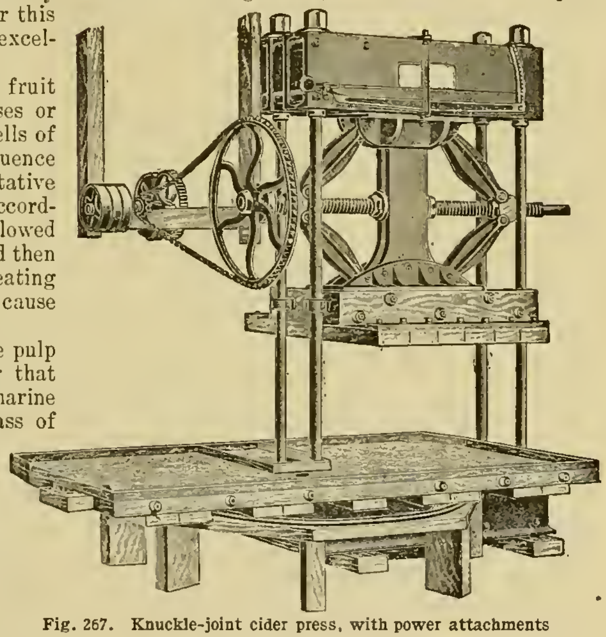

Fig. 267. Knuckle-joint cider press, with power attachments and reversible platform.

III. Vinegar

Vinegar as used as an article of food is the product of a process of fermentation in which a liquid of low alcoholic content is changed to a dilute solution of acetic acid, together with certain compounds which give a fruity ethereal odor or "bouquet." This substance has been known for a very long time, as is not strange when it is noted that the change goes on in nature, entirely without man's intervention, if the juices of sweet fruits are exposed to the activity of numerous microorganisms which are abundant in the soil and on the surfaces of the fruits themselves.

For certain uses, or when only the acidity characteristic of the acetic acid is desired, "vinegar essence," containing high percentages of acetic acid in a relatively pure state, may be made from certain kinds of wood by a process of distillation. Undoubtedly much of the cheaper grades of vinegar for table use has its origin in this way. It is cheaper than the production of the acetic acid by fermentation. By a proper admixture of ethers and flavor-giving bodies a solution may be made which simulates the product of the fermentation process, but never has the "bouquet" and the fine quality which characterizes the latter kind.

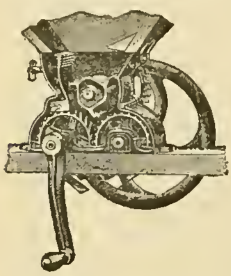
Fig. 268. The cutting or grinding mechanism of a cider mill.

Fermentation vinegar.

Fermentation vinegar, or that properly used as a condiment, may be prepared from numerous kinds of alcoholic solutions, but especially from cider, wine or beer, through the agency of a class of bacteria generally known as the acetic bacteria. These little organisms have the power, under proper conditions of temperature and aëration, of oxidizing the alcohol to acetic acid and water in accordance with the chemical equation

$$C_2H_5OH + O_2 = CH_3.COOH + H_2O$$

Probably an intermediate substance, aldehyde, is formed sometimes, although it is not certain that this is always the case.

In order to have this reaction proceed it is necessary to have (1) a lively and suitable micro-organism; (2) solutions of relatively weak alcohol, as the organisms are poisoned by amounts much over 10 per cent, and, indeed, will not work rapidly in solutions approaching this concentration; (3) an abundance of air; and (4) a well-regulated and favorable temperature.

The acetic group of bacteria comprises a number of species, perhaps twenty of which have been isolated and described, all characterized by their power of oxidizing alcohol to acetic acid almost in accordance with the chemical equation given above. They are also to be recognized by the fact that they require air for development and form large masses or scums of gelatinous character (zoöglœa), the so-called "mother of vinegar." The formation of these masses is progressive, and goes on so long as the food and other conditions remain suitable for the organisms. The cell wall of each individual swells to a large size and becomes practically fused with the cell wall of its neighbor, until huge masses of jelly-like consistency, and containing millions of bacterial cells, are produced.

The upper temperature limit of growth of the organisms is about 42° C., the lower limit about 5° to 6° C., while the action is manifested most strongly at about 34° C., a fact that is of great importance in the production of vinegar.

Methods of making vinegar.

Two distinct methods of vinegar manufacture have been developed. One of these is practically an imitation of what might be called the natural acetic fermentation, while the other is a fermentation carried out under forced draught. The former is generally called the French or Orleans method because it was and still is used in making vinegar from wine; while the latter is known as the "quick process" or the German process.

The custom prevailing among farmers in this country is, in many respects, similar to the Orleans method. It is well known that if a barrel of cider be freely opened so that air comes in intimate contact with the cider it "turns," especially if kept at a moderately warm temperature. The explanation of this is that the organisms, which were present in large numbers on the skins of the fruit, gain entrance to the cider, but so long as there is no free access of air they develop but slowly, if at all. Given access to air and a favorable temperature, they immediately begin the oxidation of the alcohol to acetic acid, and the cider turns slowly to vinegar.

In the Orleans method this process is varied somewhat. Vats or barrels having free access of air are filled about a quarter full of good vinegar. This supplies the "culture." An equal amount of wine is then added and the alcohol oxidized. At the end of a few days another quantity of wine is added and finally a third. The vat is now full, and after the oxidation of the alcohol has become essentially complete, three-quarters of the vinegar is removed and the process repeated over and over. By this method excellent vinegar may be made, but with considerable expenditure of time.

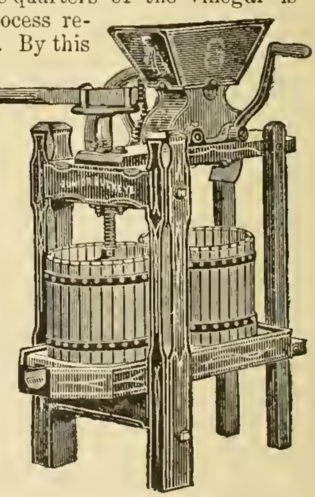
Fig. 269. Farm cider press.

The "quick process" is based on the facts previously noted,—namely, the rapid oxidation at the optimum temperature of 34° C. and necessity for large amount of air. In the "quick process" large tanks, technically known as "generators," are employed. These are in the form of truncated cones, six to twenty feet high, with a false bottom near the lower end and a perforated horizontal disk or false head near the upper end. The space between is filled with some substance which is without action on either solution or bacteria and which will supply a large amount of surface to the air. This surface is usually supplied by use of shavings, blocks of wood, cobs, strips of rattan, coal and the like.

The generator must first be charged or infected with the proper kind of bacteria. This is generally done by pouring through it a culture of some desirable species. The organisms are deposited on the surfaces of the substratum employed and devolpe their zoöglœa masses, so that the whole is covered with a layer of the slimy mother.

In the perforated disk or false head are a large number of small holes, each generally provided with a piece of wicking or string, down which the alcoholic solution can trickle and thus be brought, in a thin layer, in contact with the bacteria. The alcoholic solution is introduced into the space above the false head, either by a spout, tilting trough or "sparger," a set of revolving arms perforated with holes from which the alcoholic solution is forced into the top of the generator.

Below the false bottom is a row of holes through which air is admitted, and at the bottom a receptacle for the liquid which has passed through the generator. The oxidation of the alcohol within produces heat, and there is a constant updraught of air inside the generator from the holes below. Thus the solution which has been added is constantly coming in contact with fresh organisms and fresh air and oxidation is rapid. It is found practically that it requires about 1,000 liters of air to oxidize each 100 grams of alcohol.

Great care has to be taken with the heating as well as the ventilation of a vinegar factory. Since so much heat of oxidation is produced within the generators where the action is taking place, it is necessary to regulate the surrounding temperature so as not to get too high heat for the best bacterial activity. As the oxidation is usually not complete in a single generator, a vinegar factory is generally so arranged that the solution has to be pumped but once, and then flows by gravity from one generator to another until all the alcohol has been oxidized.

It is manifest that any substance which can be fermented to alcohol may be used as a starting point in vinegar-making. Thus, sugar, starch, and the like, may be used, but in such cases a preliminary alcoholic fermentation, by means of yeast, is necessary.

The product of the fermentation by the acetic bacteria, while mainly acetic acid and water, also contains acetal, aldehyde, and acetic and formic ethers, all of which combine to give the typical fruity refreshing odor and the characteristic taste.

The yield based on theory.

Knowing the alcoholic strength of the solution fermented, the chemist can easily calculate what the theoretical yield should be from the equation given. In practice it is found that the yield is about 80 to 90 per cent of the amount theoretically possible, and may even fall to 70 per cent.

The character of the organisms may be of importance here in addition to the other factors which have been indirectly suggested above (evaporation and insufficient oxidation). Some forms of acetic bacteria are so powerful in their oxidizing abilities that they even attack the acetic acid itself, oxidizing it to carbon dioxid and water.

Special vinegars.

Special kinds of vinegars are sometimes prepared, having peculiar or characteristic tastes and odors. These are generally due to the addition of essential oils of certain plants, or maceration of the plants themselves with some of the vinegar. Tarragon, anise or herb vinegar may be cited as belonging to this class.

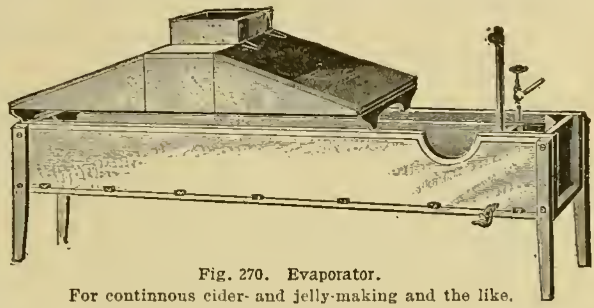

Fig. 270. Evaporator.
For continnous cider- and jelly-making and the like.

Home-making of cider vinegar.

The following instructions for making cider vinegar at home are from Bulletin No. 258 of the New York Agricultural Experiment Station (1904):

"Among the conditions which may produce vinegar below standard are these: (1) The juice may be poor to start with because made from varieties of apples low in sugar, from green apples or from overripe or decayed apples; or the juice may be watered either directly or by watering the pomace and pressing a second time. (2) The fermentation processes may be delayed or disturbed by using dirty fruit or unclean barrels, thus affording entrance to undesirable organisms and causing the wrong kind of fermentation; the temperature may be too low to insure the necessary activity of favorable organisms; or air may be excluded by filling the barrels too full or putting the bung in too tight so that the bacteria can not live and work. (3) The acetic acid may disappear after its formation, destructive fermentation being encouraged by leaving the bung-hole of the barrel open or the barrel only partially full.

"Briefly summarized, the method to be employed for the manufacture of good vinegar at home, without the use of generators, is this: Use sound, ripe apples, picked or picked up before they have become dirty, if possible, otherwise washed. Observe the ordinary precautions to secure cleanliness in grinding and pressing, and discard all juice from second pressings. If possible, let the juice stand in some large receptacle for a few days to settle, then draw off the clear portion into well-cleaned barrels which have been treated with steam or boiling water, filling them only two-thirds or three-fourths full. Leave the bung out, but put in a loose plug of cotton to decrease evaporation and to prevent the entrance of dirt. If these barrels are stored in ordinary cellars, where the temperature does not go below 50° or 45° Fahr., the alcoholic fermentation will be complete in about six months; but by having the storage room at a temperature of 65° or 70° the time can be considerably shortened, and the addition of Fleischmann's compressed yeast or its equivalent at the rate of one cake to five gallons of juice may reduce the time to three months or less. Use a little water thoroughly to disintegrate the yeast cake before adding it to the juice. The temperature should not go above 70° for any length of time, to avoid loss of the alcohol by evaporation.

"After the sugar has all disappeared from the juice, that is, when the cider has entirely ceased "working" as revealed by the absence of gas bubbles, draw off the clear portion of the cider, rinse out the barrel, replace the liquid and add two to four quarts of good vinegar containing some "mother" and place at a temperature of 65° to 75° Fahr. The acetic fermentation may be complete in three months or may take eighteen months, according to the conditions under which it is carried on; or if stored in cool cellars may take two years or more. If the alcoholic fermentation be carried on in the cool cellar and the barrel be then taken to a warmer place, as outdoors during the summer, the time of vinegar formation may be reduced from that given above to fifteen or eighteen months. Where the alcoholic fermentation is hastened by warm temperature, storage and the use of yeast and the acetic fermentation favored by warmth and a good vinegar "start," it is possible to produce good merchantable vinegar in casks in six to twelve months. When the acetic fermentation has gone far enough to produce 4.5 to 5 per cent of acetic acid, the barrels should be made as full as possible and tightly corked in order to prevent destructive changes and consequent deterioration of the vinegar."

Literature on cider and vinegar.

For cider, consult Bulletins Nos. 71 and 88, United States Department of Agriculture (Division of Chemistry); Bulletins Nos. 136, 143, 150, Virginia Experiment Station; J. M. Trowbridge, The Cider-makers' Handbook, New York, 1890; C. W. Radcliffe Cooke, A Book about Cider and Perry, London, 1898. An early American book was J. S. Buell's, The Cider-makers' Manual, Buffalo, N. Y., 1869. Brannt, Manufacture of Vinegar, etc., London.

For vinegar, consult Bulletins No. 258, A Study of the Chemistry of Home-made Cider Vinegar, and No. 258, popular edition, Making Cider Vinegar at Home, New York (State) Agricultural Experiment Station; Bulletin No. 22, Pennsylvania Department of Agriculture.

INDUSTRIAL ALCOHOL—DENATURED ALCOHOL

By *H. W. Wiley*

The term "denatured alcohol" is applied to alcohol intended to be used for industrial purposes, which is so treated as to render it unfit for use as a beverage. Pure alcohol is used extensively for mixing with other beverages, such as whisky, brandy and rum. It is much cheaper than any of these and can be used in large quantities without the consumer being aware of it. It is this particular use of alcohol which denaturing is intended to prevent.

In the manufacture of neutral spirits there is separated in the process of distillation 10 to 15 per cent of the total volume of the distillate which it is found impossible to purify so highly as to make it suitable for the mixing purposes above stated. It is, however, of a character which renders it easily prepared for drinking by those who are not particular respecting the kind of alcohol which they consume. In the trade this product is known as "alcohol," and is a lower grade of the more refined article known as neutral spirits. Heretofore this article has been sold for industrial purposes and for the preservation of specimens, subject to a tax of one dollar and ten cents on every proof gallon or about two dollars on every wine gallon of alcohol of 95 per cent strength. It is this product which it is proposed to use for industrial purposes under the existing law permitting its sale free from tax when sufficiently denatured as to be unsuitable for consumption.

Preparing denatured alcohol.

Industrial alcohol is derived from a number of sources. In this country it has been made chiefly from corn, in Germany it is made principally from potatoes; in France it is made chiefly from sugar-beets and beet-sugar and molasses. It may be made, however, from any material which contains sugar or starch, and nearly all plants contain both. Alcohol is also distilled from wood. Wood alcohol is an entirely different kind of alcohol, but is a real alcohol, the same in chemical classification as that derived from corn and sugar. For example, sawdust is treated with an acid under pressure which converts it into dextrose, and this dextrose is subsequently fermented, producing with proper distillation a pure ethyl alcohol.

The alcohol which is made for industrial purposes, after it is produced by fermentation of any of the substances mentioned, is separated by the processes of distillation and purifying and concentrated by the processes usually employed for making alcohol and neutral spirits. Under the Revenue Law, alcohol of this character may be denatured in bonded warehouses by adding to it such substances as are approved by the Commissioner of Internal Revenue. For general purposes alcohol is denatured by means of wood alcohol, or wood spirits, and benzine, which is one of the varieties of coal-oil products. The wood alcohol is added at the rate of ten gallons per hundred, and the benzine at the rate of one-half gallon per hundred. Wood alcohol may be used with pyridin bases in the following proportions: To each 100 gallons of alcohol of not less than 180 proof, two gallons of wood alcohol and one-half gallon of pyridin bases. Alcohol thus treated is said to be denatured for general purposes, suitable for burning in lamps to produce illumination, in stoves for heating and baking, in engines for driving automobiles, and in certain industries in the preparation of varnishes and veneers. There are many uses of an industrial character, however, to which alcohol treated in this way could not be put. The law, therefore, permits special denaturing agents for special purposes, and the Commissioner of Internal Revenue establishes, from time to time, special forms of denaturing.

As an example of special denaturing the method of treating alcohol for the manufacture of tobacco may be cited. To each one hundred gallons of alcohol there is added one gallon of the following solution: 12 gallons of an aqueous solution containing 40 per cent nicotine, $\frac{4}{10}$ pound acid yellow dye (fast yellow), $\frac{4}{10}$ pound tetrazo brilliant blue, and sufficient water to make 100 gallons. It is seen by the above regulation that alcohol to be used in the manufacture of tobacco is denatured principally with nicotine, which is a poisonous alkaloid naturally existing in tobacco. The addition of this nicotine in connection with the coloring matters is sufficient warning to the intending drinker that the material is not fit for consumption.

Alcohol can be denatured only in a Government bonded warehouse under the supervision of the Revenue officials, and when so denatured is marked under the supervision of the Revenue officials and can then be sent into commerce free of tax.

Economic uses of denatured alcohol.

Denatured alcohol, or industrial alcohol, is used extensively in the manufacture of coal-tar dyes, smokeless powder, varnishes, lacquers, ether, medicines and pharmaceutical preparations, imitation silk, artificial vinegar, flavoring extracts, and in many other industries. The present law does not permit the use of free alcohol, however, for making any medicinal preparations, and therefore it cannot be used free of tax in this country for making ether or any medicine or pharmaceutical preparation except in cases in which it is entirely eliminated before the material goes into use. In other countries it is used for these purposes tax free.

Many manufacturing industries in this country have been prevented from development because of the high tax on the industrial alcohol which they were compelled to use. For example, the manufacture of smokeless powder, except for Government use, has grown very slowly in the United States because such powder, made as it is usually with ether and alcohol, costs eighty cents to one dollar and twenty-five cents a pound when the tax on the alcohol must be paid. If tax-free alcohol could be used for making smokeless powder it probably could be made for thirty-five to forty cents a pound. At present prices of the material used in this country, viz., corn, the actual cost of a gallon of alcohol of 95 per cent strength is not much less than thirty cents. A gallon of such alcohol weighs, in round numbers, seven pounds, and requires fourteen pounds of starch or sugar for its production. A bushel of corn will make not to exceed two and one-half gallons of such alcohol. At forty cents a bushel it is seen that the raw material for the making of a gallon of alcohol would cost at least sixteen cents, that is, the starch in corn is worth a little over a cent a pound. The cost of manufacturing and packing for market is not much less than fourteen cents, making the total cost of each gallon thirty cents. In order that fair profits may be secured, a gallon of denatured alcohol cannot be sold at retail at much less than forty cents.

In order that the price be brought lower cheaper raw materials must be secured. Perhaps the most hopeful source is found in the refuse of the sugar factories and refineries. The molasses which comes from the manufacture of high-grade sugar usually contains so many impurities as not to be suitable for consumption. This alcohol can be had very cheap. About two and one-half gallons of it will make one gallon of industrial alcohol. At eight cents a gallon the material would cost just about as much as the quantity of corn necessary to make a gallon. As the sugar industry increases in this country and the processes of making sugar become more efficient, the molasses will be worth a less price and probably will furnish in the future a large part of the industrial alcohol required. The refuse of certain factories, such as those which can sweet corn, may also be utilized. The sandy fields of the south Atlantic coast may be made to produce large crops of sweet-potatoes and yams suitable for the manufacture of industrial alcohol.

At present it is seen that industrial alcohol cannot be used for many purposes in competition with gasoline. There are, however, many purposes for which industrial alcohol can be used, as in the manufacturing industries mentioned. The immediate future, therefore, will see a very large increase in the quantity of alcohol used in this country for certain manufacturing purposes, but will not see much of an increase of the use of alcohol for driving engines, automobiles and like purposes. One important use of denatured alcohol will be for illumination and for heating purposes in the household. For these purposes gasoline is altogether too dangerous and denatured alcohol will naturally take its place.

The law authorizing the denaturing of alcohol did not make any changes in the law relating to the manufacture of alcohol. It follows, therefore, that alcohol which is manufactured for industrial purposes must be made under exactly the same supervision of the Internal Revenue as attends the manufacture of alcoholic compounds for beverage purposes.

Literature.

Farmers' Bulletins No. 268, Industrial Alcohol: Sources and Manufacture, and No. 269, Industrial Alcohol: Uses and Statistics, United States Department of Agriculture, Washington, D. C.

BREWING

By *Samuel C. Prescott*

By the term brewing is generally comprehended the processes by which ale or beer is prepared from its raw materials. These processes are somewhat diversified in character, and as a result the brewing industry is one of exceptional interest to the biologist and chemist.

Briefly, we may define brewing as the series of chemical changes by which barley or other grain or saccharine materials are prepared, subjected to alcoholic fermentation by means of yeast, and made into a beverage of low or moderate alcoholic percentage. The brewing industry is dependent on two fundamental chemical changes: First, the transformation of starch to sugar by enzyme action, and second, the fermentation of the sugar thus formed.

The transformation of starch to sugar.

It has long been known that starch may be hydrolyzed or converted into sugar through the intervention of certain digestive or fermentative enzymes.

In the germination of seeds, as barley, which have a large amount of stored-up starch, a similar action takes place, and the starch is changed by the action of enzymes secreted by the living cells of the seed into a sugar, maltose, which by the action of yeast is "fermented."

Fermentation of sugars.

The alcoholic fermentation of sugars has been known and practiced for hundreds of years. Its true nature, and the exciting cause, and the character of the products were not thoroughly elucidated until within comparatively recent years. Many theories of alcoholic fermentation have been current, but it remained for Traube, in 1858, to suggest what appears to be the true explanation of fermentation. According to his theory, fermentation is brought about by the action of substances secreted within the cells (ferments or enzymes) which act in a way analogous to that of digestive ferments, but in this case transfer oxygen from one group of atoms to another, thereby causing a breaking up of a complex sugar into simpler substances. Strangely enough, this theory did not gain general credence and support, and it was not until the discovery of zymase in yeast, by Buchner, in 1897, that the accuracy of Traube's theory became evident.

Many species of yeast are known, but those of industrial importance belong especially to the two species, *Saccharomyces cerevisiæ* and *Saccharomyces ellipsoideus.* The former is the yeast employed in brewing, while the latter is the specific fermentation organism of wine.

The action of yeast on sugar may be expressed chemically by the equation:

$$\underset{\text{Sugar.}}{C_6H_{12}O_6} = \underset{\text{Carbon dioxid.}}{2CO_2} + \underset{\text{Alcohol.}}{2C_2H_5OH.}$$

Types of beer.

While the fundamental chemical changes indicated above are basic for the brewing industry, we may nevertheless recognize a number of types of the finished product as, for example:

(1) *The Munich or Bavarian type* of lager beer with dark color, malt flavor, and sweetish taste, not with pronounced aroma and flavor of hops, usually sparkling and lively, or bubbling with carbon dioxid gas.

(2) *The Pilsen or Bohemian type* of lager beer with light color, pronounced hop aroma and bitter taste, not particularly sweet, and also usually lively and sparkling.

(3) *The American type* of lager beer, brilliant, clear, lively and sparkling, light in color, pronounced hop aroma, but less bitter than Bohemian.

(4) *Ale*, with light color, very marked bitter taste and aroma of hops, and with rather high percentage of alcohol and tart taste in the aged product; may be either lively or still, generally clear.

(5) *Stout*, with very dark color, sweet taste and malt flavor, heavier than ale, but generally containing less alcohol; usually lively and with tart taste in aged product.

(6) *Weiss beer*, very light in color, no marked hop or malt flavor; pronouncedly tart and very lively, but generally turbid rather than brilliant.

(7) *Common or steam beer*, light in color, hop aroma and bitter taste, not very pronounced; very lively, but not necessarily brilliant.

Beers may be further classified according to the kind of fermentation employed in their production. Certain types of yeast, known as "bottom yeast," and causing "bottom fermentation," are employed in the preparation of the German lager beers and the American lager and steam beers. Ale, porter, stout and Weiss beer, on the contrary, are fermented by "top yeasts." Bottom fermentation differs from top fermentation in the temperature at which action takes place, the amount of acid formed, the amount of alcohol formed (generally) and in the behavior of the organisms, the bottom ferment developing especially in the depths of the liquid, while with top fermentation abundant masses of yeast are found at the surface of the solution. Certain differences in chemical and biological behavior have also been detected, but the organisms have been generally supposed to be of the same species (*S. cerevisiæ*). Of late, however, the question of species of yeast has been regarded with less certainty than in earlier years.

We may now follow through the actual processes comprehended in brewing.

(1) *Malting.*

This is the general name given to the process whereby the starch of barley or other grain is changed to maltose by the diastatic enzyme. The product is known as "malt." The grain is carefully selected and cleaned, and then is subjected to a steeping process in "steep tanks," or big iron cylindrical hoppers with conical bottoms. The object of steeping is to soften the outer coating and promote rapid germination. When the steeping has been sufficient, the grain is carried to the place where germination takes place.

Until comparatively recently, the malting took place on what are known as the growing floors or malting floors, large cement floors in rooms kept at the proper temperature and light regulation. Of late years, mechanical devices have been introduced so that most of the malting of today is done by the "box" system, although some use of revolving drums is made. In the box system, the malt after steeping is introduced into long box-like compartments with perforated floors, through which the properly warmed moist air passes. Traveling over and along these boxes are stirrer-like devices, which lift, stir, and aërate the grain. As the grain is kept at favorable and constant humidity and temperature, germination takes place rapidly and in the course of a few days the acrospire or germinating sprout of the grain is well developed, and the rootlets are apparent.

In drum malting, a much smaller amount of air is used than with the mechanical floors or boxes, and there is also more uniformity in the treatment, as the aëration, moistening, and the like can be regulated nicely by mechanical means. The "drum" consists of two concentric perforated cylinders with the grain in the space between. The drums revolve, thus keeping the grain in motion, and causing more perfect aëration, as the grain in all parts of the cylinder receives uniform treatment. When the green malt has reached the desired stage of growth, further change is prevented by quick drying or "kilning." The green malt is carried by conveyors to perforated floors below which are furnaces, so that heat to any desired degree may be applied. By the control of the two processes of malting and kilning, the malt may be prepared for the different kinds of beers indicated above. Of all the ingredients used in brewing no other one has so much importance as the malt, for the character of the beer depends very largely on it, beers of totally different character being possible because of the differences in chemical composition due to the varied malting processes. The color of the beer is determined largely by the heat applied in kilning; the chemical character by both malting and kilning. The product now obtained is known as malt, and presents the same general appearance as the grain itself, except that it may be much darker in color, owing to the roasting.

(2) *Preparation of the wort.*

The prepared malt is next to be made into a "mash," from which the "wort" is obtained. The malt is ground and mixed with warm water in the proper proportion, and then heated in a kettle or "mash tub," provided with a stirrer. This process not only dissolves the maltose and the soluble proteids already produced in the grain during the malting period, but it also brings about further conversion of starch to maltose, malto-dextrins, and dextrin and liberates some of the enzymes, which are developed in germination to a greater amount than the starch-content of the grain demands. It is therefore possible to introduce still more starchy material in the form of corn-flakes and the like, which the excess of diastase may convert into fermentable sugar.

The taps are then opened and the liquid part, now known as the "wort," is allowed to run off; the spent grain is washed or "sparged" by sprinkling with hot water several times.

The wort is next boiled with the addition of hops. The hops give a bitter flavor to the beer and aid in its preservation; moreover, the hop-oil and tannins seem to assist materially in the precipitation of some of the proteid matter. The whole process of boiling might be regarded as having several results, e. g., destruction of diastase, precipitation of the proteids, concentration, extraction of hop-oil and hop resin, and sterilization.

After settling, the wort is again drawn off and the residue sparged. The hot wort is then cooled by passing over a large Baudelot cooler, or "beer-fall," consisting of a series of copper pipes through which cold water or a solution from a refrigerating machine passes. The cooling is accompanied by aëration, which is very desirable; but great care should be taken at this point to prevent infection by bacteria and other microörganisms from the air. Special devices to prevent this are in use in the most scientific breweries.

(3) *Fermentation.*

After proper cooling and aërating, the fresh wort is ready to pass to the fermenting tuns, and is inoculated with yeast or "pitched." In case pure cultures of yeast are not maintained for fermenting, the yeast is frequently added to the wort in the pan at the base of the Baudelot cooler, and the whole mixed mass run through pipes to the fermenting room. When special pure cultures are employed, a "pure culture apparatus" is necessary. In this the yeast is developed, starting from a single cell, until sufficient has been prepared to "pitch" the whole volume of wort.

As has already been stated, the top fermentation is employed for ale, stout, porter, and Weiss beer, and the bottom fermentation for lager and American steam beer. Bottom fermentation proceeds at temperatures ranging from 42° to 51° Fahr., top fermentation at 57° to 73° Fahr. The control of temperatures in the fermenting cellar is therefore a matter of importance. The bottom fermentation proceeds somewhat the more slowly, requiring eight to fifteen or sixteen days, while top fermentation is finished in a few days.

Fermentation may be regarded as occurring in two distinct stages:

(1) The "primary" or "principal" fermentation, in which the maltose is especially acted on at temperatures of 42° to 51° Fahr., for bottom yeasts, and 57° to 73° Fahr., for top yeasts.

(2) The "secondary" or "after-fermentation," in which the malto-dextrin is transformed by bottom yeasts at 34° to 37° Fahr., and by top yeasts at about 55° Fahr. The yeasts used should in either case be freshly developed, free from contaminating organisms, and in actively growing condition. The amount added depends on a number of conditions, so that the experienced brewer uses his judgment rather than a definite rule.

The fermenting tuns are generally large wooden tanks (50-barrel capacity) in the form of a truncated cone, open at the top, and provided with a coil of pipe in the bottom to regulate temperature.

Bottom-fermentation beers.— In lager-beer making, after the tanks are filled with the freshly aërated, pitched wort, the fermentation sets in slowly at first. Within fifteen to twenty-four hours, small bubbles of gas appear around the the walls of the tank, and the whole surface is soon after covered with a fine white foam or froth. This gradually increases in amount, but remains thickest at the walls of the tank. When the foam becomes a certain depth, owing to the active fermentation, a breaking up into rounded masses is seen, and a general movement from the walls toward the middle of the tank. This is known as the "Kraüsen" or "cauliflower" stage, from the resemblance of the masses of foam to heads of cauliflower. Two stages of "Kraüsen" are recognized — "young Kraüsen" and "high Kraüsen."

As a large amount of heat is developed by fermentation, it is necessary to keep the solution during this period down to about 50° Fahr. by means of the attemperators, and, as soon as the fermentation slackens in activity, the temperature is brought to 39° to 40° Fahr.

The whole period of fermentation is of eight to sixteen days' duration. During this time, the color of the beer deepens, and the suspended yeast and other materials should collect in little flecks, leaving the beer perfectly clear. A large amount of yeast is developed during fermentation, as the sugar is transformed to alcohol and carbon dioxid. The carbon dioxid escapes as gas, displacing the air over the fermenting liquid in the vats. About one-fifth of one per cent remains in solution.

The amount of solids in solution is determined by an instrument known as a saccharometer. As fermentation proceeds the readings become less and less, showing the "attenuation" of the beer.

When the principal fermentation is at an end, the beer is practically ready for the storage vats, where it undergoes the secondary fermentation. During the primary fermentation the sugar is not all destroyed, and this residue of maltose and some of the malto-dextrin are now slowly acted on by the yeast, and eventually become very clear. The duration of storage depends on the destiny of the beer; if for present use, a quick treatment with clarification is employed; if for export, a storage period varying from six weeks to three months follows.

(4) *Finishing.*

The beer finally undergoes a finishing process in the "chip cellar." The objects here are: (1) to produce a lively, that is, well-carbonated beer, either by adding "Kraüsen" or by carborating or both, and (2) to produce brilliancy, which is done by clarifying with isinglass or "chips," or by filtration. "Chips" are small pieces of wood, which expose a large surface to the beer and to which suspended matters readily adhere.

The process of clarification by the use of chips or isinglass is known as "fining." After fining, the casks containing the beer are tightly bunged so that the solution may become charged with carbon-dioxid and promote sedimentation of suspended material left in the beer. After the proper period for bringing about the desired results, the beer is "racked," that is, run off into the barrels or kegs, in which it goes to the trade.

Clarification by filtration is now much used. This process consists in forcing the beer under pressure through layers of wood-pulp, by which means the suspended matters are mechanically removed. The composition of a finished beer is obviously dependent on the amount of raw materials used. and the method of treatment employed. The amount of alcohol in ordinary beers varies from about 3.2 to about 4.5 per cent.

Top-fermentation beers.

Top-fermentation beers or "ale" differ from those previously mentioned in the method of treatment, although in the main the equipment of the brewery is essentially the same. A carbonating room may take the place of the chip cellar.

In the preparation of present-use ales, about 70 per cent of malt and 30 per cent of unmalted grain is used (or 75 per cent malt and 25 per cent sugar). The mashing is carried out until conversion of the starch is complete, when the solution is bailed, the hops being added and run into the fermenting tanks. Here the phenomenon differentiating ale fermentation from beer fermentation takes place After being pitched with the requisite amount o' yeast,— the temperature being not far from 60f Fahr.,— bubbles of carbon dioxid begin to rise to the surface in two to three hours. In two or three hours more the froth appears on the surface around the sides of the tank, and soon covers the whole surface. The "cauliflower stage" is reached and is followed by the "rocky head stage." Great masses or heads of foam are developed until they may attain a height of three or four feet above the surface of the wort, owing to the violent ebullition. The frothy appearance gives place to the more compact "yeasty head," which consists of masses of yeast carried up by the gas and accumulating at the surface.

About forty-eight hours after pitching, the yeast is in such amount that it is skimmed off, or removed, and this process is repeated from time to time, until the practical judgment of the brewer determines when to stop. After the active fermentation is over, the ale is allowed to settle for two days, when it is filled into the trade barrels, and to it is added 10 per cent of Kraüsen, taken thirty-six hours after pitching.

For brilliant ales the treatment is nearly the same, but, in general, great care is taken in fining and the solution is carbonated.

Ales contain more alcohol than lager beers, while the amount of extract may be variable. The average of several samples of stock ale analyzed by Wahl and Henius gave 55 per cent. Cream and sparkling ales contain less alcohol, ranging from 4.0 to 4.90 per cent. Analyses of many samples show that American ales are less alcoholic than the English products.

PART III

NORTH AMERICAN FIELD CROPS

Having now obtained a general view of some of the primary considerations involved in the growing and handling of all crops, we may proceed to specific discussions of the different kinds of crops. In this work we are to confine ourselves to field crops, or those that are considered to be a part of general farm practice. In doing so, we distinguish these crops from the horticultural crops. This distinction is customary rather than logical; but it has special justification in this instance because the horticultural crops are treated in the Editor's Cyclopedia of American Horticulture. Certain of the horticultural crop groups are grown under general field conditions, however; and in order to give the present work some further degree of completeness, particularly with reference to farm management questions, comprehensive articles are inserted on Fruit-growing, Nurseries and Truck-growing.

Agronomy.

The classification of agricultural ideas has gone farther in the colleges of agriculture than elsewhere. The curriculum of the modern college presents such a dividing of the subject as would have been considered impossible a quarter-century ago. This dividing of the field and rearranging of the groups will proceed. The old professorship of agriculture is breaking up into component or separable parts, each part in charge of a specialist. One of these parts is agronomy. This is a new word to common speech. Its literal equivalent is "the law of the fields." The group of subjects comprised in agronomy is not yet clearly defined, nor is the group homogeneous. Animal husbandry, dairy industry, agricultural engineering and machinery are distinguished from it. It signifies, practically, field crops and their management. Horticulture and forestry are also distinguished, for practical rather than for rational reasons. It comprises all such questions as crop management, rotations and the cultivation of field crops. This Volume II is practically a treatise on agronomy, together with some questions of technology (in Part II) that properly lie outside its scope.

Phytotechny.

All knowledge, practice and industries concerned in the raising of animals have been included, in recent discussions, under the one word zoötechny (from two Greek words meaning *animal* and *art* or *handicraft*). Similarly, the knowledge, practice and industries concerned in the growing of plants have very recently been designated by the new word phytotechny (*phyton*, Greek for plant). This word is practically equivalent to the phrase "Plant Industry," as applied to a bureau in the United States Department of Agriculture. It includes agronomy, horticulture, forestry, and any other knowledge directly associated with the rearing of plants.

Crop-growing advice.

Perhaps no agricultural writing needs to be more carefully read than that giving advice on the growing of the different crops. In the first place, the reader must recognize the fact that bits of advice which are so small and apparently unimportant as to be overlooked may be the very ones that determine success or failure in a given crop. Yet, in the second place, too much blind reliance on these very points may be disastrous in certain years or under peculiar conditions. The reader, if he intends practicing what he reads, must have some groundwork or background of experience or reason, whereby he is to test all things. Again, allowance must always be made for the local color of the writing. Farming is a local business. One's experience is usually acquired in one locality, or in localities that are similar: he is likely to have this locality chiefly in mind in his writing. Still again, it makes a difference whether the writer or the reader is thinking of small-area or large-area enterprises. There is a tendency for the large-area man, or the man who lives in one of the great homogeneous agricultural regions, to think that his farming establishes the norm by which all other farming shall be judged. The best individual farming is not necessarily to be found in the so-called best farming regions; but it is easier and safer to generalize from the large-area regions.

These remarks suggest the proper purpose or value of a book on agriculture: such a book is valuable for its suggestion and its guidance rather than for its dictum. The failure of the old-time "book farming" was quite as much the fault of the reader as of the book. The reader who has called himself the "practical farmer" has usually wanted recipes. If one were writing a book for a single township, he probably could give something like positive directions. The writers in these volumes have given their best information and advice; but beyond that point they cannot assume responsibility.

In this volume the special crop articles state the Latin name of the species of plants involved, with synonymous or equivalent names immediately following in parentheses. The name of the natural family follows: this indicates the plant's relationships. The abbreviated words following the Latin binomials indicate the author of the binomial: Linn., signifies Linnæus; Willd., Willdenow; Trin., Trinius; DC., De Candolle, the elder; ADC., Alphonse De Candolle. These and others are authors who originally described the plants or who gave them their proper places and standing in the classification of human knowledge. The botanical history of many of the plants is traced more fully in the other Cyclopedia. These technical records suggest to the student sources of information and means of tracing records and origins; and for the general reader they will not lessen the value of the advice that follows them.

So far as practicable, the subjects are arranged here in alphabetical order. In some cases whole crop groups are treated together, and in other cases only single species are so handled. This may lead to some confusion as to the place in which a given plant is discussed, but the index will set the reader right. As much space has been given to each subject as seemed to be necessary to present it adequately; therefore, the lengths of the articles may bear little relation to the economic importance of the crops they discuss.

Literature.

References to the literature of agronomical knowledge will be found in many appropriate places in the first two volumes of this Cyclopedia. The writings on special crops or crop groups are mentioned under those crops in the pages that follow. Some of the general American crop literature in book form may be recorded here: Johnson, How Crops Grow and How Crops Feed, two notable and standard works (the former went to a revised edition in 1890); Morrow and Hunt, Soils and Crops of the Farm; Hunt, The Cereals in America; Saunders, The Leading Cereal Crops in Canada (Report Experimental Farms, 1903); Brooks, Agriculture (Vol. II); Wilcox and Smith, Farmer's Cyclopedia of Agriculture. Several recent text-books of agriculture give brief discussions on the growing of various crops. The reader should keep himself in touch with current discussions and progress by means of the agricultural press and the various kinds of government publications.

ALFALFA or **LUCERNE.** *Medicago sativa*, Linn. *Leguminosæ*. Figs. 271–282.

By *J. M. Westgate.*

A deep-rooted, long-lived, perennial forage plant. Stems 1 to 4 feet high, numerous from a crown; leaves numerous, pinnate; leaflets 3, obovate-oblong, prominently toothed near apex; flowers purple, rarely white, clover-shaped, in oblong, compact racemes (Fig. 271); stamens 10, united into a tube around the single pistil, one of them on the upper side partly free; pods slightly pubescent, coiled in 2 or 3 spirals (Fig. 273); seeds several, kidney-shaped, one-twelfth inch long. Alfalfa is a staple forage plant of the agricultural districts of southern Europe, southwestern Asia, South America and western United States. It is native to southwestern Asia, and was in use centuries before the Christian era. It spread successively from Media (Persia), to Greece (Persian War, about 480 B.C.), Italy (first century A.D.), Spain (Saracean Invasion, eighth century A.D.), Mexico and South America (Spanish Invasion, sixteenth century).

Alfalfa was introduced into California from Chile (1854) and has spread over the irrigated regions of the West. It came from Mexico to Texas in the early part of the nineteenth century. Its production has been extended more recently to the non-irrigated parts of the Great Plains region. It was introduced into New York from Europe as early as 1791. Its culture in the East has been confined to comparatively limited areas. Several sections of the South are proving to be adapted to its growth. It has been grown, experimentally

Plate V. Alfalfa at the blooming stage.

at least, in all parts of the United States, and is competing with red clover in certain sections of the East, especially on well-drained calcareous soils. It is the principal forage plant of the United States west of Iowa and Missouri. In 1899 the acreage in the United States was 2,094,011, and the tonnage 5,220,671.

Varieties.

The varieties are largely adaptive (drought-, cold-, disease- or alkali-resistant) and little structural difference is to be noted between them and the ordinary variety, which includes the great bulk of European- and American-grown seed. There is no apparent difference between the California seed introduced originally from Chile and the European importations into the eastern United States.

Turkestan.—The original importation was secured from Turkestan by N. E. Hansen, under the auspices of the United States Department of Agriculture. Seed from the drier, colder parts of Turkestan has produced a hardier and more drought-resistant crop than ordinary alfalfa, though apparently no hardier than Grimm and northern Montana seed. The forage is sweeter and has finer stalks than ordinary alfalfa. As seed production in the United States is difficult, the commercial seed is largely imported. Experiments indicate that it is slightly superior in the semi-arid West, where the moisture is sufficient for but one or two crops a season of ordinary alfalfa.

Fig. 271. Alfalfa.

Fig. 272. Alfalfa flowers. Enlarged.

Grimm.—This was first noted in Carver county, Minnesota, where it is hardy. It was introduced by the Minnesota Experiment Station. It is apparently slightly hardier than Turkestan alfalfa. Perhaps identical with Sand lucerne.

Dry-land.—This is the name given throughout the West to seed (especially Utah-grown) produced without irrigation in areas of light rainfall.

Arabian. — Arabian alfalfa was introduced through the United States Department of Agriculture. It is of apparent value in the Southwest, and is a prolific yielder. The stems and leaves are pubescent.

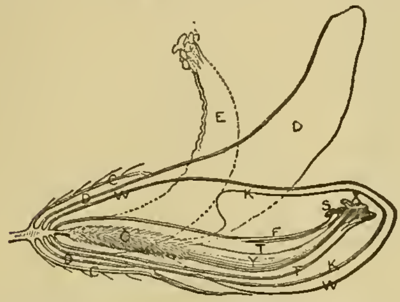

Fig. 273. Diagrammatic cross-section through alfalfa flower, showing relation of parts. Dotted lines show position taken by stamen-tube, resulting from the disarticulation of parts by insects. The upper filaments contract and forcibly bend the anthers and stigma upward against the body of the insect. C, calyx; D, standard; W, wing; K, keel; T, stamen-tube; F, filament of free stamen; X, stigma; Y, style; O, ovary; E, erect position of stamen-tube after release.

Sand lucern.—This is thought to be a cross between *Medicago sativa* and *M. falcata.* It has been grown successfully by the Michigan and Wisconsin Experiment Stations. Its production is still in the experimental stage, but it is proving hardy and a heavy yielder on light, sandy soils in Michigan. The flowers vary from yellow to purple. The seed came originally from Germany.

Propagation and production.

A deep, well-drained, non-acid, fertile soil reasonably free from weeds is required. Excessive alkalinity (in the West) is overcome by flooding and draining; acidity (East) is corrected by liming. Well-rotted manure is a satisfactory fertilizer. A deep, permeable subsoil is necessary, as the roots normally extend to depths of six to twelve feet, and sometimes to considerably greater depths. (Fig. 275.) Inoculation of the seed or soil with root nodule bacteria is generally advisable in the humid regions. Repeated harrowings after plowing produce the fine well-settled seed-bed required. For seeding in the West, twelve to twenty pounds, and in the East, twenty to thirty pounds of seed per acre are used, broadcasted and harrowed or drilled in one and one-half inches deep, or less in clay soils, generally without a nurse crop. Choking out by weeds the first summer and winter-killing the first winter are to be especially guarded against.

Fig. 274. Alfalfa seed-pods. Enlarged.

Late summer seeding, which permits considerable growth before winter and reduces danger from weeds to a minimum, is to be recommended if the moisture conditions are favorable, unless danger from winter-killing (North) makes spring seeding necessary. In the North the plants should go into the winter with a considerable growth to hold snow to check freezing and heaving. Occasional mowings the first year, with the cutter-bar set high, hold the weeds in check and induce heavier stooling. It is not pastured until after the first year and then but sparingly. In the West the stand lasts indefinitely, but in the East it is often run out by June-grass or Kentucky blue-grass (*Poa pratensis*) and in the middle South by crab-grass. Disking with the disks set nearly straight is destructive to weeds and beneficial to alfalfa plants over two years old. The number of cuttings (one ton or more each) varies from two or three, where the summers are short, to six or seven where they are long. A normal yield is four to five tons per acre. It is cut when the first blooms appear, as later cutting reduces the protein content and decreases the feeding value. Great care is necessary to prevent the loss of leaves, which constitute as high as 63 per cent of the total protein of the plant. In the West it is usually raked into windrows a few hours after cutting, and as soon as cured sufficiently to prevent heating is hauled to the stack, or baler, on racks or hay sweeps, "go-devils" or "bullrakes." Hayforks (capacity 300 to 600 pounds) facilitate stacking and reduce the loss of leaves. In humid regions the hay is cocked somewhat green from the windrows, and when sufficiently cured is hauled on racks to the stack or barn.

Fig. 275. Alfalfa plant; roots well established.

Uses.

The feeding value of alfalfa depends on its high protein content and palatability. Alone it constitutes a maintenance ration, but it is generally fed in connection with starchy feeds. It is superior to clover hay in feeding value and may be substituted in part for bran in a dairy ration in the proportion of one and one-half pounds of alfalfa to one pound of bran.

It affords excellent pasture but must be grazed with caution, as cattle are likely to bloat, especially if turned on when hungry or when the alfalfa is wet.

It is well adapted for soiling purposes, but is little used for silage unless continued rains prevent field curing.

In common with other legumes it is a valuable soil-renovator, although in the West it is rarely turned under, the fields sometimes remaining in alfalfa fifty years.

Fig. 277. Alfalfa leaf-spot.

The hay is sometimes ground and sold as alfalfa meal, either pure or mixed with prepared concentrates such as bran, corn chop and molasses. A considerable saving in freight rates is effected by this process, as the ordinary bales are too bulky to be shipped to the best advantage.

For ordinary shipment the hay is baled 110 cubic feet to the ton. For transoceanic shipment double compressed bales are used (fifty-five to eighty-five cubic feet to the ton).

Fig. 276. Dodder on alfalfa (after first cutting).

Causes of failure.

The causes of failure may be stated under three heads, as follows:

(1) General.— Lack of attention to soil requirements, preparation of ground and care the first year.

(2) Weeds.— Fox-tail and crab-grass in the Middle West, June-grass (*Poa pratensis*) in the North, Johnson grass and crab-grass in the South. The remedies for these are the use of clean land, frequent mowings and occasional diskings.

(3) Inoculation.— Lack of inoculation (humid sections) is often a cause of failure. Harrowing in soil from an old alfalfa field at seeding time is the natural method and generally successful. The disadvantages of this method lie in the difficulty of transportation (100 to 400 pounds per acre) and the danger of introducing weeds and plant diseases. The commercial cultures formerly on the market

did not prove generally successful. With the improvement in methods of preparation and application now being made by the United States Department of Agriculture, the effectiveness of the artificial cultures promises to equal that of the soil transfer method without its disadvantages.

Enemies.

Dodder, or love-vine.—(Fig. 276.) This is a parasitic weed with golden thread-like stems and no leaves. It is especially troublesome in New York and Utah, being carried with the seed as an impurity. The remedy is close cutting and careful removal of the stalks from the field. Burning the infested area and close pasturing frequently are successful.

Fig. 278. First cutting of alfalfa in New Jersey.

Leaf-spot (*Pseudopeziza medicaginis.*)—(Fig. 277.) This is the most common disease and is especially noticeable when the plants are allowed to stand for seed. It is held in check by mowing, as the spore production is reduced and the growth of the plants made more vigorous.

Anthracnose (*Colletotrichum trifolii*, Bain).—This is a new disease, reported only from the humid states. It attacks the stems, producing well-defined purple patches. The plants turn yellow at the top and sometimes are killed over a considerable part of the field. Mowing the infested area and the application of a nitrate fertilizer probably are the best procedures. It is sometimes necessary to plow the infested area to prevent further spreading.

Root-rot (*Ozonium sp.*).—This disease is confined to the South and is the same as the cotton root-rot. It spreads in circular patches in the field. The only remedy is plowing under and keeping the land out of alfalfa until the spores are destroyed.

Animals.—Gophers (*Geomys spp.* and *Thomomys spp.*) and prairie dogs (*Cynomys spp.*) do considerable damage in the West, especially where it is impossible to irrigate. Traps, carbon bisulfid, arsenic and strychnine are effective remedies.

Insects.—The web-worm, army-worm and grasshoppers are destructive at times in the West. Mowing the field promptly checks the increase by reducing the food-supply. Fall disking is destructive to grasshopper eggs.

Literature.

Practically all of the experiment stations have issued bulletins on alfalfa-growing in their respective states. The following list includes only a few of the more important. Discussions will also be found in most of the more recent general works on agriculture and throughout the agricultural press: Alfalfa, F. D. Coburn, 1901; The Book of Alfalfa, Coburn, 1906; Lucerne Grass, B. Rosque, London, 1765; Compt. Rend. Acad. Sci. (Paris) 134 (1902), No. 2, pp. 75–80; Agricultural Gazette, N. S. W., 7, 1896; United States Department of Agriculture, Farmers' Bulletins No. 194, "Alfalfa Seed," and No. 215, "Alfalfa Growing"; Canada, Central Experimental Farm, Bulletin No. 46; Pennsylvania Bulletin No. 129; Kansas Board of Agriculture Quarterly, March, 1900. The following bulletins of state experiment stations: Alabama, Bulletin No. 127; Colorado, Bulletin No. 35; Kansas, Bulletins Nos. 85, 114; Michigan, Bulletin No. 225; Minnesota, Bulletin No. 80; Mississippi, Circular No. 18; Maryland, Bulletin No. 85; Nebraska, Bulletin No. 35; New Jersey, Bulletin No. 190; New York, State Station, Bulletins Nos. 16, 80, 118, N. S.; New York, Cornell Station, Bulletins Nos. 221, 237; North Carolina, Bulletin No. 60; Oregon, Bulletin No. 76; Texas, Bulletins Nos. 22, 66; Utah, Bulletins Nos. 48, 58, 91; Wisconsin, Bulletins Nos. 112, 121.

Alfalfa in the Central West.

By *F. D. Coburn.*

The appreciation and increased sowings of alfalfa, within recent years, in the states and territories west of the Missouri river, and especially in the plains region eastward from the Rocky mountains, have constituted one of the phenomena of American agriculture. Typical of this has been its advancement in Kansas, where, prior to 1891, no official cognizance had been given it as one of

Fig. 279. Practical way of protecting alfalfa from rain while curing.

the state's products, and where, in that year, the official enumerators discovered a total of but 34,384 acres. In 1906, there were 614,813 acres, and two counties (which in 1891 had together but 800 acres) had, combined, an acreage of more than

69,200, and twenty-five counties had more than 10,000 acres each.

The aforetime theory that alfalfa would not thrive without irrigation, or unless planted on soils that were proved to be adapted to the growth of corn or cottonwood trees, has been found to be entirely fallacious, and, instead, alfalfa is growing with more or less prosperity on much of the wide diversity of soils the western half of the continent affords, however unpromising their appearance, whether river "bottom" land or the high plateaus 60 to 100 feet above available water, gravel, desert sand or richest mold. In fact, in many places supposedly least encouraging, and even on rough lands far removed from any accessible water-supply, it grows with a persistence that almost tempts one to class it as a weed. Owing to its yields of several profitable cuttings in a season, its unusual protein content, extreme palatability to live-stock of nearly every class, and its longevity, aside from its nitrogen-gathering qualities, the extent and penetration of its root-system and the soil-improving effect as fertilizer and renovator, it is rated as by far the most desirable forage plant in cultivation. In California and elsewhere it has produced in a season, under the most favorable conditions, when irrigated, six to nine cuttings, and in Oklahoma, without irrigation, has yielded nine cuttings, averaging one and one-half tons per acre of cured hay. The hay is a large factor in live-stock-raising, and it is coming to be shipped extensively in bales to distant markets, even so remote as Hawaii, Alaska, and various transoceanic points. Mills are established in various parts of the country for grinding the hay into meal, which is economically transported and affords convenient material, used with most wholesome results, for balancing properly the rations of milch cows, horses and poultry. In many parts of the Central West, by seeding to alfalfa, lands have been doubled and trebled in value, and in numerous instances its being planted on them has converted lands before regarded as practically worthless into highly profitable investments.

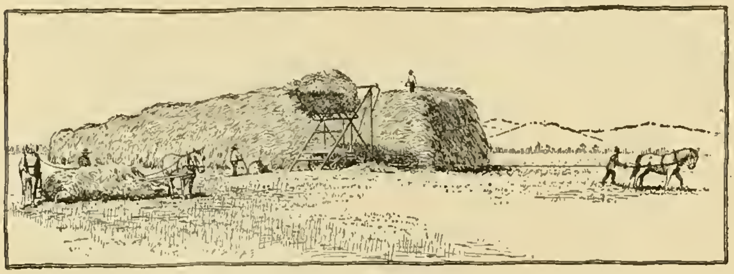
Fig. 281. Stacking alfalfa in the West with the alfalfa-stacker.

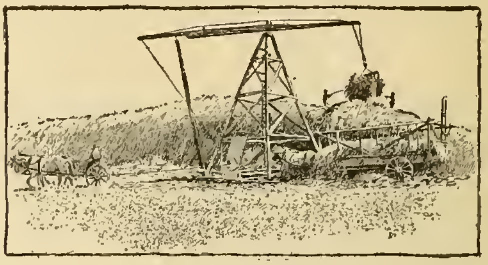
Fig. 280. Stacking alfalfa in the West by the derrick stacker.

The method of seeding found most satisfactory is with horse-drills, which deposit the seed at a depth of an inch or less, in rows six to eight inches apart, fifteen to twenty pounds per acre, on land in fine tilth, harrowed smooth, and somewhat compacted rather than light and porous. By some growers, half of the seed is drilled in one direction and the other half crosswise of this, to facilitate its more equable distribution. Other growers sow the seed broadcast from either the hand or a machine. Sowing in August is more popular than spring seeding, and without a nurse crop. A disk-harrow, which stirs the soil surface, destroys weeds, and splits and spreads the root crowns, causing an increased number and finer growth of stems, is the approved cultivator, and on many fields it is used immediately after each mowing, always adding vigor to the succeeding growth.

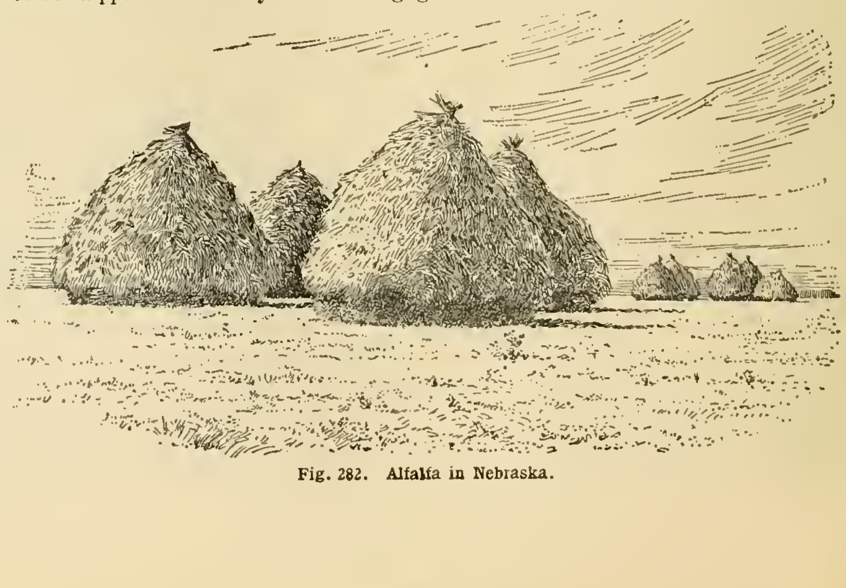
Fig. 282. Alfalfa in Nebraska.

Alfalfa in the East.

By *F. E. Dawley.*

It should be known that alfalfa was independently introduced in the East, although its present vogue has been quickened by the interest arising in the West. An earnest attempt was made to introduce it into New York state (under its French name, lucerne), in 1790 to 1800. In 1793, Robert Livingston had fifteen acres growing in Jefferson county, divided into seven plots, each given different treatment. It is reported as "growing luxuriantly" during the first season, then turning yellow and "pining away." In 1812, it was tried in Central New York by Sterling Lamson and Moses Dewitt with about the same result, although straggling plants from this parentage, it is thought, are still growing. In 1852, Henry Meigs exhibited a few plants before the American Institute in New York.

All of these attempts seem to have proved unsatisfactory, and alfalfa-growing on a successful basis can be traced to a shipment of seed in the chaff, which was hand-gathered on the Pacific coast and sent to Onondaga county, New York, in 1867. With this came the inoculation which seemed necessary to prevent the plants dying the second year because of the lack of root nodules.

In 1894, the New York State Experiment Station at Geneva issued a bulletin on "Alfalfa Forage for Milch Cows," and the agitation of the subject at farmers' institutes, together with the reports of successful fields in Onondaga county, New York, seemed to awaken new interest in the crop; and a little later, when it was learned definitely that old fields where it was growing successfully contained bacteria which could be transplanted to other fields and cause the plant to grow there, its spread became more rapid and today marks one of the great achievements of science as applied to agriculture. Where drainage and physical conditions are favorable in the East, alfalfa will flourish, if seeded properly and the soil inoculated when necessary.

It is usually advised, in the East, to sow alfalfa in spring (between oat and corn planting) unless the land is very foul, in which case the land may be cleaned and the seed sown in July or August.

In the East, where dairy farming in the future must occupy the attention of a large proportion of land-owners, the advent of alfalfa marks a new era. Home-grown protein in alfalfa will solve the question of economical milk production, whether the silo can be made available or not.

The first and last cuttings of alfalfa can be ensiled if the weather conditions are not favorable for curing it for hay. The writer put the first alfalfa into the silo in 1891, and has stored more or less of it in that way each year since with satisfactory results. This method solves the curing of the first crop, which is the greatest difficulty to be overcome in the East. Alfalfa is now being ground into meal, and if the last crop, cut before it is in blossom, is used for this purpose, it makes a very satisfactory product. The first alfalfa meal was ground in Fayetteville, New York, in 1891, the machines being made by Samuel Jackson.

ALFILARIA. *Erodium cicutarium,* L'Her. *Geraniaceæ.* Filaree; heron's-bill; pin-grass and pin-clover (whence the name alfilaria, from Spanish for *pin,* in allusion to the pin-like carpels or "seeds"); name spelled also alfileria and alfilerilla. By the Spanish, it is called alfilerilla, the double "l" being pronounced as "y," with accent on the last syllable. Western farmers usually call it "filaree," with accent on the first syllable. Fig. 283.

By *J. J. Thornber.*

Alfilaria is a small, annual, hairy, slightly viscid, erect or ascending herb, attaining a height of six to eighteen inches, utilized as wild range pasture, and now sometimes grown for hay. The leaves are opposite or alternate, and pinnate, the divisions being finely dissected nearly to the mid-vein. It forms a compact, many-leaved rosette which frequently attains a diameter of ten to twelve inches. The flower parts are in fives, and are produced in axillary, stalked, several-flowered clusters or umbels. The flowers are purple. In fruit, the five styles of the flower elongate conspicuously, become hairy on the inside, and at maturity are dehiscent (that is, are separated into definite parts), and twisted spirally, the seeds at the lower ends of the styles becoming in the meantime sharp-pointed at their bases. The plant generally has a slight musky odor.

Fig. 283. Alfilaria, affording range pasture in the southwest.

Seven other species of Erodium are found in this country. Two species, introduced from the Mediterranean region—*E. moschatum,* known as musk filaree or musk clover, and *E. Botrys*—are grown in the Pacific coast country. The Texan alfilaria, *E. Texanum,* is a native species occurring in the southwest.

History.

Alfilaria is a native of the Mediterranean region, where it is regarded, commonly, as a weed. From there it has spread over parts of Europe, Asia and Africa, and North and South America. It was probably introduced by the Spanish into the western hemisphere in the sixteenth century, in parts of Mexico and South America, and later in California. From these centers it has gradually spread over large areas. It is probably not a native of the Pacific coast country.

Distribution.

The region of the greatest production of alfilaria is confined to California, Nevada, Arizona, New Mexico and Utah. It also extends into Mexico and Central America and parts of South America. The distribution is affected and to a large extent determined by a few climatic features, namely, mild winter temperatures, fall and winter precipitation, and altitude as influencing precipitation and temperature. Soil conditions are of minor importance, although, in general, alkalinity should be avoided. A rainfall in winter and spring of five to seven inches will serve to produce a good growth of the crop. Two or three inches of rainfall in December, January and February are needed to start the plants. If the moisture conditions are right, growth will take place through the winter, subject to occasional checks due to unusually low temperatures.

Elevation as related to rainfall and temperature is important. Alfilaria does best between 1,500 and 4,500 feet altitude. Above this height the winter temperatures are generally too severe for growth, and below it there is likely to be deficient rainfall.

The fact that alfilaria begins its growth in the late fall or early winter adapts it especially to southwestern United States. At that time the moisture conditions are most satisfactory. The plant rapidly develops the low, spreading rosette, which gets the maximum amount of heat and light. The formation of a deep taproot enables it to withstand drought and to start a rapid growth when the warm days come. In Washington and similar latitudes, alfilaria is usually a spring or summer plant.

Growth.

The seed and seeding.—Heretofore seeding has been accomplished largely by sheep, and the method has been sufficiently successful to be considered an effective and reliable system. The seeds are furnished with twisted awns and an abundance of hairs so disposed as to aid them to fasten to and penetrate the furry coats of animals. Sheep, on passing through a field of alfilaria, get more or less covered with the seeds, besides carrying away many between their toes. The incessant trampling serves to plant the seed to the proper depth. The same is true of other stock.

When planting is to be done over a considerable area, the seed should be gathered and sown as soon thereafter as convenient. If the seed is stored through the summer and sown in the fall, a large percentage of it will lie in the ground for a year; whereas, if it is sown soon after maturity, the summer weather seems to fit it for quick growth when fall rains come. The seeds mature in spring and are gathered in May and June. If ungathered, they will remain on or in the ground in a dormant state until fall, no matter how favorable the conditions for growth. A southern exposure is preferable. If the seeding can be done among shrubs, the seedling plants will be protected against animals until they are established. The partial shade afforded by the shrubs also seems to have a beneficial effect, making the temperature and moisture conditions more uniform. The seed is harrowed in to a depth of about a half inch.

Development.—The fall rains induce rapid germination and growth, and the seedlings soon develop compact, many-leaved rosettes, which lie close to the ground. The rosettes grow slowly during the winter by increasing the leaf surface. Flowerbuds are formed at their centers. At the same time a deep heavy taproot is formed. The flowers begin to show with the first warm days of late winter. Several vigorous stems soon spring up from each plant, which continue to grow until April or May. Six to eight weeks elapse between the flowers and the formation of much seed.

Uses.

As a forage crop.—Wherever alfilaria has become abundant it has doubled the spring forage supply, without interfering with the later growth of summer species, principally grasses. Once established it is permanent unless grazed to the detriment of seed production, which is unlikely. It is relished by all range stock, at all stages of its growth. It is especially relished by sheep, which are able to nibble its flattened rosettes some time before the larger animals. The only objection is that the seeds in the wool reduce the value of the latter as much as a cent and a half a pound. Shearing twice a year—in March and September—has been found to reduce this objection to a minimum. As a forage crop, alfilaria is both nutritious and succulent.

As a hay crop.—The use of alfilaria as a hay plant is yet limited. If cut when in blossom and cured as is alfalfa it is very palatable. But, in order to attain a growth sufficient for this purpose, it should be grown under favorable conditions on the richer soils of valleys, swales, mesas and similar areas. Under ordinary conditions, a fair yield is a ton and a half of hay per acre. Unfortunately, the common method of handling the crop for hay is exceedingly wasteful, the long weathering causing the loss of the most valuable constituents.

Composition of alfilaria hay.—Analyses made at the Arizona Experiment Station by Vinson showed alfilaria to contain a high percentage of ash. The fat is present in larger proportion than in alfalfa, but slightly less than in most varieties of hay. The protein content is high, comparing favorably with hay from legumes. The crude fiber is moderate, being about the same as in good timothy hay. The carbohydrates are abundant.

Literature.

Comparatively little has been written on alfilaria in this country. The most comprehensive discussion is found in Bulletin No. 52, of the Agricultural Experiment Station of the University of Arizona, from which this article is largely adapted. A few of the experiment stations have bulletins on the subject, and the 1901 Yearbook of the United States Department of Agriculture gives a few notes.

ARROW-ROOT. Fig. 284.

By *S. M. Tracy.*

Arrow-root starch is a product manufactured from the underground parts of a number of different plants grown in tropical and subtropical countries. It is valued principally as a food for invalids, especially in cases of persistent diarrhea and dysentery. In South Africa and the East Indies, *Maranta arundinacea* (Fig. 284) is the plant most commonly cultivated for this purpose. This is much grown in the Bermuda islands, and therefore is commonly known as Bermuda arrow-root. In Australia, *Maranta nobilis, Manihot utilissima* (cassava) and several species of Canna,—*C. Achiras, C. glauca, C. edulis*, and others,—are used for the same purpose, and *C. flaccida*, a native of the southern part of the United States, is one of the most profitable species. Recent experiments show that the common canna used in this country for decorative purposes (*C. Indica*, Indian shot) can be made a profitable source of arrow-root in all the southern states. In the Pacific islands, especially in Guam, the Hawaiian islands and the Philippines, *Tacca pinnatifida*, a plant belonging to the Taccaceæ and closely related to the yams, is more commonly used, and to a considerable extent also in India. Both the marantas and the cannas have fleshy rhizomes, while the cassava and the tacca have fleshy roots resembling sweet-potatoes. Cassava starch is considered the best for laundry purposes and is much used by manufacturers of linen goods. Some varieties of this plant received recently from Colombia, South America, yield as much as 39 per cent of their weight as starch.

Manufacture.—From whatever source the arrow-root may be derived, the process of manufacture is practically the same. The fresh roots are washed and are then grated to a fine pulp. This pulp is diluted with water and repeatedly strained, diluted and settled to remove all fibrous material, and also to extract the coloring matter and a bitter principle which is more or less prominent in all the roots used in the manufacture of the starch. The commercial value of the arrowroot is largely dependent on the number of washings, as each successive washing renders the starch whiter, more palatable and more easily digested, though it is said that the darker-colored product which has been given fewer washings is more effective when used for the curative treatment of dysentery.

Arrow-root starch is not now produced in the United States, but a starch made from cassava (*Manihot utilissima*) is used very largely as a substitute, and appears to be more valuable. Cassava is grown extensively in Florida, and its cultivation is extending westward along the gulf coast to Texas.

The following notes on Bermuda arrow-root are by T. J. Harris, Superintendent of Public Gardens, Hamilton, Bermuda:

"The commercial value of the arrow-root depends largely on the soil and climate in which it is grown and the care bestowed on its manufacture. The St. Vincent product is sold for 2¼d. per pound, while Bermuda arrow-root brings 1s. 9d. per pound in the open market. It is of special value as food for invalids, as it contains nothing whatever of a deleterious nature. Dissolved and injected with laudanum, it is a specific for extreme cases of dysentery. In Bermuda, every care is taken to ensure absolute cleanliness, the natural conditions aiding in this respect: the soil in which the rhizomes are grown is a red, sandy loam derived from coral rock, and is quite devoid of volcanic mineral substances; the perpetually damp atmosphere ensures the gradual and even deposition of each successive layer on the starch granule; the water used in the washing is distilled in a dustless atmosphere and caught on immaculate lime-washed roofs.

Fig. 284. Bermuda arrow-root shoots (*Maranta arundinacea*).

"There is but one factory in Bermuda, working on a capital of £3,000 and paying about 10 per cent per annum.

"An acre of arrow-root in Bermuda will yield in a fair season about 14,000 pounds of rhizomes, 15 per cent of which is recovered as dried starch."

BANANA-GROWING IN AMERICAN TROPICS. Figs. 285, 286.

By *G. N. Collins.*

The rapidly attained popularity of the banana in the United States offers a striking example of a recent addition to our traditional list of foods. Thirty years ago the banana was practically unknown outside the tropics, yet to-day it must be classed as one of our staple articles of diet. This rapid growth in favor is doubtless due to the peculiar character of the fruit, which is entirely unlike any of the temperate and subtropical products in use previously. It is, perhaps, the best adapted of fruits for handling in large quantities. One stroke of the machete gathers 75 to 150 individual bananas, compactly united into a cluster convenient for handling, comparable to an entire crate of any of our northern fruits. The structure of the individual fruits is equally convenient, since they are protected perfectly by a tough skin which is removed readily without the use of any instrument, while the pulp is luscious without being juicy.

Throughout tropical America the banana is considered a vegetable rather than a fruit. Indeed, as a fruit the banana is taking a relatively more important place in the United States than in the regions in which it is grown. Thus, in Porto Rico, it would be classed fourth or fifth in a list of the most popular fruits, while as a vegetable it would rank second or perhaps first.

Botanical discussion.

The banana plant, or tree, as it is often called, is a large herb with a perennial rootstock. The part above the base, which reaches a height of ten to thirty feet, consists entirely of the leaves and their clasping, sheath-like petioles. The inflorescence forces its way through this stem-like growth and appears as a large raceme, which soon becomes pendent. The flowers are borne in clusters of eight to fifteen, which when mature are known as "hands." Each cluster is enclosed in a large subtending bract, purple in most species, that rolls back and drops as the flowers open. The basal flowers, which open first, are pistillate, with only aborted stamens. Toward the apex the stamens become larger and more perfect, while the pistil is gradually reduced, until at the apex the flowers are entirely staminate. Usually less than half of the flower-clusters develop as fruit, though the opening of the staminate flowers toward the apex continues until the fruit at the base is mature. The closely packed clusters of unopened flowers at the end of the fruit-stalk are known as the "navel." (For accounts of the botanical characters, see Cyclopedia of American Horticulture, under *Banana* and *Musa.*)

Fig. 285. Loading bananas on a plantation in Costa Rica.

Varieties.

The almost countless varieties of bananas and plantains are all classified under species of the genus Musa, which, with five other genera, comprises the family Musaceæ. In the latest revision by Schumann the genus is divided into forty-two species. The various varieties of edible bananas are usually all included under the two species *M. paradisiaca* and *M. Cavendishii.* The latter is the dwarf banana, grown in the Canary islands for the English market and also in Hawaii. *M. paradisiaca* has two sub-species : *normalis*, comprising the plantains or cooking bananas, which are of coarse texture and only slightly sweet, and *sapientum*, comprising the majority of the varieties of sweet-fruited bananas that may be eaten raw. By many writers the plantain (*normalis*) and the common banana (*sapientum*) are regarded as distinct botanical species. Practically the only variety that appears in the northern markets is the Martinique or Jamaica, also known as Gros Michel and Bluefields. The chief advantage of this variety is the superior shipping quality of the fruit. It is to be regretted that this one desirable character has been allowed to exclude all the other varieties, many of which are decidedly superior as table fruit.

The plantains or cooking bananas are worthy of greater consideration than they receive in this country. Throughout all tropical countries they are preferred for cooking, and it would seem only a question of time until they will be added to our list of vegetables. In New Orleans the population is sufficiently in touch with the tropics to afford a limited market for plantains, and about 6,000,000 individual plantains are annually shipped to that city from British Honduras.

Propagation and growth.

The banana is entirely seedless, and propagation is accomplished by planting the suckers or sprouts that arise from the base of old plants. These are of two kinds, known as "broad leaf" and "sword" suckers. The former arise from short, thick, sessile bulbs borne at the surface of the ground around the parent plant, the latter from stalked bulbs that arise lower down. Sword suckers are usually considered the more desirable. For planting, these are removed when about six feet high and the bulbs four or five inches in diameter. As soon as they are taken up they are cut back to about one foot in length, and in this condition they can be kept for a month or more before planting.

The banana is very exacting with respect to soil. To do well the land must be very rich in humus, moist, but very well drained. In poor situations the plants may do well at first, but will run out in a few years and need to be replanted, whereas on good land they will continue to produce fine crops for fifteen or twenty years.

The plants are usually spaced fourteen to twenty feet each way, except in parts of Costa Rica, where a system of block planting, originated by Mr. John Keith, is practiced. This system, which has shown an increased yield wherever tried, is to plant in blocks of four plants each, the individual plants being about four feet apart, in the form of a square; the blocks are 25 x 25 feet. This provides a better shade for the base of the plant during the early stages of its growth, and thus prevents excessive suckering.

The plants usually require about twelve months to produce a mature bunch. Before the bunch appears, suckers will start from the base which will take the place of the old plant or trunk, when it is cut down in harvesting the bunch. Only enough suckers are allowed to develop to keep up the succession of plants, and it requires some experience to judge of the proper time to allow suckers to grow so that there will be large cuttings in the season when the highest prices prevail. Until the plants are large enough to shade the ground, it is necessary to keep down the growth of grass and weeds. Some planters have found it profitable to sow cowpeas at the time of planting, which occupy the ground and reduce the number of cleanings that it is necessary to make. One of the worst enemies of the banana-grower is grass. Its appearance in a plantation may be taken as a sign that the plantation will soon cease to be productive. It is not clear whether the grass is merely an indication that the soil is in some way depleted, or whether it is itself the real cause of the deterioration.

Diseases.

The banana is attacked by comparatively few diseases. The only one causing serious damage in any of the centers of production here considered appeared in the Bocas del Toro region of Panama. This disease has been made the subject of a special investigation and found to be of bacterial origin. The same disease has been reported in Costa Rica, but it seldom attacks vigorous plants growing in suitable situations.

Production.

The chief centers of banana production in America are Costa Rica and Jamaica. The imports for the year 1905, by countries, were as follows :

Jamaica	$3,245,536
Costa Rica	1,888,939
Cuba	1,437,952
Honduras	1,430,580
Colombia	585,489
Panama	415,495
Nicaragua	391,142
Santo Domingo	283,950
British Honduras	112,605
Guatemala	97,688
Other countries	8,445

There are marked differences between the cultures of Costa Rica and Jamaica, and also in the methods of handling the fruit. In Costa Rica the plants grow to a much larger size and produce, on the average, larger bunches. In Jamaica the minimum bunch that is accepted is that of five hands, while in Costa Rica nothing smaller than seven hands will be received. In Costa Rica the culture is less intensive than in Jamaica. In the latter place, especially on the south side of the island where the plantations are irrigated, they present a very regular appearance. The ground is kept clean and the rows in good alignment. In Costa Rica, many of the large plantations receive little attention aside from the removing of superfluous suckers.

Transportation.

As bananas are all grown in the tropics and all sold in temperate countries, the industry is to a large extent a question of transportation. This phase of the subject has received much more careful attention than has the more strictly agricultural side. The business is chiefly in the hands of large companies, which are interested primarily in transportation. These are now consolidated, so that nearly all the fruit received in the northern markets is handled by the United Fruit Company.

When locating plantations in Costa Rica, land is usually selected through which it is possible to construct railroads, this consideration bearing quite as much weight as the nature of the land. Every effort is made to handle the fruit promptly. In many cases it is possible to leave the fruit on the plant until the steamer that is to transport it is sighted. Telephonic orders are then sent to the different plantation managers and the fruit is rushed in by train-loads, so that it not infrequently happens that a steamer leaves the wharf at Port Limon with 30,000 bunches of

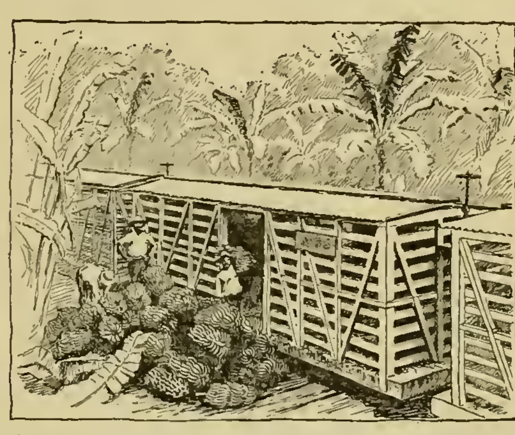

Fig. 286. Loading into cars that run to the wharf. Costa Rica.

bananas that were growing in the plantations twenty-four hours before. The service calls for steamers especially constructed to carry this fruit. The holds are especially well ventilated, and in many of the more recent steamers the air is artificially cooled before it passes over the fruit. Cold storage in the ordinary sense can not be applied to the banana. If the green fruit is subjected to a temperature much below 50°, it is injured, so that, although it may keep almost indefinitely, it will never ripen. To avoid this, the wharves and the cars into which the bananas are loaded are heated in bringing the fruit into northern ports in the winter months.

The distribution of bananas to the various cities is handled with the same expedition as the shipping. Before a cargo arrives it is apportioned to the different centers of consumption, so that in a few hours after the arrival of a ship the fruit is on its way to distant parts of the country.

Literature.

The Banana in Hawaii, J. E. Higgins (1904), Hawaii Agric. Exp. Sta., Bull. No. 7 ; The Banana Industry in Jamaica, Wm. Fawcett (1903), Bull. Botanical Dept., Jamaica, Vol. IX, part 9; Text-Book of Tropical Agriculture, H. A. A. Nicholls (1892).

BARLEY. *Hordeum sativum,* Jessen. *Gramineæ.* Figs. 287–94.

By *R. A. Moore.*

An annual cereal grain, supposed to be native of western Asia, and cultivated from the earliest times. It is grown for the grain and herbage, the grain being used as food for live-stock, but chiefly in the making of malt for beer. Flowers perfect, the stamens 3, styles 2, arranged in spikelets that are borne 2 to 6 on notches or nodes of the rachis and forming a long head or spike; flowering glumes 5-nerved, one of them usually long-awned, usually persisting about the grain as a hull; empty glumes very narrow and surrounding the spikelet.

Barley was very widely grown before the Christian era and was used largely as food for human consumption. Its use as a bread plant was universal throughout the civilized countries of Europe, Asia and Africa, down to the close of the fifteenth century. It gradually gave way to the better grains for bread-making, and is now, and will henceforth probably be used mostly as an animal food and for brewing purposes. The inhabitants of the European and Asiatic countries used barley rather generally as a food for horses, and the practice is common at present in several of those regions.

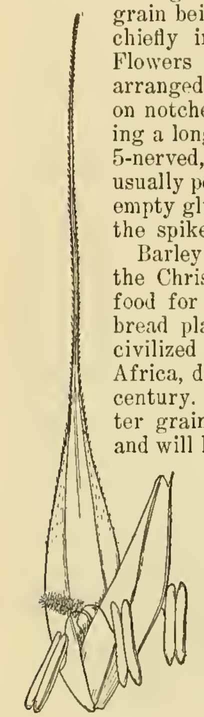
Fig. 287. Flower of barley.

According to the Twelfth Census there were in the United States 272,913 farms reported as producing barley in 1899. They devoted to the crop 4,470,196 acres, and secured a production of 119,634,877 bushels, valued at $41,631,762. The four states giving the highest production are, in order, California, Minnesota, North Dakota and Wisconsin. According to the Fourth Census of Canada (1901), there were in the Dominion, 871,800 acres in barley, which produced 22,224,366 bushels.

Varieties.

For all practical purposes, barley may be classified as six-rowed, four-rowed, and two-rowed. There are also beardless, bearded and hulless varieties of the above groups. The four-rowed barley does not seem to be a distinct variety, but a variation of the six-rowed, as often the six-rowed barley drops two rows midway up the spike, the upper part being nearly four-rowed.

Linnæus and the earlier botanists recognized six species :

Six-rowed barleys .	*a.*	Hordeum hexastichum
	b.	Hordeum vulgare
Two-rowed barleys .	*c.*	Hordeum distichum
	d.	Hordeum Zeocriton
Naked barleys . .	*e.*	Hordeum cœleste
	f.	Hordeum nudum

Botanists now generally group all these as subtypes under the botanical name of *Hordeum sativum,* which is taken in the sense of a group-species. All the cultivated barleys are supposed to be derived from the wild West Asian *Hordeum spontaneum,* C. Koch.

The term "variety" is used by seedsmen, plant-breeders and farmers in a wider and not so rigid sense as that applied by the botanist. Races of barley, the type of which has been materially changed by careful selection or cross-breeding for a period of years, are in common practice designated as "varieties."

The Manshury or Manchuria, Oderbrucker, Golden Queen, Hanna, Silver King, and the like, are terms that have been given to various strains of barley, and each is often used as applying to a distinct variety. In common practice the name of the country from which a grain is received is often applied to the variety and may become known over a great extent of territory. The Manshury barley is known throughout the United States and Canada, and is more generally grown in parts of the middle West than any other type.

Culture.

Adaptability.—Barley is grown under a wider range of soil and climatic conditions than any other cereal, and readily adjusts itself to the natural environments under which it is placed. In Europe, barley is grown from the Mediterranean sea to Lapland, 70° north latitude, and in


Fig. 288. Heads of Manshury (or Manchuria) barley, for comparison with Oderbrucker.


Fig. 289. Characteristic heads of Oderbrucker barley, with lower beards clipped to show arrangement of kernels from side and edge.

America from southern California and eastward to the Copper River Experiment Station farm in Alaska. While barley can be raised on a wide range of soils, it grows best and yields the most marketable grain when grown on old, well-subdued lands, where the plant-food is readily obtainable. Barley is an early-maturing cereal, and the root growth is shorter and less abundant than that of oats or wheat; consequently, it is necessary to sow it on land that is in a high state of fertility and cultivation. A rich clay loam seems to be preferable. It is easily injured while the plants are young by an overabundance of moisture, and, therefore, should not be sown on land that is soggy, or where the water-line is too near the surface.

Fig. 290. Three spikelets at joint of rachis, a characteristic common to the six-rowed barleys.

Rotation.— Barley should be grown in rotation, and not continuously on the same land. When corn is one of the crops, a good rotation is corn on land that the previous year had been in hay or pasture, and barley to follow corn, at which time the land should be seeded to clover and timothy, or clover and bluegrass. One or two crops of clover can be cut the year following barley, and the land can be used for pasture or hay-land the year following clover. The land may be manured to advantage at any time after the clover is secured, preferably the following fall and winter. By running a fine-tooth harrow over the grass-land in the spring, the manure will be distributed evenly, and the fine roots of the various grasses will hold the fertility near the surface, where it can be utilized to a certain extent by the grasses and subsequently by the following corn and barley crops. The above is recommended when a regular four years' rotation is desired. Barley does well on land that has grown potatoes, beets and garden-truck the previous year.

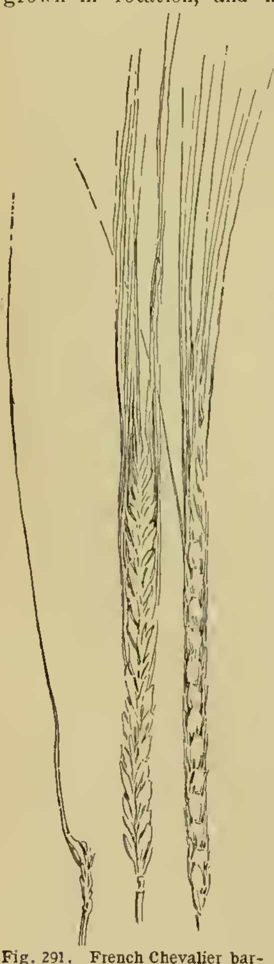

Fig. 291. French Chevalier barley, a standard two-rowed variety. Lower beards clipped to show arrangement of kernels from side and edges.

Seed-bed.—Much care should be given to the preparation of the seed-bed to get the best yields. Fall-plowing is preferable to spring-plowing. When the land is fall-plowed, it should be disked thoroughly in the spring and put in good tilth as early as the ground will admit of working to advantage. After disking, if the ground is inclined to be lumpy, it should have a planker or roller run over it to crush the lumps; then the preparation is finished by going over the ground with a fine-tooth harrow.

Sowing the seed.—Barley is sown with either the drill or the broadcast seeder at the rate of one and one-half to two and one-half bushels of seed per acre; when the seeder is used, about one peck more seed per acre should be used than when it is sown with the drill. The time of seeding varies in different localities, but in general follows the wheat-seeding, and precedes oat-sowing. In Wisconsin, barley is sown April 10 to May 10, depending on the earliness or lateness of the season. In the southern states, barley is sown with success in the fall, but spring-seeding is the general custom throughout the barley-growing states of the North. In Wisconsin, at the Experiment Station farm, all except one of the tests made with fall-sown barley have resulted in a complete failure.

After the barley is sown, it is well to run over the surface of the ground with a fine-tooth harrow. Lumps of dirt, clots of manure or any coarse litter should not be left on the land.

No cereal crop can be used to better advantage as a nurse crop with alfalfa, clover or hay grasses in general, than barley, as it seldom lodges and is not so tall and leafy as to prevent the entrance of air and sunlight. It does not draw so heavily on the moisture of the soil as the other cereals, which is a decided advantage to the clover and grasses. When used as a nurse crop with alfalfa or common clovers, it should be seeded at the rate of three pecks or one bushel of seed per acre. When it is desirable to sow barley on very rich, mellow soil, it is well not to sow more than five pecks per acre, as the tendency is to lodge, if sown more thickly. Barley fills better than most cereals after lodging, but is fully as difficult to harvest, and therefore an effort should be made at the time of seeding to prevent lodging, when the soil is of doubtful character.

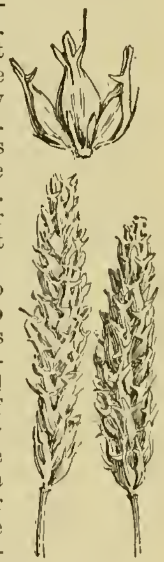

Fig. 292. Beardless hulless six-rowed barley.

If land is very rich, and the cereal crops generally lodge, the over-abundance of fertility can be reduced readily by growing corn, wheat or millet. Often a crop of millet can be secured after a cutting of oat-hay has been taken from the land, which will usually put the land in proper condition for barley the following year. As a rule, the farmer will have more difficulty in supplying his land with the proper food elements as a preparation for a barley crop than in reducing them.

Fig. 293. McEvans bearded hulless barley, with lower beards clipped to show arrangement of kernels from side and edge. Kernel joined to rachis, with beard extended, at right.

Harvesting.—One of the chief arguments used against barley-culture in the past has been the many annoyances experienced because of the beards while binding, threshing and other handling. This attitude displayed by farmers led to the introduction of beardless barleys, which have not as yet proceeded beyond the experimental stage. At the Wisconsin Station, through a several years' test, the beardless barleys were found to be weak in straw and poor yielders compared with the bearded barleys. The kernels were much more shrunken, and did not look so healthy and vigorous. The grain of the beardless barleys weighed two to ten pounds less per measured bushel than that of the bearded barleys grown under the same conditions. The yield was fifteen bushels less per acre than that of the Manshury or Oderbrucker barleys on the Station farm. The objection to the beards by barley-growers is considerably lessened since the advent of the harvester and self-feeder.

Barley is more easily injured by rain, dew or sunshine than the other cereal crops, and is often reduced in value from the maltster's standpoint one-half because of discoloration of the grain. The discoloration of the grain does not cause the feeding elements to deteriorate, to any great extent, and the farmer should feed such grain rather than try to force it on the market. To prevent discoloration, the grain should be harvested before the ripening has advanced too far. If put in round shocks, using about ten bundles in a shock and covering with two bundles as a cap, barley will cure nicely without discoloring unless heavy rains occur. The bundles used for capping can be drawn in and threshed separately from the bulk of the crop, and retained for feed or seed.

Barley diseases.

Barley is affected by rust, mildew and smut. No effective remedy has been found for rust and mildew. Smut can be reduced by the formaldehyde method of treatment. Smut is a fungous disease caused by minute spores lodging underneath the hull of the barley grains previous to the ripening period. These little spores remain inactive until the barley is planted, when they germinate with the seed and send hair-like threads up through the stem of the plant. Practically all heads growing from a seed which contains the smut spores are smutted and the grain is destroyed. As soon as the smut is matured fully, it is blown by the wind to unaffected heads of barley and finds lodging beneath the hulls of the unripened kernels. The hulls close over the spores at the time of ripening and hold them securely until germination begins when the spores begin their deadly work.

Two kinds of smut affect barley, the closed or covered smut (*Ustilago hordei*), and the loose smut (*Ustilago nuda*). The formaldehyde treatment is satisfactory against the closed smut, but not against the loose or open smut. Hot water is now recommended for both kinds. The barley crop of Wisconsin was affected with smut to the extent of 5 per cent in the season of 1905. When barley had been sown on test with and without treatment, a reduction of 4 per cent was reported in favor of the treated seed.

Treatment.—Make a solution by pouring one pint of formaldehyde into twenty gallons of water, the solution to be placed in barrels or a trough. Sacks of barley should be submerged in the solution for ten minutes, then emptied on a threshing floor or platform to dry. After the treatment, if the seed barley is covered for about two hours with oilcloth or blankets so that the fumes of the formaldehyde can act on the spores, the treatment will be much more effective.

Extensive experiments have been made at the Wisconsin Station with the hot-water treatment of seed for smut. The hot-water treatment was found thoroughly effective against both kinds of smut, and it is a very simple operation. The grain is placed in gunny sacks and submerged for twelve hours in cold water to soften the hull and berry. It is then removed and allowed to drain for an hour. The sacks are then submerged in hot water at a constant temperature of 130° F., for a period of not over six minutes. Provision must be made to add hot water to keep the temperature constant, as it will be lowered when the grain is put in. It is well to put the grain in another tank of hot water that has a temperature a little below 130° F., in order to heat the grain before putting it in the tank with the constant temperature. The seed

Plate VI. Barley. A two-rowed variety of the Chevalier type

should be sown the same day or the day following, as it will sprout. The experiments made at Wisconsin are reported in the Twenty-third Annual Report of the Wisconsin Agricultural Experiment Station, 1906.

Fig. 294. Barley ready for shipment. Gallatin county, Montana.

Uses in America.

In the United States and Canada, barley is used almost exclusively for malting purposes and as a food for domestic animals. Its use as a human diet is limited, being confined to a few preparations commonly known as pearl barley. In the Pacific states barley is grown generally as hay and grain for horses. As a hay it is cut and cured when in the early milk stage. The grain is fed whole, or milled by passing between rollers which merely crush it. If ground like mill feeds, the abundance of gluten therein makes a sticky mass when brought in contact with moisture. Horses are fed barley only to a limited extent in the oat-growing states. In Canada and the United States, swine and poultry are fed rather generally on barley, and all feeders attest to its high value as a producer of pork and bacon of the finest grade. The use of barley as a food for domestic animals is becoming more popular as the farmers learn its feeding value.

By-products.

The principal by-products of barley when used for brewing, are malt-sprouts and brewers' grains, the latter of which are used extensively as feed for dairy animals. Horses and other farm animals are fed to a limited extent on brewers' grains, and are said to relish them. The brewers' grains, which may be secured either wet or dry, are the barley grains after the soluble dextrin and sugar have been extracted for the purpose of making beer. These by-products accumulate at breweries in great quantities, and often can be purchased for less than the actual fertilizing value contained therein. By judicious feeding and a proper regard to the saving of the manure a farmer may secure the feeding value practically free.

The digestible nutrients, fertilizing constituents and composition as given in Henry's "Feeds and Feeding" are as follows :

Digestible Nutrients and Fertilizing Constituents of Barley, Malt-sprouts and Brewers' Grains.

Name of Feed	Dry matter in 100 pounds	Digestible nutrients in 100 pounds			Fertilizer constituents in 1,000 pounds		
		Protein	Carbohydrates	Ether extract	Nitrogen	Phosphoric acid	Potash
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Barley	89.1	8.7	65.6	1.6	15.1	7.9	4.8
Malt-sprouts	89.8	18.6	37.1	1.7	35.5	14.3	16.3
Brewers' grains (wet)	24.3	3.9	9.3	1.4	8.9	3.1	0.5
Brewers' grains (dried)	91.8	15.7	36.3	5.1	36.2	10.3	0.9

Average Composition of Barley and its By-Products.

	Percentage composition						
	Water	Ash	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Number of analyses
Barley	10.9	2.4	12.4	2.7	69.8	1.8	10
Barley meal	11.9	2.6	10.5	6.5	66.3	2.2	3
Barley screenings	12.2	3.6	12.3	7.3	61.8	2.8	2
Brewers' grains (wet)	75.7	1.0	5.4	3.8	12.5	1.6	15
Brewers' grains (dried)	8.2	3.6	19.9	11.0	51.7	5.6	3
Malt-sprouts	10.2	5.7	23.2	10.7	48.5	1.7	4
Straw	8.3	3.8	3.7	42.0	39.5	2.7	

Literature.

The reader is referred to the bulletins issued by several of the experiment stations, and by the United States Department of Agriculture. More or less extended treatment of barley is given in the following publications : American Brewers' Review ; Fream, Elements of Agriculture ; Henry, Feeds and Feeding; Hunt, Cereals in America; Wilcox and Smith, Farmers' Cyclopedia of Agriculture; Wisconsin Experiment Association, 3d and 4th reports; Wisconsin Experiment Station reports, 20, 21, 22, 23; Yearbooks of the United States Department of Agriculture.

BEAN, FIELD. *Phaseolus vulgaris*, Linn. *Leguminosæ.* Figs. 295-302.

By *J. L. Stone.*

Annual plants of bush or twining habit, of unknown habitat but probably native to the New World, grown for the edible seeds. Leaves 3-foliolate, the leaflets stalked and stipellate, entire; flowers papilionaceous, greenish, whitish or tinted with blue or blush, few at the apex of a short axillary peduncle, the stamens 9 and 1, pistil 1 and contained within the stamen tube, which is enclosed in the spiralled or twisted keel (*a*, Fig. 295); fruit a long, 2-valved pod containing many oblong or sometimes oval seeds of many colors. The common garden snap beans are of the same species. The bush beans are often separated as a distinct species, *P. nanus*, but both bush and pole varieties are undoubtedly domestic derivatives of one species.

Fig. 295. Flowers of the common bean (*Phaseolus vulgaris*), with one flower opened (*a*) to show the structure.

History.

While beans have been grown and used for human food in various forms from a very early date, the production of commercial dried beans is of recent origin. It is stated that in 1836 Stephen Coe brought from the eastern part of New York into the town of Yates, Orleans county, a single pint of beans. He planted them, and from the successive products of three years, his son, Tunis H. Coe, in 1839 raised a small crop of beans and sold a load of thirty-three bushels to H. V. Prentiss, of Albion, the only man in the county who could be induced to buy so many. This is supposed to be the first load of beans sold in western New York, and it is probable that up to that time there had not existed anywhere in the world an organized industry for producing and distributing commercial dried beans.

From this humble beginning sprang an industry that has produced in the state of New York alone for the last thirty years one to two million bushels of beans per year. For many years the production of commercial beans was confined to Orleans county, but it gradually spread to other counties and later was taken up in other states. This development has occurred in about sixty years, but during the first twenty-five years of this period the production did not rise to 2 per cent of its present volume. The early settlers of western New York depended principally on the sale of wheat for their cash income, and eastern markets were largely dependent on the wheat grown in western New York. The advent of the weevil in 1846, which proved very destructive in the wheat-fields, offered to farmers the first inducement to experiment in raising beans. However, the industry made little growth down to 1861. At this time the government began to buy beans for use in the army and during the years of the civil war production increased very rapidly. At the close of the war the government demand ceased, but the soldiers had learned to eat beans and they carried the habit back with them into home life and induced others to eat beans also. Thus arose the consumptive demand for beans that has made possible the great development of the industry. Other causes have influenced the extension of the consumption of beans in certain localities, but none were of so widespread influence as the civil war. At the present time the practice of canning beans in convenient and attractive forms is doing much to extend their use.

According to the Twelfth Census of the United States (crop of 1899), Michigan is the largest producer of commercial dried beans of any of the states. In the previous census reports of the crops of 1879 and 1889, New York ranked first in bean production. In 1879, New York produced 42.4 per cent and in 1889, 35.1 per cent of the total crop of the United States. The weather conditions in New York in 1899 were more unfavorable and the bean crop was numerically small, falling to 26.9 per cent of the total crop of the United States, while Michigan produced 35.7 per cent of the same. It is asserted by dealers in beans in New York that the state still leads in production in normal seasons, but owing to the fact that no

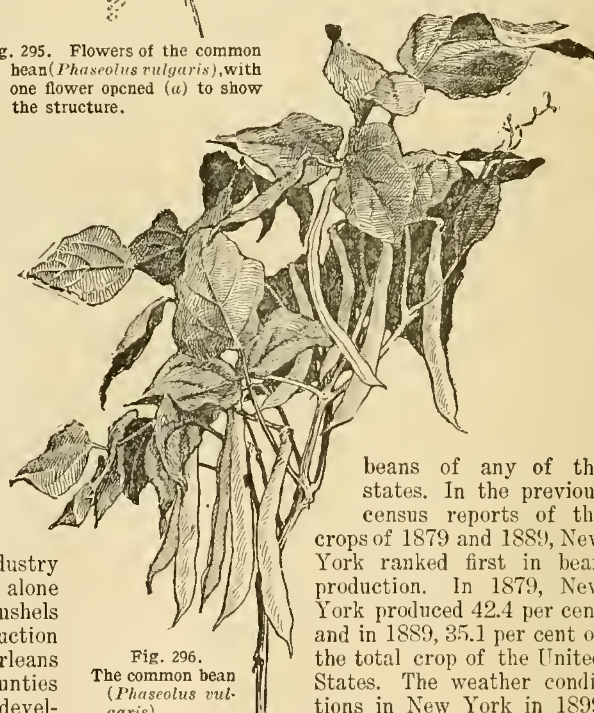

Fig. 296. The common bean (*Phaseolus vulgaris*).

statistics relating to beans are taken except in census years, it is difficult to confirm or refute the assertion.

The following table, from the Report of the Twelfth Census, gives the statistics of bean production for the season 1899 as compared with 1889:

Climate.—As to the climatic limitations of commercial bean-growing, we are uncertain. As a matter of fact, the industry is at present confined to the northern border of the United States, a part of California and to southern Canada. The garden beans are extensively grown in more southern and warmer localities, and no doubt the field crop

States Cultivating 1,000 Acres or More of Beans in 1899. Arranged in Descending Order of Production; Also the Production in 1889.

States	Acres	Number of bushels produced	Value	Average bushels per acre	Average price per bushel	Production in 1889	Per cent of increase
Michigan	167,025	1,806,413	$2,361,020	10.8	$1.31	434,014	316.2
New York	129,298	1,360,445	2,472,668	10.5	1.82	1,111,510	22.4
California	45,861	658,515	1,022,586	14.4	1.55	713,480	7.7*
Florida	9,189	176,304	139,349	19.2	0.79	6,613	2,566.0
Maine	10,252	137,290	290,885	13.4	2.12	149,710	8.3*
Virginia	6,411	56,189	66,066	8.8	1.18	24,048	133.7
North Carolina	5,381	49,518	50,703	9.2	1.02	36,909	34.2
Tennessee	5,563	48,736	57,660	8.8	1.18	29,780	63.7
Missouri	4,376	45,647	73,850	10.4	1.62	29,632	54.0
Minnesota	3,290	36,317	49,685	11.0	1.37	61,009	40.5*
New Mexico	3,349	36,022	73,001	10.8	2.03	7,843	359.3
Indiana	2,999	30,171	46,281	10.1	1.53	34,988	13.8*
Illinois	3,451	30,122	46,084	8.7	1.53	21,308	41.4
New Hampshire	2,892	29,990	62,799	10.4	2.09	44,589	32.7*
Colorado	2,634	28,570	49,169	10.8	1.72	7,265	293.3
Vermont	2,404	27,172	51,629	11.3	1.90	31,880	14.8*
Iowa	2,427	24,903	38,296	10.3	1.54	33,769	26.3*
Pennsylvania	2,182	23,957	38,719	11.0	1.62	11,356	110.0
Ohio	1,828	19,042	33,307	10.4	1.75	30,213	37.0*
Alabama	1,765	17,865	15,507	10.1	0.87	4,841	269.0
Georgia	1,927	17,489	17,982	9.1	1.03	19,619	10.9*
Arkansas	1,490	15,582	17,046	10.5	1.09	8,570	81.8
South Carolina	1,657	14,925	13,936	9.0	.93	8,018	86.1

*Decrease.

The Dominion of Canada had 46,634 acres of beans in 1901, with a yield of 861,327 bushels.

Culture.

Soil.—"Too poor to grow white beans" is a common expression with some farmers in describing soils in a low state of fertility. This would seem to indicate that beans will thrive on poor land better than most crops. Beans will grow on a variety of soils and perhaps give fair yields on soils not strong enough for satisfactory results with corn or potatoes; nevertheless, profitable bean-growing requires soils well adapted to the crop and in a good or even high state of fertility. Like most leguminous crops, beans reach their highest development on limestone soils. Clay loams, if well drained, and sandy or gravelly loams if well supplied with humus and properly fertilized, will grow profitable crops of beans. Heavy clay and sandy soils are less suitable. Peaty soils are not desirable, as they produce a rank growth of vine that is subject to diseases and the ripening of the seeds is uneven. Land that will produce both good corn and good wheat will grow beans successfully, although the beans will not thrive on such heavy soils as will wheat nor on such light soils as will corn.

would grow there satisfactorily. Insects and other pests are more abundant, however, in the warmer localities and they interfere with the ripening of sound seed, and probably would render results with the field crop uncertain. The market-gareners of the South resort to northern-grown beans for seed because of the prevalence of the weevil in seed of their own production. It is probable that the effect of climate on the pests of the bean crop has more influence in limiting the area of production than has either soil or climate on the crop itself. Even within the limits of New York there are great differences in the destructiveness of the weevil. Beans grown in the northern counties are rarely affected by weevil, while those grown in the southern counties as rarely escape.

Place in rotation.—Beans do best on an inverted clover sod and usually are given this place in the rotation. A three-year rotation of clover, beans and wheat is practiced in a considerable part of the bean-growing section. Corn and potatoes are usually secondary to beans in these localities. When grown, they get a part of the clover sod and are often followed by beans, so that the rotation becomes one of four years. When beans are to be followed by winter wheat, the early-maturing varieties are preferred, as they are off the land early enough to permit thorough fitting of the soil for wheat. Late-maturing varieties are more frequently followed by some spring-sown crop, as oats.

Seed-bed.—Early plowing is essential to best results with beans. As the planting is not done till late spring at earliest, there is a tendency, owing to pressure of other work or to slackness, to delay plowing till near the time of planting, much to the disadvantage of the crop. As in the case of wheat and buckwheat, the land should be plowed five or six weeks before the time of planting and should receive frequent harrowings to bring it into the best possible condition. By this treatment a

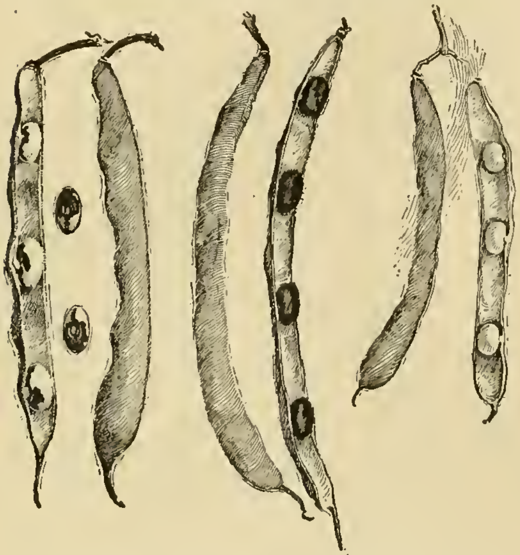

Fig. 297. Types of beans. Left, Yellow-eye; center, Black Turtle-soup; right, Boston Small Pea. (Reduced.)

larger quantity of moisture is held in the subsoil and becomes available for the crop later in the season. The weed seeds are also given a chance to germinate and to be killed before planting, so the after-tillage of the crop is less expensive. More frequently than otherwise the crop suffers for want of moisture at some period in its growth, and early plowing and thorough fitting are the best means of guarding against this contingency. Probably no one thing results in so much loss to bean-growers as late and hasty fitting of the land.

When grown on poor land, beans respond well to dressings of barnyard manure or of commercial fertilizer, though it is not a general practice to manure or fertilize the crop. In experiments conducted by the Cornell Experiment Station, it is indicated that applications of phosphoric acid are especially likely to prove profitable.

Seed.—The quantity of seed required per acre varies with the variety. Of the small varieties (Marrow Pea and Boston Small Pea), many growers plant one-half bushel per acre, although some secure better results with three pecks or even one bushel. Five or six pecks of Kidney beans are recommended, and intermediate amounts of other sorts, according to size.

Planting.—Beans are usually grown in drills. The distance between rows varies from twenty-four to thirty-two inches; it is usually twenty-eight inches. The ordinary grain drill is used almost exclusively for planting, by stopping the tubes that are not needed. Special bean planters are sometimes used in planting large-seeded varieties, as some of the grain drills will not handle these successfully.

The time of planting varies somewhat with the locality, but more especially with the variety of bean. The Kidney and Black Turtle-soup varieties require more time for development than the smaller beans and should be planted somewhat earlier. In New York, the Kidneys are usually planted in the last half of May, while the Pea and Medium varieties should be planted June 5 to 20. The Marrows and Yellow-eyes come intermediate.

Very early planting of beans is not to be recommended. If placed in soil too cold or too wet for quick germination the seeds rot quickly, and even if a fair stand is secured the young plants do not get an even start. The strongest and best seeds start first under these unfavorable conditions and a little later some of the weaker seeds grow, resulting in a stand of plants of unequal size and vigor. This uneven start results in uneven ripening at harvest time,—one of the troubles of the bean-grower. This trouble is not so likely to be met if the planting be deferred till the soil becomes warm and in a condition to favor rapid germination and vigorous growth.

Cultivation.—Beans come up quickly under favorable conditions, and cultivation may begin early. The young plants are tender and break easily at first, hence care is required in working among them. Some farmers use the weeder on the crop after the plants have formed several leaves, but this practice is of doubtful propriety, as any mutilation of the plants increases the liability to disease. Cultivators of various designs are used in the bean-fields; the ordinary one-horse hand-cultivator has been used chiefly in the past; but wheel tools cultivating two or more rows at a time are now in much favor. Tillage should be frequent enough to prevent weeds getting a foothold or a crust forming at the surface of the soil. Cultivation should not be given while the leaves are wet from dew or rain, as under these conditions disease spores are readily transferred from diseased to healthy plants.

Varieties of field beans.

There are grown in the states seven or eight distinct varieties of commercial beans and some of these have several sub-varieties. These varieties are quite distinct from the vegetable or garden sorts that are grown for the canning factories or for sale in the green state. They may be named as follows: the Pea varieties, including Marrow Pea bean, Boston Small Pea bean; Medium bean (with sub-varieties of Day Leafless Medium, Blue-pod Medium, Burlingame Medium and White Wonder); White Marrow (with sub-variety Vineless Marrow); Red Marrow (which is probably a sub-variety of

Red Kidney); Improved Yellow-eye, White Kidney, Red Kidney and Black Turtle-soup. The four varieties constituting the bulk of the beans produced in New York are the Pea beans, the Mediums, the Red Kidney and the White Marrows, and in the order named. The others are grown in limited quantities. The White Marrow, Yellow-eye, and Red and White Kidney varieties seem to require a stronger and more fertile soil to produce a satisfactory crop than do the Pea or Medium varieties. Data secured by the Cornell Station indicate that in their present state of fertility most New York soils will produce larger yields of the smaller white varieties than of the larger ones.

Harvesting.

Formerly beans were harvested by hand-labor, but now this work is done chiefly by machinery. The bean harvester or cutter (Fig. 302) is a two-wheeled machine, having two steel blades so adjusted that as the machine passes over the ground they sweep along just at or below the surface and cut the bean-stalks or pull them up. The blades are set obliquely, sloping backward and toward one another, so that the two rows of beans which are pulled at one time are moved toward one another and left in a single row. Soon after the beans are pulled, men pass along with forks, throwing them into small bunches; or they are made into bunches by the use of a horse-rake. After drying, perhaps for one day, the bunches are turned and so

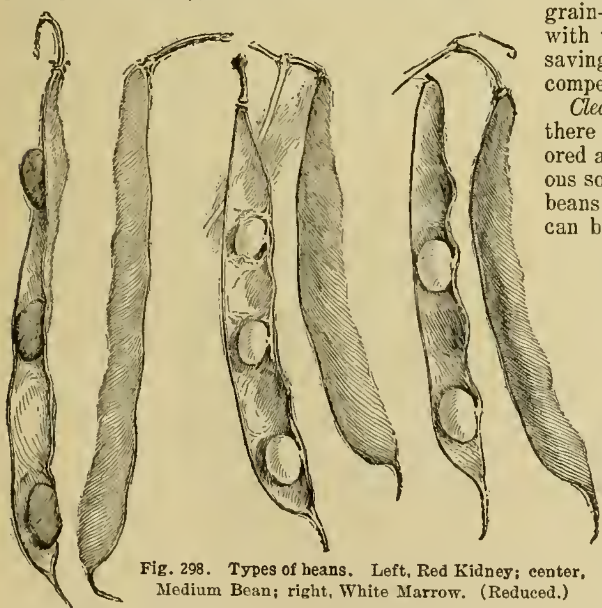

Fig. 298. Types of beans. Left, Red Kidney; center, Medium Bean; right, White Marrow. (Reduced.)

moved that three rows, as left by the puller, are made into one, leaving space between rows to drive through with wagons. If drying weather prevails, they will become fit for drawing and storing in the barns without further turning; but if the weather is unfavorable, the bunches must be turned frequently to prevent the beans in those pods resting on the ground becoming damaged. Wet weather does not injure the crop seriously

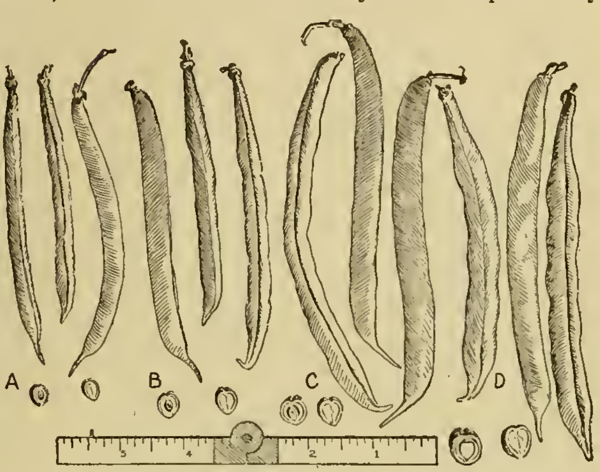

Fig. 299. A garden bean at various stages of development. A, first picking (for "string" beans); B, about half grown; C, about three-fourths grown; D, fully-grown pods.

providing the beans are not allowed to rest on the wet ground long at a time; but the frequent turning necessary to prevent their taking harm involves considerable labor. When dry, they are stored in barns like hay and may be threshed at convenience. The threshing is done by specially constructed machines much like the ordinary grain-thresher. Some growers prefer to thresh with the old-fashioned flail, maintaining that the saving in beans that otherwise would be split, compensates for the slower work.

Cleaning.—As the beans come from the threshers, there are among them more or less that are discolored and damaged, and also gravel and dirt of various sorts. This refuse must be removed before the beans are ready for market. Much of this work can be done by machinery, but some of it must be accomplished by hand-picking. Usually, beans going into market are "hand-picked," which means that practically every bean is perfect. The work of preparing the crop for market is now almost exclusively in the hands of the bean dealers. At many of the railway stations in the bean-growing sections are "bean-houses," usually the property of a local produce dealer who buys the crops of the locality. The farmer delivers his crop at the bean-house. It is sampled. The sample is weighed, picked and weighed again to determine the loss by picking. The farmer is usually paid for the estimated amount of picked beans which he delivers.

At the bean-houses the beans are run through special machines that remove much of the refuse and sometimes grade the beans according to size. The hand-picking is usually performed by women and girls. The work is much facilitated by a mechanical device which causes the beans, thinly spread on a movable canvas apron, to pass slowly in front of the picker, who has opportunity to see each bean and time to pick out the gravel and damaged beans. By means of a foot-lever the operator controls the movement of the apron and the rapidity of the flow of the beans, which are led by means of spouts from the storage room above. Some dealers arrange the work so as to keep ten to twenty persons employed throughout the year.

By-products.

Cull beans.—A by-product of the bean-houses are the damaged beans removed from the crop. These are mixed with more or less of gravel which the machines could not separate from the beans. These cull beans have a high feeding value, although the admixture of gravel interferes somewhat with their use. Sheep are fond of beans and will sort them out, leaving the gravel. Swine eat the cooked beans, and by stirring in water while cooking, the gravel falls to the bottom of the vessel and leaves the food practically free from it. Ground and mixed with other grains, the beans may be fed to cattle, and when the animals become accustomed to them they are apparently relished, although at first they are usually rejected. The presence of the gravel is especially objectionable when it is desired to grind the beans. Probably the best use of cull beans is for sheep and swine food, and for this purpose they have a higher value than farmers have usually assigned to them. It is important, however, that they be fed in connection with other more carbonaceous foods, as corn, instead of being made the exclusive diet, or the health of the animals may be impaired. Samples of cull beans from the bean-houses of New York have been analyzed by Cavanaugh and reported on as follows:

COMPOSITION OF CULL BEANS.

	Water	Protein	Fiber	Nitrogen-free extract	Fat	Ash	Refuse mostly gravel
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Cull beans	10.00	21.60	3.70	47.50	1.20	3.20	12.80

Bean-straw is also a by-product of considerable economic importance as forage. Sheep are fond of the pods and thrive on them. When fed to dairy cows they are productive of good results. Although if used freely there is a tendency to produce looseness of the bowels, a danger that should be guarded against. The digestible nutrients contained by bean-straw, as computed by Cavanaugh, are as follows:

DIGESTIBLE NUTRIENTS IN BEAN STRAW.

	Total dry matter	Protein	Carbohydrates + (fat x 2¼)	Total	Nutritive ratio
	Per cent	Per cent	Per cent	Per cent	Per cent
Bean straw	95.00	3.60	39.70	43.40	1 : 11.0

Diseases.

There are a number of diseases affecting the bean plant, each of which assumes considerable economic importance at times. The most destructive of these is the bean anthracnose (*Colletotrichum Lindemuthianum*, Fig. 58), though bean-blight (*Bacterium phaseoli*) also often causes considerable loss. In 1904 and 1905, these diseases, especially

Fig. 300. A garden bean with full crop.

the former, were very abundant and destructive in New York. The bean anthracnose occurs in almost every case as the result of planting diseased seed. If conditions are favorable it may develop rapidly, resulting in the destruction of the plant while still small; or under other conditions its progress may be so slow as to attract little attention till the pods are well formed, when it may appear as "pod-spot." The diseased seedlings may be recognized by the brown or black sunken spots or pits on the stems and cotyledons. The stem may become so diseased and weakened at the base as to fall over of its own weight. When the beans are affected after the leaves are well developed, these will show the disease chiefly on the under side along the veins, which become brownish and dead. The blade itself may often become affected. If the attack develops late in the season, it is on the pods that it becomes most characteristic and destructive. Here it forms large, dark brown sunken spots in the tissue of the pods. The spores of the fungus may often be seen as a tiny pink mass at the center of these spots or pits. The disease gradually works through the pods, and, attacking the seeds, forms pits or discolored places in them. When the seeds are dried the fungus becomes dormant, only to become active again the next season, when the diseased cotyledons are lifted above the soil on the growing stalks. Diseased seed usually may be recognized by the discolored areas on the coat and by the shriveled condition.

Weather conditions do not cause or originate bean anthracnose, but they have very much to do with its development and destructiveness. The spores are held together by a gummy substance which is easily dissolved in water, permitting them to be disseminated to healthy plants by means of insects, tools of tillage and in other ways. It is for this reason that tilling beans while wet with dew or rain almost always results in marked increase of anthracnose.

The treatment for anthracnose must be preventive rather than curative. Below are given what are now considered to be the best means of controlling this trouble:

(1) Plant clean seed. If possible, secure seed from fields known to be free from the anthracnose. If seed from diseased fields must be planted, it should be hand-sorted carefully, and all seeds not perfect and bright should be rejected.

(2) Go over the field just after the beans are up, and carefully remove and burn all diseased seedlings. If left on the ground they will serve as centers of infection for the growing plants.

Fig. 301. Bean plant in crop.

(3) Spray thoroughly with Bordeaux mixture. The normal strength should be used: 6 lbs. vitriol, 4 pounds lime, 50 to 60 gallons water. The addition of resin soap will add to the effectiveness of the mixture by making it spread more evenly, and it will be less easily washed off by rains (resin soap: 2 pounds resin, 1 pound crystallized salsoda, 2 quarts water; boil until a clear brown solution is secured). Add this to one barrel of the Bordeaux. Apply thoroughly with a nozzle giving a fine spray. The first application should be made just about the time the third leaf is expanding, or

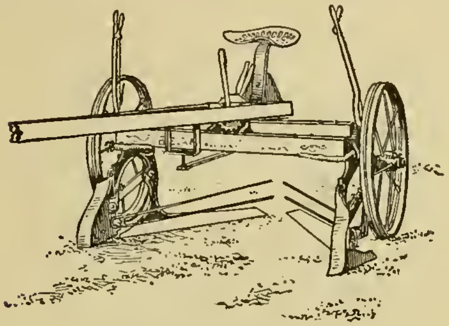

Fig. 302. Bean harvester.

earlier if the disease appears to any considerable extent. Repeat the application three or four times at intervals of ten to fourteen days or whenever the rains wash the Bordeaux off.

(4) Do not hoe or cultivate diseased beans when they are wet, as this will tend to spread the disease to healthy plants.

Insect enemies.

The most troublesome insect pest of the bean industry in localities where it abounds is the bean-weevil (*Bruchus obtectus*). The adult is a brown-gray beetle about an eighth of an inch in length. In the field, the eggs are deposited on or inserted in the pod through a hole made by the jaws of the female and through openings caused by the drying and splitting of the pods. In dried beans the eggs are dropped loosely among the beans or placed in the holes made by the beetles in their exit from the seed. The eggs hatch in five to twenty days, being much influenced by temperature. The young larvæ burrow into the beans and there undergo their transformations, emerging as mature beetles. The larval stage lasts eleven to forty-two days, and the pupal stage five to eighteen days, so that the life-cycle covers a period twenty-one to eighty days according to season and locality. Hence a number of generations are produced annually. In localities where these beetles abound the damage done to the mature beans is often such as to render them valueless for human food or for seed and of but little value for stock-feeding.

No effective means are known for the prevention of the attacks of the bean-weevil in the field; hence, we must place our chief reliance on the thorough destruction of the insects in the dried seed and perhaps not attempt the production of culinary dried beans in localities infested with the weevil. Fortunately the weevil seems not to have established itself in those parts of the United States where the dried-bean industry is most developed, which is the region bordering on the Saint Lawrence river and the Great Lakes. The northern counties of New York seem to be free from this pest, while in the southern counties the bean industry is practically excluded because of it.

The weevil in beans may be destroyed by the same methods employed in the case of pea-weevil, which see. If the infestation is but partial and treatment is resorted to immediately after harvest the seed may be preserved in satisfactory condition for planting.

Literature.

The following publications will be found helpful. The first three are concerned with the culture of beans and the remainder with bean enemies:— Transactions of New York Agricultural Society, 1895, p. 323; 1897, p. 323; Cornell University Experiment Station Bulletin No. 210; Report of New York State Department of Agriculture, Vol. 3, 1890, p. 49; Transactions New York State Agricultural Society, 1892, p. 238; Tenth Annual Report of New York State Experiment Station, Geneva, p. 23; Yearbook, United States Department of Agriculture, 1898, p. 233; Connecticut (New Haven) Experiment Station, 20th and 21st Reports, Part III, p. 189; Cornell University Experiment Station Bulletin No. 239.

BEAN, BROAD. *Vicia Faba*, Linn. (*Faba vulgaris*, Moench.) *Leguminosæ* (Windsor, Horse, English Dwarf or Scotch Bean). Figs. 303, 304.

By *John Fixter.*

The broad bean is grown for its grain or seed, which is used as food for man and for live-stock, and also for its herbage, which is used as fodder. It is a strong, erect annual, 2 to 4 feet tall, glabrous or nearly so, and very leafy; leaflets 2 to 6, the terminal one wanting or represented by a rudimentary tendril, oval to elliptic and obtuse or

Fig. 303. Flowers and leaf of the broad bean.

mucronate-pointed; flowers axillary, dull white and with a large blue-black spot; pods numerous, large and thick, two or three inches up to eighteen inches long; the seeds large and often flat.

This bean has been in cultivation since prehistoric times, and its nativity is in doubt. It is probably native to northern Africa and southwestern Asia. It is much grown in the Old World. In America its cultivation is restricted by our hot, dry summers and it is little grown outside of Canada. It is adapted in a measure to the northern Pacific coast country and to similar regions where the summer temperatures do not run high. It is particularly successful in the maritime provinces of Canada. The plant is hardy. Its culture has been spreading since the introduction of the silo.

Varieties.

The varieties of broad beans are numerous. It is of no value to recommend any special varieties, as local conditions largely determine which is profitable, and experience alone can direct the grower in his choice.

Culture.

Soils.—Broad beans will thrive on a wide range of soils, as long as they are rich, deep and well drained. It does best on clay loams. Immediately after the preceding crop is removed the land should be gang-plowed. In order to destroy all weeds, late summer and autumn cultivation should be given, if possible. Late in the fall the land is plowed deeply; and if there is a stiff subsoil, the subsoil plow should be employed. Just before planting in the spring, the land is given a thorough surface cultivation to destroy any weeds that may have started, and to make the seed-bed fine.

Manuring.—In the fall or spring, a dressing of barnyard manure is given, at the rate of twelve tons per acre. If the manuring is not performed until winter or early spring it will be necessary to plow the land again.

Seeding.—When grown for seed broad beans are commonly sown with a grain drill in rows twenty-eight to thirty-five inches apart. They may be hand planted. The plants should stand about two inches apart in the row. Forty to fifty pounds of seed per acre are required. When grown for silage, fodder or green-manure, it is best to sow in rows 21 inches apart. The plants will grow thicker but not mature so early, giving a heavier yield per acre. It will then be necessary to sow 50 to 60 pounds of seed per acre. The best time for planting in eastern Canada is May 15 to June 1.

Place in the rotation.—Broad beans usually come between two grain crops, but as they can make use of a liberal supply of humus they may profitably follow meadow or pasture. For the bean crop a field should generally be used that is in need of cleaning; and poor soils may be greatly benefited because of the nitrogen-gathering habit of the broad beans.

Subsequent care.—Just before the plants appear above the surface, a thorough harrowing should be given to destroy weeds. Care must be taken not to tear up the small bean plants. It is advisable to use a harrow that has short teeth, or teeth that slope backward. After the plants are up, frequent cultivations should be given until the plants meet in the rows.

Harvesting.—If the crop is to be used for silage, it should be cut when the grain is in the late dough stage, that is, just before it is ripe. When ensiled, one part of beans should be mixed with ten parts of corn. If the plants are grown for their seeds, the seeds or grain should be allowed thoroughly to ripen, when the plants may be cut with an ordinary corn harvester. A fair yield of beans is about thirty bushels to the acre. After threshing, care should be taken to see that the grain is thoroughly dry, otherwise it may heat in the storehouse.

Uses.

The broad bean has a diversity of uses,—the grain as food for man and stock, the fodder for silage and soiling, and the plant as a cover-crop and soil-renovator; and "coffee" may be made from the beans. The plant has been largely tested at some of the Canadian experimental farms, and is frequently mentioned in the reports of these experimental farms. In the report for 1904 (pp. 125, 126) is the following discussion of its use as a cover-crop:

"In the report for 1903, experiments on the use of the English horse bean and hairy vetch were described. It was shown that horse beans and hairy vetch sown in rows twenty-eight inches apart had given very satisfactory results. These were sown in this way because it is sometimes difficult to get a good 'stand' for a cover-crop in the autumn, by sowing about the middle of July and later, owing to the dry weather which often occurs after seeding, delaying the germination of the seed; and in the North it is very desirable to have the cover-crop tall, so that it will hold the snow. By sowing the seed in rows, it can be sown comparatively early, and the soil cultivated between the rows when the plants come up, thus conserving moisture and making sure of a good cover-crop. Cultivation may be discontinued about the middle of July or a little later. The horse beans sown on June 18, 1903, were three feet six inches to four feet in height on September 21, and it was estimated that the green crop per acre was 7 tons 733 pounds above ground and 2 tons 852 pounds of roots, or a total of 9 tons 1,585 pounds per acre, containing, according to the figures given by Mr. Frank T. Shutt, Chemist of the Experimental Farms, in his report for 1903, 78 pounds of nitrogen as compared with 130 pounds from mammoth red clover, and 147 pounds from hairy vetch. These beans stood up well all winter, holding the snow admirably, and by spring were still two to two and one-half feet in height. A land roller was put on as soon as the soil was in condition to work, and the beans were rolled down. The disk-harrow was then used and it was found that they broke up readily; they were then cultivated in with a spring-tooth cultivator. Owing to the coarse nature of the stems, they were noticed in the soil longer than clover or vetch, but in a comparatively short time they decayed and gave practically no trouble. Horse beans were again sown in drills, this year on June 16, and were three feet five inches in height when frozen. The advantage of horse beans is that they winter-kill and are easily worked under in the spring, while hairy vetch and clover are more difficult to deal with, and if left until late in the spring will take considerable moisture from the soil. The disadvantage of the horse bean is that there is no mat of vegetation close to the soil, and if there should be a winter without snow, it might not prove so effective as red clover or hairy vetch. In order to ensure a mat of vegetation which would cover the ground in winter, and which would be dead in the spring, rape was used in one part of the orchard, and it is thought that English horse beans and rape grown together will prove one of the most satisfactory cover-crops where they will succeed. The horse beans will furnish nitrogen and humus, and will hold the snow well; the rape will cover the ground, thus protecting the roots, and will also add humus. At Ottawa, horse beans sown in the last week of June, at the rate of one bushel per acre, in drills twenty-eight inches apart, and cultivated two or three times, and rape sown broadcast between the rows in the latter half of August, should furnish a very satisfactory combination. Both English horse beans and rape are moisture-loving plants, and will not succeed so well in dry soils as they will where there is a fair amount of moisture. When the hairy vetch is grown for seed, horse beans sown in drills at the same time as the vetch should prove very useful the following season in holding up the vines, thus insuring a larger crop of seed."

Fig. 304. Broad beans in the field.

In Canadian experiments with oats and barley after different crops, it was found that the broad bean is an excellent crop to use in the rotation. Many farms undoubtedly would be greatly benefited by growing this crop as a soil-restorer. Following is the yield per acre of oats grown after various crops, in comparison with the broad bean:

	Bus.	lbs.	Length of straw
After flax oats gave	49	14	40 to 45 in.
After grain oats gave	58	28	43 to 48 in.
After broad bean oats gave . .	69	14	46 to 50 in.
After soybean oats gave . . .	49	14	40 to 45 in.
After corn oats gave	52	32	40 to 45 in.
After millet oats gave	43	18	36 to 40 in.

The next year barley was grown on the same plots as the above, with the following results:

	Bus.	lbs.	Length of straw
After flax, 2 years previous, barley .	35		37 to 39 in.
After grain, 2 years previous, barley .	39	8	36 to 38 in.
After broad bean, 2 years previous, barley	40		38 to 40 in.
After soybean, 2 years previous, barley	31	32	33 to 35 in.

BEGGARWEED. *Desmodium tortuosum*, D. C. *Leguminosæ*. (The name *Meibomia* is now often substituted for *Desmodium*.) Giant Beggarweed, Florida Clover. Figs. 305, 306, 307.

By *H. Harold Hume.*

A strong, upright, branched annual, grown far South for hay, forage and cover-crop, reaching a height of six to eight feet, with broad, trifoliolate leaves and small inconspicuous flowers in panicled racemes. The seeds are small, yellowish, flattened, and resemble red clover in weight, and in size, shape and color; they are borne in hispid, jointed pods, which break apart at maturity and cling to the coats of animals or clothing of persons. It is closely related to the beggar-lice of the North. Beggarweed is a leguminous plant, in its general value and characteristics resembling the clovers. Most plants of this genus are weeds, this particular one being the only species grown as a cultivated crop. It is found as a native plant in the West Indies, and throughout northern Florida and southern Georgia, while in cultivation it is found all over Florida and elsewhere in the southern states.

Culture.

The seed is slow in starting, usually not germinating until June, and unless the land is cultivated early in the season to destroy weeds of different kinds, it may be crowded out. The seeding should not be done till the ground is warm and moist. When seeding is resorted to on new land, seed with the hulls still attached is preferable, as the pods, because of the adhering dust, carry the necessary bacterial inoculation with them; otherwise, the clean seed is preferable to the pods, because of the more uniform germination. Ten to twelve pounds of seed, sown broadcast, are required per acre. When grown for seed, five or six pounds of clean seed per acre is sufficient. When the stand is thick, the plants produce single stems. When growing apart from each other, they are much branched, stout and coarse. Hence, to produce the best quality of hay, a liberal amount of seed should be used. The seed must not be buried deeply, and need not be covered at all if planted at the beginning of the summer rains.

As a hay crop, it succeeds best on land containing a considerable amount of moisture. On high, dry lands it may also be grown, but the yield is not so heavy as on the lower lands. When once well established, but little care is needed to secure a crop from year to year. It re-seeds itself without fail, and will continue to occupy a piece of ground unless destroyed by cultivation, or close cutting, whereby seed development is prevented. When, for any reason, it is desired to remove the crop from a piece of land, this may be easily accomplished by cutting sufficiently late to prevent seed formation, and by cultivating during the time the young plants are coming up.

Place in the rotation.

Beggarweed fits well into the rotation with farm crops. In corn lands it may be allowed to grow after the corn is laid by, the early cultivation of the corn crop interfering in no way with the after crop of beggarweed. An excellent rotation in many sections is: First year, corn and beggarweed; second year, cotton; third year, beggarweed.

Harvesting.

The beggarweed crop may be cut twice during the summer. The cuttings should be made just as the plants begin to bloom, when they should be three or four feet high. The second crop is produced from buds on the stubble left after the first cutting, and should be cut at the same

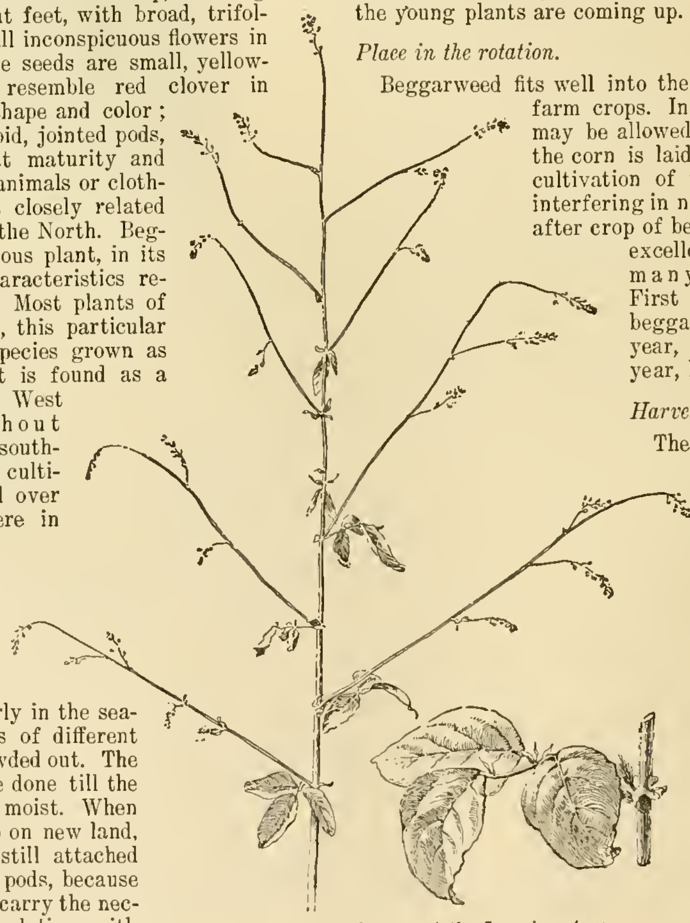

Fig. 305. Beggarweed spray at the flowering stage.

stage. After this, the crop should not be molested, but should be allowed to grow at will, bloom, and produce seed for the next season. The second cutting should not be made too late, else the third growth may not have sufficient time to mature seed before the November frosts destroy the plants ; and if it is cut after full bloom, there will be considerable loss, due to the falling of the lower leaves. Fair yields are one ton per acre for each cutting, though not uncommonly the two cuttings will make four to six tons. The hay is easily cured by the ordinary methods of handling.

Fig. 306. Beggarweed.

Uses.

As a cover-crop.—As a cover-crop for orchards in sections where it will succeed, beggarweed has no superior. It is a vigorous grower, a good nitrogen-gatherer and is free from the nematode worms which produce root-knot. For the last reason it is particularly desirable as a cover-crop for peaches, figs and other fruits susceptible to injury from nematodes, and its self-sowing habit makes it cheap.

Fig. 307. Field of beggarweed.

As a forage.—Beggarweed is rich in protein and makes a good quality of forage, relished by farm stock. Its nutritive ratio is about the same as that of red clover. It is most effectual when fed with a coarse forage rather strong in carbohydrates.

BERSEEM. *Trifolium Alexandrinum,* Linn. *Leguminosæ.* Known also as Egyptian clover. Fig. 308.

By *V. A. Clark.*

An annual, clover-like forage plant recently introduced from Egypt and now being grown experimentally in the United States, especially in the irrigated Southwest. Its particular recommendations are rapid growth, adaptability to alkali lands and usefulness in reclaiming them, high rank as a nitrogen-gatherer, unusual food value and conditioning properties, exceptional succulence, palatability and heavy yield. Berseem is the basis of Egyptian agriculture, both by reason of its instrumentality in the reclamation of alkali land and of its almost universal use as forage. The plant is two to five feet tall, according to variety, heads whitish, intermediate in size and shape between common red and white clovers. Muscowi, Fachl and Saida are the principal varieties, distinct in form and cultural adaptations. Muscowi is the rankest grower.

Fig. 308. Berseem heads (*Trifolium Alexandrinum*).

There is not yet experience enough with berseem in the United States to warrant definite cultural directions. Naturally wet land, even that on which water stands a part of the time, is best. The seed is broadcasted at fifteen to twenty pounds per acre and harrowed in lightly, as for alfalfa or clover. November plantings have been most successful in avoiding winter-killing in southern Arizona, the plants being one-half to one inch high when the first frost comes. One cutting is secured in April and one in May, after which the plant succumbs to increasing heat. Frequent irrigation is required. Harvesting is the same as for alfalfa or clover.

The principal American literature to date is the United States Department of Agriculture, Bureau of Plant Industry Bulletin, No. 23. (See also *Trifolium Alexandrinum,* under *Clover;* also, page 79.)

BROOM-CORN. *Andropogon Sorghum,* Brot. var. *technicus* (*Sorghum vulgare,* Pers. var.) *Gramineæ.* Fig. 309.

By *C. W. Warburton.*

Broom-corn belongs to the grass family and to the same species as sorghum, kafir corn and Jerusalem corn. It differs from other varieties of the species in having the seeds borne in panicles with long, straight branches. The seed-head or panicle, known to growers and manufacturers as "brush," is the valuable part of the plant and is used for the manufacture of brooms of all kinds. There are two groups of broom-corn, the standard and the dwarf, varying only in height of plant and character of brush. The standard grows ten to fifteen feet in height, with a brush eighteen to thirty inches long; the dwarf grows but four to six feet tall, with a brush one to two feet long. The dwarf broom-corn is used most largely in the production of whisk and other small brooms, while the stronger brush of the standard type is used in carpet brooms. Many varietal names are given both dwarf and standard types; they differ but little, however, and in reality but the two types are grown.

Fig. 309. Standard or tall broom-corn.

Area of cultivation.

One essential in the production of broom-corn of good quality is dry, clear weather when the brush is maturing and during the harvest season. Rain at this time causes discoloration of the brush and a consequent deterioration in value. For this reason, the central Mississippi valley and the plains of Kansas, Oklahoma and the Panhandle of Texas are best adapted to the growing of this crop. The regions of greatest production are central Illinois, central Kansas and western Oklahoma, Illinois growing the standard sorts and Kansas and Oklahoma the dwarf varieties.

Culture.

With proper climatic conditions, any soil which will produce good corn is adapted to broom-corn. To secure a crop of uniform quality, it is essential that the land should be uniform. As the plants grow slowly at first, the field should be in good tilth and as free from weeds as possible.

The land should be prepared as for corn, but planting should be delayed until the soil is thoroughly warmed. In the sections where broom-corn is largely grown, the planting season includes May and the first half of June. The rows of standard broom-corn should be three and one-half feet apart, and of the dwarf sorts three feet, with the plants three or four inches apart in the drill. About two quarts of seed are required to sow an acre. Planting may be done with an ordinary corn-planter, using sorghum plates, or with a grain drill having part of the holes covered. Cultivation should be frequent and shallow, using the harrow or weeder early in the season and any of the shallow-running cultivators later.

Harvesting and handling.

To secure the best quality of brush, the harvesting should be done about the close of the blooming period. The brush becomes stiff and brittle if the seed is allowed to ripen, and is greatly reduced in value. Dwarf broom-corn is usually harvested by pulling the heads by hand, leaving a foot or more of the stalk attached. Standard broom-corn, because of its height, must be "tabled" before harvesting. This "tabling" consists in bending the stalks of adjacent rows at a height of about three feet diagonally across the space between the rows, so that the seed-heads of each row extend about two feet beyond the adjoining one, and are in position for cutting. The stalks are then cut a few inches below the head and the heads laid on the tables thus formed, in position for hauling.

After the brush has been cut or pulled, it is hauled to the drying sheds where it is sorted and threshed. Sorting is simply the separation of coarse or knotty brush from the uniform straight heads; when the crop is grown on a small scale, the seed may be removed by "scraping" by hand; when largely grown, the brush should be cleaned with a broom-corn thresher. After threshing, the brush should be dried so as to maintain its uniform green color. Rapid drying without direct sunlight is necessary to accomplish this result, open sheds usually being used for the purpose. After the brush is thoroughly dried it should be baled, the bales weighing 300 to 400 pounds. The crop is then ready for the market. In sections where the crop is largely produced, buyers are usually on hand to purchase it; elsewhere, communications should be addressed to large users of the crop for quotations. The price varies with the quality of the crop and the production, usually running from $50 to $100 per ton. An acre of dwarf broom-corn should produce at least 400 pounds of brush; an acre of standard 600 to 700 pounds.

As special equipment for the handling of this crop is needed in the matter of drying sheds, thresher and baler, as well as a considerable force at harvest-time, the business of growing it should be a fairly permanent one, and farmers are not justified in growing broom-corn for a single year only.

Literature.

Farmers' Bulletin No. 174 of the United States Department of Agriculture, "Broom-Corn," by C. P. Hartley, gives very concise treatment of this crop. Several experiment station publications have also been devoted to it. For further account of broom-corn in its botanical relations, see the article on *Sorghum*.

BUCKWHEAT. *Fagopyrum esculentum*, Mœnch and *F. Tataricum*, Gærtn. *Polygonaceæ.* Figs. 310–314.

By *J. L. Stone.*

The true or common buckwheat is of one species, *Fagopyrum esculentum*, Figs. 310, 311 (*F. emarginatum* is a variant form characterized by a notched akene), but the India-wheat (*F. Tataricum*), Fig. 313, is sometimes known as buckwheat. The buckwheat is an annual, grown for the flour that is made from the contents of the 3-cornered akene, native of Europe and northern Asia. Leaves triangular or hastate in outline; flowers white, fragrant, in dense terminal panicles or clustered racemes.

Buckwheat is of erect habit, under ordinary conditions attaining about three feet in height. The root system consists of one primary root and several branches, the former extending well downward to reach moist earth; but the total development of roots is not large. The stem varies from one-fourth to five-eighths of an inch in diameter and from green to purplish red in color while fresh, changing to brown at maturity.

Only one stem is produced from each seed; the plant, instead of tillering or producing suckers, branches more or less freely, depending on the thickness of seeding. It thus adapts itself to its environment even more completely than the cereals which tiller freely. The leaves are alternate, triangular-heart-shaped, slightly longer than broad, varying from two to four inches in length, and borne on a petiole varying from very short to four inches in length. The flowers are white, tinged with red or pink, and are borne on the end of the stem or on a slender peduncle springing from the axil of the leaves. They are without petals, but the parts of the calyx have the appearance of petals and the bloom is so abundant that fields of buckwheat make a beautiful appearance. There are eight stamens and one three-parted pistil. On threshing the ripened grain, the calyx remains attached at the base of the seed. Two forms of flowers are produced: one with long stamens and short styles, and the other with short stamens and long styles. Though each plant bears but one form of flower, the seeds from either form will produce plants bearing both forms. This arrangement is thought to facilitate crossing by means of insect visitation. The grain of buckwheat consists of a single seed enclosed in a pericarp which in botany is known as an akene. The pericarp or hull is thick, hard, smooth and shining, and varies in color from a silver gray to a brown or black. It separates readily from its contents. In form the grain is a triangular pyramid with a rounded base. The usual length of the grain is three-sixteenths to three-eighths of an inch, and the width one-eighth to three-sixteenths of an inch. In states of chief production the legal weight of buckwheat is forty-eight pounds per bushel. In some others it varies from forty to fifty-six pounds.

The name "buckwheat" seems to be a corruption of the German *buchweisen*, meaning beech-wheat, a name given to the plant because of the shape of the seeds, being similar to that of the beech-nut, while their food constituents are similar to those of wheat grains. Botanically, buckwheat is not a cereal, but since its seeds serve the same purposes as the cereal grains it is usually classed in market reports among the cereals. The family to which buckwheat belongs (Polygonaceæ) includes several well-known troublesome weeds, as sorrel and dock (Rumex) and smartweed, knotweed and bindweed (Polygonum).

Fig. 310. Plan of buckwheat blossom (*Fagopyrum esculentum*). Enlarged.

The notch-seeded buckwheat (*Fagopyrum emarginatum*, no doubt only a form of *F. esculentum*) is not known to have been grown in this country but is reported as cultivated in India and China. It is distinguished by having the angles of the hull extended into wide margins or wings.

The Tartary buckwheat or India-wheat (*Fagopyrum Tataricum*, Figs. 312, 313) is cultivated in the cooler and more mountainous regions of Asia and to some extent in Canada and Maine. It is recommended for superior hardiness. It has been tried in Pennsylvania but without satisfactory results. The grain is smaller than the common buckwheat, the plants are more slender and the leaves arrow-shaped. The flowers are small and greenish and are borne in axillary mostly simple racemes along the stem, so that a field of it does not have the white and floriferous appearance that a field of buckwheat does. It is earlier than common buckwheat. It has been sold as duckwheat.

The common buckwheat is the most valuable and the most widely grown form. It is met with wild in China and Siberia and enters into the agriculture of every country where grain crops are cultivated. In China it has been grown and used for food from time immemorial. In Japan it is held in general esteem and in Russia it is also largely consumed. It has been cultivated for centuries in England, France, Spain, Italy and Germany. In all the European countries it is consumed chiefly by the poorer classes, but it has remained for the American housewife to learn how to prepare it so as to please the palate of the epicure. The buckwheat pancake is a peculiarly American preparation. Formerly, buckwheat constituted the major part of the bread diet of the greater part of the rural population of the New England and Middle States in the winter season. It has now won its way to the breakfast-table of the city resident as well, and when served hot with maple syrup it is considered the peer of the finest productions of the French chef. In some persons, buckwheat tends to produce irritation of the skin when freely eaten.

Fig. 311. Buckwheat (*Fagopyrum esculentum*).

Composition.

The following table, compiled by Hunt, shows the composition of the grain, straw, flour, middlings and hulls of buckwheat:

	Grain	Straw	Flour	Middlings	Hulls
Number of analyses . . .	8.0	3.0	4.0	6.0	3.0
Water	12.6	9.9	14.6	12.7	10.1
Ash.	2.0	5.5	1.0	5.1	2.0
Protein (N x 6.25) . . .	10.0	5.2	6.9	28.1	4.8
Crude fiber	8.7	43.0	.3	4.2	44.7
Nitrogen-free extract . .	64.5	35.1	75.8	42.4	37.7
Fat	2.2	1.3	1.4	7.6	.9

Owing to its thick, heavy hull, buckwheat contains a larger percentage of crude fiber than the cereal grains. The percentage of protein and nitrogen-free extract is somewhat lower than in the case of wheat. Buckwheat flour contains only about two-thirds as much protein as wheat flour. The straw of buckwheat contains a somewhat higher percentage of protein and crude fiber and a lower percentage of nitrogen-free extract than wheat straw. Buckwheat middlings, because of its high percentage of protein and fat, is in great demand as a food for dairy cows. The hulls are so hard and indigestible that they are not often used for animal food, although the analysis would suggest that they have some feeding value.

Production.

The high-water mark in the production of buckwheat in the United States seems to have been reached in 1866, when the crop, as reported by the United States Department of Agriculture, was 22,791,839 bushels. The average crop for the five years, 1866 to 1870, was 18,257,428 bushels. The average yield for the five years, 1901 to 1905, was 14,898,361 bushels. While the total production in the United States has not equaled in recent years that of the sixties, the crop in the states of chief production has increased in volume. New York and Pennsylvania now produce more than two-thirds of the total crop of the United States. Maine, Michigan, Wisconsin, West Virginia, North Carolina, New Jersey and Massachusetts, ranking in the order named, produce the major part of the other third. The acreage of buckwheat in the Dominion of Canada in 1901 was 261,726; the bushels, 4,547,159.

Fig. 312. Seeds of buckwheat and India-wheat. Left, *Fagopyrum esculentum*; right, *F. Tataricum*. Seed of *F. Tataricum* is smaller and has a wrinkled surface and wavy edges.

Culture.

Climate.—A moist, cool climate is most favorable for buckwheat, although seeds will germinate in a very dry soil, and considerable heat during the early stages of growth is an advantage. High temperatures during the period of seed formation, especially hot sunshine following showers, is usually disastrous to the yield, causing blasting of the flowers. The same effect is attributed to strong east winds. The yield is much reduced by drought during this period. Buckwheat will mature in a shorter period than any other grain crop, eight or ten weeks being sufficient under favorable conditions. It is thus well adapted to high altitudes and short seasons, but its period of growth must be free from frosts, as the plants are very sensitive to them.

Fig. 313. India-wheat or duckwheat (*Fagopyrum Tataricum*).

Soils. — Buckwheat will grow on a wide range of soils, but those of a rather light, well-drained character are best suited. It will give fair yields on soils too poor or too badly tilled to produce most other crops, and seems to be less affected by soil than by season. It is not desirable, however, to attempt to grow buckwheat on very rich land, as under such conditions the crop frequently lodges badly with results even more serious than occur when other grain crops go down, as the plant has no method of rising again. This ability to produce fair crops on poor soils and under indifferent cultivation has led to buckwheat being often considered the poor farmer's crop and to poor and unskilled farmers being dubbed "buckwheaters." The crop lends itself well to the farmer who lacks capital to secure timely labor or to wait for returns on investments in tillage and fertilizer. It may be planted after the rush of spring work is over; it may be resorted to as a substitute for spring crops or meadows that have failed, and it brings quick return for investment in fertilizer. Buckwheat responds to more generous and intelligent treatment and deserves to be held in higher esteem than it usually enjoys.

Fertilizing.— Stable manure is not usually applied to land intended for buckwheat, but is reserved for more exacting crops. Moderate applications of manure, however, on poor soils result in largely increased yields. When grown on poor land, buckwheat responds well to moderate dressings of even low-grade fertilizers, and many farmers who do not use fertilizers on other crops find it profitable to buy for this. In experiments conducted at the Cornell Experiment Station on rather heavy soil, but in a state of fertility to produce a fair crop without fertilizing, applications of acid rock, dried blood and muriate of potash produced uncertain and somewhat contradictory results.

Seed-bed. — Since buckwheat is not usually planted till the last of June, owing to pressure of other work or to shiftlessness, the land too often is not plowed till just before seeding and then receives hasty and indifferent fitting. This allows little time for sods and other organic matter to decay and become incorporated with the soil, and capillarity is not reëstablished between the subsoil and the seed-bed. Under these conditions the development of the crop is slow, and if drought ensues disaster is the result. Early plowing of the land, so as to allow of several harrowings at intervals of two weeks and a thorough settling of the soil, nearly insures the maximum crop the land is capable of producing. If early plowing is impracticable, then greater attention should be given to thorough fitting of the seed-bed.

Seed and seeding.—The amount of seed used per acre varies from three to five pecks, but is usually four pecks. It may be sown with the ordinary grain drill or broadcasted and harrowed in.

The time of seeding varies in different localities; in New York and Pennsylvania it is the last week in June or the first week in July. To avoid hot weather while the grain is forming, it is desirable to sow as late as possible and have the crop well developed before severe frosts occur. Buckwheat begins to bloom before the plants have nearly reached full growth and continues to bloom till stopped by frost or the harvest. Hence there will be at harvest time on the same plants mature and immature grain and flowers. It is sought to cut the crop just before the first hard frost. Much of the immature grain will ripen while lying in the swath or gavel.

Harvesting. — Buckwheat is rarely harvested with the self-binder, but may be cut with the hand cradle or the dropper-reaper. To avoid the shelling and loss of the more mature grains, it is preferably cut early in the morning, while damp from dew or during damp, cloudy weather. It is usually allowed to lie a few days in swath or gavel, when it is set up in small independent shocks or stooks. It is not bound tightly by bands like most cereal grains, but the tops of the shocks are held together by a few stems being twisted around in a way peculiar to the crop. This setting up is also usually done when the crop is damp, to avoid shelling of the grain. The unthreshed crop is not often stored in barns or stacked but is threshed direct from the field. Formerly much of the threshing was done with the hand flail, in which case it was necessary that the work be done on a dry, airy day, so that the grain would shell easily. If threshed by machinery neither crop nor day need be so dry, and it is usual to remove from the thresher the spiked concave and put in its place a smooth one, or a suitable piece of hardwood plank. This is to avoid cracking the grain and unnecessarily breaking the straw. The pedicels bearing the seeds are slender, and these as well as the straw, when dry, are

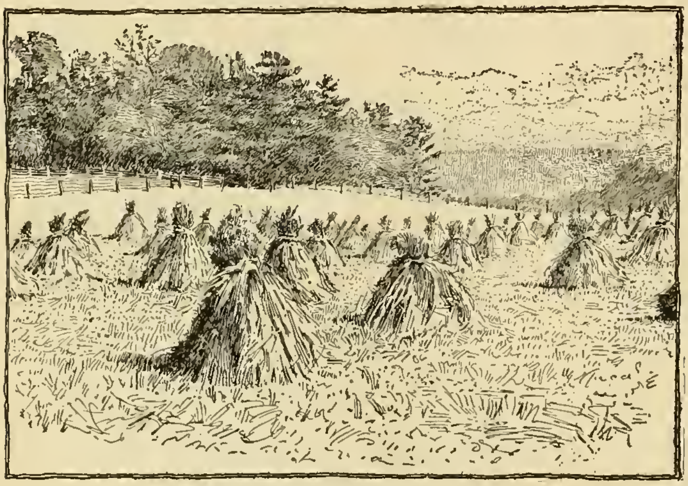

Fig. 314. Buckwheat in the shock.

brittle, so that buckwheat threshes much easier than the cereals.

Place in the rotation.—Buckwheat generally has no definite place assigned it in the rotation of crops. This is chiefly due to its being resorted to as a substitute for meadow or spring-planted crops that have failed. The poorer lands and the leftover fields are usually sown to buckwheat. While buckwheat seems not to be materially affected by the crop that precedes it, on the other hand it is reported unfavorably to affect certain crops when they follow it. Oats and corn are said by many to be less successful after buckwheat than after other crops. That this is so has not been established by any experiment station. Buckwheat leaves the soil in a peculiarly mellow, ashy condition. In the case of rather heavy soils on which it is desired to grow potatoes this is a decided benefit, and in some localities the practice of preceding potatoes by buckwheat, for the purpose of securing this effect, has become common. The following rotation is sometimes recommended for such soils : clover, buckwheat, potatoes, oats or wheat with clover-seeding. The first crop of clover is harvested early and the land immediately plowed and sown to buckwheat as a preparation for potatoes.

Varieties.

There are three principal varieties of buckwheat grown in America : the common Gray, Silver-hull and Japanese. The Silver-hull is slightly smaller than the common Gray ; the color is lighter and of a glossy, silvery appearance. The Japanese is larger than the Gray and of somewhat darker color, and there is a tendency for the angles or edges of the hull to extend into a wing, making the faces of the grain more concave. The plant of the Japanese variety is a somewhat larger grower than the others and the flowers seem not to be so subject to blasting from hot sunshine. For this reason it is recommended in some localities to sow the Silver-hull and Japanese varieties mixed, it being asserted that the hardier Japanese variety will shade and protect the other from the hot sunshine, thus avoiding blasting and securing a larger zone of seed-bearing straw than is furnished by either sort alone, a larger yield resulting.

Each of these varieties has produced largest yield in certain tests. It seems that there is an adaptation of variety to soil or climate, or, perhaps, to weather conditions, that has not yet been worked out, which produces these contradictory results. However, the yielding quality of the Japanese variety is usually conceded to be superior to the others. Formerly, the flouring qualities of this variety were pronounced by many millers to be inferior to the other sorts, and not infrequently the price of Japanese buckwheat was five or ten cents per bushel less than the others. In some localities this condition still prevails ; in others the reverse is true. In parts of Seneca county, N. Y., in recent seasons the millers have offered an advance of five cents per bushel for the Japanese variety. Whether this results from change in the quality of the grain due to acclimatization or to better adaptation of the milling methods to the variety has not been ascertained.

Uses.

Formerly a considerable part of the buckwheat was used for animal food, only enough flour being manufactured to meet the requirements of the rural districts during the winter season. Of late, the demand for the flour in the cities has been such that most of the grain is ground for flour and less of the flour is consumed in the rural districts.

Buckwheat flour is whiter than that made from wheat and has a peculiar mealy feel to the hand that enables one readily to distinguish it from wheat flour. The first flour on the market after harvest brings a high price, but the price rapidly declines as the supply increases. The grain must be well dried and the grinding done in cool, dry weather to get best results in milling. The yield of flour per bushel of buckwheat is usually about twenty-five pounds, though twenty-eight or more may be secured if the grain is plump and very dry. The middlings, a by-product of the flouring process, is much sought by dairymen as food for dairy cows because of its high content of protein. The hulls have little or no value. Sometimes they are ground and used as an adulterant for black pepper.

Buckwheat grain is much relished by poultry and has the reputation of being of special value in egg production. In recent feeding experiments this reputation is scarcely sustained.

Buckwheat is also a well-known honey plant (see Vol. III).

Enemies.

The buckwheat crop is unusually free from interference from weeds or plant diseases. It starts so quickly and grows so rapidly that most weeds get no chance to make headway against it. In fact, buckwheat is one of the best crops for cleaning land by smothering out weed growths. Wild birds as well as domestic are fond of the grain, and, when abundant, sometimes cause considerable loss. No insect or fungous troubles have been sufficiently destructive to attract much attention.

Literalure.

The literature on buckwheat is meager. A few of the experiment stations have bulletins on the subject, and discussions have been published in the Yearbooks of the United States Department of Agriculture, and in the agricultural press, notably, the Country Gentleman. The three publications following devote some space to buckwheat: Hunt, Cereals in America, pp. 400–410; Wilson, Our Farm Crops, London, Vol. 1, pp. 188–196; Cornell Bulletin, No. 238.

such plants our common headed cabbage (*Brassica oleracea*, var. *capitata*, DC.) has been derived; others bear small cabbages in the axils of leaves and from such the Brussels sprout (*Brassica oleracea*, var. *gemmifera*, Hort.) has arisen. The leaves of the wild plant are bluish green, fleshy and hairless like those of the cultivated cabbage, and either entire or indented in outline. The latter character apparently has been developed to a marked degree in our kale (*Brassica oleracea*, var. *acephala*, DC.), of which there are so many forms; other wild plants show the blistered leaf which is seen in such an exaggerated form in the Savoy cabbage (*Brassica oleracea*, var. *bullala*, DC.) and also in the Brussels sprout. The leaves of the wild plant are normally green, but they become red or purple by exposure to the sun or when old and diseased; by selection we have developed the reddish or purple color as a permanent character in all the forms. Finally, the flower has been modified. In the wild plant the flowers are borne on stalks much like a large wild carrot, some of the stalks being long and others short. By selection of plants in which the flower-stalks had a tendency to become thickened and shortened, the cauliflower and broccoli (*Brassica oleracea*, var. *botrytis*, DC.) probably were produced, the former from a thick-ribbed smooth-leaved form, and the latter from a thin-ribbed form.

The wild cabbage has been used as food from time immemorial. The head cabbage was developed in northern Europe, where it has long been grown. The headless forms were early grown in southern Europe. Climatic conditions seem to have contributed in deciding this division of types. The bulk of

Fig. 315. Cabbage shapes. Left, flat; left center, round or ball; center, egg-shaped; right center, oval; right, conical.

the crop in the United States is grown in the North; although early cabbages for spring consumption are grown in large quantities, in the winter, in the southern states, as also the collard, a headless type.

De Candolle (Trans. Hort. Soc. London, Vol. 5, 1–43; Prodr. 1.213) grouped the descendants of the wild cabbage under six heads:

- *Brassica oleracea acephala*, the kales, thousand-headed cabbage, etc.
- *Brassica oleracea capitata*, the headed cabbage or common cabbage.
- *Brassica oleracea bullata*, the Savoy cabbage.
- *Brassica caulorapa*, kohlrabi.
- *Brassica oleracea gemmifera*, the Brussels sprouts.
- *Brassica oleracea bolrytis*, the cauliflower and broccoli.

CABBAGE FOR STOCK-FEEDING. *Brassica oleracea*, Linn. *Cruciferæ*. Figs. 315–317.

By *Samuel Fraser.*

Cabbage is a name at present applied to a large group of plants. The wild cabbage (*Brassica oleracea*, var. *sylvestris*) is looked on as the prototype of these species. It occurs wild in Europe, on the coast of England. It has a crooked, half-ligneous, branching stalk, is perennial and bears seed when two, three or four years old. The stalks may be three to four inches in diameter and may bear green, herbaceous, cylindrical branches. Looking at this plant and at kohlrabi (*Brassica caulorapa*) it is easy to see that the latter is not distantly removed from the cabbage. Some of the wild plants bear small heads at the summit of the stem, and from

The first four groups are grown for stock-feeding as well as for human consumption. The last two are grown exclusively for table use.

Cabbages have been cultivated from time immemorial for human food. The Greek writers do not mention the head cabbage, but Columella and Pliny do, although it is believed that they referred to some soft-headed form. The hard-headed form was in use in England in the fourteenth century, and is mentioned as a New England product in the poem attributed to Governor Bradford, written in 1656.

Composition.

The average composition usually given for cabbages is water 90.5 per cent and dry matter 9.5 per cent. In twenty-two analyses of five varieties made at Cornell University during 1904–1906, the average dry matter content varied between 5.74 and 8.42 per cent, an average considerably below that usually given. The content of protein is high, the 9.5 per cent of dry matter being made up of ash 1.4 per cent, protein 2.4 per cent, crude fiber 1.5 per cent, nitrogen-free extract 3.9 per cent, ether extract 0.4 per cent.

Propagation and cultivation.

The plant may be grown successfully on any soil that is in good condition. It is a gross feeder, and care must be taken to supply it with an abundant but not excessive supply of moisture and to keep the land well stirred. Rich, heavy loams are to be preferred for the production of heavy yields

Fig. 316. Types of cabbage heads. Left, compact head; right, loose head.

for cattle-feeding. Deep fall-plowing is advisable, and the land should be loose, friable and moist; an application of ten to twenty tons of manure per acre may be made in the fall before plowing, and this may be supplemented by fertilizers, and, if the land has not been limed recently, by an application at the rate of 1,000 pounds of quicklime per acre, to be applied in the spring and harrowed in. Manure, lime and fertilizers should be uniformly applied. Frequently, fertilizers are applied at the rate of 400 to 800 pounds of acid phosphate (16 per cent available) or its equivalent, i. e., 60 to 130 pounds of phosphoric acid; 100 to 150 pounds of muriate of potash; fifty pounds of nitrate of soda per acre, in spring and harrowed in; and about 150 pounds of nitrate of soda per acre, applied to the plants when they are growing, in three applications of about fifty pounds each at intervals of ten days, beginning as soon as they are about four inches tall. This pushes them through the critical period when their leaf surface is small and when a single green worm is able to eat a plant in a day.

The seed is sometimes treated by dipping it in a solution of formalin of the strength of 1 to 240 in order to destroy the spores of black-rot. It is then dried and sown. The seeds may be sown in a bed and transplanted with a transplanting machine; or they may be sown where the plants are to stand. Both methods are successful. In the latter case, one to one and a half pounds of seed is required per acre; in the former, less seed is used, say one-fourth to three-fourths pound. A drill, which will drop four or five seeds twenty-seven or thirty inches apart in rows is needed. In this case the plants will be thinned to one plant as soon as three inches tall. For New York, sowing early in May is advisable, although later sowing may give smaller heads which will keep better in storage; but there will be a correspondingly diminished yield.

No crop responds better to good tillage, and if this be given every seven or ten days and the small applications of nitrate of soda, already mentioned, be harrowed in, the plants will soon meet in the rows; then tillage ceases. For success, it is essential that there be a good plant in every place; 7,500 to 9,000 plants should be grown per acre. Rows thirty inches apart seem to be convenient, the plants being twenty-four to thirty inches apart in the row. Cabbages may be grown in the place of corn or any other intertilled crop in the rotation.

Varieties.

Some of the best varieties for stock-feeding purposes are: Surehead and Autumn King (both of which mature in September when sown in May, and must then be used); Volga, a new Russian variety of merit; Drumhead or Flat Dutch, a standard variety. Danish Ballhead and Hollander give rather lower yields but are considered better for storage.

The varieties may be classified according to shape (Fig. 315), as

Flat,—as Drumhead, Surehead, Flat Dutch.
Round,—as Danish Ballhead.
Obovate or egg-shaped,—as Early York, Late York.
Elliptical or oval,—as Sugar Loaf.
Conical, tapering to apex,—as Early Jersey Wakefield, Winnigstadt, Pomeranian and Oxhearts.

Varieties are spoken of as early, medium or late in maturing; and as having green, purple or variegated leaves.

The cabbage is a good illustration of a plant which has reached that stage in which it is much influenced by its environment. Not only has it been in a variable state for some time, but man has been interested in the plant and prepared to pick out and preserve some of the variations which are of value to him. These two factors are necessary for the improvement of plants.

Harvesting.

In stock-feeding, the cabbages are hauled from the fields as required. The aim is to have something to feed from the first of September until November, and during this time the plants are cut as required, or sheep are folded on them. Cabbages are stored in regular storage houses or in pits six or eight feet wide which are dug out about two feet below ground and roofed in with boards and straw, the apex of the roof being about six feet above ground. The heads are stored upside down and kept cool, moist, and yet well ventilated, until used or sold.

Plants saved for seed production may be laid on their side, with the roots in the ground and a furrow plowed over them. In spring they should be

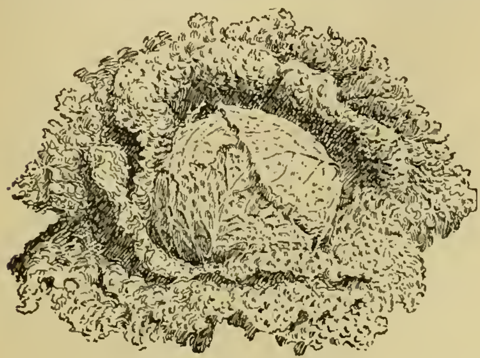

Fig. 317. Savoy cabbage.

taken up and planted about four feet apart each way in rich, well-prepared land. The plants cross-pollinate, and two varieties should not be grown near together.

Obstructions to growth.

Clubroot or anbury (*Plasmodiophora brassicæ*) is a fungous disease which attacks many cruciferous plants; it is common among turnips, causing them to rot badly. It can be combated readily by liming the land at intervals of four or five years, as suggested, and applying the lime with the cruciferous crop; by destroying all cruciferous weeds and by arranging the rotation so that such crops will not be taken too frequently.

Black-rot, or stem-rot (*Pseudomonas campestris*), is a bacterial disease and is one of the most disastrous troubles of the cabbage. It is often found on wild mustard and other cruciferous weeds, which act as hosts in spreading it. There is no cure. Prevention by disinfection of seed, destruction of diseased specimens, a good rotation, the control of insects which may carry the germs, is suggested. A diseased crop should not be stored. It is better to sell the plants while they are good.

The flea-beetle (*Phyllotreta vittata*), a small, black, quick-moving insect, sometimes destroys the seedlings while they are in their first leaves. The best means of combating is to sow plenty of seed and to thin the crop if all come through.

The green cabbage-worm (*Pieris rapæ*) may be combated in the case of young plants by spraying with resin-lime mixture containing Paris green, arsenate of lead in water as for potatoes, or, if not abundant, by hand-picking. If the first brood, which is usually small, be controlled, little trouble need be feared for the remainder of the season.

The cabbage-looper (*Plusia brassicæ*) frequently does considerable damage and is dealt with in the same way as the green worm. The cabbage root-maggot (*Phorbia brassicæ*) sometimes injures the roots. In the southern states the harlequin cabbage-bug does considerable injury; it is checked by sowing mustard and radishes in the cabbage-fields for the bugs to congregate on and then destroying these by spraying with kerosene or burning. The blow-torch passed slowly over the crop will also destroy these insects. The cabbage-aphis is sometimes combated by spraying with kerosene emulsion or tobacco powder.

Marketing.

Cabbage is a crop which may be sold for human consumption if the price is high enough, or it may be fed to stock. In the former case it is frequently sold by the car-lot. When grown for the retail trade it may be advisable to crowd the plants, by putting more on the acre, in order to keep the size down, so that the heads may be retailed for five cents each. This would require heads weighing four to six pounds each, instead of eight or ten pounds, as might be expected ordinarily.

Exhibiting.

The important points are uniformity in size; a minimum of outside leaves to head; a small percentage of stump to leaf when the head is cut open; a firm head, the leaves being closely packed together and lapping over each other in the center; freedom from evidence of disease or insect injury; true to name and type.

Literature.

Cabbages, Cauliflower, and Allied Vegetables, C. L. Allen (1902), Orange Judd Co., New York; Cabbages, How to Grow Them, J. J. H. Gregory (1881), Marblehead, Mass.; How to Grow Cabbages, Pedersen and Howard (1888), W. A. Burpee & Co., Philadelphia, Pa.; Cabbage and Cauliflower for Profit, J. M. Lupton (1898), W. A. Burpee & Co., Philadelphia, Pa.; Forage Crops, pp. 145–169, Thomas Shaw (1900), Orange Judd Co., New York; Cyclopedia of American Horticulture, Article on Cabbage, L. H. Bailey (1900), Macmillan Co.; Black Rot, United States Department of Agriculture, Washington, D. C., Farmers' Bulletin No. 68; same, Wisconsin Experiment Station, Madison, Wis., Bulletin No. 65; same, New York State Experiment Station, Geneva, N. Y., Bulletin Nos. 251, 232; Cornell Experiment Station, Bulletin No. 242; Vermont Experiment Station, Burlington, Vt., Bulletin No. 66. For crop management in the southern states, consult Texas Experiment Station Bulletins, Nos. 57, 69, and for other agricultural experiment station literature, consult Experiment Station Record, published by the Office of Experiment Stations, Washington, D. C.

Fig. 318. Cacao tree of the "Criollo" type, showing manner of bearing fruit.

CACAO. *Theobroma spp. Stereuliaceæ.* Figs. 318–320; Fig. 119, Vol. I.

By *G. N. Collins.*

Chocolate and cocoa, the manufactured forms of cacao, are the product of the seeds of several species of Theobroma, a strictly American genus. *Theobroma Cacao* is the species producing the greater part of the cacao of commerce, though *T. angustifolia* and *T. pentagona* also contribute. The discoverers of the New World found these plants in cultivation by the natives of southern Mexico and Central America, and the methods then in vogue have been but slightly improved, although the culture has been extended to practically all parts of the tropics.

As with most cultivated plants, the natural distribution of the species is a matter of some conjecture, but there seems little doubt that cacao is truly indigenous in parts of Central and South America. In fact, it is rather unusual that a plant cultivated from such a remote period should resemble so closely the wild forms as is the case with cacao, wild plants found in the forests of western Costa Rica being sometimes used to stock small plantations at the present time.

It appears probable that in the cultivation of this plant the principle of the fixing of atmospheric nitrogen by means of leguminous plants was first utilized by man, although of course without realization of the true meaning of the method. The superiority of leguminous trees for shade in cacao plantations was well known to the early cultivators, and it was only after many costly experiments that European planters reached the same conclusion.

Cacao is a small tree usually about ten to thirty feet in height, bearing its flowers and fruits on the old wood of the trunk and larger branches. The flowers are perfect and five-parted, the anthers inclosed in pockets of the petals. The means by which these are released and pollination accomplished is not definitely known. The way in which the flowers are borne, as well as their structure, would seem to point to some crawling insect as the most probable means.

Propagation.

The plant is propagated exclusively by seed. These will not retain their vitality when dried. They are usually planted in seed-beds or small bamboo pots. They germinate very promptly, the seed consisting almost entirely of the crumpled cotyledons, which need only to unfold. As soon as the plants are one to two feet high, they are transplanted to their permanent place. It is the loss attendant on this operation that has led many to adopt the method of planting the seeds directly where the plants are to remain. The distance for planting is usually ten to fifteen feet each way. The difficulty in transplanting cacao is probably the reason why the culture is largely confined to very moist regions, as under such conditions the loss is less, although the plants, when once established, are more healthy and productive in regions where there is sufficient dry season to hold fungous diseases in check.

Harvesting and handling.

The plants require about four years to mature sufficiently to bear, and they continue to be productive for twenty or thirty years and more. The pods, as the fruits are called, are six inches to nearly a foot in length and contain twenty to thirty-five seeds. They are gathered by hand, in most cases, or by the aid of a specially constructed knife mounted on a long pole. Great care should be exercised in removing the fruit, as the point of attachment is surrounded by dormant buds that are to produce future crops, and these are destroyed if the fruit is torn from the tree.

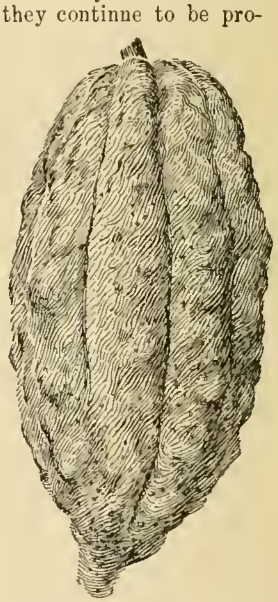

Fig. 319. "Criollo" cacao pod. Jamaica.

Fermentation.—After the crop is gathered, the pods are sometimes opened immediately, or they may be allowed to lie one to eight days before opening; when the latter practice is followed, it takes the place, to some extent, of the fermentation to which the beans are usually subjected after they are removed from the pods. The extent to which the seeds are fermented varies in different countries and with different varieties. The strong, bitter varieties are usually allowed to ferment for five to eight days, while for the milder, white-seeded forms, one to four days is considered sufficient. When the cacao is washed, it is important that the seeds be fermented first, as otherwise it is extremely difficult to remove the sweet mucilaginous substance with which the seeds are surrounded, and which, if not removed, will leave the dried beans dark-colored and of a dirty appearance. On small plantations, the fermentation is accomplished by simply covering the beans in a box or other receptacle and allowing them to remain one to eight days. A better arrangement, when there are larger quantities, is to place them in revolving boxes, so arranged as to stir the beans without loss of heat, and thus to insure uniform action. During the process the temperature should not exceed 135° Fahrenheit.

Washing and drying.—With fermented beans the washing is a comparatively simple operation, and is usually accomplished by agitating the seeds in running water for a few minutes. The drying is a much more difficult operation and one concerning which there is great difference of opinion. Sun-drying is still popular with many progressive planters. Originally, the seeds were simply spread in an open place and gathered before every shower; a more expeditious arrangement is to place the seeds on trays arranged to roll under a roof at one end of the "patio" or "barbecue," as the open space is called. Many plantations are equipped with machines for artifically drying the beans. The ordinary drying machines used for grain and other seeds are not well adapted to drying cacao, for the reason that in these machines the seeds are agitated. This injures the delicate outer covering of cacao. Future handling of the seeds will then cause the cotyledons or "nibs" to break up, thus entailing a loss in weight and making the cacao more susceptible to molds and other fungous attacks.

Varieties.

Although the greatest diversity exists in cacao, there are few well-marked varieties. There is little uniformity in the application of varietal names in different countries, and the trade classification is on a geographical basis. In general, cacao may be divided into the mild white-seeded forms, and those with purple seeds, which are much more bitter. The former are usually known as "Criollo" cacao and have been further divided into a number of varieties. Among the purple-seeded cacaos, the best known and most distinct form is "Calabacillo," characterized by a short, blunt-pointed pod with a slight constriction at the stem end. The walls of the pod are thick and the seeds small and very bitter. In spite of the lower price which this variety commands, it is one of the most widely cultivated, and its popularity with planters probably is increasing. It is prolific and very hardy, an important consideration, as there are a number of serious diseases for which remedies are not known.

Uniformity of product.

A serious obstacle in the way of cacao-culture is the difficulty of producing a uniform product. Even when the most rigid seed selection is practiced, great diversity appears in the product. It has been thought to overcome this by asexual propagation, a method not likely to be successful. Cacao in a seed product, and the seed is composed of the embryo of the new plant, which means, of course, that if a flower is cross-pollinated the effect of this cross-pollination will be immediately apparent in the seed and not postponed until the next generation, as with fruit products or those seeds which are composed largely of endosperm. If, therefore, the diversity of cacao is due to cross-breeding, it will not be possible to prevent this diversity by budding except in isolated cases where whole plantations are stocked from the buds of a single plant, and sufficiently removed from all other cacao plants to guard against pollination from other forms.

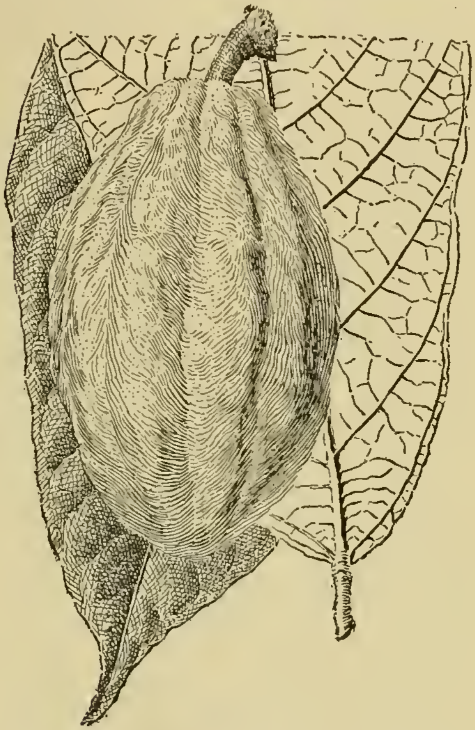

Fig. 320. "Calabacillo" cacao pod and leaf. Costa Rica.

Production.

The growth of the use of cacao in the United States has been unusually rapid. In 1898, only $3,933,000 worth were imported, while in 1905 this had increased to $9,484,000. The greater part of the cacao used in this country is imported from Trinidad. The milder cacaos, more especially adapted to drinking, are imported from Ceylon and Ecuador. The highest-priced cacao on the market is that grown in a small region in the interior of Ecuador. In the trade this is known as "arriba."

The following table, taken from the Monthly Summary of Commerce and Finance of July, 1905, gives the cacao production of the world in 1897:

Cacao Production of the World, 1897.

Countries	Quantity Tons
Ecuador	22,000
Trinidad	10,000
Other British West Indies	9,000
Portuguese Africa	7,700
Brazil	7,500
Venezuela	6,000
Dutch Guiana	4,500
Haiti	4,000
Colomhia	3,000
Ceylon	1,650
Java	1,000
Guadeloupe and Martinique	800
Santo Domingo	150
Niger Coast	55
French Guiana	30
Congo	5
Total	77,390

Although there are regions in Hawaii, Porto Rico and the Philippines well adapted to the growing of cacao, these islands produce only an infinitesimal part of the seventy million pounds annually consumed in this country. With a knowledge of the necessary conditions of growth and an appreciation of the value of a uniform product, the growing of cacao in our tropical islands should be a pleasant and remunerative occupation.

Literature.

For fuller information the following references are given: Cacao, J. H. Hart (1900), second edition; Uebersicht der bis jetzt bekannten Arten von Theobroma, G. Bernoulli (1871); Cacao Culture in the Philippines, W. S. Lyon (1902), Philippine Bureau of Agriculture, Farmers' Bulletin No. 2; Expedition nach Central- und Südamerika, Paul Preuss (1901); Les Plantes Tropicales de Grande Culture, E. de Wildeman (1902); Cacao: All About It, "Historicus" (1896); A Treatise on Cacao, F. Emmanuel Olivieri (1903), Trinidad.

CACTI AS FORAGE. Figs. 321, 322.

Stock in the southern part of the range country feed more or less on prickly pear, and under pressure of hard circumstances will forage on many kinds of cacti. Fat cattle often eat the fruits of certain cacti, apparently from preference. Inasmuch as great areas of the southern range country produce cacti of many kinds and in abundance, it becomes an important question as to how far the plants can be profitably utilized for forage. The interest in the subject is naturally increasing, with the settlement of the country; and this interest has been hastened of late by the discussions regarding the breeding of spineless cacti.

So far as present investigations show, spineless cacti are of little economic importance under existing range conditions in the West unless grown to maturity in enclosures. The only reason why cacti can remain on the range and attain full growth is because of the protection the spines give them. On an overstocked range, spineless cacti would be consumed before they had fairly started growth. Fig. 321 shows what occurs when cattle have access to more or less spineless forms. In many sections, jack-rabbits are destructive to the spineless cacti.

The spineless cactus is not a recent development. The following flat-jointed Opuntias are spineless in large part: *O. decumbens; O. tomentosa; O. Pescorvi; O. vulgaris; O. Rafinesquii; O. crassa; O. Ficus-Indica; O. filipendula;* forms of *O. robusta; O. rubescens.*

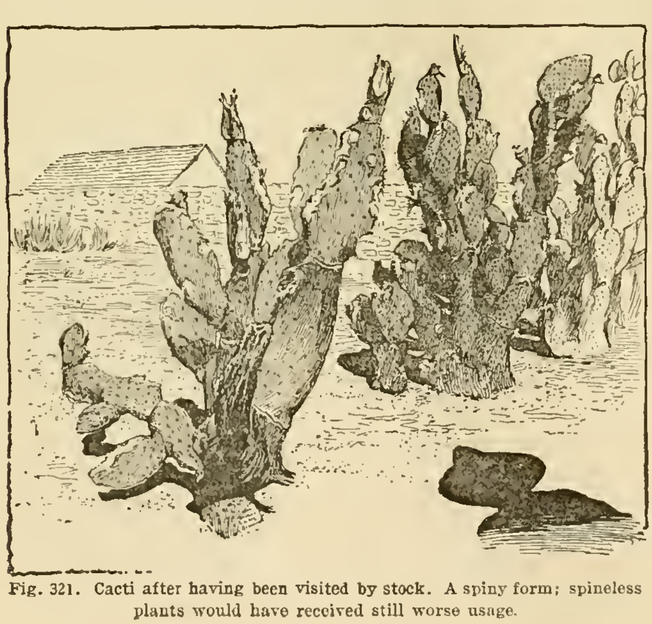

Fig. 321. Cacti after having been visited by stock. A spiny form; spineless plants would have received still worse usage.

The following Opuntias are spineless but have objectionable spicules: *O. basilaris; O. inamœna; O. inermis; O. microdasys; O. microcarpa; O. rufida; O. Treleasii.*

Many spineless forms are grown in Mexico that might easily be propagated if that kind were thought to be of any practical value. Present knowledge is not sufficient to state whether the spineless forms will grow as well as the native spiny forms in the same region.

The use of spine-bearing cacti.

The spines are of course objectionable to the feeding of cacti. Whether spineless cacti will some day be regularly bred and planted it is not necessary now to enquire: the spines are easily and cheaply burned off.

With a gasoline blow-torch, or

prickly-pear burner, as it is called, the spines have been singed from a number of species of cactus common to the Southwest. The Arizona Experiment Station tested several species in this way. (Fig. 322.) Previous to the experiment, it had been

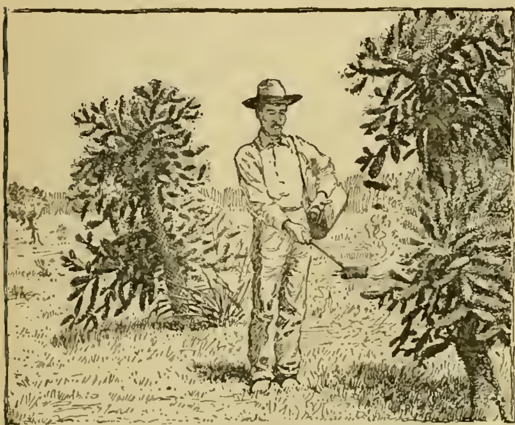

Fig. 322. Singeing the cholla (*Opuntia fulgida*) with a prickly pear burner.

noticed that the stock was browsing on the cactus shrubs, especially on the less spiny fruits. The first fifty plants that were singed were literally devoured by the stock, the prickly pears being eaten nearly to the ground, while only the trunks and woody branches of the chollas remained. It was soon evident that the animals were feeding entirely on the singed cacti, which they readily distinguished from the unsinged. The amount that should be fed from a plant at one time varies with species and condition of growth.

The machine used costs eighteen dollars. It consumes eight to ten gallons of gasoline per day. One man with a machine can feed 400 head of cattle all the spiny cacti they will eat. It is estimated that 7,000 to 11,000 pounds of cactus forage can be prepared daily in this way, at a cost of about two dollars and forty cents, not including the hire of the man. The work and the cost are justified if cattle can thereby be carried over periods of shortage. The amount of water in this forage, as estimated at the Arizona Experiment Station, is approximately 75 to 80 per cent, leaving 20 to 25 per cent, or 1,600 to 2,500 pounds of solid matter for the day's work. This large amount of water is of considerable value to the thirsty cattle as it no doubt enables them to browse much farther from their watering places than they otherwise could.

At the New Mexico Experiment Station, experiments were made to test the value of one kind of cactus forage for dairy cows. The spines were singed off in the way mentoned above. The cactus was then run through a root-cutter. When the cows became accustomed to it they ate forty to fifty pounds per day, in connection with a grain ration and a little hay. It seemed to be about eqnal in value to sugar-beets, pound for pound.

Composition of cactus forage.

Analysis of cactus stems and fruit were made at the Arizona Experiment Station, and are reported in Bulletin No. 51 of that station. The ash content of the kinds analyzed was found to be high; the fiber is low; nitrogen-free extract is present in high average amount; protein is more than half that contained in alfalfa hay and about the same as that in grama grass; ether extract is high in the seeds, but the seeds are not digested by the animal; the fiber content of the seeds is also high.

Literature.

For fuller information, the reader should consult Bull. 74 of the Bureau of Plant Industry, United States Department of Agriculture, and Bull. 91 of the Bureau of Animal Industry; also publications of the Arizona and New Mexico Experiment Stations. Bull. 60, New Mexico, gives results of many analyses of leading species.

CASSAVA. *Manihot utilissima*, Pohl. (*Jatropha Manihot*, Linn. *Janipha Manihot*, H. B. K.). *Euphorbiaceæ.* Cassava (U. S.), manioc, mandioca, aypi, yuca, and others (S. Amer.), tunglu-bok, simul-alu, tan-u, and others (India). Figs. 323, 324.

By *S. M. Tracy.*

A shrubby plant, perennial in the tropics but annual in temperate regions, cultivated for its fleshy roots which are used for the manufacture of starch, Brazilian arrow-root and tapioca, for feeding domestic animals, and for the table. The cultivated forms are not known in a wild condition, but are undoubtedly natives of the American tropics.

The cultivated form is a shrub three to ten feet in height, the stem and branches forking regularly in threes, with long-petioled, palmately-parted leaves having usually five to nine divisions reaching nearly to the base, the sections being entire and elliptical or spatulate in outline. The growing plant bears a strong resemblance to the castor-bean (ricinus), to which it is closely related. The valuable part of the plant is its cluster of fleshy roots, which have a resemblance to the sweet-potato, though often reaching six or eight feet in length.

While two species have been described as the original types of the cultivated form of cassava—the "bitter," *Manihot utilissima*, Pohl., containing a considerable quantity of hydrocyanic acid, and the "sweet," *Manihot Aipi*, Pohl, containing little of the poisonous acid,—recent investigations indicate that all the cultivated forms have been developed from a single stock, probably the *M. Aipi*. Careful structural and chemical examinations of a very large number of cultivated forms from Ecuador, Colombia and the West Indies, including both sweet and bitter sorts, show no constant differences. In different varieties the color of the root may vary from dark red to light yellow or almost white, while the stems and petioles show equal variations, but either of these characters may change in the first generation when plants are grown from seeds. The roots of all varieties contain some hydrocyanic (prussic) acid, the quantity varying from a mere trace in some of the sweet varieties to as much as .03 per cent in some of the so-called "bitter" sorts; but the quantity in any variety, even when grown from cuttings, varies greatly with seasons, soils and climates. So far as is known, all varieties grown in the United States contain so little of the acid as to be harmless, and the same is said to be true of the sorts grown in India. The most poisonous varieties often cause death a few minutes after being eaten raw, but become perfectly harmless when cooked or dried, and even when pulped and exposed a few hours to the heat of the sun.

Fig. 323. Cassava roots.

History.

Cassava was in common use in tropical America when the country was first explored by the Spaniards, and was introduced into western Africa in the sixteenth century, and into southern Asia a little later. There is no record of its introduction into the United States, but it was abundant in Florida as early as 1860, and was in common use there during the civil war as a source of starch. It gradually came into use for the feeding of livestock, and, between 1895 and 1900, establishments for the manufacture of starch on a commercial basis were opened in that state. The area of its cultivation for feeding purposes has been extended gradually westward, and it is now becoming common as far west as Texas.

Culture.

The plant requires a light, sandy and fairly fertile soil for its best success. While it produces abundantly on heavy soils, the digging of the roots is too expensive for profit. Some varieties make a vigorous growth where the annual rainfall does not exceed twenty inches, while others endure as much as 200 inches without injury. Some varieties mature within six months from planting, while others require two years before they are ready for gathering. The sweet varieties are usually more hardy, mature more quickly and yield less abundantly than the bitter sorts.

Propagation.—It is usually propagated by cuttings made from the stems, although a few of the early-maturing varieties may be propagated by seeds. In tropical countries these cuttings may be made at any time, but in temperate regions considerable care is needed to preserve the seed-canes through the winter. Late in the fall, just before frost, the matured canes are cut above the surface of the ground, the immature tops are removed and the canes are buried in windrows, much as sugar-cane is preserved. Early in the spring, about corn-planting time, these seed-canes are cut into pieces four to six inches in length and planted in checks about four feet apart. The cultivation of the crop is similar to that given to corn.

Harvesting.—The roots are ready for use as early as October, but may be left in the ground until the following March. As they begin to decay only a few days after being disturbed, it is the common practice to dig them only as they are wanted for use. Under ordinary conditions in the United States, the yield of merchantable roots is about six tons per acre, though yields of ten to twenty tons are often secured. In more tropical regions much heavier yields are common.

Uses.

Average roots, grown in the United States, contain 25 to 30 per cent of starch, about 80 per cent of which is secured in the process of manufacture. The factory residue, containing about 25 per cent of starch, is in good demand for the feeding of horses and cattle, being valued about with corn meal. The roots, either boiled or roasted, form a staple article of human food in all tropical countries.

Literature.

If further information is desired, the reader should consult the following: Farmers' Bulletin No. 167, United States Department of Agriculture; Sweet Cassava, Bulletin No. 44, Division of Chemistry, United States Department of Agriculture; Manufacture of Starch from Potatoes and Cassava,

Fig. 324. A field of cassava in Florida.

Bulletin No. 58, Division of Chemistry, United States Department of Agriculture; Agricultural Ledger, 1904, No. 10, Calcutta, India; Bulletin of Botanical Department, Jamaica, Vol. IX, Part 6.

CASTOR-BEAN. *Ricinus communis*, Linn. *Euphorbiaceæ.* Figs. 325–330.

By *E. Mead Wilcox.*

Castor-oil is derived from the seeds or beans of ricinus, a coarse perennial plant (treated as annual in temperate climates), bearing large alternate palmately lobed leaves, flowers in large terminal clusters, and varicolored seeds in prickly three-membered pods or burs. The flowers are unisexual and are gathered on a frequently much elongated axis, the staminate flowers generally being along the lower, the pistillate along the upper part of the inflorescence; flowers without petals; stamens many; pistils three, two-parted, red.

Fig. 325. Flowers of castor-bean. A, Staminate; B, pistillate.

The castor-oil plant belongs to a family that has over four thousand species and is developed most highly in the tropics. It furnishes a great variety of useful products, among which may be named cassava or tapioca, caoutchouc and shellac. In the tropics, the castor-bean grows to a tree thirty to forty feet high, but in temperate regions it is a large annual.

Fig. 326. Castor-bean inflorescence.

The original home of the castor-oil plant was in Africa or India, but it is now cultivated in all the warmer parts of the world, either for its oil or as an ornamental plant. The highest yield of oil is secured in the tropics, and it is grown only for ornamental purposes in the northern part of the corn-belt, where it would be a failure if grown for oil. It is said, however, that the oil secured from beans grown in the temperate climate of the United States is superior for medicinal purposes to that grown in the tropics.

In the United States the plant is now cultivated commercially in Oklahoma, Illinois, Missouri and Kansas, Oklahoma producing probably over half the total product. The product of the beans in the United States has fallen off very much in recent years, and we are becoming more and more dependent on the supply from India.

Culture.

Soil.—The plant prefers a rich, well-drained sandy or clay loam and will not do well on either a stiff clay or a light sand. In this respect it may be said to do well on soil suited to corn or wheat. If virgin soil is not employed, one must apply either manure or commercial fertilizers to keep up the supply of available nitrogen, potash and phosphoric acid.

Planting.—The seeds are planted either in rows four to five feet apart each way, or else in rows about four feet apart and only eighteen inches apart in the row. When the plants are about six to eight inches high they are thinned to a stand of one plant per hill. It may be found desirable to pour water, nearly boiling hot, over the seeds and allow them to stand, without further heating, for twenty-four hours. This treatment seems to ensure a more uniform and prompt germination. The plants are cultivated level to keep down the weeds, as is corn, until they are about two feet high, from which time they should be able to take care of themselves.

From four to six seeds are planted in a hill, to allow for all accidents. At the greater distances (4 x 5 feet) about one and one-half quarts of seed are required for an acre; at the lesser distances (4 x 1½ feet), about four quarts are required.

Varieties.

Numerous varieties are known, the types most used for ornamental purposes generally being larger than those found among the cultivated oil-yielding plants. The oil-bearing varieties are distinguished by the color, shape and size of the seeds and leaves and the color of the stem. They differ considerably among themselves as to their oil-producing powers, but they cannot be characterized so readily botanically. The writer seems to have been the first to undertake the systematic breeding of the castor-oil bean for the express purpose of increasing its oil-producing quality. This work was started in Okla-

Fig. 327. Castor-bean fruits.

homa and was continued there by Shaw and Nicholson, and is now being continued in Alabama by the writer.

Harvesting.

If the beans are planted from the middle of April to the first of May, one may expect to see the first ripe fruits in July ; and from this date to the first frost the pods will continue to ripen and the harvest must be continued. The pods are so constructed as to throw the seeds to a considerable distance when the wall of the pod breaks, and hence the necessity of collecting the entire fruit-cluster as soon as it turns dark brown. These clusters are cut off with a sharp instrument and hauled away in a tight wagon-box. They are then spread on a tight floor in the barn and left to dry and crack open. When all the seeds are out of the pods they may be swept together and passed through a hand fanning mill and stored in some dry place until sold. Frosted beans should never be mixed with the good ones, as they will reduce the value of the whole lot. If gathered at the proper time and handled as indicated, the labor item may be reduced to a minimum.

Fig. 328. Castor-bean. Mature plant.

One of the points to be kept in mind in the breeding work is to develop a type in which the fruits in any one cluster will ripen at the same time to prevent loss. The work of gathering the crop is tedious and could be much reduced in this way.

Enemies.

Fortunately the castor-oil plant has no serious pests as yet among either fungi or insects.

Manufacture.

The manufacture of castor-oil is largely concentrated at present in Jersey City and St. Louis. The former place presses much of the imported material, while the St. Louis mills handle largely the production of the western states. The hydraulic press is the essential feature of these mills, as the common method is to crush by hydraulic pressure without any further treatment than the mere removal of foreign matter. The seeds are not decorticated, as is practiced with cotton seed in making cottonseed-oil. In some cases the seeds are steamed before pressing, but though this permits of more rapid extraction, it yields an oil of inferior quality for medicinal and other purposes. Most of the mills leave in the residue 10 per cent or more of oil.

The residue, called castor pomace, is a very good fertilizer material, but is poisonous to stock and cannot be employed as cottonseed meal. In some places it is prized as a fertilizer for tobacco and other plants.

Fig. 329. Castor-bean seedling.

Uses.

Castor-oil is used largely in the dyeing of cotton goods, and for that purpose is converted by means of concentrated acids into a sort of soluble oil, which, because of the ready solubility of the alizarine dye in it, is often called alizarine-assistant or Turkey-red oil. It is not employed so extensively in medicine as formerly, although among the rural population in the southern United States, and among the negroes particularly, it is still largely used. It is employed also in various other ways, such as in the manufacture of "sticky" fly-paper and "glycerine" soap.

Literature.

A few references are here given :—The Castor-Oil Plant, Miscellaneous Circular, United States Department of Agriculture, No. 1, pp. 1–4; F. C. Burtis : Castor Beans (1899), Oklahoma Experiment Station, Bulletin No. 44, pp. 7–9 ; Crop and Forage Notes (1900), Oklahoma Experiment Station, Bulletin No. 48, p. 11 ; C. M. Daugherty: The Industry in Oil Seeds, Yearbook, United States Department of Agriculture (1903), pp. 411–426 ; The Castor-Oil Industry, Yearbook, United States Department of Agriculture (1904), 287–298 ; G. E. Hicks, Oil-producing Seeds, Yearbook, United States Department of Agriculture (1895), pp. 185–204 ; G. L. Holter and J. Fields: Fertilizer Analyses of Castor Bean Plants (1897), Oklahoma Experiment Station, Bulletin No. 25, pp. 7, 8 ; A Study of the Castor-Oil Plant (1898), Oklahoma Experiment Station, Bulletin No. 32, pp. 11–14 ; Determination of Oil in Castor Beans (1898), Oklahoma Experiment Station,

Fig. 330. Castor-bean seeds.

Bulletin No. 32, pp. 14, 15; P. MacOwan, The Castor-Oil Plant, and Its Growth to Produce Machine Oil (1897), Agricultural Miscellanea, Cape of Good Hope, 13, pp. 483–487; G. E. Morrow and J. H. Bone, Castor Beans (1898), Oklahoma Experiment Station, Bulletin No. 33, pp. 13, 14; W. R. Shaw, The Improvement of the Castor Plant (1902), Oklahoma Experiment Station, Bulletin No. 54, pp. 1-10; J. G. Smith, Castor Bean, Hawaii Experiment Station, Press Bulletin No. 2, pp. 1, 2; A. Zimmermann, Die Ricinus-Kultur, Der Pflanzer (1905), 1, pp. 76–88.

CHICORY ROOT. *Cichorium Intybus*, Linn. *Compositæ.* Figs. 331, 332.

By *T. Lyttleton Lyon.*

The cultivated chicory or succory has an enlarged taproot resembling, in some varieties, the root of the parsnip, and in others, that of the forage beet, but it does not attain the size of the latter. The taproots range from eight inches to two feet or more in length and one to three inches

Fig. 331. Flowers and leaves of the chicory plant.

in diameter. The plant is perennial. The seed-stalks bear clusters of brilliant blue or occasionally pink or white flowers (closing about noon), and are nearly destitute of leaves except near the base. The florets are all perfect, and all ligulate or rayed; pappus a short chaffy corona. The leaves and roots have a milk-white juice. When escaped from cultivation, chicory becomes a pestiferous weed.

Culture.

Chicory may be raised on almost any good land north of the fortieth parallel of latitude. Localities and soils that have demonstrated their suitability to the production of sugar-beets are also well adapted to the growth of chicory.

Chicory grows best on a well-drained loam soil, and it is important that it be free from large stones and from hard-pan, because of their interference with the development of the long, straight root that chicory should possess. The plant is strongly drought-resistant. The methods of culture are very similar to those used in raising sugar-beets, and instructions given for that crop may be followed by the chicory-raiser. The only essential difference is in the planting. One to one and one-half pounds of seed per acre are used, and should be drilled in not deeper than one-half to three-fourths of an inch. The culture requires very careful attention and much hand-labor.

Uses.

The principal use to which chicory is put, and for which it is most largely grown, is that of an adulterant or substitute for coffee. For this purpose the taproot is dried, roasted and ground, and either mixed with ground coffee or used alone. In Europe its use in this way is very common. Many of the European countries have laws to prevent the adulteration of chicory, as it is considered that no other adulterant for coffee is so desirable. The flavor that pure chicory imparts when roasted, ground and boiled, does not resemble that of coffee, but is rather bitter. However, when it is mixed with a good quality of coffee in the proportion of one part of chicory to three or four parts of coffee, the result is very pleasing, and by many persons such a mixture is considered superior in flavor to pure coffee. In spite of the fact that pure chicory does not resemble coffee in flavor, it is used in this condition as a table beverage both in Europe and in the United States, although the consumption in the latter country is comparatively small. The chicory root is also used medicinally and the leaves as a salad, but the consumption for these purposes is small.

Importations.

Most of the chicory used in the United States is imported from European countries. The larger part of this comes from Belgium and the remainder from Germany, Great Britain, Netherlands and France. The annual importation of raw and prepared roots increased gradually to a maximum of 17,329,170 pounds, valued at $246,393, in 1897, but dropped in 1899 to 494,616 pounds, valued at $13,414. The decrease was practically all in the raw product, the importation of prepared roots amounting to 399,009 pounds in 1897, and to 335,347 pounds in 1899. By 1904, the total importation had reached the figure of 4,672,515 pounds, valued at $88,487. The Twelfth Census reports a production of 21,495,870 pounds of chicory root in the United States in 1899. Of this, 19,876 970 pounds were raised in Michigan.

Importance as an industry.

The fact that this commodity is imported into America has led to the establishment of the industry here, although the market for the product has never permitted an extensive development. Michigan, Nebraska, Illinois and Wisconsin have been most active in its prosecution. The industry naturally centers around a factory for preparing

Fig. 332. Various types of chicory roots.

the roots, as the raw product is too bulky to permit of long shipments. The business of manufacturing chicory roots into a finished product has been a somewhat uncertain one, owing to the ease with which the market is glutted by a large crop in this country or in Europe. The farmer usually raises chicory on contract with a manufacturer, the former agreeing to plant a stipulated number of acres and to deliver the roots to the factory, the latter guaranteeing to pay a certain price per ton for all roots delivered. Unless such a contract can be made, it would be unwise under ordinary circumstances, for a farmer to plant chicory.

Profits from culture.

The price paid for chicory roots ranges from six to eight dollars per ton. Six to ten tons per acre may be expected under ordinary conditions. The cost of raising an acre of chicory will vary from thirty to forty dollars.

Literature.

Bulletin No. 19 of the Division of Botany, of the United States Department of Agriculture, is a monograph on the subject. Bulletin No. 49 of the Nebraska Experiment Station contains directions for the culture of chicory. The Cyclopedia of American Horticulture contains an article on chicory as a medicinal and salad-making plant. [See also article on chicory in Farmers' Cyclopedia, Orange Judd Co., New York city.]

CLOVER. Figs. 333–343.

The word clover is popularly used to designate herbaceous forage plants of several genera of the family Leguminosæ, but by botanists it is restricted to species of the genus Trifolium. In this article, the clovers are considered to be Trifoliums. The Florida clover will be found under the article Beggarweed, the Japan clover under Lespedeza, the bur and hop clovers under Medicago, the Sweet, Bokhara or tree clover under Melilotus. Related plants are alfalfa, serradella, sulla, sainfoin, vetch, lupine.

The genus Trifolium comprises probably two hundred or more species and marked natural varieties, most frequent in the temperate parts of the northern hemisphere, but occuring also on mountains in tropical countries, and to some extent in South Africa. They are annual, biennial or perennial, usually with compound leaves of three leaflets (whence the name *trifolium*), but in some species of five or seven leaflets, and papilionaceous (pea-like) small flowers usually in dense heads; stamens ten, nine of them united by their filaments; fruit a very small and usually indehiscent pod containing few nearly spherical seeds. The flowers are white or in shades of red, red-purple or yellow. Several of the clovers are sometimes grown for ornament [see Cyclopedia of American Horticulture], but the great value of the plants lies in their usefulness for green-manuring [see Vol. I, page 504] and for forage [see, also, *Forage, Meadows and Pastures*, in this volume]. The important agricultural clovers are *Trifolium pratense, T. hybridum, T. repens, T. incarnatum* and *T. Alexandrinum*; several other species are more or less weedy plants along roadsides and in waste places. The important forage clovers and also most of the weedy kinds are native of the Old World.

The ability to grow clover successfully and uniformly is one of the marks of a good farmer in the northern states and Canada. Clover of some kind is almost a necessary part of self-sustaining rotations in these regions. In the very short rotations in which clover occurs, the land is likely to refuse to produce clover after a few courses. In that case, other crops may be substituted for a time. It is not known just why clover will not grow in certain cases. In Europe much is said about "clover sickness," but it is doubtful whether the same cause or condition is present in this country, at least to any great extent. Experiments at Rothamsted, as reported in 1901, "seem to exclude the supposition that the primary cause of failure ('clover sickness') is either destruction by parasitic plants or insects, injury from excreted matter, or shade of a corn crop, and to indicate that it must be looked for in exhaustion of some kind within the range of the roots." It has been asserted by others that lack of available potash in the subsoil is the cause. Güssow, reporting to the Royal Agricultural Society of England in 1903, considers the fungus *Sclerotinia ciborioides* to be the real cause of clover sickness. The refusal of lands in America to produce clover is probably due to various causes. It is frequently attributed to soil

Plate VII. Red Clover

acidity. Lack of the nitrogen-gathering bacteria may sometimes be a cause. Inoculation of soils with artificial cultures has been tried, but not with uniform or very important results, although the nitragin culture has given promising returns in Europe. Inoculation with soil from an inoculated field has given good results in this country, and its value seems to be fully demonstrated.

Group I. The forage clovers.

(1) Red clover, medium red clover (*Trifolium pratense*, Linn.) Fig. 333, is one of the most important of hay plants. It is variable in size, habit and other characteristics, suggesting that it offers a promising field for the plant-breeder. It is usually perennial, although tending to run out after the third year, and sometimes even after the second year. It is a spreading, hairy plant, bearing purplish (or sometimes rarely white) heads on the summits of branching, leafy stems, the upper leaf being nearly or quite sessile and borne close under the head; leaflets oval or oblong-ovate, sometimes notched at the end, very short-stalked, marked with a prominent whitish spot.

Fig. 333. Red clover.

The perennial, mammoth, or pea-vine red clover (var. *perenne*) has less tendency to die out after the second year, is of taller and stouter growth than the common red, the flower-head somewhat stalked, the plant bearing mostly larger and darker heads and maturing later. This is the most valuable of the cultivated red clovers. It is the plant commonly known as *Trifolium medium*, and is designated by Thomas Shaw as *T. magnum*. By some it has been considered to be the result of crossing between *T. pratense* and the true *T. medium*. The botanical or descriptive characters that are usually employed to separate the mammoth clover (var. *perenne*) from the common or medium red (*T. pratense*) are of small diagnostic value. The chief distinction seems to lie in the perennial character, the larger size and the later maturity.

The zigzag or cow clover (the true *Trifolium medium*, Linn.) seems not to be in cultivation in this country. Stems usually flexuose or zigzag; leaflets and stipules narrow, usually elliptical, not spotted, the edges entire or slightly toothed toward the base; heads standing one or two inches above the upper leaf, globular to oblong. There are no important and constant botanical differences between *T. medium* and the forms of *T. pratense*. The chief distinguishing marks of *T. medium* are the always more or less peduncled heads (only infrequently peduncled in *T. pratense*), more oblong heads with brighter-colored flowers, the narrower stipules and leaflets. The perennial form of *T. pratense*, or mammoth clover, is apparently a different plant; the name *perenne* has been applied to it in popular writings, but the name has no technical botanical standing.

The Orel clover (*T. pratense* var. *foliosum*, Brand) is a hairless form introduced from Russia. It "is distinguished by the dustlessness of its hay, due to almost complete absence of hairiness from all parts of the plant, by its heavy yields for the first crop, by its leafiness and the persistence of the basal leaves, by the succulence of the stems, which improves greatly the quality of the hay and reduces the waste due to woody uneatable portions, by greater palatability than hay from domestic seed, and by the fact that it comes to proper maturity for harvesting from ten days to two weeks later than the ordinary American red clover" [Charles J. Brand, Bulletin No. 95, Bureau of Plant Industry, United States Department of Agriculture, 1906]. The plants are more upright than those of the common red clover and branch more freely; the spots are sometimes absent from the leaves; the flower-heads are smaller and less compact and tend to be more elongated. It seems to be perennial. This new clover has been tested in a number of places in the United States and Canada with promising results. It is recommended as a supplement to common red clover. It is thought that it may profitably supplant common red clover "where the best methods of management indicate that only one crop, either of hay or seed and a light aftermath, or some good pasturage can be advantageously expected from clover-fields" because of its "extraordinarily heavy first crop and the free seeding capacity."

Fig. 334. Mammoth or perennial clover (*Trifolium pratense*, var. *perenne*).

The succeeding articles on Clover, by Smith and Wing, together with the discussion under Meadows and under Green-manures in Vol. I, will sufficiently explain the uses and culture of the red clovers.

Alsike or Swedish clover (*T. hybridum*, Linn.) (Fig. 335) is a tall-growing, slender-stemmed perennial clover with small whitish or rose-colored heads; the leaves are long-stalked, the leaflets obovate and serrulate. The alsike is readily distinguished from the white clover by its forking stalks (the flower-stems not rising directly from the ground) and the pinkish heads (which are usually white toward the top). One of the best of the clovers, particularly on moist and cool lands, both for pasture and hay; also an excellent bee plant. Alsike is the name of a parish in Sweden.

Alsike clover is especially valuable for hay, either grown alone or in combination with grasses or with mammoth clover. It produces a very fine, soft hay that is likely to be nearly all consumed by live-stock. On well-prepared and adaptable land and heavily seeded (about fifteen pounds to the acre), it makes a dense and heavy cover two feet deep. It is very hardy and may be sown early in spring, but as the seed is small it should not be covered very deep. Usually, only one cutting is secured in the northern regions, where it thrives best. A good yield of seed per acre is four bushels.

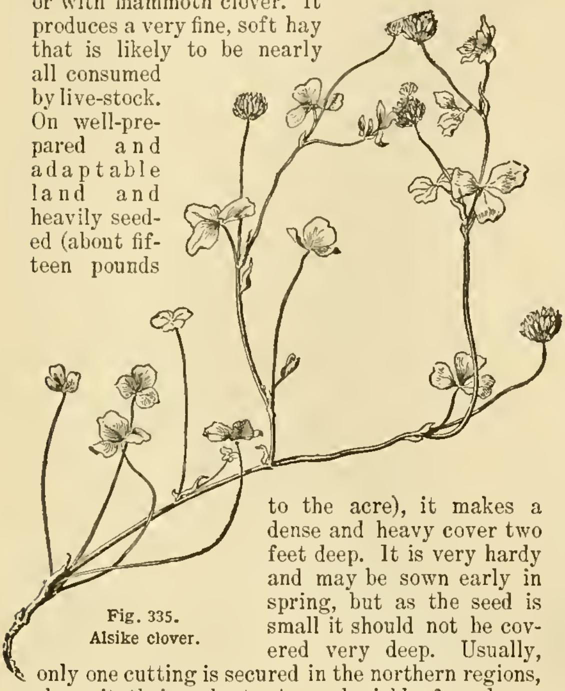
Fig. 335. Alsike clover.

White clover (*T. repens*, Linn.) (Figs. 336, 337) is a low creeping perennial, bearing its small fragrant white heads on slender peduncles that spring directly from the stem that roots along the surface of the ground; leaves long-stalked, the leaflets obcordate and more or less small-toothed. Useful for pasture, and for bees, and prized by many on lawns.

White clover thrives in cool climates, or the cool part of the year, and on lands that are retentive of moisture. It is very hardy, and it spreads rapidly when once established. It withstands grazing well, and is prized for pastures in those regions and on those lands that are adapted to it. It is rarely sown as a meadow plant for hay, but it often works into moist meadows, making excellent "bottom." It is often sown in pastures. It should be sown very early, so that it may become established before warm weather. About ten to twelve pounds of seed is sown to the acre. On lawns, twice or more than this quantity may be sown if one is fond of the plant. For seed purposes, as much as four pounds may be sown; the yield of seed will range from two and one-half to six bushels per acre.

The Ladino clover, mentioned on page 75, is a variety of white clover (var. *latus*) much grown in mountain valleys of Italy, especially under irrigation. It is distinguished from the ordinary white clover by having much larger leaflets and taller stems, yielding about twice as much at each cutting. It is said to be the chief forage and hay crop of a large part of the irrigated regions of the Po valley, in which region it is reputed to outyield alfalfa and to make a better crop of hay. Owing to the prostrate stem, the hay consists entirely of leaves and flowers. From the fact that the tips of the stems are not cut off it revives very quickly after being mown, blossoms usually appearing within ten days. Four or five cuttings are made each season at intervals of thirty-five to forty days. Owing to the fact that the roots are comparatively shallow, it will succeed on thin land under irrigation where alfalfa fails. This clover has been tested to a very limited extent in the United States, but with promising results. The seed is four times as expensive as that of common white clover. This is called "giant broad-leaved white clover," "an improved variety of the common white clover" from northern Italy, in Bulletin No. 98 of the North Carolina Experiment Station. "The plant is much more robust and has larger leaves than the common species, but produces very little seed."

Crimson clover (*T. incarnatum*, Linn.) (Fig. 338) is an annual, erect, soft-hairy plant, strong-growing and standing erect, two to three feet high, with oblong, dense heads (becoming two to three inches long) of brilliant crimson flowers; leaves long-stalked, the leaflets broadly obovate and obtuse, and small-toothed. Now much used for cover-cropping [see *Cover-crops* and *Fruit-growing*] and also for forage.

Although annual, it survives the winter if sown in late summer or early fall. It should become well rooted before winter sets in. Crimson clover requires considerable heat in its early stages, and therefore, it usually does not thrive in Canada

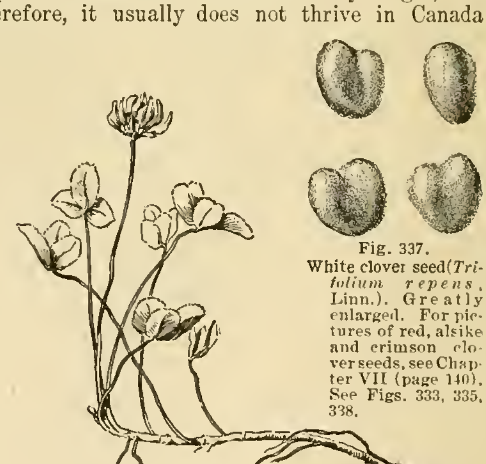
Fig. 337. White clover seed (*Trifolium repens*, Linn.). Greatly enlarged. For pictures of red, alsike and crimson clover seeds, see Chapter VII (page 140). See Figs. 333, 335, 338.

Fig. 336. White clover.

and the northern states. About fifteen to twenty pounds of seed is used to the acre if the crop is sown alone. When well established, crimson clover may be pastured in the fall and again in spring. Cut before it arrives at full bloom it makes fairly good hay, although the very hairy character of the plant tends to the formation of hair-balls in the stomachs of the animals. An acre should yield five to ten bushels of seed.

Berseem or Egyptian clover (*T. Alexandrinum*, Linn.) (Figs. 91, 308) is annual, with yellowish white flowers in oblong heads, erect and tall, somewhat hairy. [See *Berseem*, page 215.]

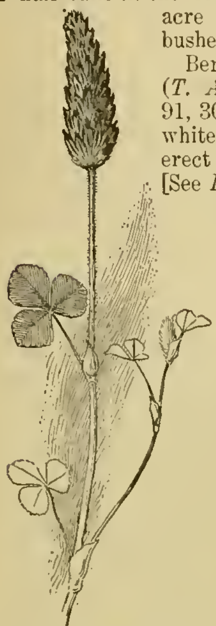

Fig. 338. Crimson clover.

Fig. 339. *Trifolium agrarium.*

Group II. Less important or weed clovers.

The small, introduced clovers of this group, occurring about cultivated lands or along roadsides, are of two kinds,—the yellow-flowered and the silky-headed. They are all low, more or less trailing or weak-spreading annual plants, producing little herbage and of small value where other clovers will succeed. One of the black medics (*Medicago lupulina*, the bur or hop clover) is often confused with the true clovers.

The commonest yellow-headed clovers are *Trifolium agrarium*, Linn., sometimes called yellow or hop clover (Fig. 339), with ovate-oblong leaflets that are all sessile and narrow stipules attached prominently to the petiole, the plant about a foot high; *T. procumbens*, Linn., the low or creeping hop clover (Fig. 340), with wedge-shaped leaflets, the terminal one of which is short-stalked, and short stipules, the heads smaller (one-half inch, or less, long), and the plant more spreading and about six inches tall. *T. agrarium* (sometimes called *T. aureum*) is very abundant on sandy lands in some parts of the country, and is considered to be of some value as pasture.

The other group comprises only one common species, the rabbit-foot or stone clover (*T. arvense*, Linn.) (Fig. 341). The plant grows a foot high, silky-gray all over, the leaflets linear or oblanceolate, the whitish-flowered heads becoming silky and soft. This clover is often so abundant on light lands as to form the principal growth after harvest. It might be utilized in some places as an early mulch or a catch-crop.

Group III. Wild or little-known clovers.

There are a good number of native clovers, but they have not come into prominence agriculturally and they need not be discussed here. Descriptions of them may be found in the standard floras. Some of these clovers have been cultivated to a limited extent, or in an experimental way, in this country or abroad. Feeding-value analyses have been made of some of them at the Oregon Experiment Station (Bulletin No. 62), of *T. Wormskioldii*, at the California Station (Report of 1895–7). The wild *T. Beckwithii* is mentioned as worthy of cultivation by J. G. Smith in Bulletin No. 2, Division of Agrostology, United States Department of Agriculture.

Literature.

Thomas Shaw, "Clovers and How to Grow Them," 1906; chapters and references in various crop books, as the books on forage crops by Hunt, Voorhees and others; scattered bulletins of Experiment Stations and the United States Department of Agriculture.

Fig. 340. *Trifolium procumbens.*

Fig. 341. Rabbit-foot clover (*Trifolium arvense*).

Red Clover Seed-Growing.

By *C. B. Smith.*

The clover-seed crop of the United States, in 1900, was placed by the census of that year at 1,349,209 bushels. Over 85 per cent of the crop was produced in the group of states including Indiana, Ohio, Illinois, Wisconsin and Michigan,—mentioned in the decreasing order of their importance. The yield varies from nothing to eight bushels per acre, the average being not far from two to three bushels. Six bushels per acre is a good yield, and eight bushels a large yield. The price for the past five years has varied from four to thirteen dollars per hundred pounds. Good seed can seldom be bought for less than five dollars per bushel. Chicago, Cincinnati, Toledo and Detroit are the large market centers for this crop. The price is usually higher in Chicago than in the other cities mentioned.

Color.

Fresh red clover seed of good quality has a bright plump appearance. The seeds vary in color from dark violet to yellow, with all intermediate shades. Sometimes green and brown or black seeds are found in greater or less abundance. The violet and yellow seeds are produced in about equal abundance and are generally considered equally valuable for planting. The dark seeds are heaviest, followed by the variegated, and the average of these is still heavier than the lighter-colored seed. The predominating color of the seed sown usually predominates also in the resulting seed-crop. European investigations show a higher yield of leaf and stem from yellow than from violet seed.

Size.

In size, red clover seed varies from twelve million to twenty-five million seeds per bushel, the average for American seed being sixteen to eighteen million per bushel. M'Alpine points out, as a result of English experiments, that small seed may produce more forage than a like weight of large seed, because more plants are produced. The rank early growth produced by large seed sown with grain is of no importance, since a hay crop is not cut until the following year, when the weaker plants from small seed may compete in size with plants from large seed.

Grades.

Several grades of clover seed are usually on the market. The value of a sample of seed depends on its cleanness, the percentage and vigor of germination, size and origin. Generally speaking, northern-grown seed is superior to southern seed. American seed gives much better results in the United States than European seed, which is sometimes imported.

Clover seed is seldom clean. Besides dirt, weed seeds are found in greater or less abundance; the cheaper grades of clover seed frequently contain enormous quantities, amounting to 80 or 90 per cent. Old seed or weathered seed does not germinate well. Green-colored seeds make weak plants. The vigor of germination of brown seeds decreases rather regularly from light brown to dark brown or black. The presence of any large quantity of brown or black seeds indicates low grade. Alsike and timothy seed are rather generally found in red clover seed, and, while not injurious, lower the grade. Farmers should buy their clover seed considerably in advance of the time it is needed for sowing, and examine it for purity and germinating power. The United States Department of Agriculture and many of the state experiment stations will also examine the seed free of charge if requested. Adulterated clover seed is the chief source of new weeds on the farm.

Seeding.

In growing clover for seed, sow clean seed on clean land. Upland soil of only medium fertility gives the best results. The crop is seeded either alone or with grain, as is usual for hay, but must not be mixed with other grass seed. Eight to fifteen pounds of clean seed per acre should be used, depending on the size of the seed and its percentage germination.

Harvesting.

The first crop is usually cut for hay in most clover-growing sections, and the second crop of the same season cut for seed. If the first crop is left for seed, new growth springs up before the first plants mature. The plants which mature first fall down, producing a tangled mass, the field remains in bloom six to eight weeks instead of twenty or thirty days, and the results are generally very unsatisfactory. These remarks apply particularly to the first year. They do not apply when the field is grazed or cut back about the middle of June. In a few sections, as northern Michigan, which has lately become an important clover seed section, the first crop of each season is the one used for seed. The second crop there matures too late for seed. The yield secured from the first crop averages close to six bushels per acre, and one instance of twelve bushels per acre from mammoth red clover has been reported. A. D. Hopkins states that in West Virginia the first crop is as well filled with seed as the second.

Another reason in most sections for using the second crop of the season for seed is that if it does not fill well with seed, the first hay crop has paid for the use of the land.

Again, bumble-bees and other insects which are believed to be essential for the cross-fertilization of clover flowers and the production of seed, are more abundant late in the summer than during the period when the first crop is in bloom. Darwin first pointed out the relationship between bees and clover seed. He covered 100 heads with matting. These produced no seed, while 100 heads exposed to insect visits produced 2,700 seed. A very large number of pollen-collecting insects work on red clover and effect cross-fertilization, but bumble-bees are the most frequent visitors. It is still an open question whether or not red clover is self-fertile. Experiments in England by Garton and in the United States by W. J. Beal and by the writer seem to indicate that it is in part at least self-fertile.

It is often a question whether to cut the crop for hay or to save it for seed. The hay is certain; the seed-crop speculative. If left for seed the crop is spoiled for hay. As a rule, if the heads selected at random contain twenty-five to thirty seeds each, it will pay to save the crop for seed. In a test by the writer, twenty-five heads gathered from a twenty-acre field of first-crop clover averaged twenty-three seeds per head. This field yielded two bushels of seed per acre. Twenty-five heads from a seven-acre field of first-crop clover alongside averaged fifty-three seeds per head and the yield was eight bushels per acre. With mammoth red clover, seed-growers generally pasture off or clip black the first crop about the middle of June. This retards the crop and gives a more uniform bloom, the straw is reduced and the yield of seed generally increased. In most cases, this practice gives the best results with June clover when the first crop is saved for seed.

Clover is ready to cut when the heads are brown and the seeds shell out plump and hard. Alsike clover should be cut even before all the heads are fully ripe, as it shells out much more readily than red clover. Either a mower or reaper may be used for cutting. In tangled clover the mower is best, while with the reaper less raking is required. When possible, clover is hulled directly from the field. This is particularly desirable with red clover, which is bulky to handle. The danger of a long wet period at hulling time makes leaving in the field precarious; the wise farmer will provide some shelter for his crop rather than run this risk. Clover should be hauled in a rack with a tight bottom, particularly alsike. As the seed comes from the huller it is mixed with more or less dirt and foreign seeds and should be recleaned before marketing. It is usually sold by sample.

Insect enemies.— There are two very important insect enemies of clover seed, the clover flower midge (*Dasyneura leguminicola*) and the clover-seed fly (*Bruchophagus funebris*). These insects are found all over the United States and Canada. The entire clover seed crop is sometimes destroyed by the flower midge alone. The remedy is to feed off or mow the first crop just before timothy heads out. Pasturing or clipping back in spring to delay blooming ten days is useful. The clover-seed fly is seldom noticed, though it causes enormous injury. It eats out the seed, leaving only the light shell, which in threshing is blown away, leaving no trace of the insect's work. No practicable remedy is known.

Literature.

The subject of red clover seed-production has not as yet been studied exhaustively, and the literature on the subject is very fragmentary and scattering. Consult Darwin, Cross- and Self-fertilization in the Vegetable Kingdom; A. D. Hopkins, The Flowering Habits and Fertilization of the Flowers of Red Clover, Proceedings Society Promotion of Agricultural Science, 1896; A. N. M'Alpine, Production of New Types of Clovers and Grasses, Transactions Highland Agricultural Society, Vol. 10, 1898, p. 135; Clover Farming, Henry Wallace, 1898; Clovers and How to Grow Them, T. Shaw, 1906; Clover Seed and Methods of Testing for Percentage Germination, United States Department Agriculture, Farmers' Bulletin No. 123; Michigan Board of Agriculture Reports, 1879, 1881, 1886; United States Bureau Entomology, Circular No. 69.

Clover: Its culture and uses. Figs. 342, 343.

By *Joseph E. Wing.*

For centuries, good farm practice has been based on the regular use of clovers in the rotation. Long before the scientist had found how clovers enriched soils the farmer had observed the fact and had founded his practice on it. There is no other means of so surely and cheaply enriching the soil for succeeding crops as the growing of leguminous crops, chief among which are the clovers.

The requirements of clovers are simple, and much alike for each kind. They feed actively on the mineral elements of the soil and revel in soils rich in potassium and phosphorus. They send their roots deep into the subsoil and find there much mineral wealth. On their rootlets develop tubercles filled with myriads of bacteria, which gather nitrogen from the soil-air and make it available to other plants on their death.

Soil requirements and preparation.

Clover thrives on sweet soils, that is, soils containing much carbonate of lime. Good farming is much dependent on limestone. Where soils are acid, agriculture and the growth of clovers decay. Where there is abundant lime in the soil, acidity does not occur. Many regions that once grew good clover will not grow it now, and when the soils are studied they are found to be acid, and yet these soils may overlie the solid limestone rock, only a few feet down. Whenever fragments of this rock are mixed through the soil, clovers will thrive.

There are other soils that never contained much lime, and that within recent years have become too acid to permit the growth of clovers. Liming is the first requisite to restore clovers to these lands. The safest form is the crushed or ground and unburned limestone. This is neutral, and it does not attack the humus nor set free nitrogen. Acids will attack it and be destroyed, and any residue will remain for future years. Carbonate of lime in ground form, unburned, may be applied in large quantities and at small expense; it is a permanent investment that should yield dividends for a long time. It is quite safe to use as much as three to eight tons of carbonate of lime to an acre of land, and much more has been applied without harm. Next in importance to lime for clovers is the supply of phosphorus. Clover demands an abundance of phosphorus. This may be applied in any form, either by the use of acidulated rock, by "floats" used in connection with stable manures, or by the use of bone-meal. If there is then present a normal amount of potash, the clover will thrive. For best results, however, there should be a certain amount of vegetable matter in the soil. Humus puts "life" into the soil, adds plant-food and enlivens the soil by letting in the air and by encouraging the earthworms; it also introduces bacteria in great abundance, and these may help the growth of the clover and add to the wealth of the soil.

The writer has in mind an old field from which clover had been long banished because of its poor condition. It was divided into two parts, both alike enriched with suitable mineral fertilizers. One-half was given no manure, the other half was given a very light covering of yard manure. Both were sown to red clover. The result was striking. The growth of clover on the part given the little manure was several times as heavy as that on the unmanured part; and the enrichment of the land by the aid of the clovers was proportionately greater where the heavy clover grew.

Red clover.

Common red clover, the most useful and widely spread of the clover family, is, fortunately, of very easy propagation. The common practice is to sow it on winter wheat in the late winter or early spring. It is commonly sown directly on the soil without any preparation whatever. Thus sown, it frequently succeeds, though there are failures enough to indicate the need of a better practice. In sowing red clover with wheat it is wise to wait until settled weather has come, in late March or early April, and the land has become dry enough to harrow; then thoroughly stir the ground with a harrow, sow the seed and again harrow to cover it. Thus treated, if the soil is reasonably fertile, and if it is sweet, failure can come only from very unusually bad weather, or from the lodging and smothering effect of the wheat crop. If care is used in making the seed-bed, ten pounds of red clover seed to the acre is enough. There should be mixed with the seed a small percentage of alfalfa seed when there is a likelihood that at some near time the land may be seeded to alfalfa, since the scattered plants of alfalfa will in time become inoculated with the proper alfalfa bacteria and the later growth of the alfalfa thus be assured.

Seeding with oats.—Clover sown with oats is not usually so successful as when sown with wheat, for the reason that the oats are very leafy and their shade hurts the clover. The oats often lodge on good ground, and if they escape this they draw much more heavily on the land for moisture than either wheat or barley, so that they may exhaust

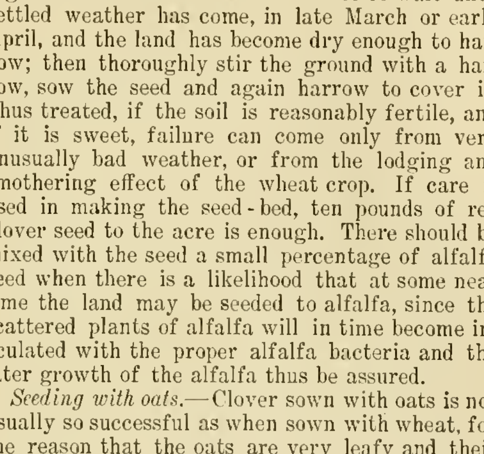

Fig. 342. Clover in cocks.

the moisture to such an extent that the young clover will die when the oats are taken away.

There are, however, two ways of sowing with oats that give uniformly good results. The one is thoroughly to prepare the land, sow a less quantity of oats than usual, say a bushel to the acre, and the clover seed, covering the latter lightly, then leaving the ground smooth by the use of a plank drag. When the oats are in bloom and before they have formed seed they are mown for hay. They will then have damaged the clover very little, and often there will be a crop of clover hay in the fall of the same year.

The other system, which is the better, is to sow the oats as heavy as two bushels to the acre, with the clover seed, and when the oats are sixteen inches high to turn in sheep to eat the crop down quickly; then take the sheep away and let the oats and clover come again. This pasturing may be repeated two or three times in the summer, care being taken not to let the animals remain too long at a time. Remarkably strong, vigorous stands of clover are secured in this way.

Seeding with barley.—Spring barley makes an ideal nurse crop for young red clover. The beardless barley is best, since it comes off the ground early. It does not shade the clover much and sufficiently subdues the annual grasses. Barley may be cut for hay or allowed to ripen its grain, although if it should lodge it should be cut for hay at once.

Care of young clover.—No animals should be pastured on the clover long enough to eat it close to the ground, and it should always go into winter with a good growth to hold snow and protect the roots. However, it should not be permitted to bloom the first summer, since red clover is an uncertain biennial, and when it has bloomed and made seed it is so much weakened that it easily dies. Should it show much bloom the first summer, it may be mown, and either made into hay or allowed to lie for mulch and protection. No animals should ever be permitted to tread on clover meadows in the winter time.

Making clover hay.—Red clover makes a most useful hay, but it is seldom secured in its best condition. It should be mown when in full bloom and before any of the heads have turned brown, tedded or turned once or twice, raked and put up in small cocks, piled as high as convenient. In the cocks it will lose a part of its moisture. After a few days, depending on the weather, the cocks should be opened in several large flakes, while the sun is hot. These may be turned again, and drawn to the mow. In putting a large quantity of clover hay in the mow it need not be so dry as though only a few loads were gathered together, since the large quantity accumulates enough heat to kill germs of mould and to dry out the entire mass. This makes a sweet, palatable hay of brown color, free from much dust or mould. Hay caps are useful in making clover hay. It should not be too much sun-dried or many of the leaves will be lost.

The practical test of whether clover hay is in condition to put in the mow is to take a wisp of it and twist it violently. If no moisture can be seen to exude from the stems, it may be stored. It should never be put in while there is any dew or rain on it. The old practice of putting up clover hay by means of alternate layers of clover, partly cured, and dry straw, is a good one, and results in first-rate hay, and causes a part of the straw to be eaten.

Clover as pasture.—Clover pasture is admirably adapted to hog-raising, and cattle thrive on it if restricted so that they do not bloat. For pasture, red clover should be mixed with some sort of grass, since it is too nitrogenous to be relished alone. Much better results are secured when the animals grazing on it can find grasses with which to vary their diet. For this purpose, timothy is often sown with clover, and awnless brome-grass (*Bromus inermis*) is excellent for the purpose; or the animals may be given access to a field of grasses. There will be very much less bloating when the pastures are mixed.

If a mixture of salt and air-slaked lime is kept where the animals may find it, there will be less bloating. When animals become accustomed to grazing on clover they should be permitted to remain constantly there, as the risk is less than if they are taken off and put back at intervals.

Clover for soiling.—Very much better results are secured in soiling clovers than in pasturing them. They may be cut when in bloom, or before, and hauled to the animals. Several times as much forage will then be secured from a given area as though the animals ran on the ground and wasted and trod down a large part. Here, also, the precaution of feeding complementary feeds with the clovers, to counterbalance the excess protein, must be observed.

Bringing clover in old pastures.—If on old pastures, fertilizers rich in lime and phosphorus, such as basic slag, with potash if the soil needs it, are used, and no clover seed sown, there will frequently come a decided sprinkling of clovers of the sort that have become natural to the field, and they will grow with extraordinary vigor. On an adjoining field, should one sow nitrate of soda, he will observe the disappearance of the clovers and the rioting of grasses.

Clover for silage.—For silage, clovers should be cut when full of sap and be put in the silo with no waste of time. They should be in full bloom. In general, corn pays best in the silo, the clover in hay being held to feed with it.

Mammoth clover.

This is a form of red clover. It is rather more persistent, much coarser, more productive and makes a coarser hay not so much relished by stock. It is better than common red clover for enriching soils, but is inferior to it as a hay plant.

Alsike clover.

On certain soils, rather inclined to wetness, alsike clover thrives better than the red clover, and is an excellent forage and bee pasture. It may be seeded and treated as has been directed for red clover.

Crimson clover.

This is the "trifolium" of Great Britain. It is an annual, sown in the fall, which blooms, makes seed and dies the following summer. It is most often employed as a catch-crop, after maize or vegetables. Crimson clover thrives in a warm, sandy soil and in regions south of the Ohio river, though it is used to some extent north of that line. It makes good pasturage and fair hay, though it is said to be dangerous to horses owing to the hairs on the seed-stems. It is often used as a soiling crop. It enriches soils remarkably, and when adapted to the soil and climate is of great value. It well repays fertilizing with phosphorus and potassium. Crimson clover is especially well adapted to the south Atlantic seaboard.

White clover.

This is a small perennial plant, with creeping stems rooting at the joints. It comes naturally in pastures and along roadsides, especially where

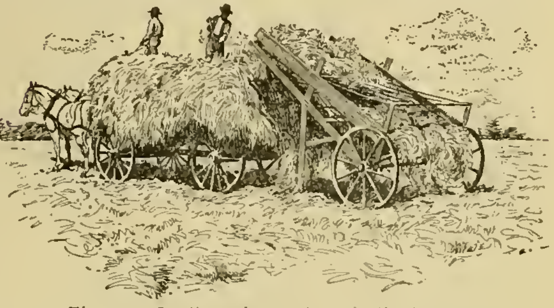

Fig. 343. Loading crimson clover in the South.

there is lime in the soil. It makes good bee pasture, and is liked by all animals. When in seed it sometimes salivates horses, making them to "slobber." It is exceedingly nutritious. It should be sown in all mixtures for permanent pastures. The seed being very small, no more than two to four pounds per acre need be sown. It does well with most grasses, enriching the soil, giving place to them when they are vigorous, but reappearing again when they are subdued. It is usually too short for hay. All animals relish it, and it is very fattening except in unusually cold, wet seasons.

COFFEE AND COFFEE-GROWING, with Special Reference to Porto Rico and Hawaii (*Coffea Arabica*, Linn., and *C. Liberica*, Hiern). *Rubiaceæ*. Figs. 344–353.

By *J. W. Van Leenhoff.*

Coffee-growing is essentially a tropical industry. It is of vast proportions. The annual production in the world exceeds 1,500,000,000 pounds. Within recent years there has been over-planting and over-production, with a consequent falling in price that has practically stamped out the industry in parts of the Hawaiian islands and elsewhere. Africa, Arabia, Brazil, Venezuela, Colombia, Central America, Ceylon, Hawaiian islands, Java, Mexico, Porto Rico, all grow considerable coffee, Brazil alone producing nearly three-fourths of the world's supply. The two species, *Coffea Arabica* and *C. Liberica*, furnish most of the commercial product. [For a botanical discussion of species, see *Coffea*, Cyclopedia of American Horticulture.]

In order to show the extent to which the industry has grown, the following table of production and consumption is given. It was prepared by Steinwender, Stoffregen & Co., New York City, on January, 1, 1907.

PRODUCTION AND CONSUMPTION IN BAGS* OF ALL KINDS OF COFFEE FOR THE LAST FIFTEEN YEARS.

Production (Crops)				Consumption			World's Visible Supply on July 1	
Crop Year	Rio & Santos	All Others	Total	Total	Production Over Consumption	Consumption Over Production		
1890–1	5,358,000	3,965,000	9,323,000	8,718,661	604,339	. . . .	1891	1,909,120
1891–2	7,397,000	4,582,000	11,979,000	10,804,551	1,174,449	. . . .	1892	2,955,023
1892–3	6,202,000	5,082,000	11,284,000	10,946,228	337,772	. . . .	1893	3,100,618
1893–4	4,309,000	5,092,000	9,401,000	10,571,533	. . . .	1,170,533	1894	2,146,423
1894–5	6,695,000	5,069,000	11,764,000	11,212,851	551,149	. . . .	1895	3,115,680
1895–6	5,476,000	4,901,000	10,377,000	11,142,813	. . . .	765,813	1896	2,588,193
1896–7	8,680,000	5,238,000	13,918,000	12,244,204	1,673,796	. . . .	1897	3,975,880
1897–8	10,462,000	5,596,000	16,058,000	14,571,902	1,486,098	. . . .	1898	5,435,974
1898–9	8,771,000	4,985,000	13,756,000	13,480,904	275,096	. . . .	1899	6,200,013
1899–1900	8,959,000	4,842,000	13,801,000	14,972,699	. . . .	1,171,699	1900	5,840,561
1900–1	10,927,000	4,173,000	15,100,000	14,329,925	770,075	. . . .	1901	6,867,627
1901–2	15,439,000	4,296,000	19,735,000	15,516,663	4,218,337	. . . .	1902	11,261,331
1902–3	12,324,000	4,340,000	16,664,000	15,966,498	697,502	. . . .	1903	11,900,173
1903–4	10,408,000	5,575,000	15,983,000	16,133,707	. . . .	150,707	1904	12,361,454
1904–5	9,968,000	4,480,000	14,448,000	16,163,353	. . . .	1,715,353	1905	11,265,510
1905–6	10,227,000	4,565,000	14,792,000	16,741,215	. . . .	1,949,215	1906	9,636,563

*A bag is 132 pounds.

History.

Nicholas Witsen, a Hollander, was the first to transfer the coffee plant from its native soil in Arabia, thus laying the foundation on which gradually the world's present enormous coffee industry has developed. The plant prospered which he took from Mocha in 1690, and planted in Batavia, capital of the Dutch East Indies. It is probable that seed from this tree and its descendants were in the course of time transported to the different coffee zones of the world, where its descendants now cover vast areas and are the means of sustenance for millions of people, while its products have become almost a necessity of life for millions more.

A seedling was sent from Batavia to the Botanical Gardens in Amsterdam, from which in 1712 the French artillery officer, Ressous, secured a seedling. He gave it to King Louis XIV, who had it planted in the Jardin des Plantes, where it soon died. In 1714, the Burgomaster of Amsterdam sent another seedling to Louis XIV which was planted in the Jardin des Plantes, lived and produced seeds, of which, after an unsuccessful attempt by Dr. Isambert, a seedling was brought in 1720 to Martinque by a French officer, de Clieux, and planted with success. Seeds from this plant were distributed to the colonists in Martinique and other French possessions in the Antilles. Not many years later, French refugees form Hayti brought seeds to Porto Rico.

General culture.

Climate.— Coffee reaches its best development at altitudes of 1,000 to 2,500 feet above sea-level, 2,000 feet being perhaps the optimum elevation. Other conditions being favorable, very good crops are grown frequently at lesser altitudes. Generally, the higher elevations are associated with greater rainfall and a lower temperature, making less shade necessary. The higher altitudes seem to produce a larger bean. A rainfall of 50 to 200 inches annually, evenly distributed, gives best results. Freedom from severe winds is essential. An equable temperature, having an average minimum of not less than 60° is required.

Soil.— Coffee will thrive on a variety of soils, but a deep, rich soil is desirable, a large content of humus being especially favorable. Volcanic deposits are well adapted. In Porto Rico, the Adjuntas clay and Alonzo clay give the best results. The former is a pink-red or dark brown clay, three to eight inches deep, underlaid by a pink or red subsoil twenty inches or more in depth. The latter is a dark, purplish clay loam, eight to thirty-six inches deep, containing more or less pebbles and boulders. These clay soils are subject to less

Fig. 344. Coffee flowers (*Coffea Arabica*).

erosion, as a rule, than sandy ones, retain moisture better and wear much longer. Very sandy or gravelly soils, especially if closely underlaid by coarse gravel or broken rock, should be avoided. If such soils are virgin, the coffee trees will grow well for a few years but will soon fall into a decline, owing to the rapidity with which such soils deteriorate under the washing of heavy tropical rains. After the humus and surface fertility of such soils are depleted they withstand drought poorly, because of their porous nature and the steep topography of most of the country which so quickly and completely drains away the water. The clay soils are more retentive of moisture and retain their fertility longer.

As a rule, the coffee lands are naturally well drained, but occasional small and comparatively level areas occur, which need artificial drainage. In constructing drains, care should be exercised so to place them as to cause the minimum amount of erosion.

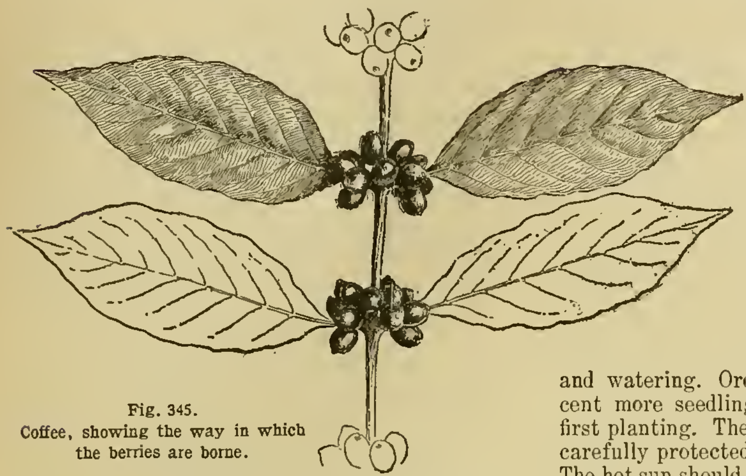

Fig. 345.
Coffee, showing the way in which the berries are borne.

Other things equal, virgin forest land will give best results, because of its greater fertility. Its fertility and freeness from noxious weeds, thus reducing the subsequent cost of weeding the plantation, will often more than counterbalance the extra cost of clearing the land and the disadvantages of poor location, with reference to transportation, frequently attendant on the taking up of new land.

Preparing the land.—If time permits, the land should be cleared as thoroughly as possible, and all the waste material burned. Some persons recommend not burning over the land, in order to save ferns which are invariably found in forest lands. It is presumed that the ferns keep the ground moist, prevent weeds from growing, protect the young coffee trees from insects and do not interfere with the growth of the coffee. Frequently the trees that are cut are allowed to rot on the land, the branches being trimmed so as not to interfere with the planting; or the underbrush may be cleared away and the trees girdled. The latter practice, however, is not to be commended, as it later is dangerous to the workers and to the coffee trees. Still another practice is to clear the underbrush and allow the trees to stand, planting the coffee directly under the forest trees, the trees being removed only after the artificial shade has grown. Trees should be left standing on ridges and on the side from which the prevailing wind blows, to serve as windbreaks. If the winds are strong, it may be necessary to plant some quick-growing tree as a windbreak where the forest trees will not serve. If roads and drainage-ditches are necessary, they should be constructed as soon as the land is cleared.

Seedling plants.— Volunteer seedlings, which occur in large numbers in all coffee groves, are usually procured. They are generally drawn from the ground by main force, though occasionally a spade or other instrument is employed. They vary from one to three years old, according to the preference of the planter. Frequently, however, seedlings are raised in seed-beds, which is the more rational practice, as the volunteer seedlings cannot be relied on fully. For this, the best-developed berries should be chosen and carefully pulped by hand. The seed-beds are best located near the permanent planting, and should be of such a size as to facilitate planting, weeding and watering. Ordinarily it is safe to raise 25 per cent more seedlings than will be needed for the first planting. The seed-beds must be shaded and carefully protected from heavy downpours of rain. The hot sun should not strike the plants. (Fig. 348.)

The soil for the bed must be fined and leveled, and free from extraneous matter. It should be moistened thoroughly the evening previous to planting the seeds. The seeds are pressed lightly into the soil, about two inches apart each way. The bed is covered with a layer of wood-ashes and again moistened. As soon as the first round leaves are formed the plants may be transplanted into the nursery-beds. This will generally occur in about ten or twelve weeks after the seeds have been planted.

The nursery-beds are similar to the seed-beds. The young plants are set in rows about six inches apart each way. Only those are reset that have straight, well-developed taproots. The taproots are cut back to a length of about four inches. Much care is required in the planting to see that the plants are set straight, and that they are buried just

Fig. 346. Coffee-tree branches loaded with berries. Guatemala coffee.

to the same height on the stock that they were in the seed-bed. The nursery-bed is watered after planting, and from time to time if the weather is dry. As the plants develop the shade is generally removed until they are exposed to full sunlight. It should be planned to expose them to the full light and air when they have developed four pairs of leaves. After being exposed for some time they are ready to be planted in the field. It is preferable that five pairs of true leaves be developed before transplanting. (Fig. 349.)

Planting.—The planting distances should be marked carefully before any of the trees are set. The best distance between the rows is still unsettled. Seven to nine feet is common practice. Where coffee can be grown on somewhat flat land, as in Brazil, and machines used between the rows, a greater distance is desirable. The coffee lands in Porto Rico are generally very steep and irregular.

Holes about two feet deep and as wide as necessary are made at the points determined for the planting. In Porto Rico a good practice is to place the subsoil on the lower side of the hole, and fill the hole only with surface-soil scraped from the vicinity. This makes a small table or flat, which can be gradually enlarged, which expedites hoeing about the young trees and reduces soil-washing during heavy rains.

Planting is done usually at the beginning of the rainy season, as it is necessary that the soil be moist and the sky at least partly cloudy. The seedlings to be planted should be thrifty and well developed. If branches have been formed and the stem thickened, the seedlings should be pruned back to about six inches from the collar. Planting is an important process and should be done with great care. It is important that the taproot be planted straight, and that it be not injured. The safest way is to lift the seedling on a spade, with the earth attached. The roots must not be exposed

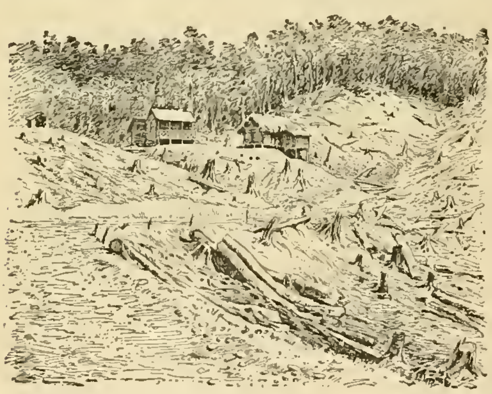

Fig. 347. The beginning of a coffee plantation; clearing the forest. Dwelling house and workman's house are shown, constructed from the felled forest trees, sawn by hand.

to the sun, and any that extend beyond the clod should be removed by sharp scissors. The seedling is placed in the center of the hole, and the soil pressed firmly about it. The collar should be slightly below the surface. If the seedlings are set bare, that is, without the clod, the plant hole should be filled and a hole of sufficient size made in the center by means of a rounded stick or dibber. The space about the root must be completely

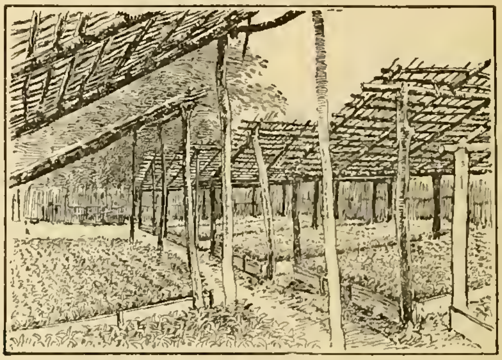

Fig. 348. Coffee seed and nursery beds under artificial shade. Porto Rico Experiment Station.

filled. Only seedlings that have not yet developed branches may be planted bare. The taproots are cut with sharp scissors at the point where they bend easily, and the side roots are pruned. The taproot should not touch the bottom of the plant hole, and the side roots should be placed as nearly normally as possible.

Sometimes the fields are not ready to receive the seedlings when the latter are ready, and the seedlings develop too far. They should be cut back to about six inches, as above mentioned, and planted as "stumps." Stumps are more vigorous and may be planted when the sun is shining, providing the roots are not exposed to the sun. Many shoots or suckers will soon appear. When these become about two inches long, all but one should be removed with a sharp pruning knife. The remaining shoot should develop into a strong plant more quickly than the seedlings.

A certain percentage of the total number of trees set out will fail, and this number must be provided for resetting. An allowance of 10 per cent for this should be an abundance; and, with proper care, it would be excessive.

Cultivation and subsequent care.—After the trees are set and the plantation started, the further care is very slight. The work consists almost entirely of weeding and replanting. One man can look after ten to fifteen acres. The weeding is done twice a year generally. It is essential that the land be kept clean, and that no weeds be allowed to run to seed. When the land becomes hard, surface tillage will be required. A practical method is to cultivate in a circle around the tree, gradually enlarging the area as the tree branches. The first cultivation should always be made outside the original plant hole. Good crops demand that the soil be kept loose. The frequency of cultivations will be determined by the frequency with which the soil becomes sun-dried or packed by heavy rains. The extent of erosion or washing must also be considered, as in the steeper plantations it may make much surface tillage inadvisable.

Suckers should be removed as they appear and dead branches and unnecessary and undesirable parts cut away. The practice of pruning is falling into disuse in many coffee-growing regions because of labor and financial conditions, and has been entirely abandoned in Hawaii. It is frequently advisable to allow a lower shoot to remain to replace the original stem which has suffered from the dying off of the lower branches. When the new stem begins to bear, the old one may be removed.

Fig. 349. Coffee seedling.

Shade.—The most mooted question in coffee-culture is that of shade. The opinion that heavy shading is necessary has led to much injury of the industry, notably in Porto Rico. That high-grade coffee can be grown without shade has been shown in Guatemala and Brazil. The prevalent idea that shading benefits the foliage and fruit is erroneous. However, it is quite probable that shading the ground is a cultural advantage. Leguminous trees are frequently planted for shade, and their nitrogen-collecting powers have no doubt been beneficial to the coffee-plants. In Java, Ceylon and Africa, leguminous trees are used largely. Other possible advantages are protection against drought, and the moderation of the temperature of the upper layers of soil. The shade trees must not be so dense as to shut out light and air. A single tree may be placed in the center between blocks of four coffee trees each; that is, each block of four trees will have a shade tree on each side of it in the row. For a discussion of this subject the reader should consult Bulletin No. 25, Division of Botany, United States Department of Agriculture, Shade in Coffee Culture, by O. F. Cook.

The trees used for shading in Porto Rico are guaba (*Inga vera*), guamá (*Inga laurina*), moca (*Andira inermis*), and bucare (*Erythrina micropteryx*). The first two are used most extensively. In Mexico, the shade tree is *Inga Inicuil*. In Hawaii, coffee shading is practiced, the trees used being, in order of importance, silky oak (*Grevillea robusta*), kukui, Java plum and Monterey cypress. The native ohia tree, the principal forest tree in Hawaii, is usually left standing at intervals in new land until the planted grevillea is large enough to afford protection. (Fig. 350.) In Hamakua, the *Grevillea robusta* has been found so much superior to all other trees that it is now the only one recommended. It is clean and free from blight, and throws off leaves profusely, thus reducing the hoeing and supplying fertilizing material to the soil. Furthermore, the shade is variegated, and not too dense. The best practice seems to be to provide a row of shade trees every thirty-five or forty feet.

The shade trees are pruned generally by cutting away the lower branches and clearing them of dead wood; and they are thinned out when neccessary.

In new plantations the ferns are allowed to remain to supply shade for the coffee seedlings, and more especially to lessen the loss from cutworms, which are very destructive to cultivated plants when the field is completely cleared.

Most of the planters hold to the idea that if the coffee trees are topped, shade is a necessity; if the trees are not topped, no shade is required; but if the soil is poor or the field wind-swept, shade is beneficial.

Harvesting.—The coffee trees begin to bear

Fig. 350. A coffee plantation in an Ohia forest, Hawaiian islands.

about the third year, giving light crops until the fifth or sixth year. The trees blossom at least three times a year, the fore blossoming, the large blossoming, and the after blossoming. These occur in the months of February, March, April and May, according to location. Generally after seven or

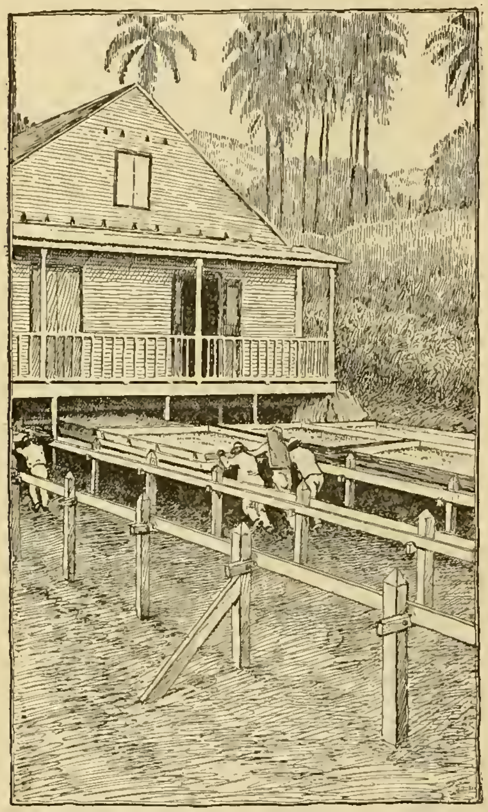

Fig. 351. Method of drying coffee in the sun in drawers that are slid under a house when there is no sunshine.

eight months the berries are ripe. This throws the harvesting in the last four months of the year. The berries ripen unevenly, so that the plantation must be gone over several times. The picking is done by hand. The yield per tree varies greatly, according to the care given. One pound of dry coffee per tree is a general estimate, although this may be greatly increased.

In Porto Rico the pickers are paid by the measure, which is called "almud" and should contain twenty liters. About six or seven cents are paid for a measure. Twenty liters of berries are equal to about five pounds of coffee ready for the market. The expense of picking is $1.20 to $1.40 per 100 pounds of coffee. In Hawaii, the cost of picking and transporting the coffee to the mill averages about three and one-half to four and one-half cents per pound of market coffee.

Handling the product.

When the berries are picked they are subjected to one of two processes. The berries may be dried at once and later put through machines called "hullers," to extract the seed ; or they may be "pulped," that is, have the outer fleshy coat removed, before drying. In Porto Rico, pulping is usually done at once. The pulping machine is driven by hand, water or other power. Sometimes the separated pulp is used as a fertilizer. The beans are collected in wooden or cement tanks in which they remain to ferment upwards of thirty hours, in order further to disintegrate the saccharine matter of the external coat, after which they are washed, either mechanically or by hand, and put on large cement floors in the sun to dry to a point where they can be stored safely. From these floors or from the storeroom they are put in drying drawers. These drawers, for the most part, are constructed underneath the high floors of houses, run on rails in the open, where they are kept as long as there is sunshine (Fig. 351); at the least danger of rain the drawers are run back under shelter. During the whole drying process the grains are repeatedly turned. In some places mechanical hot-air drying apparatus is used. As soon as the coffee is dry, which should be when it is brittle when broken between the teeth, it is either hulled or left in the parchment (the tough inner integument, also called hornskin) and taken in 100-pound bags to the most convenient market. Coffee merchants established there buy the coffee for cash. They hull, polish and separate it into different grades by special and mostly modern machinery, and finally pick it over by hand.

Hawaiian coffee is all fermented and washed. It is thought by many that the method of fermenting has a strong influence on the flavor of the coffee. The Hawaiian berry is first run through a pulping machine, immediately after being picked. When hulled, the bean in the parchment is fermented in shallow trays or bins eight to twelve inches in depth. When the beans have fermented and there is no longer a marked rising temperature, they are washed in a stream of running water to remove the gum and then transferred to drying-houses, or the product is taken to the beach and dried in the sun. This product, known as parchment, is then packed and sent to the coffee milling establishments and is run through machinery which removes the parchment. The beans are then graded and polished and in many establishments hand-picked. When put up in bags of 100 to 150 pounds, the coffee is ready for market.

Enemies.

While a number of insects and fungi infest coffee plantations to a greater or less extent, the crop is remarkably free from serious annoyance. In Hawaii there are no serious diseases or insect pests, the torpedo bug (*Siphanta acuta*) and the brown-eyed disease (*Cercospora coffeicola*) of leaf and berry being the most troublesome. Both are readily amenable to preventive measures, the best preventive being thorough cultivation, the proper degree of shading, and the use of fertilizers. The coffee blight (*Pulvinaria psidii*) has done serious damage in some districts. It seems to occur principally in neglected plantations. It will probably

Plate VIII. Coffee in bearing. Shaded by orange. Cuba

continue to be a pest, since it infests also the guava and certain ferns. Nematode worms are often present in the roots, and rarely occur in the stem and berry, causing the latter to drop before maturity. A "black fly" (aphid) is abundant on new growth in Hawaii.

Porto Rico is not so fortunate in the point of numbers of enemies, but is comparatively free from serious annoyance. The diseases and insect pests thus far observed are as follows:

Coffee leaf blight, provisionally called by F. S. Earle, *Sclerotium sp.*, is a fungus which covers the trees from the roots up with brownish mycelial threads, spreading out, as the leaves are reached, into a fine white weft. The attacked leaves blacken soon and fall. The remedy is plenty of sunlight and spraying with Bordeaux mixture.

Stilbum flavidum, so-called American coffee disease, is a fungus making on the leaves nearly round spots of about one centimeter in diameter and of a yellowish color, causing the leaves to drop. Reducing excessive shade is recommended as a remedy. Lately the same fungus has been discovered on the fruit, causing blackened spots on the pulp and seeming to eat its way into one of the kernels, on the parchment of which it causes wart-like growths which extend to the kernel itself. Spraying with Bordeaux mixture is being tried.

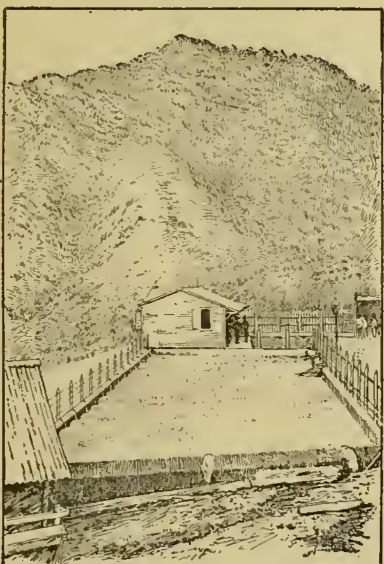

Fig. 352. Cement floor for air-drying the wet-washed coffee.

These diseases, as well as coffee root-rot, do not occur frequently, however, and mostly in too moist and overshaded localities.

Coffee leaf-miner (*Leucoptera coffeella*) is perhaps the most serious coffee pest thus far observed. It is a minute silvery moth, which in its larval state burrows within the leaf tissues, causing brown, dead patches on the leaves. Sometimes more than one larva is found in the same patch, and the leaves are sometimes covered with such patches, thus seriously deranging the nutrition of the plant. On rich soil the harm is not very apparent, but must certainly influence the crop. On poorer soils the leaves drop off, leaving the trees entirely leafless or with only a pair of small leaves at the point of each branch, thus giving the growth of the plant a tremendous setback. Hand-picking and burning the attacked leaves have been resorted to, but without result; as soon as new leaves are formed they are again and again attacked. Thus far the only remedies are its natural enemies (discovered on the island in 1904 by O. W. Barrett), *Chrysocharis livida*, and *Zagrammosoma multilineata*, parasites, the larvæ of which are found inside the coffee leaf-miner on which they feed, and an apparently fungous disease which attacks the miner in its larval state. It has been estimated that the leaf-miner is responsible for the loss of upwards of $100,000 worth of coffee in Porto Rico annually.

Coffee scale (*Lecanium hemisphericum*) is present everywhere. It sometimes occurs so plentifully on the tender twigs that they seem to dry out, but this is very seldom, and the harm from the scale is not otherwise apparent. Larvæ of lady-birds, and a white fungous disease which seems to grow in the bodies of the scale, spreading over all the scale on the same twig or stem or plant, seem to be sufficient to hold the scale in check.

Weevils do much harm in some places by eating the young leaves, and by attacking the green soft parts of the twigs, in some instances causing those parts bearing the fruit to drop or die. The most damage apparently is done in young coffee. Mealy bugs sometimes appear at the roots of old trees. May beetles dig holes in the earth near the stem and their larvæ do damage to the roots. Other larvæ, bugs, rats and ants attack the coffee plant, but none of them is serious.

Coffee in Porto Rico.

The climate and soil and nearness to European and North American markets, the dense population and the short distances between the seaports and the mountain slopes on which the coffee is grown, adapt Porto Rico especially to this industry. The rugged mountainous topography which comprises three-fourths of the total area, makes the cultivation of other important crops than coffee almost impossible. As a result, coffee-growing has become the leading industry of the island, and the crop is grown in nearly every district. The best coffee is produced in the southwestern part. Formerly coffee was grown on the lowland, where it did well. The production of sugar, however, has driven most of it to the highlands. The high-water mark was reached in 1896, when 58,780,000 pounds, valued at $13,519,400, were exported. Most of this went to Europe. Spain takes a large share, and Austria, Hungary, Italy, France and Germany are good markets. United States takes very little of the output. The lower grades are shipped to Cuba or are sold for home consumption. The acreage in 1904 was reported as 183,541. The industry is not in so prosperous condition as it should be. The changed political relations of the island, with the attendant effect on its commerce, the general decrease in the price of coffee on the market, and the destructive hurricane of 1899, from which many plantations have not recovered, have all tended to depress the industry. The average production per acre had fallen in 1903 to 250 pounds. This could be increased to 1,000 pounds with improved methods. Selection for quality or yield has been little practiced, and the planting methods are careless. It is gratifying to note, however, that modern methods of cultivation are finding a place. A project for the establishment of a school for coffee-growers is under consideration by the government.

According to the census of 1899, the average size of coffee plantations was nine acres. A few have 1,000 acres and more. A considerable number have 100 to 1,000 acres, but the majority consist of less than 100 acres, even going so low as a fraction of an acre. The larger plantations, as a rule, have their own population, who live in houses or huts provided for them by the plantation, free of rent. Usually they live in families, of which only the male members work in the fields, except in harvest time, when the entire family goes to pick coffee. This help may be supplemented, when necessary, by laborers from the smaller towns in the interior or by small proprietors. Full-grown laborers get thirty-five cents and boys ten cents and up for a day's work of about eleven hours. Much work, however, is done by contract, which nets the workers more. The quality of the labor is very satisfactory, and is mostly white.

Fig. 353. Coffee mill in Hawaii.

Coffee in Hawaii.

Coffee has been cultivated in the Hawaiian islands for eighty years or more. The conditions for producing this crop are almost unexcelled. There are over 300,000 acres of land adapted both by soil and location to the production of a high-grade product. The climate is equable, the temperature seldom dropping below 50° or rising above 85°. Some experiments are being made with rubber trees as a coffee shade, and indications are that their success will materially add to the value of the coffee land in Hawaii. The low prices now paid for coffee, however, are discouraging new plantings. The annual production is about 3,000,000 pounds. Yields of 750 pounds of marketable coffee per acre are secured in Kona and Hamakua on fields that receive proper attention. The coffees are mild, and of high flavor, and frequently sell above the average market prices. The bean is large and flat, resembling Javan rather than Brazilian coffees. All of the coffee produced in Hawaii is milled and graded before being sent to market. Practically no parchment is exported. The average cost of production is about nine and one-half cents per pound. The picking season in the Kona or leeward districts runs from November to January, and in the windward districts from January to May. Fig. 353 is a Hawaiian coffee mill.

There are three types of coffee in cultivation,—the so-called native Hawaiian of unknown source, introduced into the islands about eighty years ago, a hardy form which stands neglect and hard usage and lack of care better than any other cultural form in Hawaii; the Java, introduced directly from Java about fifteen years ago; and Horner's Guatemala, said to have been introduced from Guatemala about 1890, but its exact source is uncertain, probably Javan. The last is the one most largely cultivated in Hawaii. It is a hardy tree that bears heavily, and is not very subject to disease. The berry is large and flat like the best grades of imported Java.

The industry is suffering because of the low prices for coffee. The hope for reviving the industry lies in the creation of a market in the United States for Hawaiian coffees individually. Growers assert that the industry will soon be ruined unless the United States government protects it by tariff.

Literature.

Coffee, Its Culture and Commerce, C. G. Warnford Loch, editor, 1888, contains a compilation of nearly all the literature then existing. Other works are : Colonial Reports, Darling & Sons, London ; The Improvement of Indian Agriculture, Dr. J. A. Voelcker, London ; Tropical Agriculture, P. L. Simmonds, London ; Ceylon Soils and Manures, John Hughes, London ; Tropische Agrikultur, Semler ; Culture du Caféier, C. Raoul, Paris, 1899 ; Shade in Coffee Culture, O. F. Cook, Bulletin No. 25, Division of Botany, United States Department of Agriculture. Various German, French and Dutch publications contain valuable discussions of coffee. For a discussion of the industry in Porto Rico, the reader should consult Coffee Planting in Porto Rico, J. W. Van Leenhoff, Circular No. 5, Porto Rico Agricultural Experiment Station, from which parts of this article are adapted. For Hawaii, see the Annual Reports of the Hawaii Agricultural Experiment Station, 1901, 1902, 1903. See list of publications on tropical agriculture, Vol. I, page 99. References on the industry in Porto Rico and Hawaii will also be found in the articles on these countries in Vol. I (pages 109, 114).

COTTON. *Gossypium. Malvaceæ.* Figs. 354–367.

By *Herbert J. Webber* and *E. B. Boykin.*

The cotton of commerce is the hair or fiber on seeds of plants belonging to the genus Gossypium, a member of the Mallow family. This genus is distinguished from the other genera of the family by the presence

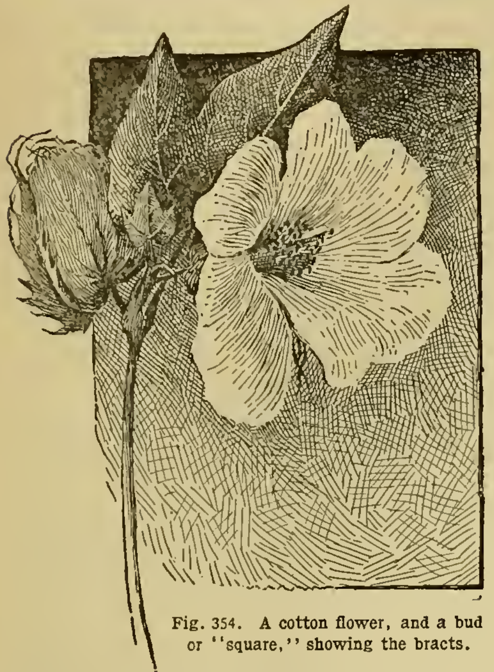

Fig. 354. A cotton flower, and a bud or "square," showing the bracts.

of three to five bracts surrounding the flowers, and by the seed being covered with wool. Many attempts have been made to classify and limit the species of Gossypium, but so far the authorities have failed to agree. The great variability and tendency to hybridize make it very difficult to determine to what species a given plant may belong. However, it is commonly conceded that there are only a few species whose products enter into commerce, and that the bulk of the production is from two species, namely, *G. hirsutum*, which furnishes the upland cottons (Figs. 101, 355, 356, 357), and *G. Barbadense*, the source of the sea-island and Egyptian cottons (Figs. 100, 356, 357). The ordinary upland cotton in American literature has been commonly referred to as *G. herbaceum*, but after a careful study of types Mr. L. H. Dewey, of the United States Department of Agriculture, has concluded that this is an error and that our upland cotton, which is apparently derived from a wild Mexican variety, is *G. hirsutum.* In the United States *G. hirsutum* and *G. Barbadense* are the only two species that are cultivated commercially. The crop of India, which, aside from that of the United States, is the largest produced by any country, is probably derived principally from varieties of *G. herbaceum*, while the Egyptian crop is produced by varieties which are supposed to belong to the species *G. Barbadense.* The Egyptian cotton varieties resemble sea-island cotton very closely in all of their principal characters aside from the lint, which in some of the varieties, such as Mit-afifi and Ashmouni, is light brown and rather coarse and crinkly.

All cultivated species are perennial in climates without frost, but in cultivation they are usually treated as annuals. The plants are mostly shrubby, more or less branching and two to ten feet high. The roots consist of several laterals, and a taproot which penetrates the soil to a considerable depth. The limbs of sea-island are smooth, while those of upland are covered with delicate, whitish hairs. The leaves are three- to five-lobed — sea-island usually having three and the upland five. The flowers are perfect and resemble the hollyhock or hibiscus. When newly open they are large and white in upland, turning red with age, and creamy yellow in sea-island, with a purple spot at the base of each petal. They are surrounded by three to five fringed or deeply cut bracts forming the "squares"—the number corresponding to the number of cells in the bolls or pods. These bracts are much larger and the indentations are deeper and more numerous in sea-island than in upland varieties. Stamens are many, united in a tube about the single compound pistil; stigmas three to five. The fruit consists of three- to five-celled capsules or "bolls" which burst open at maturity through the middle of the cells, each cell liberating seven to ten seeds covered with long fibers. The fiber is a tubular hair-like cell $\frac{1}{1500}$ to $\frac{1}{1200}$ of an inch in diameter, somewhat flattened, and spirally twisted. It is this latter character which gives the cotton its spinning qualities. The length, tenacity and fineness of the fibers determines the value of the cotton. Sea-island excels upland in these respects and therefore commands a much better price. Sea-island cotton seeds are small, black and smooth, while, as a rule, upland seeds are larger, and, after the fiber is removed, are covered with a dense whitish or greenish fuzz. The bolls of sea-island rarely contain more than three cells, while those of upland usually have four and sometimes five. Sea-island bolls are much smaller and more pointed than upland.

Fig. 355. Mature plant of upland cotton.

There are many commercial varieties in each of the above species which have never been classified botanically, and whose true history will probably never be known. It is very difficult to classify them, owing to the readiness with which they are cross-fertilized and the great range of variation of the individual plants in a given variety. Some of them possess characters which suggest that they are produced by the hybridization of sea-island and upland varieties, while many seem to be the products of natural variation and selection.

Aside from the cottons ordinarily classed as sea-island and upland, which are cultivated extensively in the United States, a third group, known as long-staple uplands (Fig. 357), is grown in considerable quantity, over 100,000 bales being produced annually. The long-staple upland cotton ranges from one and one-fourth to one and five-eighths inches in length of lint. While the derivation of the long-staple upland varieties is not positively known, it is probable that they have developed from variations of the ordinary short-staple upland, and they are ordinarily referred to the same species (*G. hirsutum*).

History.

In what land and in what period of antiquity cotton was first used will probably never be known. Its use seems to be coeval with human history. Early writers tell us that it was worn by the ancient Egyptians and used for other purposes, more than a thousand years before Christ. With the progress of civilization it has grown in favor and in extent of cultivation, until it has become one of the most important crops in the world, the greatest of all fiber crops, and the most widely manufactured of all textiles. This great extension of the industry, however, has developed within comparatively recent years. Previous to the middle of the eighteenth century, cotton had to be spun and woven by hand machines. There was also great difficulty experienced in separating the seed from the fibers, as it had to be done by hand. This work was usually done at night. After finishing the ordinary

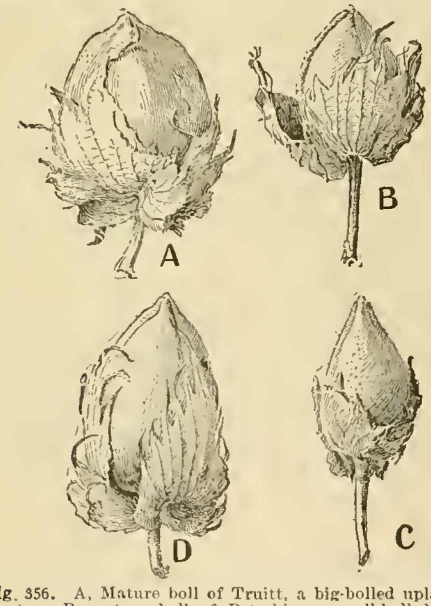

Fig. 356. A, Mature boll of Truitt, a big-bolled upland cotton; B, mature boll of Peterkin, a small-bolled upland cotton; C, mature boll of sea-island cotton; D, mature boll of Griffin, a long-staple upland cotton. (About one-half natural size.)

day's work, the members of the family would gather around the fireside and begin the work of pulling the fibers from the seed with their fingers, the task of each one being to separate four pounds, or enough seed to fill one of his or her shoes. Because of these primitive methods of manufacturing the article and the great difficulty in separating the lint from the seed, it was for a long time produced only in limited quantities, mainly for domestic purposes, and thus prevented assuming the dignity of an important industry until little over a century ago. In the latter half of the eighteenth century there was a great industrial revolution. The cotton industry was greatly stimulated, mainly by the invention of the spinning-jenny, the self-acting mule, the power loom, the steam engine, the saw-gin, and other useful machines. After these inventions, the house industry soon gave way to the factory, and machines were substituted for hand labor. The demand for raw material became greater, and production was immensely increased. There was a minute division of labor and a great specialization of the industry. The markets for the manufactured products were enormously extended, and thus was developed almost as oy magic the most widely diversified industry in the world.

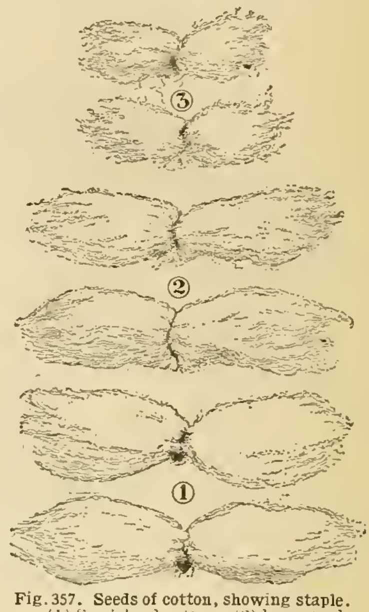

Fig. 357. Seeds of cotton, showing staple. (1) Sea-island cotton; (2) long-staple upland cotton (Allen); (3) upland cotton. (Slightly over one half natural size.)

The growth of the cotton industry in this country has been marvelous indeed. With but few interruptions, there has been a rapid and steady increase in production since the invention of the saw-gin by Whitney. Estimating 500 pounds as an average bale, in 1792 less than 6,000 bales were produced; in 1820 the production was 320,000 bales, in 1840 it reached 1,668,221 bales, and by 1860 it had increased to 4,483,311 bales. During the great civil war in the sixties, the production of cotton practically ceased, thereby causing a cotton famine in this country and in Europe. Hundreds of mills had to cease running, thousands of operatives were thrown out of employment, and prices soared beyond all bounds, reaching the high mark of over a dollar per pound and carrying the shock of the contest to the uttermost parts of the globe. During this period great efforts were made to stimulate the production of cotton in India and other parts of the world. The failure of other countries to supply the demand while stimulated by these fabulous prices is a splendid demonstration of the practical impossibility of maintaining the industry without the American cotton. After the close of the civil war, production was resumed in this country and has been continued since at a rapid rate of increase, reaching 8,547,468 bales in 1892, and 13,693,279 bales in 1904. In a single century, from 1804 to 1904, the crop increased from 130,000 bales, valued at $13,000,014, to 13,693,279 bales, valued at $557,147,306.65. In the early history of cotton cultivation the seeds were not valued at all. Growers were troubled to know how to get rid of them. But in 1904 the seeds alone were valued at $90,258,227.86, making the total value of that year's crop, unmanufactured, $647,405,534.51.

Cotton now furnishes clothing for a large part of the human race, and millions of people are devoting their exclusive attention to its cultivation. Millions more are engaged in its transportation and manufacture, and it furnishes the basis of credit for a large part of this country and Europe. In fact, the magnitude of the cotton industry has become so great that any disaster to it will seriously disturb the economic conditions of the world.

Regions of cultivation.

Cotton is probably indigenous to the tropical and semi-tropical regions of both hemispheres. The earliest records of the Asiatics and Egyptians speak of it; Columbus found it growing abundantly in the West Indies, while other early explorers found it growing in Mexico and South America. Its range has been greatly extended by the amelioration due to cultivation, and now it may be said to extend around the world, embracing thirty to forty degrees of latitude on either side of the equator. However, various modifications due to economic, soil and climatic conditions exist in this wide belt, the most favorable conditions being found in the United States. The soil and climatic requirements of sea-island cotton limit its growth mainly to the islands and lands along the coast of South Carolina, Georgia and Florida, while upland cotton is adapted to a much wider range of conditions and its production far exceeds that of sea-island.

There is no region in the world which has such a favorable combination of suitable land, intelligent and plentiful labor, cheap capital and adequate transportation facilities for the cultivation of cotton as the cotton-belt of the United States. It has been the chief source of supply of the cotton mills of the world, for in this section has been raised several times the quantity of cotton produced in all other countries of the globe. There are various other countries which seem to possess the soil and climatic requirement for its growth, but for various economic reasons the industry has not been greatly developed in them; however, a considerable quantity is produced in the following countries, in about the order named: India, Egypt, China, Italy, Turkey, Brazil, West Indies, Mexico, South Africa, Australia and South Sea Islands.

There are no available statistics showing the annual crops of all cotton-producing countries, but the consumption of the mills of Great Britain, the continent of Europe, the United States, India, Japan, Canada, Mexico, and other countries fairly approximates the world's production. According to the United States census of 1900, the consumption for the year 1899–1900 was 13,535,000 bales of 500 pounds each. In the year 1900 the United States produced 9,990,900 bales. This will give an idea of the unique position which this country occupies among the cotton-producing countries of the world.

Cotton culture.

The two important crops of southern United States are cotton and corn,—the former as a money crop and the latter as a food crop. These two have been grown almost to the exclusion of home supplies. The cost of cultivation of corn is less than of cotton, but even at the lowest prices reached by cotton in many decades, it is a better-paying crop. So we find cotton as the very center and soul of southern agriculture.

Profitable cotton-growing depends on the climate, fertility of the soil, good preparation of the land before planting, thorough cultivation of the growing crop, and the quality of the seed.

Climate.—The climatic requirements are plenty of moisture during the growing and fruiting period, dry weather during the opening and harvest season, and a temperature ranging from 60° to 90° Fahrenheit for at least six months of the year. Too cool weather in the spring stunts the plants; too much rain during the growing season encourages plant development at the expense of boll production, renders cultivation difficult and promotes the growth of weeds; drought stunts the plant, causes early maturity and reduces the yield; and early frost in the fall reduces the crop by preventing the further development of the young bolls and causing them to open prematurely.

Rotation.—A three-course rotation is easily adapted to many of the cotton-growing farms. The following have given satisfaction: (1) Cotton, followed by crimson clover; (2) corn; (3) wheat, followed by cowpeas; or, (1) Cotton; (2) corn, with cowpeas; (3) oats, with cowpeas. Several rotations are suggested for the cotton-growing states on pages 100–106. A short-course rotation (of two or three years) is fundamentally essential in the cotton-belt.

Soil and fertility.—Cotton very readily adjusts itself to the soil conditions, and will usually yield a crop in proportion to the fertility of the land; however, there are certain necessary expenses in the cultivation of cotton regardless of the yield, and it is unprofitable to grow it on land which is not sufficiently fertile to produce a crop whose value exceeds these expenses. In some sections, like the delta region of Mississippi, and various parts of Louisiana, Texas and Arkansas, the soils are rich enough to do this, but most of the cotton lands require the application of artificial manures, the rotation of crops and other means of increasing or retaining their fertility to enable them to grow cotton profitably. Millions of tons of commercial fertilizers, consisting largely of acid phosphate, kainit, muriate of potash, nitrate of soda and cottonseed-meal, are used annually by cotton-growers to enrich their land.

Barnyard manures also serve an important purpose in improving cotton lands. They supply a small quantity of plant-food and a considerable quantity of organic matter which opens the soil and improves its mechanical condition. They are also supposed to act on the constituents of the soil in a chemical way, converting the plant-food into an available condition for the use of the plants.

Probably one of the cheapest and most effective means of soil-improvement is crop rotation. Cotton would never exhaust the land if washing could be entirely prevented and the seeds were returned to it each year, as the lint cotton, the part necessarily removed, contains only a very small quantity of plant-food; but unfortunately in many cases the seeds are also removed without substituting their equivalent in other manures. This is a source of great loss, for the seed contains large quantities of the most valuable elements of plant-food. Surface washing is also a source of great impoverishment to cotton-fields, as the nature of the crop necessitates a method of tillage which causes an extreme surface exposure of the soil for practically every month in the year, thereby intensifying the bad effects of heavy rains. During heavy rains the water is quickly shed into the middles of the rows, where it is confined to a very small part of the available area and has great power to wash away the fine soil as it runs off. Unless these conditions can be counterbalanced, cotton-fields will gradually grow poor. This can be accomplished in a large measure by planting from time to time leguminous crops which enrich the soil by collecting nitrogen from the air, and which occupy a larger part of the surface and necessitate a minimum surface exposure of the soil, thereby greatly reducing the loss by surface washing. This is usually done by rotating cotton with corn, small grain and cowpeas.

Other methods of preventing soil-washing are terracing, deep plowing, and running the rows at right angles to the direction of the slope of the land.

Preparation of the land.—The preparation of the land before planting consists of breaking the soil and making the seed-beds. This breaking can be done in the winter or just before planting. As a rule, when cotton is to be planted after grain or other crops, the land is broken broadcast with a turn-plow in the winter. The rows are laid off several weeks previous to planting, and the seed-beds are made just before planting. When cotton has been grown on the land the previous year, the above method is sometimes followed, but more frequently the new bed is made in the old middle, and the trouble of laying off new rows is thereby avoided. The method is not so important, the only essential point being to have the soil thoroughly broken, and to have fresh, loose seed-beds.

Seeding.—There are cotton-planters on the market that give good service. Some of them, however, have a tendency to drop too many seeds, making much hand-hoeing or chopping necessary later in the removal of the surplus plants. The number of plants can be reduced and the stand regulated in part by the use of a weeder or a harrow when the plants are small. Many farmers dig plant-holes with a hoe and drop eight to ten seeds in each hole. In consequence of the waste in planting, the quantity of seed per acre varies considerably. The seed required will vary from one to three bushels per acre. One bushel is plenty when properly sown.

The common practice is to have the rows four feet apart. On the lighter soils three to three and one-half feet will give as good results. This distance, as well as that between the plants in the row, varies with varieties and soil conditions. The distance between the plants in the rows varies from twelve to twenty-four inches. Twenty inches is, perhaps, a safe distance on good soils. On poor soils the planting should be closer.

Time of planting.—It is the general experience that cotton planted early most often gives best results. The time of planting varies with the different localities. In Florida and southern Georgia, cotton can be planted much earlier than in North Carolina or Tennessee. The following table of dates, from Mr. A. B. Shepperson's "Cotton Facts," will give the approximate dates when planting begins and ends:

States	Usual date to begin planting	Usual date to finish planting
North Carolina	April 15	May 10
South Carolina	April 15	May 7
Georgia	April 10	May 1
Florida	April 1	May 1
Alabama	April 5	May 10
Mississippi	April 5	May 10
Louisiana	April 1	May 10
Texas	March 15	May 10
Arkansas	April 15	May 15
Tennessee	April 15	May 15

Thinning.—After the seeds come up to a stand, the cotton is chopped out with hoes, leaving one hill for every twelve to twenty inches and one to three plants in each hill. A few days later it is thinned again, removing all but one plant from each hill, leaving the most vigorous one.

Cultivation.—Owing to the variable weather conditions, the subsequent cultivation can not follow any specific methods. However, it is very important to cultivate the crop thoroughly and rapidly, thus giving the plants an opportunity to make a steady and vigorous growth from the time of germination throughout the growing season. In cultivation, sweeps (Fig. 358) are ordinarily used, which break the ground to a depth of about two inches, leaving a loose soil mulch over the surface. If this is done thoroughly and as soon as possible after each heavy rain, surface evaporation

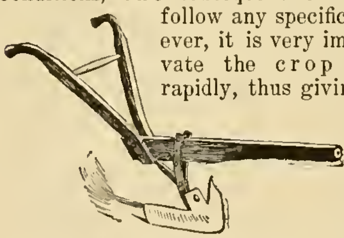

Fig. 358.
Sweep used in cultivating cotton.

is reduced, and the bad effect of drought lessened; excessive capillary action near the surface is prevented, and the plant-food in solution is thus kept from being carried above the root zone and left by evaporation at the surface, where it can be redissolved and washed away by the heavy rains; a better circulation of air in the interstices of the soil is secured; a larger proportion of the rainfall

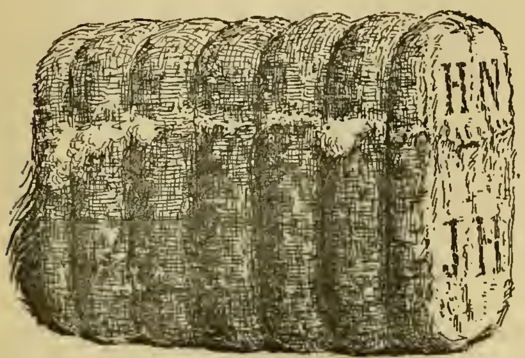

Fig. 359. A bale of cotton. Bales are of different sizes and shapes, depending on the apparatus in which they are pressed; but they usually weigh about 500 pounds. The average yield is about one-third of a bale to the acre. A good crop is one bale; an extra crop is a bale and a half.

goes into the soil instead of running off, consequently the loss of fertility by surface washing is lessened, and the plants are thereby enabled to get the maximum benefit of the plant-food and moisture in the soil.

Use of heavy seed for planting.—Recent experiments by the writers demonstrate the value of separating cotton seed, and planting only the heaviest grade. Plantings of heavy seed have given an increase in yield of over 10 per cent more than plantings of the same seed unseparated. Thoroughly practical machines and methods of separation have been devised, so that it is now possible for every grower to separate his planting seed at very slight expense. Descriptions of the methods and machines are given in recent publications of the United States Department of Agriculture.

Picking.

Picking or gathering the cotton in the fields is a heavy item of expense. In upland varieties it amounts to thirty-five to seventy-five cents per hundred pounds of seed cotton, and more for sea-island. It must be picked by hand, as no mechanical appliance for harvesting has yet been invented which gives satisfactory results in practical working. The amount of cotton that one person can pick in a day varies from 100 to 500 pounds, depending on the skill of the picker. One man can very easily care for the cultivation of twenty acres of cotton, but it requires two to four pickers to harvest such a crop rapidly enough to prevent loss. This extra labor in harvest time is usually supplied by the wives and children of the laborers. The harvest season extends over a period of about four months, beginning August 15 to September 10, according to the locality.

The great desideratum of the cotton-grower of today is a machine for picking or harvesting the crop. Several machines now under trial, using the principle of a spirally twisting steel picking fingers, have proved promising in preliminary trials and it seems very probable that a thoroughly satisfactory picking machine will ultimately be secured.

Ginning.

Upland cotton is ginned (the lint or fiber taken off the seeds) with saw-gins. Ginning outfits are established all over the cotton-belt, where the cotton is ginned for the near-by growers. These outfits consist of an elevator for sucking the cotton from the wagons to the gin, a gin, or as a rule one to six gins, and a press where the cotton is packed into bales. (Fig. 359). A modern ginning outfit can gin and pack thirty to forty bales per day. The operation usually costs the grower a dollar to a dollar and a half per bale. Saw-gins frequently cut and seriously injure the fibers, and for this reason they are not used in ginning sea-island cotton. A specially constructed roller-gin is used for this purpose. However, it is adapted only to ginning smooth-seeded varieties; therefore, it cannot be used for ginning the tufted-seeded upland varieties.

After ginning and baling, if the cotton is to be shipped a very great distance, it is usually recompressed into smaller bulk. Cotton compress companies are located mainly in the larger cities and usually handle enormous quantities of cotton (Fig. 360).

Insects and diseases.

There are many insect pests which are a menace to cotton-growers. Among those which do the most serious damage are the red spiders, caterpillars, plant-lice, cutworms, cottonboll-worms and Mexican cottonboll-weevils (Figs. 361–363).

Cotton is also attacked by a large number of diseases. The roots and stems of the plants are frequently affected by root-knot, sore-shin, wilt, and anthracnose of the stem. Among the diseases

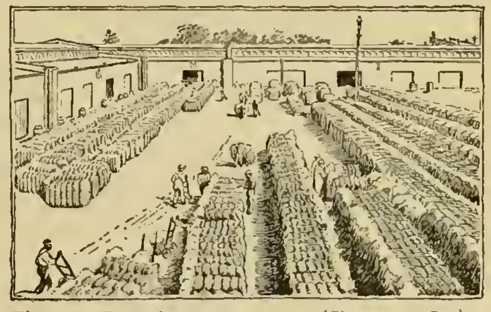

Fig. 360. Yard of a cotton compress (Shreveport, La.).

of the leaves are rust, which is a common term applied to a large number of diseases, angular leaf-spot, leaf-blight and mildew. The bolls are often seriously damaged by anthracnose, boll-rot and shedding.

Clean cultivation is an essential factor in holding in check many plant enemies, as it destroys in part their lodging places and food supplies. A thorough dusting with Paris green will control the webworms and cotton-square borers. Plant-lice are destroyed by plowing under their host plants in late fall or winter. When it becomes necessary to take some other course, spraying with whale-oil soap, kerosene emulsion or tobacco solution is effective. Cutworms are controlled by placing about the fields bunches of grass or weeds immersed in Paris green. The better method, how-

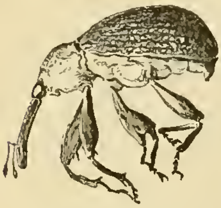

Fig. 361. Mexican cottonboll-weevil. Enlarged.

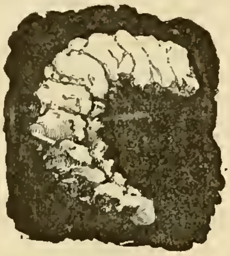

Fig. 362. Larva of Mexican cotton-boll-weevil. More enlarged.

ever, is to kill them by thorough winter cultivation, and keeping down all vegetation in the early spring.

The cotton-worm (*Aletia argillacea*), bollworm (*Heliothis armiger*) and Mexican cottonboll-weevil (*Anthonomus grandis*) are not so easily controlled, and their ravages have been costly. The cotton-worm is now more easily controlled than formerly. It is a blue-green caterpillar, with black spots and stripes on its back. It is most severe in late summer, but is present the entire summer. There are several generations each year. The common method of combating it is to apply dry Paris green to the plants.

The cottonboll-worm is a common garden pest, attacking various crops, as corn, tomatoes, peas and squash. The caterpillar is somewhat darker than the cotton-worm, but otherwise the two are very similar in their early stages. This, too, has several generations in a season. It is most effectively controlled by the planting of an early trap-crop. Sweet corn is much used. As soon as the corn is infested it is removed and destroyed or fed to stock. Lantern traps for the moths and arsenical sprays for the worms have given limited success.

The most serious problem confronting the cotton-grower today is the control of the Mexican cottonboll-weevil, which is threatening the destruction of the industry. The weevil is small, three-eighths inch, or less, in length, of a dark brown or black color. The eggs are laid in the young bolls, and the larvæ begin their work by eating the inside of the bolls. No very effective direct method of combating the weevil has been found. Its control depends on strict attention to many details in the culture of the crop, and to a modification of the farm practice. It is very important to mature the crop early, and then to clean up the plantation as soon as the cotton is picked, burning or plowing down all stalks and refuse; this will largely control the weevil, at the same time that it improves the cropping practice. The seed should be fumigated with carbon bisulfid to be sure that the pest is not introduced in this way. Early trap-crops may be planted about places where the weevils are likely to hibernate, as about cotton-gins, and sprayed with arsenical poisons; later the crops are destroyed. Sometimes the weevils are jarred from the trap-crop into pans, and destroyed. Volunteer cotton-plants must be destroyed. Attention must be given to the picking and destroying of infested squares. All rubbish, infested squares that have dropped, stalks remaining at the end of the season, weeds and litter should be gathered and burned.

Among the diseases attacking the cotton-plant, wilt is controlled by planting disease-resistant seed, the burning and careful destruction of all infested plants, and the rotation of crops. Soreshin, or damping-off, is checked by liming the soil and cultivation to keep the surface mulch dry. It is caused by excessive dampness. No remedy for anthracnose is known. Red-rust is not serious. Vigorous plants will withstand it. It is usually localized in its attacks. Crop rotation is the most effective means of controlling the root-knot fungus (see article on "Soil Diseases." Vol. I, page 450). Angular leaf-spot attacks the plants in June and July, forming watery spots on the leaves. The growing of vigorous plants is the best insurance against infestation by it. Leaf-blight is common but not very serious. It forms a tan or light spot, surrounded by irregular reddish spots, on the older or less vigorous leaves. No remedy has been sug-

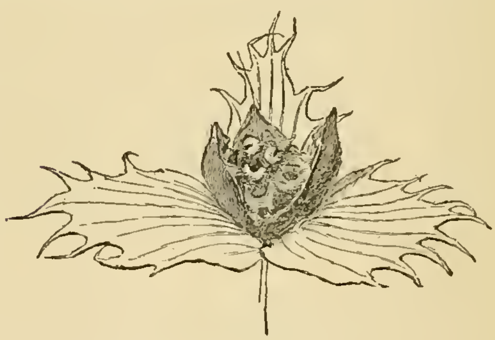

Fig. 363. Cotton boll infested with three boll-weevil larvæ. Figs. 361-3 adapted from Yearbooks.

gested. Mildew is not serious and no treatment has been found.

Shedding of the bolls is common in unfavorable seasons. Extremes of rain and drought, or their alternation, are the probable causes. The trouble is to be prevented to some extent by maintaining good soil conditions and employing hardier varieties.

Manufacture.

The manufacture of cotton consists of the various processes in the production of thread or yarn and woven fabrics from the fiber. The spinning of yarn and the manufacture of coarse cotton cloth has been practiced in many parts of the world from a remote period. Until slightly over a century ago, only very rude implements were used, the work being done almost entirely by hand machines. However, the industry has been completely revolutionized, and the enterprise of modern commerce has carried the cheap products of modern machinery to remote sections of the earth, rendering the hand-spun and clumsily woven cloth of earlier periods practically extinct.

There are various steps in the process of spinning. The loose cotton from the bale is first run through an opener or picker, where it is subjected to the action of a beater, which cleans it from impurities such as broken seed, fragments of leaves, burs and stalks, dirt, and the like, separates the individual fibers, and delivers the cotton at the end of the machine in a uniform layer, called a lap. The lapping machine is fed with three laps at once and the three layers are drawn out to the thickness of one, the object being to neutralize the irregularities of each layer by averaging them with those of two others. From here it goes to the carding, combing and drawing machines, which extract the very short fibers, straighten out the others, and secure a uniform distribution of them in parallel series. It is next drawn through the "slubbing-frame," the "intermediate frame" and the "roving frame," which draw the "sliver" to a more uniform size and give it a slight twist. It then passes to the last process, the spinning, where it is still more twisted.

By far the largest part of the yarn is woven into plain cloth, but a considerable quantity is used as warps in woolen and worsted goods or for knitting into underwear, and a large part of the product of sea-island cotton is converted into sewing thread.

Within recent years the process known as mercerization has become an important adjunct to cotton manufacturing. It consists of subjecting the cotton to the action of caustic soda dissolved in water, washing it with pure water, then treating it with dilute sulfuric acid and again washing it with water. The treatment causes both a chemical and a physical change in the constitution of the fiber. The fiber before treatment is flattened and somewhat twisted, but by mercerization it becomes rounded into cylindrical shape, the walls of the tube become thicker and the cavity is correspondingly reduced, the surface becomes smoother, the length of the fiber is reduced, it assumes a spiral shape and acquires greater strength. The industry has become very important. According to the Twelfth Census, over 7,973,000 yards of cloth and 1,600,000 pounds of yarn were mercerized in 1900, causing an additional value of $697,490. Egyptian and sea-island cottons are best adapted to mercerization, as they have long, silky fibers which are more uniformly acted on.

Great Britain is the chief seat of cotton manufacture. The United States ranks second. For a long time the industry in this country was mainly confined to the New England states, but in recent years it has rapidly risen into prominence in the southern states. Since the year 1890, this section has probably enjoyed a greater activity in the development of the industry than any other section in the world. The achievements in those states have been so marvelous as to cause serious alarm in New England and Great Britain. However, the southern mills are engaged mainly in producing yarn and cheap grades of goods; therefore their products are not nearly so valuable as those of New England and Great Britain. The following tables will give an idea of the status of the industry, as shown by Shepperson's "Cotton Facts" and the United States census report:

Number of Spindles and Consumption of Cotton for the Year 1902–03 in Countries Named.

	Great Britain	Continent of Europe	Northern states of United States	Southern states of United States	Total in United States	India
Spindles	47,000,000	34,300,000	15,100,000	6,900,000	22,000,000	5,007,000
Consumption in bales (500 pounds each)	3,185,000	5,148,000	1,980,000	1,910,000	3,890,000	1,350,000

Summary of the Industry in the United States as Shown by the Census Reports of 1900.

	No. of establishments	Capital	Salaried officials, clerks, etc.		Wage-earners		Miscellaneous expenses	Cost of material used	Value of products
			Number	Salaries	Average number	Total wages			
Cotton goods .	973	$460,842,772	4,713	$7,123,574	297,929	$85,126,310	$21,650,144	$173,441,390	$332,806,156
Cotton, small wares . . .	82	6,397,385	189	226,625	4,932	1,563,442	462,534	3,110,137	6,394,164
Total	1,055	$467,240,157	4,902	$7,350,199	302,861	$86,689,752	$22,112,678	$176,551,527	$339,200,320

By-products.

Until comparatively recent years, cotton was grown entirely for its fiber, but now the by-products represent a large percentage of the total value of the crop. The roots supply a chemical substance similar in its action to ergot; the bark is used to some extent for making bagging, coarse carpets and the like; but by far the most valuable by-products come from the seeds. For a long time growers either threw them into a stream or disposed of them in some other convenient way, as they were not regarded as having any value. Later they were used for manure; finally the value of their oil was discovered, and a great industry has been developed in extracting and refining it. About 7 per cent of the seeds produced are used for planting, a large quantity are still used for manure, but the bulk of them are run through the oil mills. The quantity thus consumed from the crop of 1904 was 4,032,375 tons, or 63.2 per cent of the total supply. The average price per ton paid to growers for them this season (1904) was $14.15. At this rate the value of the entire crop of seed was over $90,000,000.

When the seeds reach the oil mills they are reginned for the purpose of removing the fuzz which covers them. This fuzz is called linters. It amounts to about thirty pounds per ton of seed and is used in upholstering, making cheap felts, and the like. The seeds are then run through a machine which separates the hulls from the kernels. The hulls are used very largely for cattle food; however, they have some other minor uses. The kernels, "meats," are steamed or cooked and then placed in presses, where they are subjected to an enormous pressure for the purpose of extracting the oil. The residue is called oil cake. It is ground into meal and used as a concentrated cattle food and as a fertilizer. A ton of seed yields thirty-eight to forty-five gallons of crude oil, which is refined in mills especially constructed for this purpose. This oil has a great variety of uses—the more refined part being used for human food

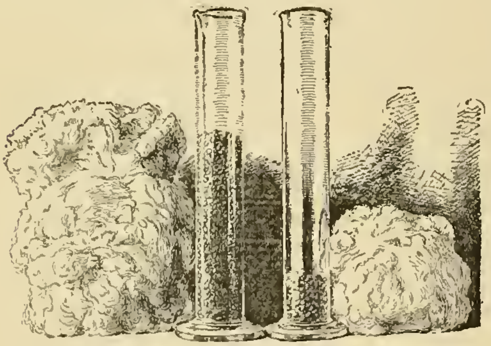

Fig. 364. Product of select plant (left) and ordinary plant (right) from same field. Left, seed 632 grams, lint 314 grams; right, seed 113 grams, lint 51 grams.

under various names, while the less refined part is used for soap stocks and in various other manufacturing processes.

Cotton breeding.

Breeding is one of the important factors in the production of a good cotton crop, which is almost wholly neglected. The great majority of cotton-planters ordinarily use any cotton seed without regard to variety and without practicing any selection. On the seed depends the crop, and it is just as important to use good seed as it is to cultivate and manure the crop. The results of careful experiments have shown that by systematically selecting and improving the seed, the yield can be greatly increased with but little extra

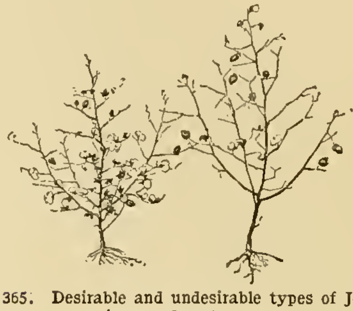

Fig. 365. Desirable and undesirable types of Jones improved cotton.

cost (Fig. 364). In any general field crop where the margin of profit is so slight as in cotton, it behooves the grower to use every possible method to increase the profit, and no cotton-grower can afford to neglect the proper selection of the seed which he expects to plant. Every cotton-grower, in attempting to improve his crop, should test comparatively a number of the standard varieties in order to determine what variety or varieties do the best under the local conditions presented on his plantation. This test of varieties is important, and should precede any work of breeding, as it is important to start the breeding with the best available foundation stock.

How to improve cotton by selection.—Selection of type.—After having tested varieties and determined in general what variety is best suited to the local conditions, grow a large field of this variety on soil which is as uniform throughout as can be selected. Give this field ordinary cultivation. The next step is to determine what type of plant of this variety is the best. Every grower knows a good cotton plant. Ordinarily, plants should be selected of medium height and stocky, with the habit of putting on numerous bolls early in the season on the lower branches (Fig. 365). A careful observation of the plants in the field will enable the grower easily to determine the best type of plant, which gives the most cotton in general earliest in the season. Earliness in almost all cases is an important point, and in sections threatened by the boll-weevil and boll-worm, earliness of maturity should always enter into the consideration of the type of plants selected.

Selection of plants.—After having determined the type of plant which is thought to be most desirable, the next process is to make the actual selection of plants. The selection should be made just before the first picking. Delay the first picking until the cotton is pretty well open and needs picking rather badly. Then go over the field row by row, walking slowly along each row and letting the eye have sufficient time to size up each plant. The great majority of the plants can be thrown out at a glance. When good plants are observed, examine them carefully, and if they are up to what is considered the highest standard, mark them by tying a strip of white rag to one of the upper limbs where it will show plainly. The problem is to select from a large field possibly about one hundred of the best plants. In marking the plants the first time, probably two or three hundred will be chosen. After this first preliminary examination, the field should be gone over a second time, and the marks removed from any plants which are not truly superior plants, reducing the total number probably to one hundred marked plants.

In this second examination, attention should be given to the amount of lint on the seed, as this in general determines the lint turn-out, and is important. The breeder should be provided with a small aluminum pocket-comb, about four inches long, which can be used to separate and straighten out the fibers on the seed, so that the covering or amount of fibers becomes plainly visible, as well as the length of the fiber. Every cotton-grower should learn this method of cotton-combing, as it is essential to the careful judging of cotton. By using the fingers, the cotton can be separated or parted down the middle of the seed; and then carefully using the comb, holding the fibers at their base meanwhile to prevent their being torn off the seed, the fibers can be combed out straight, as shown in Fig. 366. In this way, the amount of lint on the seed, and the length and uniformity of length, become clearly visible and easy to judge. The process of combing requires some practice before it can be done successfully, but it will well repay the time spent in learning. As one goes over the plants either the first or the second time, several seeds from different bolls on each plant should be combed out, and any plants discarded in which the seeds are not well covered with lint of good length. In ordinary short-staple cotton, no plant should be taken for seed which does not produce lint of at least one inch in length. In the long-staple uplands, the standard of length will necessarily depend on the variety grown, as some sorts produce $1\frac{3}{8}$-inch lint, while others produce as high as $1\frac{5}{8}$-inch lint.

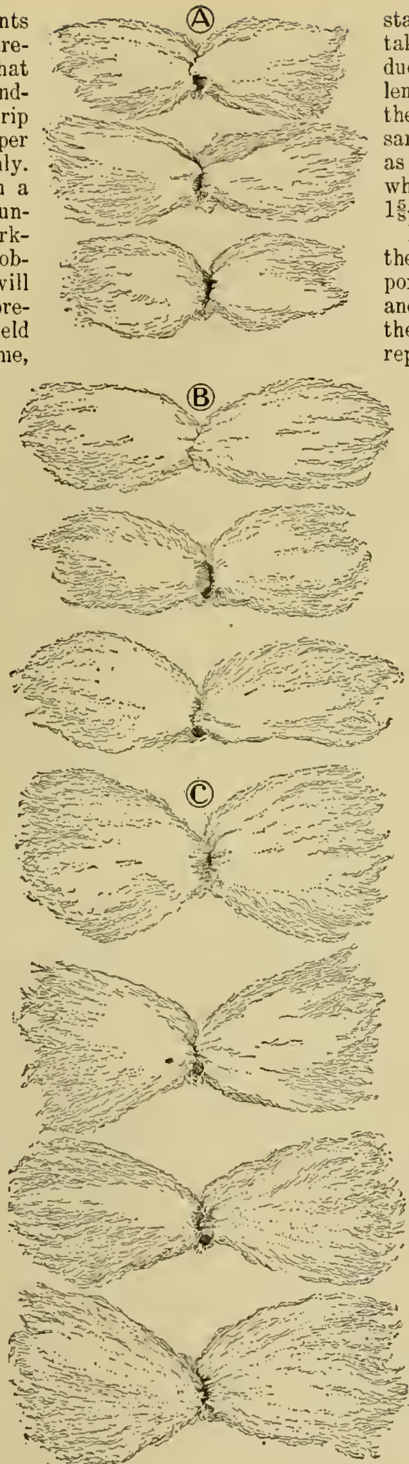

Fig. 366. Improvement in length and abundance of lint produced by selection. A, Imported Egyptian cotton; B, first-generation selection; C, second-generation selection.

In going over the select plants the second time, take all these important points into consideration, and retain only those which are the very best plants and which represent the highest ideal type. These plants should be plainly labeled and numbered, and the product of each plant should be picked separately in a paper bag numbered to correspond with the number on the plant. The best bags to be used in picking and preserving separately the product of each of the select plants are the ordinary manila paper bags of about eight-pound size, which can ordinarily be purchased in any grocery store. The first pick can be made in these numbered bags and preserved, and the same bags can be taken to the field and the second or later picks placed in them, comparing the numbers on the plants and bags each time, to see that the product of each plant is kept together.

Ginning the select plants.—At the close of the season some special arrangement should be made so that a single gin can be disconnected from the stand of gins and used to gin these select plants. The gin should be arranged so that the seed cotton of a single plant can be fed in and ginned. After the product of each plant is ginned, the seed should be carefully collected and placed back in its numbered bag. It is highly important that the seed from each select plant be kept separate and free from mixture with other seeds.

Keeping records.—It is very important, if the breeder is to know what advance is being made, that records be preserved showing the weight of seed cotton and the lint produced by each select plant. With these weights, the percentage of lint can be determined readily, and all of the important factors which go to produce a heavy yield thus be recorded. The preservation of such notes regarding the select plants will enable a comparison to be made of plants selected in various years, and will greatly enhance the value and interest of the work.

Planting the selections.—The next year a field should be chosen for the breeding patch which has good soil, typical of the plantation and region so far as possible. It is important that the soil throughout the patch be of uniform quality and kind, and not patchy. Do not choose the richest and best land available, as this may be different from the land on which the improved variety is later to be grown. The breeding patch, if possible, should be isolated from any other cotton-field a distance of 500 to 1,000 feet at least. This is to avoid crossing or mixing with different varieties and unselected stock. Such isolation is very important, if we are to avoid deterioration. A good place to put the isolated patch is in the middle of a corn-field, where it is surrounded for some distance on each side by corn. If an isolated patch cannot be provided, the breeding patch as a second choice may be in one corner of a cotton-field planted with seed of the same variety from which the selections were made the preceding year. Under no conditions place the breeding patch in close proximity to cotton of other varieties or kind. The writer would urge that an isolated patch be provided in all cases, as this insures that all fertilization will be by pollen from plants coming from select mothers. The seed from each individual should be planted in a single row by itself, a plant to a row, by what may be termed the "plant-to-row" method. As each row is planted, a stake with the number on it of the plant from which the seed was taken should be placed at the end. Owing to the small quantity of the seed from each selection, it is best to plant it in hills about eighteen or twenty inches apart in the rows, dropping five to eight seeds in a hill. In the thinning or chopping, the laborers should be instructed carefully to cut out all but the strongest and most vigorous plant of each hill. Give the breeding patch the same manuring and cultivation as is given an ordinary crop, but remember that in all cases this should be sufficient and thorough to insure the best results.

Examination and selection of progenies. — When the cotton in the breeding patch is well open and it is important that the first picking should be made, go over the patch very carefully and study the progenies from the different select plants. It is important to determine which of the plants selected the first year has transmitted to its progeny, in the greatest degree, the good qualities of high yield, good lint and other features, for which it was selected. This is probably the most important point to be determined in all breeding work, as a select plant to be good must have the property of transmitting its desirable qualities to its progeny. A careful comparison of the one hundred or more progenies will usually result in the breeder finding a few progenies or rows which, as a whole, are considerably superior to the others. When these have been found, they should be marked, and the individual selections for continuing the breeding should be taken from these rows.

Making the second-generation selections. — After the best progenies in the breeding patch have been selected, the breeder should then carefully go over these progenies, plant by plant, and select and mark those plants which are found to be the most productive, and come up to the standard set for length of lint, abundance of lint to seed, type of plant, and the like. The plants selected should be numbered as in the year preceding. A good system of numbering these selected plants, which will show their pedigree at a glance, is as follows: For example, if one of the best progenies is from the original selection No. 2, label the selections in this row 2–1, 2–2, 2–3, 2–4, 2–5, and so on, the second number after the dash being the number of the individual selected in this generation, while the first number, 2, is the number of the original selection. In the same way, if progeny 51 is one of the best, the selections made from this would be numbered 51–1, 51–2, 51–3, and so on. When the third-generation selections are made, they should be numbered in the same way, separating the generation by a dash. For example, the selections made from progeny of 51–1 would be labeled 51–1–1, 51–1–2, 51–1–3.

The second-generation selections should be picked separately, as in the case of the first-generation selections, and ginned separately, the seed being preserved to plant a breeding patch the next or third year.

Securing select seed for general planting. — To secure select seed for planting a general crop, take intelligent pickers and train them to recognize a good, productive plant. Then, after having selected and marked the best plants in the breeding patch, send these pickers over the breeding patch, instructing them to pick all of the seed from the productive plants that are not marked as special selects. Use this seed to plant a general crop. If this seed is not sufficient to plant a general crop, plant what you can with it, in what may be termed a multiplication plot, and from this multiplication plot have the select pickers pick sufficient seed, as above indicated, to plant a general crop the ensuing year.

Continuing the selection.—In the third year, the individual selections made the second year should be planted in a special breeding patch, such as described for planting the first-year selections, and the planting should be made in the same way, using the "plant-to-row" method. The individual selections should be made in the same way as in the first and second years, when the progenies of the second-year selections have reached fruiting condition.

In the succeeding years, the same method should be pursued, forming, as will be seen, a continuous method of pedigree selection. Each year, also, second choice seed should be taken from the breeding patch to furnish seed to plant a larger

Plate IX. Picking cotton in Mississippi

multiplication plot, from which in turn choice seed can be taken to plant a general crop.

Literature.

The following are some of the principal works treating on cotton: Structure of the Cotton Fibre in its Relation to Technical Applications, F. H. Bowman, Second Edition, Manchester, 1881; Cotton: Its Uses, Varieties, Fibre Structure, Cultivation, etc., C. P. Brooks, New York, 1898; Cotton: Its Cultivation, Marketing, Manufacture, etc., C. W. Burkett, New York, Doubleday, Page & Co., 1906; The Cotton Plant: Its History, Botany, Chemistry, Culture, Enemies and Uses, United States Department of Agriculture, Office of Experiment Stations, Bulletin No. 33, Washington, 1896, 433 pages; Notes on Egyptian Agriculture, Geo. P. Foaden, United States Department of Agriculture, Bureau of Plant Industry, Bulletin No. 62; Lyman, Cotton Planters' Manual; Cotton Facts, A. B. Shepperson, New York; Cotton and Cotton Oil, Cotton Planting, Cultivation, Harvesting, etc., D. A. Tompkins, Charlotte, North Carolina, 1901, two vols.; Transactions, New England Cotton Manufacturers' Association, Waltham, Mass. (issued annually); The Cost of Cotton Production, J. W. Watkins, United States Department of Agriculture, Division of Statistics, Bulletin No. 16; Watt, Dictionary of Economic Plants; Improvement of Cotton by Seed Selection, H. J. Webber, United States Department of Agriculture, Yearbook, 1902; Growing of Long-Staple Upland Cotton, H. J. Webber, United States Department of Agriculture, Yearbook, 1904; Story of the Cotton Plant, Frederick Wilkinson, D. Appleton & Co., New York, 1902. In addition, bulletins issued by the agricultural experiment stations in the cotton-growing states, give much valuable advice on specific phases of the subject. Perhaps the best published information on cotton soils is the record of the work done by Hilgard, found in the Report of the Tenth Census, Vols. V and VI.

Practical Suggestions on Cotton-Growing.

By *W. B. Mercier.*

The following comments on cotton culture are drawn from the author's personal experience, mostly in Mississippi and Louisiana. The advice will necessarily need to be modified somewhat for other regions and conditions.

Fertilizers.—Cotton does not make excessive demands on the soil, but it is a clean-culture crop, and adds little humus to the soil, so that its continued growth will wear out even the richest delta lands. Crop rotation, with the growing of a legume crop after the small grain and in the corn, is the most satisfactory way of rejuvenating the soil. But all lands will be benefited by the addition of some fertilizer. It hastens maturity on bottom lands, and increases the yield on poor uplands. Many farmers produce 500 to 800 pounds, and more, of lint per acre, while the average yield is less than 200 pounds per acre. It is evident that many growers are doing a losing business. The reason is not hard to find, when we consider that cotton is grown on the same land continuously without fertilizers or other means of supplying the constant drain. The writer averages 350 pounds of lint per acre on large areas of hill land, with the application of 200 pounds of commercial fertilizer per acre in drills under the cotton. It has been his experience that with medium preparation and culture, about 250 pounds of commercial fertilizer per acre is the most profitable quantity to apply. A greater quantity will frequently produce a greater yield, but it is doubtful whether it is economy. In the more sterile soils in some parts of the eastern states, however, from 600 to 1000 pounds of fertilizer is frequently used per acre with profit. On fresh lands, and on lands on which leguminous crops have been grown, acid phosphate alone gives best results. On medium to poor soils, cottonseed-meal and acid phosphate mixed equally gives splendid results. Potash does not give beneficial results as a cotton fertilizer in Mississippi or Louisiana, as is shown by experiments. Notwithstanding this fact, 90 per cent of all fertilizer sold in these states contains potash.

Variety to plant.—There are two general kinds of cotton grown, long-staple and short-staple. The writer has grown both, and always with the result that the short-staple is the more profitable under average conditions. He has never grown a long-staple variety that would yield more than 70 per cent as much as short-staple variety on the same land with the same treatment. No long-staple he has yet tried gives more than 27 per cent lint, while any good short-staple gives 33 to 35 per cent lint. The difference in price is usually about two to three cents a pound.

There are so many varieties of cotton seed now offered for sale that one not accustomed to the advertising schemes of the high-priced new variety man will be puzzled to know what is best to plant. There are, in fact, only a few distinct varieties. One not familiar with the business cannot do better than to consult the leading farmers in his section as to what are the best varieties for that special locality. Some varieties will do well in one place that will be failures in another. In the writer's experience, a short-staple variety, making a vigorous growth with medium long limbs, good-sized bolls, and seed with a tendency to early maturity, is best for general culture.

Growth characteristics.—A few facts in regard to the general nature of the cotton plant may be of interest. There is no fixed time as to when the seed will germinate after being planted, as this is governed entirely by the temperature and the moisture in the soil. Also, there is no definite interval from the date of germination to the time when the first "form" or square is seen, as this is determined by various factors, such as time of planting, variety, soil, temperature and culture. It will average twenty-one days from the time a square first appears until it is a bloom; then it will average forty-two days from the bloom to the time of opening. The first blooms will be a few days longer in opening, as will also the first bolls. The bloom opens wide early in the morning, and is of a light cream-color; it begins to close and change to a pink color in the afternoon, and by the following morning is a deep pink color, and falls to the ground.

Gathering season.—The gathering season usually begins in the hill country about the first of September, reaches its height in October, and is generally finished, except for scattering bolls, in November. On bottom-lands, the season usually begins later and lasts longer. The writer makes about three pickings, getting 20 per cent the first time, 60 per cent the second, and the remainder the third or last time.

Handling the crop.—Before gins were so numerous, farmers would pick out several bales, and often their entire crop, before hauling to the gin. When this was the practice, we had a much prettier staple. The practice now is to pick, haul and gin the same day, if possible. This is not a good practice, for much of the cotton is green, and nearly always has on it dew or rain enough to make it damp; hence it is impossible for the gin to do first-class work. The ginner is often crowded, in this way, until he cannot do good work. Many public gins employ incompetent men, and through their carelessness there is great loss to the farmers.

The package in which cotton is marketed is called a bale, and it is recognized as the most unwieldy package handled in commerce. It is only because of the pressing demand for cotton that many carriers will handle it. For a number of years the round, compressed bale was used, and it was much more convenient and neat. There is a great demand now for a better package. A bale of cotton (Fig. 359) weighs about 500 pounds. A characteristic load of cotton is shown in Fig. 367.

Marketing.—The usual means of marketing the cotton crop is unfortunate, to say the least. Ninety per cent of the business is done on what is known as the "furnishing" or credit system. The crop is virtually put in the hands of the merchant and commission man before the seeds are planted. The farmer pledges his crop to the merchant for supplies (mules, tools, feed for himself and teams) to make his crop with. The merchant, in turn, pledges all the cotton he controls to the commission man and banker for money to supply the farmer. This system necessarily forces the bulk of the crop on the market in three or four months. Consequently, the speculators and others interested manipulate the prices very much to their own liking, and nearly always to the hurt of the producer. There is a decided tendency of recent years, however, to market the crop more slowly, and its effect has already been felt in the markets. A complete change in the system must be effected before the farmers are to get their proportion of the value of the product.

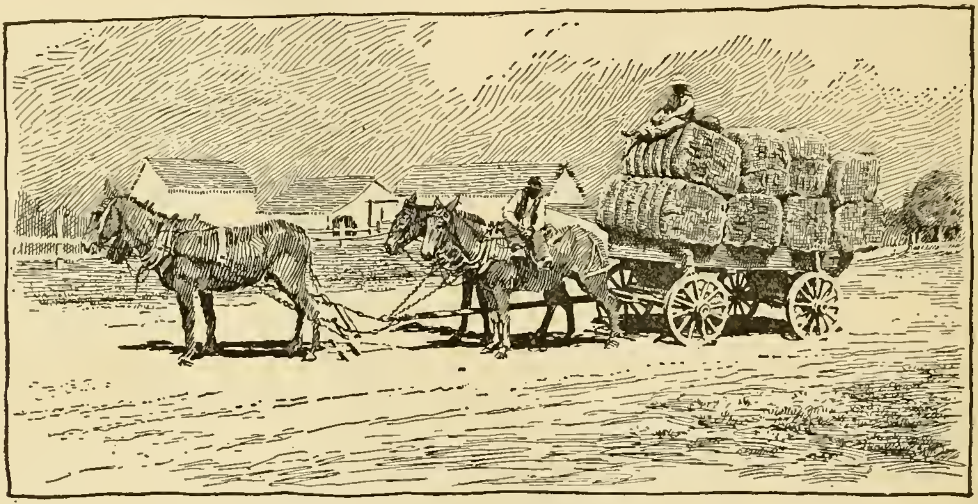

Fig. 367. Typical cotton-hauling scene. Mississippi.

The prices received for cotton varies from year to year, depending on a number of conditions. The law of supply and demand is the determining factor. Ten cents per pound of lint cotton may be taken as the market price at present.

COVER-CROPS. Figs. 368–370.

By *E. B. Voorhees.*

The term "cover-crop," which, until 1893, was not distinguished from "catch-crop," or from "green-manure crop," is now applied to a crop grown to prevent injury and losses to soils, and either directly or indirectly to improve them, and often to afford protection to trees or other plants, rather than to secure the proceeds or products of the crop itself. A catch-crop is one that is grown between the periods of other crops, as after early potatoes and before winter wheat; or, sometimes the word is used to designate companion-crops, or those that are grown between the rows of other crops, as turnips grown between potatoes. The purpose of the catch-crop is to utilize the land to the utmost, securing an incidental crop. Green-manure crops are those grown for the purpose of enriching the land, whereas cover-crops are grown to protect the land, or trees, or other plants that may be growing on it. Cover-crops may or may not be green-manure crops. Cover-crops usually remain on the ground in winter. [See the article on *Fruit-growing* for another discussion of cover-crops.]

Uses of cover-crops.

Cover-crops are used, (1) to prevent the loss of soluble plant-food, which occurs when lands are left uncovered during the late fall and winter, especially in the case of corn, potato and tobacco lands, and for small-fruits or cultivated orchards; (2) to prevent the galling or surface erosion of hillsides or slopes by winter rains; and (3) to prevent root injury by excessive freezing of orchard lands, which danger, however, is apparent chiefly in the North and West, from Nebraska to North Dakota, Minnesota, Wisconsin and Canada. In all of these cases, the benefits, in addition to those mentioned, are due to the introduction into such soils of vegetable matter.

The advantages of cover-crops in conserving and increasing fertility may be stated more in detail as follows: They absorb the plant-food from insoluble sources, and convert it into organic forms; they retain plant-food, particularly of a nitrogenous character, that would be carried away from a bare soil by leaching; and they regulate temperature and moisture conditions, thus promoting nitrification when seasonal conditions are favorable. Cover-crops improve physical character by providing roots to break up the soil particles and make them finer, besides adding vegetable matter or humus-forming material to the land, thus making the moisture conditions more favorable. They encourage the deeper rooting of orchard trees and prevent deep freezing by acting as a mulch. The effect of the cover-crop on the land will depend, to some degree, on the root habit of the crop. The clovers are very deep rooters (Fig. 369), and are prized for this reason as well as for other merits.

Crops that are used as a cover to accomplish these results should not be confused with those which are used for green-manures. If they are made to serve as green-manures the real advantage of the cover-crop may be lost, for if a cover-crop is left too late in the spring it may cause injury by robbing the main crop of the needed moisture; and when plowed down, after making too large a growth, it will injure spring-sown crops by cutting off the capillary supply of ground-water. These points should be carefully observed, for while many cover-crops may serve a specially useful purpose as green-manures, the direct manurial effect should be regarded as an incidental gain, secondary to that secured from their use as cover-crops.

Plants used as cover-crops.

A very large number of plants have been used for cover-crops in the United States. These may be divided into two groups, viz., the legumes, or nitrogen-gatherers, and the non-legumes, or those which are sometimes distinguished as nitrogen-consumers. Of the legumes, the following have been used with considerable success: the several varieties of red clover and Canada field-peas, widely useful in the northern tier of states; alfalfa, in the western states and California; soybeans, cowpeas and crimson clover in the central and southern states; velvet bean and beggarweed, especially useful only in the South; hairy vetch and spring vetch, most successfully used in the South, though rather generally grown in the northern states; sweet clover and sometimes, for peculiar conditions, serradella. Of the non-legumes, rye, wheat, oats and barley of the cereals are probably more commonly used than any others; rape and turnips of various varieties are used commonly, though they are not hardy in the northern sections of the country; buckwheat, white mustard and spurry have also been used with satisfaction under special conditions. Various mixtures and combinations of these plants are sometimes used, in order that the cover may extend through a longer period, or to insure a covering of the land should conditions be unfavorable for one or more members of the combination.

Fig. 368. Crimson clover as an orchard cover-crop. Usually it should be plowed under before it blooms.

The knowledge gained through experiment station work as to the usefulness of cover-crops, is constantly increasing, and they are now considered an important part of rational agricultural practice.

Kind of crops to use.

The principle that should govern in the use of cover-crops is to employ such crops as may accomplish the special purposes desired. To get the best results, a cover-crop should be used when there is a period in a succession of crops in a rotation when the land would be likely to lie bare for any considerable period, or, as in the case of orchards, when it is desirable to increase the vegetable matter in the soil and to retard the vegetative growth of the trees and bushes, and thus to encourage a more complete maturity of the plant.

The kind of crop to plant must be determined by the local conditions and the local needs; that is, whether a grass, cereal, legume, or cruciferous plant shall be used, will depend on whether the habits of growth and characteristics of the plant will accomplish the purpose desired. For example, in the southern states, Bermuda-grass is admirably adapted to prevent erosion of land, yet this crop would not be recommended for northern conditions. In Delaware, and in certain other of the middle states, crimson clover is generally seeded in corn as a cover-crop. It is hardy, grows well in the fall, and protects the soil during the winter; in addition, it starts early and grows rapidly in the spring, accumulating a large mass of vegetable matter containing nitrogen, in time to plow down for a spring crop. The conditions in these states are favorable for the use of crimson clover as a cover-crop, whereas farther north the plant is not hardy and may serve as a cover-crop only in the fall. In the more northern sections, therefore, wheat or rye would be more desirable, as it will serve as a cover during the fall and continue to grow through the winter and early spring, absorbing and retaining soluble plant-food and gathering useful vegetable matter.

In market-gardening, when it is necessary to plant early in spring, such crops as turnips, rape, oats, Canada peas, cowpeas, or soybeans, which die after freezing weather, are serviceable as fall cover-crops, because they accumulate large quantities of vegetable matter, cover the land with a mulch during the late fall and early winter, and are in condition to decay rapidly when the ground is plowed, which frequently may be done in early March.

Literature.

The following bibliography of some of the experiments conducted in this country will serve as a guide to the kind of crop to be grown under the varying conditions of climate, location and cropping:

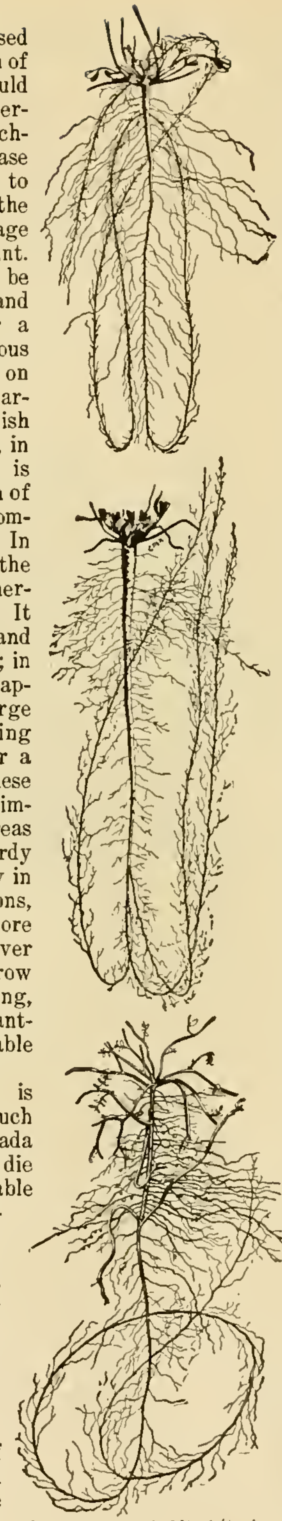

Fig. 369. Root habit of (top) crimson, (middle) mammoth clover, (bottom) winter vetch. Cornell Exp. Sta.

Tennessee Experiment Station, Bulletin No. 4; Nebraska Experiment Station, Report 1899, pp. 50–61; Canada Experimental Farms, Ottawa, Canada, Report 1901, pp. 140–152; Ontario Agricultural College and Experiment Station, Report 1904; Cornell Experiment Station, Bulletin No. 198; Report of the Secretary of Agriculture, Nova Scotia, 1902, Part I, pp. 70–90; Massachusetts Experiment Station, Bulletin No. 82; Missouri Fruit Experiment Station, Bulletin No. 4; Delaware Experiment Station, Bulletins Nos. 60 and 61; Michigan Experiment Station, Special Bulletins Nos. 27 and 30; Connecticut Experiment Station, Bulletin No. 149; Proceedings of Western New York Horticultural Society, 1901, pp. 12–17; American Agriculturist, 1902, pp. 79 and 100. The term cover-crop was first used in this signification by Bailey in 1893, Cornell Bulletin No. 61.

COWPEA. *Vigna unguiculata*, Walp. *Leguminosæ*. Figs. 370, 371.

By *J. F. Duggar*.

A summer-growing annual more closely related to the bean than to the pea, grown for forage, for green-manuring and cover-cropping, and sometimes for human food. The habit of the plant varies greatly, some varieties being erect or bush-like and others distinctly trailing. All intermediate forms occur, and the habit is dependent not only on variety, but on soil, time of planting and climatic conditions. The cowpea is never a true climber, being without tendrils, but its slender runners twine around adjacent objects. The leaves are three-foliolate, and somewhat similar in shape and appearance to those of the common garden bean. The flowers are usually whitish or whitish purple, sometimes with a yellowish cast. The pods are normally of straw color, but are sometimes purplish or dark. They vary in length from five to ten inches and contain numerous edible seeds. The seeds are usually kidney-shaped or roundish, but in some varieties the ends are slightly truncated.

The cowpea, although belonging to the genus Vigna, is closely related to species of the section Strophostyles of Phaseolus. It is a native of India and the region northwestward to the southern part of the Trans-Caspian District, but has been a cultivated crop for two thousand years or more. It was introduced into the West Indies in the latter half of the seventeenth century, and began to be cultivated on the mainland of America somewhat later. At various times the cowpea has been known under several botanical names, the most common names being *V. Sinensis* and *V. Catjang.* The American varieties of the cowpea, however, are correctly classified as *V. unguiculata* (*V. Sinensis*), while the name *V. Catjang* properly applies to another species easily distinguished by its much smaller and more torose pods, and by its smaller seeds. By some, however, *V. unguiculata* is considered to be a synonym of *V. Catjang.*

Geographical distribution.

Varieties of cowpeas have become widely distributed throughout the world, but only in China, India and the southern part of the United States has this plant been an important factor in agriculture. Although cultivated in the United States for about a century, not until recent years has its cultivation received much attention north of the Ohio and Potomac rivers, and north or west of Arkansas and Texas. Within the past ten years, stimulated by tests made at the various agricultural experiment stations, the cultivation of the plant has been carried northward, and it now promises to fill an important place throughout the greater part of the humid United States. The northern limit of cultivation has never been traced in detail, but in a general way this area may be regarded as including the states of Massachusetts, New Jersey, Pennsylvania, much of New York, Ohio, Indiana and Illinois, all of Missouri, Kansas, Oklahoma and Texas, and of course the region south and east of these states.

Westward of this line it may serve a useful purpose, but can scarcely compete with alfalfa or red clover where these plants are generally successful.

Composition.

The seed of the cowpea is rather uniform in composition and is very rich in nitrogen, but not so rich in this element as is soybean seed. The forage varies considerably in composition because of the variation in the quantities of pods and leaves.

ANALYSES OF PARTS OF THE COWPEA PLANT.

	Moisture	Ash	Protein	Fiber	Nitrogen-free extract	Ether extract
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Hay*	10.70	7.50	16.60	20.10	42.20	2.90
Green forage*	83.60	1.70	2.40	4.80	7.10	0.40
Silage ‡	79.30	2.90	2.70	6.00	7.60	1.50
Seed, shelled*	14.80	3.20	20.80	4.10	55.70	1.40
Hulls †	10.46	2.81	6.36	41.43	38.49	0.45
Leaves**	10.65	10.98	22.44	16.78	31.69	7.46
Leaves †	11.05	11.24	18.84	19.74	32.48	6.71
Fine stems and leaf stems**	8.97	6.87	11.88	43.59	30.74	1.75
Coarse stems**	8.47	4.92	9.44	42.19	33.12	1.86
Stems†	10.00	6.20	5.87	38.84	38.20	0.89
Fallen leaves and leaf stems**	9.75	20.78	10.44	20.45	31.96	6.62
Roots and stubble**	5.25	24.75	8.63	56.25	3.82	1.48

*Handbook of Experiment Station Work.
**Alabama Station Bulletin, No. 118.
† Louisiana Station Bulletin, No. 40; average for 12 varieties.
‡ Henry's "Feeds and Feeding."

FERTILIZING CONSTITUENTS IN THE PARTS OF THE COWPEA PLANT.

	Moisture	Nitrogen	Phosphoric acid	Potash
	Per cent	Per cent	Per cent	Per cent
Entire plant (*b*)	10.95	1.95	0.52	1.47
Hay, blooming stage (*a*)	8.15	2.57	0.81	2.86
Hay, ripening stage (*a*)	9.05	2.46	0.85	2.14
Leaves (*a*)	10.65	3.59	0.78	1.49
Leaves (*b*)	11.05	3.01	0.22	1.12
Fine stems and leaf stems (*a*)	8.97	1.90	0.64	0.68
Leaf stems (*b*)	9.64	0.98	0.50	1.33
Coarse stems (*a*)	8.47	1.51	0.42	1.49
Stems (*b*)	10.00	1.09	0.34	2.25
Fallen leaves and leaf stems (*a*)	9.75	1.67	0.37	1.09
Ripening stage, fallen leaves and stems (*a*)	7.80	1.83	0.64	1.45
Blooming stage, fallen leaves and leaf stems (*a*)	6.80	1.36	0.59	1.15
Fallen leaves (*c*)	10.51	1.92	0.30	0.80
Roots and stubble (*a*)	5.25	1.38	0.26	1.11
Roots and stubble, blooming stage (*a*)	7.00	1.05	0.41	2.11
Roots and stubble, ripening stage (*a*)	7.77	1.17	0.48	1.51
Roots (*b*)	. .	1.32	0.42	1.51
Roots (*c*)	10.12	1.09	0.33	2.19
Dried tubercles	. .	5.02	. .	. .

(*a*) Alabama Station Bulletin, No. 120; average 6 varieties. (*b*) Louisiana Station Bulletin, No. 40; average 12 varieties.
(*c*) Louisiana Bulletin, No. 55; 1 variety.

Varieties.

The cowpea is subject to such wide and easy variation as the result of climate and other environment that any treatment of varieties is unsatisfactory. More than one hundred different names are on record purporting to be names of varieties, but in reality many of these are synonyms. Dodson states (Louisiana Experiment Station, Bulletin No. 40) that there are probably about five botanical varieties, namely, those with (1) red seed, (2) black seed, (3) white seed, (4) the clay varieties, and (5) granite and similar strains, with fine, dark markings on a brown background. He regards all others as connecting links or intermediate hybrids. However, we must recognize a considerable number of true agricultural varieties, with fairly good distinctions, whatever may have been their origin. Perhaps the best attempt to classify any considerable number of varieties was that made by Starnes in Bulletin No. 26 of the Georgia Experiment Station, which classification is here quoted:

"Among the more important characteristics which distinguish the different varieties are the following, in the order of their probable importance:

CHARACTERISTICS:

(1) *Form of pea.* Main divisions:
- (*a*) Crowders.
- (*b*) Kidneys.

(2) *Habit of growth.* Divisions:
- (*a*) Trailing.
- (*b*) Recumbent.
- (*c*) Semi-recumbent.
- (*d*) Erect.

(3) *Time of maturity.* Divisions:
- (*a*) Very early.
- (*b*) Early.
- (*c*) Medium.
- (*d*) Late.
- (*e*) Very late.

(4) *Color of pod.* Divisions:
- (*a*) Dark pods.
- (*b*) Light pods.

(5) *Color of peas.* Divisions too numerous to specify.

(6) *Size of pods.* Divisions:
- (*a*) Very large.
- (*b*) Large.
- (*c*) Medium.
- (*d*) Small.
- (*e*) Very small.

(7) *Size of peas.*
- (*a*) Very large.
- (*b*) Large.
- (*c*) Medium.
- (*d*) Small.
- (*e*) Very small.

(1) *Form of pea.*

"The form or shape of the pea necessarily involves, as well, the form or shape of the pod. Two main forms appear to be assumed: (*a*) A rounded form so closely packed in the pod that the sides of the pea are flattened or indented, giving the pod a tightly stuffed, corrugated, plethoric appearance. This class of pea is known as crowder. (*b*) A flattened form, kidney-shaped, and placed farther apart in the pod, which is smoother and leaner in appearance. The pods of crowders are generally stubby and short, those of the kidney type, long.

Fig. 370. Cowpeas as a cover-crop. Useful either in orchards or general field conditions.

"Both of these types combine indiscriminately the other points of difference, being of diverse sizes and colors of pea and of either shade of pod, while their habit of growth is as likely to be trailing as erect, and they are of all stages of maturity. Among the forty odd varieties tested this year at the station, the following are crowders—all the others kidneys:

"Mush, Purple Hull Crowder, Red Crowder, Small Lady, Smith No. 14, Speckled Crowder, Sugar Crowder, White Crowder, Williams Hybrid.

(2) *Habit of growth.*

"The following divisions obtain in regard to growth:

(*a*) Trailing: Conch, Red Eye, Williams Hybrid.
(*b*) Recumbent: Calico, Congo, Large Lady, Lilac Red Pod, New Era, Pony, Red Crowder, Red Ripper, Saddleback, Small Lady, Smith No. 7, Smith No. 9, Smith No. 14, Speckled Crowder, Sugar Crowder, Vacuum, White, White Brown Hull, White Crowder, White Giant.
(*c*) Semi-recumbent: Black, Black Eye, Blue Hull, Chocolate, Constitution, Everlasting, Forage or Shinny, Granite, Gourd, Mathews, Mush, Purple Hull Crowder, Redding, Red Yellow Hull, Rice, Shrimp, Smith No. 15, Taylor Prolific.
(*d*) Erect: Clay, Coffee, Quadroon, Red, Unknown, Whippoorwill, Wonderful.

"While the four divisions enumerated—trailing, recumbent, semi-recumbent and erect—are sufficiently distinct to form separate classes, it must be noted that any variety, no matter how erect its general habit, will trail or run before the end of the season if planted very early and in rich ground. This characteristic has led to some confusion in the identification of varieties.

(3) *Time of maturity.*

"The divisions with regard to maturity are even more distinct than those characterizing growth; they are as follows:

(*a*) Very Early: Chocolate, Congo, New Era, Vacuum, White Giant.
(*b*) Early: Granite, Red Crowder, Red Eye, Red Yellow Hull, Saddleback, Smith No. 9, Whippoorwill.
(*c*) Medium: Coffee, Large Lady, Lilac Red Pod, Mush, Pony, Small Lady, Smith No. 7, Smith No. 15, White, White Brown Hull.
(*d*) Late. Black Eye, Everlasting, White Crowder, Williams Hybrid.
(*e*) Very Late: Black, Blue Hull, Calico, Clay, Conch, Forage or Shinny, Gourd, Mathews, Purple Hull Crowder, Quadroon, Red, Redding, Red Ripper, Rice, Shrimp, Smith No. 14, Speckled Crowder, Sugar Crowder, Taylor Prolific, Unknown, Wonderful.

"Of all varieties, Conch is the latest and the flattest grower, trailing close to the ground like a potato vine.

(4) *Color of pods.*

"Certain varieties possess pods of a dark color, some almost brown when ripe, others reddish brown and still others bluish black or purple. The color of the pod bears no relation whatever to the color of the enclosed pea, which ranges from pure white through different mottled shades to red.

"The following peas are dark hulled, all others are light or yellow hulled:

White Brown Hull; color of pod, dark brown.
Blue Hull; color of pod, blue-black.
Red Eye; color of pod, blue-black.
Purple Hull Crowder; color of pod, purplish black.
Lilac Red Pod; color of pod, reddish purple.
Saddleback; color of pod, purplish black.

(5) *Color of peas.*

"Naturally, more diversity is apparent in this feature than in any other. The following list of peas tested the present season is grouped according to color:

White: Black Eye, Blue Hull, Conch, Large Lady, Mush, Pony, Red Eye, Rice, Small Lady, Smith No. 7, Smith No. 14, Smith No. 15, Sugar Crowder, Taylor Prolific, Vacuum, White, White Brown Hull, White Crowder, White Giant.
Lemon: Smith No. 9.
Pale Buff: Unknown, Wonderful, Quadroon.
Pinkish Buff: Everlasting.
Cream: Clay.
Clear Pink: Shrimp.
Dull Red: Purple Hull Crowder, Red, Red Crowder, Redding, Red Ripper, Red Yellow Hull.
Lilac Mottled: Lilac Red Pod.
Red Mottled: Calico, Saddleback.
Brown Mottled: Chocolate, Coffee, Williams Hybrid.
Brown Speckled (on gray ground): Granite, Speckled Crowder, Whippoorwill.
Brown Speckled (on blue ground): New Era.
Black Mottled: Gourd, Mathews.
Jet Black: Black, Constitution, Congo, Forage or Shinny.

(6) *Size of pods.*

(*a*) Very large: Calico, Gourd, Mathews.
(*b*) Large: Black Eye, Clay, Coffee, Conch, Congo, Forage or Shinny, Granite, Quadroon, Red, Smith No. 15, Unknown, Vacuum, Whippoorwill, White Giant, Wonderful.
(*c*) Medium: Black, Blue Hull, Chocolate, Everlasting, Lilac Red Pod, New Era, Red Eye, Red Ripper, Saddleback, Smith No. 9, Speckled Crowder, Taylor Prolific, White, White Brown Hull, White Crowder, Williams Hybrid.
(*d*) Small: Constitution, Large Lady, Mush, Pony, Purple Hull Crowder, Red Yellow Hull, Rice, Shrimp, Smith No. 7, Smith No. 14, Sugar Crowder.
(*e*) Very Small: Red Crowder, Redding, Small Lady.

(7) *Size of pea.*

(*a*) Very Large: Calico, Congo, Granite, White Giant.
(*b*) Large: Blue Hull, Coffee, Gourd, Lilac Red Pod, Mathews, Red Ripper, Red Yellow Hull, Smith No. 9, Speckled Crowder, Vacuum, White Crowder.
(*c*) Medium: Black, Black Eye, Chocolate, Clay, Conch, Forage or Shinny, Mush, New Era, Pony, Purple Hull Crowder, Quadroon, Red, Red Crowder, Red Eye, Smith No. 7, Smith No. 15, Taylor Prolific, Unknown, White Brown Hull, Whippoorwill, Williams Hybrid, Wonderful.
(*d*) Small: Everlasting, Large Lady, Redding, Rice, Saddleback, Shrimp, Smith No. 14, Sugar Crowder.
(*e*) Very Small: Constitution, Small Lady, White.

"There are other minor characteristics, as that of smooth and wrinkled surface, serving to distinguish varieties otherwise apparently identical. Blue Hull, Chocolate, Pony, Saddleback, Vacuum and White Giant, are wrinkled. All of the others are smooth."

Detailed descriptions of a number of varieties may be found in bulletins of the various agricultural experiment stations, especially in Georgia Bulletin No. 26, Texas Bulletin No. 34, and Louisiana Bulletins Nos. 19 and 29.

In the Gulf states, the two varieties most extensively grown are Whippoorwill or Speckled, and Unknown or Wonderful. In yield of forage the Unknown is at or near the head of the list in the southern part of the cotton-belt. Its large yield and relatively upright growth make it a favorite for forage, while its heavy yield and large stems and roots make it one of the best for the improvement of the soil. It is not suitable for growing for seed much beyond the limit of the Gulf and South Atlantic states, nor for any purpose in the far North, being a very late variety. Whippoorwill, a bushy or erect, rather early variety, is a general favorite for seed production, and is suitable for cultivation for forage or soil-improvement as far north as New York. The very early varieties, for example New Era, Warren Hybrid, Warren Extra-Early, and Extra-Early Black Eye, mature seed considerably north of the line where the Whippoorwill completely matures. But both in the North and South, earliness is at the sacrifice of yield of forage. On the other hand, the New Era

Fig. 371. A cowpea (*Vigna unguiculata*).

and some other early varieties are prolific bearers of seed, and on rich land make very satisfactory hay.

The Iron cowpea is unique in being practically exempt from cowpea wilt, and from attacks of nematode worms, which commends it for use on the sandy soils of the southern parts of the Gulf and South Atlantic states. The seed resembles that of the Clay pea, and the plant in habit may be classed as a moderate runner. The yield of hay is good and of seed medium. The leaves are retained well, even after the plant has matured a fair crop of seed, so that hay may be made from this variety, while blooms, ripe pods and leaves are all abundant on the same plant. In mild winters in the Gulf states, the seeds lie in the ground uninjured, germinating late in the following spring.

For forage or soil-improvement in southern Ohio, Alva Agee recommends the Black, a variety somewhat later than the Whippoorwill, and distinguished both North and South for its large yield of forage. At the Georgia Experiment Station, the varieties leading in yield of forage were Black, Mathews, Gourd, White, Taylor Prolific, Blue Hull, Speckled Crowder, White Crowder, Mush and Williams Hybrid. At the Alabama Station, among the most prolific producers of forage are Unknown or Wonderful, Clay and Iron. Among the varieties yielding most seed at the southern experiment stations are Black, Clay, Unknown, Taylor, New Era and Whippoorwill.

Conditions that tend to dwarf the plant, to make it more erect or bushy and to hasten maturity are (1) planting late in the season and (2) growing the parent seed in high latitudes.

Culture.

Soil.—The cowpea is adapted to a wide range of land, being able to make some growth on practically all soils except those that continue wet during the summer. Near the northern limit of its cultivation, sandy and loamy soils are preferable, as they hasten maturity. There its best use is for soil-improvement, which indicates that its usual place is on soil too poor or otherwise unsuited for the successful growth of red clover. A moderate degree of acidity is not fatal to its thrifty growth.

Climate.—The cowpea is a native of a warm climate and is very susceptible to frost. Near the northern limit of its cultivation it must be started as early as the season is well settled, so as to give time for it to reach the desired degree of maturity; but planting should be deferred until the soil is fairly warm. In the Gulf states, the earliest practicable date for sowing is the latter part of April, but this is usually at a disadvantage except when two crops per year are desired on the same land. May and June are the months preferred in the South. In Delaware, the latter part of June and early part of July have been found more desirable dates for sowing cowpeas than late May and early June. Early sowing has a tendency to cause the production of an excessive growth of runners, and may even change the habit of bush varieties. While moderately early planting usually increases the total yield of forage and the amount of tangling, rather late planting affords a larger yield of seed and tends to the development of a bushy plant.

Planting.—Land on which cowpeas are to be grown should be plowed and well harrowed. Then planting may be done either in drills or broadcast, the method to be used depending on a number of conditions. Broadcast sowing reduces the labor but increases the quantity of seed. Usually, when soil and season are favorable, broadcast sowing gives a somewhat larger yield of hay, but in seasons of drought, drilling and subsequent cultivation make a fair yield more certain than broadcasting. To broadcast cowpeas they may be sown by hand and afterwards disked or cultivated into the loose soil, or they may be put in with a grain-drill with every tube open. On sandy soil they are sometimes sown broadcast and plowed in shallow. In drilling cowpeas, the distance between the rows is usually thirty-two to thirty-six inches. The seeds are dropped either by hand, by a one-horse planter, by the modern corn-planter in which the cells in the dropping plates may be filled to fit the peas, or by the grain-drill with most of the outlets closed. The grain-drills best adapted to this purpose are those having gravity or friction feeding devices, as the force feeds crack a much larger percentage of the peas. Drilling and cultivation usually afford the larger yield of seed.

The seed.— The preferred quantity of seed for sowing broadcast is four to six pecks per acre, but varieties with large seeds may require a larger amount. For planting in drills, two to three pecks per acre are usually sufficient when the rows are wide enough to permit cultivation. At the Arkansas station, it has been found that the common practice mentioned above involves a larger quantity of seed than is necessary. In case drilled and cultivated cowpeas are to be mown, care must be taken to cultivate level, using ordinary cultivators, or, in the South, heel scrapes. In the South, cowpeas are often sown broadcast or drilled among the growing corn. The seed is planted when the cultivation of the corn is nearly or quite finished.

Inoculation has never been found necessary in the South because of the general prevalence in southern soils of the germ that causes the development of tubercles on the roots of cowpeas. However, there may be small areas in which this crop is seldom cultivated, where at first it will be an advantage to use as inoculating material 1,000 or more pounds per acre of pulverized soil from a field where cowpeas have recently grown and developed abundant tubercles. In a number of localities in the northern and western states, when cowpeas were first introduced, few nodules developed on the roots; whenever this occurs the need for inoculation is indicated.

Pollination.—The cowpea is self-pollinated. Dodson made notes of the insect visitors, and concluded that insects were seldom concerned in bearing pollen from bloom to bloom. Artificial cross-pollination is exceedingly difficult in the field, but a larger percentage of hand-pollination is successful when the plants are grown in a greenhouse.

Companion-cropping.—Since the leaves of the cowpea easily fall off in curing, unless weather conditions are altogether favorable, it is sometimes advantageous to grow cowpeas in connection with some grass crop, the presence of which makes curing quicker and entangles the leaves, thus preventing their loss. For this purpose the latest varieties of millet, especially German millet, are satisfactory for mixing with the early varieties of cowpeas, sowing one to one and one-half pecks of millet per acre with one bushel or more of cowpeas. Soybeans are sometimes grown in connection with cowpeas. Many southern farmers prefer a mixture of cowpeas and amber sorghum, about one bushel of each per acre. The admixture of sorghum greatly increases the yield on fair or good land, but somewhat increases the difficulty of curing the forage. A volunteer growth of crab-grass is, perhaps, in the Gulf states, the most generally satisfactory addition to cowpea hay.

A satisfactory mixture for the silo consists of drilled corn and cowpeas, the latter sometimes being drilled in several weeks after the planting of the corn. Although the cowpeas usually constitute the smaller part of this forage, their presence serves to increase the percentage of protein in the silage.

Manuring.—The cowpea is most useful on the poorest grades of land, but often needs the help of commercial fertilizers. In the South, the most general requirement is for phosphoric acid, although on some poor and very sandy soils the addition of potash as well as phosphate is profitable. Tests in Delaware and Connecticut indicated that potash, which was used at the rate of 160 pounds (muriate of potash) per acre, was the principal fertilizer needed. A common application is 200 to 400 pounds of acid phosphate per acre, to which, on soils needing potash, may be added fifty pounds of muriate of potash or an equivalent amount of kainit. The cowpea is a leguminous plant, and so, after reaching the stage at which its roots are abundantly supplied with tubercles, derives its nitrogen very largely from the air. Hence, the use of nitrogenous fertilizers is not generally very economical, though the cowpea, in common with nearly all other plants, thrives best in the presence of vegetable matter, and profits greatly by an application of stable manure, of which, however, more advantageous use can usually be made. The yield is very slightly increased by applications of nitrate of soda, and nitrogenous fertilizers have little effect on the composition of the resulting forage. In one test at the Connecticut Storrs Experiment Station (Report 1893), potash not only increased the yield but increased the percentage of protein in the forage.

Harvesting.—In curing cowpea hay, the same rules obtain as in curing clover hay. Especial care must be taken to leave the cut forage exposed to the sun in the swath for as short a time as practicable, the curing being completed in cocks, or in such other way as to protect the bulk of the hay from long exposure to the sun. No definite rule can be given, but it is usual to rake the hay twenty-four to thirty-six hours after mowing and to pile it in cocks the afternoon of the second day after mowing. Here in fair weather it should remain for two or three days, at the end of which time the cocks may be opened for a few hours before being hauled to the barn.

One method of hay-curing is thus described in Bulletin No. 40, of the Mississippi Experiment Station: "The mower is started in the morning as soon as the dew is off and run until noon. . . . As soon as the top of the cut vine is well wilted the field is run over with a tedder. . . . When the crop is very heavy the tedder is used a second time. Vines that have been cut in the morning and teddered in the afternoon are usually dry enough to put in small cocks the next afternoon, and if the weather promises to be favorable they are allowed to remain in the cocks two or three days before they are hauled to the barn. If it should rain before the vines are put in cocks they are not touched until the surface is well dried, and are then tedded as though freshly cut. We find the only safe plan is to put the hay for a few weeks in a stack covered with straw, or, still better, in a barn, where it should not be piled too deep. After a month it may be packed without danger of finding moldy or dusty hay in the centers of the bales."

Some persons store cowpea hay in the barn when merely well wilted, and disavow any fear of spontaneous combustion or molding. When this is done it is necessary that the crop be nearly mature, about one-half of the pods having assumed a straw-color; that there be no external moisture on the plants when placed in the mow; and that the hay be not moved, no matter how hot it may become, since forking over the hay would admit additional oxygen that would facilitate fermentation or combustion. Until more is known of the conditions under which this procedure may be safe, it cannot be generally recommended.

In the southern states, September and October are usually the driest months, and if the crop can be sown at such time as to bring the haying season in these months, this, together with the use of haycaps (Fig. 279), will greatly reduce the danger of loss in curing.

The harvesting of cowpea seed is not yet on a satisfactory basis. The pods are usually picked by hand and afterwards shelled by beating with a flail. Pickers have been patented and tested, but never extensively manufactured nor adopted. Hand-picking, the usual procedure, is too slow. The most rapid method is to cut the vines after most of the pods have matured, using a reaper or scythe; carefully to cure the whole in cocks; and to pass the vines and pods through a shredder, which cracks very few of the peas. Some persons advise running the vines through a grain thresher, driven at low speed and with blank concaves, precautions which in our experience have not entirely prevented the cracking of a considerable proportion of the peas.

Uses.

The cowpea is useful for the following purposes:

(1) For the improvement of the land, through the addition of vegetable matter and of nitrogen secured from the soil air.

(2) For forage that may be utilized either as hay, as a soiling crop, for silage, or for pasturage.

(3) For the production of a highly nutritious seed crop that serves as food for mankind and for domestic animals.

(4) As a crop to fit the land for sod, in the North.

The most profitable means of utilizing the crop is to use the top as forage, and to secure in addition the very considerable fertilizing effect of the roots, stubble and other residue left on the land. By this method the forage is utilized twice, once as food for animals and later in the form of barnyard manure, which will then be very rich in nitrogen. If the crop cannot be converted into hay, the next best use is to pasture it, thus leaving most of the fertilizing material on the land.

The analyses heretofore given show that all parts of the cowpea plant are rich in nitrogen. The hay is similar in composition to wheat-bran, and experiments at the Alabama Experiment Station (Bulletin No. 123) showed that one ton of cowpea hay was practically equal to 1,720 pounds of wheat-bran in the ration of dairy cows. At this station, the grazing of cowpeas by dairy cows showed a value of about five dollars per acre of cowpeas grown as a catch-crop between the rows of corn, and a value of about eight dollars per acre in low-priced pork when nearly ripe cowpeas were grazed by hogs (Bulletin No. 118). The cowpea makes a satisfactory silage when passed through a silage cutter and well weighted in the silo. It is usually preferable, however, to mix in the silo cowpeas with corn or sorghum.

The cowpea as a fertilizer.—What clover is to the North and West as a means of improving the fertility of the soil, the cowpea is to regions south of the clover-belt. A ton of cowpea hay contains about forty pounds of nitrogen; hence, with a yield of two tons of hay per acre, we have in the entire plant, including roots and stubble, more than 100 pounds of nitrogen per acre, equivalent to more than in 600 pounds of nitrate of soda. Of the total nitrogen in the plant, that in the roots and stubble usually constitutes 20 to 40 per cent, averaging about 30 per cent.

Crops grown after the stubble of the cowpea, yield considerably more than when following non-leguminous plants, but usually much less than when the entire growth of the preceding crop of cowpeas has been plowed under as fertilizer.

Diseases and insect enemies.

In parts of the southern states near the coast, and especially on sandy soil long in cultivation, the cowpea is subject to the cowpea wilt (*Neocosmospora vasinfecta*, var. *tracheiphila*) and to injuries of the root by nematode worms (*Heterodera radicicola*). To both maladies the Iron variety is practically or entirely immune. Mildew, leaf-spot and other diseases of the foliage occur, but extensive damage from these is unusual. The leaves are sometimes eaten by grasshoppers and other insects.

Literature.

The literature on cowpeas is extensive. Much information will be found in the agricultural press and agricultural books. A few bulletins and reports are mentioned here:

Alabama (College) Experiment Station Bulletins, Nos. 14, 107, 114, 118, 120, 122 and 123; Alabama (Canebrake) Experiment Station Bulletins, Nos. 9, 10 and 22; Arkansas Experiment Station Bulletins, Nos. 31, 58, 61, 68, 70 and 77; Connecticut (Storrs) Experiment Station Bulletins, Nos. 6 and 23; Reports 1888, 1893, 1895; Delaware Experiment Station Bulletins, Nos. 46, 55 and 61;

Reports 1892, 1893, 1895; Georgia Experiment Station Bulletins, Nos. 3, 17, 23, 26 and 71; Illinois Experiment Station Bulletin, No. 94; Kentucky Experiment Station Bulletin, No. 98; Report, 1902; Louisiana Experiment Station Bulletins, Nos. 8, 19, 29, 40, 55 and 72; Michigan Experiment Station Bulletins, Nos. 224 and 227; Mississippi Experiment Station Bulletin, No. 40; Missouri Experiment Station Bulletin, No. 34; New Jersey Experiment Station Bulletins, Nos. 161, 174 and 180; Report, 1893; North Carolina Experiment Station Bulletins, Nos. 73, 98 and 162; Oklahoma Experiment Station Bulletin, No. 68; Reports 1899, 1901 and 1905; South Carolina Experiment Station Report, 1889; Texas Experiment Station Bulletin, No. 34; Vermont Experiment Station Report, 1895; Pennsylvania Experiment Station Report, 1895; Bulletin, No. 130; United States Department of Agriculture, Bureau of Plant Industry Bulletin, No. 25; United States Department of Agriculture (Agrostology 64), Circular, No. 24; United States Department of Agriculture Yearbook for 1896.

DYES AND DYEING. Figs. 372–378.

By *C. S. Doggett.*

Dyestuff materials are derived from the animal and vegetable kingdoms, and, in the last fifty years, those made synthetically from products obtained from coal-tar. In 1856, W. H. Perkin, an English chemist, discovered the production of a violet dye when experimenting with aniline, a body found in coal-tar; soon afterwards, other dyes were made from the same products and they became known as aniline colors. Unfortunately, these colors were inferior to the natural coloring matters, which they surpassed in brilliancy, so that, although very many artificial colors have been made that equal or surpass those derived from natural products (in some instances the identical natural product being made synthetically), "aniline colors" even today are regarded in the popular mind with more or less suspicion. Over twenty-five thousand patents have been taken out covering these dyes or processes relating thereto, and more than two thousand artificial dyestuffs have found more or less commercial value. The natural coloring matters are rapidly becoming of historic interest only and their culture is being abandoned. A few are now secured from native trees of the forest. Twenty-five years ago madder began to be replaced by alizarine, the coloring principle found in it, which is now manufactured in enormous quantities; and within the last six years, the artificial production of indigo has been compelling the producers of the natural product to improve their methods or succumb. Indeed, it is only the cheap labor of India that renders any competition possible.

Dyestuffs are used for coloring all sorts of materials. Addition of coloring matter to a food product to disguise its appearance or character partakes of the nature of fraud. Harmless coloring materials may be used in confectionery and the like, where it is evident that no deceit is intended.

Coloring materials vary so much in properties that it is not possible in this place to give the details of their extraction. Coloring matters that exist as such are extracted with the proper solvent: water-alcohol and ether are the chief solvents. Many of the natural coloring matters, such as that of logwood, are not found in plants in the free state, but in combination with a glucose-like body, and are called glucosids, and only after a kind of fermentation or oxidation is the coloring principle in condition to be extracted. In common with many plants possessing medicinal properties, the special ferment also exists in the plant, so that fermentation proceeds when the proper conditions are met.

List of natural animal and vegetable colors.

The following very complete list of natural colors of vegetable and animal origin, compiled by Wilton G. Berry and published in Circular No. 25, of the Bureau of Chemistry, Department of Agriculture, rescues from oblivion many coloring matters and fairly indicates their importance and use. The source of the color is given in Italics:

Alder bark: *Alnus glutinosa.* Yellow.

Alkanet: *Baphorhiza tinctoria* (*Alkanna tinctoria, Anchusa tinctoria*). Used in coloring oils, medicines, pomades, wine, etc. Red to crimson. Alkanna green has also been prepared from the root.

Aloes: Cape aloe (*Aloe spicata*), *A. arborescens, A. lucida, A. Succotrina, A. vera.* Yellow.

Al root or Aich root, soorangee, suranjee (India): *Morinda citrifolia, M. tinctoria.* Alumina lake, yellow.

Annatto, or anotto, orlean, roucou, orenetto, attalo, terra orellana, achiote: *Bixa Orellana.* Used for coloring oils, butter, etc. (Fig. 372.)

Archil, or orchil, orseille, oricello, orchilla: *Roccella Montagnei* (new), *R. fuciformis* (old), *R. tinctoria.* Also prepared from any lichens containing orcin or its derivatives, i. e., *Variolaria, Lecanora, Evernia, Cladonia, Ramalina, Usnea.* Appears in liquid, paste, and powder forms, the latter being a sulfonated derivative. Dyes unmordanted wool in neutral, alkaline and acid solutions, giving a bright bluish red. The color is not fast to light.

Asbarg or gandhaki (Afghanistan): *Delphinium Zalil.* Yellow lakes prepared from the blossoms.

Bahia wood: *Cæsalpinia Brasiliensis.* Exported from Bahia. Sometimes called Brazilwood. See under Redwoods.

Barberry: *Berberis vulgaris.* Yellow basic dye.

Barwood, or camwood, kambe wood, bois du cam: *Baphia nitida.* From west coast of Africa and Jamaica. See under Redwoods.

Bastard hemp: *Datisca cannabina.* Alkaline solutions, yellow.

Bilberry, or whortleberry: *Vaccinium membranaceum, V. Myrtillus.* Blue to purple.

Box myrtle, or yangmœ of China, kaiphal of India: *Myrica Nagi* (*M. sapida* and *M. integrifolia*), *M. rubra.* Alumina lake, brown orange.

Brazilwood, or fernambourgwood, pernambuco wood, fernambuck wood, bois de fernambuoc, rothholz: *Guilandina crista, Cæsalpinia Braziliensis.* Chiefly from Brazil and Jamaica. See under Redwoods.

Brazilettowood, or Jamaica redwood, Bahama redwood: *Balsamea sp.* See under Redwoods.

Buckthorn: *Rhamnus cathartica.* Purple juice which when treated with alkali becomes green. Used in confectionery as sap green.

Buckwheat: *Fagopyrum esculentum.* Yellow color from leaves and stalk.

Buttercup: *Ranunculus bulbosus* and other species. Yellow.

Cabbage: *Brassica oleracea.* Contains cauline, probably identical with the cyanine of wine.

Camwood, or gaban wood, poa-gaban: Closely allied to barwood. From African coast. See under Redwoods.

Fig. 372. Annatto pods, from which butter color is derived.

Capers: *Capparis spinosa.* Yellow.

Caramel: Sugar heated above its melting point turns brown and is converted into caramel. Brown.

Carrot: *Daucus Carota.* Yellow.

Catechu: *Acacia Catechu,* Ourouparia gambier. Brown to dull red colors. Influenced by oxidation. Contains catechin.

Celery, or smallage: *Apium graveolens.* Yellow-green.

Chamomile (Ger.), or matricario: *Matricaria Chamomilla.* Alumina lake, yellow.

Chay root, or chè root, cherri vello, sayavee, imbural, turbuli: *Oldenlandia umbellata.* Contains alizarin, purpurin, etc. See under Madder.

Chelidoine juice: *Chelidonium majus.* Yellow.

Chica-red, or crajina: *Arrabidæa Chica* (*Bignonia Chica*). Vermilion-red powder, insoluble in water; alkaline solutions, orange to red.

Chinese green, or lokoa: *Rhamnus tinctoria, R. Dahurica.* Only green dye other than chlorophyll.

Chinese yellow: *Gardenia grandiflora.* Other Chinese yellows are wongsky, wongsky, wongschy, hoang-teng, hoang-tschi, hoang-pe-pi, and ti-hoang.

Chrysamic acid: Aloes. Action of nitric acid on aloes. Yellow in alcohol.

Chlorophyll: Green color of plants.

Cochineal, or cochenille, coccionella: *Coccus cacti* (dried bodies of the female insect). Contains carminic acid soluble in water with purple color; lakes, red to purple; alum or tin lakes, cochineal carmine or coccerin.

Cotinin: Preparation from young fustic. Yellow.

Cranberry or red bilberry: *Vaccinium Vitis-Idæa.* Red.

Cudbear, or cudbeard, perseo: *Lecanora tinctoria, Variolaria orcina* (lichens). Differs from archil in being in powder and free from excess of ammonia. Bluish red.

Cyanin: Coloring matter from petals of flowers. Occurs in wine. Blue, turning pink with vegetable acids.

Dragon's blood (palm): *Dæmonorops Draco.* Red resin, used chiefly for coloring varnishes, for preparing gold lacquers, for tooth tinctures and powders, and for staining marbles.

Dragon's blood (Socotra): *Dracæna Cinnabari.* Red resin.

Dwarf elder: *Sambucus Ebulus.* Red.

Dyer's broom: *Genista tinctoria.* Yellow.

Dyer's woodruff: *Asperula tinctoria.* Contains colors similar to alizarin.

Elderberry: *Sambucus Canadensis, S. nigra, S. pubens.* Red.

Fairy cup or blood cup: *Chlorosplenium æruginosum.* Calcium lake, green.

Flavin: Prepared from oak bark. Olive yellow to dark brown powder. Yellow.

Forget-me-not: *Myosotis palustris.* See Cyanin.

French purple: Prepared from archil by treatment with acid.

Fustic (old) or yellow Brazilwood, Holland yellow wood, murier des teinturiers, bois jaune, gelbholz: *Chlorophora tinctoria* (*Morus tinctoria*). Contains morin and maclurin. Yellow.

Fustic (young) or bois jaune de Hongrie, du Tirol, Fisetholz, fustel: *Rhus Cotinus.* Contains fisitin. Yellow.

Galangal (Chinese): *Alpinia officinarum.* Alkaline solutions, yellow. Used in Russia for making "Nastoika," a liquor.

Galangal (Javan): *Alpinia Galanga.* Alkaline solutions, yellow.

Gamboge: *Garcinia Hanburyi, G. Morella.* Red resin. Lakes, yellow.

Garancin: Formerly prepared from madder. Of historic interest only.

Gentian: *Gentiana lutea.* Alkaline solutions, yellow.

Goa powder: *Vouacapoua Araroba* (*Andira Araroba*) Aguiar. Contains chrysarobin and chrysophanic acid. Yellow.

Golden seal or Canadian yellow root: *Hydrastis Canadensis.* Yellow basic dye. See Medicinal Plants.

Harmala red: *Peganum Harmala.* Basic color insoluble in water; alkaline solutions, red.

Heartsease, or pansy, lady's delight: *Viola tricolor,* var. *arvensis.* Yields quercetin. Yellow.

Hollyhock: *Althæa rosea, Malva sylvestris, M. rotundifolia.* Solutions, violet-red. Crimson with acids. Green with alkalies. Alumina lake, violet-blue.

Horse-chestnut: lakes, yellow.

Indian yellow, or piuri, piouri, purree, purrea arabica, jaune indien. Prepared in India from the urine of cows fed on mango leaves, and contains yellow coloring matters, free and in form of magnesium or calcium salts.

Indigo: *Indigofera Anil* and other species. (Fig. 373.) Insoluble in water. Becomes soluble by treatment with sulfuric acid, forming sulpho salts. Indigo carmine (blue). Soluble under reduction to indigo white in alkaline solutions containing a reducing agent, such as copperas, zinc dust, glucose, and certain organic ferments, bran being employed in wool dyeing. On exposure to air, indigo white is oxidized to indigo. The dyeing process depends on this reaction. Indigo made artificially is very largely used. Indigo was once an important product of South Carolina.

"In 1742, George Lucas, governor of Antigua, sent the first seeds of the indigo plant to Carolina, to his daughter, Miss Eliza Lucas (afterwards the mother of Charles Cotesworth Pinckney). With much perseverance, after several disappointments, she succeeded in growing the plant and extracting the indigo from it. Parliament shortly after placed a bounty on the production of indigo in British possessions, and this crop attained a rapid development in Carolina. In 1754, 216,924 pounds and, in 1777, 1,107,660 pounds were produced. But the war with the mother country, the competition of indigo-culture in the East Indies, the unpleasant odor emitted and the swarms of flies attracted by the fermentation of the weeds in the vats, and above all the absorbing interest in the cotton crop, caused the rapid decline of its culture, and in the early part of this century it had ceased to be a staple product, although it was in cultivation in remote places as late as 1848." (From "South Carolina," by Harry Hammond.)

Jackwood, or jack fruit of Ceylon: *Artocarpus integrifolia.* Alumina lake, yellow.

Kamala, or kameela, ramelas, rottlera: *Echinus Philippinensis* (*Rotllera tinctoria*). Red powder.

Kermes berries, or portugal berries, poke berries, pigeon berries, scoke berries: *Phytolacca Americana* (*Phytolacca decandra*). Reddish.

Kermes, or false kermes berries, graines de kermes, vermillon vegetal: *Coccus ilicis* (dried bodies of the female insect). Solutions and lakes, blood red.

Kino: *Pterocarpus Marsupium, Butea frondosa, B. superba,* and varieties, *Eucalyptus corymbosa.* Red color.

Lac-dye, or lac-lac: *Coccus laccæ* (from the female insect). Colors similar to cochineal.

Lapacho, or taigu wood: *Tecoma Lapacho* and allied species. Yellow color.

Lima wood, or Costa Rica redwood: Similar to St. Martha wood. See under Redwoods.

Liquorice: *Glycyrrhiza glabra.* Brown.

Litmus, or tournesol: *Rocella, Lecanora, Variolaria* (lichens). Red and blue. Used as an indicator by chemists; acids change the blue to red, and alkalies the red to blue.

Logwood, or Campechy wood, Blauholz: *Hæmatoxylum Campechianum.* The unfermented extract forms yellow solutions if neutral, and blue precipitate with calcareous water. The unfermented solution contains chiefly a glucoside which, on fermentation, yields hæmatoxylin, and the latter is easily oxidized to hæmatein. Various colored lakes are formed. Hæmatoxylin forms rose-red color with alum and a black violet lake with iron alum. Hæmatein forms bluish violet with alkalies; reddish purple with sodium carbonate; reddish purple with ammonia; bluish violet lake with ammoniacal copper sulfate; violet lake with ammoniacal tin chlorid; black with ammoniacal iron alum. Logwood and fustic are the principal natural coloring matters not yet replaced by artificial products. They are not used so exclusively as hitherto. Their coloring principles have not yet been made synthetically, and their low price and good qualities keep them important.

Fig. 374. Madder (*Rubia tinctorum*). *a* and *b* and their opposites are probably not true leaves but large leaf-like stipules; the leaves of *R. tinctorum* are opposite. Former source of the Turkey red dye.

Lopez root: *Toddalia aculeala.* Contains berberin. Yellow.

Lomatiol: *Tricondylus ilicifolia, Tricondylus myricoides.* Yellow.

Madder: *Rubia tinctorum.* (Fig. 374). Natural source of alizarin dyes. Formerly considered the most important of all dye-stuffs used by calico-printers, and cultivated very extensively in Italy and France, but is now entirely displaced by artificial alizarin. The plant is a native of Asia Minor. Color dyed with it is the well-known Turkey red.

Mang-koudur, or oungkoudon, song-kou-long, jong koutong: *Morinda umbellata.* Lakes, yellow to red.

Marsh marigold: *Caltha palustris.* Yellow.

Mountain wormwood, or Genepi des alpes: *Artemisia Absinthium.* Yellowish.

Munjeet: *Rubia cordifolia.* Similar to madder.

Myrtle berry: *Myrtus communis.* Bluish red.

Nettle: *Urtica* sp.

Nicaragua wood: *Guilandina echinala.* Boughs or twigs used. See Redwoods.

Onion: *Allium Cepa.* Alumina lake, yellow-brown.

Oregon grape root: *Berberis Aquifolium.* Yellow basic dye.

Panama crimson: Vine called "China."

Parsley: *Apium Petroselinum.* Alumina lake, yellow.

Peachwood, or St. Martha wood, Martin wood, bois du

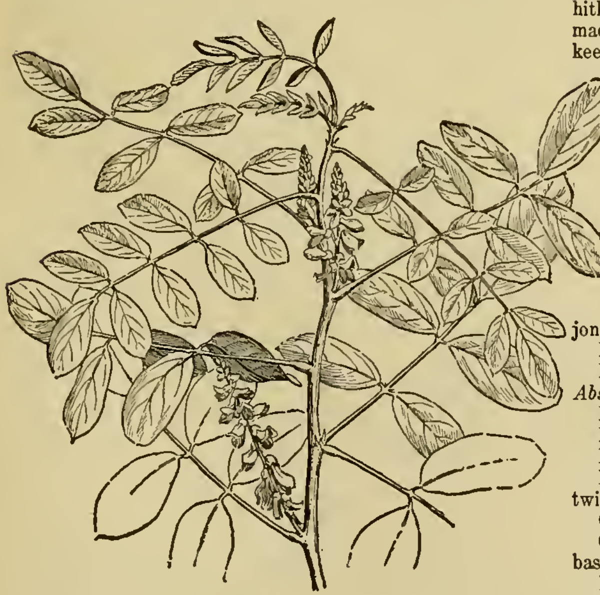

Fig. 373. Indigo (*Indigofera Anil*), formerly grown in the South, and still cultivated in India.

sang: *Cuilandina echinata.* From the Sierra Nevada in Mexico. See under Redwoods.

Persian berries, or yellow berries, Kreutzbeeren, Avignon-Körner, graines de perse, graines jaunes, graines d' Avignon (*Rhamnus infectoria*), French berries (*R. Alaternus*), Spanish berries (*R. saxatilis*), Italian berries (*R. infectoria*), Hungarian berries (*R. cathartica*). Alum lake, bright yellow; iron lake, dark olive.

Poppy, or field red corn: *Papaver Rhœas.* Red.

Poplar buds: *Populus* sp. Alumina lake, yellow.

Prickly pear: *Opuntia vulgaris.* Red. One of the chief species of cacti on which the cochineal (which see) insect lives and propagates.

Privet berries: *Ligustrum vulgare.* Bluish red.

Purple heart: *Copaifera publiflora.* Alum lake, yellow.

Puriri: *Vitex littoralis.* Alum lake, yellow.

Quercitron: *Quercus velutina* and varieties: Yields quercetin, yellow. Quercitron bark extract is still used extensively.

Quebracho: *Quebrachia Lorentzii.* Yellow color.

Redwoods: See Brazil, Bahia, Peach, Nicaragua, Sapan, Lima, Braziletto, Barwood and Camwood. These woods

Fig. 375. Safflower (*Carthamus tinctorius*). Source of a yellow dye.

yield on treatment various red to yellow-red colored solutions, no two woods giving exactly the same shades; i. e., Brazilin, probably occurring as a glucoside, forms Brazilein on oxidation and yields lakes similar to alizarin in shade, but inferior in all other qualities. Florence, Berlin and Venetian lakes are lakes of the soluble redwoods.

Rhubarb: *Rheum officinale.* Yields chrysophanis acid. Yellow.

Rue: *Ruta graveolens.* Alum lake, yellow.

Safflower, or dyer's saffron, carthame, safran bâtard, bastard saffron: *Carthamus tinctorius.* (Fig. 375). Yellow. Triturated with French chalk and dried, forms various bright "rouges".

Saffron, or azafran (Afgh.): *Crocus sativus.* Yellow. (Fig. 376).

Sage: *Salvia officinalis.* Yellow.

Sandalwood, or santalwood, lignum santalum, red santalwood, Saunders wood, red sandalwood, red Sanders wood, bois de santal, Sandelholz: *Pterocarpus santalinus, P. Indicus.* Contains santalin, a fine red powder easily soluble in alcohol and acetic acid with a blood-red color. See under Redwoods.

Sapan wood, or sappan wood, Japan wood, bois du Japon; also called red sandalwood, santalwood, sumbawa wood: *Cæsalpina Sappan.* Probably identical with caliatur wood or cariatur wood. See under Redwoods.

Saw-wort: *Serratula tinctoria.* Alumina lake, yellow.

Sepia: *Sepia officinalis, Loligo tunicata* and other species of cuttle-fish common in the Mediterranean and Adriatic. Dark brown coloring matter from the ink-bag of these animals. The pure pigment constitutes four-fifths of the dried ink-bags as they occur in commerce. Dark brown ink-like pigment.

Sorgo red, or durrha: *Andropogon Sorghum.* Lakes. crimson red.

Spanish trefoil: *Trifolium* sp.

Spinach: *Spinacia oleracea.* Yellow.

Stringy bark: *Eucalyptus macrorhyncha.* Orange to yellow.

Sun dew: *Drosera Whittakerii.* Lakes red to brown.

Sumac (Cape), or pruim bast: *Calpoan compressum.* Alum lake, yellow.

Sumac (Sicilian): *Rhus Coriaria.* Alum lake, olive.

Sumac (Virginian): *Rhus hirta.* This and the above are used in dyeing processes as a source of tannin.

Tyrian purple: *Murex, Purpura, Buccinium,* etc. (sea shells). The purple dye of the Phœnicians, Greeks and Romans.

Turmeric, or curcuma, Indian saffron, terra merita, souchet, safran d' Inde: *Curcuma longa, C. rotunda.* Yellow.

Ventilago Madras-patana, or oural patti, pitti, lokandi, kanwait, etc.: *Ventilago Madraspatana.* Lakes, blue.

Virginia creeper: *Parthenocissus* (or *Ampelopsis*) *quinquefolia.* Red color.

Waifa, or hoai-hoa, Chinese yellow berries: *Sophora Japonica.* Alumina lake, yellow.

Wallflower: *Cheiranthus Cheiri.* Yellow lakes prepared from the blossoms.

Wall lichen: *Parmelia parietina.* Yellow.

Waras: *Moghania congesta* (*Flemingia congesta*). Red resinous powder.

Weld, or wau, gaude, yellow weed, dyer's rocket: *Reseda Luteola.* (Fig. 377). Alumina lake, yellow. With chromium, olive-yellow; with tin, bright yellow; with iron, olive. Considered superior to all other natural yellow coloring matters, but now displaced by several synthetic dyestuffs.

Whitethorn, or blackthorn: *Cratægus oxyacantha.* Yellow lakes from blossoms.

Woad, or pastel, waid: *Isatis tinctoria, I. Lusitanica.* (Fig. 378). Contains indigo. Formerly cultivated in England and Holland.

Mineral coloring matters.

Of the many inorganic coloring matters, only chrome yellow, chrome orange, iron and manganese oxids and Prussian blue may be treated under dyestuffs. None of these is used as such, but they are produced on textiles by chemical reactions

The goods are first treated with a solution of one of the chemicals, and then on working in another solution the pigment is produced. In calico-printing, any pigment can be fastened mechanically as in ordinary printing, except that gum arabic, dextrin, starch, albumen, and the like, are employed instead of varnishes.

Fig. 376. Saffron (*Crocus sativus*). Source of a yellow dye.

Definitions.

Lakes are insoluble compounds of alumina and coloring matters. If these are formed by themselves, a color-lake or pigment is produced; but if a fabric is first impregnated with alum or other metallic salts for which the fiber has an affinity, on subsequent treatment in the coloring solution the color-lake is produced in and on the fiber, which is then said to be dyed. Several other metallic oxids also possess similar properties, often giving different colored precipitates with the same dyestuffs. These metallic compounds are called "mordants" (from the French mordre, to bite). Tannic acid forms insoluble compounds with an entire series of coloring matters and is similarly used.

Although dyeing has been practiced from time immemorial, and by all nations of the globe, no satisfactory theory has been advanced to explain the process. Mechanical attraction, chemical affinity and "solid solution" are given as explanations, all having experimental evidence in support. In wool dyeing, the chemical affinity theory best elucidates the process.

Classification of dyestuffs.

The dyestuffs may be classified either according to their chemical composition, in accordance with the fibers for which they are most suitable, or with the methods used in their application. The first classification is of importance to the chemist, while the last is best for practical purposes, and is shown in the following grouping:

(*a*) Direct cotton colors. These dye cotton in full shades without the aid of mordants; in conjunction with them, certain salts, such as glauber salt or common salt, are used to aid in the absorption of the dye, as these salts tend to force it out of the solution. Alkaline salts, such as soda, soap or phosphate of soda, have an opposite effect and tend to retard the dyeing process and to prevent uneven dyeing. The direct cotton colors also act as mordants, combining with the colors of the following class. These dyes may be converted into others by treatment with certain chemicals, thus making a new dye on the goods.

(*b*) Basic colors. Colors of a basic nature, which form compounds with tannic acid, insoluble in water, and which dye the vegetable fibers with the aid, and animal fibers without the aid, of mordants.

(*c*) Acid colors. Colors of an acid nature, which dye the animal fibers without the aid of mordants.

(*d*) Mordant colors. Colors which are dyed with the aid of metallic mordants. Most of the natural coloring matters come under this head.

(*e*) Sulfur colors. Colors of recent discovery. Most of them are insoluble in water, but soluble in water containing sodium sulfid. They are used for vegetable fibers as direct colors, and are similarly applied.

(*f*) Miscellaneous colors. These include those having little in common, and require individual treatment. Some of the most important come under this head.

(1) Indigo. See same in list of natural coloring matters.

(2) Eosines and rhodamines. Especially valuable for producing brilliant pigments in conjunction with metallic precipitants, for making artificial vermilion, etc.

(3) Aniline black is produced by impregnating the cotton yarn or cloth with aniline and the proper amounts of the required chemicals; on after-treatment, oxidation takes place and the color is formed. Other colors of much

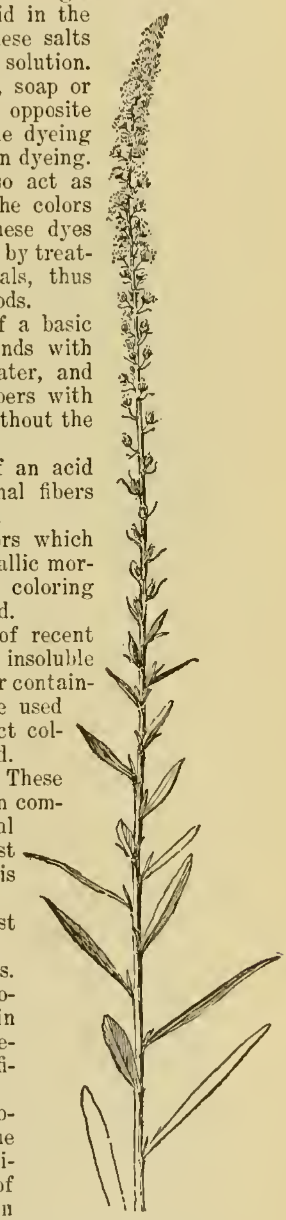

Fig. 377. Weld, or dyer's rocket (*Reseda luteola*). Source of a yellow dye.

importance are produced by processes which consist essentially in manufacturing the dye in an insoluble form in the goods.

Calico-printing.

Calico-printing may be considered as local dyeing. It is the art of producing on woven material a design in color by certain processes, one of which

Fig. 378. Woad (*Isatis tinctoria*). *a*, Lower leaf; *b*, first year leaf; *c*, mature fruit. Source of a blue dye.

is a printing process. The art has been developed from the early painting of cloth in India (in Calicut, hence the name "calico") to the modern print. There is probably no other industry in which so great a combination of artistic, mechanical, chemical and technical skill of the highest order is required, and this, too, to produce so cheap a finished product. Formerly the prints were made from wooden blocks cut in relief, there being a set of blocks equal in number to the colors desired if the pattern were small, or, if large, as many for each color as were necessary to make the complete design. This process is known as block printing and is done by hand. For large designs, or for those of more than twenty colors, this method is employed today and to a considerable extent to meet the demand for more artistic goods. The Japanese produce some very beautiful goods by applying the colors with stencils. This method can be used by any one, and very artistic effects can be produced at a trifling expense. In fact, this work should prove most interesting to amateurs, as most elaborate designs may be made.

The modern calico-printing machine consists of a large iron cylinder about which copper rollers are mounted. The cylinder is padded and the design is engraved in the copper rollers, each roller being engraved to apply one color ; as many rollers are necessary as there are colors in the pattern. Beneath each roller is a trough or "color-box" from which the color is carried to the roller by a wooden roller covered with cloth, or by a cylindrical brush. The entire surface of the copper becomes coated with the color, but as it revolves, a sharp blade, known as the "doctor," scrapes off all the color except that in the engraved part. The cloth to be printed passes between the large cylinder and the copper rollers, and the color is transferred to it. With one passage the entire design is produced. In order to give it a resilient surface, an endless web, called the blanket, also passes through, and between it and the cloth to be printed unbleached cloth passes, which serves to take up the surplus color. A second "doctor," called the lint doctor, removes any loose fibers from the copper roller. The rollers are so mounted in the framework that they may be adjusted while the machine is in operation, so that any misfit can be corrected. As the cloth passes from the machine it is dried and given such other treatment as the style of work may require.

Pigments are printed by being mixed with blood albumen, or the white of egg, for delicate shades. On steaming the printed goods, the albumen is coagulated, becomes insoluble and fixes the color. Basic colors are mixed with tannin and acetic acid, in which the tannin lake of the color is soluble ; in drying, the acetic acid evaporates and the insoluble lake is produced. Mordant colors are similarly applied.

Another process consists in printing on the thickened mordants and then dyeing the goods. The color is fixed where the mordant has been printed.

Patterns are produced by printing dyed goods with chemicals which destroy the color. This is known as discharge work. Starches, gums, flour and other similar bodies are used in making the printing pastes. Wool, silk and yarns are also printed; the latter, however, on a machine in which the design is in relief. Both sides of the cloth may be printed in one passage through a double machine. If the patterns on both sides are to be alike and are required to fit properly, it is necessary to have the sets of rollers engraved in pairs, and in reverse order.

Home dyeing.

In all dyeing processes it is essential to have the goods free from grease, dirt and foreign matter, and, for light colors, they should be bleached. In home dyeing, strict attention should be paid to cleanliness of the goods, and care taken accurately to carry out dyeing instructions. The package dyes, sold everywhere, are very serviceable, though not always entirely satisfactory. It should be remembered that the after-processes add a great deal to the appearance of the goods, and that amateurs have neither the necessary apparatus nor the skill of the professional dyer. Valuable material should be sent to a first-class dyer.

By carrying out the following tests on small samples, which can be made readily, the suitability of the material for any particular use may be ascertained easily, and much after-annoyance avoided:

(1) Fastness to light and atmospheric influences. The sample is exposed to sunlight under glass, and compared from time to time with a reserved part. Expose for two or more weeks; the longer the better. A more severe test is to expose to the weather.

(2) Fastness to rubbing. Rub with a piece of white cloth.

(3) Fastness to ironing. Press with a hot-iron, and compare.

(4) Fastness to washing. Wash with hot soap four times, allowing the goods to dry in the air between each two treatments.

(5) Fastness to alkali. Immerse in strong ammonia and then in washing soda (one part in ten of water); dry without washing.

(6) Fastness to perspiration. Treat for one hour with a teaspoonful of 30 per cent acetic acid in a pint of water at about blood heat. White wine vinegar diluted with an equal quantity of water will answer.

(7) Fastness to boiling in soda. Boil for one hour in a gallon of water in which two ounces of washing soda and one-half ounce of castile soap have been dissolved.

Literature.

Georgivics, Chemistry of Dyestuffs; A. G. Green, Survey of the Organic Colouring Matters; Allen, Commercial Organic Analysis; Fraps, Principles of Dyeing; Knecht, Rawson and Rosenthal, Manual of Dyeing; Hummel, Dyeing of Textile Fabrics; Cain and Thorpe, Synthetic Dyestuffs; Rawson, Gardner and Laycock, Dict. of Dyes, Mordants, etc.; Crookes, Handbook of Dyeing and Calico-printing; Rothwell, Printing of Textile Fabrics; Leffmann-Weyl, Sanitary Relations of the Coal Tar Colors; Berry, Coloring Matters for Foodstuffs and Methods for their Detection (being Bulletin No. 25 of the Bureau of Chemistry, United States Department of Agriculture; this also contains many references to literature on the subject); Bulletin No. 100 of same; Sadtler, Industrial Organic Chemistry, contains a full bibliography on the subject. The book, Programme of the City and Guilds of London Institute, contains very full lists of books on many branches of technology, including dyeing and bleaching; Patterson, Colour Matching on Textiles; Rawson, Gardner and Laycock, Dictionary of Dyes, Mordants, etc.; Hurst, Silk Dyeing and Printing.

FARM GARDEN. Figs. 379–391.

The farmer's garden should be simple, ample and abounding. There is no need that it be stinted or cramped. The hand labor is increased when the garden is small and enclosed, for the spaces are narrow and the rows short, preventing the use of a horse. A garden area should be as much a part of the farm establishment as the cows or chickens are.

Fig. 379. A farm vegetable-garden, made up of long, wide rows that admit of cultivation by horse.

Three classes of products may be grown in farm gardens,—flowers, vegetables, fruits. If the establishment is a fruit-farm, the fruits will be supplied from the orchards or fields; but even then there may be some kinds of fruit that will be grown only in a garden space. The garden may be field-like in its size and treatment; it may be called a garden because it is part of the home idea rather than the money-profit idea, being accessible to the residence and supplying products that are used therein.

Long, straight rows allow of cultivating by horse. As land is plenty, the rows may be placed far apart. Too often the farmer follows the distances advised in the catalogues and books, and thereby plants his garden so close that he must hoe it and till it by hand. The distances given in the books are those that the plants require in order to arrive at proper development; greater distances are no harm to the plants. At one side of the garden area, the bush-fruits and asparagus and rhubarb may be placed. The other parts may be planted in rotation. Even some of the flowers may occupy long free rows in the garden space, affording abundance of bloom which may be picked with the same freedom that tomatoes and strawberries are picked. Or, the flower-garden may be made a part of the landscape or pictorial setting of the

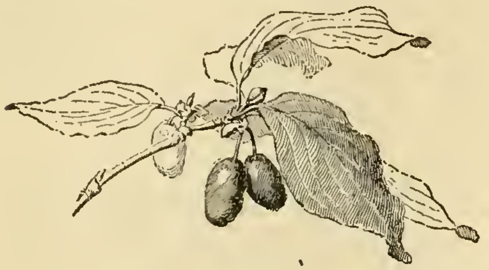

Fig. 380. Cornel cherry (*Cornus Mas*). An early blooming small tree, the handsome little fruits of which are sometimes used in preserves. Example of an odd or interesting plant that may be grown in a home garden.

residence; this relationship of it is discussed in Chapter IX of Vol. I, particularly at pages 312, 317–18.

Whether a part of the landscape features or of the separate garden area, the flowers should be of the kinds that require least special care and are surest to afford abundant bloom under indifferent or even adverse conditions. The main part of the flower-garden should be permanent, comprising perennial plants. Such plants come up of themselves year after year. Many of the perennials, as the phloxes, need to be divided or renewed (page 10) now and then, but this entails less labor than the growing of most annuals. Some of the perennials that are easily grown and that will unite to extend their bloom from early spring to late fall are as follows: Snowdrop and snowflake, crocus, tulip, hyacinth, narcissus, polyanthus, English daisy, pinks, forget-me-not, peony, bleeding heart, lychnis, columbine, iris, larkspur, poppies, lilies, yucca, gas plant or dictamnus, hollyhock, phlox (improved kinds), certain kinds of sunflowers, Golden Glow rudbeckia, perennial pea, outdoor chrysanthemums, goldenrods, asters, Japanese anemone.

Some of the most easily grown and satisfactory annuals for the general flower-garden are: China aster, marigold, cornflower or bachelor's button, petunia, verbena, sweet alyssum, *Phlox Drummondii*, cosmos (for late bloom), annual chrysanthemum, zinnia, stock, pansy (for a moist or semi-shady place), nasturtium, sweet sultan, nicotiana (two or three kinds), annual poppies (bloom of short duration), balsam, portulaca or rose moss (for sunny places), sweet pea, morning-glory, hyacinth bean.

Certain shrubs may be grown primarily for their flowers as well as for their shrub effect, as: Lilac, syringa or mock-orange, crape myrtle (at the South), deutzias, hydrangea, snowball, spireas, blue spirea or caryopteris, weigela, rose of sharon or hibiscus, kerria or Japan rose, and various wild bushes of most neighborhoods.

The Farm Fruit- and Vegetable-Gardens.

By *S. T. Maynard.*

The farmer's garden is proverbially the least productive area on the farm, whereas it should be the most productive and profitable, and should afford an abundance of the most wholesome luxuries of country living, fruits, vegetables and flowers, in a condition in which they cannot be found on the market. The farm affords a variety of soils from which may be selected that which is adapted for the best growth of garden products. It provides all of the tools needed for the most thorough cultivation. It can supply an

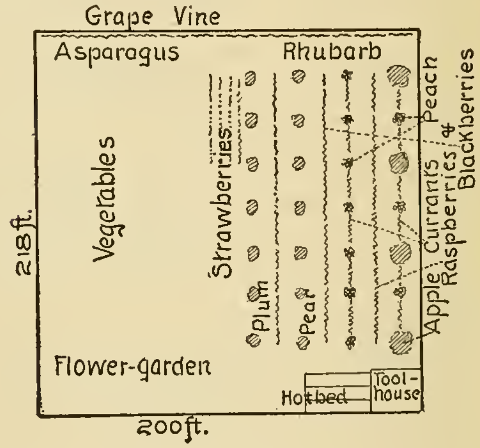

Fig. 382. Garden plan, with short rows.

abundance of plant-food, and the farmer or some of his family is on the place all the time and can look after the garden. The garden should afford recreation for the women and children of the family, and a means, if they choose, of earning a little "pin money" by the sale of surplus products. The home garden is also a place in which various interesting fruits and other plants may be grown, largely for curiosity (Fig. 380). It is a place for odds and ends of things mentioned in books and advertized in catalogues.

The garden may be divided into three parts or separate gardens, — the fruit-, vegetable- and flower-gardens; or all may be combined in

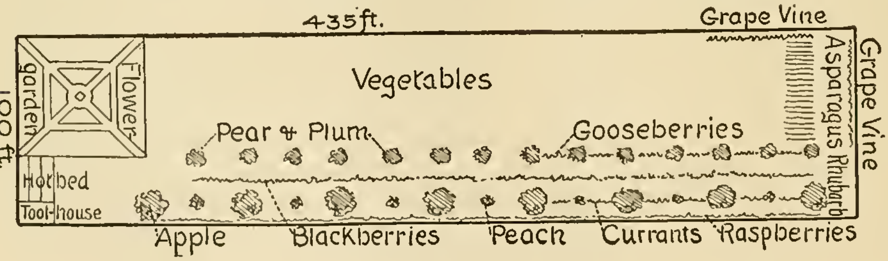

Fig. 381. Garden plan, with long rows.

one. (Figs. 381 and 382). On the farm there are advantages in having the three divisions in one lot, and that not far from the house. The daily supplies may be gathered easily, and it will be more constantly under the eye and will be less liable to neglect. However, it may be best to have each separated a little from the others, when land is abundant. The work can then be performed more easily than when all are mixed together.

Location of the garden.

The vegetable-garden may be a part of any field crop, such as corn or potatoes, the vegetables being planted at the ends of the field rows so that both crops may be cultivated at once.

The best soil for the apple, pear and plum trees is a rich, deep, moist loam, on an elevation sloping to the southwest, west or northwest, to insure good circulation of air and thus some freedom from blights and rots. The peach and the cherry do best in a thinner soil, if possible on a northwest or western slope. The cherry, especially the sweet varieties, will grow on the lawn or by the roadside without cultivation, so long as the soil is good. The peach is generally given thorough cultivation, but may be made to grow in turf if an abundance of plant-food is supplied, and the grass is cut frequently under them, or a mulch is spread as far as the branches extend. The trees must be made to grow vigorously, whether in the garden or on the lawn. [See the article on *Fruit-growing.*]

Small-fruits generally succeed well on any deep, loamy soil containing an abundance of organic matter from decaying turf, stable manure or green crops turned under.

Making the garden.

If the land for the garden is clear and we are starting a new one, the first effort is to put the soil in good condition by plowing under a liberal quantity of stable manure, or by growing a cover-crop to be plowed under the season before the garden is to be made. For this purpose, peas and oats may be sown in the spring, and when the latter are in bloom the crop is turned under and harrowed thoroughly a few times until about August 1. Then peas and barley are sown. This crop is left on the land until the following spring to protect it from washing, and is plowed under whenever the land is needed, from April to June.

For vegetables, a dressing of five to ten cords per acre of fine, rich stable manure should then be worked into the soil with a disk- or spring-tooth harrow. If stable manure is not available, any good commercial garden fertilizer may be used, at the rate of one-half to one ton per acre, or 50 to 120 pounds per square rod. This may seem to be a large quantity of fertilizing material to apply, but garden vegetables must make a quick growth to be succulent. Market-gardeners frequently use fifteen to twenty cords, or more, of stable manure per acre, and commercial fertilizer in addition, and make greater profits than if less were used.

The large orchard fruits.

Given a well-fitted soil, good trees are the first essentials for success. They should be secured from a reliable nursery as near home as possible. Strong No. 1, two-year-old trees of apples, pears, cherries and European plums should be chosen having a clean, straight trunk and a growth of three to six clean branches, one to two feet long, starting at three to four feet from the ground. No. 1 one-year-old peach, Japanese plums, and some varieties of cherries, are better than older trees. Many orchardists prefer a small No. 1, or a No. 2 peach tree, as a low head can be formed more certainly from it than from larger trees.

Preparing the trees for planting.—As the roots of trees dug from the nursery are largely destroyed in digging, it is always best to remove a large part of the top at planting. Cut the lateral shoots back to a few inches in length, cutting out entirely any shoots not needed to form a good head. In the formation of the head we leave only three or four main branches. Each of these is branched when a foot or more in length. The purpose is to have three or four main lateral branches and one central leader.

The modern orchard tree is grown with a low head, the main branches starting about three or four feet from the ground; but in a mixed garden, where we cultivate other crops among and under the trees, they must be trained higher in order that the horse may go under them with the plow and cultivator.

Planting.—If the land has been fitted by deep plowing, the hole for the tree need be only as large as the spread of the roots; if not, then a hole considerably larger must be dug, making the soil fine and mellow a foot or more deep. Fine, rich soil must be worked firmly about the roots until the hole is nearly full and the roots well covered, when the remainder of the soil is spread on loosely to serve as a mulch. Coarse green stable manure should not be placed in contact with the roots, but it is very valuable on the surface about the tree, or over the roots when the hole is about half-filled.

After-pruning and care.—If young trees are properly pruned when set out, they will require but little pruning until they begin to bear, except to check the growth of shoots coming out on the trunk or along the main branches that are not desired to make a well-formed head. Here and there should be cut out branches that cross others or tend to smother their foliage by drooping down on them. The tree should be kept shapely. In pruning old fruit trees, the aim should be to prevent crossing and crowding of the branches and to thin out the old wood, so that the number of fruits is reduced, and young and vigorous wood will take its place. The ends and the highest branches should be cut back so that the lower branches will be renewed and sunlight and air admitted.

Pear, peach and plum trees are pruned in practically the same way as the apple, except that they all need more heading in to force the growth into the lower and lateral branches.

Varieties of large fruits.

The nursery catalogues give long lists of varieties of all of the large fruits, and from their description it would seem as if all were valuable, when in any one locality perhaps a half-dozen varieties comprise nearly all of the valuable qualities desired. Varieties suggested as excellent for general cultivation for home use are as follows:

Apples: Summer: Astrachan, Oldenburg, Williams, Yellow Transparent.—Autumn: Gravenstein, McIntosh, Wealthy, Fall Pippin.—Winter: Hubbardston, Jonathan, King, Baldwin, R. I. Greening, Spy.

Pears: Clapp, Bartlett, Seckel, Sheldon, Bosc, Hovey.

Peaches: Mountain Rose, Oldmixon, Crawford Early, Elberta.

Plums: European: Bradshaw, Lombard, Imperial Gage, Damson, Lincoln, Quackenboss, Fellenburg, General Hand.—Japanese: Abundance, Burbank, Wickson, October Purple.

Cherries: Sweet: Governor Wood, Yellow Spanish, Black Tartarian, Downer Late.—Sour: Early Richmond, Montmorency.

Fig. 383. Dwarf apples, on doucin roots. These roots are not hardy in the upper Mississippi valley.

The following varieties are adapted for home use in the colder parts of Ontario and Quebec (W. T. Macoun):

Apples: Yellow Transparent, Duchess, Lowland Raspberry, Langford Beauty, St. Lawrence, Wealthy, McIntosh, Fameuse, Swazie, Milwaukee, Scott Winter, Baxter.

Pears: Flemish Beauty, in favorable localities.

Plums: American: Bixby, Mankato, Cheney, Wolf, Hawkeye, Stoddard.—European: Mount Royal, Raynes, Glass, Montmorency, Perdrigen.—Russian: Early Red.

Cherries: Orel 25, Ostheim (Minnesota), Montmorency.

For Iowa (A. T. Erwin):

Apples: Summer: Duchess, Lowland Raspberry, Benoni.—Fall: Wealthy, Grimes Golden.—Winter: Roman Stem, Jonathan, Stayman Winesap, Gano.

Crabs: Florence, Whitney.

For severe locations in northern Iowa:

Apples: Duchess, Charlamoff, Patten Greening, Wealthy, Okabena.

Pears: Seckel, Lincoln, Longworth, Kieffer.

Peaches: Champion, Greensboro, Hill Chili, Russell.

Plums: Wyant, Brittlewood, Hunt, Hammer, Wild Goose, Miner.

Cherries: Montmorency, Early Richmond.

For Colorado, eastern slope (W. Paddock):

Apples: Summer: Yellow Transparent, Red June, Oldenburg.—Fall: Wealthy, Utter, Plum Cider.—Winter: Jonathan, Stayman Winesap, Delicious.

Plums: DeSoto, American Eagle, Arctic.

Cherries: Montmorency, Morello.

For Colorado, western slope:

Apples: Summer: Yellow Transparent, Red June.—Fall: Maiden Blush.—Autumn: Strawberry.—Winter: Jonathan, Winesap, Rome Beauty, Grimes.

Pears: Bartlett, Howell, Seckel.

Peaches: Crawford, Elberta, Mountain Rose.

Plums: Burbank, Italian Prune, French Prune.

Cherries: Mayduke, Black Tartarian, Bing.

For Alabama (R. S. Mackintosh):

Apples: Early: Early Harvest, Astrachan, Horse, Red June.—Autumn: Buncombe, Equinetele.—Late: Winesap, Terry, Yates.

Figs: Celestial, Brunswick, Brown Turkey, Lemon, Green Ischia.

Pears: Kiefer, LeConte, Garber.

Pecans: Stuart, Frotscher, Pabst, Centennial.

Peaches: Sneed, Greensboro, Alexander, Mamie Ross, Carman, Elberta, Family Favorite, Belle, Mountain Rose, Emma, Gen. Lee, Globe, Picquet, Columbia.

Persimmons, Japanese: Hachiya, Yemon, Okame, Tsura-no-ko, Yedo-Ichi, Hiyakume.

Pomegranates: Acid, Large Sweet, Spanish Ruby.

Plums: Red June, Burbank, Abundance, Gonzales.

Gathering fruit for home use.

Most fruits for home use should be allowed to ripen on the tree, and with low-headed trees this can be done, if there is a mulch on the surface so that fruits that fall on the ground will not be much injured. With early, bright-colored apples, this is the practice of many growers. The fruit is allowed to color perfectly, when it falls to the ground and is picked up every morning and marketed in open bushel-boxes. Pears should be allowed to reach full maturity, but should be picked while hard and ripened in a dark, dry place. Peaches, plums and cherries should get mellow on the tree before being picked for home use. For market and to extend the season, all of these fruits may be picked before they are mellow, but they should be fully grown, and may be kept several weeks or months if put in cold-storage at a temperature between 32° and 33°. The season may be considerably extended without cold-storage by gathering at one time only the fruits that are fully ripe.

Winter fruit should be allowed to hang on the trees until fully mature, but must be picked before it mellows and before heavy freezing weather comes. After picking, it should be put in a place with an even, low temperature. On the farm this may be in a north shed, the north side of a high building, or a cellar, where the temperature has been lowered by opening the windows on frosty nights and closing them during the day, or by a quantity of cracked ice and salt (ice-cream freezing mixture). A half-ton of ice and fifty pounds of salt will cool a large space down to a good keeping temperature for most fruits. This temperature in the North can be kept low by closing the doors and windows during the day and opening them at night, when the outside temperature is lower than that inside.

Dwarf fruit trees.

Pear trees are prevented from growing large by being budded on quince stocks. Apples are dwarfed by being worked on paradise or doucin stocks (small-stature forms of apple tree). Dwarfs occupy less space than standard or free stocks, usually come into bearing earlier, but they require more care in pruning, spraying and thinning. Dwarf pears are often grown commercially, but dwarf apples are not yet planted for profit in this country. Any variety of apple may be grown on the dwarf stocks; but inasmuch as apple-dwarfing is a home-garden practice, only good dessert varieties should be grown. Dwarf pears may be planted ten to twenty feet apart, depending on how closely they are kept headed in. About one rod asunder each way is the usual distance. Apples on doucin (Fig. 383) may be given such distances; those on paradise stocks may be set at half these distances. All dwarfs should be started low and kept well headed back. Paradise-stock apple trees should be little more than bushes, or they may be trained as espaliers or cordons. [For further information, see Waugh's "Dwarf Fruit Trees," New York, 1906, and Bailey's "Pruning-Book."]

Small-fruits.

The average farmer's family consumes less of the small cultivated fruits than the average city or village family, notwithstanding the advantages they have for producing fruit of the best quality, and that may be used in a fresh, ripe condition.

The strawberry.—The strawberry is especially adapted to growth in the home garden, and is of the greatest importance from the fact that a crop can be secured in a little over a year from planting. Its yield per acre is equal to that of the apple in quantity. We may expect to secure 5,000 to 15,000 quarts to the acre, or 50 to 150 barrels, which, with apple trees 40 x 40 feet apart, making about thirty trees to the acre, would be three to five barrels per tree, which is above the yearly average.

For the largest and best returns from small-fruits it is best to plant on new land. The strawberry is fruited by most growers only one or two seasons, and after the fruit has been gathered the plants and mulch are plowed under. The land is then devoted to some crop, such as celery or late cabbage, that may be planted after the middle of July. New land, old pasture or clover sod, is planted with potatoes or some other hoed crop to get rid of the white grub (larva of the May beetle). The following spring strawberry plants are set as early as the land will work up fine and mellow. Some growers further prepare land of this kind by sowing a crop of peas and barley after the potatoes; or sufficient organic matter may be incorporated by plowing under a heavy dressing of manure in the fall. Thorough cultivation must be practiced and all weeds kept down from the time the plants are set until the ground freezes in the fall.

In the North the beds must be protected in winter from freezing and thawing. A covering of straw, old hay, coarse, strawy manure, pine needles or other light material, put on just before severe freezing weather, will serve. Only a light covering, two or three inches thick, is needed, just enough to shade the ground, as the injury comes from the tearing action on the roots and crowns by freezing and thawing, and the lifting of the plants out of the ground.

Raspberry and blackberry.—These two bush-fruits do best in a rather moist, loamy soil, although they may be grown successfully on any soil that contains a good quantity of organic matter, if the surface is kept fine and mellow during the entire season, and especially in hot, dry weather. Plantations are generally renewed after growing six to ten years in one place, although under favorable conditions they sometimes last longer. The best time for planting is in the early fall, root-cutting plants being better than those from suckers, although the latter are more frequently used.

They are grown in hills or in rows, the former requiring a stake at each hill, or low-training of the bushes by top pruning to make them branch low and thus stand without supports. Cultivation may be done with the horse both ways, when the hill-method is used.

In rows, the canes may be supported by two

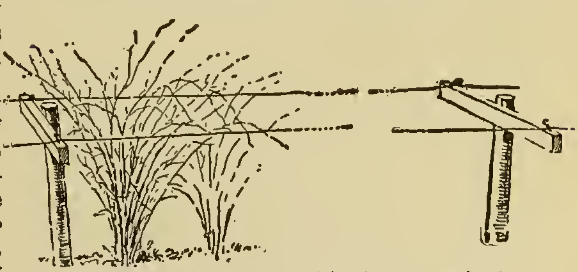

Fig. 384. A simple method of holding berry canes in place.

wires, one stretched on each side of the plants and held in place by a nail driven into the cross-piece of the support, slanting toward the center. (Fig. 384.) The wires may be raised at any time and drawn into the middle of the row so as to get outside of all the canes, and then be put back in place, thus drawing all the outside canes close together between the wires. The wires may be caught over the stake without any cross-arm, but this sometimes breaks the canes that are drawn in

Fig. 385. Raspberry (Columbian) before pruning.

next to the stake. No. 12 galvanized iron wire is used for this purpose.

The pruning required is simply the removal of the fruiting canes as soon as the crop is gathered. If in hills and the canes are not supported by stakes or wires, the ends of the new canes are pinched to make them grow stocky. In spring the bushes may be cut back. (Figs. 385, 386.)

The raspberry is easily pruned with the hand pruning-shears, but to do the work comfortably among blackberries, long-handled shears or a blackberry hook is required, with which to reach in among the thorny canes.

Few varieties are perfectly hardy, and so the canes may need protection during the winter in the North. Raspberry canes are easily protected by bending them over and laying them on the ground; blackberry plants must be loosened a little at the roots to enable them to bend without breaking. Blackberries are seldom covered except in the extreme North.

Currants and gooseberries.—These two fruits are almost necessities in the farm garden. They are easily grown and yield a large quantity of fruit for the space occupied and the labor expended. They delight in a deep, moist, rich soil, the size of the fruit depending more on the richness of the soil than on the variety. Strong one-year-old plants are best. They are planted four by six feet apart. The pruning required is to remove wood more than three or four years old to encourage the growth of strong new canes. The best fruit is borne on wood two or three years old.

The greatest difficulty to be met is the injury by the currant-worm, which eats the foliage soon after the leaves unfold. This pest is destroyed by dusting the bushes with powdered hellebore when the leaves are wet, or applying it in water. A blight attacks the leaves soon after the fruit is ripened, sometimes causing them to fall, thus leaving the bushes bare from the middle of July until winter. This weakens the bushes so much that the fruit the following season is small and of poor quality. Spraying the bushes with Bordeaux mixture is often necessary.

The gooseberry requires practically the same treatment as the currant and is subject to the same pests. The English varieties are more subject to mildew. The fruit is not so much in demand in the markets, but is delicious and should be more largely used.

Varieties of small-fruits.

The following varieties of small-fruits are recommended for general home planting:

Strawberries: Brandywine (St.), Sample (P.), Marshall (St.), Clyde (St.), Senator Dunlap (P.), Haverland (P.)

Raspberries: Cuthbert, Columbian, Loudon, Cumberland.

Blackberries: Agawam, Snyder, Ancient Briton, Eldorado.

Currants: Fay Red Cross, Wilder, White Grape, White Imperial.

Gooseberries: Downing, Red Jacket, Josselyn.

The following varieties are adapted for home use in the colder parts of Ontario and Quebec (W. T. Macoun):

Strawberries: William Belt, Bubach, Greenville, Lovett, Splendid, Senator Dunlap, Excelsior.

Raspberries, Red: Herbert, Clarke, Cuthbert, Marlboro.—Yellow: Golden Queen.—Black: Hilborn, Older.

Blackberries: Agawam, Snyder.

Currants: Red: Pomona, Victoria, Wilder, Cherry.—White: White Grape.—Black: Saunders, Victoria, Collin Prolific.

Gooseberries: Red Jacket, Downing or Pearl.

For Iowa (A. T. Erwin):

Strawberries: Dunlap, Bederwood, Warfield.

Raspberries: Red, Cuthert, Turner, London.—Black: Gregg, Older, Cumberland.

Fig. 386. Raspberry (Columbian) after pruning.

Blackberries: Ancient Briton, Snyder.

Currants: Perfection, Red Dutch, White Grape, Red Cross.

Gooseberries: Champion.

For Colorado, eastern slope of the Rocky mountains (W. Paddock):

Strawberries: Captain Jack, Jucunda.
Raspberries: Red: Marlboro.—Black: Kansas.
Blackberries: Wilson, Erie.
Currants: Cherry, Fay, White Grape.
Gooseberries: Downing, Champion.

For Colorado, western slope:

Raspberries: Red: Cuthbert, Marlboro.—Black: Gregg.
Currants: Cherry, Red Cross, White Grape.
Gooseberries: Chautauqua, Downing, Oregon.

For Alabama and neighboring regions (R. S. Macintosh):

Strawberries: Excelsior, Lady Thompson, Klondike, Aroma, Gandy.
Raspberries (North Alabama only): Turner, Cuthbert, Loudon, King.
Blackberries: Dallas, Mercereau.
Currants and *Gooseberries:* Not grown.
Dewberries: Australian.

The grape.

The grape may be grown on a trellis, a fence, a stone wall or the sides of a building. The best trellis is made of stakes and No. 14 galvanized wire, as the vines cling to the wires and do not need much tying. For the best results, the vine should have a warm southern exposure and a thin, well-underdrained soil. The third, fourth and possibly the fifth year from planting the fruit may be good without pruning, but as the canes grow older they form many lateral branches, thus producing a large number of small bunches of fruit that never ripen or are so small as to be of little value, and which are specially liable to rot. The remedy is pruning.

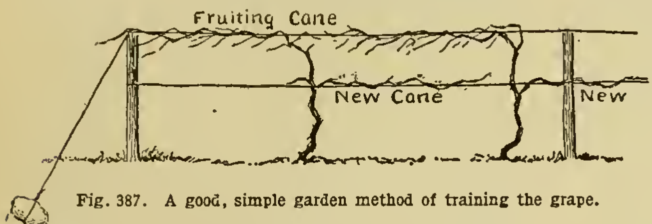

Fig. 387. A good, simple garden method of training the grape.

The rule for pruning grape-vines, under all conditions, is to cut away each year as much of the old wood as possible, saving enough strong new or year-old canes to replace those cut away. Each new cane must have an abundance of space so that the sun and air will surround the leaves and fruit and thus prevent rot and mildew. The number of new canes to be preserved depends on the strength of the vine, the space to be covered and the root space occupied.

A single vine may be made to cover a very large space if the feeding area in the soil is sufficient. An instance of this is the noted Mission vines in California, which sometimes cover thousands of square feet of surface and produce tons of fruit.

A very simple, yet very satisfactory method of training the vine, is shown in Fig. 387. By this system, all the pruning required is to cut away in the fall or winter the old fruiting canes and bring up the new canes to take their places. During the growing seasons, the laterals on the fruiting canes are kept pinched off just beyond the last bunch of fruit, and all laterals along the main vine and the new cane are kept from growing by pinching off as soon as they start. The pruning of vinifera grapes, grown in California, is quite different from this.

Varieties of grapes.—The most generally adapted varieties of grapes are as follows:

Purple: Worden, Concord, Campbell.—Red: Delaware, Brighton, Wyoming Red.—White: Winchell, Niagara, Diamond.

The following varieties are adapted for home use in the colder parts of Ontario and Quebec (W. T. Macoun):

Purple: Moore Early, Campbell Early, Rogers 17, Merrimac, Wilder.—Red: Moyer, Delaware, Brighton, Lindley.—White: Golden Drop, Moore Diamond.

For Iowa (A. T. Erwin):

Purple: Worden, Moore Early, Concord.—Red: Delaware, Brighton.

For Colorado, eastern slope (W. Paddock):

Purple: Concord, Moore Early.—Red: Brighton, Delaware.—White: Niagara.

Colorado, western slope (W. Paddock):

Worden, Purple Damascus, Cornichon, Brighton, Niagara, Sweet Water.

For Alabama (R. S. Macintosh):

Moore Early, Concord, Delaware, Niagara.—Scuppernong, Eden, Memory.

The vegetable-garden.

It is a painful fact that very many farmers buy their vegetables from the market, where they are received from the metropolitan markets, other farmers having grown them. In many cases, to be sure, it is cheaper to buy, because it is difficult to secure labor to grow them; but a different farming plan might enable one to raise vegetables with greater economy. The successful market-gardener endeavors to keep his land occupied with growing crops all of the time, and makes his land very rich, that the crops may grow quickly and be tender and succulent. Most farmers till too much land. In most cases, if the land were made richer, we might grow our garden crops on half of the area, or less, with more profit and much less labor. A small area, made rich and thoroughly tilled and cared for, would supply a large family. The entire area need not be planted at the beginning of the season. If such crops as radishes, lettuce and peas are put in very early they may be harvested in time for sweet corn, cucumbers, squash, late beets, cabbage, cauliflower, and the like; after early beans, sweet corn, potatoes and others, we may plant celery, turnips, spinach, and the like. To secure a succession of such vegetables as sweet corn and peas, early, medium and late varieties are planted at one time, and some standard sort is put in at intervals of a week or ten days afterwards. It is well to provide means, as boxes and hotbeds, to start or force plants ahead of their season, if the most interesting and useful results are to be secured. (See Figs. 388–390.)

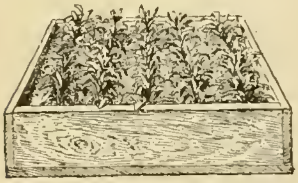

Fig. 388. A "flat" or box in which garden seeds are started.

Success in growing vegetables depends on: (1) the condition of the soil; (2) good seed; (3) planting; and (4) the after care and cultivation.

The soil.—In no one place can we find a perfect soil for all kinds of vegetables, but, as previously urged, a rich soil will largely make up for deficiency in variety. The question of the soil can not be discussed further here.

The seed.—The modern methods of seed-testing enable the dealer to offer seeds of good germinating qualities and the purchaser to know whether the seeds are good before planting; but, as to the purity of the products, one must take the word of the dealer, and he should buy only of reliable seedsmen. (Consult Chapter VII.)

A simple seed-tester can be made with two dinner-plates, a little fine clean sand, and two sheets of blotting-paper or cheese-cloth. (Fig. 391.) Put the sand in the plate, level it off nearly full, and saturate until water almost stands on the surface; then spread over the blotting-paper or cheese-cloth and place on it the seeds,—ten, fifty or one hundred of each. The larger the number the more accurate the test. Over the seeds spread another sheet of blotting-paper or cloth, and cover all with another dinner-plate.

Much of the success of this work depends on the temperature at which the sand is kept. As

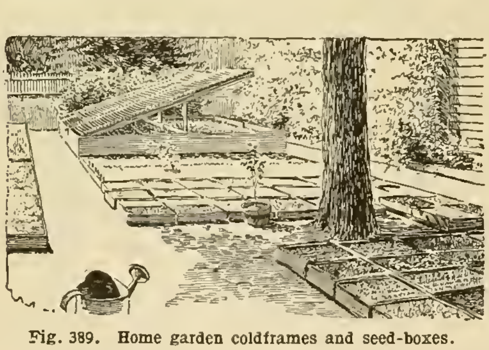

Fig. 389. Home garden coldframes and seed-boxes. (Garden of Luther Burbank.)

nearly as possible this should be the same as would be required for the best germination in the open ground. The best temperature for radishes, turnips, cabbage, lettuce, beets, celery, parsnips, grasses, and the like, is 40° to 50° at night and 50° to 60° during the day; for corn, beans, cucumbers, melons, squashes, tomatoes, peppers, eggplants, and the like, 50° to 60° at night and 60° to 70° during the day is desirable.

Planting.—With a fine mellow seed-bed, seeds should be covered according to their size and the condition of the weather. Fine seeds should be covered three or four times their thickness in dry weather, and less deeply in wet weather. The soil should be pressed firmly about the seed; the drier the soil the more firm should be the pressure. Very fine seeds, like those of celery, are sown on the surface, a little fine soil is sifted on them, and a sheet of cheese-cloth is spread over and wet down. This prevents washing of the soil and holds the moisture in contact with the seeds. Fine sphagnum moss sifted on answers the same purpose. As soon as the seeds begin to germinate, the cloth must be removed and the bed shaded until the plants become well established. Fine seeds may be shaded with

Fig. 390. Method of forcing rhubarb by means of half-barrels.

a little fine hay or rowen to keep the surface of the ground moist; but if too much is put on it will cause them to decay.

Cultivation and protection.—No crop, either of fruit or vegetables, will grow without some cultivation and care and protection from insects and fungous pests. As suggested in Fig. 379, all crops should be arranged in rows wide enough so that the work of stirring the soil may be done with the horse. With a fine-tooth cultivator this may be done even with plants that grow from very fine seeds, like celery, onions and carrots. To preserve regular distances between the centers of rows, and to occupy the land closely, onions, carrots or other small-topped plants may be sown in double rows; that is, there may be two rows one foot apart, with two and one-half or three feet clear space for cultivation to the next two rows one foot apart.

Harvesting the vegetable crop.—Early vegetables are of little value if left in the ground long after they have reached the size for table use. Radishes, turnips, beets, kohlrabi and similar root crops become fibrous and woody, while lettuce, spinach, cabbage, cauliflower and the like run to seed. Therefore, if there is any surplus of summer vegetables not needed by the family, it should be gathered and disposed of so that plant-food may not be taken from the ground. All winter vegetables should be tender and succulent when gathered and should be stored in a cool, slightly moist place, at a temperature of between 32° and 33°. To keep beets, parsnips and similar crops from wilting, they may be packed in cool, slightly moist leaves. A good time to gather these is in the morning after a frost, or when there is a little snow on them. If packed in barrels or bins, a layer of leaves is first put in the bottom, then the roots are mixed with a few leaves and a covering of leaves is put on top. A piece of burlap or a grain bag spread over all will keep the leaves in place.

Varieties of vegetables.—Much of the value of any variety of vegetable depends on the selection or strain of the seed-stock. One variety is known and popular in one section and a different variety in another section, so that no list of varieties adapted to all localities can be given. It is important that each gardener grow varieties or strains of varieties that are known to be generally successful in his own locality. Varieties change greatly from year to year, and it would be of little use to give lists.

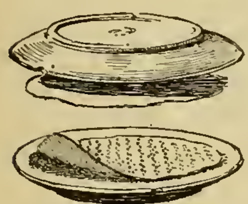

Fig. 391. Home-made seed-tester. (See Fig. 210.)

Protection from insects and fungous pests.

There is no crop grown on the farm or in the garden that is not attacked by some pest, and if no attempt is made to control the pests many of the crops will be failures. An equipment for spraying is indispensable, and farmers and gardeners should cöoperate and equip themselves with a power sprayer by which the work of a whole community may be done promptly, thoroughly and cheaply. Through the state experiment stations one can know what these pests are and how best to control them. For chewing insects we may use hellebore, Paris green, arsenate of lead or other arsenates. For sucking insects, scales, aphides, and the like, we may use whale-oil soap, kerosene emulsion, lime and sulfur wash, or other insecticides that kill by contact. For blights, rusts, and rots we have an almost universal fungicide in the Bordeaux mixture. Spraying or other remedy must be employed promptly and thoroughly as soon as a pest appears.

Full directions for the use of insecticides and fungicides may be secured from the state experiment stations. [See also Chapter II, "Insects and Diseases."]

Literature.

Green, Vegetable Gardening; Fletcher, How to Make a Fruit Garden; Fullerton, How to Make a Vegetable Garden, and How to Make a Flower Garden (two books); Greiner, How to Make the Garden Pay; Henderson, Gardening for Pleasure; Maynard, Successful Fruit Culture, and Home Decoration (two books); Williams, Window Gardening; Mell, Gardening for the South; Wickson, California Vegetables; Bailey, The Principles of Vegetable-Gardening, The Principles of Fruit-Growing, Garden-Making, The Pruning-Book, The Nursery-Book; Hunn and Bailey, Amateur's Practical Garden-Book; Card, Bush-Fruits. There are now many available books in this field, and the home gardener need not lack for enthusiastic advice.

FIBER PLANTS. Figs. 392–404.

By *Lyster H. Dewey.*

Fiber-producing plants are second only to food plants in agricultural importance. In continental United States, however, cotton, hemp and flax are the only fiber plants cultivated commercially, and, aside from cotton and hemp, most of the raw fibers used in our industries are imported. In an article of this scope, only the leading commercial fibers can be discussed. The reader of literature on fibers will find many names of materials that are used in tropical countries, but the fibers may not be subjects of export. In Mexico and Central America the name "pita" is widely used for a great variety of plant fibers, but none of them is produced in sufficient quantity to become an article of commerce outside those countries. Bamboo, okra, paper mulberry and pandanus (screw-pine) afford fibers that are used by natives in many countries.

Commercial plant fibers include (1) *Textile fibers*, used for spinning into yarns for woven and knit goods, thread, twine and cordage, such as cotton, hemp and sisal; including brush fibers, used in making brushes, such as ixtle and piassaba. (2) *Plaiting* or *rough weaving fibers*, used for hats, mats and baskets, such as straw, raffia and rushes. (3) *Filling* or *stuffing fibers*, used for mattresses, cushions and upholstering, such as Florida moss, crin vegetal and kapok. (4) *Natural textures*, such as Cuba bast, used in millinery goods and wrapping cigars. (5) *Paper materials*, such as jute butts, esparto, straw and wood pulp. The last two groups are not specially discussed here.

I. Textile Fibers

Textile fibers are readily classified by origin, character and use into three groups: (*a*) *Cottons*, hair-like single cells, one-half to two inches long, growing on the seed in closed seed-pods, used for spinning into fine yarns for woven and knit goods, threads, twines and cords of small diameter. (*b*) *Soft fibers*, long strands of overlapping cells produced in the bast or inner bark of the stalks of plants such as flax, hemp, jute and ramie, capable of subdivision into fine flexible soft strands, used for spinning into yarn for fine woven goods and also for threads, twines and cordage of small diameter. (*c*) *Hard fibers*, long strands of overlapping cells, somewhat lignified or woody in character, extending through the tissues of thick fleshy leaves or leaf stems of plants such as agaves, bananas, phormium, sansevierias and yuccas. While often capable of fine subdivision, these hard fibers are stiffer than bast fibers of the same degree of fineness. Hard fibers are used chiefly for coarse twines and cordage of all sizes up to eighteen-inch (circumference) towing hawsers.

(*a*) Cottons (see article on Cotton).

Cotton is produced by several species of the genus Gossypium belonging to the Mallow family. The most important commercial cottons belong to two distinct groups, as follows:

(1) *Occidental cottons, of American origin.*

Gossypium hirsutum, Linn. American upland cotton, native in tropical America, now cultivated from Virginia to Texas and Oklahoma, also in Mexico, Argentina, Turkestan and in many parts of India.

Gossypium Barbadense, Linn. Sea-island cotton, native in tropical America, now cultivated on the islands and adjacent shores of South Carolina, and through the interior of southern Georgia and northern Florida, also in the West Indies; and Egyptian cotton, cultivated in Egypt and recently introduced in the colonies in both East and West Africa.

Gossypium Peruvianum, Cav. Peruvian cotton, cultivated in Peru and also to some extent in Africa.

(2) *Oriental cottons, of Asiatic or African origin.*

Gossypium herbaceum, Linn. Cultivated in India, Asia Minor and southern Europe.

Gossypium arboreum, Linn. Cultivated in India, China and Japan.

Gossypium Wightianum, Tod. Cultivated in India, China, Japan, Korea and Transcaucasia.

In the United States, 25,000,000 to 30,000,000 acres, about one-third the acreage of corn, is planted in cotton each year. The annual production ranges from 10,000,000 to 12,000,000 bales of 500 pounds each, more than half of which is exported. Fifty million to 75,000,000 pounds, chiefly Egyptian cotton, valued at $6,000,000 to $11,000,000, are imported, as it differs in quality from that produced here.

(*b*) Soft Fibers.— *Flax* (see article on Flax).

Flax fiber is secured from the inner bark of the straw of the flax plant, *Linum usitatissimum*, Linn., belonging to the *Linaceæ* or Flax family. This plant, originating in Asia, is now cultivated commercially for fiber in Russia, Siberia, Austria, Hungary, Holland, Belgium, France, Italy, Sweden, Ireland, Canada and the United States. In the United States, flax fiber is produced in eastern Michigan, Wisconsin, Minnesota, Oregon and Washington. About 2,000 to 3,000 acres are devoted to fiber flax each year in this country, producing an average of about 450 pounds of fiber per acre, or a total of 900,000 to 1,350,000 pounds valued at $90,000 to $135,000. The importations for use in the twenty flax spinning mills during the past ten years have averaged annually 7,701 tons, valued at $1,865,473. The imports include water-retted Belgian flax, making the average value higher than that of the dew-retted American flax.

Hemp (see article on Hemp).

Hemp is a soft fiber obtained from the inner bark of the hemp plant, *Cannabis sativa*, Linn., an annual belonging to the *Moraceæ* or Mulberry family. Originating in central Asia, hemp is now cultivated for fiber production in China, Japan, Russia, Hungary, Italy, France and the United States. In this country hemp is one of the principal crops of the bluegrass region in central Kentucky, 10,000 to 20,000 acres being grown there each year. Smaller areas, rarely exceeding a total of 1,000 acres, are grown nearly every year in Michigan, Minnesota, Nebraska and California.

The annual production of rough hemp in the United States amounts to 4,000 to 10,000 tons, valued at $480,000 to $1,200,000. The annual average quantity of hemp imported in the past ten years is 4,982 tons, with an annual average value of $716,264. There has been a general upward tendency in prices in the past fifteen years. With a more general use of harvesting machinery and fiber-cleaning machinery, now being introduced, the crop may be grown more economically and its cultivation will doubtless extend over much wider areas.

Jute. (Figs. 392, 393.)

Jute fiber is derived from the inner bark of two species of plants,—jute, *Corchorus capsularis*, Linn., and nalta jute, *Corchorus olitorius*, Linn., both native in northern India. They belong to the *Tiliaceæ* or Linden family. They are cultivated commercially in India, Farther India, China, Formosa and southern Japan. The plants may be grown without difficulty in suitable soils in all warm, moist countries, but the large amount of hand labor required in the preparation of the fiber has prevented the development of the industry outside of Asia.

The two kinds of jute plants are almost identical in appearance except in the form of the seed-pods.

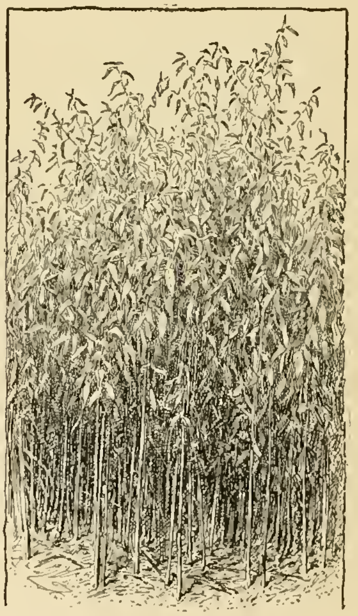

Fig. 392. Jute (*Corchorus capsularis*) ready for harvest.

(Fig. 393.) They are herbaceous annuals similar in habit to hemp, but more slender and less inclined to branch when standing alone. When grown broadcast for fiber, the slender whip-like stalks, one-fourth to one-half inch in diameter and five to fifteen feet in height, bear no branches except at the top. The basal lobes of the leaves of both species terminate in slender points. The seed-pods of *C. capsularis* are nearly spherical, while those of *C. olitorius* are prismatic or nearly cylindrical.

Fig. 393. Jute, left (*Corchorus capsularis*); right, Nalta Jute (*Corchorus olitorius*). Branches with seed-pods.

The best fiber is produced by *C. capsularis*, and this species is more extensively cultivated. The cultivation of *C. olitorius* is confined largely to the warmer and wetter regions near the coast. Several horticultural varieties are recognized in India, the most important of which are the following: "Serajganj," "Narainganj," "Dacca" and "Desi." These names are from towns or centers of jute cultivation north of Calcutta in the Bengal Province.

By far the greater part of the jute fiber imported into this country is of the Serajganj variety, usually known in our markets as "Seragunge." This is of a creamy yellow or light buff color, finer and softer than hemp. The Dacca fiber is very similar, and also the Narainganj, except that the latter is somewhat coarser. The Desi fiber, obtained from nalta jute, is finer in texture and of a dark gray color, the difference in color being due chiefly to different methods of preparation.

Jute grows best on alluvial or clay loam soils retentive of moisture, and where the air is warm and moist during the growing period. It will grow well on second bottoms or on low lands not subject to inundation. The land should be well plowed and harrowed to induce a rapid and uniform growth of the seedlings and thus prevent their being overtopped by weeds. The seed is sown in spring, broadcast, at the rate of twelve to twenty-five pounds per acre. Plants from thick seeding produce finer but weaker fiber.

The crop is harvested when in flower, about three months after sowing. The stalks are cut with a knife or sickle, or pulled by hand. They are cured in gavels or shocks, or often taken immediately to be retted in ponds or slow-running streams. The retting process, lasting one to three weeks, requires close watching to prevent over-retting. The fiber is stripped by hand from the wet stalks, cleaned by drawing it through the hands and whipping it on the water, washed, dried, and then packed in bales of about 400 pounds each for market. The coarse, flaggy fiber from the ends of the stalks, five to fifteen inches long, is often cut off and baled separately, and sold as "jute butts." The yield of fiber ranges from 700 to 3,000 pounds per acre.

The jute crop of India, chiefly in the province of Bengal, occupies 2,000,000 to 3,000,000 acres each year, and the annual product amounts to 2,000,000,000 to 3,200,000,000 pounds. The prices in New York in ten years ended December 31, 1906, have ranged from three to six and three-fourth cents per pound for long fiber, and one to three cents for jute butts. The importations of jute, including jute butts, in these ten years, have ranged from 50,000 to 140,000 tons, valued at $1,500,000 to $6,500,000. In this period there has been a general tendency to increased acreage in India, increased importations, and an upward tendency in prices.

Jute is used most extensively for gunny sacks, wool sacks, cotton bale covering, grain sacks (especially on the Pacific coast), for wool twine and wrapping twine, and either alone or with other fibers in carpets and rugs. It is the cheapest, most easily spun, and most extensively used of the soft fibers. It is not so strong as flax or hemp. Its most important defect is its rapid deterioration.

Repeated experiments have demonstrated that jute can be grown successfully in the south Atlantic and Gulf coast regions, but until mechanical methods have been devised for preparing the fiber it is not likely that the cultivation could be practiced with profit in this country.

China jute.

China jute is a rather coarse grayish white, soft fiber imported in limited quantities from China. It is derived from the bast of the Ch'ing ma, *Abutilon Avicennæ*, an annual malvaceous plant native in Asia and cultivated in eastern China. The plant has become widely introduced in the United States, where it is regarded as a troublesome weed and is called Indian mallow, velvet-leaf and butter-print. It grows three to eight feet tall, and has large heart-shaped, velvety leaves and small yellow flowers.

In China this plant is sown broadcast on upland or alluvial soils, and the fiber is prepared by retting the stalks in water, then breaking and cleaning by hand. The fiber is similar to jute, but slightly stronger and coarser, and as commonly prepared, more flaggy, making it more difficult to spin on machinery. It takes dyes very readily, a quality of importance in jute rugs, but owing to the difficulty of working it, and its rapid deterioration, there is little demand for it. The prices paid for it in this country are usually a fraction of a cent below those paid for jute.

The plant grows well on alluvial and sandy loam soils from New Jersey to Kansas and Nebraska, but without mechanical methods for preparing the fiber it could not be cultivated with profit.

Ramie (Fig. 394).

Ramie, *Bœhmeria nivea*, Hook and Arn., is a perennial-rooted, herbaceous plant belonging to the *Urticaceæ* or Nettle family. The rather slender stalks, bearing heart-shaped leaves green above and white beneath, attain a height of three to eight feet. When the plants are crowded thickly,

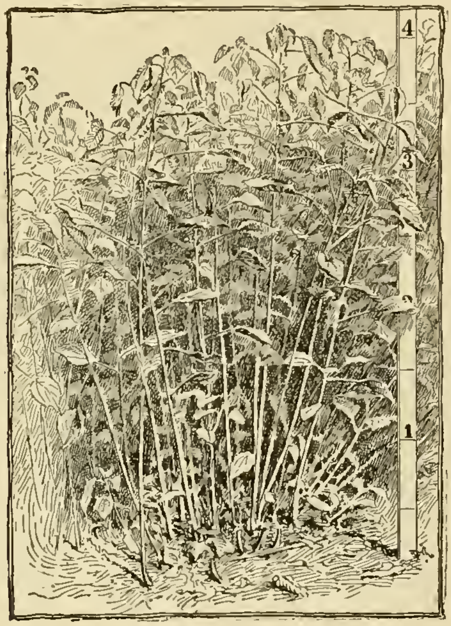

Fig. 394. Ramie (*Bœhmeria nivea*). Second crop of the season ready for harvest.

as they should be for fiber production, they bear no branches. When cut during the growing season, new shoots spring up from the roots, so that two to four crops may be had each season.

Ramie is native in Asia, and is cultivated commercially in China, Formosa, southern Japan and to a less extent in India. It has been widely introduced in experimental cultivation in the warmer temperate zones of both hemispheres. The plant may be grown without difficulty, but it has not been demonstrated that the fiber may be produced profitably outside of Asia.

Ramie requires a fertile soil, not subject to drought, but with good drainage. It grows well on sandy loam or alluvial soils, but can not be grown successfully either on stiff clay or light sandy soils. It requires a warm moist climate during the growing season.

The plant is propagated by seeds and by root-cuttings, and in India to some extent by cuttings of the stems. Transplanting root-cuttings is the surest method, but growing from seeds, if carefully attended to, gives a larger number of plants for the same labor. The seed is very small, like tobacco seed. It is germinated in glass-covered flats in greenhouses, or in warm weather out-of-doors in beds inclosed with boards and muslin or canvas cover which is frequently sprinkled. The seeds are sown on the surface, pressed down, but not covered, and they require a warm moist atmosphere for germination. When about an inch high the seedlings must be gradually accustomed to drier air, to prevent damping off. When eight to twelve inches high, and after several days' exposure to outdoor conditions, they may be transplanted to the field. The seedlings are set in rows about twenty-four inches apart, and about ten inches apart in the row. If root-cuttings are used instead of seedlings they may be transplanted directly to the field, in rows the same distance apart. In either case, the space between the rows must be cultivated until the ramie is high enough to shade the ground.

Seedlings or roots set out in May or early June should yield the first crop of shoots about the last of August. Afterward two to four crops should be produced each season. As the plants grow more thickly after the first crop, there will be fewer branching stalks and an increased yield. On rich soil, the fertility of which is kept up by the application of barnyard manure, the plants will continue to yield shoots for twenty years or longer. Where the winters are cold enough to freeze the ground to a depth of three inches, or to the tops of the roots, the land should be mulched every fall.

The shoots are harvested when they begin to produce flowers (Fig. 394). The stalks are cut or broken by hand. In some parts of China the individual stalks are cut as they reach maturity, the younger stalks being left to develop and the harvest being thus practically continuous in the same field. In some places the plants are allowed to dry and are afterward soaked in water before preparing the fiber, but usually the bark, including the fiber, is peeled off immediately after the stalk is cut. It is then cleaned while still fresh by drawing it between a wooden or bone knife and a bamboo thimble, which removes the outer bark and most of the green coloring matter, after which it is dried. This hand-cleaned but not degummed fiber is known commercially as "ramie ribbons" or "China grass." In China, after more or less manipulation to subdivide it, it is spun and woven by hand, being used very extensively for summer clothing. It is exported to Europe where it is degummed, bleached, and combed, making a fine silky filasse for spinning.

Ramie yields two to four cuttings each year after the first, and at each cutting four to eight tons per acre of green stalks from which the leaves have been stripped. The yield of dry ramie ribbons is about eighty pounds per ton of green stalks. These ribbons are quoted in European markets at four to eight dollars per hundredweight. There is a wide variation in quality, the best coming from Formosa.

Practically no market for ramie fiber has been established in the United States, and few ramie goods, sold as ramie, are made in this country. It is used extensively for dress goods in China, Japan and Korea, and in Europe its use is increasing for portières, upholstered furniture, clothing and various other kinds of woven and knit goods, but thus far, excepting the knit ramie underwear made in Europe, ramie goods are little known in the United States.

Rhea (*Bœhmeria tenacissima*), also called ramie, is cultivated to a small extent in India and the East India islands. It differs from *B. nivea* in having leaves green on both surfaces, and in requiring a more tropical climate.


Fig. 395. Aramina (*Urena lobata*).

Aramina. (Fig. 395.)

Aramina, a word meaning "little wire," is a trade name recently applied in Brazil to the fiber secured from the inner bark of the carrapicho plant, *Urena lobata*, Linn. (Fig. 395.) This plant is a shrubby perennial, belonging to the *Malvaceæ* or Mallow family. It is native in India, but is now widely distributed in the warmer parts of both hemispheres. It is an aggressive weed in Florida, and is there called "Cæsar weed." Its fiber, obtained in small quantities from wild plants, is used in a domestic way in many places, as for paper and cordage in St. Thome, for cheap cordage in Porto Rico, for sacking and twine in India, tie material for house-building in West Africa, and fishing-nets in Brazil. Only in the Sao Paulo in southern Brazil is the plant regularly cultivated for fiber production on a commercial scale. It is there called "guaxima." The fiber is prepared by stripping it by machinery in the field, drying, and shipping to the factory where it is treated chemically and mechanically to prepare it for spinning. It is asserted that it will yield about 900 pounds of fiber per acre.

The fiber is four to eight feet long, light yellow or creamy white, somewhat ribbon-like, but capable of fine subdivision. It resembles India jute in color, texture, length and strength, but lasts better. It is used most extensively in making sacks for shipping coffee, but it has been demonstrated that when suitably prepared it may be used in the manufacture of ropes, canvas, carpets, trimmings and curtains.

Sunn hemp. (Fig. 396.)

Sunn hemp is a bast fiber obtained from *Crotolaria juncea*, an annual plant of the *Leguminosæ* or Bean family. (Fig. 396.) It is raised most extensively in central India. Like hemp and flax, it is not known in the wild state except where it has escaped from cultivation. It requires a light sandy soil and only a moderate rainfall,—fifteen to thirty inches. It will endure more cold than jute. The seed is sown broadcast at the rate of fifty to one hundred pounds per acre, usually in the spring, although in some localties it is grown as a winter crop. The plants are harvested by cutting with a sickle, or more frequently are pulled by hand, at flowering time or soon after. After the stalks have wilted so that the leaves fall readily, they are placed in bundles in stagnant pools or slow-running streams for retting, a process requiring four to eight days. When sufficiently retted, workmen enter the water, and, picking up the stalks a handful at a time, beat them on the surface of the water until the fiber separates. The fiber is further cleaned by washing it and wringing it by hand. It is then hung on bamboo poles to dry in the sun. The average yield of fiber is about 640 pounds per acre.

Sunn hemp is lighter colored, coarser and stronger than jute, and lasts better. It is stiffer than jute or hemp, and cannot be spun so readily.


Fig. 396. Sunn hemp (*Crotolaria juncea*).

It is used in India for cordage, sacking, and generally as a substitute for jute. The small quantities imported into the United States are used for the manufacture of coarse twines.

The sunn hemp plant grows well in southern Florida, and as a leguminous crop, improving the fertility of the soil, it would doubtless be valuable in rotation if there were a satisfactory mechanical method for preparing the fiber.

Ambari.

Ambari, or deccan hemp, is a bast fiber obtained from *Hibiscus cannabinus*, an annual belonging to the *Malvaceæ* or Mallow family. The plant has deeply parted leaves, giving it somewhat the appearance of true hemp, though the foliage is much lighter in color. The stalks and leaf-stems are covered with very short spines, making them disagreeable to handle when mature.

The plant is cultivated in India. In Egypt it is grown on the borders of the fields for a windbreak. The fiber is prepared in about the same way as that of sunn hemp. It is called "Bimlipitam jute" in the London market. A very similar plant has recently been exploited in Brazil under the name *Canhamo Braziliensis Perini*.

Miscellaneous bast fibers.

Bast fibers for domestic purposes have been secured from many different kinds of plants, but in most instances these have been superseded by commercial twines and cordage. Some of the most important of these fibers are the following:

(1) Majagua (*Paritium tiliaceum*), used for halters and cordage for small boats in Porto Rico and Cuba.

(2) Olona (*Touchardia latifolia*), formerly used for harpoon lines and fishing lines in the Hawaiian islands.

Fig. 397. Indian hemp (*Apocynum cannabinum*), a common native plant.

(3) Colorado river hemp (*Sesbania macrocarpa*), growing wild in large quantities on the overflowed lands near the mouth of the Colorado river, used by the Indians for bowstrings and other light cordage.

(4) Indian hemp (*Apocynum cannabinum*). — A perennial plant of the Dogbane family, native throughout the greater part of the United States and especially abundant in the West. It was the most important source of bast fiber used by the North American Indians. (Fig. 397.)

(*c*) Hard Fibers.

The most important hard fibers are abacá, sisal, New Zealand hemp, Mauritius hemp, ixtle and Sanseveria.

Abacá. (Fig. 398; also Fig. 142, Vol. I.)

Abacá or Manila hemp is derived from the sheathing leaf-stems of the abacá plant, *Musa textilis*, Nee., a perennial belonging to the *Musaceæ* or Banana family. [See account in Vol. I, page 125.]

Fig. 398. Abacá (*Musa textilis*). Two-year-old seedlings.

The fiber, as found in our market, is six to twelve feet in length, rather coarse and stiff, reddish yellow to nearly white, light in weight, and the better grades remarkably strong. The approximate breaking strain of the current abacá ropes of different sizes is as follows:

¼-inch diameter	550 pounds.
½-inch diameter	2,000 pounds.
1-inch diameter	7,000 pounds.
2-inch diameter	25,000 pounds.

The abacá plant is very similar in appearance to the banana plant. It consists of a stalk or trunk six to fifteen inches in diameter, and six to fifteen feet high, made up of herbaceous, concentric, overlapping leaf-stems, bearing at the summit long, pinnately-veined leaves. (Fig. 398.) It reaches maturity when two to five years old. A flower-stalk pushes up through the center of the trunk, emerging at the top where it bears a cluster of flowers, followed by small, seed-bearing inedible bananas. The stalk then dies, but meanwhile two to twenty others of various ages are growing in a rather open clump from the same root. The fiber is composed of the fibrovascular bundles near the outer surfaces of the leaf-stems.

Abacá is native in the Philippines. It has been distributed throughout the greater part of the Philippine archipelago, and also has been introduced into Guam, Borneo and the Andamann islands. It is cultivated commercially only in a comparatively small part of the Philippines. The most important abacá districts are the Camarines, Albay and Sorsogon in the southern part of Luzon, and the islands southward, Mindoro, Marinduque, Masbate, Samar, Leyte, Cebu, Negros and Mindanao.

A heavy and evenly distributed rainfall, sixty inches or more, and a continuous warm temperature are essential to the successful growth of abacá. A rich, deep, well-drained, mellow soil, containing plenty of humus, is necessary for well-developed plants. The best abacá lates (plantations) are on the southern and eastern coasts, and on the lower slopes of old volcanoes. Abacá is grown on the same land ten years or longer, without rotation or the application of fertilizer. While the plants sometimes persist in low land, they will not make a good growth in swampy ground or where the soil remains saturated about their roots.

Abacá plants may be propagated by seeds, root-cuttings or suckers. In practice, suckers are used almost universally, except when they must be transported long distances. Good seed is difficult to secure, since cultivated plants are cut before the seed is ripe; and, furthermore, it is of very uncertain germination. Seeds must be germinated in a carefully prepared and protected seed-bed, and the seedlings transplanted to the field. Suckers or root-cuttings are set out directly in rows nine to twelve feet apart each way, or about 225 to 530 plants per acre. Sweet-potatoes ("camotes") or some other crop are sometimes grown with abacá. The grass and weeds must be cut every two or three months, and the soil immediately around the abacá plants kept loose to allow a free growth of suckers. Experiments on the San Ramon Government Farm indicate that abacá plants make a much better growth on land plowed before setting and then kept well cultivated by horse-power cultivators, than on land merely cleared and burned over, then cultivated with sweet-potatoes, as is the usual custom. Unless shade trees have been left at intervals of twenty to thirty yards, corn should be planted between the rows to serve as a partial shade and protection from the wind.

The stalks are cut between the flowering and fruiting stages. If cut earlier or later the fiber will be of inferior quality. The first stalks are ready to cut twenty to thirty-six months after planting, and afterwards the fields are cut over about once in eight months until the plants become unproductive at the end of fifteen to forty years. The new plants continue to grow as the older ones are cut. The plants are cut with a sharp bolo, leaving the stump three to six inches high, slanting so as to shed water.

Immediately after the stalk is cut the leaves are trimmed off. The outer fiber-bearing surface of each successive leaf-stem composing the trunk is then stripped off with the aid of a bone knife. The fiber is cleaned by drawing these fresh green strips between a knife and a block of wood, the knife being pressed against the wood by means of a spring pole. The work requires strength and skill. Twenty-five pounds of clean dry fiber is a fair day's work. The annual yield of fiber varies from 300 to 1,000 pounds per acre, the average being probably not far from 500 pounds.

Abacá fiber is used in the Philippines for making hand-woven cloth, known as "tinampipi" and "sinamay." The fiber for this purpose is selected and tied end to end, not spun into yarn. It is also used for domestic cordage. Nearly all of the abacá fiber exported is used in making twines and cordage. It is used for the best grades of binder twine, well-drilling cables, power-transmission rope, hoisting rope, and for nearly all marine cordage. Old manila rope, especially worn-out marine cordage, is used to make "rope manila paper." Abacá rope of the best quality has a working strength about twice as great as sisal. Standard or current abacá is about one and one-half times as strong as sisal. It is also lighter and more durable.

Abacá fiber constitutes about three-fourths of the total exports of the Philippines. The principal markets are the United States and Great Britain. The importations into the United States during the past ten years are shown in the following table:

Year	Quantity	Value	Average import price per ton
	Tons		
1896	47,244	$3,604,585	$76 30
1897	46,260	3,408,322	73 68
1898	50,270	3,239,341	64 44
1899	53,195	6,211,475	116 77
1900	42,624	7,172,368	168 27
1901	43,735	7,115,446	162 69
1902	56,453	10,555,272	186 97
1903	61,648	11,885,510	192 79
1904	65,666	11,423,395	173 96
1905	61,562	12,065,270	195 98

Sisal or *henequen*. (Figs. 399, 400; also Fig. 22.)

The fiber known in our markets as sisal is obtained from the leaves of two closely related plants, henequen, *Agave rigida*, var. *elongata*, Baker, and sisal, *Agave rigida*, var. *Sisalana*, Engelm. These

Fig. 399. Sisal (*Agave rigida*, var. *Sisalana*). No leaves are cut above an angle on the stem of 45°.

plants belong to the *Amaryllidaceæ* or Amaryllis family, and are somewhat similar in appearance to the century plant. They are both native in Yucatan and there, as elsewhere in Spanish America, both are called henequen. The varieties are distinguished in Yucatan by the Maya names, "sacci" for var.

elongata, and "yaxci" for var. *Sisalana*. The variety *elongata*, cultivated only in Spanish America, is known by the growers as "henequen," while the variety *Sisalana*, cultivated mostly in English-speaking countries, is called by the growers "sisal."

Both plants are perennial. They have rosettes of fifty to seventy-five rigid, nearly straight, erect or

Fig. 400. Drying fiber of sisal.

spreading leaves, three to five feet long, three to five inches wide, and about one-fourth inch thick above the base, terminating in a sharp reddish brown spine about one inch long. At maturity, eight to twenty-five years, the plant sends up a flower-stalk ten to twenty feet high, bearing dense clusters of erect flowers at the ends of horizontal candelabra-like branches. The flowers are followed by bulbils, or sometimes by seed-pods in *elongata*, 1,000 to 4,000 bulbils ("mast plants") being borne on a single "pole." After flowering, the plant dies. Suckers are sent up from the roots after the first year until the plant dies. Sisal is a hard fiber three to five feet long, rather coarse and stiff, light yellow or nearly white, nearly always lighter-colored than abacá.

The variety *elongala*, henequen or sacci, develops an elongated trunk two to six feet high, and its leaves, two to two and one-half inches thick at the base, always have marginal spines, while the variety *Sisalana*, sisal or yaxci, has no distinct trunk; its leaves are usually without marginal spines and rarely more than one inch thick at the base. It produces a stronger, softer, whiter fiber, but in less quantity than the other variety.

In eastern Yucatan the variety *Sisalana* is cultivated to a small extent for fiber for domestic purposes, for hammocks, bags and the like, but the fiber for export is secured from the variety *elongata*, cultivated most extensively in the region about Merida. This variety is also cultivated in Cuba, and to some extent in East Africa. The variety *Sisalana* is cultivated in the Bahamas, Turks and Caicos islands, Santo Domingo, Hawaii, Central America, East Africa and India. The production of Yucatan exceeds the combined production from all the other localities.

Sisal requires a continuous warm and rather dry climate. The lowest recorded temperature in the sisal-growing region of Yucatan is 48°, and the annual rainfall twenty-nine to thirty-nine inches. It endures light frosts in Tamaulipas.

In Yucatan, and also in the Bahamas, the principal regions of sisal cultivation, the plants are grown almost exclusively over partly disintegrated porous lime rock, largely of coral or shell origin. Sisal will not grow well in light, sandy soil, nor where water stands about its roots. In most places it is grown at altitudes not more than 100 feet above sea-level.

Land is prepared by cutting and burning the brush, and, unless too stony, it is plowed. Lines about nine feet apart are marked, and the plants are set about five feet apart in the rows. Suckers taken from old plantations are used for propagation, except for starting plantations at long distances, when bulbils are sometimes used, as they are smaller and more easily transported. So far as possible, the young plants are set out at the beginning of the rainy season, especially in regions subject to severe drought. After the plants are set they require no further care, except to cut the weeds and grass about twice each year. Cultivation should be given two or three times each year when the character of the soil permits. Vegetation must be kept down, as it chokes and retards the growth of sisal plants and furnishes material for field fires, the most serious menace to the crop.

The leaves are cut when three to five feet in length, and the outer ones are nearly horizontal. In the Bahamas the first crop is cut in the third or fourth year after the plants are set, and annual crops thereafter for six to twelve years. In Yucatan, the first crop is not cut until the sixth or seventh year, and after that a crop is cut every eight months for twelve to twenty-five years. The leaves are cut with a large knife and tied in bundles of twenty-five each, for transporting to the cleaning-machine. Only the outer leaves are taken.

Nearly all of the sisal of commerce is cleaned by machinery. The different kinds of machines are all similar in principle. The fresh green leaves are fed sidewise at the rate of 10,000 to 30,000 per hour, and the green pulp crushed, beaten and scraped away by two or three rapidly revolving drums, against which first one end of the leaf and then the other is pressed by means of adjustable curved aprons. In some machines, streams of water play on the fiber as it passes from the scraping wheels. It is taken directly from the machine to the drying-yard, and, when dry, is baled for market, usually without sorting, as it is rather uniform in quality.

The yield of fiber ranges from 3 to 4 per cent of the weight of the green leaves. The average yield of clean, dry fiber is usually between 500 and 1,000 pounds per acre.

Sisal is used most extensively for binder twine. It is also used for lariats and general cordage of one inch diameter and under for use on land. It kinks in pulley-blocks and rots in salt water, hence is not suitable for hoisting-ropes or marine cordage. It is heavier than abacá, and its working strength is about one-third less than that of current abacá rope of the same size and type.

The increasing importance of sisal in our fiber industries is indicated by the following table, showing the annual imports and increasing values during the past ten years:

Year	Quantity	Value	Average import price per ton
	Tons		
1896	52,130	$3,412,760	$65 47
1897	63,266	3,834,732	60 61
1898	69,322	5,169,900	74 58
1899	71,898	9,211,377	128 12
1900	76,922	11,782,263	153 17
1901	70,076	7,972,564	113 77
1902	89,583	11,961,213	133 52
1903	87,025	13,289,444	152 71
1904	109,214	15,935,555	145 91
1905	100,301	15,250,859	152 05

Phormium or New Zealand hemp. (Fig. 401).

The fiber known commercially as New Zealand hemp and New Zealand flax is obtained from the leaves of the *Phormium* hemp plant, *Phormium tenax*, Forst., belonging to the *Liliaceæ* or Lily family. Neither the plant nor the fiber has any resemblance to hemp or flax.

The plant is similar in habit to the common blue flag or iris, but much larger. Its many

Fig. 401. New Zealand hemp (*Phormium tenax*).

coarse, grass-like leaves, one-half to one and one-fourth inches wide and three to twelve feet long, grow in dense clumps from perennial roots. A flower-stalk bearing lily-like flowers grows at length from the center of the leaf-cluster. The old roots in the middle become weaker and die, and the outer plants in turn become new centers of growth. Many different varieties are recognized, varying in length and width of leaves, and in habit as well as habitat.

The plant is native in New Zealand, and is distributed in many parts of Australasia. It has been introduced as an ornamental in California and the southern states, and also in Europe, even as far north as Ireland and Scotland. It is cultivated for fiber-production on a commercial scale in New Zealand, and to a small extent in southern Europe. It is the only important hard-fiber plant of the temperate zones. In New Zealand it grows between latitudes 35° and 45°, where it is subject to frost and snow, but it will not endure the more severe winters of our northern states. It grows best in a rich, porous, sandy or loamy soil, moist but with good drainage. Some of the varieties will grow in swamps.

It is propagated by transplanting roots. The leaves are cut about once each year, and the fiber is cleaned in part by machinery. The machines thus far brought out leave the fiber but partly cleaned, requiring considerable hand-work to prepare it for market. Under favorable conditions, the plants yield 800 to 1,200 pounds of fiber per acre.

The fiber is five to ten feet long, reddish yellow or nearly white. In color and appearance it resembles abacá, but it is much softer, more flexible, usually more finely subdivided and less strong. It is somewhat elastic, a valuable quality in tow-lines, and it is less injured by salt water than other commercial hard fibers aside from abacá.

It is used for fodder yarn, lath yarn, and either mixed with sisal or abacá or alone for binder twine. In New Zealand, and also in Europe, it is made up into a great variety of woven goods.

It has been quoted in the New York market at one-half to one cent per pound less than sisal until recently. The demand for it is gradually increasing.

Mauritius hemp (Fig. 402).

Mauritius hemp is a hard fiber obtained from the leaves of the Mauritius fiber plant, *Furcræa fœtida*, Haw. (*F. gigantea*), belonging to the *Amaryllidaceæ* or Amaryllis family.

Aloes vert, as the plant is called in Mauritius, is a perennial, with a rosette of sixty to eighty erect or spreading, straight, rigid leaves, six to ten inches wide, and four to eight feet long, similar in appearance to agave leaves, but usually thinner above the base in proportion to their size, and somewhat plicate toward the apex. The terminal spine is rather weak and the marginal spines weak and irregular, or usually absent. The flower-stalk, attaining a height of fifteen to fifty feet, bears a rather loose panicle of drooping, light yellowish green flowers, followed by bulbils. Suckers are produced from the roots, and if the young flower-stalk is broken, suckers are produced in abundance from adventitious buds.

Aloes vert is native in tropical America, but it is widely distributed in the tropics of both hemispheres. This and closely related species are the "maguey" of Porto Rico, the "molina" of Hawaii, the "pita floja" of Costa Rica, the "fique" of

Venezuela, and one of the plants called "cabulla" of Central America. In most of these countries its fiber is produced in small quantities for domestic use, but only in the islands of Mauritius and St. Helena is it systematically cultivated for the production of fiber for export.

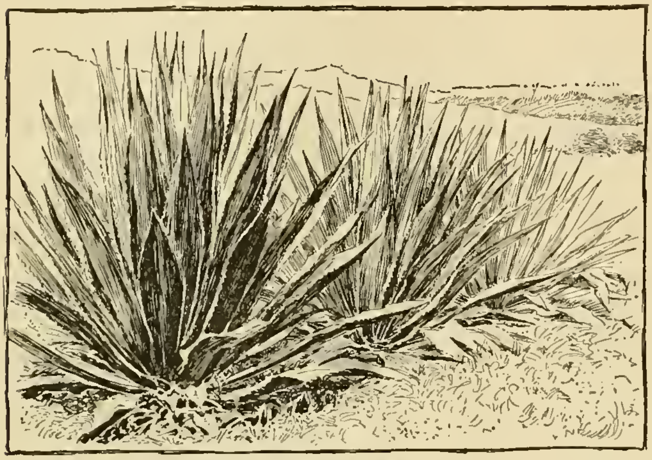

Fig. 402. Porto Rican Maguey (*Furcræa tuberosa*). Three-year-old plants from bulbs.

It requires for its best development a tropical climate with a moderate rainfall, and a soil of good fertility. Under favorable conditions it grows more rapidly than sisal, producing its first crop of leaves in the third year.

The leaves are crushed and the pulp scraped away by machines, but the fiber is afterward washed in soap and water, rinsed, dried, beaten and picked over, requiring a large amount of handling. The green leaves yield about 3 per cent of dry fiber, the yield per acre ranging from 1,000 to 2,000 pounds.

Mauritius fiber is white, soft, more elastic than sisal, but also weaker. It is used either alone or mixed with sisal and other fibers in the cheaper grades of coarse twine and cordage of small diameter. During the past five years Mauritius hemp has been quoted in the New York market at six to seven and seven-eighths cents per pound, usually one-fourth to one cent per pound less than sisal.

Ixtle. (Figs. 403, 404.)

Ixtle (ēxt′-lē) or istle (ēst′-lē) and tampico are names applied to a group of hard fibers ten to thirty inches long, obtained from the cogollos (cō-hōl′-yōs) or inner immature leaves of several different kinds of agaves and yuccas, all growing without cultivation on the dry table-lands of northern-central Mexico. None of the ixtle-producing plants has been cultivated for fiber production, and they are rarely found even in botanical gardens or collections of economic plants.

Three kinds of ixtle are recognized by the trade. (In trade quotations the name is usually spelled istle, instead of the Mexican ixtle.)

(1) Jaumave istle (How-mah′-vé), a nearly white fiber twenty to thirty inches long, resembling sisal but somewhat finer and more flexible, is used largely in the cheaper grades of twine and cordage and for ore sacks. This fiber is secured from *Agave lophantha* in the Jaumave valley about sixty miles from Victoria, in Tamaulipas. (Fig. 403.)

(2) Tula istle, shorter and coarser than Jaumave istle, also used for the cheaper grades of cordage, is especially adapted for the manufacture of brushes. This fiber is secured partly from *Agave Lecheguilla* (Fig. 404) in the states of San Luis Potosi, Coahuila, Tamaulipas, Nuevo Leon and Zacatecas. The plant is abundant in western Texas, but rarely utilized there. The leaves of *Agave univittata*, *A. cærulescens* and *A. Kerchœvei*, all growing in the dry highlands of the above-named states, are also used for the production of tula istle.

(3) Palma istle, a rather gummy, yellowish fiber, ten to thirty inches long, used chiefly in the manufacture of cordage, is obtained from several species of yuccas or "palmas," as these plants are called in Mexico, the principal ones being "palma samandoca," *Samuela carnerosana;* "palma pita," *Yucca Treculeana* and *Y. Treculeana*, var. *canaliculata*. All of these plants grow along the lower slopes of the mountains rising from the high table-lands of Mexico.

The ixtle fibers are cleaned chiefly by hand by drawing each leaf, first one end and then the other, repeatedly between a blunt knife and a block of wood. The palma leaves have to be steamed or given an alkaline bath before the pulp can be scraped away. Machines are beginning to be used for cleaning ixtle, but the results are not yet entirely satisfactory.

Ixtle fibers have been used in Mexico for textile purposes from prehistoric times, but until within the last decade they were used in this country only for shoe-brushes, clothes-brushes, scrubbing-brushes and the like. The high prices of sisal and abacá have made it necessary to introduce cheaper fibers for low-priced cordage, and improved cordage machinery has made it possible to use ixtle fibers with good effect. The fiber is strong and durable, but rather stiff and harsh. Sacks made of ixtle are said to endure ten years of constant use in handling ores in Mexican mines. In the past ten years the importations of ixtle fibers have increased

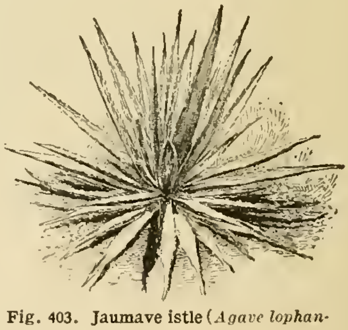

Fig. 403. Jaumave istle (*Agave lophantha*). Fiber is obtained from the inner leaves.

from 6,000 tons to 15,000 tons, and the prices have risen from one and one-half and three cents to four and five and one-half cents per pound.

Manila maguey.

This is a hard fiber similar to sisal, but not quite so strong. It is obtained from the leaves of the Manila maguey plant, *Agave Cantula*, natnralized in the Philippines and now being cultivated there.

Aloe fiber.

Bombay and Manila aloe fibers are hard fibers three to five feet long, similar in appearance to sisal but weaker and more elastic, used to some extent in the manufacture of medium grades of cordage. They are obtained from the leaves of agaves.

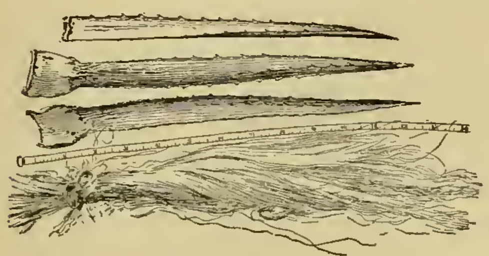

Fig. 404. Lecheguilla leaves and fiber.

Maguey fiber.

Fiber for domestic use is occasionally obtained from the leaves of the large maguey plants, *Agave atrovirens, A. eollina, A. Potosina, A. Tequilana* and *A. vivipara*, growing in central Mexico. The introduction of fiber-cleaning machinery in the last two years gives promise of the production of Mexican maguey fiber in commercial quantities. The fiber is three to eight feet long, nearly white, elastic, but not so strong as sisal. Several species of magueys are cultivated for the production of the Mexican beverages, pulque and mexcal, but none of them is cultivated primarily for fiber.

Zapupe.

Two agaves, known as "zapupe verde" and "zapupe azul," have been planted extensively in recent years for fiber production in the states of Tamaulipas and Vera Cruz, Mexico. Both have straight, rigid leaves, three to six feet long, narrower, thinner and more numerous than the leaves of sisal or henequen. Zapupe verde, having green leaves, has long been cultivated for fiber by the Indians of the district of Tantoyuca, Vera Cruz. Zapupe azul, with bluish glaucous leaves, is of uncertain origin. In appearance it very closely resembles Tequila azul, *Agave Tequilana*, but it is not used in eastern Mexico for the production of "tequila wine." Both species of zapupe produce fiber very similar in quality. It is finer and more flexible than sisal, and of about the same strength when compared by weight. It is extracted on sisal-cleaning machines, but it has not been placed on the market in sufficient quantities to determine its real market value.

Sansevierias.

The name "bowstring hemp" is applied to most of the fibers obtained from the leaves of a dozen or more species of the genus Sansevieria of the Lily family. Most of these species are native in tropical Africa, especially the dry bush country from Abyssinia to Mozambique. One of the earliest known of this group of fibers is "moorva" or "murva," obtained from the leaves of *Sansevieria Roxburghiana* in India and Australasia. It is said that this fine, elastic, strong fiber was used by the ancient Hindus for making bow strings. Two species, *Sansevieria Guineensis* and *S. longiflora*, are widely distributed in the American tropics. Numerous unsuccessful attempts have been made to exploit these plants. Recent efforts in Venezuela promise better results. At Nairobi and Voi, British East Africa, the fibers of *Sansevieria Stuckeyi* and *S. Ehrenbergii* are being extracted in commercial quantities by machines similar to those used for extracting sisal. The first has cylindrical leaves standing up from the ground like green stakes four to eight feet high, and one to two inches in diameter. The second has clusters of equitant leaves three to five feet long and one to two inches thick, arrow-shaped or triangular in cross-section. The leaves of both species yield 7 to 10 per cent of dry fiber. The fiber is similar to sisal in appearance, and is suited to the manufacture of twines and cordage. It has not been produced in sufficient quantities to establish a market value.

Bromelia fibers.

Hard fibers of remarkable strength and fineness are obtained from the leaves of at least four different species of Bromelias growing without cultivation in the moist lowlands from eastern Mexico through Central America to Colombia, Brazil and Paraguay. These include the "caraguata" of Argentina, and the pita, silk grass (Honduras) and pinuela of Colombia, Central America and Mexico, obtained from *B. Karatas, B. sylvestris* and *B. Pinguin*. These fibers carefully prepared are sometimes sold in the Mexican market at one dollar (Mexican) per pound. The finest Mexican hammocks are made chiefly of this fiber. It is also used for making game-bags, and even fiddle-strings. The plants grow abundantly over thousands of acres, but there are no satisfactory machines for cleaning the fiber, and it is not produced in quantities sufficient for export.

Pineapple fiber.

Pineapple fiber is obtained from the leaves of the pineapple plant, *Ananas sativus*, Schult., cultivated in nearly all warm countries for the fruit. The fiber is produced chiefly in the Philippines from long-leaved varieties cultivated especially for fiber, the fruits of these varieties being of little or no value. The fiber is cleaned by hand, by scraping away the pulp with a bone or a piece of broken crockery. After various processes, usually including beating, washing and sorting, the fibers are tied together end to end. The strands made in this manner, not spun or twisted into yarn, are woven by hand in the Philippines, making the beautiful piña cloth.

Attempts to use the leaves of pineapples in Florida for fiber production have not given results that would warrant taking up the work on a commercial scale.

II. Plaiting and Rough-weaving Fibers

Coir.

Coir, or coconut fiber, is obtained from the thick outer husk of the coconut, or fruit of the coco palm, *Cocos nucifera*, Linn., belonging to the *Palmaceæ* or Palm family. Coir is a rather coarse, stiff, elastic fiber four to ten inches long, of a brownish color. In this country it is used for door-mats and floor covering. In Asia, and to some extent in Europe, it is used for cables and towing hawsers, valued for their elasticity and lightness. It is sometimes woven into coarse sail-cloth.

The coconut palm grows in abundance along the sandy shores of nearly all tropical countries, and occasionally in inland localities, but the production of the coir of commerce is confined almost exclusively to the Laccadive islands and adjacent shores of southern India and Ceylon, and in southern China. Coir is obtained from green coconuts. The fiber from mature coconuts, such as are sold in the markets, is coarse and brittle and of little value except for jadoo fiber, used in place of leaf-mold for growing conservatory plants. Machinery is now used for shredding the fiber and twisting it into a coarse yarn, the form in which it is exported.

Raffia.

Raffia is a flat, ribbon-like fiber, consisting of strips of the epidermis peeled from the leaves of the raffia palm, *Raphia Ruffia*, Mart., growing in Madagascar, and the jupati palm, *Raphia tædigera*, Mart., of eastern Brazil. These palms belong to the Palm family. They are plentiful in the wild state, and are not systematically cultivated.

In this country raffia was formerly used almost exclusively as a tie material in nurseries and gardens, but now it is largely used in basketry, millinery and various kinds of fancy work. Its use for these purposes has increased the demand and resulted in doubling the price within the last six years. In Madagascar, raffia is made into woven goods.

Matting fibers.

Matting fibers are plaiting or rough-weaving materials, not textile fibers. Entire stalks or leaves are used with a warp of cotton or hemp yarn, or in many instances, especially in the Pacific islands, the same or similar materials are used in both directions, that is, for warp as well as woof.

Japanese matting is made from the mat rush, "round grass" or "bingo-i," *Juncus effusus*, Linn., or the "three-cornered grass," "shichito-i," *Cyperus tegetiformis*, Roxb. The mat rush is distributed throughout the greater part of the north temperate zone. It is plentiful in many parts of the United States, but is not used here except as a tie material by Chinese gardeners. In Japan and the region about Shanghai, China, it is cultivated with great care in the rice-fields.

It is propagated by roots set out first in nursery beds, then transplanted to the fields late in the fall after the rice crop has been removed. The crop is hoed, well fertilized and watered, somewhat like rice. It is cut in July. The roots are then dug to make room for transplanting rice, and to be used for future planting. The shoots are dipped in a pond of water, holding white clay in suspension, to give them a coating which tends to preserve their color and toughness. When dry they are stored away in bundles until used.

In the Ningpo and Canton districts of China, and in Formosa, the Chinese mat rush "Kiam-tsau," *Cyperus tegetiformis*, is cultivated largely in the rice-fields to supply material for matting. In the region about Calcutta and for the fine Tinnevelly mats of south India *Cyperus tegetum*, Roxb., is used. Its leaves are harder than those of *C. tegetiformis.*

Nearly all of the "round grass," *Juncus*, used for matting is from cultivated plants, and the stalks, mostly sterile shoots, are used whole, while the sedges, "three-cornered grass" of the genus *Cyperus*, are largely from wild plants, and the stalks are split into two or three sections before drying. The matting made in China and Japan is woven on hand-looms, and affords employment to thousands of men, women and children. The United States imports floor matting to the value of about $4,000,000 every year, and its use is steadily increasing.

A power-loom has been devised for weaving floor matting, and efforts are being made, with only partial success thus far, for securing in this country a satisfactory supply of rushes.

Hat fibers.

Hats are made from round or flat plaited or woven fibrous material, chiefly straw or shredded leaves of palms or palm-like plants. Panama hats are made from finely divided strips of the palm-like leaves of the "jipi-japa" plant, *Carludovica palmata*. This plant belongs to the *Cyclanthaceæ*, not to the Palm family. It is a native in Central America and tropical South America. The fan-like leaves, two to six feet in diameter, borne on stalks six to fourteen feet high, are cut while young, slit into shreds and immersed in boiling water, then dried and bleached in the sun. In drying, the slender strips roll up into cylinders, like fine straws. These are woven by hand into bowl-shaped bags, and afterward pressed into the form of hats. The weaving is done chiefly in the morning and evening, as the dry air of mid-day makes the straw too brittle to work well. The finest panama hats are made in Ecuador and Colombia. Cheaper grades are made from other species of carludovica.

Porto Rican hats are made from the leaves of the "yaray" or hat palm, *Inodes casearia*, a rather small palm scattered across the southern part of Porto Rico and most abundant near the shore a few miles south of Mayaguez. The palm leaves are treated very much like those of the jipi-japa. The weaving is done by women and girls in their own homes. The center of the industry is at Cabo Rojo, where the open plaza in the center of the town is devoted to drying and bleaching the leaves.

Straw braids for hats are made from different kinds of straw. Wheat and allied species are used extensively in southern Europe and also in China. In Europe the straw is grown chiefly in the provinces of Tuscany, Modena and Vienza, in northern Italy. The seed is sown thickly, and the straw is pulled up by the roots before maturity. After drying, the upper joints, the only part used for fine braids, are removed by hand, sorted and tied in bundles. This straw is used for the Tuscan, Leghorn, Venetian and Swiss braids, extensively used for hats for both men and women. Rye is also grown in Italy, where it is treated much like wheat for the production of a plaiting straw. Barley and rice are cultivated in Japan for the production of Japanese straw braid, which is exported in large quantities to the United States.

III. Upholstery and Stuffing Fibers

This group includes a large number of fibrous materials of vegetable origin. The straw of flax, grown for seed and threshed in an ordinary grain-threshing machine, thus ruining it for textile purposes, is put through a series of fluted rollers, which crush it and fit it for a coarse stuffing material used in couches, car seats and carriage cushions.

Crin vegetal is a fiber obtained from a small palm, *Chamærops humilis*, native in Algeria and cultivated in southern Europe. The leaves of the plant are shredded and the strands twisted into a coarse yarn, making, when picked open, an elastic material somewhat like curled hair. A similar material is also made from the leaves of the saw palmetto, which grows in great abundance over hundreds of acres in Florida and westward along the gulf coast of Texas.

Florida moss (*Dendropogon*, or *Tillandsia, usneoides*), not a true moss, but a flowering epiphytic plant of the same family as the pineapple, grows in abundance on trees along rivers and bayous in the coast region from the Dismal Swamp of Virginia to Florida and Mexico. When abundant it is very injurious to the trees on which it grows, often becoming a serious pest in orange groves. In many places in Florida it is collected, and placed in heaps until fermented to loosen the outer covering, which is removed by running it through a crude machine consisting essentially of a revolving toothed cylinder and toothed concaves. The tough inner fibrous material resembling horse-hair is extensively used for cushions and mattresses.

Kapok is a soft cotton-like down growing in the seed-pods of the silk-cotton trees, *Ceiba pentandra, Ceiba grandiflora* and *Bombax malabaricum*, native in the tropics of both hemispheres. Although abundant in many parts of the tropics, nearly all of the kapok of commerce comes from the Dutch East Indies and Ceylon. The pods are collected from the wild trees, and the down separated from the outer covering and from most of the seeds and packed for shipment. It is too short and brittle for spinning, but it is very light, fluffy and elastic, making an excellent substitute for feathers for cushions, pillows and mattresses; and it is also used in place of cork and hair in life-preservers.

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FLAX. *Linum usitatissimum*, Linn. *Linaceæ.* Linum (Latin), Linon (Greek), Lein (German), Lin (French), Llin (Celtic). It is from these names that we get our common words, linen, lint, linseed and line. The specific Latin name means "most useful." [See also *Fiber Plants.*] Figs. 405–410.

By *C. P. Bull.*

Flax is annual, grown for the fiber of the bast and the oil of the seeds. It grows one to four feet tall. Flowers are borne in cymose inflorescences

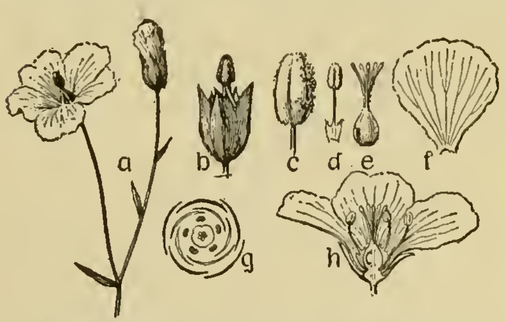

Fig. 405. The flax flower. *a*, open flower and bud just opening; *b*, petals removed, showing close relation of anthers and stigmas; *c*, anther and pollen; *d*, stamen; *e*, pistil; *f*, petal; *g*, plan of flower; *h*, section showing arrangement of parts.

and are distinctly 5-parted in every respect; stamens 10, monodelphous; stigma 5-parted; sepals 5; petals 5, blue, sometimes white; each loculus of the ovary is incompletely halved and bears 2 seeds; fruit, a capsule, 5-celled, with 10 seeds. This species is the only cultivated form of the flax family (*Linaceæ*), except for ornament, but some of the species so closely resemble it that the husbandman would be unable to recognize any difference. A large number of species are recognized by botanists. Bessey reports 135 species in all, and 22 native to America. Some of these are perennial. Many of them are of easy culture in an open and warm place, where they are fully exposed to the sun, giving attractive bloom.

History.

It is not definitely known to what country may be attributed the origin of the flax plant. *L. angustifolium* is said to grow wild from Palestine to the Canary islands. It is also reported as being the species grown by the Swiss lake dwellers. *L. usitatissimum*, it is said, is the ancient flax of Egypt and Assyria. The ancient use of the fiber is evident from the fact that the Egyptian mummies are found wrapped in linen and the flax plant is carved on their tombs. Another evidence of its antiquity is found in Genesis xli. 42: "Pharaoh took off his ring from his hand and put it on Joseph's hand and arrayed him in vestures of fine linen." Its introduction into Europe dates from very remote times. Its importance was materially lessened by the general introduction and use of cotton.

The introduction of flax into the United States was made at an early date, probably by the early Pilgrims. No definite records are available. Up to some thirty or more years ago it formed a part of most farmers' harvest, but since the opening of the new lands in the West, and the wonderful manufacturing achievements, it has been a crop with which to reclaim the native sod. The farmers of older lands gave up its culture to cheaper lands. At present (1906), a new interest is awakening. A wide-spread use for the fiber calls for added care in harvesting, and a better knowledge of the science of agriculture develops the fact that flax is not "hard" on the land, and that crop rotation permits of the use of the crop on every well-managed farm. The production of flax in America is now placed on an entirely new basis.

Geographical distribution.

In America the flax industry stands as one of the oldest. The production of flax has been confined largely to the newer, western lands, as it gradually became less profitable on the older eastern farms. The importance of the industry in the United States is shown by the number of acres (2,534,836) devoted to flax, the number of bushels (28,477,753) of seed produced, and the farm value ($24,049,072) of the crop. [These figures and following table from the agricultural Yearbook, 1905.] For the most part, flax is grown in the northern states and Canada, the two Dakotas and Minnesota producing about 90 per cent of the total American product.

Production of Flaxseed in Minnesota and North Dakota.

	Acres	Bushels	Farm value per acre	Farm value per bushel	Yield per acre
Minnesota . . .	449,008	5,073,790	$9 72*	$0 86	11.3 bus.
North Dakota . .	1,357,171	15,743,184	9 74*	84	11.6 bus.
	1,806,179	20,816,974			

*Computed.

It does not seem to matter much, for the production of flax seed, whether the climate be hot or cold. It is grown in north and south Europe, and in this country from Texas to Manitoba. For fiber, however, it has been asserted that certain localities, as Michigan and Oregon, produce a better quality for spinning purposes.

The production of flax seed at present exceeds the home demand, but a ready market is found in European countries, especially England, for all the export trade that can be supplied. The exports are mostly by-products of the oil-mills,—oil-cake and oil-meal. Until the year 1891, the domestic supply was not equal to the demand, and most of the flax seed used in the East was imported from Europe, the home products being nearly all manufactured and used in the states west of the Alleghanies.

Average Yields of Grains in Bushels Per Acre for 1902, 1903 and 1904 in Minnesota.

	Wheat	Oats	Barley	Flax	Corn
	Bus.	Bus.	Bus.	Bus.	Bus.
Marshall	14.5	47	28.5	12.2	40
Northfield . . .	. .	47	31	11.8	40-50
Halstad	13.3	29.5	27.4	9.1	. . .

Propagation and cultivation

The propagation of flax is entirely by the seed, which is planted in the spring (the middle of May to the middle of June in Minnesota) of the same season that the crop is harvested. It requires eighty-five to one hundred days in which to mature the crop. At present, flax in the United States and Canada is grown almost exclusively for seed. The demand for linseed oil has been an important factor in stimulating the seed-producing feature. The fiber has been neglected in this country until the last few years. Several companies are now at work on machinery and other equipment necessary to the making of cordage and coarse-woven materials.

Cost of Producing Flax in Minnesota.

	Land value	Land rental	Cost of producing	Total cost
Marshall, Southwest Minnesota.	$60 00	$3 00	$5 857	$8 857
Halstad, Northwest Minnesota.	30 00	1 80	5 053	6 853
Northfield, Southeast Minnesota.	70 00	3 50	6 326	9 826
Large farm, Northwest Minnesota.	30 00	1 80	4 337	6 137

These figures represent the cost when flax is grown on stubble land. When it is grown on new breaking, the cost is slightly higher.

Choice of soil.— The flax, having a delicate and relatively small root system, and growing to maturity in so short a time, demands a soil that is rich in soluble organic matter and in moisture. The character of the soil does not seem to be of so much importance. Good crops have been produced on very sandy soil, but the straw in such cases is very short. On the other hand, the larger crops are grown on the heavier clay soils, but in this case at the expense of the quality of the fiber. Experiments have been conducted in various states on many types of soil, and the consensus of opinion seems to be that the heavier lands give better results, but that more seems to depend on the preparation before seeding than on the type of soils. In short, experience teaches that flax may be grown on a variety of soils, but for the best results a moist, deep, friable loam or clay loam is preferable. In the great flax-growing areas of the Northwest, the virgin upland-prairie homestead farms are plowed and seeded to flax without regard to the soil. In the older sections, flax is used as a reclamation crop to reduce the low land to arable fields. These low-lying pieces (prairie sloughs) vary in size from one to several acres, and originally were too wet for cropping, but as the country became older, the water gradually disappeared so as to render them useful for pasture and finally dry enough to plow. The farmers, eager for more acres on which to grow grain, have reclaimed the border of these sloughs from year to year, and are thus maintaining the annual flax area and getting their farms into form and condition for systematic crop rotation. Thus, flax has been valuable in subduing the virgin sod. On the older and heavier lands it has a tendency to improve the physical condition of the soil.

Preparing the soil.—This feature in the flax industry receives too little attention. A common practice in the western states is to break the sod in July or August and "back-set" later in the fall, but more often the back-setting is not done. The following spring the soil is harrowed (or disked if the farmer possesses a disk) and seeded. It is worthy of note in this connection that on the new prairie upland sod thus treated, the yield, often as high as thirty bushels per acre, is sufficient to pay the price of the land. It is generally conceded, however, that flax needs a better prepared soil, and, as the country grows older, the preparation of the seed-bed receives more and more attention. No definite rules can be laid down that would be suitable for all types of soil, and in all climates, but a few general principles must always be observed:

(1) The land should be plowed deep in the fall previous to the spring in which the seed is to be sown. If the land is sod, five inches will be sufficient, but if it is old land, it should be stirred six to eight inches deep.

(2) Heavy clay soils should be worked deeper than the lighter loam or sandy soils.

(3) Generally it is not advisable to harrow in the fall.

(4) In the spring, the heaviest of soils should be plowed again, then disked and harrowed until smooth and firm. The lighter soil should be disked as early as it is sufficiently dry to permit of working, then harrowed and pulverized fine.

(5) Flax should not be seeded on land that is wet, lumpy or weedy.

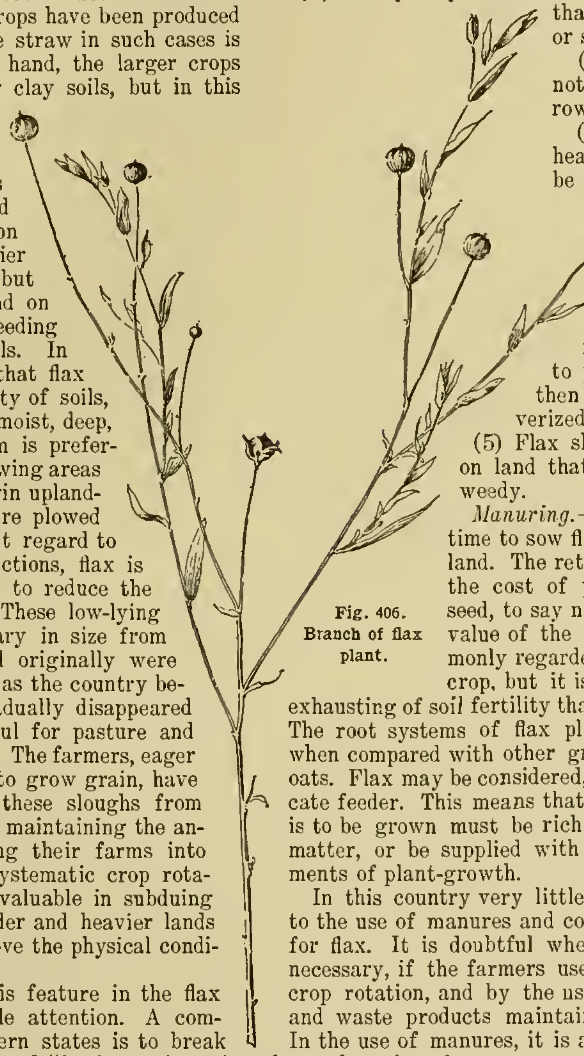

Fig. 406. Branch of flax plant.

Manuring.—It is a waste of time to sow flax on impoverished land. The returns will not repay the cost of production and the seed, to say nothing of the rental value of the land. Flax is commonly regarded as an exhausting crop, but it is relatively no more exhausting of soil fertility than other grain crops. The root systems of flax plants are not large when compared with other grains, as wheat and oats. Flax may be considered, therefore, as a delicate feeder. This means that soil on which flax is to be grown must be rich in soluble organic matter, or be supplied with the necessary elements of plant-growth.

In this country very little attention is given to the use of manures and commercial fertilizers for flax. It is doubtful whether the latter are necessary, if the farmers use proper systems of crop rotation, and by the use of farm manures and waste products maintain the soil fertility. In the use of manures, it is always preferable to have them in a fine or composted condition, especially on the lighter soils. It is not advisable to apply the manure the same year that the seed is sown, as it causes an uneven crop, a tendency toward coarseness of the fiber, and frequently light seed. Aside from this, it brings more or less weed seed to the soil. A few of the states report the use of fertilizers, such as nitrate of soda, muriate of potash, dried blood, dissolved bone-black, dried, fish and various barnyard manures, but no authentic results have yet been recorded.

The eastern states, as a rule, practice methods of manuring, while the western country gives little or no attention to this feature of crop production. On the older farms of the East, fertilizing is necessary for the success of the crop. On the newer western farms, flax may be grown for a number of years without the use of manures; but, sooner or later, manures will become an absolute necessity.

It is recommended that the shives from the mill and the flax straw from the threshing machine be returned to the soil. If this is done, a very large part of the fertilizing ingredients are returned. The only elements removed and not returned to the soil are those of the seed, which are as follows: Water, 12.3 per cent; ash, 3.4 per cent; crude fiber, 7.2 per cent; albuminoids, 20.5 per cent; carbohydrates, 19.6 per cent; fats, 37 per cent of the total weight of the seed. When the straw is pool-retted for the manufacturing of the fiber, large returns may be secured by sprinkling the pool steep, which is rich in organic matter, on the flax-field. This is likely to introduce the wilt disease, however, if flax is to follow in the next few years.

The seed.—It was supposed for a long time that, in order to procure the best results, seed-flax must be imported, at least every three or four years, from the flax-growing countries of Europe. However true this may be for the production of the flax fiber, it does not hold true for the production of seed. Many imported varieties of flax have been tested at the Minnesota Experiment Station, but none has proved so valuable a seed-producer as the common or native flax, which is undoubtedly an acclimated stock of the well-known Riga. It is not definitely known that it is necessary to import seed in order to secure fiber for the production of the finer linens.

In growing flax for seed, a farmer can afford to use nothing but the best. There is such a vast difference in the individual seeds in their power of growth and production, that to use the small, shrunken seeds is but to encourage a small yield. In ordinary farm practice, however, it is seldom that a farmer makes any effort to select the largest, heaviest, plumpest and most matured seed (those known by experience and experiment to give best results) for seeding purposes. He sells all the seed as threshed, except enough in the bottom of the bin to plant his next year's acreage, many times not even saving this, but depending on the local elevator for seed the next spring.

The selection of the seed can best be made on the specific gravity basis, i. e., taking advantage of the difference in the weights of the seeds. The ordinary fanning-mills will do this work quickly and effectively when operated intelligently. The better form to use is the "sideshake" mill. This form drops the seed off the feed-board under the hopper in a steady stream. The wind blast here catches and carries the grain with it to various distances according to the weight of the kernels, the lightest seeds being carried out at the back of the mill, while the heaviest ones drop nearly straight down. By setting the sieves in the lower shoes of the "shake" (one so as to catch the heavy kernels and the other farther out so as to catch the medium and lighter grains), the best can be saved for seed and the other, called "market grain," can be cleaned. The small percentage thus saved does not lower the market grade of the grain, for separating this from the chaff and lightest seeds more than compensates for the small percentage saved for seed purposes. So far as the writer is aware, no experiments have been made comparing the results from good, medium and poor seed-flax, but with all other classes of crops the results have shown marked advantages in favor of the well-graded seeds.

Seeding practices.—Flax is planted in the spring after all danger from frost is past. As it requires only eighty-five to one hundred days for maturing, the planting is seldom done before May 10 in the Middle Northwest. In some of the new sections on low spots where water stands on the surface in the early spring, the planting season is materially lengthened, seeding often being done as late as July 1. It is unsafe, however, to sow flax later than June 15 in the great northwest flax section. Early seeding, May 10 to 20, always gives the best results, as the plants get well rooted and strong before the hot, dry summer weather comes.

From an account given in Report No. 10 of the United States Office of Fiber Investigation, the following dates for sowing and harvesting in the various states are taken:

State	Sown	Cut	Days
Massachusetts	April 29	August 1–6	94–100
Connecticut	May 11	Aug. 7–23	88
New York	May 22–April 30	July 13–August 26	45–97
Maryland	May 4	August 25	113
Kentucky	April 29	August 11	105
Ohio	April 30	July 15	77
Indiana	April 10–15	Sept. 5–12	148–150
Illinois	April 24	July 30	98
Kansas	May 30	August 3	76
Missouri	May 23	August 1–3	71–83
Iowa	March 15–June 10	August 15–October 1	114–154
California	April 25	June 20	57
Wisconsin	June 1	August 30	92
Michigan	April 20	August 20	92
Minnesota	April 30–June 1	August 7–Sept. 5	78–119
Nebraska	May 7	August 3	89
South Dakota	May 15	August 15	93
Oregon	May 18	August 14	89

The depth to plant varies somewhat with the soil and season. On the heavier, wet soils the seed should be planted shallower than on the lighter soils. In the ordinary soils, flax should be planted not deeper than one and one-half inches.

The quantity of seed used by the American farmer varies from two to six pecks per acre. For the production of seed, the Minnesota Experiment Station has found that for Minnesota conditions two pecks give most satisfactory results, but the farmers of the Northwest usually sow a little more. For fiber, the quantity sown is never less than four pecks per acre, six pecks being generally considered best.

If the flax is grown for seed, it is at the expense of the quantity and quality of fiber, and conversely. The difference is occasioned by the thickness of the seeding. The quantity of seed produced depends on the number of branches that bear the seed-bolls. By sowing two to three pecks per acre, the plants are sufficiently far apart to permit of reasonable branching. Under such conditions, the straw grows about thirty inches long. When six pecks per acre are seeded, the plants are very close together, thus preventing the branching habit and forcing a taller and finer growth.

Fig. 407. Flax. At A is shown a plant grown for seed; at B, for fiber. The difference between open and close planting is evident.

At present, there are but two general methods of sowing, viz., with the so-called grain drill and with the ordinary broadcast seeder. With the former, the seeds are planted in parallel rows six to eight inches apart. All seeds are placed at an even depth and in a compact seed-bed. This method is preferred for seed production, as the plants have a better chance to branch and to form seed-bolls. In broadcasting, the seeds are scattered promiscuously over the ground and covered by the gangs of cultivating teeth following the seed spouts. By this method, a trifle more seed is needed per acre. For fiber purposes, the broadcast method is said to produce a better and more even quality. Any conditions which stimulate branching or coarseness are adverse to the making of a long, fine fiber. The drill rows permit of an uneven crowding which brings about an uneven growth of the plants (Fig. 407).

Place in rotation.—Although flax is not a gross feeder and does not yield profitable returns if planted on the same land year after year, it is not exceptionally "hard" on the soil. It requires an abundance of organic matter in the soil, and for this reason follows corn (for which barnyard manure has been applied), a clover sod, or a grass-ley to good advantage. Since flax does not do well on any one field oftener than once in six or seven years, it works best into long-course rotations. A suggested rotation of this kind is as follows: First year, corn; second year, oats or barley, or both; third year, wheat (seeded to grass or clover); fourth year, meadow; fifth and sixth years, pasture or meadow as desired; sixth or seventh year (as the case may be), flax is planted. It is often suggested to plant flax once in two cycles of a short-course rotation. In such a case it would come every other year, or three or four years in succession in every alternate cycle of the rotation; thus, in a four-year rotation, flax would appear on the same field once in eight years:

Four-Year Rotation with Flax.

Year	Field I	Field II	Field III	Field IV
1906 . . .	Corn	Oats	Clover	Flax
1907 . . .	Oats	Clover	Flax	Corn
1908 . . .	Clover	Flax	Corn	Oats
1909 . . .	Flax	Corn	Oats	Clover
1910* . .	Corn	Oats	Clover	Wheat
1911* . .	Oats	Clover	Wheat	Corn
1912* . .	Clover	Wheat	Corn	Oats
1913* . .	Wheat	Corn	Oats	Clover
1914 . . .	Corn	Oats	Clover	Flax
1915 . . .	Oats	Clover	Flax	Corn

*No flax during this cycle of the rotation.

Varieties.—The average American farmer recognizes but two general varieties of flax,—the White Blossom Dutch and the Russian Riga. The latter is generally used and is considered best. The former has been tested repeatedly at the Minnesota and North Dakota Experiment Stations, but no stock has yet been found to surpass the Riga in seed production. At Yale, Michigan, and at Corvallis, Oregon, the growers for the most part have followed the example of the farmers of Great Britain, Holland and Belgium, and imported new seed from Russia (and some from Holland) every two or three years. It is reported that the home-grown seed does not produce so fine a grade of fiber as the imported seed. It is also said that the White Blossom Dutch variety loses its white blossom character in a few years after importation. In this connection, it is worthy of note that the new flax (Minn. No. 25), introduced in 1905 by the Minnesota Experiment Station to the farmers of Minnesota, came to the Station in 1891 as a white blossom variety. It now has a blue blossom. If such changes take place in color characters, it is not unreasonable to suppose that the character of the fiber may also be affected by the change. However, the quality of the fiber of home-grown flax is being improved by breeding. Experts state that the low grade of fiber of American flax is due to the method of sowing more than to the seed.

The high-priced labor of this country is nearly a complete barrier to the production of flax for fiber chiefly. For this reason it is imperative, in the Middle Northwest at least, that a fair crop of both seed and fiber be produced. Varieties of superior seed- and fiber-yielding properties have been secured, but until labor is cheaper and more reliable, or until a higher price is paid for fiber, the growing of flax fiber will have to be coupled with seed production. It must not be inferred from this that flax is grown for fiber alone in the flax-producing countries of Europe, excepting perhaps in parts of Ireland; the seed is saved and is regarded to be a secondary product of considerable value.

Breeding.

The systematic American breeding of flax has been limited to the Minnesota and North Dakota Experiment Stations. But limited as it is, some lessons have been learned and results have been secured that are of vast economic importance. The Minnesota Station has bred two high-yielding varieties, one for seed and one for fiber. North Dakota Station has bred one that has proved to be noticeably wilt-resistant.

Minnesota experiments.—The general plan for breeding flax at Minnesota has been as follows:

(1) To secure, through systematic methods of testing, a few of the most promising varieties.

(2) To save the seed of these and to grade it carefully, eliminating all but the very best seeds.

(3) To plant two to five thousand hills of each, with two or three seeds per hill. (Fig. 408.)

(4) When the plants are a few inches high, to thin to one plant per hill.

(5) At maturity the best ten to twenty-five plants are secured by a gradual elimination of the poorest plants. These are selected on the basis of the economic character that is desired: If seed is the object, the plants selected are those that have a number of top branches and bear a large number of seed-bolls. If fiber is desired, the tallest, stiffest and least branched are saved. The plants thus selected are termed mother-plants and are given a register number (nursery-stock number). Certain notes are taken on them, as height, number of branches, quantity of seed, and the like, and the best 250 seeds are saved to plant a centgener the succeeding year.[1]

(6) At harvest the next year, the best ten plants are again selected from which the seeds are saved as one lot. The total number of plants is recorded. All plants are carefully tied in a bundle and threshed in an especially devised centgener thresher. The total weight of the seed from all the plants is divided by the number of plants, thus giving the average weight per plant. This weight, together with centgener notes, is a measure of the inherited ability of the mother-plant. Such a centgener test goes on for three years.

(7) At the end of three years an average is made of each mother-plant's progeny for the three years. The best one or two nursery-stock numbers having highest yields, other things being equal, are saved for future trial. All others are discarded.

(8) The best of all the bulk seed, saved from all plants harvested the last year of the three years' test, is planted in a "nursery increase plot," and given a Minnesota number.[2] From the field plot results another three years' test, and the average is made. Each year such notes as height, days to mature, per cent lodged, evenness in height and ripening, type, yield per acre, and the like, are taken.

(9) If in this test a certain stock shows by its record, as did Minnesota No. 25, that it is superior to all others, the bulk seed is again saved. This seed is planted in "field increase plots" until several hundred bushels of well-graded seed are secured.

(10) This "field increased" seed is then sold to farmers of the state in lots of four bushels or less, at a price slightly above the ordinary market price of flax.

(11) These farmers, by signing a contract, become coöperators of the Experiment Station. At harvest time a blank form of inquiry is sent to each coöperating farmer to fill out and return to the Experiment Station. From the replies, a comparison of the new variety with the common variety under farm conditions is made.

(12) Inquiries coming in from other farmers in following years for the improved variety are referred to the coöperators.

To illustrate the results that have been secured, the following table giving the results of comparative tests made by forty-eight farmers in various parts of Minnesota is introduced:

FLAX, MINNESOTA NO. 25 COMPARED WITH COMMON VARIETIES.

Minnesota No. 25	15.0 bushels per acre
Common flax grown by farmers .	11.9 bushels per acre
Gain	3.1 bushels per acre
Rate of increase	26 per cent

MINNESOTA NO. 25 COMPARED WITH VARIETIES SOLD BY COMMERCIAL HOUSES IN 1901.

	Yield 1902	Yield 1903	Yield 1904	Average yield 3 trials
Minnesota No. 25	21.4	19.3	17.1	19.3
Minnesota No. 12, Seedsmen .	11.4	19.1	18.4	16.3
Minnesota No. 14, Seedsmen .	12.5	20.3	15.4	16.0
Minnesota No. 13, Seedsmen .	9.6	20.0	16.6	15.4

Average yield of Minnesota No. 25 for three years is 19.3 bushels.
Average yield of three commercial varieties for three years is 15.9 bushels.
Increase in favor of Minnesota No. 25 is 3.4 bushels.

In addition to the improvement shown in these tables, No. 25 is a week earlier than common varieties, and is more even in growth and in maturity.

North Dakota experiments.—At the North Dakota Experiment Station, Bolley has been breeding flax with a view to getting a variety that is immune to the wilt disease. In this work, he has followed closely the Darwinian hypothesis that success attends the survival of the fittest. One of the common varieties was selected and planted on a

[1] Centgener is a name given to the product of a single mother-plant; in this case used to designate the plants resulting from the 250 or more selected seeds.

[2] A Minnesota number is given to any new accession introduced into the field test in comparison with all other promising stocks and varieties from various sources.

plot of soil known to be "flax-sick." The majority of the plants succumbed to the disease. The very few that survived were carefully harvested and stored. The seeds from these were in turn planted on "flax-sick" soil. Year by year the proportion of plants surviving the attacks of the disease grew larger until, in 1904, a comparatively immune or wilt-resisting variety was secured. This experiment, though simple and dealing only with one of our economic crops, has an immense economic value. It opens the road to success in breeding disease-resistant varieties of all our field crops, garden crops and flowers.

Harvesting.

The ideal way to harvest flax for the best quality of fiber is to pull it by hand, thus securing the full length. In Europe, where labor is cheap and the acreage per farmer small, the flax is nearly always pulled and stood up in bunches (stooks) to dry, but the high price of labor and the relative efficiency of harvesting machinery makes the pulling of flax almost prohibitive in America, and it is practiced only to a very limited extent.

When flax is grown exclusively for the seed, it is cut with the self-rake reaper or the binder. Occasionally, in the absence of a better machine, the mower is used. Its use, however, is not at all satisfactory, as it leaves the crop in condition difficult to handle without considerable loss. When cut with the binder, the farmers seldom use twine, and the gavels are thrown from the machine and lay as if cut with a reaper. If twine is used, the bundles are gathered into small, loose shocks that permit of rapid drying. If cut with the reaper, the gavels are left in position as they fall until well dried on the upper side. They are then turned with an old-style barley fork so as to expose the other side to the sun. When dry, the crop is either stacked or

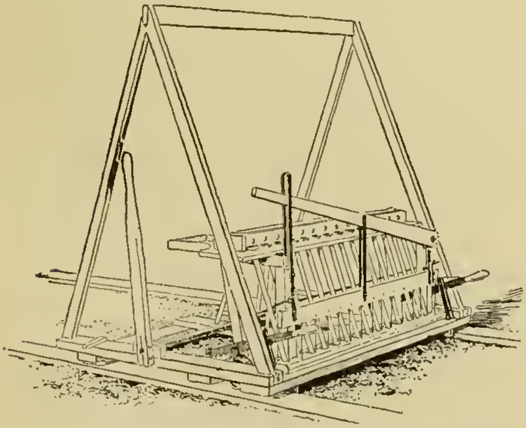

Fig. 408. Nursery planting machine used in breeding experiments.

threshed. Often, in the absence of the threshing outfit, the crop remains in the field until the outfit arrives. For this reason, there is considerable loss caused by rains. The flax grown on the low ground is generally low grade if not carefully guarded, through molding and successive wetting and drying. A flax field at harvest-maturity is shown in Fig. 409.

A few trials have been made to determine the possibilities of heading the standing flax, then cutting and binding the straw, thus possibly decreasing the cost of preparing the straw for man-

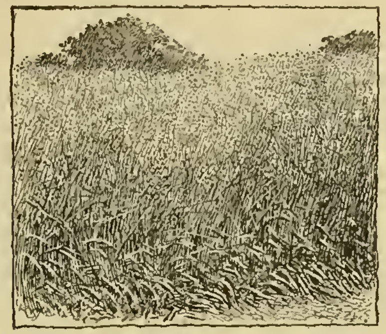

Fig. 409. Field of flax ready for harvest.

ufacturing purposes. Nothing has as yet proved to be practicable. Ideas of special machines for pulling and preparing the flax have been conceived, but thus far efforts have failed.

Obstructions to growth.

Weeds.—One of the greatest drawbacks to the production of flax is the ever-present weed incursion, which sooner or later must be met by every farmer. On old land, especially, is it impossible successfully to grow flax for seed with present methods of culture. On the newer lands weeds are no serious menace to the crop, although they are generally present in limited numbers. The nature of the flax plant gives ample opportunity, with thin sowings for seed purposes, for weeds to develop. When five or six pecks are seeded per acre, weeds are crowded out if the ground is well prepared before sowing, thus giving the plants a good start before the weeds get started. A good system of crop rotation with flax following a grass-lay or a corn crop for which manure has been applied, will quite eliminate this trouble.

The weeds commonly found in flax-fields of the Northwest are as follows: Foxtail (*Chætochloa viridis*), lamb's-quarter (*Chenopodium album*), pigweed (*Amaranthus retroflexus*), pepper-grass (*Lepidium Virginicum*), wild mustard (*Brassica arvensis*) and other of the mustard family, French weed (*Thlaspi arvense*), smartweed (*Polygonum Persicaria*). Many other weeds occasionally find their way into the flax-field, but do not attract attention as do those named. None of the weed seeds are exceptionally difficult to separate from flax seed, but when present they increase the cost of manufacturing and decrease the market price, and cause a dockage to be levied, not to mention the cost of freight on them. In the flax-straw, weeds greatly decrease the value of the fiber. The weed-stalks are hard to break. When broken, the pieces catch in the fibers and cause tangling and breaking.

They also interfere with the scutching. Any weed-fibers that get into the skein are a detriment to the cloth or cord manufactured.

Disease.—One of the most dreaded of all diseases of field crops is the flax-wilt (*Fusarium lini*, Bolley). So prevalent is the disease that no flax-bearing country is free from it. Bolley says, "The plants are attacked at all ages and die early or late in the stage of growth, according to the time and intensity of the attack. If the soil is much affected, that is to say, 'flax-sick,' most of the plants are killed before they get through the surface of the ground." Young plants, two to five inches high, wilt suddenly, dry up, and soon decay if the weather becomes moist. Older plants take on a sickly, weak, yellowish appearance, wilt at the top, slowly die, turn brown and dry up. Nearly mature plants when attacked, but not dead, are easily pulled, the roots breaking off at about the level of the furrow slice. The diseased roots have a very characteristic ashy appearance.

Flax-wilt is different from many fungous diseases, in that it lives a long time in the soil and that it is carried with the seed. Thus, a wilt-free soil may produce a flax-wilt crop if the seed-flax was grown on flax-wilt ground; or a flax-wilt soil will produce a flax-wilt crop even though the seed had no flax-wilt to carry with it. In either case, however, the first crop under these conditions may not give much evidence of the disease. Succeeding crops would be badly infested.

A careful and exact study of the life-history of the cause of flax-wilt has made it possible successfully to combat it. The fungus is an imperfect one and lives normally as a saprophyte, but occasionally becomes a parasite. Its chief means of distribution is by the spores which are carried on the seed of the flax. Obviously, then, by treating the seed, the disease can be very largely obviated.

Until recently, no treatment for the dreaded flax-wilt disease had been discovered, but the working out of the life-history of the fungus by Bolley, brought out the fact that treatment of the seed with certain fungicides will eliminate the disease from seeds known to be from an infected crop. A farmer with soil free from flax-wilt germs can safely sow seed from a flax-wilt crop if the seed has been thoroughly treated. At the North Dakota Experiment Station, a series of tests were made to prove the value of seed treatment for flax-wilt, and in every instance when the seed was treated and sown on soil free from wilt, there were no signs of the disease. But the same lot, untreated, sown on wilt-free soil, showed the presence of the disease.

There were several fungicides which might be used, but it was necessary to find one that was strong enough to kill the spores of the wilt and yet not injure the vitality of the seed. Formalin is recommended as the cheapest and quickest effectual solution. The treatment as recommended by Bolley is as follows: Mix thoroughly one pint or one pound of the formalin with forty gallons of water. This quantity of solution is sufficient to treat about one hundred bushels of seed. Before applying the solution, the seed must be carefully cleaned and graded with a fanning-mill. If this is not done, pieces of broken stems and shriveled seeds carrying the disease will not be completely disinfected. Thus the wilt will be carried to the soil.

In treating the seed, it is advised that about five bushels be spread thinly on a floor or canvas. The solution is then sprayed on the seed with a fine nozzle (a common sprinkling-pot or a patent sprayer may be used). At the same time the flax is stirred rapidly with a rake or shovel in order to get every seed in contact with the fungicide. After spraying, the stirring should continue a short time to aid the drying.

Care in the application of the solution is important. An excess of water will cause the flax seed to stick together and will interfere with seeding. Ordinarily, with careful treatment, the grain can be seeded in a few hours after treatment. [See also page 50.]

Flax rust (*Melampsora lini*) is another menace to the flax crop, but happily it is not causing much damage. It was first reported in the Northwest in 1905,—a very wet season. It completely destroyed some fields in the Red river valley. It is not probable that great damage will come from this disease, since flax for the most part is grown in small, disconnected areas and is changed from field to field.

Manufacture.

Flax has long been known as a valuable plant for the production of wearing apparel and matting fiber. It has also been the source of a valuable oil, useful for many purposes, especially in the making of paints. Until recently, flax has been grown almost exclusively for its oil in this country. There were no means to make use of the fiber and compete with the fiber productions of Europe.

At present there are four distinct manufacturing interests which employ the flax crop. One of these uses only the seed. The other three are distinctly fiber industries, and manufacture cloth, thread and yarn, insulating material and binding twine. For these interests, the crop is generally taken from the farmer just as he is pleased to harvest it. In a few instances, as at Yale, Michigan, the crop is sometimes pulled by hand. For the oil-mills, the flax seed is commonly delivered direct to the local elevator from the threshing machine. From here, in due time, it finds its way to the mill, where it is separated from weed seeds and other foreign material before being ground.

Linseed oil.—One of the first commercial manufacturing uses to which flax was put in America was based on the oil contained in the seed. The demand for linseed oil, as it is called, and the industry have developed rapidly, until an oil-manufacturing plant today entails an investment of a million or more dollars and employs hundreds of men.

The supply of flax for the oil-mill is shipped mostly from the local elevators, and stands in the transfer yards until graded by the State Inspection Department. In the meantime, it is bargained for by the various firms. The cars are then side-tracked to the mills, where the mill hands unload into their elevators. Once in the elevator bins, the flax is spouted into the hoppers of large cleaners, which by means of their many shakes and sieves separate the flax from the straw, dust, weeds and other seeds. The foreign seeds are sold for various purposes. The flax is elevated from the cleaner to a vertical system of five large rolls or breaks; the upper ones barely crush the berries, while the lower ones reduce them to a fine meal, which is carried to large cookers that temper it and heat it to 160° to 200°. Some seeds need more moisture, others have too much. The tempering adds to or takes from the grain enough moisture to bring it to a common temper. From the cookers the hot meal is drawn into a conveyor that distributes it evenly in a mould about 12 x 20 x 2½ inches. To hold the meal after these moulds are removed, a camel's-hair cloth is placed around it. The moulds or forms are placed in a hydraulic press and subjected to a pressure of 3,500 pounds per square inch. The oil is squeezed out and flows into a small sluice tank to rid it of the finest meal particles. It then goes to the large tank or to the refining tanks. From these the various grades of oil are drawn off into original packages (barrels, etc.) for market.

The grades of oil are named according to a system peculiar to each mill. Thus, the same grade of oil may have two or more names as it is put out from two or more mills. The oils are used for a variety of purposes, from the making of patent-leather shoes to paints.

Fiber.— The processes employed in making the various products from flax fiber are too long to be described in detail. The old methods followed by our fathers and mothers, as recently as 1870, were crude, but were apace with the progress of other industries at that time. A half-acre or an acre was the extent of the flax-field, but each farmer grew some flax for making the family's "homespun." The flax was pulled, retted, hackeled, spun and woven by hand. Today, the hand labor is eliminated almost entirely. In fact, it is difficult to get men to do any of the hard work for which machinery has been invented. When cut, if the flax is stood up in shocks, there is damage done to the stalks where they touch the moist soil.

After harvesting, the seed is threshed from the straw. This is done in some instances by holding the heads of the bundles in the cylinder of the threshing machine. In others, the heads are cut from the stalks in the process of breaking and are threshed in a separate device. In olden days, the seed was pounded out by whipping the "hand" (a handful) over a barrel, or it was "rippled," that is, drawn through a coarse comb.

Flax grown for fiber in this country is threshed by passing the heads repeatedly between rapidly revolving cylinders or belt pulleys, the seed being afterward cleaned with fanning-mills. Special threshing machines are used at the two binder twine factories.

In preparing the fiber for weaving, the straw must be passed through a process of decay, called retting. This loosens the outer covering and shives (the inner or woody part of the plant) from the bast fibers and makes the separation of the fiber easy. The retting is accomplished in two ways: (1) By aërial- or dew-retting, i. e., spreading the flax on the ground in an open field or pasture; (2) by placing the bundles in slow-flowing streams or pools (Fig. 410). The latter is the true way of retting, makes a whiter, better fiber and is much quicker. The steeping in this way acts constantly on the mucilage that holds the fiber and wood together. Rain-water is said to be best, although river-water is most commonly used. One or two weeks is sufficient time for pool-retting, while many weeks are often necessary properly to dew-ret.

It is obvious that the fermentation must stop at the proper time. This is observed to be just when the fiber separates easily and freely from the woody stalks. The straw should then be removed from the water and spread out thinly and allowed thoroughly to dry. When dry, the straw goes to the "break." The hand-break was a large wooden mallet which fitted into a V-shaped bed-piece and was worked up and down by hand. The power-breaks vary in style, but consist essentially of corrugated rollers which draw the straw through and at the same time crinkle the fiber and break the shives into small pieces. From the break the broken straw is scutched and hackled, i. e., pounded by hand or

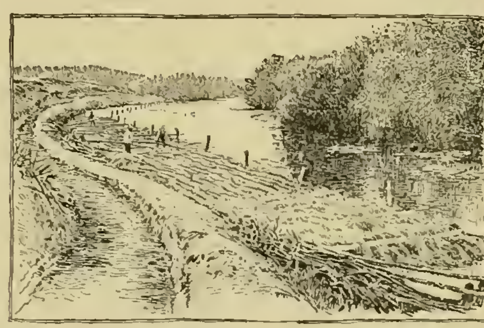

Fig. 410. Retting flax in the river at Northfield, Minn.

pulled over a series of rapidly revolving fingered rollers to remove the shives.

In scutching, the broken straw is held in handfuls against revolving paddles which beat off the shives. In hackling, the scutched fiber is drawn by hand across sets of fixed upright steel pins to comb, separate and straighten the fibers. Machine hackles are used for cheaper grades in some mills.

In the early days the fiber went to the loom without further preparation or treatment. But the latter-day American must have his linen immaculate and uncolored by threads of natural color. For this reason the fiber goes through a boiling and bleaching before it is made into cloth. This practice, to a certain degree, is detrimental to the lasting quality of the cloth.

This, however, does not apply to American-grown flax, as this flax is not used for fine linens. Shoe-thread, carpet-yarns, fishing-lines and seine-twines are products of the best American flax, and huck toweling or crash from the tow. (Tow is the coarse and broken material resulting from scutching.)

As yet, manufacturers use the American-grown flax fiber only for making the coarse grade of cloth (crash, so-called "Russian linen," toweling). All of the fiber for making the finer linens is imported from Europe. The American farmer must soon learn the necessity of producing flax with a long-line fiber. In this work the various experiment stations will prove a valuable source of aid.

Binding twine.—The making of binding twine from flax is a new industry. For this the flax does not require retting. It is bought from the farmer and delivered unthreshed, as it was cut and cured, from the field to a baling station. The company bales it and ships it to a warehouse to become thoroughly dry. When dry, the straw is passed through a tempering tunnel, on an endless moving apron. Here it is heated to drive off any excess moisture. It next passes sidewise through a heading and break machine. The straw comes out fluted, with the shives broken, and falls on a moving platform which conveys it into a slowly revolving spiked apron. On the moving apron a small quantity of heavy, coarse fiber (similar to sisal) is added to give the twine stability. From the spiked apron it is removed by a very rapidly revolving spiked apron which draws the strand out and brings it to a common center, where it is delivered into a tall, cylindrical basket. These baskets of fiber are fed into other machines which draw the strands out more and aid in removing the last of the shives, and which again deliver the strands to baskets. From these the fiber is fed into the twiner and skeiner, a machine which twists the twine and reels it on large wooden spools. These spools are taken to the ballers, where the twine is reeled off and wound into balls. The balls are then baled the same as other binding twine. A tester takes an occasional ball and tests its strength and length to see that the output is held up to a good average.

As yet, there is no cordage but binding twine being manufactured. It is but a question of time when American flax will be manufactured into all grades of cord and thread and rope.

Miscellaneous uses.—For upholstering and similar purposes, flax fiber is being used extensively in the Northwest. The so-called tow mills receive the straw from the farmers just as it comes from the threshing machine, and put it up in bales and ship it to the central market or factory. One extensive industry is located in Minnesota. At this place the fiber is chemically prepared and passed into layers of different thicknesses. The thinner ones are sewed between two pieces of building paper. Such material is used for insulating, cold storage, refrigerator cars, ice-boxes, and the like.

Exhibiting.

There has been as yet no attempt, so far as the writer is aware, to gather the flax and its various products (in process of manufacturing) for exhibition purposes. At the Minnesota Experiment Station the writer is gathering samples of material illustrative of the various steps in the development of flax from the seed to the manufactured products, with a view to having a connected museum history of flax. Such an exhibit will be of immense value from an educational standpoint, and would very properly occupy museum space in any educational institution, at agricultural expositions and fairs. It is seldom that anything but the seed is exhibited. A few bundles of the mature straw are often used for decoration. These are not generally so labeled that the average visitor knows what they are. Managers of expositions and fairs, as well as exhibitors, have much to learn in improving the manner of display.

Markets.

There are no special markets for flax. As a rule, farmers do not hold their crop long after threshing. They sell the seed to the local elevator. A few ship direct to the factories. The great bulk of the straw is burned. The grain companies buy flax seed as they do other grain, and sell to the linseed mills according to the standard grade and price. The seed often is transferred directly to the consumer; at other times it is stored in terminal elevators. The average farm price of flax for the past ten years is $1.094 per bushel. The ten-year average Minneapolis price is $1.205 per bushel.

Market grades of Minnesota commercial flax seed.

No. 1 Northwestern.—Shall be mature, sound, dry and sweet. It shall be northern-grown. The maximum field-, stack-, storage- or other damaged seed shall not exceed 12 per cent. The minimum weight shall be fifty-one pounds to the measured bushel of commercially pure flax.

No. 1 flax seed.—No. 1 flax seed shall be northern-grown, sound, dry and free from mustiness, and carrying not more than 25 per cent of immature or field-, stack-, storage- or other damaged flax seed; and it must weigh not less than fifty pounds to the measured bushel of commercially pure seed.

Rejected flax seed.—Flax seed that is bin-burnt, immature, field-damaged or musty, and yet not to a degree to be unfit for storage, and having a test weight of not less than forty-seven pounds to the bushel of commercially pure seed, shall be rejected.

No-grade flax seed.—Flax seed that is damp, warm, mouldy, very musty, or otherwise unfit for storage, or having a weight of less than forty-seven pounds to the measured bushel of commercially pure seed, shall be no-grade.

The above grades represent only one market. The grades for other markets differ somewhat and depend on the location.

Literature.

Textile Fibers, Maxwell; Yearbook United States Department Agriculture; Fiber Investigations, Reports, United States Department Agriculture, Martin Dodge; North Dakota and other State Experiment Station Bulletins; Minnesota Plant Diseases, E. M. Freeman; Soils and Crops of the Farm, Morrow and Hunt.

FORAGE CROPS.

Forage is herbage food, whether green or cured. The forage crops are grasses (whether utilized in meadows, pastures or otherwise), all coarse natural grazing crops such as animals are likely to find provided in nature, and miscellaneous roots and vegetative parts grown specifically for feeding purposes. They are distinguished from the threshed grains and all manufactured products. It will be seen at once that there are two cultural groups comprised in the class of forage crops,—the group occupying the land for a series of years (meadows and pastures), and the group comprising the annual-grown or biennial-grown plants (as maize, cowpea, pea, millet, roots). These groups overlap, however, so that no hard and fast line can be drawn between them.

The word *roughage* is applied to the coarser forage products, as maize, cowpeas, kafir corn; sometimes it is used as equivalent to forage.

Fodder is practically equivalent to the word forage, but is less specific; it is by some restricted to dried or cured forage. The word is commonly used for the coarser kinds, in distinction from hay.

Soiling is the feeding of green harvested forage direct from the field to the animals. The feed is carried to them. This system is distinguished from pasturing. The animals are kept in small enclosures or in stalls, and thereby their feed is regulated and the crop is not injured by them. The term is probably derived from that use or origin of the verb *to soil* that indicates *to satisfy* or *to fill.*

A species of pasturing is sometimes known as soiling. By means of movable fences, the animals are allowed to graze a part of the crop clean, and then to move on at the next feeding to fresh foraging. This use of the term is allowable, since the object is the same,—to supply the animal with a given amount of succulent food: the animal does the harvesting. This practice may be known as *pasture soiling.*

It would not do to allow animals to roam at will and to gorge themselves in such crops as maize, growing grain, heavy alfalfa, clover or cowpeas; consequently the animals are *soiled* on these crops in one way or another.

Silage is green or uncured forage that is preserved, or ensiled, in a tight receptacle or silo. Silage is discussed in Vol. III in its feeding relations. Its philosophy is discussed in the present volume under *Maize* and *Silage.*

There are several special or restricted usages of the term "forage plants" or "forage crops"; but common-language usage must prevail with a word which has so long been general property.

In this Cyclopedia, the main forage groups are treated separately, for cultural and other reasons. Some of the leading forage discussions may be found under *Grasses, Meadows* and *Pastures, Legumes, Root-Crops, Soiling Crops, Silage.* Detailed information on the different kinds of forage crops is given under the names of the crops, in the proper alphabetic order. Some of the leading forage crops are alfalfa, cabbage, the various cereals, clovers, cowpea, kafir corn, maize or Indian corn, mangels, millet, rape, soybeans, sorghum, vetches.

There are very many minor plants that are used for forage in a small way now and then. Such of these plants as give promise of becoming important or have attracted attention are treated together in this article. Many native plants are foraged by live-stock now and then, but it would be interminable and unprofitable to try to discuss them here. Their names sometimes occur in current agricultural literature. Most of them have been mentioned in one place or another in experiment station literature, and they can be traced through The Experiment Station Record. Unless a plant has been prominently mentioned, it is not discussed in this book.

Literature

The current periodical and bulletin literature on forage crops is very large. Some of the book-writings are as follows: Flint, Grasses and Forage Plants, J. H. Sanders Publishing Company, Chicago; Shaw, Forage Crops, Clovers, Grasses, Soiling Crops and the Silo (four books), Orange Judd Company, New York city; Wallace, Clover Culture, Iowa Homestead, Des Moines, Iowa; Hunt, Forage and Fiber Crops in America, Orange Judd Company; Beal, The Grasses of North America, two vols., Henry Holt Co.; Spillman, Farm Grasses of the United States, Orange Judd Company, New York; Myrick, The Book of Corn, Orange Judd Company;

Fig. 411. White Flint forage corn. Yield, twelve tons per acre. New Jersey.

Dreer, Grasses and Clovers; Phares, Farmers' Book of Grasses; Coburn, Alfalfa; Peer, Soiling Crops and Ensilage, M. F. Mansfield, New York city; Stebler and Schröter, The Best Forage Plants, London; Voorhees, Forage-Cropping.

The Significance of Forage-Cropping.

By *Charles S. Phelps.*

The term forage refers to any form of herbage used as food for live-stock. It consists of the leaves and stems of fresh or air-dried plants, together, in some cases, with the attached seeds. It includes mainly pasturage and soiling crops; hay of the meadow-grasses, legumes, millet, and cereals; field-cured fodder corn, sorghum, and kafir corn; the stems and leaves of some grain crops after the seeds are removed; silage crops; and root crops. The acreage in forage crops, according to the census of 1900, exclusive of pasture lands, represents approximately 15 per cent of all improved land, and a little over 21 per cent of the area devoted to all crops, while the percentage of the total value of all crops is 16.6. Forage crops stand second in total acreage and in total value in the list of cultivated crops, corn being in the lead, while the value per acre is only seventeen cents less than the average for the cereals.

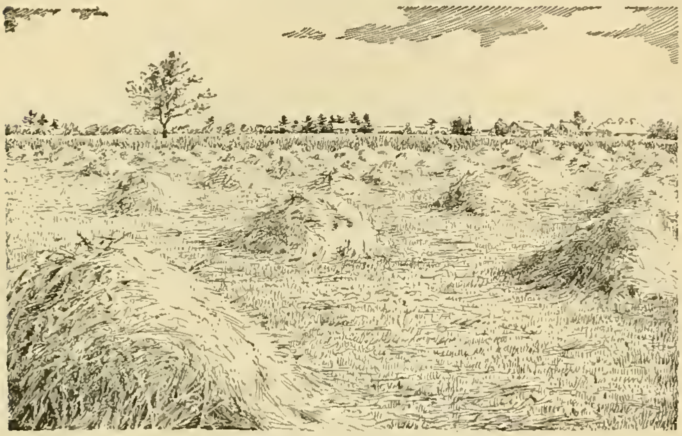

Fig. 412. Pea-and-oat hay. Ten acres, average yield, 2.15 ton per acre. New Jersey.

Pasturage was the earliest form of forage used and is still the chief food of live-stock in nearly all countries in the summer season. In earlier times pasture lands were all held and used in common and only small fenced areas were devoted to the growing of cultivated crops. As the population increased, the proportion of cultivated lands became larger and the proportion devoted to grazing became less. This change was necessary in order that the land might furnish support for the increasing inhabitants. In the earliest days of stock-raising, dried fodder was the only feed used in winter in cold climates. Wild grasses were doubtless the first plants dried for winter use. The ease with which these could be air-dried and preserved led to the selection of the seed of some of the best kinds, and to their being sown on cultivated lands. Little is known as to when the common grasses were first brought into cultivation, or which kinds are the oldest. It is said by one writer that up to 1815 not over three or four species were in cultivation throughout Europe. Clover was introduced into England from Flanders about 1650 and soon took an important place in the agriculture of that country. In the earlier history of this country all cereal grains were needed as food for man, and dried herbage was used exclusively as food for live-stock. Little effort was made to produce milk or to fatten cattle, sheep or swine, except during the summer season. The live-stock was sustained through the winter on what was often less than a healthy maintenance ration. As the country developed and the proportion of the non-agricultural population grew larger, animal products increased in market value and the winter production of such products became profitable. This led not only to the use of grain feeds, but to the production of a better grade of forage.

In many parts of this country there are large areas so rough and uneven as to be of little value for any other use than pastures. Even in the newer parts of our country there is a steady decrease in the area devoted to grazing and a steady increase in the area devoted to cereals. In the older European countries the area used exclusively for pastures is much less than in the United States. Where land values are high it is a common practice to rotate pasture with cultivated lands, and in this way the pastures are improved and made to support more stock. Areas in use for growing grain are frequently sown to clover or rape in the spring and thus are fitted to supplement the regular pastures late in the season.

In many parts of Europe and in some of the more densely populated parts of this country, the summer feeding of green forage crops, or soiling, is replacing pasture feeding. By this plan of feeding, more stock can be kept on a given area, the expense for fencing is greatly reduced and the manure can be more completely saved, but the labor involved is somewhat greater. In this country the high price of labor and the large amount of rough, low-priced land will long defer the general adoption of the soiling system. Irregularity in the supply of pasture, however, as a result of periodic droughts, makes advisable the partial substitution of green forage for pasture feeding. Such a plan of feeding is especially suited to high-priced lands, because more stock can be kept per acre than by exclusive pasturing. A large number of crops can be made available for this plan of feeding, and these can be grown so as to furnish valuable feed throughout the summer season. A number of soiling crop successions have been published by the experiment stations, those by the New Jersey, Connecticut (Storrs) and the Massachusetts Stations probably being the best.

The preservation of herbage in an air-dried state for winter use is a common practice in all countries where snow covers the ground part of the year. In the northern part of the United States, east of the Mississippi, grasses and clovers are more generally grown for hay than any other crops. In the southern belt of states cowpeas, soybeans and Japan and crimson clovers form the chief hay crops, while in parts of the Rocky mountain region and Pacific coast states alfalfa is grown almost exclusively as a dry fodder. On many farms where dairying is an important branch of farming the grain crops, cut before the seed is matured, add much to the supply of dry fodder. Some of the annual grasses, such as the millets and Hungarian grass, are grown in most of the states. These prove especially valuable because of the short period needed for their growth and the large yields given by some varieties, especially the Japanese millet. They often prove useful to supplement the regular hay crop during seasons of shortage in that crop. In some of the southern states and in Kansas and Nebraska, sorghum and kafir corn are grown considerably and field-dried as cattle feeds. These crops thrive better in regions of low rainfall than do the common grasses or maize. In the older states of the East, the stover of the corn crop has been carefully saved and utilized for many years, but in the great corn belt, up to within a few years, this part of the crop has been left in the field to be used only for grazing, while much of it was trampled by the cattle and thus wasted. As a system of mixed husbandry replaced exclusive grain-growing, the value of the stover was more fully appreciated, and the crop is now generally saved and used in feeding.

The preservation of forage in the form of silage has given rise to a newer branch of forage-cropping. It affords a means of preserving coarse, bulky fodders, that can be dried only with difficulty, in a small space, and thus renders them available in a succulent form when green feeds cannot be obtained. While the preservation of fodders in a closed pit was practiced in Germany before 1850, the first experiments with the silo in this country were made in 1875. At first their introduction was slow, but they soon found many advocates, and since 1880 their use has increased rapidly. The chief reason for the general adoption of the silo in the northern belt of states is that corn, a crop well adapted to the climate, is the best one for preserving in the silo, coupled with the fact that silage is a cheap and valuable feed for dairy stock. Silage is not likely to replace dry fodders, yet in all of the older states it has become an important adjunct to the older system of dry feeding, particularly for the dairy.

The growing of forage crops lies at the foundation of the practice of mixed husbandry. The rearing of live-stock and the marketing of the greater part of the farm crops in the form of animal products affords greater immediate profit and causes a smaller drain on soil fertility than does the direct sale of farm crops. Except in warm climates, animal husbandry, and especially dairying, can be practiced successfully only where forage is grown and stored for winter use. As the market value of grains becomes higher, owing to the increasing demand for cereal foods by man, forage-cropping is sure to take a more prominent place in animal husbandry, and effort will be made to produce forage of higher food value.

The great group of forage crops comprised in the grass family are all deficient in protein, while the plants of the clover family are relatively rich in protein. The tendency of late years has been to grow more forage of the plants of the clover family, and their use for this purpose is likely to increase as grain-feeds become more expensive.

Forage-cropping affords opportunity for a more complete system of crop rotation than does grain-farming. On all stock- or dairy-farms a rotation should be arranged so as to include grasses and clovers, the smaller cereals, and corn grown for silage or for grain. A valuable rotation on dairy-farms will be found to be a six-years plan consisting of (1) rye sown after grass, with clover as a cover-crop; (2) corn, with a cover-crop of rye or clover; (3) oats; (4) clover and mixed grasses, to be continued for three years.

Where the winters are mild and the ground is free from snow much of the time, there is great waste of fertility unless a winter cover is provided. Forage crops like rye, rape and clover, often can be grown for this purpose, and at the same time furnish valuable pasturage in the fall or spring. The adaptability of the crimson and the Japan clovers to the mild climate of the South makes these crops particularly valuable as cover-crops in that part of the country. Experiments at the Minnesota Experiment Station have shown that continuous grain-growing is very wasteful of soil fertility, not so much because of the large amount of plant-food removed by the crops as because of

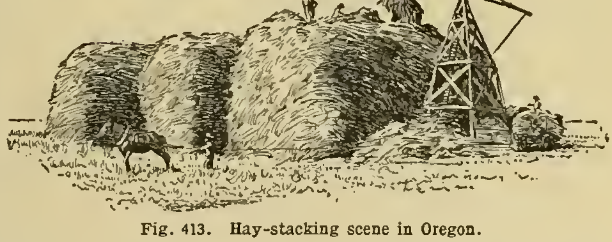

Fig. 413. Hay-stacking scene in Oregon.

the decomposition of the humus and the loss from the surface soil of the soluble constituents. A rotation with cereals and clover was found greatly to reduce the loss from what took place under continuous grain-culture. Most forage crops are also directly less exhaustive of soil fertility than the grain crops, and than many of the truck crops. The grass crop serves, in a measure, as a soil-renovator, preventing the loss of humus and of plant-food by keeping the soil covered with a crop throughout the growing season. The turf and fine "aftergrowth" adds much to the fertility of the surface soil, when the meadows are plowed for cultivated crops. The clovers, and other legumes, so extensively grown as forage, take much of their nitrogen from the air and add considerable to the stores already in the soil. As a rule, forage-cropping and the feeding of the forage to farm livestock is therefore a more economical system of farm management than the direct sale of farm crops.

Incidental Forage-like Plants. Figs. 414–423.

By the *Editor*, *C. F. Wheeler*, and others.

The main forage crops are treated elsewhere in this Cyclopedia, in their proper alphabetical order. There are many incidental and little-grown plants sometimes mentioned in connection with forage and rotation discussions that may be brought together here.

Bird's-foot clover, Bird's-foot trefoil, Yellow trefoil (*Lotus corniculatus*). *Leguminosæ.* A perennial clover-like plant with a long taproot, stems spreading, from a few inches to two feet long, with clusters of five to ten bright yellow flowers on the ends of the stems. It is widely spread in the Old World and naturalized in this country, especially in the South, where cattle and sheep eat it readily. It withstands drought and may be sown in mixtures in dry pastures. It does well on light, sterile soils, and roots deeply. It begins to grow early, and is chiefly valuable as a spring pasture.

Broom sedge. A name applied to several species of Andropogon or Beard-grass, especially to *Andropogon Virginicus*, which is common in sandy soil from eastern Massachusetts to Virginia, Illinois and southward. Stock eat this grass readily when it is young, and it furnishes pasturage during the season. When fields are left without cultivation for a time, it becomes one of the worst weeds.

Buffalo pea. A name given to *Astragalus crassicarpus* (*Leguminosæ*), which grows throughout the Mississippi valley. The straggling stems produce many fleshy pods two-thirds of an inch in diameter, which are relished by hogs, sheep and cattle. The pods appear early in the spring and reach full size the last of April in southern Texas and by June in North Dakota. Successful attempts to cultivate this plant are not on record.

Burnet (*Poterium Sanguisorba*). A deeply rooting perennial herb of the rose family about a foot high, with alternate leaves and small flowers in a dense head. It is a native of limestone regions in central and southern Europe and temperate Russian Asia, where it is used for pasture. Early in the last century it was highly recommended in this country for the same purpose, but it is seldom seen in cultivation at present. It is fairly hardy and somewhat drought-resistant in places. It is not very palatable, and is a weak grower. It is adapted to dry, sandy and calcareous soils. It may be sown in April and again in September in mixtures. It is seeded at the rate of thirty pounds to the acre. The leaves are sometimes used in flavoring soups and other dishes.

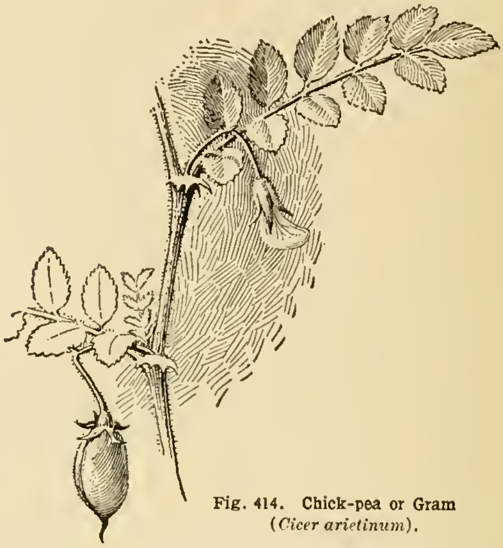

Fig. 414. Chick-pea or Gram (*Cicer arietinum*).

Chick-pea (*Cicer arietinum*). *Leguminosæ.* Fig. 414. Also called Gram, Garbanzo, Idaho pea, Chuna, Bengal grain. A native in Europe, and little cultivated here. It is much grown in southern Europe, Asia and Mexico for its seeds, which are used for cattle food and also as human food. It is a branching annual, growing two feet high, as a bushy, hairy plant. Many upright stems rise from the same root. The leaves have several pairs of small, roundish or oblong leaflets; the flowers are white or reddish, small, single and axillary, on short stalks. The seed is roundish, flattened on the sides, with a projection on one side. The plant matures in about ninety days, and yields little green stuff. The herbage contains a poisonous secretion that renders it unfit for stock feed.

The seed is sown at the rate of thirty to fifty pounds per acre, depending on whether it is drilled or broadcasted. It is planted late in the spring. There are several varieties, adapted to a wide range of soils; a loam soil is best. It is better adapted to arid and semi-arid regions than to humid. It is very sensitive to cold, and likes plenty of sun during its growing period. It is valuable as a nitrogen-gatherer, and the seeds are useful for horse, cattle, sheep and poultry feeding. Under the name of chuna a variety was introduced in the Southwest to be used as a substitute for coffee. The chick-pea is used as an adulterant of coffee.

Chinese yam (*Dioscorea glabra*). *Dioscoreaceæ.* This plant was introduced into this country as a substitute for the potato soon after the rot threatened the extermination of the potato. For a while it was cultivated. It forms a long, club-shaped root two to three feet long, being largest at the lower end. The plant is propagated from small bulblets or tubers that are produced in the axils of the leaves, or from cuttings of the upper part of the root. On a rich loamy soil, the yield of these tubers may exceed fifty bushels per acre. Animals are fond of the herbage, and hogs relish the small tubers that lie on the ground uninjured through moderate winters. In France it is sometimes cultivated by sowing the bulblets broadcast. The roots are extremely brittle, and being largest below they are difficult and expensive to dig. At present it is seldom grown except as an ornamental vine.

Chufa (*Cyperus esculentus*, sometimes known as earth almond). A perennial sedge (family *Cyperaceæ*) that is frequently a noxious weed in low damp places on southern farms. It produces an abundance of small, cylindrical, underground tubers. The tubers or nuts are much relished by hogs. The hogs are generally turned on the field and allowed to harvest the crop. When cultivated, the nut has a fine flavor if properly dried.

The crop does best on sandy soil that has been well fertilized. Heavy soils should be avoided. The tubers are planted early in spring, and about two inches deep. The rows are two to four feet apart, and the tubers are set twelve to fifteen inches apart in the row. No cultivation is necessary, except that weeds must not be allowed to grow. In October or November the tubers will be ripe, and the hogs may be turned on. The crop is recommended for fattening hogs.

Colza. An annual variety of *Brassica campestris* (the rutabaga species), also called summer rape. It is cultivated especially for oil in Europe. It is unfortunate that in England and many parts of the continent the name coleseed or colza has been applied to rape as a synonymous term. They are perfectly distinct; the seed produce of colza is much greater, though inferior to rape. The Swedish turnip is a cultivated form of this plant, bearing somewhat the relation to the normal form that kohlrabi does to the cabbage.

Elliott's Sida (*Sida Elliottii*). *Malvaceæ.* A deep-rooting, malvaceous shrubby plant of some value as a dry-land forage. It is rather drought-resistant, but does best on moist land or under irrigation. It will not stand frost. It is a scant grower, reaching only about one foot in height and bearing little foliage, which is against it. Stock like it, and rabbits are destructive to it. It matures seed, and has been found to volunteer. It has been tested at the California Station.

Fenugreek (*Trigonella Fœnum-Græcum*). *Leguminosæ.* An annual forage and medicinal plant introduced from the Mediterranean region. Stems erect, more or less branched, eight to twelve inches or more high; leaves three-foliolate; leaflets smooth, wedge-oblong, obtuse, coarsely toothed above, about one inch long; flowers one or two in the axils of the leaves, sessile or nearly so, yellowish; pod linear, one and one-half to three inches long, more or less curved, veiny, long-beaked. The seeds have aromatic and stimulant qualities, and are used in veterinary medicine and in patent cattle feeds. The pods ripen successively from the bottom of the plant to the top; this results in the shattering of the older pods, making it necessary to harvest the plant while many of the pods are still green. The yield of seed is small.

Fenugreek is a low grower and cannot be cut to advantage with the mower. It is not a promising crop for soils deficient in lime. It is scarcely worth cultivating for forage, as the yield is small and it is little relished. It endures low temperatures, but requires an abundance of moisture to make winter growth. In its native home, it is seeded in the spring at the rate of thirteen to sixteen pounds per acre, preferably after rains.

Furze (*Ulex Europæus*). *Leguminosæ.* Also called Gorse and Whin. A shrub, native of Great Britain and adjacent parts of Europe, where it is much used as a winter forage, the green sprigs of one year's growth being eaten. Branches dark green, spiny, usually almost leafless; flowers yellow, papilionaceous, axillary and often crowded at ends of branches.

The plant is propagated by seed at the rate of twenty-five pounds per acre, or by greenwood cuttings under glass when used as an ornamental. It grows in waste places and rocky hillsides unfavorable for cultivated crops. It prefers a sandy or gravelly soil and a sunny exposure. The seed comes up sparingly and the plants are usually killed by hot, dry summers. It may furnish some grazing, but is of little value. [Fig. 2608, Cyclo. Hort.]

Fig. 415. Flat pea (*Lathyrus sylvestris*).

Flat pea (*Lathyrus sylvestris*). *Leguminosæ.* Fig. 415. A tall viny plant, native of Europe, introduced about twenty years ago under the name of *Lathyrus sylvestris*, var. *Wagneri*. Wagner improved the wild plant by cultivation and recommended it as a very promising new forage plant. The Experiment Station at Michigan tried the flat pea extensively for ten years, and reached the conclusion that it is of little value as a fodder plant or green-manure. In Kansas it was slow to start, but yielded an excellent forage for a long period. It is adapted to soils that will grow alfalfa. It is very resistant to drought and has been recommended for arid regions. It has given fair results in parts of the South, but its real worth has not been established.

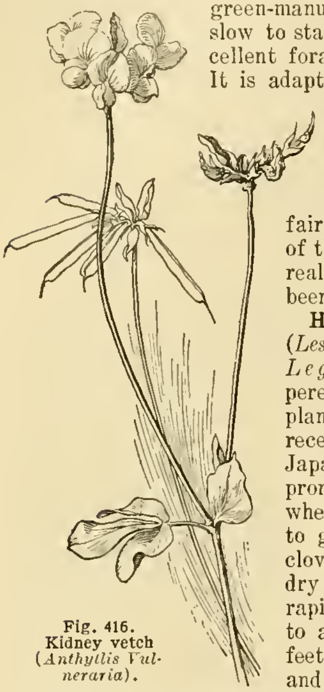

Fig. 416. Kidney vetch (*Anthyllis Vulneraria*).

Hagy or **Hagi** (*Lespedeza bicolor*). *Leguminosæ*. A perennial forage plant, introduced in recent years from Japan, that has some promise for lands where it is difficult to get a catch of clover, and on light, dry soils. It grows rapidly, sometimes to a height of six feet, and is leafy and bushy. It is planted in the spring, sprouts readily, flowers late in summer and remains green until killed by hard frost. Its usefulness is limited somewhat by the fact that it becomes woody soon after blooming. It has small blue flowers and produces a heavy crop of seeds. Grown also for ornament. [See Fig. 1263, Cyclopedia of American Horticulture.]

Kidney vetch (*Anthyllis Vulneraria*). *Leguminosæ*. Fig. 416. Perennial, with spreading stems to a foot high; whole plant covered with short silky hairs; flower-heads in pairs at the ends of the branches; flowers small, yellow to a deep red. It is found throughout Europe and western Asia, from the Mediterranean to the arctic circle. It grows where soil is poor, in limestone regions. It was first cultivated by a German peasant about fifty years ago. It has been reported as of small value wherever tried in the United States. [See Circular No. 6, Revised, page 7, Division of Agrostology, United States Department of Agriculture.]

Krishum. Under this name the inhabitants of Cashmere cultivate a leafy species of the blue-flag genus for forage (*Iris ensata*, Thunb., var. *pabularia*, Naudin, or *Iris pabularia*, Naudin). Figs. 417, 418. Seeds of this plant have been offered for some years by at least one American seedsman, but it does not appear to have attracted much attention. The plant is perfectly hardy and vigorous at Ithaca, New York, on poor soil, but it has not been tried for forage, being used as an interesting border plant. It makes a profusion of ribbed grass-like leaves nearly or quite a half-inch wide, reaching a height of two to three feet. The leaves are said to afford hay and pasturage. It is a perennial, the subterranean parts forming a tough hard growth. The flowers are small, not showy, lilac-blue. Krishum is said to thrive in very dry places.

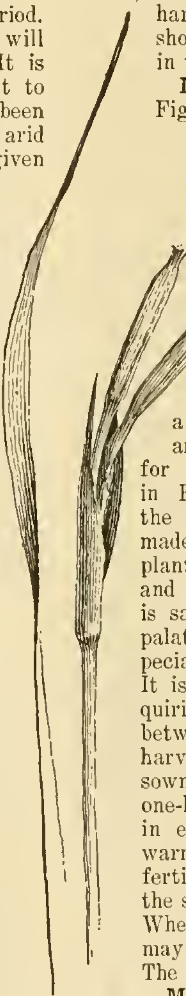

Fig. 417. Krishum (*Iris pabularia*).

Lentil (*Lens esculenta*). *Leguminosæ*. Fig. 419. A much-branched, tufted annual, one to one and one-half feet high. The leaves have several leaflets and end in a tendril. The flowers are small, white or pale blue, axillary and borne in pairs. The pods are short and broad, very flat, and contain two flat seeds. The lentil is a very ancient food plant, and ranks among the most nutritious of vegetables for human food. It is used in Europe and somewhat in the United States for fodder, made from the vines. If the plant is cut early in its growth, and is cured properly, it is said to make a very palatable stock food, especially for dairy cows. It is of easy culture, requiring no special care between seed-time and harvest. The seed may be sown in drills one and one-half to two feet apart, in early spring, preferably on warm, sandy soils of moderate fertility. It is harvested when the stems begin to turn yellow. When the pods are dry the seed may be beaten out with a flail. The plant is hardy and prolific.

Mesquit (*Prosopis juliflora*). *Leguminosæ*. A small, spiny shrub or tree which is the most common woody plant of the southwestern arid region. It is often found in groves with a short trunk much like an apple tree. It is very valuable as a honey plant, as its period of bloom extends over two months. Its forage value lies in the pulpy edible pods which are six to ten inches long, containing about a dozen hard seeds. The pods are very nutritious, and are eaten by natives and travelers as well as by stock. The leaves, pods and bark are rich in tannin. The seeds are said to be next in value to barley for fattening horses, cattle, sheep and hogs.

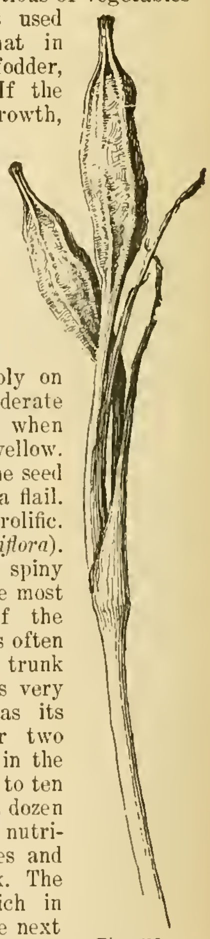

Fig. 418. *Iris pabularia* seed-pods.

Mexican clover (*Richardsonia scabra*). *Rubiaceæ.* Known also as Spanish clover, Florida clover, pigeon weed, ipecac weed, water parsley and others. An annual forage plant, native of Mexico and Central

Fig. 419. Lentil (*Lens esculenta*).

America, but naturalized along the gulf coast and occasionally farther north. Stems branching, diffuse, two to four feet long, creeping; leaves numerous, oval, rough; flowers nearly white, in small heads. In its general habit it resembles red clover.

Mexican clover makes its best growth late in the season and comes into cultivated fields after other crops are removed. It demands a sandy soil for its best growth. The yield of hay may exceed two tons per acre, and is commonly mixed with crab-grass. The hay seems to be succulent, nutritious and palatable to most stock, though feeders are not agreed as to its value. It is not adapted for pasturage. Its chief value is as a renovator of sandy soils, and as a covering for the ground in late fall and winter, to be plowed under in the spring.

Modiola (*Modiola decumbens*). *Malvaceæ.* A perennial forage plant introduced from Chile into California. Its value has not been fully determined. It is much liked by stock and seems to increase the flow of milk when fed to dairy cows. A few growers have considered it nearly equal in value to alfalfa. It has wide adaptability to soils, withstanding alkali, and thriving on either moist or dry lands. It grows readily from either seeds or the nodes on the prostrate stems.

Partridge pea, Sensitive pea, Magothy Bay bean (*Cassia Chamæcrista*). *Leguminosæ.* Fig. 420. A native stout herb with showy yellow purple-spotted flowers, highly recommended in colonial times in Maryland and Virginia for green-manuring [see page 106]. So far as known to the writers it was not used directly as forage, but only to prepare land for forage and other crops. It is one of the plants called "sheep-kill," said to be very purgative to sheep. The practice was to plant the partridge pea with oats in spring, using about one pint of the seed to one bushel of oats. After the harvesting of the oats, the partridge peas grew to maturity and produced a large crop of seed. The next year this land was put in corn. The cultivation of the corn resulted in destroying large numbers of the seedlings, but a sufficient quantity of them came on after the last cultivation of the corn to produce a satisfactory stand. The opinion was general that, with a rotation of oats or rye and corn, it was very advantageous to grow the partridge peas, especially as having once been seeded they persist for many years without re-seeding. To a very slight extent the plant is still used in this way, but owing to the enormous superiority of the cowpea this use has been practically abandoned. [See Trans. Amer. Phil. Soc. III, p. 226 (1793). Magothy bay is in Maryland on Chesapeake bay.]

Prickly comfrey (*Symphytum asperrimum.*) *Boraginaceæ.* Fig. 421. A perennial forage plant; stem erect, two to four feet; leaves dark rich green, long and narrow, abundant, rough, mucilaginous; flowers purple, in nodding, one-sided clusters. It has given greatest success in New York, Michigan and Florida, in the latter state on waste lands. It is now rarely grown in this country. It is said to be much grown in Europe. If cut and fed in the green state, the leaves and stalks make valuable forage. Stock must be trained to like it, as it is somewhat unpalatable. It is used for soiling, but is not to be pastured and does not make good hay. Prickly comfrey produces an abundance of seeds, but is nearly always propagated by cuttings of the fleshy roots. The planting distance varies from eighteen to thirty-six inches each way. As the plants attain a large size, the greater distance is preferable. A light sandy soil is best; several cuttings may be had each year.

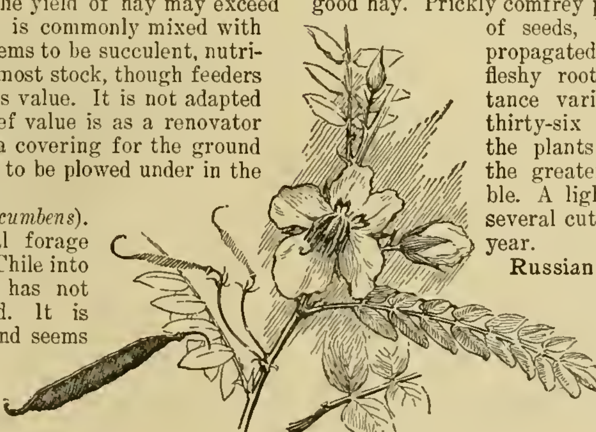

Fig. 420. Partridge pea. An old-time rotation plant.

Russian thistle (*Salsola Tragus*). *Chenopodiaceæ.* Fig. 422. Introduced from northern Europe into the northwestern United States by Russian immigrants about thirty years ago. For a time it was thought that the rapid spread of the pest would render farming impossible west of the Mississippi, but at present it is considered harmless and perhaps of some value as a forage plant when fed early.

Fig. 421. Prickly comfrey (*Symphytum asperrimum*).

Sacaline (*Polygonum Sachalinense*). *Polygonaceæ.* A tall bushy perennial (6–12 ft.) forage plant that gives little promise. It does not grow well from seeds, but may be propagated by root-cuttings. The stems are woody when two to three feet high; leaves broad and heart-shaped. It is not drought-resistant. It met with some success in Florida, where the succulent young stems were relished by stock. It forms a great mass of roots and is tenacious. Once much advertised as a forage plant. (Fig. 1881, Cyclo. Hort.)

Samphire (*Salicornia herbacea*). *Chenopodiaceæ.* A succulent annual plant with leafless, jointed, branching stems six inches to two feet high. It belongs to the goosefoot or pigweed family. It is abundant along the coast from Anticosti south to Georgia; it is also found in salt marshes in the interior from Manitoba to Utah. It is much relished by cattle. Not in cultivation.

Scotch broom (*Cytisus scoparius*). *Leguminosæ.* A leguminous shrub, with yellow pea-like flowers on nearly leafless green stiff branches, native to Europe. (Fig. 423.) It is naturalized in this country, growing on stony or sterile soils and establishing itself in open woodlands. The slender twigs are used in parts of Europe as a sheep forage, being said to be more valuable than furze. It appears not to have attracted much attention as a forage plant in North America. As a naturalized plant it occurs mostly from New Jersey, southward in the seaboard region, and it is reported in Massachusetts and Nova Scotia; also on Vancouver Island.

Shad scale (*Atriplex canescens*). *Chenopodiaceæ.* The most important of the American saltbushes, of which there are about fifty species in the western part of North America. Shad scale is a scurfy, branching, shrubby perennial growing four to ten feet high. The fruit has four broad thin wings looking somewhat like shad scales. It is native of the high valleys and plains of Wyoming, Nevada, Arizona, New Mexico and western Texas. The leaves and branches are eaten by cattle. Seeds are produced in great abundance, often a half bushel or more on a single plant. These are readily eaten by sheep and are considered very fattening. In the Southwest shad scale is found on alkaline soils, and even withstands small amounts of the black alkali. Its resistance to cold adds greatly to its value. (See Farmers' Bulletin, No. 108, U. S. Department of Agriculture; also article on *Saltbushes*.)

Square-pod pea (*Lotus tetragonolobus*). *Leguminosæ.* A quick-growing annual, native of southern Europe, where it is grown for ornament and for salad. It is notable for its heavy production of root-tubercles, making it a valuable soil-renovator. It makes an unusually heavy growth of herbage, having yielded in test plats at the California Station, where it was introduced, at the rate of twenty-four to twenty-six tons per acre, equal to about five tons of air-dry hay. The seeds are rather large, and are borne in four-sided, winged pods. It has been disappointing, however, as it is unable to withstand frost and brief intervals of drought in the winter season, rendering it unfit for field growth.

Sulla (*Hedysarum coronarium*). *Leguminosæ.* A strongly-rooted, vigorous perennial legume with numerous very succulent radical compound leaves

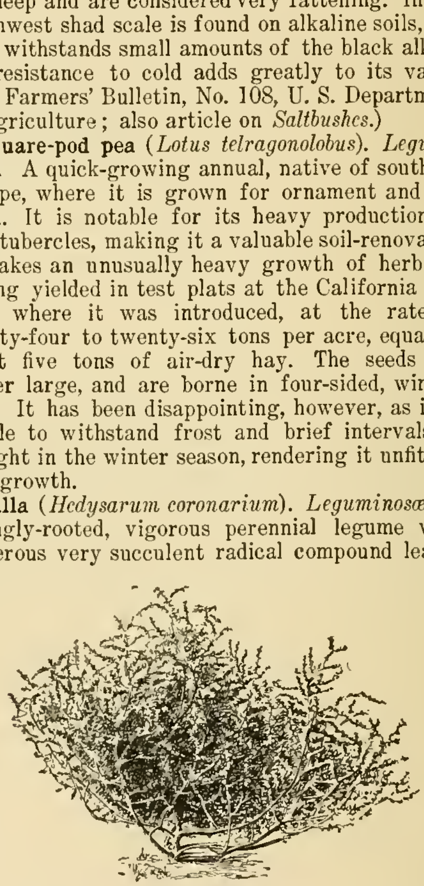

Fig. 422. Russian thistle (*Salsola Tragus*).

one to six feet high, according to soil and climatic conditions. It is a native of southern Europe. In the dry climate of Algeria in soil not irrigated, sulla was the most satisfactory plant grown for feeding and green-manuring. It failed in North Carolina, and was of no value in Michigan. It grows vigorously in early spring, but is tender, and will not stand frost. It is not recommended except in Florida. There it grows through the winter. [Bulletin No. 22, Division of Agrostology, page 57.]

Tarweed (*Madia sativa*). *Compositæ.* A rank-growing annual, native in Chile and California. A variety is said to be a useful plant for sheep pastures in dry soil. It is cultivated in the arid Southwest and parts of California. In many places it is considered a troublesome weed. In Chile it is grown for the lubricating oil contained in its seeds. The leaves have a viscid exudation and the plant has a rank odor. It is spring-sown and grows rapidly after warm weather comes. The seed-heads ripen unevenly and shatter badly.

Fig. 423. Scotch broom (*Cytisus scoparius*).

Tagasaste (*Cytisus proliferus* var. *albus*). *Leguminosæ.* A shrub, native in the Canary islands where it is greatly valued as a forage. It is used there chiefly for cows and is said greatly to increase the flow of milk. On the strength of its reputation there it has been introduced into many countries for the same purpose. It has been tested at the California Station and elsewhere, with rather unfavorable results. Unless kept down by browsing or grown in dry places, it becomes large and woody, good only for firewood. On drier lands it makes a low, shrubby growth that is browsed by stock when the more succulent grasses disappear. All of the plant is exceedingly leafy. It has been recommended for all stock, but has not yet demonstrated such general usefulness. It is said to be unsuitable for horses except as a dry fodder. It is intolerant to frost. It has been recommended for light, dry soils. A loose, friable soil is an advantage, as the taproot can penetrate to greater depths, enabling it better to withstand drought. The soil should be well drained. In favorable situations it grows luxuriantly, and is very attractive because of its dark green foliage and profusion of white flowers which are much visited by bees. It is adapted to barren hilly lands, and will endure for twenty years or more.

Tangier pea (*Lathyrus Tingitanus*). *Leguminosæ.* Tangier Scarlet Pea. A vigorous annual plant, native of Barbary. Stems spreading, winged, glabrous, three feet long; leaflets linear-lanceolate, obtuse, mucronulate; stipules lanceolate; peduncle two-flowered; flowers dark red-purple; pod four to five inches long. The seeds may be used for table use and the plant is liked by cattle. It is spring-planted in close drills. It seems to be hardy, and as a native of the Mediterranean region it should be resistant to heat and drought. It was first tried in California in 1889. It is sometimes grown as a flower-garden plant. [See Fig. 1242, Cyclopedia of American Horticulture.]

Teff (native name of *Eragrostis Abyssinica*). An annual grass of northeast Africa, grown for food; its small grains are made into bread. Two varieties are cultivated, a white and a red variety, the first being much superior to the second. It produces seeds abundantly and may be of use for hay in the southern states. When grown from imported seed, it makes a heavy yield of fine hay, but seed grown in this country has thus far germinated poorly.

White mustard (*Brassica alba*). *Cruciferæ.* An erect, much-branched annual, bearing stiff hairs on the stem. The leaves are deeply cut and rough-hairy. The flowers are yellow. The pods are spreading, hairy, the lower part thick and few-seeded; the seeds are large, roundish, pale yellow, and sticky when wet. It is widely scattered, appearing as a weed, but is grown for its seed, as a catch-crop, green-manure and forage. It is a short-season crop and a rank grower, exceedingly rich in nitrogen, which gives it its value for these purposes. Many attempts have been made to show that it draws on the nitrogen supply of the air in the same way as legumes, but they have failed. As a catch-crop it is most useful, since it may be sown after many other crops are harvested, or in the last cultivation of tilled crops, as corn, when it will serve the purpose of pasture for sheep or young stock, as a cover to prevent soil-washing in winter, conserve soil nitrogen, and improve the soil as a green-manure when plowed under. There is little difficulty in ridding the land of mustard where it has been grown. It is not much used by cattle, and must be supplemented when used for sheep or young stock.

White mustard will thrive on a wide range of soils, but does best on a calcareous loam soil that is well supplied with moisture. It is sown any time after the danger of frost is past in the spring, as it is very susceptible to frost. It may be sown alone for pasture or green-manure, at the rate of six to fifteen pounds of seed per acre, broadcasted. If sown with rape or a like crop, as is recommended to lessen bloating of sheep pastured on the rape, the proportion of mustard to rape should be about one to three. It may be advisable to sow the mustard after the rape is started, as it matures more quickly. The stalks quickly become woody, so it is best to pasture the mustard before it blooms; and when it is to be used as a green-manure it should be plowed under before it gets woody. White mustard, as also black mustard and charlock, are now common weeds.

FORESTS. Figs. 424-487.

If agriculture is the raising of products from the land, then forestry is a part of agriculture. In the past we have considered the forest to be the free and uncontrollable gift of nature, as are the mines, the sea and the air. We have also been obliged, in all the older regions, to destroy the forest to make it possible to practice farming. Unlike the mines and the sea, however, the forest can be renewed. The renewing is a species of cropping. This cropping has its own laws and demands its own special practices, but it is cropping, nevertheless.

Most persons have the tree sense well developed, but do not have the forest sense developed. Ever so many trees may not make a forest. The forest is an organism. One tree has relation to other trees, and it thrives or fails to thrive largely because of that relationship. The forest has climate and weather. It has flora and fauna. The forest must be treated as a unit, not merely as a collection of trees, any more than a city is treated as a mere collection of houses. A person may be ever so skilful in growing forest trees and yet know nothing about forestry. A man may be ever so good a builder, but may know nothing about planning, organizing and administering a city.

The planting and care of trees is *arboriculture*. The trees may be pears, oranges, maples or pines. The raising and care of trees in forests is *silviculture*; this is one part of forestry. Other parts of forestry are forest management, harvesting, marketing.

If a forest is a crop, the product must be harvested. This means that the trees must be cut. The person who merely admires trees, thinks of them as inviolate. They may be inviolate in the yard or on the roadside, but in the forest they are destined for harvest, as are the stalks in a cornfield. If the crop is to be harvested, provision must be made for raising a new crop. As the natural forests disappear, timber must be raised. Some of it must be raised on ordinary farms. With all the use of cement and iron, the demand for timber is increasing. A forest may be as necessary to a good-sized farm as pastures are. The farm forest, therefore, becomes one factor in the general scheme of farm management,—as consciously part of it as the orchard, or the cereal lands, or the live-stock.

If one is to understand what forestry is, he must get it out of his head that natural forests are necessarily perfect forests. From the standpoint of products, man can grow a much better forest than the major part of the natural forests. The natural forests are likely to be as weedy as neglected corn-fields, with whole acres that have a good tree only here and there, and great ranges of trees that are contending with most adverse conditions.

In all the old eastern states, the woodlot is an almost constant part of the farms. It is a ready source of home supplies. In the last census year New York furnished more than seven and one-half millions of dollars' worth of farm forest products (probably one-third of the state is in woodland), leading all the states and being closely seconded only by Michigan. Probably every one of these farm woodlots can be improved more markedly than can the orchards on the same farms.

The novelty of systematized ideas about forest-cropping is indicated by the newness of the word forestry itself. The first lexicon definition of forestry in this country seems to have appeared in Webster's Dictionary in 1880. Even in 1895 the Standard Dictionary defined it as a word of very limited usage. At the present day it is misunderstood by the greater part of the persons who use it: most of them think it means merely tree-planting, even shade-tree planting; others think it means the cutting or lumbering of the native forests. It is not the purpose of the Editor to attempt a definition here—what has just preceded may give a hint, and what is to come will explain some of the field;—but it may be said that it has to do both with the making of new forests and with the utilization of the old ones. A modern cyclopedia of agriculture would be greatly deficient if it omitted a rather full discussion of the subject of farm forests.

While forestry is an agricultural subject, it is also a public policy subject, a fact that is expressed in the German custom of associating forestry instruction with the schools or departments of economics. Forests are concerned with the public welfare in the maintenance of water-courses, regulation of floods, and modification of wind and weather; and they afford a means of utilizing public and communal lands and of providing public supplies. In other countries, whole towns or communities own forests in common. There are regions in this country in which it would undoubtedly pay the town, county or state to purchase lands for the purpose of setting them aside as long-time investments in timber-growing. Under wise management, a town forest might go a long way toward paying town expenses, at the same time that it protected the streams, held back the rainfall, afforded labor in the winter, encouraged thrift in the inhabitants and contributed to the attractiveness and wholesomeness of the region. A man might do far worse than to bequeath a forest to maintain a school (at the same time that it kept the children close to nature and to home), or to aid a charity, or to provide for dependents. The United States and Canadian governments are fully alive to the public policy aspects of forestry questions, as is evidenced by their growing forest services, a subject that will be considered briefly again in Volume IV of this work.

There is still another aspect of the forest that must not be overlooked. It is essentially native, natural and wild. It maintains an area of abundant and free life in the midst of a civilization that razes and levels the surface of the earth. It is part of the real out-of-doors, comparable with the mountains and the sea. No child should be forbidden the influence of a forest; and no nation can afford to lose the forest if it hopes to foster freedom and inspiration.

Plate X. Destruction of American forests by fire. Northern Michigan

Farm Woodlot: Its Place in the Farm Economy.

By *B. E. Fernow.*

When the first settlers in the northeastern United States hewed their farms out of the forest, turning into pasture and field the larger part of their holdings, they left parts uncut for their domestic wood-supply,—the farm woodlot. This was to furnish fence-posts and rails, repair wood for buildings and implements, and, above all, fuel. It was natural to clear the better land first and to leave for the woodlot the poorer parts; and this is proper. Unsuitableness of the ground for farm use and inconvenience of location were probably the main or only considerations by which the woodlot was reserved. It is not likely that the idea of a timber crop, which could be reaped and re-grown at will, like other farm crops, had been present either in locating or in using the crop. It was considered merely a storehouse of material from which the farmer might draw at any time to supply his needs. If the intention had been to make it serve its purpose continuously, it was certainly, in most cases, treated most improperly,—culled and cut without any regard to reproduction. Instead of using first the dead and dying, the crooked and inferior trees, the limbs and leavings, for fire-wood, and thus improving the condition of the remaining growth, body-wood of the best trees was considered none too good for the stove, and the best trees of the best kind were chosen for posts, fence-rails and other inferior uses.

As a consequence of this culling system, which left only undesirable kinds and trees,—the weeds among tree-growth,—many woodlots have become well-nigh useless, mere weed patches. Many have ceased to supply even the domestic fire-wood. The soil, which was of little use for anything but a timber crop, is rendered still less useful under this

Fig. 424. A typical Vermont woodlot (sugar-bush) showing the rocky ground better adapted to forest growth than to agriculture.

treatment. In addition, the compacting of the soil by the constant running of cattle makes the starting of a crop of seedlings nearly impossible. It would not pay to turn it into field or pasture; the farm has by so much lost in value, simply because the woodlot was worked like a mine instead of like a crop. If, after cutting the original growth, a new crop sprang up, this was merely an accident or natural sequence, not a result secured by a deliberate effort or premeditated plan, except in sporadic

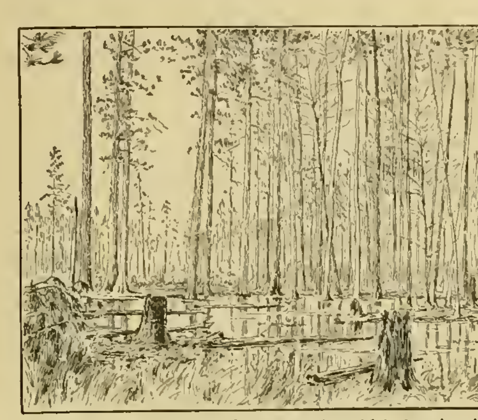

Fig. 425. Forest growth in swamp in which farming is impossible. Absolute forest land.

cases. In the deciduous forest, composed of broad-leaf trees, the sprouting capacity of the stumps was responsible for re-growth, and many woodlots became sprout-lands, which were cut over and over again, also without any care for the stocks, and by this neglect and the browsing of cattle became poorer and poorer. In this way, notably in the southern New England states and Atlantic coast sections, a regular system of coppice, as this kind of sprout-forest is technically called, being cut over every twenty to thirty years, established itself.

There are cases on record, however, and probably many cases have remained unrecorded, in which farmers in the East have deliberately sown or planted pine and other trees for a timber crop. Again, abandoned fields and pastures have been seeded to pine and other kinds of trees by natural processes, increasing the woodlot area. Undoubtedly, there have also been sporadic efforts to improve the resulting timber crop by thinning, and other practices of conservative treatment have existed here and there; but until very lately such efforts have been extremely rare.

In many of the southern states, the proportion of woodland to field in farmers' hands is still such that the woodlot forms the larger part, and the farmed area is shifted by making new clearings, the exhausted farm land relapsing into woodland. Similar conditions are also still prevalent in the western forested sections.

When the forestless prairies and plains were being taken up for farm use, and it became necessary or desirable to plant trees, it was not only or not so much the question of wood-supplies as climatic amelioration that was looked for in the woodlot, and here, therefore, the location was considered with reference to its function as a wind-break; the plantings were made around the house and farm-buildings, or on the windward side of the orchard, or in shelter-belts alongside of fields.

Within the last ten or fifteen years, since not only the stores of the farm woodlots, but the forest resources of the country in general, have begun to show signs of exhaustion, there has been more attention paid to the woodlots, and the propriety of treating them as crops rather than as storehouses or mines, has been frequently discussed. Besides, their value to the farm, aside from furnishing the domestic supply of wood, is also more fully recognized.

In this connection it may be proper to point out that wood prices have risen in the past, and will rise still more rapidly in the future, and hence the neglected woodlot may become a more important

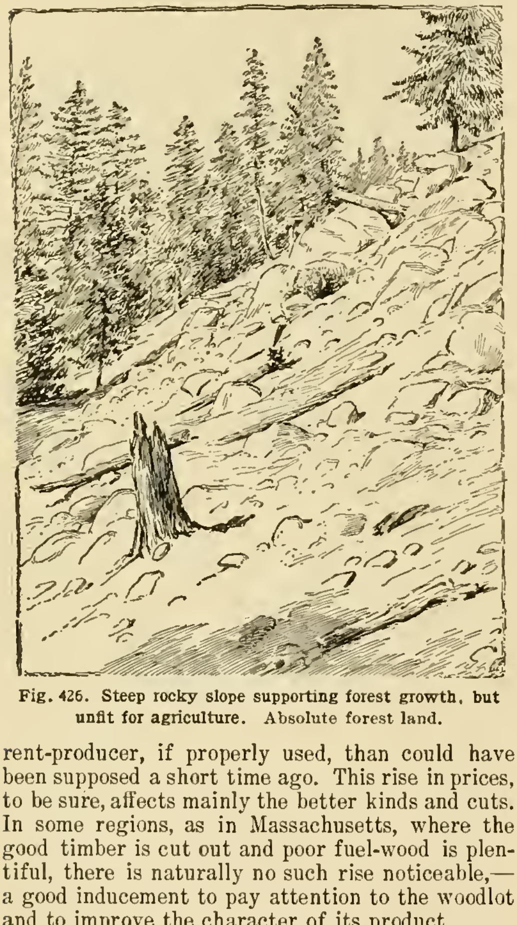

Fig. 426. Steep rocky slope supporting forest growth, but unfit for agriculture. Absolute forest land.

rent-producer, if properly used, than could have been supposed a short time ago. This rise in prices, to be sure, affects mainly the better kinds and cuts. In some regions, as in Massachusetts, where the good timber is cut out and poor fuel-wood is plentiful, there is naturally no such rise noticeable,—a good inducement to pay attention to the woodlot and to improve the character of its product.

One point that the average farmer raises against timber-cropping is that it takes time to grow wood, and one must wait twenty, thirty, forty or more years before one can harvest. This is true. Nevertheless, we insist that it is good policy to bestow the patience required, considering that this crop is frequently growing on soil otherwise useless; that each year it grows nearer to a realizing value, and hence increases the value of the farm, even though it may not admit of harvest,—and all this without any expense, or, at most, very little.

Moreover, with a woodlot already in existence, the time at which the results of improvement in the methods of its treatment are reaped are by no means so distant. The response in increased increment will be soon experienced; with little expenditure, the rate of growth may be doubled and the result reaped within five or six years. This is one of the places where, again and again, mere care in the use has produced astonishing results.

On a well-regulated farm of 160 acres, at least forty to fifty acres could be advantageously kept under wood, even if only the home consumption is to be satisfactorily supplied by the annual growth, and the waste land to be made productive.

Importance of the woodlot.

As to the importance of the woodlots and their value to the nation as wood-producers, we can gain an idea from the Census statistics. For the year 1900 the Census shows that over $100,000,000 worth of wood was cut on farmers' woodlots, and that in round numbers about one-third of the area held in farmers' hands is under wood, or waste fit only for wood production, namely, about two hundred and eighty million acres.

The value of the woodlot to the farmer we may place in four categories :

(1) *As a wood-supply.*—In many cases, the obvious value which lies in the supply of wood materials may be the least important one, and, if there were no other advantages to be derived, the farmer might very well dispense with it. The development of means of transportation and improvement of roads have made coal accessible to many farmers, so that the fuel-supply, to these at least, is not now so important a question as it once was. Again, wire fences are better and often cheaper than the wooden fences. The wood trade in many regions is so well developed that the farmer can buy wood-supplies of any description from the lumber-yard.

But, aside from the fact that these new ways require expenditures of ready cash, the length of haulage and the consequent waste of time and energy often make it economy to rely on home supplies. There come times, also, as in continued snow-blockades or during coal strikes, when independence from such market supplies is appreciated; many farming communities deficient in woodlots have suffered fuel-famines which set them a-thinking about their waste places that might have furnished the needed fuel.

Yet we must admit that, with the exception of such rare occasions, the wood-supply question frequently may not of itself be a sufficient reason for maintaining woodlots.

(2) *As a poor-land crop.*— The greatest value of the woodlot is that it is capable of producing more returns from certain parts of the farm than any other crop, from those parts which are not fit for farm use because of soil conditions or topography. We have heard a great deal about unprofitable farming. We feel sure that, in many cases, lack of proper adaptation of crop to soils and lack of consideration for the small matters, neglect of the

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apparently unimportant corners of the farm, may account for it. There are on most farms soils that are fit only for timber crops; there are also everywhere conditions of farm soils and of markets which make it doubtful whether farming the soil pays; others, where pasturing is the only profitable use of the ground; and, again, others where, although farm crops might still be raised, timber cropping alone is advisable.

A German authority on farming matters some years ago made an extensive investigation to find out when, under the conditions prevailing in his country, it was more profitable to abandon farming and to plant to forest. He found that on land fit only for oats and rye, which does not give a net yield of more than eighty cents per acre, or on wheat soil of more than one dollar and eighty cents per acre, it would pay better to plant to forest, pine in the first case and spruce in the second case, provided the owner could wait forty or fifty years for the return. According to various circumstances, the financial result from wood-cropping would then be 15 to 60 per cent higher than the accumulated farm returns, with wood at three to seven cents per cubic foot, and an annual production of sixty to seventy cubic feet per acre, say two-thirds of a cord. Although we cite this calculation from a foreign country, where entirely different conditions of market exist, merely to make it clear that such matters are capable of calculation, yet the figuring may not vary so very much in this country with spruce wood worth now four cents or more, and pine in places bringing twelve to sixteen cents per cubic foot.

(3) *Utilizing of labor.*— A value not to be underestimated lies in the fact that the work in the woods can be performed at the season when other work is slack. This factor is discussed at length in the succeeding article.

(4) *In its influence on its environment.*— Lastly, we should mention the influence of the woodlot on

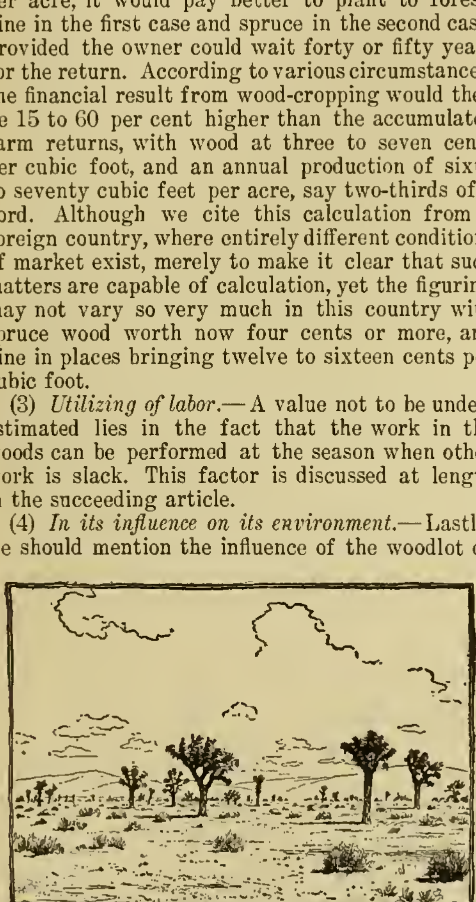

Fig. 427. Desert where yuccas still maintain themselves, but farm crops fail entirely. (Figs. 424 to 428 are from photographs loaned by the Forest Service.)

the climatic, soil and water conditions of the farm, wherein in some situations may lie its greatest value: not only on the wind-swept prairie farms, but in the eastern and southern sections of the country as well. We are not inclined to overestimate these influences. But we do know that springs have run dry when the shading wood was cut off and were replenished when forest conditions were reëstablished. Not everywhere and under all circumstances will this be experienced, for there are other influences at work which give rise to springs and which may be so potent that the forest influence becomes negligible. Yet the fact that in general on mountain slopes a forest cover is influential in producing equable water conditions, that it prevents erosion and washing of the soil, is not doubted by any one who has studied the history of the results of deforestation in France, where thousands of farmers became homeless by the terrible work of the torrential mountain streams and where, by reforesting, favorable conditions have been reëstablished. In our southern states, especially where the compact soils are liable to gullying, the proper location of woodlots, together with proper methods of cultivation, will reduce this danger.

Fig. 428. Characteristic root system of trees, enabling them to grow on soils and situations unsuitable to farm crops.

The philosophy of this forest influence lies in the fact that a forest cover changes surface drainage into sub-drainage, checking the rush of water over the ground by the litter, brush and tree trunks, and thus giving time for it to penetrate the soil and to drain off slowly. Generally speaking, larger amounts of water penetrate the soil and are stored under forest growth, which prevents rapid evaporation. Later it becomes available by subdrainage, feeding the springs and other subsoil waters, and thus ultimately becoming a benefit to neighboring fields. This action presupposes that the effective forest floor of mulch and litter and shrubs has not been destroyed by fire or by overpasturing and tramping by cattle.

The farmer in the West has learned by experience the benefit of the windbreak, and orchardists have long known its value; but that crops in fields protected by timber-belts yield better than in unprotected fields, and especially that winter frosts are prevented by such protection, is not fully realized by farmers. By preventing deep freezing of the soil the winter cold is not so much prolonged, and the frequent fogs and mists that hover near forest growths prevent many frosts. That stock will thrive better where it can find protection from the cold blasts of winter and the heat of the sun in summer, is another fact which gives value to the woodlot where stock is kept out.

Experiments have shown that every foot in height of a forest growth will protect one rod in distance, and a series of small timber-belts would produce most favorable farm conditions.

This windbreak benefit, as well as that of regulating water and soil conditions, is secured by proper location of forest areas. While, therefore, in the first place, soils and situations unfit for farm purposes are to be selected for the woodlot, to secure its beneficial influences may make other disposition desirable.


Fig. 429. American larch (*Larix Americana*).

Factors in woodlot management.

Choice of species.—While we speak of a timber crop as one, there is quite as much variety possible in timber crops as in farm crops. Not only are there many different kinds of wood, each possessing distinct qualities and fit for distinct employment, but there are differences of treatment which produce differences of result. There are the conifers,—pines, spruces, hemlocks, firs, larch, cedar and the like,—which furnish building materials and grow from seed only (with few exceptions), requiring a long time to make suitable size for the purpose for which they are best fitted; and there are the broad-leaf trees of great variety, hard and soft woods, fit for a variety of purposes, and often becoming available for use sooner than the conifers, capable of reproduction by sprouting from the stump (coppice) as well as by seed.


Fig. 430. Arborvitæ (*Thuya occidentalis*).

Whether it be in the management of an established woodlot or the starting of a new plantation, a choice of species and method of treatment must be made from the first, with the object clearly in view that the crop is to serve.


Fig. 431. Bald cypress (*Taxodium distichum*).

Limitations as to output.—We have started to consider the woodlot as destined, in the first place, to supply domestic needs of fuel and small-dimension material; but the question may arise whether it could not be managed with a view to supplying the general market. By general market we mean the requirements of sawmills and lumber-yards. Excepting special cases, the farmers' woodlot is not well fitted for the practice of commercial forestry,—the growing of timber for the general market. The reasons for this inaptitude are partly economic, partly based on the natural history of forest-growth, and on silvicultural peculiarities.


Fig. 432. Black walnut (*Juglans nigra*).

Wood is a crop which, unlike other farm crops, does not have a physical maturity indicating the harvest time. This time is a question of decision by the harvester, based on financial considerations, or on considerations of size. Size is ultimately the basis of financial considerations also, for with increasing size the usefulness and value of the tree increases; and size is, of course, a question of time. Therefore, by the accretion in diameter and height, the timber crop not only grows in volume annually, but in value also. Practically valueless until, say ten years, it then may begin to be fit for hop-poles, hoop-poles, bean-poles and the like; at twenty years, not only a larger amount of good fuel wood, but posts and fence-rails may be cut; at thirty years, in addition, telegraph poles and railroad ties and perhaps some other small-dimension material may be secured; but to grow logs for mill use we should have to wait twice that time. It would be rare to get satisfactory log sizes before sixty to seventy years, for the sawing of logs of small dimension is wasteful and unprofitable; for example, the loss in slabs and saw-kerf with logs twelve inches in diameter, under best practice is still over 30 per cent, and of logs eight inches in diameter may be over 60 per cent. And since with most species, on the poorer soils which are to be devoted to the timber crop, even these sizes are not plentiful, though the crop is well tended, the long-time element involved would, in most cases, deter the farmer from engaging in growing saw-timber.


Fig. 433. Butternut (*Juglans cinerea*).

There are also reasons against such a proposition, which lie in the nature of forest development and the limitations of the woodlot. If size of the tree is of importance in determining its value and harvest time, size of the area on which forestry is to be practiced is of importance in determining the purpose and method of management. The limited size of the woodlot, say fifty acres at most, if a continuous business with annual harvests of sixty-year-old timber were contemplated, would make the annual harvest so small as to appear impracticable except under special conditions, while an intermittent management, under which larger areas or quantities from period to period are harvested, may find equal objection because of the requirement of the sawmills for assured amounts of annual supply. The growing of log timber in the woodlot, therefore, in most cases will be found impracticable as a business proposition. In addition, the usually isolated position of the wood-lot in small patches is inimical to timber-growing. Exposed on all sides to the drying winds, the soil under the older trees standing more open is likely to deteriorate, and not only thereby is the increment on the standing timber reduced, but natural regeneration is impeded, and other silvicultural practices are rendered more difficult, unless special pains are taken to preserve a "wind mantle" on the outskirts. Altogether, it will be found in most places impracticable to devote the woodlot to any other purpose than the production of home supplies of fuel and small-dimension material.

Coöperative management.—The difficulties mentioned, however, could be overcome and the farmers' woodlands profitably devoted to log-timber production, if they were located together and managed coöperatively under one plan. Such coöpera-

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tive management by farmers exists in Europe; it has the same advantages as any trust organization, and makes possible the conduct of forest-cropping in a business-like way under business conditions, and under direction of a competent manager. This would be impracticable for the individual owner.

Distinction between field and forest crops.—While the farmer is the cultivator of the soil and has this general calling in common with the forester, and hence may properly learn to manage his forest crop, he must realize that the farm crop and the forest crop have, after all, not very much in common, and he must appreciate the difference between the two, if he is to make a success of his woodlot management.

We have seen that, from the business point of view, the long time of development and the absence of a definite maturity indicating harvest time make an essential difference between field crops and forest crops. When to cut the timber crop is a matter of judgment and calculation, based on measurement. There are in every vocation of life those who conduct their business indifferently by the "hit or miss" method, without measuring or figuring; but, even if farming could be conducted by such a method, for a mistake in one year can be corrected the next, it is most detrimental in forest-cropping. Mistakes often show themselves here only after many years, and can be corrected only once in a lifetime. Much more deliberation is advisable, and measuring and figuring are indispensable, if business success is desired in forest management.

Not less striking is the difference in the natural history of the two crops and, in consequence, of their treatment. This difference lies essentially in three directions: (1) the forest crop makes different demands for its development from the field crops; (2) is not necessarily reproduced by cutting and replanting, as is usual with farm crops, although this may be done; and (3) its development cannot be influenced to any extent as in farm crops, by the methods of fertilizing and cultivating the soil with which the farmer is familiar. By the mere mode of harvesting the old crop, the new crop can be produced, and almost alone by the use of the axe can its development be accelerated.

The most important condition which in these operations needs consideration is the light which is at the disposal of the different components of the crop. The timber crop, as a rule, is not of one kind, but of different species in mixture which grow at different rates and make different demands for light; or, at least, it is of different-sized trees, and the question arises which of them to favor with additional light by removal of their neighbors. We see, then, that while the forest crop, like the wheat crop, consists of masses of the crop plant, unlike the wheat crop the single individual in the forest crop requires attention.

It is the manipulation of light conditions, also, that provides a desirable seed-bed, secures plentiful seed production, gives a satisfactory start, and influences the progress of the young crop.

The forest crop makes very little demand on the elements of plant-food in the soil, getting its carbon from the air and drawing on the soil chiefly for water. [This question is discussed in detail in the succeeding article.]

Again, the farm crop is dependent on the weather, success or failure being a matter of the seasons of each year, and the operations of sowing, cultivating and harvesting requiring prompt attention. The forest crop, although also dependent on the season, is never an entire failure, and, consisting of the accumulations of annual increments, averages up the good and the bad seasons in its final harvest.


Fig. 434. Mountain ash (*Sorbus Americana*).

There is also a greater latitude as to the time when operations in the forest crop may be performed. A few years' difference in making the desirable improvement cuttings does not entail heavy loss, and only when attention is required by the the young crop may a few weeks or months of delay be detrimental. The harvesting may usually be done when convenient.


Fig. 435. White ash (*Fraxinus Americana*).

Finally, in the woodlot managed under coppice or under coppice with standards (that is, a coppice-growth with a short rotation, with occasional trees [standards] which are given a longer rotation), which are the most suitable systems for a farmer's use, only a little knowledge and skill are required to make a success. As has been pointed out, a simple, judicious working plan, laid out once for all, is desirable with a crop which takes such a long time to mature, while in the farm crops changes from year to year may be desirable.


Fig. 436. Hop hornbeam or ironwood (*Ostrya Virginica*).

Forest distribution in the United States.

We may anticipate a very different attitude of farmers to their woodlots and a very different treatment in the different sections of the country by virtue of the difference in forest conditions, as well as in market conditions. From these points of view we can divide the country variously into regions.

Botanically speaking, it has been customary to divide the country from east to west into three great regions: (1) Atlantic forest region,


Fig. 437. Beech (*Fagus ferruginea*, or *F. Americana*).

bounded by the Mississippi basin on the west and reaching south into Texas, once a large hard-wood forest, often mixed with conifers which also sometimes occupy extensive areas by themselves. (2) The Pacific forest region on the western mountains, composed almost exclusively of coniferous growth, and (3) the prairies and plains region, between the first and second regions, bearing only scattered tree growth, mainly along the water courses.

Fig. 438. Black locust (*Robinia Pseudacacia*).

If we add climatic and economic considerations, many more subdivisions may be made, and certainly not less than a dozen would fairly represent the different conditions.

Fig. 439. Honey locust (*Gleditschia triacanthos*).

Maine, perhaps the best wooded state in the country, is still so much in the woods that it stands by itself; but, taking the entire New England states as a group, we find that they are still one-half in woodland, and, according to the nature of the topography and soil, must remain so for many years. This is also the most densely populated section of the country, and the farmer's woodlot, which is usually within easy reach of a market, should occupy an important position and would pay well if properly cared for, and if not merely abandoned to eke out an existence. Coppice-growth and white pine groves on abandoned pastures and fields are the characteristic features of the woodlot area.

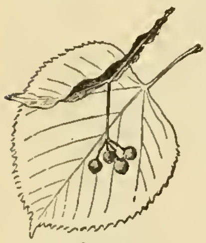

Fig. 440. Basswood (*Tilia Americana*).

Not very different are the conditions in the Middle Atlantic states, except that a much larger area is and can be under cultivation, more than one-half being now under farm. Hard-woods, especially chestnut and oak, are in preponderance. The easy reproduction of the white pine, which is a striking feature on New England farms, is not seen here.

Fig. 441. Western catalpa (*Catalpa speciosa*).

The Southern Atlantic states exhibit at least three different topographic regions: the coast region of sandy lowlands and swamps, in which coniferous growth prevails; the foothill region of mixed growth; and the mountain region in which hard-woods are most prominent. These states are still almost as extensively wooded or else as unfit for agricultural use as Maine, but have only one-third the population per square mile of the first two divisions, hence, the woodlot question is probably rarely raised. Abandoned or neglected fields grow up so readily to wood that the forest constantly threatens to regain its empire.

Much the same conditions prevail in the Gulf states, except that here the lower half is mostly an extended, sandy, pine forest, the northern uplands having hard-wood with pine intermixed. Hardly 20 per cent is cultivated, and the population is still very much less than in the Southern Atlantic states.

The central southern states, north of this group, are much better developed, with over 35 per cent under farm and a population as dense as in the southern Atlantic states. The forest is mainly hard-wood and is densest in the eastern mountain region.

The largest farm area is found in the three states, Ohio, Indiana and Illinois, with over 70 per cent of the land improved and a population which rivals in density the New England states. Here is another region in which proper management of the woodlot would unquestionably pay, since scarcely over 12 per cent is in forest, and the waste land scarcely 18 per cent, most of which could probably also be utilized for timber crops. These states are almost devoid of coniferous growth.

The lake states, which have supplied the bulk of our lumber consumption for so many years, are being rapidly exhausted of their coniferous growth, although the extensive hard-wood areas will still hold out for a generation. The southern parts are sufficiently densely populated to make attention to farm forestry worthy of consideration.

Placing in one division, although climatic and economic conditions are variable within it, the great and practically forestless interior area of approximately one million five hundred thousand square miles, we have that part of the country in which timber-planting has been long practiced, where climatic amelioration is the main function of the woodlots, and where there is endless opportunity for further extension and more rational management.

The Rocky mountain region is relatively scantily wooded with short coniferous growth, improving to the northward. Farmers and miners will some day bemoan the destruction by fire which has so uselessly wasted thousands of square miles.

The mountain regions of the Pacific coast states are still so densely wooded with magnificent coniferous growth, that the practice of farm forestry probably could not find lodgment even in the agricultural valleys adjoining. But in southern California there are forestless regions where the woodlot, planted eucalyptus groves, has already earned its well-appreciated position.

Forests of Canada.

The forest area of Canada, including the woodlands of the northern territories and of the prairies, is estimated at approximately 1,250,000 square miles, but the area in strictly commercially valuable wood probably does not now exceed 500,000 square miles, nearly half of which is in British Columbia. Commercial timber is now, and will continue to be, secured from the forests of the old eastern provinces and British Columbia, the remaining territory being either forestless or depleted of its valuable timber. Some twenty-five millions of acres have been cut out in the settlement of the country for farm purposes.

The composition in general is the same as that of the northern forest in the United States: hardwoods (birch, maple and elm prevailing) with conifers mixed, the latter, especially spruce, becoming pure occasionally. The nearly pure hardwood forest of the southern Ontario peninsula has been supplanted almost entirely by farms, and here, even for domestic fuel, coal, imported from the United States, is used. Although white pine, the most important staple, is found in all parts of this forest region, the best and largest supplies are now confined to the region north of Georgian bay. Unopened spruce- and fir-lands still abound, especially in Quebec on the Gaspé peninsula. Spruce forms also the largest share in the composition of the New Brunswick, Nova Scotia and Newfoundland forest, the pine in the first two provinces having practically been cut out. Extensive, almost pure balsam-fir forest, fit for pulp wood, still covers the plateau of Cape Breton, while Prince Edward island is to the extent of 60 per cent cleared for agricultural use.

Much of this eastern forest area is not only culled of its best timber, but burnt over, and thereby deteriorated in its composition.

North of the Height of Land (a plateau with low hills, which cuts off the Atlantic region from the northern country, and marks the northern limit of commercial forest) in Ungava and westward, spruce continues to timber line, but, outside of narrow belts following the river valleys, only in open stand, branchy and stunted, hardly fit even for pulp, for the most part intermixed with birch and aspen. This open spruce forest continues more or less to the northern tundra and across the continent to within a few miles of the mouth of the Mackenzie river and the Arctic ocean, the white spruce being the most northern species. In the interior northern prairie belt groves of aspen, dense and well developed, skirt the water-courses and form an important wood-supply.

The forests of British Columbia partake of the character of the Pacific forest of the United States, the Coast Range with conifers of magnificent development, including Douglas fir, giant arborvitæ, western hemlock, bull-pine and a few others, the Rocky mountain range also of coniferous growth, but of inferior character, large areas being covered with Alpine fir and lodge-pole pine, important as soil cover and for local use in the mining districts, but lacking in commercial value.

For farm forestry, the southern part of Ontario offers the most promising field, for probably 50 per cent of the farm area would be better under wood. Beginnings of forest planting and woodlot management have been made here within the last few years with the aid of the Agricultural College at Guelph.

Factors in Timber Production. Figs. 424–428.

By *Raphael Zon.*

Although the growing of wood, inasmuch as it must make use of the soil, is a part of agricultural production, yet it has many distinctive features which justify discussing it independently. A clear understanding of the way in which wood crops grow, and of the factors involved in their production, is essential to an intelligent treatment of the farmer's woodlot.


Fig. 442. White oak (*Quercus alba*).

Three factors are invariably present in the production of all raw materials,—nature, labor, capital; and it is the way in which these factors are combined in the production of timber crops that distinguishes the latter from all other agricultural crops. While these factors have been brought out in the preceding article, it is important that we here emphasize certain features, that we may more clearly comprehend their relation to forest production, and hence to the adaptation of the woodlot to the farm scheme.


Fig. 443. Red oak (*Quercus rubra*).

Nature.

In no other agricultural crop does nature play so prominent a part as in the production of wood crops. In raising field crops the farmer deals, as a rule, with annual plants, tender and highly plastic, which have had their original characteristics radically changed in accordance with the needs and wishes of man. In the production of timber, one deals with tree-species, perennial, wild plants, yielding with difficulty to human influence. The long period, often more than a lifetime, required by trees to grow from seed to maturity, prevents man from leaving his impress on them; while the short cycle of development of agricultural plants offers opportunity, year after year, to mould and adapt them to the conditions desired. This explains, to a large extent, why our farm crops are now being widely grown in climates very different from those of their original home, while only comparatively few tree-species have been extended beyond the limits of their native region. By proper planting or timely thinning, to be sure, one can stimulate the growth of trees in

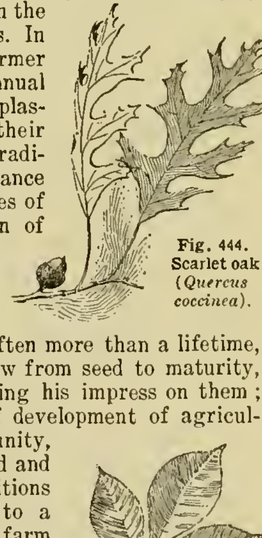
Fig. 444. Scarlet oak (*Quercus coccinea*).

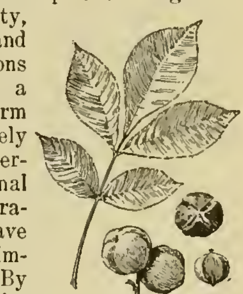
Fig. 445. Shagbark hickory (*Hicoria ovata*).

height or thickness, produce clear boles, or even improve the quality of their wood; but the power of influencing the inherent character of the species by breeding forms adapted to new climatic or soil conditions is very limited. During the long time required for the ripening of timber crops, man must practically remain a passive observer, leaving nature to do all the work of growing the wood. Timber crops must be considered, therefore, largely the work of natural forces; at least, our American forests, with very few exceptions, are a wealth produced not by labor or capital, but accumulated by nature without the assistance of man.

Although so essentially the product of the free forces of nature, the forest claims from nature much less than agricultural plants (the demands which plant-life makes on nature are the requirements of climate, soil and topography). In the North and in the mountains, the forest extends beyond the range of the hardiest cultivated plants, where, together with pasture and meadow, it is the only possible means of utilizing the soil.


Fig. 446. Tulip tree (*Liriodendron Tulipifera*).

Forest trees, as a rule, are far less sensitive to unfavorable climatic conditions than most agricultural plants. A prolonged drought that proves ruinous to farm crops is often not felt at all by forest trees, which depend for their water-supply on the deeper layers of the soil.


Fig. 447. American Elm (*Ulmus Americana*).

The forest, although it thrives best on good soils, will grow also on soils lacking the chemical and physical properties necessary for the support of agricultural crops. This is demonstrated by the magnificent pine forests which grow on dry, sandy soils, and the good growth of arborvitæ or balsam fir in swamps. The ability of forest trees to grow on poor soil is doubtless due partly to their roots, which penetrate deep into the ground and spread over large areas searching for water and food; but it is due mainly to their slight demand on the nutritive substances of the soil, especially the minerals. Beech, for example, needs annually but one-third, and the pine but one-sixth of the amount of mineral substances required by a field of wheat of the same area. Roughly speaking, the amount of mineral substances required by forest growth is about one-half of what is needed by agricultural crops, as may be inferred from the following comparative analyses of the ashes of forest and agricultural products, made by Ebermayer (Physiologische Chemie der Pflanzen, 1882: Vol. I, page 761):


Fig. 448. Chestnut (*Castanea dentata*).

Amount of Mineral Substances Consumed by Agricultural and Forest Crops Per Acre Per Year.

	Mixed agricultural products	Forest growth		Approximate ratio of forest to agricultural demand for mineral substances
		(a) Wood and leaves	(b) Wood only	
	Lbs.	Lbs.	Lbs.	
Silica (S_1O_2)	37	29	1.6	3/4
Potash (K_2O)	78	11	4	1/7
Lime (CaO)	43	62	9	3/2
Magnesia (MgO)	17	10	2	2/3
Phosphoric anhydrid (P_2O_5)	28	8	1.4	2/7
Sulfuric anhydrid (SO_3)	11	3	0.4	1/4
Other constituents	21	3	0.6	1/7
Total amount	235	126	19	1/2

Especially significant is the relation of wood and farm crops to nitrogen, the most indispensable element of plant life. The sources of nitrogen are precipitation, assimilation of the free atmospheric nitrogen, as by the root tubercles of the leguminous plants, and fertilizers. Precipitation furnishes yearly about 10.7 pounds of nitrogen per acre. An acre of beech forest consumes every year 45 pounds of nitrogen, fir forest 37 pounds, spruce forest 35 pounds, and pine forest 30 pounds; an average crop of potatoes consumes 54 pounds, wheat 55 pounds, rye 47 pounds, and barley 39 pounds. For the building up of leaves, four to five times more nitrogen is consumed than for the building up of the wood itself. The 10.7 pounds of nitrogen conveyed annually to an acre of soil by precipitation is just sufficient for the production of the wood substance, but not for the leaves. The nitrogen required for the production of the leaf substance is furnished by the forest itself in the form of fallen foliage and needles that have stored up large quantities of nitrogen. In farming, the need of nitrogen above the amount supplied by precipitation must be artificially introduced into the soil by manuring or fertilizing, or by the use of legume crops.

Since the bulk of all mineral substances is also deposited in the foliage and not in the wood (see table), the forest trees, every fall, return to the soil, in the form of dead leaves, the greater part of what they have taken up through their roots. Thus forest trees, in addition to furnishing their own fertilizer, by bringing up mineral substances from the deeper layers of the soil and depositing them on the surface, accomplish practically the same result that is brought about in farming by deep plowing. Therefore, the soil under the forest (provided the leaf litter is not removed or other-

Plate XI. A well-managed forest. "Cathedral Aisle" of white pine, Intervale, White Mountains, New Hampshire

wise destroyed) is constantly gaining in fertility instead of becoming exhausted,—just the reverse of what happens in farming, where every harvest impoverishes the soil by depriving it of a part of its nutritive substances.

While farm land must, of necessity, be fairly level, since a slope of 20° renders it unfit for tilling, and an incline of 25° unfits it even for pasture, gradients up to 45° are still capable of sustaining tree-growth. On slopes from 5° to 30°, the forest finds its true home, producing there more wood, and often yielding greater revenues than when grown in the valley. The reason for the increased growth of trees on moderate slopes is to be found in the stimulating effect of favorable exposures with their greater amount of light and air, of more perfect drainage, and of greater protection from wind and frost than is usually found on flat ground.

The ability of the forest to grow on situations too poor or otherwise unfit for agriculture led to designating such situations as absolute forest land (Figs. 425–6). To absolute forest land, therefore, belong all territory north of the range of cultivated plants, all steep slopes, gullies, situations too rocky or too dry for agricultural plants, and swamps. It is impossible, of course, always to draw a distinct line of demarcation between absolute forest land and other land, since the soil may be artificially improved, as, in the case of swamps by drainage, but such improvements are, as a rule, very costly, and in this country, where there is still a comparative abundance of land, the absolute forest soil may be made profitable without improvements, by devoting it to forest growth, for which it is fitted, as it were, by nature itself.

Labor.

The raising of agricultural crops demands a great amount of human effort. The land must be plowed, harrowed, manured or otherwise fertilized, the seeds put in the ground, the harvest gathered and threshed, and all this has to be repeated year after year.

In the growing of wood crops the application of human labor is very limited. The forest provides for the fertilization of its own soil, new crops start, as a rule, from self-sown seeds transported by wind or birds, or from stumps or roots of old trees, and wherever man does undertake to assist nature by sowing or planting cut-over land, the work on the same area has to be done only once in many years. It is only the harvesting of the timber crops which requires any considerable labor, and this occurs at very long intervals. Tens, often hundreds of years must pass before the new crop becomes ready for the axe.

While farm crops must be harvested as soon as they ripen, a delay of even a few days often causing considerable loss, the harvesting of timber crops may be postponed for many years without injury to the crop, and can be done at a time and rate most profitable and convenient to the timber owner.

The relative importance of labor as a factor in the production of timber and farm crops is well shown by the fact that while the 414,000,000 acres of improved farm land, given by the Twelfth Census, engage 10,000,000 men, or one man to every forty acres, the 700,000,000 acres of forests engage only 120,000 men, employed in harvesting the timber and getting it out to the nearest points of shipment, or one man to every 5,800 acres. This difference is especially large in this country because most of the labor that is employed in our forests is engaged solely with harvesting and transporting the timber crops, and practically none with forest-culture proper, which is still in its inception.

Fig. 449.
Cottonwood (*Populus deltoides*).

But even in forests managed most intensively, only one-tenth to one-thirtieth of the labor required by an acre of farm land is needed per acre of forest land. The different branches of agricultural production may be arranged in the order in which each calls for labor, beginning with that which needs least, as follows: Ranching, wood-growing, hay-raising, production of cereals, fruit-growing and truck-farming.

Fig. 450.
Box elder (*Acer Negundo*).

At a smaller expenditure of labor, forest land is capable of producing at the same time an equal, if not a greater amount of useful vegetable substance than farm land. Thus, common farm crops yield on an average 3,400 to 4,600 pounds of vegetable substance per acre; of this, only about one-third (1,000 to 1,500 pounds) is in the form of grain. An acre of forest produces under human care 8,000 to 10,000 pounds of vegetable substance annually, and of this about one-half is in the form of wood, the remainder being roots (450 pounds), and leaves (3,000 pounds). Deducting from the wood the amount of water held by it mechanically, there remains 1,500 to 3,600 pounds (dry weight) of vegetable substance, as the product of one acre in one year.

Fig. 451.
Silver or soft maple (*Acer dasycarpum*).

Putting these facts together with the Census figures, according to which there is one man for every forty acres of improved farm land, the inference may be drawn that in agriculture the labor of one man is instrumental in raising annually 40,000 to 60,000 pounds of useful vegetable substance; the same amount of labor expended in growing wood crops could pro-

Fig. 452.
Hard or sugar maple (*Acer saccharinum*).

duce under forest management of similar intensity, between 400,000 and 600,000 pounds of useful vegetable substance, or ten times as much. These figures, of course, must not be considered, even for a moment, as absolute. To begin with, the average acreage of farm land cultivated by one man, as given by the Census, is altogether too large, since not all land that has been reported as improved farm land is actually cultivated,—a great part of it remains idle. These figures are merely brought forward to illustrate approximately the relative rôle which labor plays in the production of wood and of agricultural products.

Fig. 453. Red cedar (*Juniperus Virginiana*).

Capital.

Wood-cropping, to be done continuously, needs investment of capital, and, in a certain sense, of a larger capital than is required for farming. The form in which most of the capital is tied up in wood-cropping is very characteristic of forestry as an industry. It is not the land that claims most of the investment, since land devoted to forest growth is, as a rule, poorer and therefore has a considerably lower value than farm land. Nor do buildings, tools, machinery or labor absorb much capital, because all these items are a source of considerably less expenditure in forestry than in farming. The forest crops do not need buildings to house them; the tools used in harvesting or caring for the harvest are very simple and inexpensive; the application of machinery, with its concentration and division of labor, is very circumscribed because of the bulkiness of the product, and because variety in the size and shape of trees requires the constant exercise of judgment on the part of the wood-cutter; there are no seeds nor manure to buy; very little wages need be paid. In other words, the capital needed for defraying the current expenses of growing wood-crops is small as compared to that needed for raising agricultural crops. Thus, while in Europe the current expenditure per acre of forest land managed most intensively does not exceed two dollars on the average, according to the figures of the United States Department of Agriculture for 1893, the cost of raising wheat and corn crops in this country was $8.88 and $8.68, respectively, not including the rent for land and the cost for superintendence.

Fig. 454. Hemlock (*Tsuga Canadensis*).

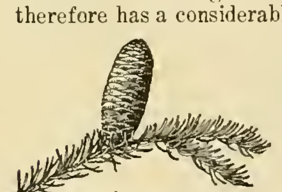

Fig. 455. Balsam fir (*Abies balsamea*).

Fig. 456. Norway spruce (*Picea excelsa*).

Fig. 457. Black spruce (*Picea Mariana*).

The chief demand for capital in continuous wood-cropping is the necessity of keeping a large supply of growing, immature trees on hand. Herein is the most essential difference between forestry and agriculture: while farm crops mature in one year, and all that has grown during the year is harvested at the end of the season, trees must be left to grow for many years before sufficient wood of the desired kind accumulates. A tree is not born old; starting from the seed or stump, it grows in height and thickness year after year until it reaches the size required for the market. If the most marketable size is attained at the age of eighty years, then to secure the best returns it must be left on the ground for eighty years to accumulate the requisite amount of wood. If one eighty-year-old tree is to be cut each year, there must be on hand seventy-nine trees of ages varying from one to seventy-nine years. When one eighty-year-old tree is cut down, seventy-nine trees must be left standing, because they are all needed to produce annually that one mature tree. Continuous wood-cropping requires, therefore, an accumulation of a large amount of immature, growing timber, which forms as essential an element in continuous wood-production as machinery does in a factory. While the farmer may dispose of the products of his annual harvest, the grower of timber crops is compelled to leave the annual growth made by the trees for a number of years, and in this way must tie up in growing trees a capital equal to the aggregate value of the unsold annual crops of the whole period. That the growing, still immature timber is a real capital and not an imaginary one, is only too well shown by the temptation to which so many owners of small timber tracts succumb, to realize on it prematurely by selling it at the first opportunity.

The larger the required sizes of trees, or the longer the period needed for their maturing, the larger must be the stock of young, growing trees on hand, and consequently the larger must be the capital tied up for continuous production of wood, and vice versa. Thus, to supply continually an annual demand for the product of one acre of eighty-year-old trees, a total area of eighty acres is needed; while one-fourth of the area would be sufficient to grow every year one acre of twenty-year-old trees, such as would make fence-posts.

In forests managed systematically for continuous timber crops, the growing stock of wood usually amounts to 75 or 80 per cent of the total investment. For this reason, the raising of continuous crops of large timber for construction purposes can be done advantageously only on considerable forest areas, with a large capital tied up permanently in young, growing trees. The owner of a small woodlot will inevitaby find it most profitable to raise chiefly fire-wood, mine props, fence-posts, ties, and similar timber products that require a comparatively short time for their production, using for that purpose only quick-growing species, or managing his forest as sprouts which possess at an early age a capacity for more rapid growth than trees started from seed. The fact, however, that the woodlot, as a rule, is not an independent enterprise, but an adjunct to farming or some other business, enables its owner to manage it not on a strictly financial basis, because of the many benefits which he derives from it indirectly, in the form of windbreak or shelter to his cattle, in addition to the products raised for his own home consumption.

There are also purely technical reasons which make extensive forest tracts better adapted for raising timber crops than small woodlots would be. In a large forest the proper distribution of trees of various ages, which is so essential to continuous wood-cropping, can be more easily attained; on a large tract the main body of forest, being well protected by the outer rows of trees on the edge of the forest, suffers less from wind than small woodlots, which are frequently exposed to the sweep of gales; in a large forest there are always more seed trees and more seed on hand, and the conditions for starting a new crop are generally more favorable than on small tracts.

Timber crops, unlike farm crops, can not be managed very intensively. Intensive industries are characterized by their capacity for absorbing a considerable amount of labor; and forestry, with the exception of harvesting timber crops, offers, as has already been pointed out, but little opportunity for the application of labor. Besides, forests grow, as a rule, on the poorest soils and roughest situations, which makes any intensive management financially unprofitable because of the expenditure being out of proportion to the possible gain in net returns. If to this be added the fact that it takes 100 to 150 years for trees to reach large dimensions, and therefore only $\frac{1}{100}$ or $\frac{1}{150}$ of the total forest area can be cut over every year, if annual sustained yields of large timber are desired, the need of vast forest areas for continuous wood-production becomes self-evident.

All this taken together emphasizes the importance of capital as a factor in the production of wood crops, and has even led to designating forestry as a "capital intensive" industry in distinction from agriculture which requires a relatively smaller fixed capital but a larger amount of labor.

The three main factors of forest production may be thus arranged in the order of their importance: Nature, capital and labor.

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Raising the Timber Crop.

By *Samuel B. Green.*

Trees may be divided into two classes: (1) Those that are called shade-enduring or tolerant, and (2) those that are light-demanding or intolerant. These characteristics of trees are of great importance in considering the subject of the renewal of growth on forest lands, or even in the matter of planting land that is not yet in forest. While it is not an absolute rule that tolerant trees have a thick mass of foliage, and intolerant have open foliage, yet this statement is so generally true that when this characteristic is known it serves as a very reliable indication. Among our tolerant trees may be mentioned the spruce, balsam, white cedar, red cedar, oak, hornbeam and hard maple. Among our intolerant species are the poplar, cottonwood, willow, soft maple, birch and jack and red pine.


Fig. 458. Redwood (*Sequoia sempervirens*).

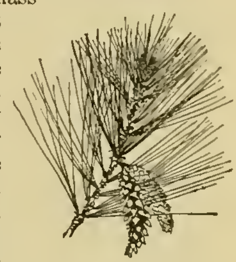
Fig. 459. White pine (*Pinus Strobus*).

The ideal forest is one that might be called a two-storied affair, that is, having an intolerant species above and a tolerant species below, much the same as in a crop of corn, where we may have pumpkins growing under the shade of the corn. Trees protect one another and are mutually helpful, and as a rule are most hardy when grown in groups. Trees also interfere with one another, and in their struggle for light and soil privileges the weaker trees are often suppressed and perhaps all of them are injured. On the other hand, crowding forces them to take on an upward growth and kills out the lower branches, which is necessary for the production of good timber. Trees that grow in the open have side branches and make inferior lumber that is full of knots.

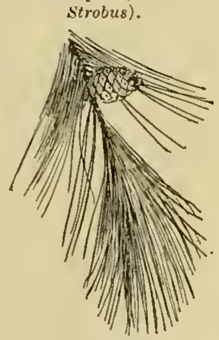
Fig. 460. Red or Norway pine (*Pinus resinosa*).


Fig. 461. Scotch pine (*Pinus sylvestris*).

The forest rotation.

There is a popular fancy that a natural rotation of trees exists, and where soft woods are cut hard-woods naturally follow, and the reverse. In reality, there is little to justify this notion. Under natural conditions, sometimes hard-wood will


Fig. 462. Grey or Jack pine (*Pinus divaricata*).

follow pine, or pine will follow the hard-woods, where the two were mixed at the time of cutting and there was on the ground a young growth which had an opportunity to grow when its competitor was removed.

When land is severely burned after being cut over, the trees that show first are the kinds that produce seed in great abundance, and whose seed will float long distances in the wind, such as poplar and birch; or else those having fruits especially liked by birds, such as the bird cherry, which is widely distributed. The pine, and perhaps other trees, may come in later, owing to their being seeded later, or owing to the later advent of conditions favorable to their germination and growth. It may often happen in the case of burned-over pine land, that pine seed is distributed over it the first year after it is burned, but owing to the lack of protection from the sun the young seedlings, which are very delicate and require slight shade, are destroyed.

On the other hand, the young poplars, on newly cleared land, may find just the condition for growth, and the land becomes thickly seeded; later there comes a general weakened condition of the poplars by reason of too much crowding. Under the growth of these weakened poplars, pine seedlings may find the right conditions of shade for their most successful growth, and will gradually force their way up through the poplars, and finally kill them out. On the other hand, the poplars, birches and other trees, grasses and shrubs growing on the land when the timber is cut, may make so strong a growth as to kill, for a time, the young pine seedlings that are on the land.

Forest regeneration.

The term regeneration is commonly used in forestry to signify the renewal of forest trees on the land. It is a convenient term and well worthy of general use. The different forms of regeneration may be referred to as, (1) regeneration by natural seeding; (2) regeneration by artificial seeding; (3) regeneration by planted seedlings; (4) regeneration by planted cuttings; (5) regeneration by sprouts and suckers (i. e., coppice-growth).

The method of regeneration best adapted for one section may not be at all fitted for another section under different conditions, and often it is best to combine two or more of the different forms of regeneration. Where natural regeneration of valuable species can be easily brought about, it is generally the best practice. This is especially true in sections where timber is comparatively cheap, as is generally the case in this country where the returns from the land can hardly be expected to pay for any great amount of labor.

(1) *Natural regeneration by seed* may be greatly assisted by stirring the surface of the soil in good seed years, just before the seed is scattered, and by thinning enough to let in light and air to the seedlings. When it is desired to have an open field adjoining woodland thus seeded, the land may be plowed or loosened with a disk harrow or drag, and put in such condition as to make a sufficiently good seed-bed. When the soil will not permit of such exceptional treatment, it may be loosened by a drag made by tying together several oak branches or small logs, which, when dragged over the ground several times, will gradually break up the surface. This will be especially necessary where there is a thick covering of mold or "duff" on the land. This same method of stirring the soil is applicable when the land is to be seeded by hand. Good seed years do not often occur in our most desirable species, and it is very important to take advantage of these good years when they do come.

Natural re-seeding is almost the only practical means of re-stocking large areas of forest lands, as other methods are too expensive. It generally takes place readily, and the chief reason why it is not more successful is the frequent destruction of the young seedlings by fires, by cattle and improper methods of logging.

The methods of cutting adapted to secure natural regeneration by seed in the forest naturally separate themselves into three systems, each of which may be best adapted to some special conditions. They are known as (1) the selection method; (2) the strip method; (3) the sprout method; and (4) the group method.

Selection method.—The selection method refers to the cutting of mature trees and the removal of inferior trees to make room for the better kinds. In this system much care should be exercised to prevent the growth of grass, which generally comes in when the cutting is done more rapidly than the seeding trees can seed the bare land and furnish it with a good covering that will keep out the grass and other weeds. On the other hand, it is just as important to exercise great care in providing sufficient light for the young seedlings which have started, so that they can make a good growth and not be shaded out by the older trees. The removal of a single tree, even though it be a large one, often lets in so little light that seedlings cannot get a good start. For this reason the group method (referred to later) is probably best adapted for general use, since it opens up a sufficient space to warrant considerable attention being paid to securing good conditions for the young seedlings.

Strip method.—The strip method may be used to advantage where the soil and tree growth is very uniform over large areas. The strip method is a form of clear cutting and is chiefly applicable to large tracts of even-aged pure stands of conifers or any light-seeded species and when there is a ready market for timber of all sizes. The location of the strips and their alternate cutting involves the laying out of plan of management for many years ahead. The woodlot owner, therefore, will seldom find it necessary to resort to this method of forest treatment.

Under this system the trees are removed in narrow strips, as a rule not wider at any time than twice the height of the trees, so that the remaining older trees can easily re-seed the denuded land; but the best width of the strips will depend on the species and the local conditions. For example, in the case of oak, perhaps, the strips should not be wider than the height of the trees, while in the case of birch, elm, maple and pines, the strips might exceed in width six or eight times the height of the trees, and still they would be re-seeded successfully. Such strips should generally be started on the side opposite the prevailing winds at seeding time, so that the seeds may be blown on to the denuded land. Of course, in the case of oak, beech and similar trees, where the wind has comparatively little effect on the carrying of the seed, this point is not to be so much insisted on.

Group method (Fig. 463).—The group method is a system of cutting irregular strips successively on the inside of certain groups. This may be termed a natural method, and for general use, especially in mixed woods, and where the land and tree conditions are rather variable, it is much the best. If this system is followed, one can adapt the method of cutting to the different species and to the different conditions which may be found in the forest. For example, a tamarack swamp, a dry knoll covered with oak, a steep hillside, and level rich rocky land covered with elm, and very often various other conditions, would very likely all be included in almost any forest track of considerable size in the northern states, and each part, for best results, should receive special treatment. Under this plan we can begin with one group or several, and we can start our regeneration in each group perhaps where there is already a good growth of desirable young trees. In fact, this system gives us a chance to begin regeneration where the greatest necessity or the best opportunity for it already exists. The size of the openings will depend, as in the strip method, on the species grown and on the natural conditions of the land. As a rule, the first openings should be one-fourth to one-half acre or more, and the strips taken around these openings should not exceed in width the height of the trees in the strips next to be cut; but, as previously stated, this matter should be determined largely by the kinds of trees. Successive strips should be cut only when the previous strips have become well stocked with trees, that is, when regeneration is accomplished. Of course, the regeneration in each of these strips should be given the same care that would be given to any well-managed forest in order to bring about a predominance of the most valuable kinds under the best light and soil conditions.

(2) *Regeneration by artificial seeding.*—Occasionally it may be desirable to sow seed in woodlands. This is often the case with ash, hard maple and birch, and with our nut-bearing trees, such as black walnut, butternut, the hickories, chestnut and oaks, which readily renew themselves by such means. These may be planted in spots or broadcasted after the land has been loosened. In the case of pine and spruce, however, success is uncertain under such treatment, and should seldom be attempted. Perhaps it is most certain to furrow out between the trees with a plow, where it is practicable, as it might be, for example, on some of the sandy lands of Wisconsin and Michigan, where furrows might be run between the trees or the land loosened in patches with a hoe. In these furrows, or in patches in the forest, the seed of pine or spruce might often find just the right conditions for growth. Such methods of treatment are occasionally used in the pine forests of northern Germany, to secure a regeneration of Scotch pine and beech. When the seed is to be sown in patches, these should seldom be over two square yards in area. From these patches the seedlings may be set in near-by openings, after they are well established. This treatment can be made successful only where the standing trees afford the proper shade conditions for the seedlings.

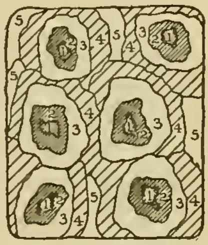

Fig. 463. Diagram illustrating group method of cutting. Cuttings are begun at points marked 1 and are gradually extended by successive cuttings, as indicated by figures 2, 3, 4 and 5. (After Schlich.)

Under some conditions, tree seeds may be sown broadcast on the land and be covered by the treading of sheep. This would often work well in the case of brushy pastures on rocky land. Ash, box-elder, maple, pine, beech and other tree seeds are sometimes sown in clear fields with oats or other grains, where the straw protects from the sun in summer and the stubble holds the snow and acts as a winter protection. Seeds of ash, maple, elm, and some other trees may sometimes be sown to advantage in the hills with corn in prairie planting, and willow cuttings may be used in the same way, or these may be planted in the hills with beans.

(3) *Regeneration by planting seedlings.*—The regeneration of land by planting seedlings is practiced to considerable extent in sections where timber is high in price. For instance, in parts of Hessen it is no uncommon sight to see large areas of land planted in spruce at as regular intervals as corn is planted on cultivated land; when the crop is mature it is taken out by the roots and the land plowed and again planted. In the parts of Hessen referred to, however, there is a good market for even the stumps of trees and the smaller twigs. Such a condition is seldom found in any part of the United States.

There is a large part of this country where the land cannot be stocked with valuable trees without resorting to replanting. This is often the most economical way of securing a stock of coniferous trees in almost any part of the United States under the conditions which frequently prevail on our cut-over lands, where there is very little chance for natural or artificial regeneration of desirable kinds by seed, owing to the fact that all seed-producing trees were cut when the land was logged or have since been destroyed by fire, and the ground covered by a growth of grass, raspberry bushes, other weeds and inferior small trees. Seedling pines often can be set out at intervals of perhaps ten feet apart each way, under conditions where they would be sufficiently crowded by the weeds, poplars, hazel-brush and other growths, so that they would take on an upright form, quite free from branches until their tops interlaced, after which they would properly crowd one another. Such planting often can be done at an expense of less than two dollars per acre. In planting seedlings under such conditions, the best implement to use is a mattock, with which a space a foot or more in diameter is cleared of brush and the soil brought into condition for the seedlings. Under very favorable conditions the work can be done for even a less figure than that given. It is not too much to expect that a man and a boy, in a day of ten hours, under reasonably favorable conditions, can plant at least 1,000 seedlings and handle them with all the care necessary to keep the roots from getting dry. Pine and spruce seedlings are best kept in a pail partially filled with water when carried to the field.

After the seedlings are planted, it is necessary for success that they be looked after for a few years until they are well established, otherwise they may be smothered by the surrounding weeds and trees. It is a good plan, under such conditions, to go over the land at least once in the summer with a large knife, and with a few slashes give the planted seedlings an advantage over the surrounding vegetation.

In the planting out of old fields, where for any reason it may be undesirable to plow the land

Fig. 464. Hardy catalpa plantation of the South Amana Colony, South Amana, Iowa. Trees twenty-four years old.

entirely, a good condition for planting may be secured by furrowing out in autumn where it is desired to plant, and in the spring planting on the edge of the furrow where the soil has fallen from the furrow-slice. In the case of hillsides of this kind that are liable to wash, the furrows should run across the slope and be made nearly level, or with a gentle slope so that the water will follow the furrows without gullying them. These furrows will hold the water and prevent the seedlings drying out. On wet land seedlings are sometimes planted on the surface, and the soil mounded up over the roots. This method is well adapted to white cedar on wet land.

(4) *Planting of cuttings.*—There are few trees that can be grown in general practice from cuttings, but it is the best way to start willows and some poplars, since seedlings of them are difficult to secure. It may often happen that willows and poplars can be planted to good advantage on the cut-over land, where renewal of growth is expected from such shade-enduring trees as basswood, hard maple, hickory and chestnut. Under such conditions the willows will grow rapidly and form a predominant covering under which the other species will flourish.

(5) *Regeneration by coppice.*—The commonest and simplest way of natural regeneration is the sprout method. This is based on the capacity possessed nearly exclusively by the hard-woods (of the conifers only by the California redwood) to renew themselves after cutting by shoots produced from the stump or roots. As a matter of fact the bulk of all our second growth hard-woods originated in this way. This method does not depend on the occurrence of good seed years, it is little affected by fires, which sometimes even stimulate a more vigorous sprouting, and is adapted to small as well as large timber tracts. The sprouts for the first 40 to 50 years grow faster than trees started from the seed and are, therefore, capable of producing tan-bark, firewood, fence posts, ties, telephone and telegraph poles within a much shorter time than trees from seed. For this reason this method lends itself most readily to woodlot owners, especially in the central hard-wood belt, where the composition of the woodlot is chiefly hard-woods and the demand for small-sized timber is great. Chestnut, oaks, particularly the chestnut oak, ashes, willows, maples and poplars are well suited for regeneration by sprouts.

In cutting coppice-growth the trees should be cut off close to the ground when they are dormant, and the stumps left highest in the center so that they will have a tendency to shed water and not be so liable to rot as when left hollow in the center. The advantage of cutting close to the ground is that the sprouts that come out from the trunk soon get roots of their own, and such sprouts are much more durable than when they depend entirely on the roots of the old stumps; and they are less liable to be broken off in a high wind. After a number of years the ability of the stump to sprout will gradually cease, although with good management and protection oak and other hard-woods may be reproduced for a long time in this way.

Choice of species to plant.

The choice of species will naturally be limited by soil and climatic conditions, and also by the time required to get returns. The slow-growing species, such as oak, ash and white pine, do not offer any great inducement for the private individual, except in the case of such kinds as renew themselves readily from the sprouts or where the land is already stocked with a young growth. The fast-growing species are the ones to which individuals are largely limited in making their plantations. Among the most desirable of these is *Catalpa speciosa*, which under favorable conditions will make good post timber in ten or fifteen years. The yellow or black locust, which has a little wider range northward, and is fully equal to the catalpa in rapidity of growth at the North, is also well adapted for post timber. In some sections the white willow and cottonwood may be grown to advantage, the willow being used largely for fuel and poles, while the cottonwood is used largely for dimension lumber in cheap construction.

These four trees promise the quickest returns of any deciduous trees that are grown in our northern states. In the case of willow, the average yield per acre of cord-wood on good soil, under favorable conditions, will not be far from three cords, when once the land is well stocked with trees. Under the conditions which exist in many central-western states, such plantations may prove very profitable. While cottonwood lumber at present is regarded as of little value in most of the timber sections, yet on our prairies it is in demand for floor boards and dimension stuff in cheap construction, and will often increase in growth at the rate of 500 to 1,000 feet board measure per acre per year.

Of the coniferous species, spruce is probably the most promising. White and Norway spruces grow at about the same rate, but as the seed of the Norway is much the more easily secured, it will naturally be given preference. It will yield thirty to thirty-five cords of pulp-wood per acre when thirty years old. It is in demand for paper pulp, and the outlook is for an increase in the price of this material.

The future will undoubtedly see a more general use made of inferior woods, by impregnating them with antiseptic materials, and it is probable that we shall, in this way, find a much wider use for such wood as that of the common cottonwood and soft maple.

Seeds and seeding.

Source of seeds.—One of the most important factors for the grower of tree seedlings to have in mind is that the source of the seeds may sometimes have a very considerable effect on the value of the seedlings. It may be laid down as a safe general rule that those seeds are most desirable which come from trees grown in a climate as severe as that in which they are to be sown. As trees reach the limit of their growth they have a tendency to become dwarfed, and the seedlings from these trees undoubtedly perpetuate (more or less) this dwarfing tendency. Hence, even though an essential point in considering the value of any tree is hardiness, the question of size is also important and should be taken into account. We may conclude, then, that since trees from milder climates generally lack in hardiness, and those from a very severe climate may lack in size, it is best to procure seeds

Fig. 465. Forest of *Picea excelsa* (known in this country as Norway spruce) in Hessen, planted for paper pulp; side branches removed as soon as dead.

from the best trees grown near by, or from those grown under similar climatic conditions elsewhere. Generally, it is not necessary to limit this range very closely, and a range of one hundred miles north or south of a given point will seldom make much difference in hardiness.

Gathering seeds.—In some cases it is best to pick the seed from the trees even before they are quite ripe, as they will generally ripen if kept dry after being picked. Very unripe seeds do not keep so well as perfectly ripe seeds. Most kinds of tree seeds can be gathered cheaply from the ground after they have fallen. This method of gathering often can be greatly facilitated by clearing the land under the trees, so that it will be smooth and even. The seeds of some species can be swept up at little expense under trees growing along highways or city streets.

Seeds of coniferous trees, such as pine, spruce, tamarack and arborvitæ, are dry and winged, but the red cedar has a fleshy, berry-like covering surrounding its seed. The seeds that grow in cones are most easily gathered before being shed from the cones. The cones should be gathered before they open, and then dried, after which those of most species will open and the seeds can be threshed out. Cones of a few trees, as those of the jack pine, will not open without artificial heat. These can be opened by gently heating them over a stove or in an oven to a temperature of 100 to 150° F. Seeds of this class grow readily, but must be very carefully stored or they will lose their vitality. They may be kept like the seed of ash and box-elder, but are more liable to injury than these kinds from too much moisture or heat, and for this reason some careful growers prefer always to keep them mixed with dry sand in a cool shed.

The seeds of the red cedar hang on the tree all winter and must be picked by hand. They should be soaked in strong lye for twenty-four hours, the fleshy covering removed by rubbing them against a fine sieve, and then stratified in sand, where they will be frozen during the winter. Even with this treatment they will seldom grow until the second year.

Fig. 466. Diagram illustrating method of planting seeds in patches in woodland.

Stratification.—Stratification is a term used to describe a certain method of storing seeds. It is adapted to almost any of our seeds, but is especially useful with the black walnut, hickory, basswood, plum, cherry, mountain ash and hawthorn. When only small quantities are to be cared for under this method, it is generally best to put them in boxes, mixed with several times their bulk of sand, and bury in the dry ground out-of-doors; but when large quantities are to be handled they may be mixed with the soil on the surface of the ground, covered with mulch and left until spring.

Seed-storing.—In the matter of storing seeds it is difficult to lay down any exact rule. However, it is perfectly safe to winter over all of the seeds of hardy plants which ripen in autumn, by burying them in sand out-of-doors, and yet the seeds of ash, hard maple, box-elder, locust, and other dry seeds may be stored to advantage in any dry, cool room. It is very important to have them thoroughly dry before they are stored in any large bulk. A very good way of wintering seeds of the ash, birch, hard maple and box-elder is to spread the seeds on the surface of the hard ground and cover with an inverted box. It is an advantage to have a small ditch around the box to carry off the water.

Seed treatment.—The seeds of leguminous trees should be scalded in order to get good results. This applies to the black, yellow and honey locust and the coffee tree. To do this successfully, the seed should be placed about one inch deep in a large milk-pan or similar vessel and hot water (130° to 160° Fahr.) poured over them, perhaps three inches deep. This should be allowed to stand until cool, when it will be found that some of the seeds have swollen. These should be picked out and the remainder treated again with hot water, and the process repeated until all have swollen. Seedlings of this class are managed in much the same way as those of ash and maple.

Seed planting (Figs. 466–469).—Seeds may be classified into three groups: (1) deciduous-tree seeds that ripen in spring and early summer; (2) deciduous-tree seeds that ripen in autumn; (3) coniferous-tree seeds.

Among the seeds that ripen in spring and early summer are soft and red maple, the elms, cottonwoods and willows. These should be gathered as soon as ripe, and, with the exception of the red elm, should be sown in a few days or weeks, as they retain their vitality but a short time. Red elm seed will not grow until the following spring.

The thousands of seedlings of cottonwood, elm and soft maple that naturally spring up along the sand-bars and river and lake shores, show what are the best conditions for the germination of these seeds, but seeds of white elm and soft maple generally do well when sown in any good garden soil. Cottonwood seedlings can be grown by scattering branches bearing unopened seed-pods along the furrows in moist soil and covering the seed lightly, when they will shell out; but they are of such uncertain growth that most nurserymen depend on the sand-bars and lake shores for their supply.

Willows are seldom grown from seed, as these are difficult to raise, and the trees start easily from cuttings. Elm, soft maple and mulberry seeds generally grow well on any good moist soil, but that which is somewhat sandy is best. They should be sown thickly in drills eight inches wide and three feet apart, when they may be easily cultivated by a horse cultivator. Or they may be sown in rows sixteen inches apart and cultivated by hand. Elm and soft maple seed should be covered about three-fourths inch, mulberry about one-fourth inch and soft maple about one inch. If the weather is dry at the time the seed is sown, the soil over the seed should be thoroughly firmed, and if the weather continues dry the rows should be watered. Watering, however, is seldom necessary on good retentive land, if the soil has been properly packed. When watering is resorted to, it is a good plan to cover the drills lightly with some mulch or litter, or shade them with boards, but these should be removed as soon as the seedlings first appear. With proper conditions, seeds so planted will start quickly and grow rapidly. The seedlings of soft maple and white elm will generally be large enough for transplanting to the young forest or windbreak the first season; however, they may be allowed to grow another year in the seed-bed without injury, but should generally

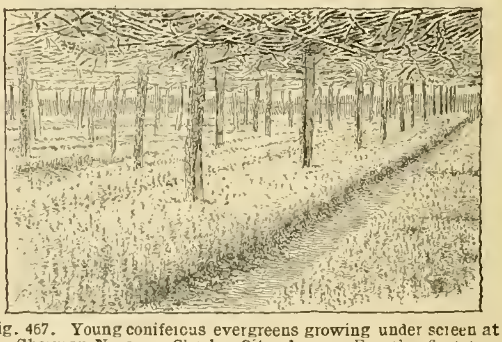

Fig. 467. Young coniferous evergreens growing under screen at Sherman Nursery, Charles City, Iowa. For the first two or three years evergreens of all kinds have to be screened from the sun, after which they need no protection.

be transplanted before the growth of the third year begins.

The seeds of deciduous trees that ripen in autumn may be sown to advantage at that time, provided the soil is such that it will not pack too firmly, or when the seeds are not liable to be washed out or eaten by rodents or other animals. Our most successful nurserymen generally prefer to sow such seeds in autumn, and they aim to bring about the conditions that make it successful, but good results also generally follow the early sowing of such seeds in the spring. The distance between the rows, and the covering, should be the same as recommended for elm seedlings.

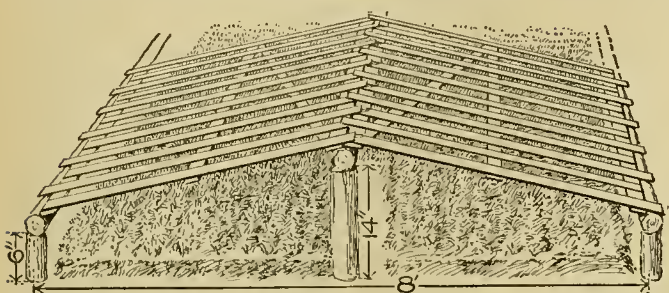

Fig. 468. Coniferous seedling bed with details of lath screen; five-eighths inch lath is used for cross and diagonal braces and one-half inch for others.

It is important to keep the soil loose and mellow between the seedlings, and to keep the weeds very carefully removed until at least the middle of July, after which they may sometimes be allowed to grow to advantage to afford winter protection; but in the case of very small seedlings this protection is best given by a light mulch, put on in autumn and taken off in spring. The weeds should be kept out.

If the seeds of red cedar, black thorn, mountain ash and others that require a long time to start are sown in the spring and do not germinate, it is a good plan to cover the bed with an inch or two of hay or leaves to keep out weeds, and let this mulch remain until the following spring, when the seeds will probably be in condition to grow. The mulch should then be removed.

Quantity to sow.—The proper quantity of seeds of deciduous trees to sow in nursery rows depends very much on the kind and quality of the seeds and the soil in which they are to be sown. As a rule, thick sowing is better than thin sowing. The seeds of box-elder, ash and maple should be sown at the rate of about one good seed to the square inch; elm and birch should be sown twice as thickly. Plums and cherries sown in drills should be allowed about one inch of row for each good seed. Black walnut, butternut, hickory and similar seeds should preferably be planted three or four in a place, where they are to grow, and all but one seedling cut out when several years old. If sown in drills, they should be placed three to six inches apart. Rather thick seeding does not seem to be any great hindrance to the making of a sufficient growth by seedlings of most of our broad-leaved trees the first year, but if left thick in the seed-bed the second year they are often seriously stunted.

The quantity of seed to sow in order to secure a given number of seedlings will depend also on the quality of the seed and on the soil and weather conditions at the time of sowing. The quality of seed varies much in different years and from different trees. The only way to be at all accurate is to test the seed, but as this is troublesome, and as the seed of most of our common trees is very cheap, it is seldom practiced, and growers simply plan to sow two or three times as much seed as would theoretically produce the number of seedlings desired.

The number of seeds in a pound varies greatly with the size of the seed and dryness. In the case of the birch there are perhaps four hundred thousand; in Scotch, shortleaf and red pine and Norway spruce there are perhaps seventy thousand; in white pine about thirty thousand; in box-elder and white ash about ten thousand; in basswood and sugar maple about eight thousand; in soft maple about four thousand; in black walnut twenty of the dry nuts in one pound, and in hickory nuts forty to sixty in a pound.

Raising coniferous trees from seed.

The land selected for the seed should have a light, porous surface soil, preferably underlaid with a moist subsoil that will not dry out easily. It should be so located as to have good circulation of air over it, that the plants may dry off quickly after rains; and it must be so shaded as to keep off about one-half of the sunlight. In practice, we aim to secure these conditions as follows: A piece of well-drained, rather sandy soil in an airy place is selected and laid out in beds four feet wide. In May, or later, the seeds are sown rather thickly (about three good seeds to a square inch), either broadcast or in rows, and covered with about one-fourth inch of sandy loam and then with about one-

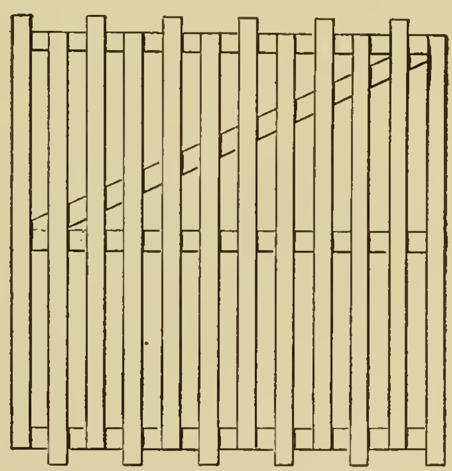

Fig. 469. One of the slat-screens used in Fig. 468.

fourth inch of clear sand. Before the seedlings break the ground, a permanent framework at least three feet above the beds is made and covered with laths, laid about one and one-half inches apart, running north and south, or with sufficient brush to shut out about one-half the sunlight; or a movable lath frame may be built, as shown in Fig. 467. If the bed is very much exposed to the winds, it should have similar protection on all sides. Under such conditions, or in woodlands where these conditions can be fulfilled, evergreens can be raised with much certainty, while, if seed is sown in the open ground, most kinds fail.

A cheap and convenient screen can be made from common lath 4 x 4 feet square, leaving a space the width of a lath between each two and nailing the ends between two lath at right angles. Such screens can be made for about thirteen cents each. Sparrows and gophers are prevented from destroying the seeds or young seedlings by placing boards along the sides of the beds and then covering the whole bed, screen and all, with small-mesh wire netting.

The most common cause of failure with those who try to raise evergreens is a fungous disease called "damping off," which occurs only while the plants are growing rapidly the first year. The seeds may start well, and the seedlings may grow vigorously for a short time, or until there is a spell of damp weather, and then die off with great rapidity. The use of sand on the surface and plenty of air circulation in moist weather, will largely remedy the difficulty.

Most of the coniferous tree seedlings grow very slowly when young. Many species do not make a growth of more than three inches the first year nor more than five or six inches the first two years. In fact, many species could be planted at the age of five or six years without inconvenience as far as the size of the tops is concerned, but the growth of the roots is more rapid when younger, especially in rich soil. For this reason, evergreen seedlings should be planted out at an age of two, or, at the most, three years, while the roots are still manageable. Under some conditions it is possible to plant out one-year-old seedlings, but, as a rule, these are too small for convenient handling or successful growth in the open.

Mulching forms an important factor in the growing of evergreen seedlings. It should consist of a three-inch covering of straw or leaves, evergreen branches or other material. This mulch should be applied to the seed-bed as soon as the seed is sown to preserve the moisture in the soil and to prevent the weeds starting before the trees. Careful watch must be kept, for if the mulch is not removed as soon as the seedlings break the soil they will all die. On the approach of winter the same sort of mulch should be put over the seedlings to protect them from the sun and from alternate freezing and thawing. This should be removed in the spring after all danger from drying, cold winds has passed.

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Practical Protection and Improvement of the Farm Woodlot.

By *Alfred Akerman.*

Most of the woodlots on American farms have been mismanaged or unmanaged. One of the serious problems facing the farmer today who sees his wood-supply rapidly diminishing is how to treat his mismanaged woodlot. Before entering into a discussion of this, however, it is well to call attention to the factors involved in the proper care of a woodlot. The first of these is protection from harm; the second is the actual improvement of the crop.

Protection.

Protection of the woodlot is fundamental, for without it planting, pruning and thinning amount to nothing. The two most important phases of this subject are protection from fire and from the grazing and browsing of animals.

Protection from fire.—In dealing with fires, as with ailments of the body, an ounce of prevention is worth a pound of cure. For this reason, farmers would do well to examine into the conditions which surround their woodlots, to ascertain whether the liability to fire may not be lessened by a few simple and inexpensive precautions. For example, a woodlot which borders on a public road may be protected by a cleared strip along the road; for a great many fires start from a cigar-stump or lighted match which is tossed aside by a passing smoker. Such cleared strips, or "fire lines" as they are called, should be cleaned up once or twice a year by burning at a time when the fire will not spread, or by raking back the leaves and other inflammable material that may have accumulated. The cost of such a precaution is insignificant in comparison with the loss from a fire in the woodlot. Fire lines are also useful between woodlots, if the neighboring property is not well protected. (Fig. 470.)

Another inexpensive preventive measure is the posting of fire notices. A great many persons, and especially boys, start fires because they are thoughtless. A notice posted in a conspicuous place will often make the careless more thoughtful.

Fig. 470. A fire line in Europe.

When a fire is set, promptness in beginning to fight it is the most important consideration. As soon as it is discovered, all hands should go to the place at once. A few minutes' delay may mean the loss of timber that it has taken years to grow ; it may mean the loss of farm buildings and haystacks as well.

The method of fighting fire varies greatly with circumstances. Sometimes a good thick brush is used to beat it out. Sometimes rakes and forks come in handy. When the soil is light the most effective method is to shovel earth on the burning material. Nothing is effective against a top fire, except a back fire ; but top fires rarely occur in farm woodlots.

Protection from grazing and browsing.— Cattle, sheep, goats and hogs should not be allowed to run in young growth, nor in old growth when reproduction is desired. Many of our broad-leaf trees are eaten greedily by cattle, which also destroy many seedlings by treading on them. It is difficult to bring about a satisfactory combination of pasture and forest. From the time the young trees have lifted their branches out of reach until the reproduction time comes round, grazing does little harm. The same is equally true of deer, moose and similar animals.

Improvement.

Pruning.—The object of pruning forest trees is to produce clear lumber. If that object can be accomplished without going to the expense of pruning, it may be dispensed with. If trees are grown at the correct distance apart, the side branches will be shaded to death while they are small, and in most cases will drop off in a few years. There are exceptions to this rule, however. Some trees retain their dead side limbs for many years ; and it may be wise to assist the tree, in such cases, in ridding itself of them. The question then resolves itself into whether the clear lumber is worth more than the cost of pruning.

In one case, at least, it is worth while to prune. The white pine (*Pinus Strobus*) is one of the trees that holds its side limbs. The price of clear pine lumber justifies a small outlay on pruning.

It is a waste of time to prune trees that have reached a diameter over six or eight inches. As just stated, the object of pruning is to secure clear lumber ; and to prune large trunks is to lock the door after the horse is stolen, for large knots are already formed.

It is also a waste of time to prune more than two hundred or three hundred trees to the acre. The very best trees, ten or fifteen feet apart, should be selected. If more than these are pruned, some of them will be shaded out before the stand is mature, or will be taken out in improvement thinning, if thinning is practiced. In either case, a part of the labor put into pruning will be lost.

In pruning, any number of dead limbs may be removed without injury to the trees ; bnt live limbs should be taken sparingly. It is a good plan to take the dead limbs up to where the live ones begin, and, if necessary, to take two or three whorls of the dying and dead ones, and then to wait a few years before going farther.

The work may be done with an axe or with strong pruning-shears. The cuts should be close to the trunk, so that the knots will grow over as soon as possible. If the axe is used, great care should be exercised not to bruise and hack the bark of the trunk.

Thinning (Figs. 471, 472).— Thinning is the most important improvement work which may be done in the woodlot. By thinning is meant the systematic removal of a part of the trees in a growing crop of timber to benefit those that remain. It should not be confused with the removal of mature trees, which is a very different operation.

Fig. 471. Dense stand of young hard-woods moderately thinned.

The practicability of thinning has been questioned. Among other things, the cost of the work, the injury by falling trees, lodgment of trees against those remaining, and increased liability to windfall have been urged. As to the cost of the work, it is conceded that in some circumstances it is prohibitive. For this reason, a young stand should be allowed to wait until the material to be removed has reached such a size that its sale will pay for its removal; and it should not be thinned again until the material to be removed has accumulated in sufficient quantity to pay for its removal. If the wood more than pays for its removal, so much the better; but if it pays only for its removal, the improvement is a net gain. The farmer who knows the price of labor, the cost of drawing to market, and the price to be secured, can easily determine when a thinning may be safely undertaken.

In reply to the other objections, it may be said that, when thinning is done properly, the

Fig. 472. Dense stand of young hard-woods in need of moderate thinning.

falling trees do little injury, they do not lodge so that they can not be brought down with a twist of a cant-hook, and the remaining trees do not blow down.

The principal object of thinning is to preserve the balance between height-growth and diameter-growth of the trees that are to form the final stand. Increase in volume is determined by height- and diameter-growth. If the trees stand too close together, height-growth will be in excess, followed by a reduction in vitality. If the trees stand too far apart, diameter-growth will be in excess, accompanied by large side limbs. In either case the quantity and quality of the timber will be affected. Therefore, by preserving the balance between the two, an acre of land is made to produce more and better lumber in a given period of time.

The extent to which a closed stand may be opened depends on several conditions. The kind or kinds of tree that compose the stand, the nature of the soil, the character of the undergrowth, the purpose for which the timber is grown, all play a part in determining the degree of thinning. This is one of the many matters in forestry that cannot be reduced to a rule, but must be based on a study of each woodlot. There are, however, several considerations which indicate the extent to which a woodlot may be thinned. The classes into which trees in a closed stand gradually become separated, in the course of their struggle for existence, are of assistance in selecting trees for removal. Four classes are usually distinguished: (1) dominant, (2) intermediate, (3) suppressed, and (4) dead. Dominant trees are those that have their crowns in the light; they have kept ahead of the others in height-growth. Intermediate trees are those that still have their crowns in the light, but are somewhat backward, and are destined to become suppressed in the near future. Suppressed trees are those that stand slightly below the intermediate class and will probably die within a few years. Now, moderate thinning would involve the removal of such of the intermediate trees as are interfering with the best development of the dominant ones. Care should be taken not to open up the stand to such an extent that undesirable undergrowth will result. In the case of shallow-rooted species, like the spruce, the stand should not be opened up too much or it will become liable to windfall. The cover must be broken into enough, however, to stimulate the growth of the remaining trees, or very little good will have been accomplished by the operation. In no case should the cover be broken to such an extent that it will not close in two or three years.

Whether suppressed and dead trees should be removed depends principally on whether they contain enough wood to make their removal, along with the remainder, worth while. Some stimulation will result from the removal of certain of the suppressed trees, but most of them are so far behind the dominant trees that are to compose the final stand that their presence or absence has little effect, one way or the other, on the development of the dominant ones. Yet it often pays to remove some of the suppressed, and sometimes even a part of the dead trees, while the more important thinning is in progress, although, except in extraordinary cases, it would not pay to go into a stand for suppressed and dead trees alone. On the general principle of cleaning a stand of all useless material that might add to the dissemination of disease or increase the danger from fire, it is sometimes expedient to remove dead and suppressed trees, when it can be done without extra cost, while thinning is being done. On the other hand, it is sometimes desirable to retain the suppressed trees, or a part of them, in order to keep the ground as well shaded as possible.

Certain species in a mixed stand are more desirable than others. If it comes to a choice between two trees of different species, other things being equal, the more desirable kind will be left. For example, a white ash and a yellow birch tree are standing side by side, and the conditions demand that one should be removed; the birch would be removed and the ash should be allowed to grow, for white ash logs sell for over twice as much as yellow birch.

A defect in an individual of a desirable kind may render it less valuable than a tree of inferior kind. For example, a decayed spot in the ash mentioned above may have made its removal preferable to that of the yellow birch.

The shape of the crown and its position relative to surrounding crowns are of special importance. The processes of respiration and assimilation are effected in the foliage which composes the crown of the tree. The crown of a tree is its lungs and stomach, so that the development and health of the crown are closely related to the growth and health of the tree; and when a decision is to be made, the position, shape and health of the crown should be given great weight.

In addition to the above considerations, which should be studied in determining the extent to which a thinning should be carried, another method, though a rough one, may be found useful. The amount of wood standing on the area to be thinned is estimated, and a percentage of the volume of the stand is removed. For example, a given stand would run twenty-six cords to the acre; about four cords an acre, or 15 per cent of the volume of the stand, would be removed in a moderate thinning.

One of the advantages of thinning that has not been mentioned, and which should not be overlooked, is that it may be combined with other operations in practice, although in theory quite distinct. As an example of this, an improvement thinning may sometimes be combined with harvesting a part of the final crop.

How to treat a mismanaged woodlot.

There is no better way to outline the treatment of mismanaged woodlots than to describe the work done in a few concrete cases.

A burned-over stand of hard-woods may be taken as an example. The species represented in the stand were chestnut, red, white and yellow oak, with scattering white-wood, white ash, sweet birch and beech. Most of the trees were of sprout origin. The stand ran about eighteen cords to the acre. Fire had been allowed to run through the lot a few seasons before. Many of the chestnuts were badly scorched about the base, and were dying back in the crown. The other trees had also suffered to a considerable extent. There was very little seedling reproduction on the ground. It was evidently impossible to do anything with any but the best of the existing trees; it would have been a waste of land to allow the others to cumber it. The stand, therefore, was severely thinned, about one-third of the volume being removed. The thinning was done in the winter; as spring came on, the tops and larger limbs were piled and burned, in order to prepare the ground for planting. Then the whole was underplanted to white pine. Two-year-old seedling stock was used, the distance being six feet each way. The planting cost about six dollars an acre. Ninety-seven per cent of the plants were alive the following spring. The wood was sold the winter following for three dollars a cord on the pile, which insured a net profit of over a dollar a cord on the thinning operation. It was removed while the snow was on the ground, and hence there was no injury to the young pines. The result of this treatment will be a pine stand with a mixture of hard-woods. A part of the hard-woods will be removed when the pine is thinned, but the remainder will remain until the final crop is gathered.

Another example is a stand of old-field white pine. When taken in hand the main body of the stand was about fifty years old, with scattering trees that were older. The older ones, or wolf trees, had a start over the others and had developed large side limbs; they were not fit for anything except the cheapest kind of lumber. The main body of the stand was too dense, and, with the help of the large wolf trees, was beginning to choke itself into a stunted condition. The stand ran about thirty-five cords to the acre. It was thinned moderately, by removing some of the intermediate and suppressed trees. Where the large wolf trees could be thrown without injury to the better growth, or without leaving too large an opening, they were taken out. Six cords of firewood and over a thousand feet of boxboards per acre were secured from the thinning. The stand may be let alone for some ten years, when it can be decided whether to cut the crop or treat it to another thinning, and allow it to grow a while longer.

Another example of a mismanaged woodlot may be cited as illustrating very different conditions. The stand was composed in part of very old chestnuts and oaks, some of them three or four feet through; and under these there was a more or less complete under-stand of chestnut, oak, birch, maple and hemlock. The party who controlled the property had been making the mistake of refusing to allow any trees to be cut; and the result was that the large trees were deteriorating and the younger ones were much too crowded. The lot was gone over carefully, and a part of the large trees removed, and at the same time a very moderate thinning was executed in the smaller growth. Care was exercised in throwing the large trees, and the smaller ones were not broken to any great extent. As reproduction was abundant in the places where no under-stand existed, it was not necessary to resort to planting. The treatment was successful financially as well as silviculturally.

Literature.

Schlich, A Manual of Forestry, Vol. II, Part III, London, Bradbury, Agnew & Co.; The Woodlot, Graves & Fisher, Washington, United States Forest Service; Alfred Akerman, Forest Thinning, Boston, Massachusetts State Forest Service.

Harvesting and Marketing the Timber Crop.

By *E. E. Bogue.*

Perhaps the most important step in the management of a timber crop is the harvesting, as on it depends the future existence and usefulness of the crop. This is strikingly true of the farm woodlot, in which every care must be exercised to perpetuate the crop in its most productive condition, to meet the annual requirements of the owner, and at the same time to be a source of income. The practices employed in harvesting the woodlot and the forest crop have many points of difference, and at

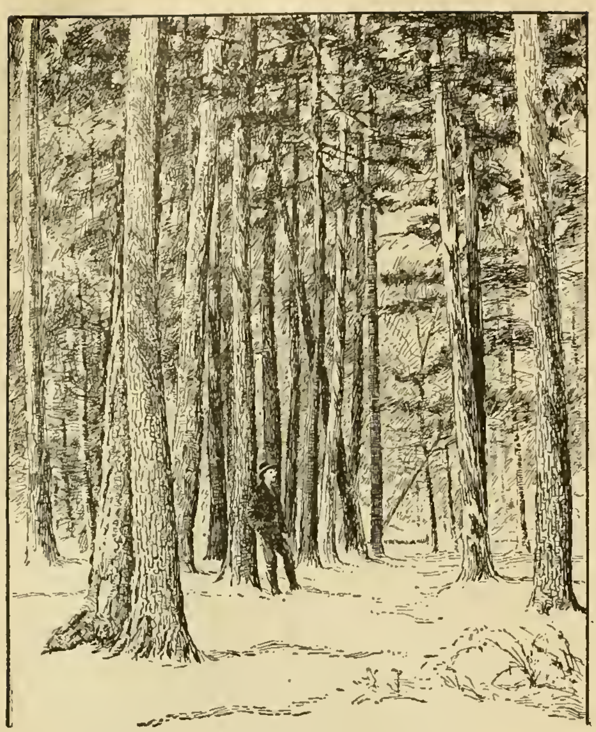

Fig. 473. Stand of pine ready for harvest.

the same time have much in common. A discussion of the practices employed in harvesting timber on a large scale will be suggestive to the thoughtful reader, and will enable him better to direct his efforts in a small way; and the few points regarding the harvesting of the farm woodlot that need especially to be noticed will be more easily comprehended.

Methods of harvesting.

There are two distinct methods of harvesting forest crops practiced in the United States,—clean cutting and selection cutting. Each has its advantages and advocates.

Clean cutting has been practiced more extensively in the past, and it is still in vogue where timber is plentiful. It has the advantage of freedom of action, little or no attention being given to saving young trees for future crops; the ground is gone over but once to secure the marketable material; and economy of logging and milling operations is effected. Clean cutting is the most practical method where the trees are even-aged or are of nearly the same size, all having reached a stage when growth is slow or has nearly ceased, and practically all are ready for the harvest. This is frequently the best method in coniferous forests, where there is often but little undergrowth. Some lumbermen who have had wide experience in cutting hard-woods, including broad-leaf trees, insist that this is the most practical method even under those conditions. In the case of clear plantings that have reached the proper stage, clean cutting is used for final harvest, thinnings having been removed from time to time.

When this method is to be employed, in order to know approximately the quantity of timber, it is customary to engage a timber-cruiser, who passes through the timber along more or less definite lines making careful observation to the right and left, estimating the quantity of timber of each kind as he passes. Record is made of the estimate of each part of a section, and at the end the estimates are summarized. It requires a man of much experience in a particular kind of timber to be of any value as a cruiser. A man habituated to the timber in the lake or gulf states would be at a loss among the redwoods and sugar pines of the West.

Selection cutting consists in removing the more mature trees of a given species or of all species down to a certain diameter limit. On large tracts a valuation survey is made at the time to determine the quantity of timber in board feet above a certain diameter limit. In measuring the diameter it is always taken at breast-height (Fig. 474), or four feet and four inches from the ground, to avoid the usual expansion at the base. The diameter limit is any that may be determined on, but is usually twelve, fourteen or sixteen inches; the lower the limit the greater the harvest at the time and the longer the period that must elapse before another equal harvest can be gathered from the same land. Usually 2 to 6 per cent of the timber is measured, and from this the remainder is estimated. If the tract is small, a higher percentage or even all the trees may be measured. As this method implies making calculations for another crop, the diameter of all species down to two inches is frequently taken. Calipers are used for measuring the diameter and a hypsometer for determining the height, although the height may be ocularly estimated for all practical purposes in that particular kind of timber. If a hypsometer is not at hand, the height of a tree or any point on it may be determined by triangulation, according to the following diagram (Fig. 475): $\frac{AB \times ab}{AC} = DE$; or, in figures, suppose AB equals 90,

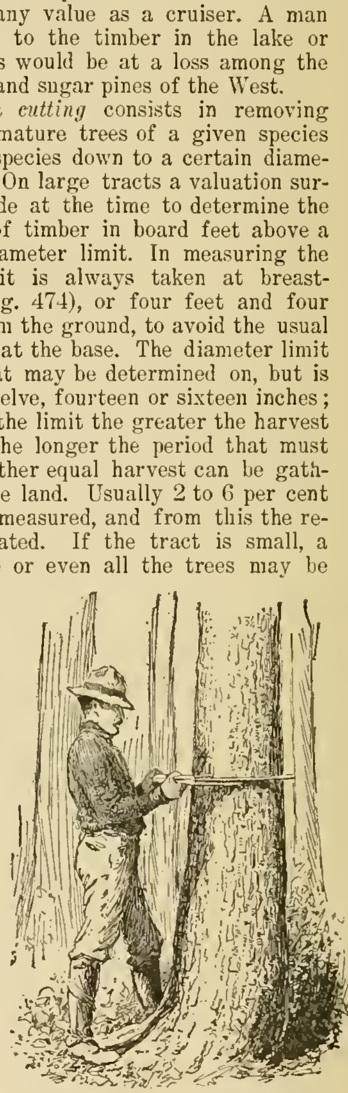

Fig. 474. Measuring with calipers.

and ab equals 20; then AB by ab equals 1800; divided by AC, supposed to equal 22, it gives nearly 82 feet as the height of the tree, or DE in the diagram.

In practice, a gang of four men is frequently engaged in making the survey. A half chain of thirty-three feet is fastened to the belt of the chain-man, who is guided by a man with a compass in order to make as straight a line as possible through the woods. A man on either side of the chain-man calipers the trees for a lateral distance of thirty-three feet, and calls out the result to the chain-man, who makes record of it on a sheet especially prepared for the purpose. The chain-man also makes note of the direction and size of streams, of hills and of inclines that may be of interest or use in the harvest. The gang proceeds for twenty half chains, when an acre has been covered. The measured acres are equal distances apart to the right and left of a base line through the tract. Sometimes circular areas of such radii as to contain a certain fraction or a whole acre, considered to be an average of the whole stand, are measured.

The volume is approximated by multiplying the area of the base of the tree at stump height by one-half the height. Each cubic foot of saw timber will cut out five to seven board feet. About eighty-five cubic feet of wood will pile up a standard cord of 4 x 4 x 8 feet, or about thirty solid cubic feet will pile up a cord of sixteen-inch wood.

As a further means of determining the most profitable procedure, stem analyses are made by determining the increase through decades by measuring the thickness of each ten annual rings, beginning at the bark. By deducting from the present volume that at any year previous, the increment during that period is obtained. From the average increment of a sufficiently large number of trees, a reasonably accurate account of what the whole area has been doing can be given and a working plan laid out. This method will determine for the owners whether the area being exploited is large enough to keep the mill running indefinitely. The capacity of mills is usually far too large for the area, so that after a few years' cut a move must be made or the mill go out of the business.

Felling. (Figs. 476, 477.)

In felling, the tree is chipped with the axe on the side in the direction in which it is to fall, in order to direct its course. Considerable skill in this matter is often necessary in order to place the tree where it is wanted on the ground. The cross-cut saw is used for the remainder of the cut, beginning on the opposite side from the chipping. When the tree is about to fall the workmen should step off at right angles to the direction the tree is taking, in order to avoid falling limbs that are often thrown in the line with the tree. No attempt should be made to drive farm animals from danger after the tree begins to fall. Failure to heed one or the other of these precautions costs numerous lives every year. Care is taken to avoid breakage as much as possible and to have the logs in a convenient place for loading. When wood is frozen, it is much more brittle than at other times. When trees are small enough to permit of it, they are cut close to the ground, which makes a saving of timber. In felling the large trees of the West, the choppers stand on a scaffolding. (Fig. 477.)

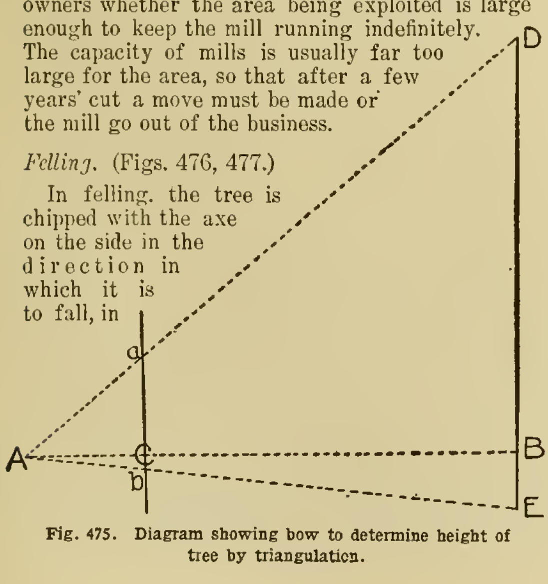

Fig. 475. Diagram showing how to determine height of tree by triangulation.


Fig. 476. Felling a tree. Drawn from a photograph of a chopper in action.

Sawmills. (Figs. 478–480.)

The location of the mill is one of the most important factors in the harvesting of a forest crop. The large mills are always located on a pond, stream or lake, in order to provide water for the steam boilers and to have water into which the logs may be rolled before they are taken into the mill. The logs are taken into the mill by means of a jack-ladder,—a heavy, endless chain that runs in the bottom of a V-shaped groove extending into the water, over which logs are floated,—or other suitable conveyance. The small portable mill, which is moved about to gather up what the larger mills do not take, is located in a position convenient to most

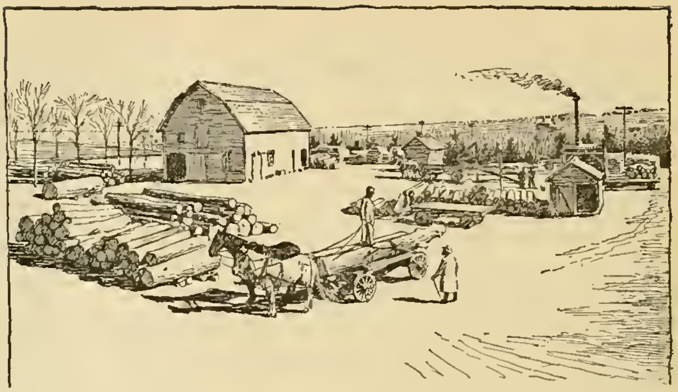
Fig. 478. Harvesting planted cottonwood. The logs were cut out as thinnings.

of the timber, the water for the boiler being supplied from a tank, pool or small stream ; and the logs are rolled on to the carriage from a skidway. The capacity of mills varies from one furnished with both circular and band saws and which runs night and day, cutting in twenty-four hours one or two hundred thousand feet, to one that runs for a longer or shorter period during the day, according to the demand of the customer and the will of the sawyer, cutting a few hundred or a thousand feet per day.

American ingenuity has modified machinery to meet the demands of the timber in each locality as far as possible. On the western coast the trees are so large that the machinery used in the East would be useless, so the power and capacity has been increased to meet the demand. Some of the logs are so large that they can not be moved and must be blasted apart to reduce them to portable or workable size. In such cases the percentage of waste is very high.

Small tools.

The small tools are few in variety but ample in quantity. Each camp is provided with a few pairs

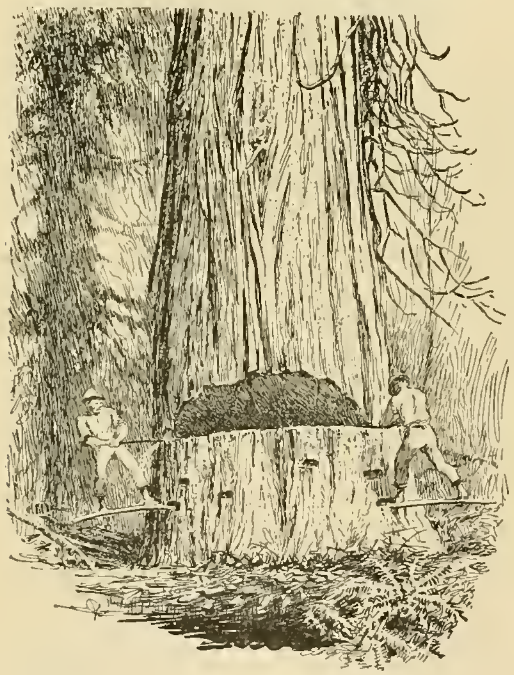
Fig. 477. Harvesting the forest crop in western Washington. The undercut on a giant cedar nearly completed; the tree will soon be felled.

of skidding tongs, which are similar to ice-tongs but heavy enough to stand the strain of one or more teams of horses. They are used to get logs out of inconvenient places. Chain is bought by the keg and made up by the blacksmith as needed. Cant-hooks for rolling logs by hand are always in evidence. Cross-cut saws are made ready for use by a man who is employed much of the time keeping them in order. Axes are bought by the dozen. A good strong man wants a four- to six-pound axe. The style known as double-bit is best liked by most choppers. The flattened handle and evenly balanced blades make guiding easier, and the edge capacity is double that of the single-bit or poled axe.

Transportation to market and mill. (Figs. 481–485.)

Water.—In the New England and lake states water has performed an important part in the transportation of logs to the mill. Logs have been thrown into the lakes and streams and carried many miles, where the lumber was available to canal, steam-boat or railway. Often the logs were left in the water for months, until some of them became water-logged and sank to the bottom. In such a bountiful harvest these were but straws and were never missed, but now companies are formed and rights are purchased for the purpose of raising these "dead-heads." The logs are peeled and piled on the bank to dry for a year, when they are again put into the water and floated to the mill, and cut into lumber, which is scarcely inferior to that which the logs would have made had they not sunk. Hard-wood logs are so heavy that they are not often driven for long distances in the water. In the southern states, cypress trees are often felled into the water and towed or poled to the bank. This is known as "jam-sticking." In certain parts of the West, wooden chutes, several miles in length and furnished with water, are used for running railway ties and other timber down the mountains.

Big wheels.—Where water is not available, other means must be resorted to. In the North, snow and ice roads are used in the cold season. During open weather in the North, and throughout the year in the South and parts of the West, what are known as "big wheels" are used (Figs. 483, 484). These wheels are said to have been used first in Michigan. They are built with a strong axle, the wheels standing six to ten feet high. Between the wheels one to several logs are suspended, the rear end being allowed to drag.

Roads.—Fairly good roads are made through the woods for a single crop, because a large number of heavy loads must be hauled over some of them. Swampers cut out the underbrush and clear away obstructions, after which grading is done if necessary.

Miscellaneous means.—In some mountainous regions, where rocks do not interfere, timber is allowed to slide down the incline on the bare ground. In the extreme West and Northwest, huge logs are dragged on the ground, rollers being supplied to convert sliding-friction into rolling-friction. Cattle, a means of power which has been largely used in harvesting crops, are used for this purpose because of their strength and convenience. In the South, what is called "drumming" is employed to a limited extent. This appliance consists of a large cylinder made to revolve, and which winds up a rope or cable, the outer end of which is fastened to the log. A much more powerful and practical method is the steam skidder, which, by means of pulleys and a cable, gathers the logs from a few thousand feet on either side of the track on which it moves and places them on the cars, if need be. Temporary tracks of either narrow or standard gauge are laid into the woods and camps, and when the timber in one place has been harvested they are taken up and relaid in another place. These are contrivances for short hauls to get the logs to the steam railway, on which they are placed and transported longer distances to the mill.

A great deal of lumber is now kiln-dried either after air-drying for a time or fresh from the saw, thereby making it fit for use much sooner than by air-drying alone. When the lumber is finally ready for the wholesale or retail dealer, it is again transported to the most likely sale-place, so that in any up-to-date market we find spruce from Maine, poplar (whitewood) from the hard-wood belt between North and South, yellow pine and cypress from the South, cedar and redwood from the West. The best grades of American lumber are shared with other countries. The poorer grades are found on the local country yards.

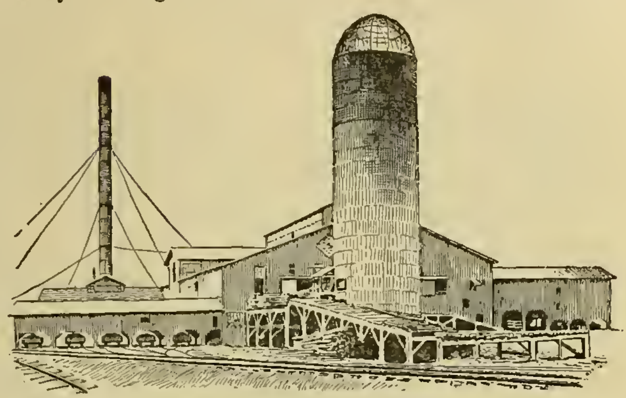

Fig. 480. Stationary sawmill.

Waste in lumbering.

Some thirty years ago only about 30 per cent of the available timber of a stand was placed on the yard. The best and most convenient was taken and the remainder left to grow, burn or decay as chance might determine. It did not pay in those days to be saving. With increased value, however, more care is now exercised to cut the crop closer. Some timber-land has been cut over for the third or fourth time, each time all that was worth harvesting being taken. Virgin stands are now worked very close in clean cutting where timber is valuable. All logs down to four inches at the top are taken to the mill, where there are two sets of saws. As the logs come into the mill, the better ones are thrown to one saw and the poorer to the other. The better logs nearly all make lumber, while the poorer ones are mostly cut into four-foot lengths from which is made wood alcohol, acetic acid, charcoal and the like. In hard-woods, the proportion is about one cord of wood to each thousand feet of lumber.

Where timber is valuable for fuel, the tops and limbs are worked into cord-wood to supply local demand, and the

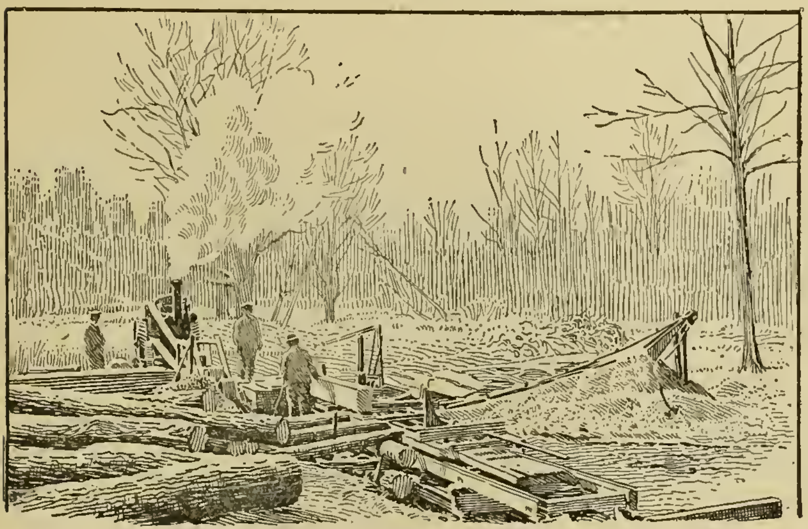

Fig. 479. Portable sawmill.

brush in some cases is burned to avoid uncontrollable fires. This should be done more frequently. The Forest Service has made investigations along this line and has found that in a certain locality in Minnesota the cost of burning the brush from pine timber was ten cents per thousand feet of lumber. In other places it would be more or less, depending on conditions. Formerly, great vertical cylinders called consumers, used for burning waste, were conspicuous objects at a large mill (Fig. 480), but present economy in some places leaves these as monuments to mark a stage in the progress in the economical development of timber harvesting. On small timber lots there need be no waste except the small brush, which should be left scattered so that it will decay more readily if it is not convenient to burn it.

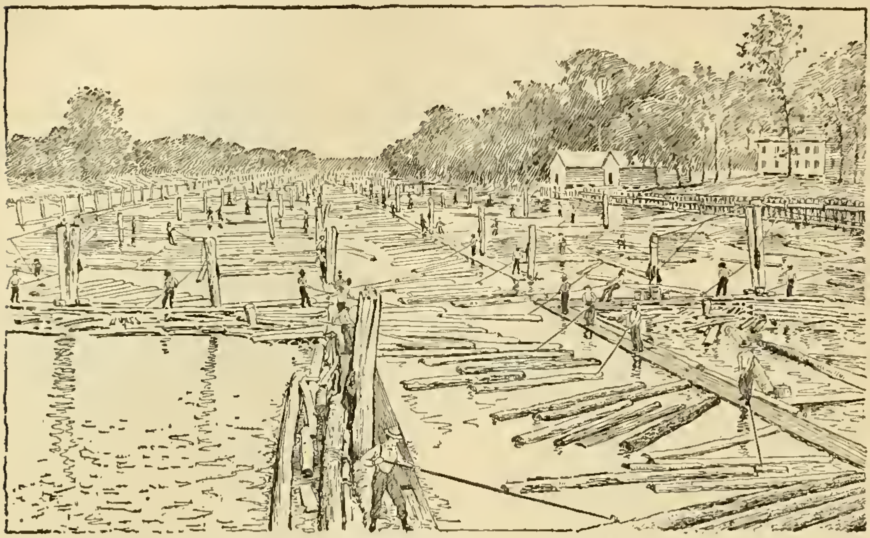

Fig. 481. Sorting logs at market. Northern Michigan.

Valuation.

In disposing of a piece of timber, the owner should know by what rule the timber is to be scaled. There are some fifty log rules; any one of them may be used, but comparatively few of them are in common use. One rule may be used in one locality and a different one in another locality. Theoretically, they should agree, because no rule can change the volume of a log. Logs are usually scaled at the small end inside the bark, but the practice of scaling in the middle prevails in some places. The rules that have found most favor are the Doyle, Doyle-Scribner, and the Scribner. Just how log rules are computed is not always easy to ascertain, but the Doyle rule is so simple that one may construct a table any time. It is essentially as follows: Reduce the diameter of the log at the small end by four inches; square one-fourth of the remainder and multiply by the length of the log in feet. By this rule, if a log is twenty inches in diameter and ten feet long, it contains 160 board feet. The Doyle rule gives less than Scribner's in logs up to about twenty-nine inches, and more than Scribner's above that.

Cost.

Other things being equal, it costs as much to harvest inferior classes of timber, like beech and maple, as it does walnut and hickory, and more than pine and cedar; hence the cost of harvest will be higher for the inferior timbers as compared with their value. The cost of laying the lumber on the yard is frequently one-half the market price. There are many factors which must be considered, any one or all of which may vary with the kind of timber, distance from mill, appliances, kind of help, wages paid, and other items. When the private owner can use help during part of the year that would otherwise be idle, as on the farm, he can deliver the logs to the mill at little expense and save that much on his stumpage.

Harvest time.

Ripeness and fitness determine when to cut.

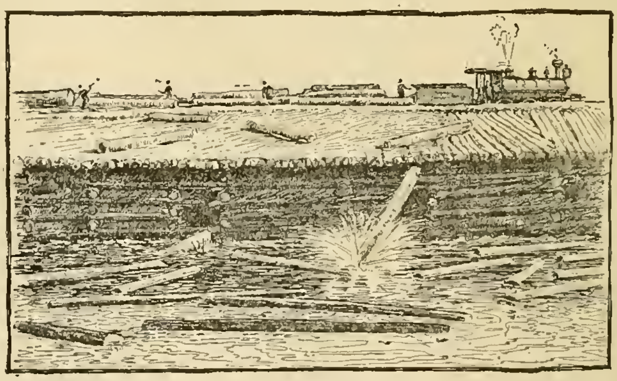

Fig. 482. Steam and water transportation. Northern Michigan.

Basket-willows, hoop-poles, fence-posts, telephone and telegraph poles, piles and the like, must be harvested when they are the proper size or age for the purpose; but for lumber, the trees should stand until the climax of growth is well passed. Trees are often swept off just when they are doing

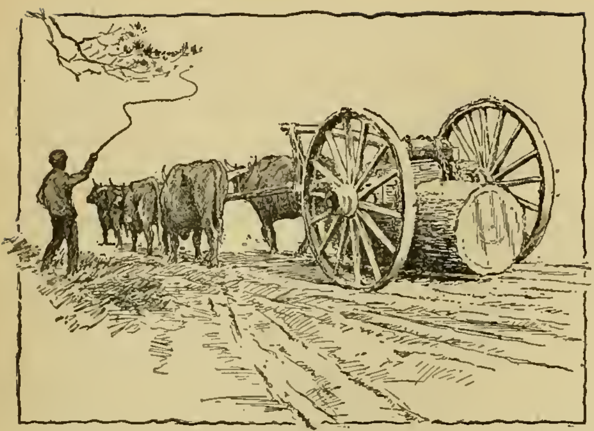

Fig. 483. The use of big wheels in harvesting of southern hard-woods. The common method of bringing in large white oak, gum and other hard-woods in the tide-water region of Virginia.

their best. This is particularly true of white pine, for which there is always a demand. This species makes its best growth from the thirtieth to the eightieth year, but good profit on clear stuff in the future is often sacrificed for box material at present. Species that are prone to decay while standing should be cut when in full vigor. The owner of small pieces of timber will adapt such appliances as best suit his needs, and choose such time or season for harvest as will most economically meet his demands.

Fig. 484. Pine logs ready for the road. Northern Michigan.

Harvesting the woodlot.

Much of what has been said applies to the farm woodlot. A few facts of special significance to the woodlot, however, should be pointed out. The farmer very frequently finds himself with a poor, thin wood crop. The best species have been removed, and the crooked and imperfect trees have been left; and this, too, without any justification. The main demand on the woodlot is for firewood, posts and poles, and, occasionally, a little dimension stuff. This can all be had to the improvement of the woodlot, when the harvesting is done judiciously. The point to keep in mind in handling the farm woodlot is to perpetuate it and make it a constant source of income. The method of harvesting will finally be determined by the purpose for which the product is desired.

Clean cutting is admissable only when there are a number of mature, valuable trees, with little or no undergrowth, and when the protection afforded by the woods is not important. If the area is to be continued as a woodland, then replanting by seed or seedlings is resorted to.

Under other conditions, selection cutting should be employed. For firewood, posts, poles and similar requirements, the dead or dying, slower-growing, undesirable species and forest weeds should be removed. For dimension stuff, only the mature trees should be taken. Care must be exercised in the selection of the cutting, in order that the conditions for the best growth of the remaining trees and the re-occupancy of the opened spaces may be promoted. It is important that the open spaces be filled either by natural growth or by planted seedlings. Judgment is required in the felling of the trees to avoid damage to the surrounding trees and to the undergrowth. The logs must be snaked out where they will least harm the seedlings.

When considerable dimension stuff is removed, a portable sawmill may be employed and placed in or near the woodlot. Frequently the logs are sledded to the local sawmill.

In colder regions the time for this work will be in winter when other farm work is not so pressing and when the logs and lumber can be moved on sleighs. Whether in summer or winter, a pair of skidding tongs will be found useful for rolling up logs, where they can be handled with a chain or for dragging them out of inconvenient places. A cant-hook is a convenience that one can not afford to be without.

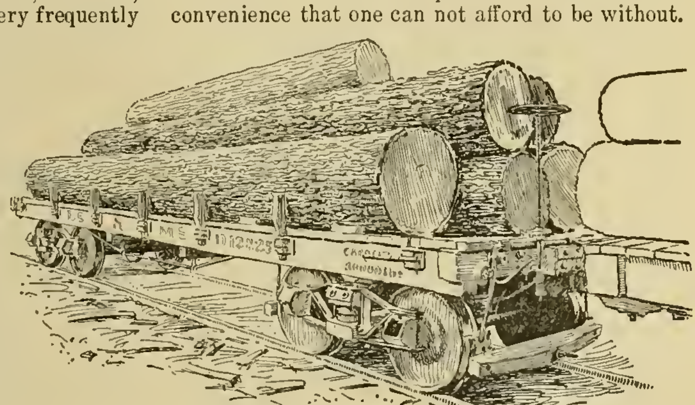

Fig. 485. Car of white pine. Grayling, Michigan.

Roads should be made with some care because nearly all young stuff is killed by driving over it a few times, and new growth does not come in for many years. Frequently a little drainage of wet places will prove very profitable.

The details of handling team, chain, sleighs and trucks can best be learned by experience.

Marketing timber crops.

The marketing of timber crops differs from that of any other farm product in several particulars. Meats are sold by the pound, eggs by the dozen, coal by the ton, grain by measure or weight, each having its standard of denomination. Timber crops are sold by the tree, acre, thousand-feet board measure, cubic foot, pound and even by the sack. The standard cord is 128 cubic feet, or a pile 8 x 4 x 4 feet; but in different localities the cord varies according to the uniform length of pieces composing it. Logs that will scale a thousand feet will generally make a little more than a standard cord of wood.

Fig. 486. An improvement thinning in planted white pine. The white pines were planted in mixture with ash and box-elder, and a partial harvesting of the crop has taken place in which box-elder, ash and poorer pines have been removed. The open areas are being filled by under-plantings of white pine and hard maple as seen in foreground.

A timber crop is an accumulation of annual growths, the nature of the plant making it impossible to market the annual growth each year. If the market conditions are not right one year, the crop may wait for even a score or more of years, or until such time as seems most favorable. The market for the crop has its ups and downs, but not nearly to the same extent as that of a perishable crop. The time and method of marketing will vary with the character of the crop itself, which varies in volume from the small willow whips only two feet in length, to the massive sequoias, the greatest of nature's organized products.

It is to the interest of the purchasing agent to buy lumber at the lowest possible price, for a thing well bought is half sold. He therefore tries to persuade the owner that his timber is not growing very fast, that some trees show evidence of decay and death, and that substitutes are on the increase, all of which may be true enough and yet not be sufficient reasons for making immediate sale. The growing rate of timber can be determined as well by the owner as by the purchaser. The area of the stump of a tree in square feet multiplied by one-half the height gives the approximate number of cubic feet in the tree. If, now, the thickness of the ten outer rings be determined, and the diameter be reduced by double this amount, we can estimate the volume of the tree ten years ago. Since the height of nearly or quite mature stands varies but little, the same height-factor may be repeatedly used. About eighty-five of the cubic feet thus determined, when cut, will make a standard cord of wood and other lengths in proportion. The increase in volume of saw timber can best be determined by cutting some of the most typical average trees into logs, and with Scribner's, Doyle's, Bauman's, or some other log book in hand, figure the board feet at present, and then by reducing the diameter by double the thickness of the ten outer rings it will give the board feet ten years before. The Woodman's Handbook, Part I, Bulletin No. 36, Forest Service of the United States Department of Agriculture, contains over forty log rules, besides much other information valuable to the man who handles timber.

It may be expected that under proper encouragement the more valuable trees in a stand may be made to increase more rapidly than under unmanaged or mismanaged conditions. While the rings of one decade may measure less than those of a past decade, the lumber in the larger tree is more valuable. Since different kinds of timber vary in rapidity of growth, the determination of one species will not answer for all.

Forestry can be practiced in an almost ideal way on the farm woodlot of five to fifty acres. Unless the quantity to be disposed of at one time is very small, one should know where the best markets are, the same as he would for other farm products. There are several publications devoted entirely to the lumber business. All large cities are great lumber markets. Chicago is a great pine market and St. Louis leads in hard-woods. It is quite possible for the forest owner to post himself on prices and prospects of market and crops by reading quotations and by correspondence with dealers. If he has a good article, it will sell almost any day. If one firm does not handle the goods he has to dispose of, it will usually direct him to parties that do. Expert advice can be secured for the asking of the official forester of the timber-owner's state or of some other. Such advice is usually given free of charge as long as there is no considerable expense of time and travel incurred. Personal inspection and consultation may be had at nominal cost. At all events, whatever plan of sale is adopted, the timber-owner should know whether selling for a lump sum, by the thousand, by the acre or by the cord, will bring him the most satisfactory returns.

The portable sawmill has done much to relieve the market of waste material. It is practicable only where there are several hundred thousand feet to be sawed. It should be a means of securing the highest price, since there is no expense of transporting almost worthless material in the form of sawdust and slab. However, what is waste today may be a valuable product tomorrow. There is now a market for both chestnut bark and wood for tannin, thus utilizing the whole tree. The tops of the trees not suitable for saw-timber are used by alcohol plants. In some places sawdust is an article of commerce. The discarded tops and butts of white cedar are now collected and made into shingles as far as the condition of the timber permits. Half-decayed pine logs and stumps are sawed into four-foot wood and shipped to brick and tile factories, or for use in other industries where wood fuel is preferable to coal. The logs that have lain on the bottom of lakes and streams for a score or more of years,—the remnants of a past harvest,—are now being raised and placed on the market.

Kinds and grades of timber products.

Willows for basketry must be marketed every year, or they become too large and too much branched. The bundles are easily handled and can be loaded on hay-racks like sheaves of grain and hauled to the basket factory or transportation medium. The price to the grower will depend very largely on the quality of crop and proximity to the place of manufacture. The whips should be two to eight feet long, all of one season's growth. The marketing of this crop differs from that of most others of its class in that there is only one use to which it is put and only basket factories buy the product. There are at present few basket factories in the United States, but since nearly all hand work is required the grower could without much outlay establish his own factory and to a large extent control the market for his crop.

The splint basket mills are less expensive to establish than sawmills and are frequently built at some railway station, where the product can easily be shipped away. The timber is cut into veneers, and all waste is used for fuel to run the machinery. The mills use up the remnants of a stand of timber, as the requirements are so moderate that crooked and knotty timber of many species can be profitably employed.

The market for small birch, elm, black ash and hickory poles for half-round split hoops has practically passed. There is, however, some demand for hickory and white oak butts, twenty-eight to forty-two inches long and at least four inches in diameter at the small end, for pick and other handles. When trees of these species and others are to be placed on the market, the owners should correspond with the manufacturers of such tools. If these companies can not use the material, they will inform the owner where such materials can be marketed. Small-sized soft-wood trees will find most profitable sale for paper pulp in regions where this material is used. Sticks four inches or more in diameter and four feet long bring three to five dollars per cord delivered at the mill. If not used for pulp they will be in demand for fruit packages. Poplar and basswood in eight-foot lengths are most profitably disposed of for porch columns. Hard-woods and some conifers of better class than for basket stuff—straight trees to twenty-four inches in diameter on the stump,—are now profitably disposed of for piling, and the longer and straighter the better. Even such common woods as beech, black ash, maple and tamarack are now used for this purpose, but are not so good as oak and cedar.

Second-growth white ash and hickory always find a ready market for handle stuff. Cedar is easily marketed in any size from posts three inches in diameter at the small end. As this timber is very light, it is often profitable to transport it on water even of small streams. As the tree generally grows in swampy situations, it is best prepared for market in winter and transported in spring. It is necessary first to peel the bark with draw knives. Trees large enough for telephone poles command high price. The available quantity is now so small in the East that poles are being shipped from as far west as Idaho to supply eastern markets.


Fig. 487. Harvesting a woodlot of mixed hard-woods in southern Connecticut. The quantity of timber removed in a heavy improvement cutting is shown by the piles of wood. Only the post trees of desirable species have been left. The original stand was dense.

Chestnut not suitable for poles is now sold for tannin, thus making use of what otherwise might be wasted.

The uses of trees large enough for sawed lumber are very numerous. Chairs, coaches, tables, tanks, beds, boxes, shingles, spokes, floors, frames, and a long list of articles of familiar and common use are examples.

Hard maple of the best quality should be marketed for flooring, but if no mill for its manufacture is at hand, it can be used for medium-priced furniture and other commodities, such as shoe lasts, boot-trees and fuel. The intrinsic value of this wood is such that it should command a much higher price than at present.

White ash has long been the common wood for ball bats, but now maple, beech and black ash are all used for low-priced goods of this class.

Immense quantities of all the cheaper grades of timber are used for dry barrels and a large number of articles classed as "pail stuff."

Elm has experienced a rapid and steady increase in price as its possibilities have become better known. It is now used for a large part of the cheaper grades of furniture. When steamed it bends readily, and for this reason is largely used for flat hoops. Attention was drawn to the possibilities of all the elms when it was discovered that rock elm is an excellent wood for the manufacture of wood-rims for bicycles. The quantity of rock and red elm is very limited, but the supply of white elm, in spite of the fact that the timber decays readily and does not grow rapidly, is holding out well, probably because it withstands exposure well and frequently occupies land that is not well adapted to cultivation or grazing. Small trees, four to twelve inches in diameter, are sometimes sold for hubs. This requires the sacrifice of young, growing stock, which, under most circumstances, would best be left in the stand. It may be stated in this connection that the pepperidge of the North, which is the black gum of the South, of suitable size, would better be used for hubs than for any other purpose.

Because of wind-shake and other defects, hemlock is uniformly used for dimension stuff. Although not a first-class lumber, there is steady demand for it at reasonable prices.

With the increased value of wood has come a substitute of the poorer sorts, where formerly only the better quality would answer. Not long since, black walnut was considered the only wood suitable for certain kinds of furniture. This has been replaced almost entirely by oak; but now oak is increasing in value to such an extent that some other wood must soon take its place. The art of veneering is helping to extend the use of the more valuable woods. Tables, desks, doors, and other articles of common use, are now made of hemlock and veneered with yellow pine, oak, or some other wood susceptible of a high finish. Consequently, timber good enough for work of this nature can be placed on the market almost any day at a good price. The owner of a fine specimen of white oak has been offered one hundred dollars for the tree on the stump, which was more than the value of an acre of the land on which the tree was growing.

Three-fourths of our timber product is from cone-bearing trees. A large proportion of this is pine. The extensive tracts of timber, composed largely of cone-bearing trees, are owned by men of large means, companies or corporations, but these organizations have not yet gained such control of supplies but that the owner of a small patch of pine, if it is properly managed and marketed, may realize rich returns from the crop. Stands that twenty years ago brought two dollars and a half per acre now bring a hundred or more. In Michigan, white pine is now worth ten dollars to twenty-five dollars per thousand feet on the stump. In Fig. 484 is seen a load of pine logs starting for market. The logs in the booms shown in Fig. 481 are mostly pine and hemlock. The car shown in Fig. 485 is loaded with 35-foot white pine logs, except a small Norway pine log (*Pinus resinosa*) on top.

Development in lumbering industries.

Some classes of timber have doubled in price in five years, while others have taken twice as long to experience a like increase in price. In spite of the many substitutes for wood, its consumption is increasing at the rate of about 3 per cent per capita per annum, the quantity now used being about three hundred and fifty cubic feet per capita in America; and forty cubic feet in Germany and fourteen cubic feet in England, where substitutes for wood are largely employed.

That the demand for timber will continue to increase can not be doubted when we are reminded that, besides consumption for many other purposes, in lumber and pulp timber alone we clear an area of good virgin forest every year as large as the states of Connecticut and Rhode Island; for boxes and crates, 50,000 acres; for matches, 400 acres; for shoe-pegs, 3,500 acres of good second-growth hard-wood; for lasts and boot-trees, 10,000 acres; while for fuel we require 17,971,200 acres, or four and one-half times the area of Connecticut and Rhode Island. These are examples of large and small consumption, the intermediate uses being almost indeterminate.

The adaptation of the inferior woods to new uses has led to the convenience of a local though small market, where a timber-owner may dispose of material that he does not need or which is ill adapted to his purpose, and at the same place he may secure building materials that better meet his requirements. The difference in price of that sold and that purchased is necessary, considering the perishable and combustible character of the goods, the long hauls, and the freight rates, all of which must ultimately be met by the consumer.

Literature.

Nearly all forestry books contain advice on harvesting. Following are a few useful references: Schlich, A Manual of Forestry; Gayer, Forstbenutzung, eighth edition; Ribbentrop, Forestry in British India; Nisbet, The Forester, Vol. II; C. A. Schenck, Forest Utilization; William F. Fox, A History of the Lumber Industry in the State of New York, Bulletin No. 34, United States Forest Service; J. E. Defenbaugh, History of the Lumber Industry of America. The Woodsman's Handbook, Part I, Bulletin No. 36, Bureau of Forestry, Washington, D. C.; Forest Mensuration, by Henry Solon Graves, John Wiley and Sons, New York, 1906; Rules and Specifications for the Grading of Lumber, Bulletin No. 71, Forest Service, United States Department of Agriculture; Grades and Amount of Lumber Sawed from Yellow Poplar, Yellow Birch, Sugar Maple and Beech, Bulletin No. 73, Forest Service.

Insect Enemies of Woodlot Trees. Figs. 488–491.

By *A. D. Hopkins.*

The insect enemies of trees in the woodlot differ with the section of country and the kind of trees represented. In the New England states, the woodlot may consist of almost pure stands of white pine, mixed spruce, pine, birch and the like, maple, oak and hickory; farther south it may consist of pure stands of scrub pine, pitch pine, black locust, or mixed hard-wood, yellow poplar, walnut, beech, chestnut; in the south Atlantic and gulf states it may be loblolly or long-leaf pine, sweet gum or mixed hard-woods; north of the gulf states it may be mixed hard-woods, with oak, hickory, locust, box elder or cottonwood predominating; in the Rocky mountain region it may be pine, spruce, aspen or cottonwood; toward the Pacific coast, scrub oak, live oak, pine or redwood; in the Northwest it will consist of a different class of trees, growing under very different conditions from those found in any other section of country.

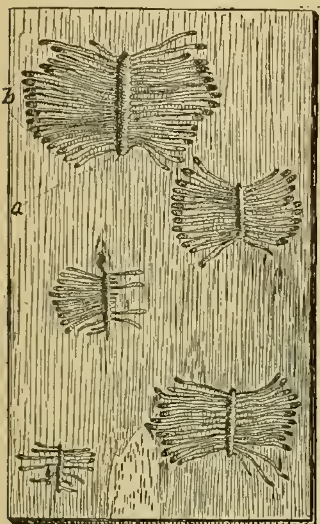

Fig. 488. Work of the hickory bark-beetle on surface of wood beneath the bark: *a*, primary gallery; *b*, larval mines.

Each tree and each section of the country has its peculiar class of insects, requiring special methods of control. It is readily seen to be impracticable to discuss in a short treatise even the more important insect enemies of the farmers' woodlots in all sections of the country. If we take one section, however, we may give some general information on the character and extent of the depredations by a few of the principal and more widely distributed enemies, and methods for their control.

Enemies of a special section.

In the section east of the Mississippi river and north of the gulf states, the average insect losses affecting the medium- to large-sized hard-wood trees of the woodlot and small forests evidently equal, or even surpass, the average losses to the same class of timber by forest fires. The hickory bark-beetle has killed a large percentage of the hickory; the black locust has been so badly damaged by the borer that in some sections where the conditions are otherwise most favorable for the growth of this valuable tree, it is rendered practically worthless; the heart-wood of some of the finest specimens of oak and chestnut is often so badly damaged by timber worms that it is valueless for anything but fuel or rough boards. While the pines and spruces suffer more perhaps from fire than from insects, especially the young growth, there are certain insects, as the white pine weevil, which often cause serious damage. Thus we see from these fonr examples alone that the insect problem is by no means the least important to be considered by the farmer in the management of his woodlot.

There are also local problems, like those presented in Massachusetts and adjoining states by the gypsy moth and brown-tail moth, which are already demanding attention through federal, state and private effort and the publication of information.

Controlling special cases.

It may appear at first that the problem of controlling the more common and widely distributed insect enemies of forest trees is difficult and expensive, when, in fact, it is often just the reverse. A few special cases are cited to demonstrate this point.

The hickory bark-beetle (*Scolytus quadrispinosus*) is a short, stout, shining, black or brownish beetle, averaging about one-eighth of an inch in length, which attacks the medium to large hickory trees in the spring and summer, and girdles them by excavating egg galleries and larval mines (Fig. 488) under the bark. The undeveloped brood passes the winter in the bark, and the matured brood of adults flies in May to August to continue the depredations. To control an outbreak of this pest it is necessary that all, or at least a large percentage of the hickory trees within a radius of a few square miles that die from any cause in the summer, be felled and utilized for fuel, or other purposes, or be burned, to kill the over-wintered broods. The work must be done in the period beginning with about the first of October and ending with the first of May. To prevent further trouble, living hickory trees for any purpose should be cut in the spring and summer, so that the tops and unused parts of the trunks may be utilized by the beetles as breeding places and thus serve as traps, when they can be destroyed the following winter by

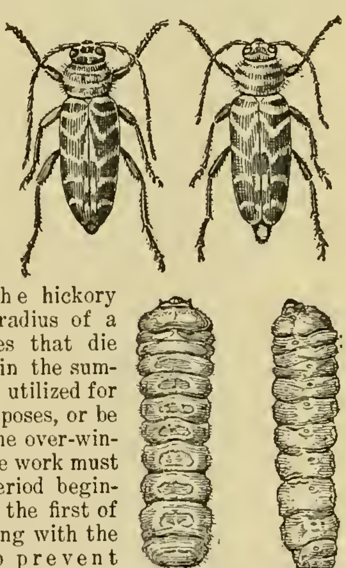

Fig. 489. Locust borer (*Cyllene robiniæ*). Upper figures, mature beetle: left, male; right, female. Lower figures, the larva, showing dorsal view on left and lateral view on right. (Upper figures enlarged slightly less than one-half; lower figures slightly more than one-half.)

burning. [For further information, see Yearbook, United States Department of Agriculture, 1903, pp. 314–317.]

The locust borer (*Cyllene robiniæ*, Fig. 489) is a whitish, elongated, round-headed grub, which hatches from an egg deposited by a black-and yellow-striped long-horned beetle, found on the trees and on the flowers of goldenrod from August to October. The eggs are deposited in August and September in the outer bark on the trunks and branches, and the young larvæ pass the winter in minute hibernating cells between the outer corky bark and the living bark. In the spring they bore through the inner bark and enter the wood. Their presence is indicated in May, June and July by the boring dust lodged in the bark and around the base of the infested trees.

The young hibernating borers may be killed from November 1 to April 1 by spraying the infested trunks and branches with kerosene emulsion, one gallon to two gallons of water. The older borers, after they have entered the wood, may be destroyed in May to July by cutting out the worst infested trees and burning them or immersing them in streams or ponds. The cutting of locust for any other purpose, however, should be done between November 1 and April 1, so that the removal of the bark from the utilized part of the trunk and the burning of the tops will kill the young borers before they enter the wood. New plantations should be made where the locust is naturally free from general injury, and seed for the purpose should be from trees which show the least damage. [For additional information, see Bulletin No. 58, Parts I and III, and Circular No. 83 of the Bureau of Entomology, United States Department of Agriculture.]

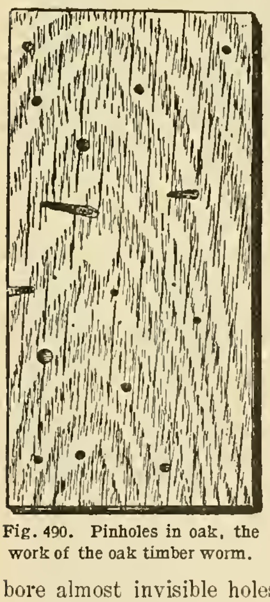

Fig. 490. Pinholes in oak, the work of the oak timber worm.

The oak timber worm (*Eupsalis minuta*) is a slender, whitish, cylindrical grub or worm, less than an inch in length, with the segments toward the head much enlarged, and the last abdominal segment smooth and rounded. These worms hatch from eggs deposited in wounds in the bark and wood of living trees, and at first bore almost invisible holes directly into the wood. The burrows are enlarged and extended in all directions through the heart-wood until the larvæ have attained their full growth. (Fig. 490.) They then transform to adults within their burrows and emerge the next spring or summer to repeat the cycle in the same wounds or in the wood of dead trees, stumps and logs, either standing or felled. An axe wound in a large healthy tree may result in attack by this insect, and later the entire heart-wood become perforated with so-called pinhole defects. Wounds made by lightning

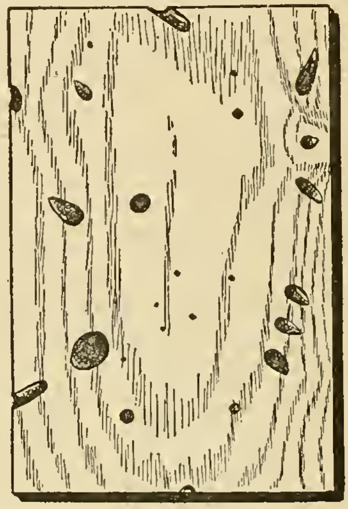

Fig. 491. Pinholes in chestnut, the work of the chestnut timber worm.

or other cause may result in the wood of the entire trunk being thus rendered worthless for stave timber, clapboards or first-class lumber. This insect breeds in great numbers in the stumps of dead trees and in the stumps and logs of felled trees, and is ever ready to attack living trees wherever a slight wound in the bark offers an opportunity. To avoid the attack of this insect on living trees, all injured or dead hard-wood trees, as well as the logs of felled ones, should be promptly utilized or burned, and newly felled trees should be cut very close to the ground and the brush tops burned over the stumps. Indeed, the disposal of all places for the breeding of this insect will always be an important feature in the management of American hard-wood forests and farmers' woodlots. [For additional information, see Yearbook, Department of Agriculture, 1903, pp. 323, 324 and Bulletin No. 35, West Virginia Agricultural Experiment Station, p. 294.]

The chestnut timber worm (*Lymexylon sericeum*) is somewhat similar in general form to the preceding, but is at once distinguished by the dark brown, horny plate with toothed edges on the last segment of the body. It hatches from an egg deposited by an elongated, brownish beetle clothed with fine silky hairs. The habit of this borer is practically the same as the oak timber worm, except that it is found principally in chestnut, though it sometimes infests red oak and white oak. It is exceedingly destructive to the heart-wood of old chestnut trees (Fig. 491), and never fails to enter the slightest wound in the bark on the trunks and around the bases of the dead branches of living trees. It also breeds in dead or felled trees, stumps, and the like, so that the method of control is practically the same as that recommended for the oak timber worm, especially as applied to chestnut and red oak.

General advice.

It should be remembered that after a tree is once attacked and seriously injured by one or more of these wood-boring insects, nothing can be done to repair the damage, and that therefore prevention is of primary importance. Thus it will be seen that the control of an outbreak of any of the principal insect enemies of the woodlot involves the adoption of methods of management by which the utilization of the infested trees at the proper time will destroy the insects and bring about the desired results with little or no additional expense, and this is to be supplemented by other features in the management which will prevent future trouble.

Some of the rules of general application are as follows:

Fell and utilize or destroy, in the fall or winter, all dying or recently dead trees before the broods of destructive enemies have had time to develop and emerge; utilize or destroy all tops, large branches, and logs from living trees cut the previous winter, spring and summer, and burn the brush over the stumps.

Avoid injury of any kind to the bark and wood of living timber, especially of oak and chestnut.

Cut and utilize the old trees which show evidences of deterioration, and those which have been injured by lightning, storm or other causes; and if the trees are infested by destructive insects, do the work in the fall and winter.

Forest and Timber Diseases. Figs. 492–497.

By *Hermann von Schrenk.*

The diseases which affect forest trees manifest themselves in various ways, depending on the part of the tree which is attacked. Diseased trees may be recognized by the yellowing or other discoloration of their leaves, a much reduced growth of the trunk and branches, the dying of the tops, the appearance of swellings on leaves or branches, and by the growth on trunks or branches of punks or toadstools. A diseased tree forms less wood than a healthy one, and in many cases decays at the heart, (Fig. 492), with a resultant total destruction of the wood, and ultimate death.

Trees are liable to become diseased from the first year on. They are most liable during the latter part of their life. A number of fungi attack seedling trees and cause their death, by strangling them or by killing the young leaves. As the trees grow older, the destruction of certain branches and leaves may not have any very serious results; but after they have reached a period of maturity, they become more subject to disease, because larger branches will be broken off; and more wounds are made in old trees than in young ones. Practically all kinds of trees are subject to disease, and some more than others. The redwood, cypress and the various cedars are comparatively free from disease; so, also, are trees like the red gum, sycamore and sassafras. The oaks, beech, birch and other hardwoods are rarely attacked when young, but become very liable to disease after they have reached the age of fifty years or more; the same is true of pines, firs and spruces.

Causes of disease, and points of attack.

Diseases of forest trees may be due either (1) to unfavorable conditions of soil and climate, or (2) to parasitic enemies, as insects, fungi and higher plants. Wet, soggy soil will produce stag-headed trees; excessive quantities of sulfur gas in the air will result in a discoloration of the foliage of the entire tree, and frequently in its ultimate death. In dry years there will be very much less disease than in years of heavy rainfall. Trees that are grown very close together will be much more subject to disease than those that are farther apart. Woodlots in which all of the trees are of one kind will be much more liable to disease than woodlots in which different kinds of trees are grown. In seedbeds, diseases will be favored by poorly drained soil and by excessive mulching. Thrifty trees will always be very much less subject to disease than weak ones.

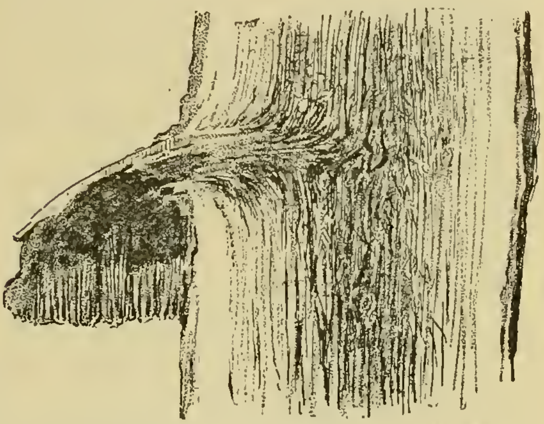

Fig. 492. Section showing how fruiting body of wood-destroying fungus grows, and the resulting internal rot.

The diseases due to fungi can be divided into (1) diseases of the living parts, and (2) diseases of the dead parts. The diseases of the living parts affect the leaves, the younger branches and the smaller roots, and a thin layer of the body of the tree, including the most recently formed wood and the inner bark. The diseases of the dead parts affect the older wood of the trunk, roots and branches, known as the "heart-wood." The fungi that cause disease of the living parts bring about local or general disturbances, which at first weaken the tree and may ultimately kill it; those that attack the heart-wood bring about the decay of the heart-wood, resulting in the loss of wood, and when the decay goes far enough, in the weakening of the tree so that it is easily broken off.

Nature of the disease fungi and their action.

Fungi are a low class of plants, consisting of fine threads, called hyphæ, many hyphæ forming the mycelium. The mycelium grows in the dead or living parts, extracting certain food substances therefrom. After varying periods, fruiting bodies are formed, which develop spores. These fruiting bodies have various shapes, varying from microscopic structures to the large punks or toadstools so commonly found on older trees. The spores are discharged into the air, and are distributed from one tree to another by the wind; they are also carried from tree to tree by insects, rain, or, when the fungi grow under the ground, by burrowing animals, such as moles and mice.

Fig. 493. Effect on wood of red spruce by the mycelum of *Polyporus borealis*. (Figs. 493, 494 are adapted from Bulletin No. 193, Cornell Experiment Station.)

When the fungus causes a disease of the leaves or branches, the spores usually germinate directly on the leaves or branches, the fungus penetrating into the living tissue, and growing there. When the fungus attacks the heart-wood of the tree, the spore must get into some wound. During the early life of the tree these wounds are very few in number, but as a tree grows older many wounds are formed, and the tendency to close these wounds, either by the formation of callus or by the exudation of gum or resin, is very much reduced. Wounds are made by deer and other browsing animals, by woodpeckers, but chiefly by the breaking off of large branches by the wind or snow. Wherever a wound is made, the spores from numerous wood-rotting fungi enter and germinate, and the mycelium of the fungus grows down into the heart-wood of the tree. When it has reached the heart-wood, it grows both up and down in the tree trunk, and results in the partial or total destruction of the wood, as shown in Figs. 492, 493 and 494. When a sufficient amount of nutritive material has been absorbed from the trunk, a punk or toadstool forms on the outside, bearing new spores, as shown in Fig. 492. Fig. 497 illustrates a different type of injury. It shows the way in which mistletoe forms a "bird's-nest" on lodge-pole pine.

The fungi that attack leaves and branches are rarely present in sufficient number to kill a large tree, although they may stunt its growth. They are very much more dangerous to extremely young trees. The so-called "damping-off" fungi belong to this group, and they are particularly active in seed-beds. As the tree grows older, the wood-rotting fungi become more important, and the older the tree gets the more liable to disease it becomes. For most kinds of trees, a certain age usually will mean an almost certain attack by one or the other of the wood-rotting fungi, and it is generally well, when such trees are used for lumber, to cut them shortly after this age has been reached. For pines this may be about eighty to one hundred years. It is the latter class of fungi that are of particular interest to the lumberman and forester.

Some of the important fungi which produce disease in forest trees are the red heart fungus (*Trametes pini*, Fig. 496), found on all coniferous trees; the false tinder fungus (*Polyporus igniarius*, Fig. 495), found on beech, apple, oak, poplar and other hardwoods, where it produces a white, soft rot of the trunk; the sulfur mushroom, which causes a brown rot of many coniferous trees, and also of oak, walnut, cherry and other deciduous trees.

The fungi that attack hewn timber and produce decay belong to a separate group. The factors which favor their development are, a certain amount of heat, oxygen, water and food supply. Dry wood will last very much longer than green wood. A post set in the ground with its bark removed will outlast one with the bark on. Sap wood is very much more liable to attack than heart-wood. The rate at which different kinds of wood will decay differs, and woods are accordingly classed as long- and short-lived. Long-lived woods are such as white oak, cypress, cedar, chestnut and redwood; and short-lived woods are such as fir, hemlock, beech, red oak, gum and the soft pines.

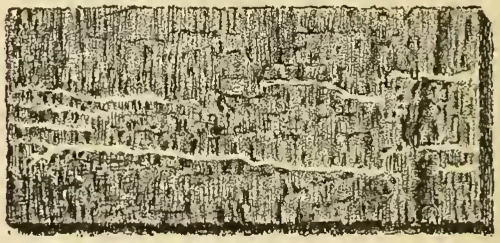

Fig. 494. Disintegration of wood by *Polyporus borealis*.

Prevention of disease.

In forest trees.—The prevention of diseases in forest trees is more or less difficult. The best method of keeping a tree healthy is to remove those conditions which favor disease. Trees should be grown in well-drained, carefully prepared soil, free from previous fungous contamination. Seed-beds in which a disease has started should be sprayed with Bordeaux mixture. Trees that become diseased because of the attack of fungi on their leaves or younger branches should likewise be sprayed with various fungicides, notably Bordeaux mixture; this will prevent all mildews and blights, to a greater or less degree. For fungi that attack the heart-wood, careful attention to wounds is advisable. Wherever a branch is broken or sawed off, the exposed surface, wherever practicable, should be coated with some antiseptic substance, preferably coal-tar creosote that has been heated. All wounds should be carefully trimmed, so as to facilitate the healing process. In large forest tracts measures of this kind may not yet be practicable, and in such cases the only preventive measure is to destroy the source of infection, as far as possible. On limited areas it is possible to remove the punks or fruiting bodies of the wood-destroying fungi and, better still, to cut down all trees which show any signs of being diseased. A careful weeding out of diseased trees will remove the source of infection for the other trees, to a very large extent.

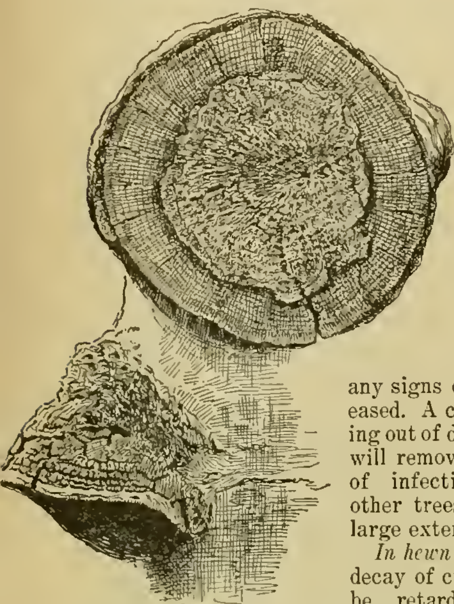

Fig. 495. Tinder fungus (*Polyporus igniarius*) on beech log. The external part of the fungus is shown below; the heart-rot injury above.

In hewn timber.—The decay of cut wood may be retarded or prevented by various means. The easiest way to prevent the development of the fungi is to "treat" all wood which is exposed to atmospheric agencies. Charring will frequently be found useful. For getting longer service out of wood, it should be chemically treated by painting with some preservative, such as carbolineum or coal-tar creosote. Care should be taken, however, that only absolutely dry wood is painted. Timber immersed in a solution of one part of corrosive sublimate to 150 parts of water will be proof against the attack of decay-producing fungi for many years. The best preservative is undoubtedly coal-tar creosote, which can either be painted on the wood or be pressed into it by various mechanical devices.

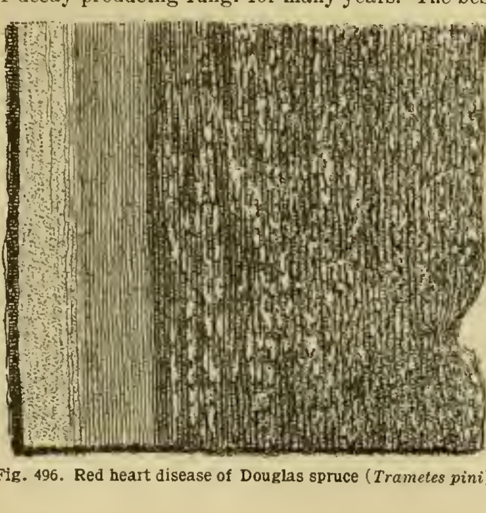

Fig. 496. Red heart disease of Douglas spruce (*Trametes pini*).

Literature.

The following are some of the more important books and papers relating to the diseases of American trees and timber: G. F. Atkinson, Studies of Some Shade Tree and Timber Destroying Fungi, Cornell Agricultural Experiment Station, Bulletin No. 193 (1901); E. M. Freeman, Minnesota Plant Diseases, Chapters on Diseases of Timber Trees (1905); Galloway and Woods, Diseases of Shade and Ornamental Trees, United States Department of Agriculture, Yearbook 1896, p. 237; Robert Hartig, Diseases of Trees (1894); F. D. Heald, A Disease of Cottonwood, Nebraska Agricultural Experiment Station, Bulletin No. 19 (1906); Perley Spaulding, A Disease of Black Oaks, Report Missouri Botanical Garden (1905); the following by Hermann von Schrenk: A Disease of Taxodium, and of Libocedrus, Report Missouri Botanical Garden, No. 11 (1899); A Disease of the Black Locust, Report Missouri Botanical Garden, No. 12 (1901); The Bluing and Red Rot of the Western Yellow Pine, Bureau of Plant Industry, Bulletin No. 36 (1903); Diseases of New England Coniferous Trees, Division of Vegetable Physiology and Pathology, United States Department of Agriculture, Bulletin No. 25; Fungous Diseases of Forest Trees, United States Department of Agriculture, Yearbook, 1900; Two Diseases of Red Cedar, Division of Vegetable Physiology and Pathology, United States Department of Agriculture, Bulletin No. 21; A Disease of White Ash, Bureau of Plant Industry, Bulletin No. 32 (1903); Decay of Timber, Bureau of Plant Industry, Bulletin No. 14; Diseases of the Hardy Catalpa, Bureau of Forestry, Bulletin No. 37; Diseases of the Redwood, Bureau of Forestry, Bulletin No. 38; Seasoning of Timber, Bureau of Forestry, Bulletin No. 41; C. S. Sargent, Silva of North America (has numerous notes on fungous and insect diseases of trees); C. Freiherr von Tubeuf, Diseases of Plants, Longmans, Green & Co., New York (1897).

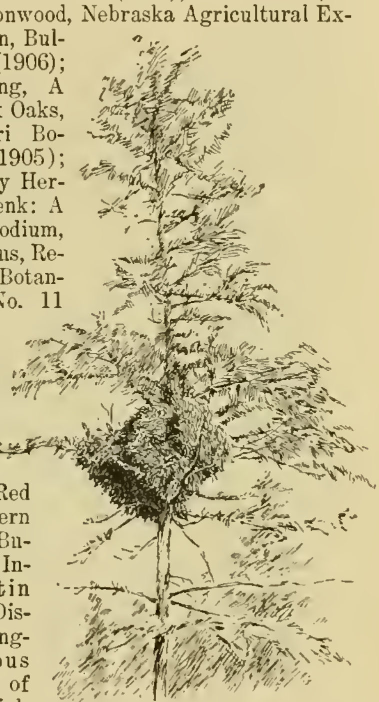

Fig. 497. Mistletoe forming "bird's nest" on lodge-pole pine.

FRUIT-GROWING. Figs. 498–505.

No branch of American agriculture has shown a more complete adaptation to modern demands and conditions than fruit-growing: it has become a large-area and real farm enterprise; the field practices have been completely changed within a score of years; the products have come to be of national importance. Persons now purchase farms for the sole purpose of raising fruit on them; and on mixed-husbandry farms the orcharding part has taken on a broader and freer spirit, and is not merely an isolated or incidental part of the farm scheme. In other words, fruit-growing has assumed commercial significance, and it must now be considered in any fair discussion of farm management.

That this has not always been true, is shown by the literature of fruit-growing. The older books are mostly a reflection of fruit-gardening, dealing with varieties and with small special practices. Within the past few years the writings have had a larger sweep, conceiving of fruit-growing in much the spirit that we conceive of grain-growing or live-stock-raising. The personal fruit-garden, as an amateur adjunct to a home, has been relatively neglected. Just now, however, there is a revival of the amateur interest in fruit-growing, expressing itself as a reaction from the commercial business, and as a result of the suburban and country-home movement. While the practices in these two types of fruit-growing are similar in principle, the types themselves are quite distinct. One is a broadly agricultural type; the other is a fancier and connoisseur type.

Where one would best engage in fruit-growing is a question difficult to answer. Once the Editor knew; but after he went away from home he began to doubt, and now he has no opinion. Fruit-growing is no longer confined to a few areas here and there. It is practicable in many regions that have been considered to lie outside the "fruit belts." Wherever any fruit has been grown successfully, it can in all probability be grown again. Sometimes a region that has not been exploited for any kind of fruit may afford excellent natural adaptabilities. The choice of a location is usually determined by the general region in which one desires to live; then the intending fruit-grower can make inquiries as to the parts of the region that are best adapted.

Fig. 498. Clean culture in an apple orchard. Ontario type of tree.

The farm plan.

The farm management phase of fruit-growing has received little careful study. The orchard occupies the land for years. Usually the man who likes to grow fruit does not care much for live-stock,—the two businesses require different mental attitudes. It is a question whether the relative lack of live-stock in fruit-growing communities is not a serious disadvantage, not only in relation to maintaining productiveness of the land, but to the developing of general rural activities. It is a question, also, whether labor, teams and implements could not be more economically utilized by some corollary system of simple field-farming. As at present conducted, orcharding is not a self-continuing or self-regulating business in the sense that good rotation-farming is; that is, there is no regular provision for utilizing the land after the orchard is removed. The grower usually does not lay out a plan of land management, one item in which is the growing of orchards. In the case of apples, the life of the orchard is so great, at least in the eastern states, that the grower feels that he is planting for a lifetime, and he leaves succeeding questions to those who may come after him. Even apple orchards may be retained too long for profit, however; and peaches, plums and some other fruits are not too long-lived to form part of a rotation plan. The rotation farmer may lay out a course that is not expected to mature within twenty years (pages 95, 96). Small-fruits are well adapted to rotationing. In fact, careful rotation is the very best means of keeping in check certain difficult diseases and pests of strawberries, raspberries and blackberries. The rotation may be between different kinds of fruits themselves, or between fruits and field-crop courses. The point is that fruit-growing practice ought not to be completely isolated from general farm management plans.

Aside from a rotation of fields, it is often advisable to lay out a rotation of crops in the orchards themselves when the trees are young. Such rotation practice would reduce the great amount of tillage labor by keeping part of the area always in clover or other sod, would correct the faults of a continuously recurring treatment, would guard against neglect, and would allow of a somewhat definite plan of work for some years ahead. The rotation should be short and should contain the maximum of tilled crops. A three-year course might fit the conditions well, for it would be adapted to the varying early stages of orchards, and would correspond with normal strawberry rotations and even with the best practice in raspberries. One to four three-year courses could be run in orchards before the trees are large enough to interfere, depending on the land, the kind of fruit and the distance apart. A three-year course for young orchards should preferably have two tilled crops and one legume or sod crop; as (1) potatoes, roots or truck-crops, (2) corn, (3) crimson clover or vetch in fall or spring; or, again, as (1) corn, (2) cotton, (3) cowpea or velvet bean. Sometimes it may be allowable to run only one tilled crop, in which case the potatoes–wheat–red clover may be useful. Care must be taken to see that first attention is given the trees, and this should call for manure or fertilizers with one or more of the courses.

Rotation, between the fruit plantations themselves, may be very desirable in some cases. If one has a hundred-acre farm on which he wishes to make a specialty of peaches, he might set aside six fields of ten acres each, and set them in twelve-year rotations or blocks, planting a new orchard every three years. In this way there would always be a new orchard coming into bearing, the grower could apply the experience of one orchard to the succeeding one, and he could prepare the land thoroughly in advance of each setting. This preparing of the land is exceedingly important in most cases and is usually neglected. It often should include thorough under-drainage. The following display shows how this plan would work out. The heavy figures show orchards in bearing; it will be seen that there are always three orchards in bearing after the plan is in full working maturity. It is assumed that six years intervene between the plantings on the same ground. The letters *a*, *b*, *c* show how the elements in a three-course crop-rotation would combine with the orchards, if it is assumed that it would be safe or desirable to crop the orchard lightly for the first three years. The blank or treeless years would be used in general field-crop practice. It must be understood that this plan is not recommended, but is given to illustrate the discussion and to suggest a line of study:

ROTATION SCHEME OF PEACH ORCHARDS.
Heavy figures represent bearing years.

First orchard	Second orchard	Third orchard	Fourth orchard	Fifth orchard	Sixth orchard
1900*a*					
1901*b*					
1902*c*					
1903	1903*a*				
1904	1904*b*				
1905	1905*c*				
1906	**1906**	1906*a*			
1907	**1907**	1907*b*			
1908	**1908**	1908*c*			
1909	**1909**	**1909**	1909*a*		
1910	**1910**	**1910**	1910*b*		
1911	**1911**	**1911**	1911*c*		
	1912	**1912**	**1912**	1912*a*	
	1913	**1913**	**1913**	1913*b*	
	1914	**1914**	**1914**	1914*c*	
		1915	**1915**	**1915**	1915*a*
		1916	**1916**	**1916**	1916*b*
		1917	**1917**	**1917**	1917*c*
1918*a*			**1918**	**1918**	**1918**
1919*b*			**1919**	**1919**	**1919**
1920*c*			**1920**	**1920**	**1920**
1921	1921*a*			**1921**	**1921**
1922	1922*b*			**1922**	**1922**
1923	1923*c*			**1923**	**1923**
1924	**1924**	1924*a*			**1924**
1925	**1925**	1925*b*			**1925**
1926	**1926**	1926*c*			**1926**
etc.	etc.	etc.			

Tillage.

In the great majority of cases, tillage for at least a part of the life of the orchard gives more satisfaction than continuous sod. This is because tillage aids in making plant-food usable and it helps to save the moisture and to keep down weeds. On steep and rough lands, clean tillage may not be desirable, both because of its cost and the exposure of the surface to washing. In lands or regions that are naturally well supplied with moisture, tillage may not be needful. Like all other agricultural practice, tilling of orchards is a local question; but the presumption is that tillage is needed, and exceptions must be explained. The fruit in well-tilled orchards is likely to be later in maturing than in comparable untilled orchards, and to have a lower color; this is indication of the effect of tillage in maintaining vegetative activity by keeping up the supply of food and moisture. The fruit-grower should learn to regulate his tillage as carefully as he does the application of manure, in order to secure the maximum of benefit and the minimum of disadvantage.

The perfecting of many wide-sweep surface-working tools has made the tilling of orchards comparatively simple and easy. The purpose of these tools is to maintain the surface mulch. When an orchard is well established, it is usually not necessary to plow deep, at least not if the original preparation has been good. Spring-plowing in bearing orchards may be necessary in order to break the soil and to make surface tillage possible, or to turn under a cover-crop; but if the soil is naturally loose and there is no herbage to be covered, it may be unnecessary to invert the soil; the surface-working tools may be set at work before the land becomes hard. Usually a spading-harrow or cutaway of some kind will first be needed, or, if the soil is crusted and weeds have got a start, a shallow-working gang-plow may be used; thereafter, spring-tooth and spike-tooth harrows, smoothing-harrows and weeders may be employed. Fall-plowing is sometimes advisable, particularly on hard lands, that the weathering may aid in the breaking down of the soil; in such case, the furrow-slice should better not be turned flat (at least not unless there is much herbage or manure on the land), but left more or less broken or on edge. The surface-working tools may be applied to this open land early in the spring before it hardens.

Fig. 499. A modern commercial peach orchard. Georgia.

In the old days, orchards were mostly in sod. Fifteen years ago the importance of tillage began to be very strongly emphasized. This gospel has thrown into strong contrast the value of various kinds of sod-treatment for special cases. Sod-treatment of orchards is now often spoken of as the "mulching system." There is no uniformity and little system in these practices, however. In some cases, the "system" is merely to leave the orchard in sod and to sell the hay; in other cases, the sod is merely pastured; in others, the grass is mown and allowed to decay on the ground; again, not only is the grass allowed to lie but straw may be added and commercial fertilizers and manure applied. It is, therefore, impossible to discuss the mulch method without knowing just what the practice is. It is apparent that these must be local practices. Some of them often give excellent results.

Cover-crops.

The present-time tillage practice in orchards assumes also a cover-crop. This cover-crop is usually grown in late summer and fall, when tillage is least needed. The chief value of the cover-crop is to supply humus, in this regard taking the place of stable manure, which usually cannot be had in quantities for large orchard areas, since stock-raising and fruit-growing are not often practiced equally on one farm. In young orchards it is possible to make cover-cropping a part of a rotation plan. [See the article on *Cover-crops*, page 258.]

Almost any quick-growing crop that produces abundant herbage may be used to advantage as a cover. A covering of weeds is often better than bare ground. In general, tillage is given early in the season. By midsummer or early fall, the cover-crop is sown, the land then being in good tilth.

Cover-crops are of two main groups,—those that survive the winter and grow again in the spring; those that are killed by frost. The former are usually to be preferred, as they are likely to produce more herbage, and more completely to occupy the land with roots, and they may better prevent deep freezing, washing, and waste of rainfall. The disadvantage is that they delay all the plowing till spring, and there is a temptation to let them grow too late in spring, thereby using too much soil moisture, and reducing the chance of a satisfactory preparation of the land. Some of the frost-killed crops may have greater effect on the land than is to be expected from the mere bulk of the herbage that they produce; this is particularly true of buckwheat. Following are some of the leading cover-crops mentioned or recommended for fruit plantations (the leguminous or nitrogen-gathering species being starred):

Living over winter.

- *Clovers
- *Hairy or winter vetch (*Vicia villosa*)
- *Sweet clover (little used)
- Winter rye
- Winter wheat

Killed by freezing.

- *Cowpea
- *Soybean
- *Velvet bean
- *Pea
- *Bean
- *Beggarweed
- *Spring vetch (*Vicia sativa*)
- Rape
- Turnip
- Oats
- Barley (little used)
- Buckwheat
- Maize
- Millet (little used)

When orchards are carrying a full crop, it may be impossible to sow a cover-crop early enough to enable it to make much headway before winter sets in. In such cases, rye is about the only recourse, for it may be sown very late, and it will make rapid growth in the earliest days of spring. Even if it does not germinate in the fall, it will probably come up in the spring and do well. A little fertilizer drilled in with the rye usually will cause a great gain in the growth of herbage. Rye will thrive fairly well even with very indifferent preparation of the land, and therefore is a most useful cover-crop on lands that are not yet well subdued.

To insure a heavy cover, the seeding should be thick. Of some covers, the seed is expensive and often difficult to secure in good quality. The grower may find it good practice to reserve one corner or side of a field for the gathering of seed. This can be readily done with winter vetch, crimson clover and the cereals. Following are average quantities of seed to sow per acre for heavy cover-crops in fruit plantations:

Barley	2–2½ bus.
Beans	1½–2 bus.
Beggarweed	5–8 lbs.
Buckwheat	1½ bus.
Clover, red	10–15 lbs.
Clover, mammoth	15–20 lbs.
Clover, crimson	15–20 lbs.
Cowpea	1½–2 bus.
Maize	2–3 bus.
Millet	1½ bus.
Oats	2–3 bus.
Pea	2–3 bus.
Rape	2–5 lbs.
Rye	1½–2 bus.
Soybean	2–4 pks.
Sweet Clover	10–12 lbs.
Turnip	4 lbs.
Velvet bean	1–4 pks.
Vetch	1½ bus.
Wheat	2–2½ bus.

Alfalfa (20 to 24 lbs. to the acre) is sometimes used as a cover-crop in orchards, being plowed a year from sowing or allowed to remain for a longer period. Various combinations or mixtures are also used; as mammoth clover 6 lbs., alfalfa 10 lbs., turnip 2 to 3 oz.; alfalfa 6 lbs., crimson clover 6 lbs., alsike clover 3 lbs., strap-leaf turnip 2 to 3 oz., all sown in midsummer; cowpeas in drills and cultivated, and rye, rape or turnips added at the last cultivation; winter vetch 1½ bus., rye ½ bus.; cowpea 1½ bus., red clover 6 lbs.; oats 2 bus., peas 2 bus.

Fig. 500. California walnut orchard, showing clean cultivation.

Fertilizing.

The special needs of fruit-bearing trees and bushes in the way of fertilizers have not yet been worked out. It is probable that practices will be greatly modified when fundamental studies are made. The current advice, given in the publications of the past ten years, holds good so far as our knowledges goes. Stable manure is of first importance in most cases, because of its humus-forming materials; when this cannot be had, cover-cropping is all the more necessary. As for commercial fertilizers, the conclusions derived from general-crop studies are applied to orchards. The orchard must be fed liberally if profitable results year by year are to be expected. Because orchards will bear now and then without fertilizing, seems to afford an excuse for not fertilizing. Muriate of potash 200 to 300 pounds, acid phosphate (available) of equal or greater quantity, and nitrate of soda 100 to 200 pounds (or its equivalent in green-manures) afford a standard application per acre annually for good orchards in full bearing, when combined with good tillage.

Fig. 501. Orchard tillage. Peach trees heavily cut back after the loss of the fruit-crop by a freeze, in order to renew the tops.

Pruning.

To reduce the competition between branches, to open the plant to light and air, to facilitate spraying, tillage and other care, pruning is necessary in all bush-fruits and trees. In the bush-fruits, old canes must be removed and new vigorous ones allowed to take their place; the bearing canes may need to be headed back to keep them within bounds. How much to prune fruit trees depends on the species, age and the locality. More pruning is needed in some localities than in others. In the hot, bright sunny regions of the plains very open-headed trees are liable to sun-scald. As a general statement, it may be said that trees should be pruned with as much pains and regularity as they are tilled or sprayed. The best season for the main pruning is late winter or very early spring. The branches should be cut close to the trunk, as long stubs do not heal readily and rot is likely to set in. We need fundamental studies of the effects of pruning; it is not unlikely that some of the current teaching is erroneous.

Special risks.

The great impediments and risks in the growing of fruits are these: (1) hard winters; (2) frosts; (3) insects; (4) plant diseases. To these must be added the climatic risks that are common to all agriculture, as too much or too little rainfall, hail-storms, destructive winds. Every experienced fruit-grower is aware of the mental attitude that he must take toward these four impediments, but for the novice these attitudes may be briefly stated. (1) Hard winters are beyond control; the fruit-grower calculates on this risk when he chooses the region in which he shall set his plantation; he chooses hardy varieties; he then endeavors to have his ground well drained, if he is in a cold climate, so that there is no standing water, to enable the tree roots to strike deep, and to produce such a condition and depth of soil as will hold much moisture and thereby prevent dry-freezing; he plans his tillage in such a way that the trees go into the winter with well-matured wood; in certain orange-growing regions, slat sheds are built over the trees. (2) Light frosts may sometimes be prevented on small areas [see Vol. I, pp. 540, 589], but in general they are beyond control, and the grower calculates on the probability of them when he chooses the particular site or exposure of his plantation. (3, 4) For most insects and diseases there are now preventives, remedies, or even specifics; the grower keeps himself informed and armed; it is a question largely of business organization, that takes in a situation and then brings to bear the means to meet it; reading a half-dozen books and all the special bulletins he can get is not too great a personal sacrifice to make in order to be prepared to meet the enemy. [See the articles on insects and diseases, pages 35–53.]

Fig. 502. Clean culture in a peach orchard. The Michigan type of tree.

Varieties.

The question of varieties is one of the most important in the whole round of fruit-growing, and also one of the most difficult of solution. A mistake in the varieties may prevent any profit or satisfaction in the plantation. Two elements in the problem are the choice of varieties, and the means of securing them true to name. The choice of varieties is largely a personal and local question, to be determined after careful study of the farm and the market. The producing of trees true to name is the nurseryman's responsibility. This responsibility is grave, and it should be rigidly enforced by public sentiment.

A new attitude toward varieties is now developing: there are varieties within varieties. That is, minor strains and adaptations of varieties may be of the greatest value, particularly when the grower expects to reach a good market under his own name. Thus, a single bush of raspberry or blackberry of a given variety may exhibit features that make it superior to all others in the field; such plant should be propagated for the owner's planting. It is illogical to expect the best results from promiscuous cions or buds of any variety of apple or pear or orange. As there are trees of individual excellence, so it may be expected that cions from those trees will tend to perpetuate those excellencies. There has therefore arisen a desire among fruit-growers who plan to produce a superior product to top-graft their young trees with cions from known parents. It is of little consequence that this method does not produce what may be called new varieties: it probably aids in producing plants of given efficiency. Every good fruit-grower, as well as every good grain-farmer or cotton-planter, now becomes consciously a plant-breeder, as the good stockman has always been an animal-breeder. [See the article on *Plant-breeding*, page 57.]

Cost.

The cost of setting up a fruit-growing business depends on many circumstances and conditions, chiefly on whether the fruit is destined for the general trade or the fancy trade and whether clean tillage is practiced. The present-day fruit-grower is a man who invests confidently and heavily in apparatus and supplies; and this is characteristic of the present tendency in American agriculture. Better and heavier horses, stronger and more powerful tools and machines, heavier fertilizing, more thorough-going methods, are among the things that are to save farming from weakness, desultoriness and incompetency.

The experience of growers is the only safe guide. The intending fruit-grower should visit representative fruit-farms to determine these points. Estimates of actual fruit-growers are given on pages 187–193 in Volume I. As a further contribution, two statements from successful men are now added.

The first of these statements is from a thorough-going fruit-grower in western New York who practices very clean tillage: "The expense and equipment on a 100-acre fruit-farm depends very much on the kind and varieties of fruit and whether the sod-and-mulch method or thorough tillage is practiced. I am a strong advocate of thorough tillage, cover-crops and commercial fertilizers; and one can readily figure that such a system involves considerably more expense than the mulch systems. After nearly ruining a ten-acre apple orchard by the sod-and-mulch method and then bringing it back into very profitable bearing by changing to thorough tillage, cover-crops and fertilizers, one can scarcely wonder why I speak so strongly in regard to this method of handling an orchard.

"The expense of tilling and caring for one hundred acres of fruit divided into forty acres of apples, forty acres of peaches and pears and twenty acres of grapes, will run about as follows: It would require eight good horses; four plows; two spring-tooth harrows; one double-action cutaway harrow; one solid disk-harrow; one Planet Jr. orchard cultivator; two-horse cultivator, on wheels; one spike-tooth iron-frame lever harrow; one duck-tooth wood-frame Waterport cultivator, with extension arm; one Syracuse grape-hoe with spring-tooth attachment; one land roller, preferably steel; one pivot-axle two-horse cultivator; two Planet Jr. one-horse cultivators; one gas power sprayer; one potato and vineyard sprayer; one three-horse fruit wagon, capacity 8,000 pounds; one two-horse fruit wagon, capacity 4,000 pounds; one two-horse fruit wagon, capacity 2,000 pounds; three grub hoes; six common hoes; three pruning-saws; three pruning-shears; one grain-drill with fertilizer attachment; one Calhoun grass-seeder; one fruit-packing house centrally located, with the necessary picking-baskets, bushel crates and grape-trays and sorting tables; rubber stencils and many small supplies; six good men, including foreman.

"As to the amount of money necessary to conduct such a plant, much will depend on the soil, climatic conditions and 'nerve' of the man at the helm. I have found that it does not pay to be niggardly in regard to putting money into such an enterprise, as our balance sheet proves."

The second statement is by a successful grower in central Kansas, on the moist, loose bottoms of the Arkansas river, who does not practice clean tillage: "There are about one hundred acres in my apple orchard, and it is therefore easy to give an idea as to what will be necessary in the way of horses, tools and labor to work such an area. At the present age of the orchard, say twelve years, one heavy team of horses will do all the disking and surface harrowing, as well as pulling the power sprayer and the loose brush from the orchard. One good heavy team will do all the work for a 100-acre orchard satisfactorily, at least in the way we work them here, in an orchard with practically all winter varieties. Taking care of fruit in the fall makes it necessary to hire teams to haul fruit back to the farm to store, as well as to help haul the loose fruit in the orchard to the shed, which will require about one team. In other words, two good teams will haul empty boxes to the orchard and return them filled with fruit to the shed.

"My idea of tools in working an orchard after it has attained the age of ten or twelve years is simply a disk-harrow or possibly a harrow provided with horizontal knives. One man beginning March 1 with one good team will do all the cultivating, haul all brush, pull the power sprayer and do any mowing of weeds that may be necessary. In a 100-acre orchard, his labor should be supplemented by that of three to spray the trees.

"The crops of corn raised between the young apple trees will amply take care of any expense in raising this orchard to the bearing age. The first year one would not lose any corn, the second year only one row,

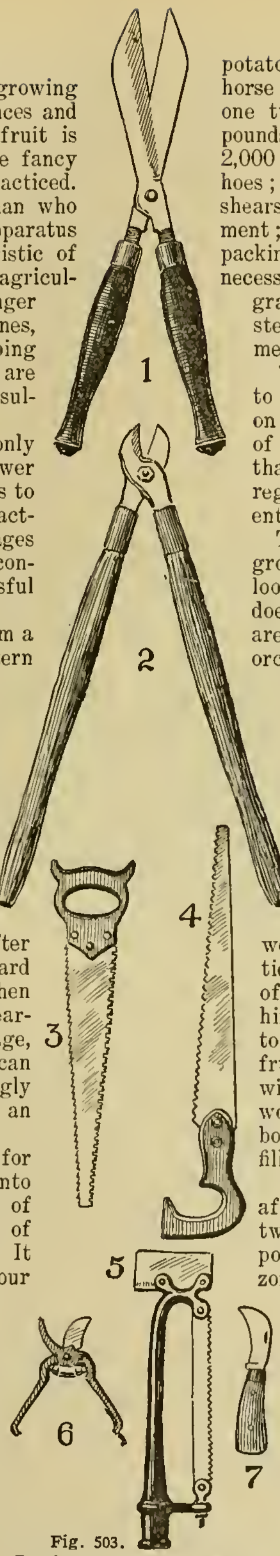

Fig. 503. Pruning tools. The saws and hand-shears (3, 4, 6) are the most useful of these tools.

the third year possibly two rows, the fourth year not over three rows, the fifth year about the same, and so on till the end of the seventh year. I would cease cropping ground entirely and expect to get some returns the eighth year.

"As to profits to be derived from the orchard, I can only give my experience in the Arkansas valley. When my 2,000 apple trees were nine years old, the crop netted $90 per acre. Next year we did not spray and lost half the crop by codlin-moth. The third year we sprayed part of the trees four times and part twice, and the part sprayed four times (these trees being twelve years old) dropped scarcely any fruit and it packed over 75 per cent No. 1; these are now bringing $1.25 per bushel. The better parts of the orchards netted $150 per acre. We figure that spraying, picking, sorting, packing, hauling to storage and loading in the car cost us, including the package, thirty-five to forty cents per bushel box, with labor at $1.75 to $2 for an average picker. In this locality, wheat on the same kind of land might average twenty bushels to the acre and the average price be about sixty cents. Some land will produce thirty to fifty bushels."

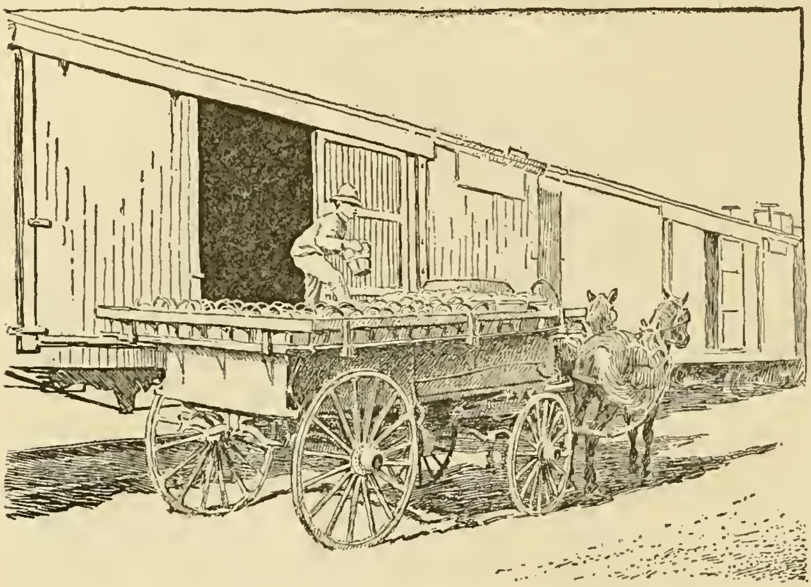

Fig. 504. Delivering peaches to cars in New York.

Market problems.

In a general article, it is impossible to give specific practical advice on the harvesting and marketing of fruits, for the practices differ with each fruit and sometimes with the community. Yet it is possible to make statements of points of view.

If a crop is worth raising with much labor and care, it is equally worth marketing. It is perhaps unusual that one man is equally competent in the growing and the selling. The professional salesman seems to be a necessity. He can usually market the products more effectively and cheaply than the general grower can. This may or may not apply to the grower of very choice and special products, that are used by a particular and personal trade: in such cases, the grower may put his products directly in the consumer's hands.

Much is said about the necessity of growing a fancy product, but this carries with it the condition that there are special means of marketing it. An unusually good article of fruit, put on the general market, usually does not pass under the owner's name or mark, and it is likely to be lost in the commoner grades; or if better prices are realized on the open market, the dealer may be the one who receives most of the extra reward. The value of grades that are much above the general market stock is secured when tho grower can make a sale while his name is still associated with the product. If there is profit in growing very special-class fruit for limited markets, there is also profit in growing staple kinds for the staple prices, if one can cheapen and economize the cost of production and if he has sufficient quantity to give volume to the business.

The above considerations determine very largely the question of the size and style of package. That is, the package is not fundamental; it is incidental to the kind of market that is to be reached. With the increasing demand for high-class products, the small, carefully graded package is coming into greater use. It is true, also, that the attractiveness of the package will stimulate sales, but, as already indicated, this advantage accrues to the grower chiefly when he has his own hand on the marketing of his products.

Merchandizing of all kinds has established new ideals and developed new values by the attention that has been given to grading and packing. It is not many years ago that boots and shoes were shipped in bulk in large cases. The small package is now a feature of trade; and each package contains only one grade of goods. Before the fruit-grower can establish a special market, he must develop a clear conception of grades. Usually, only two grades are made in fruits,—the salable and the unsalable. Of the salable part we may yet make two to four grades in some kinds of fruits. A first-class grade comprises only fruits that are physically perfect and are typical of the kind. First-class fruits are always in demand, whatever the state of the general market; and some one should be able to find the customer who wants it.

It has become a trite thing to say that care should be exercised in picking and marketing, not to injure the fruit; but recent investigations have given such advice new significance. The work of Powell and others in California, and similar investigations in other parts, have shown that a good part of the losses in oranges and other fruits in shipment is due (1) to bruises and cuts on the fruits, and (2) to failure to cool the fruits quickly after they are picked or packed. This is rational when it is considered that the organisms of decay enter at the bruised and broken places, and a high or even ordinary temperature encourages the organisms to grow rapidly. This subject is discussed in the succeeding article. The whole subject of cooling, storing and handling fruits must soon receive radical attention.

Literature.

There are now many good books on fruit-growing, presenting the subject from different points of view and for the different fruits. Mention of some of them will be found in Maynard's article on *Farm Garden*, page 273. Some of the current books covering the general field are: Thomas, American Fruit Culturist; Budd and Hansen, American Horticultural Manual (Vol. II is devoted to Systematic Pomology); Green, Amateur Fruit-Growing (with special reference to cold climates); Wickson, California Fruits; Bailey, Principles of Fruit-Growing. The progressive fruit-grower will need the discussions in experiment station bulletins, transactions of horticultural societies, and the agricultural press.

Handling and shipping fruit.

By *G. Harold Powell.*

A fundamental principle for the fruit-handler and shipper to appreciate is that a fruit is a living thing, that it passes through a life-history and finally dies from old age when it has completed its chemical and physiological changes, and that it may die prematurely from the attack of some disease. Some of the diseases, like the bitter-rot and the scab of the apple, affect it while it is on the tree, while others, like most of the soft rots of the apple, pear, orange and small-fruits, are acquired after the fruit is harvested. Diseases of the latter class generally attack it through abrasions or other physical weaknesses of the skin caused by rough handling. It is especially important to appreciate the effect of breaking the skin of a fruit and of shipping fruit that is attacked by insects or fungi, as the large commercial losses that occur annually in the storage and shipment of fruits are related primarily to these defects.

When to pick.

Most fruits should not be picked until they have reached a stage of hard ripeness. If picked earlier, the flavor is insipid, the color dull, and the wholesomeness and commercial value are impaired. Fruit

Fig. 505. Packing peaches in Michigan.

picked when immature does not keep so well as when more nearly ripe. The seeds of the apple and the pear should have turned brown, the apple and the stone fruits should be highly colored but still hard, and the small-fruits well colored but firm when picked. The pear should be picked as soon as the seeds turn brown, but before it shows ripeness in the color. Lemons are picked when they have reached a desired size, irrespective of color, and the green fruit is colored in curing. Oranges should reach full color, and should have attained good quality before picking. It is a common practice early in the season to pick the orange while the color is still green, and to color it in a room by heat and moisture from oil stoves with water pans over the flame. The practice of picking fruits in an immature condition that are to be eaten out of hand is to be strongly condemned, as it injures the reputation of the fruit to have green specimens in the hands of the consumer.

Handling the fruit.

It is difficult to give specific advice on the care that is necessary in fruit-handling. To be able to handle fruit carefully is inherent in the labor and in those who direct and advise it. A clumsy-handed individual never makes a good picker or packer, nor can the full efficiency of a labor force be attained without a high-class foreman or manager. The cause of bad handling frequently has its roots in the system of labor management. Contract labor, piece-work in picking, packing, and in other handling operations, is fundamentally weak, as it encourages large outputs, irrespective of the quality of the work. Labor paid by the day is likely to be more efficient, provided it has competent supervision. More fruit is injured by careless handling than fruit-growers suspect. Apples generally show at least 10 per cent of the fruit with the skin broken by dropping it into baskets or on the piles, or by rough handling in other respects. Peaches and the small-fruits are usually injured to a greater extent, and 2 to 60 per cent of the oranges often have the skin cut by the clippers in severing the fruit from the branch.

It is even more difficult to give specific advice regarding the details of fruit-handling. A few definite matters may be brought to the reader's attention. The stem should be left on all fruit when it is picked; lay it carefully in the picking receptacle, and pour it out with equal care. Place it in the shipping package gently, pack it firmly to prevent movement in transit, but be careful not to bruise the fruit in covering the package. Caps and cushions on apple barrels prevent injury, and a fruit-wrapper is a mechanical protection against bruising. Caution the pickers, especially, about pressing the fingers against the tender fruits, such as the peach or the small-fruits, or light-colored fruits like the Yellow Bellflower or Rhode Island Greening apples. It discolors the fruit, but may not cause decay unless the skin is broken. Pick the larger fruits in baskets or pails. Do not use a picking-bag for these fruits, except for the citrus fruits, as the fruit is more likely to be injured. Caution the pickers against striking the fruit on the spurs or branches in taking it out of the trees.

Place the fruit in the shade as soon as it is picked, and leave it exposed to the cool night air before packing, if the fruit is picked after ten o'clock in the morning. The fruit picked early in the morning may be packed at once, or quickly stored, if designed for cold-storage. The temperature of the fruit may be 10° to 30° cooler in the morning than at midday. This represents the measure of cooling that takes place in one to five days in transit in a refrigerator car. The use of the night air for cooling is especially adapted to the Pacific coast and to high altitudes, where there is a wide difference between the temperature of night and day.

Draw the fruit to the packing-house or to the shipping point on spring-wagons, and provide each wagon with a tarpaulin, if the fruit has to be drawn some distance in the sun. There may be a difference of 5 per cent of decay in Florida oranges drawn on spring-wagons and on wagons without springs.

After the fruit is picked, ship it or store it in the quickest possible time. The ripening processes progress with a bound as soon as the fruit is picked, especially in hot weather. A cool temperature checks the ripening and retards the development of the diseases. Do not pile apples in the orchard either before or after packing for any length of time, and do not allow the fruit to remain in the packing-house, except in cool weather. Rough handling, coupled with a delay in shipping or storing the fruit, causes more of the large commercial losses in storage or in transportation than all other factors combined.

The packing-house.

A large fruit-farm should be equipped with a packing-house so arranged that the fruit is unloaded from the field at one end or side of the house, and is taken out after packing at the other end or side. Packing-tables should be placed lengthwise between the entrance and exit to avoid carrying fruit around the tables. The house should be provided with doors and windows which can be opened at night. Small-fruits may be packed in temporary sheds in the field. Apples and pears that are to be shipped at once may usually be packed more cheaply in the orchard, on temporarily erected platforms and sorting devices. It is an advantage to have the sorting-tables on wheels if the work is done in the field. Fruit that is to be wrapped and packed in boxes, or is to be put up with special care, can usually be handled best in a packing-house. The packing-house may be part of a storage-plant or may be erected separately.

The fruit package.

It is wise for the average fruit-grower to use the type of package and to follow the general style of packing employed in the packing of fruits in his neighborhood. Special types of packages are applicable to a special trade, but it does not usually pay to introduce a new package or method of packing in the general trade unless the fruit can be shipped in large quantities, and can be skilfully advertised. The fruit trade is conservative and suspicious in its attitude toward innovations. Buyers become used to a certain style of package and packing for the fruits of a region. They calculate the charges of cartage, storage and other things on these types of packages, and they do not like to adopt a new method of reckoning. A slight change in the design of the label on an established brand of oranges from California has been known to cost the shipper several thousand dollars before the error could be rectified. This attitude of the fruit trade is due, in no small measure, to the large extent of dishonest packing and grading, leading the buyer to suspect that a new package or label or method of packing is a new way of deceiving the purchaser. The grower who ships to the general market will make the greatest progress by improving the grade of the fruit and the uniformity of the pack. The grower who ships to a special trade may use any type of package that is attractive. He may wrap the fruit, embellish it with tinsel, or fix it up in any other way that gives artistic effect.

Grading.

The grading of American fruits is in a chaotic condition. There is no uniformity in the principles or practices of fruit-grading. All fruits should be graded at least into sound and imperfect fruit. There is a large demand for low grades of fruit among the poorer classes, and there is no objection to the sale of low grades, provided the grade is plainly designated on the package, and the fruit is not unwholesome. The sound fruit may be still further graded into several classes, depending on the relative color, perfection and size of the fruit. In packing in boxes, each of the grades should be sized accurately, and the number should be designated on the end of the package. If there is not a large quantity of the higher grades in the sound fruit, all of it may be marked under a brand known as "orchard run," which usually means that the unsound fruit and culls have been eliminated. The orchard-run grade is in common use among apple-packers in the East, who eliminate the imperfect and the smaller sizes of perfect fruit, marking the grade as No. 1. Small-fruits can be graded into different sizes if there is sufficient variation in the size.

Selling.

It is a good policy for the average fruit-grower who does not grow large quantities of fruit to sell it on the tree, in the package, or on an f. o. b. basis, unless he belongs to an organization that has a marketing system developed, or has unusual facilities for posting himself on the condition of the crop and the market. If he does not care to sell, he may store it for a possible rise in price later on. There are many variations in the method of selling fruit that cannot be discussed in this article. It may pay the grower who has large quantities of fruit to handle it through a commission merchant. A firm should be selected that is reliable, and the grower generally should ship to no one else in the same market. If he has large quantities of fruit, he may be able to arrange with the merchant to handle his fruit exclusively. The fruit can then be advertised, the merchant can circularize the trade, or make known the virtues of the fruit in other ways. In shipping fruit to commission merchants, the grower should not lose sight of the fact that a large proportion of the commission merchants of the country have become fruit-dealers, and that they sell their own fruit in competition with the fruit that is consigned to them. The highest returns are probably received by those who are successful in developing a special trade among retail grocerymen, private individuals or other special customers. The success of a special trade depends primarily on the man who attempts to develop it. A high grade of fruit packed attractively and with scrupulous honesty has to be supplemented by personal qualities in the grower to enable him to impress on a customer the superior merits of his fruit.

Shipping.

The quick-ripening fruits that are to be shipped some distance should be forwarded in refrigerator cars in hot weather. This applies to the stone fruits, the small-fruits, grapes and the early varieties of apples and pears. It applies also to the fruits of all kinds of the Pacific coast except the citrus fruits, provided they have been handled in perfect condition. In cool weather the fruits can be shipped in special ventilator cars, or in refrigerator cars operated as ventilators, if the car is needed to protect the fruit against the cold. The carrying quality of all fruits is improved by cooling them to about 40° before loading. It requires several days in transit to reduce the temperature to 40°. If the fruit can be cooled, it can develop a higher color before picking, and the market area can be greatly extended.

GINSENG, AMERICAN. *Panax quinquefolium,* Linn. *Araliaceæ.* Figs. 506–510.

By *B. L. Hart.*

Ginseng is a small perennial herb, the thickened roots of which are used medicinally by the Chinese and Koreans. Although long known in China, the plant was first described and named botanically from North American specimens by Linnæus in 1753, as *Panax quinquefolium.* In 1843 the Chinese plant was separated by C. A. Meyer as *Panax Ginseng.* Later, these plants were transferred to the genus Aralia as *A. quinquefolia,* Decne. & Planch., and *A. Ginseng,* Baill. By some authorities the oriental *P. Ginseng* is considered

Fig. 506. The ginseng plant in bloom. It bears three leaves about one foot from the ground, each with five leaflets (whence the name *quinquefolium*).

to be only a geographical form of one cosmopolitan species, *P. quinquefolium.* The word ginseng is said to signify "man plant" in the Chinese; and the roots are apparently employed on the old doctrine of signatures, which assumes that plant forms resembling human organs, are specifics for the ills of those organs; and, as the roots of ginseng often resemble the form of a man, they are therefore specific for the ills of man.

When the plant is old enough to produce fruit it is rather conspicuous and is easily recognized, but until three or four years old it is not usually very prominent. The seedlings at first somewhat resemble newly sprouted beans, in that they send up two cotyledons, and from between them a stem with two minute leaves. These enlarge until the plant has attained its first season's growth (about two inches). The work of the plant during the first year is to develop the bud at the crown of the root, which is to produce the next season's stem and leaves. In autumn the stem dies and breaks off, leaving a scar, at the side of which is the solitary bud. In the spring of the second year this bud produces a straight, erect stem, at the top of which the one to three branch-like stalks of the compound leaves appear. Three to eight leaflets are developed, which usually rise not more than four inches from the ground. The third year eight to fifteen leaflets may be put forth, and the plant may attain a height of eight inches. In succeeding years the plant may produce three, sometimes four or even five leaf-stalks three or four inches long, each bearing five thin leaflets palmately arranged, two of them an inch or two long, the remainder three or four inches, egg-shaped in outline, with the broad end away from the stem, abruptly pointed and saw-toothed.

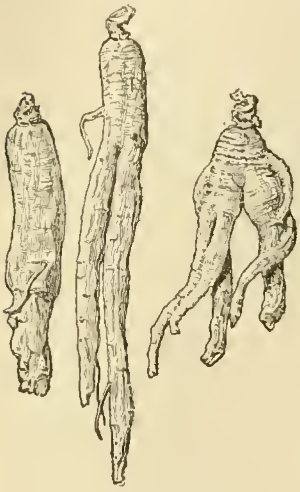

Fig. 507. Dry ginseng roots. One-third natural size.

At a point where the leaf-stalks meet, the main axis is continued into an erect flower-stalk, two to five inches long, bearing in early July, or in late June, a number of inconspicuous, yellowish green flowers. These are soon followed by the fruit, which develops rapidly, remaining green until the middle of August, when it begins to turn red, becoming scarlet and ripe in September. The berries, which have the taste of the root, are the size and shape of small wax beans, and contain two or occasionally three seeds each. No seed is produced the first year, and only an occasional berry on extra strong plants in the garden in the second season. It is only the third season that the plants produce seed in any quantity. Plants in cultivated beds produce more freely than those in the forest.

History.

American ginseng was discovered near Montreal, Canada, in 1716, by Father Laftau, a missionary among the Iroquois Indians. Soon the French began collecting it, through the Indians, for export to China. The demand thus created was so large that ginseng presently became an important article of commerce in Canada. It was not until 1750 that ginseng was found in the more southern colonies of New England. In 1751 it was found in central New York and at Stockbridge, Mass. It was also found plentifully in Vermont at the time of the settlement of that state.

Ginseng in its wild state grew abundantly in the hard-wood forests of a large part of the United States, and was dug in quantities sufficient to supply several hundred thousand pounds of the dried or prepared root each season. In the past few years the supply of forest root has greatly diminished, the result of so many persons being engaged in hunting for ginseng in the summer months and the vast extent of timber land that has been cleared for pasture. The early collectors gathered only such roots as they thought had grown to marketable size, but in the past twenty years practically no attention has been given to the age or size. Digging the root before the seed had an opportunity to ripen contributed much to the almost total extinction of the forest root, with the result that the garden cultivation of ginseng has been largely engaged in to supply the Chinese markets.

Ginseng has been grown under cultivation in America for the past twenty years, and it has been fully demonstrated that the plant can be raised successfully provided the necessary requirements are furnished.

Culture.

Ginseng is propagated from the seed produced in the small berries which ripen during the early part of September. Eighteen months are required for these seeds to germinate, and during this time they must not be allowed to dry. When the berries are gathered, they should either be planted at once or be stored in four times their bulk of clean, moist sand. A tight wooden box will answer the purpose for storing, but, as mice are very fond of ginseng seed, the top should be covered with a wire screen. The box containing the seed may be stored in a cool cellar during the stratifying process, which requires twelve months. During this time great care should be exercised in keeping the sand continually moist; if the sand gets dry, the seed will generally become moldy very soon, in which case it should be separated from the sand,

Fig. 508. Ginseng plants coming up.

thoroughly washed and repacked in new sand that has never been used for this purpose. The sand should be passed through a fine-meshed sieve before using, then when the seeds are wanted it may be sifted, making a very easy way of separating it from the seed.

After storing for ten or twelve months, as described, the outside shell will begin to crack on a large percentage of the seed, when it is ready for planting. Some growers advocate planting the seed as soon as harvested; others advise burying it in the open ground for the first twelve months; but the writer has devoted a great deal of time and study to stratifying seed and thinks that the above method will give by far the best results.

This is the Korean method of caring for ginseng seed: Remove the pulp or berry from the seed. Wash clean, place in thin cloth bag, and store in dry, cool cellar, until ready to plant. Soak the seed in blood-warm water (98°–100°) for seventy-two hours and immediately plant. Will grow in five to ten days. Seed may be planted the next year after it is harvested, or kept for any number of years. It is planted in May only after danger of frost is past.

Seed-beds.—The beds for the seed should not be over four feet wide, as this is the most convenient width for weeding and working. They should be raised several inches above the level to supply good drainage, and surrounded by six-inch boards to prevent washing. Walks between beds may be sixteen or eighteen inches wide.

In preparing the seed-bed, the soil should be worked very fine ten to twelve inches deep. The seed may be sown either in drills two inches apart each way or scattered broadcast. The latter method requires much less labor than the former and, if the seeds are scattered evenly, will be found to give as good results. When drilled in, it will be sufficient to place the seeds one inch apart, if they are to be transplanted the first season. Some growers do not transplant till the second season's growth has been completed. There are 7,000 to 7,500 seeds in a pound; southern seed will sometimes go ten thousand or more to the pound. After the seeds are sown, they should be covered with one inch of fine, rich soil. If the natural soil is a rich loam, light or sandy, it will answer the purpose, but if it is of a heavy texture a liberal quantity of leaf-mold or other light soil that is well supplied with decayed vegetable matter should be added.

September and October are the best months for sowing the seed. After the planting, no work is needed until the following spring, with the exception of giving the beds a light mulching of buckwheat straw or forest leaves to protect them during the winter. In early spring the mulching should be entirely removed before the plants make their appearance, which is in the early part of May.

In the growing season the beds must be kept free from weeds and allowed a free circulation of air, to keep the plants strong and healthy. In early autumn the seedling roots may be planted in permanent beds or left for another season's growth. Either method is practicable, as either one- or two-year-old roots are desirable for transplanting.

Permanent beds.—In locating permanent beds, ground should be chosen that slopes sufficiently to carry away the surface water. An eastern or northern exposure will be found the most desirable, as the garden is much more protected from the direct rays of the sun than with a southern or western slope. The garden should be located where it can have a free circulation of air; high ground, entirely away from buildings, is preferred.

In preparing permanent beds, the soil should be mellowed to a depth of twelve to fourteen inches; the beds should be raised four to six inches above the level, and surrounded with four- or six-inch boards, the same as the seed-beds. Ginseng will grow in almost any kind of soil, but unless it is of proper texture, the growth will be so slow that it will take several years to develop the roots to a marketable size. A light, deep, rich, well-drained soil that is supplied with decayed vegetable matter should be selected,—a soil that will not bake and crack or become firm and hard after heavy rains. New or sod ground is much preferred to land that has been tilled for several years, and, in case such soil cannot be had, leaf-mold, swamp-peat or light woods dirt should be added in liberal quantities.

September and October are the most favorable months for planting the roots, although they may be grown successfully when planted in the early spring. In planting permanent beds, none but healthy roots should be used. They should be dug carefully to avoid cutting or bruising, and great care should be taken not to injure the bud at the neck of the root, as this will set the plant back one season's growth and, in some cases, will entirely destroy the plant. The roots may be planted in rows four to five inches apart each way. The bud at the top of the roots should be covered two to two and one-half inches.

Subsequent care.—After the planting is completed, very little care is required with the exception of keeping the weeds out and harvesting the seed when ripe. The plants begin bearing seed when three years old, generally averaging twenty seeds to the plant, increasing to seventy-five to one hundred at five or six years old. Plants growing in their wild state seldom produce more than fifteen or twenty seeds in a season, regardless of their age.

Under proper cultivation, the root matures at five years old at least, and is then in its best condition for marketing. It should be harvested in October, care being taken not to cut or bruise it. The roots may be washed with a soft brush, not scrubbed until perfectly clean, but simply to remove the clots of dirt. Then they are ready for drying. When only a few pounds are to be dried, they may be placed about the stove or dried in the sun and air; when large quantities are to be dried, evaporators can be used. Evaporators never should be run at a temperature of over 85° or 90°. When the roots are thoroughly dry, they are ready for market. In case the grower does not dispose of them at once, they should be placed in sacks or boxes and stored in a cool, dry place.

Shading.

The natural home of ginseng is in the still, shady forest, protected from heavy winds and the direct rays of the sun during the growing period. In autumn it is furnished with a mulching of leaves to protect it in the best possible way from becoming injured by frost during the winter. Nature supplies these protections for the plant in its native home, and the cultivator must furnish these requirements in order to grow the plant successfully. When the beds are placed where they do not have natural shade from trees, artificial shade must be substituted. When ginseng is cultivated in the open field, the grower will find that supplying a proper degree of shade is one of the most difficult problems, and, as the locality has a great deal to do with the degree of shade necessary, it is very difficult to advise a certain kind of shade that will give the best results under all circumstances. After a careful test, the writer has concluded that more failures in ginseng-culture have been due to supplying too much shade rather than too little. Some very successful results have been secured by shading with brush, but as this requires a great deal of repairing it can hardly be recommended as a practical method. Screens built of common plaster lath or slats can be used to advantage, as will be seen in Figs. 509, 510, which give an idea how to construct a ginseng arbor.

When this style of arbor is used, the laths in overhead screens should not be more than three-fourths of an inch apart, while the laths in panels around the garden should not be closer than two inches; and the panels should be arranged so that they may be taken down in wet weather to allow the air to circulate freely, thus guarding against fungi and blight diseases affecting the plant. For

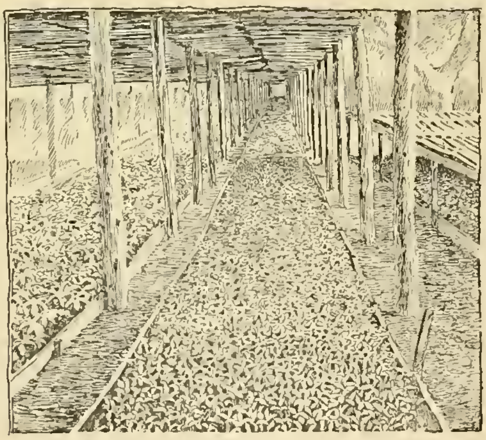

Fig. 509. A ginseng arbor with seed-beds.

top shade, the laths may be woven with galvanized wire with a common fence-weaving machine, and will be found cheap and practicable. The writer has used this style of shading to a considerable extent for the past several years, and recommends it as being superior to other styles.

With complicated arbors, sometimes the drip is very injurious to the plants during heavy storms,

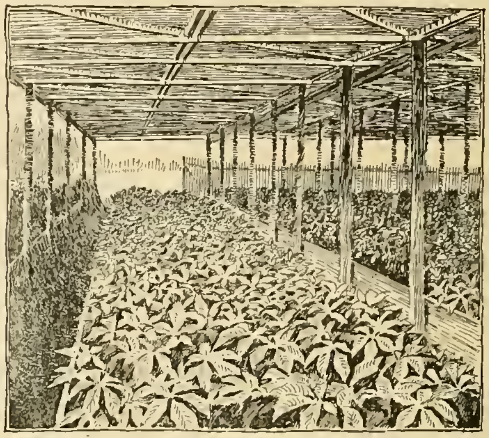

Fig. 510. Ginseng arbor with mature plants.

and with this style of shading this difficulty is overcome almost entirely.

Enemies.

Wilt.—The older ginseng plants are subject to a wilt-disease, from a fungus belonging to the genus Acrostalagmus. The leaves lose their turgidity and droop down against the stalk, which retains its upright position. The remedy is to dry the affected roots and to remove the soil from the infected beds, and to grow only vigorous roots for seed, which are more resistant.

The seedlings are also subject to wilt from various causes. Sometimes the lower end is attacked by rot,—"end rot," as it has been called,—causing the root to shrivel and the leaves and stalk to wilt. The disease seems to be associated with improper moisture conditions, and ventilation and drainage are recommended in its control.

Millipedes frequently cause the seedling to wilt and die, by eating the roots and parts of the stem underground. The millipedes are trapped by laying boards on the surface of the ground, under which they gather. It is also suggested that they may be destroyed by scattering pieces of potato poisoned with arsenic, as they attack potatoes readily.

Alternaria blight is one of the worst enemies of the ginseng-grower. It manifests itself by a spotting of the leaves. In the morning the spots look as though they had resulted from drops of scalding water, the diseased leaf-tissue being dark green and watery. When the diseased parts have become dried by the sun, the spots are yellowish and papery, the centers becoming brittle and easily broken out when handled. The leaves soon hang limp and dead from the stalks. Moist or rainy weather with high temperature seems to be most favorable to the rapid development of the disease. The disease may be prevented by a thorough application of Bordeaux mixture. The most certain method is to spray the ground thoroughly with a strong solution of copper sulfate (two pounds copper sulfate, ten to fifteen gallons water), before the plants come up. As soon as the plants begin to appear, spray thoroughly with Bordeaux mixture. As the plants come up unevenly, it may be necessary to spray daily till all are up, after which thorough spraying every ten days or two weeks until the seed-heads begin to fill, will be sufficient. When the seed-heads are filling, they should be sprayed once or twice to protect them from the form of the disease known as blast.

Soft rot of the roots is indicated by premature coloring of the foliage. The leaflets become bronze and then show a reddish coloration, followed by the wilting and death of the top. The roots rot, and become sticky, mushy and ill-smelling. This disease is destructive only in wet soils. Normally it is harmless, becoming parasitic on the roots only when their vitality is reduced by excessive moisture. The only remedy is thorough drainage.

Rot of stems and roots causes the stem to fall over from the weakening at its base, while the roots became soft and pulpy. The disease may be recognized by the large black knots on the base of the stem or on the roots. Thorough ventilation and careful drainage are recommended.

Nematode root-galls.—The nematode worm attacks ginseng plants, especially those in gardens near woodlots. The largest knots seem to be formed on the main roots. The galls may reach a large size, and rapidly rob the plant of its vitality and reduce the value of the roots. The most effective remedy is to remove the garden to an unaffected place, and to be careful not to transfer any of the worms or eggs from the old garden. Seeds or unaffected roots should be used to start the new garden. Freezing and drying of the ground are both destructive to the worms. If the soil can be steam-sterilized, the worms and eggs will both be killed.

Snails eat the foliage and stems of young plants. A good method of extermination is to trap with slices of turnip or lettuce leaves. These may be placed about the garden and turned over from time to time, and the snails killed. With the aid of a lantern they may be gathered at night from the foliage. Carbon bisulfid has been used with good effect, especially by applying along the boards, which afford an excellent hiding place for the snails. Care must be exercised not to have the carbon bisulfid very strong. Air-slaked lime applied to the soil is said to give good results.

A discussion of these pests is to be found in Cornell Bulletin No. 219, "Diseases of Ginseng," by James M. Van Hook, from which these notes are in part adapted.

Medicinal properties.

In this country ginseng is considered of little medicinal value. The root is mildly aromatic and slightly stimulant. The Chinese and Koreans, however, place a high value on it, and regard it as a panacea. In Korea, the cultivated ginseng is smaller than the wild or mountain ginseng, the root of which attains a length of a foot or more and a diameter of an inch and upward. It is said that when this wild root is administered the patient loses consciousness for a time, and for about a month is tortured by boils, eruptions, sleeplessness and other ills. Rejuvenation then begins, the skin becomes clear, the body healthy, and the person will live (such is the belief) exempt from diseases for many years. The Chinese consider that it acts as a preventive by toning up the system.

The root appears to be differently employed according to the source from which it is secured, probably partly on real and partly on fictitious grounds. There are said to be three ways of taking ginseng, viz., as pills, confection and infusion. Its medicinal value is thought to be diminished by a steaming process to which it is frequently subjected for the improvement of its color. It appears to be given the character of a confection by steeping in honey or by the use of sugar.

Markets and marketing.

Ginseng roots are purchased by raw fur dealers in New York and other large cities. Many of these dealers issue price-lists, which are mailed to growers and collectors from July to December. These buyers either dispose of their holdings to Chinese representatives or export directly to Hong Kong, which is the principal port for American goods entering China. There the roots are handled by Chinese merchants who purchase in large quantities to supply the retailers, from whom the consumers buy. That there is a demand for American root in China is certain. The native supply is limited, and it is to this country that China must look for a large share of the ginseng she uses. The market for the past two years has preferred that the roots be not washed with a brush, but that they be cleaned by a strong current of water thrown on them, as from a hose.

The market price of ginseng fluctuates more or less, chiefly because of trade conditions and the rise and fall in silver. In the years 1905 and 1906, cultivated ginseng was subject to great variation in price, even being refused at one time. Prior to this very high prices had been paid. Leading New York dealers, who furnish the prices quoted below, say the business is still in a transitional state, which will probably last two or three years, until growers produce the medium-sized, ringed, dark, uniform roots in demand among the Chinese. In the spring of 1907 when these statements were made, prices for American wild root in New York city ranged from $6.35 to $7.25 a pound, and those of cultivated, from $5.75 to $6.40.

Literature.

Kains, Ginseng: Its Cultivation, Harvesting and Market Value, Orange Judd Co., New York (1904); An Experiment in Ginseng-Culture, Pennsylvania State College Experiment Station, Bulletin No. 62; Ginseng: Its Nature and Culture, Kentucky Experiment Station, Bulletin No. 78; Diseases of Ginseng, New York (Cornell) Experiment Station, Bulletin No. 219; Pennsylvania State Department of Agriculture, Bulletin No. 27; Missouri Experiment Station, Bulletin No. 69; Division of Botany,

United States Department of Agriculture, Bulletin No. 16; Daily Consular Reports for 1905, Nos. 2162, 2284, 2287, Department of Commerce and Labor, Washington D. C.; Monthly Reports of Exports and Imports, Department of Commerce and Labor (secured from Bureau of Statistics, Washington, D. C.).

GRAIN: Shipping, Grading and Storing. Figs. 511–514.

By *C. S. Scofield.*

Before the middle of the last century, much the larger part of the grain produced in the United States was hauled to the mill by the farmer, and was either sold to the miller or ground for a toll charge and the product disposed of by the owner afterward. The high specialization of milling processes, involving more expensive milling plants, the rapid extension of grain-producing areas, and the development of railroads that offered a ready means of transporting grain long distances from the farm to the mill, have all taken place since 1850. The geographical separation of the grain-field and the mill has necessitated the development of a commercial system of moving grain from the farm to the mill, of storing it en route or at destination, and of classifying or grading it so that similar kinds may be kept together in transit and in storage.

In order to meet the needs that have arisen with the rapid development of grain production and milling in this country, American methods of handling, grading and storing grain have become more complicated and extensive than those of any other country.

Shipping and handling grain.

Instead of hauling his grain to the mill, the farmer now hauls it to the nearest railway station where there is an elevator or storage house, at which it is weighed and graded; and the farmer either takes his pay for it on the basis of the day's quoted price, or accepts a storage receipt which states the quantity and grade of the grain delivered. This storage receipt may be converted into cash at any time on the basis of the ruling market price, subject, of course, to discounts for storage and insurance charges.

From the country elevator, the grain is shipped in carload lots to central milling or distributing points, where it is usually unloaded for storage in large elevators, and from which it may be withdrawn as needed, for either shipment or manufacture. The machinery for moving grain in bulk has been developed to such a degree of efficiency that grain can be unloaded from a car or vessel and placed in storage in an elevator for a quarter of a cent a bushel. Machinery for cleaning and otherwise improving grain in large quantities has also been brought into use, so that the farmer no longer finds it profitable to attempt to clean his grain before marketing it.

Nearly all the grain marketed in the United States, east of the Rocky mountains, is handled in loose bulk after leaving the farmers' hands. It is stored in large bins in elevators and hauled from place to place in tight box-cars. This feature is unique to the American grain business. In all other parts of the world grain is handled almost exclusively in sacks. Owing to the fact that it is impossible to keep small lots of grain separate when handled in bulk, it has been necessary to use a system of classification or grading by which like kinds and qualities can be kept together and recognized as having a certain market value.

Grading and inspecting grain.

Like the custom of handling grain in quantity without sacking, the system of classifying and grading grain for commercial purposes is unique to the American grain trade. This practice was probably initiated by boatmen along the Chicago river in carrying grain from Illinois farms to Chicago. With the development of railroad traffic in the upper Mississippi valley, the movement of grain to Chicago and similar manufacturing and distributing points caused this custom of classification to spread rapidly. It soon came to be recognized as a part of the business of the trade and was very quickly put on a semi-official basis. Rules, or descriptions of grades, were made out and men were employed to do the inspecting and grading professionally.

Complaints of irregularities and injustices from various sources resulted in the transfer of the control of inspection and grading from the commercial organizations to official state organizations in some of the western states. Illinois, Minnesota, Missouri and Kansas have long had state laws and state commissions to conduct the work of inspecting and grading, as well as weighing, while Washington and Wisconsin have laws and commissions for the control of certain features of this work.

The actual work of grain inspection and grading, as now practiced, is much the same whether under state control or under the control of commercial organizations. There are two methods of doing this work: one is by what is known as track inspection and the other is office inspection, while sometimes a combination of the two is used.

Track inspection.—When the inspection is done on the track, a deputy inspector, with one or two assistants, goes into the railroad yards early in the morning every working day and opens such cars of grain as he finds there destined for his market, the names and numbers of these cars usually being furnished by the railroad companies. Each car is opened by one of the assistants and a sample of grain is taken from it with a special sampling tube and examined by the inspector, who determines the grade, tags the car with name and number of the grade, and closes it again, noting for his daily report the number of the car and the grade assigned. When the grain is destined for sale on the market, a sample is usually taken from the car and sent to the consignee for his information. In some markets practically every car is sampled and the sample sent directly to the trading floor, where it is shown for the information of buyers.

Office Inspection.—When office inspection is made, deputies are sent to the tracks in the early morning to secure samples from the cars destined to the market, and the samples are sent to the chief inspector's office and the grade determined on the basis of the sample. Some kinds of grain, notably flax, are almost always given office inspection, since it is difficult to determine the grade satisfactorily with the hasty inspection on the track.

Grading rules.—The rules for grades of grain are much the same in all American grain markets. There are slight variations from place to place, and some markets have more grades or different grades than others. The following samples of the grade rules for corn, now in use in one of the important markets, give a fair idea of the nature of such rules:

No. 1 Yellow Corn.—Shall be yellow, sound, dry, plump and well cleaned.

No. 2 Yellow Corn.—Shall be three-fourths yellow, dry, reasonably clean but not plump enough for No. 1.

No. 3 Yellow Corn.—Shall be three-fourths yellow, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 1 White Corn.—Shall be sound, dry, plump and well cleaned.

No. 2 White Corn.—Shall be seven-eighths white, dry, reasonably, clean, but not plump enough for No 1.

No. 3 White Corn.—Shall be seven-eighths white, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 1 Corn.—Shall be mixed corn, of choice quality, sound, dry and well cleaned.

No. 2 Corn.—Shall be mixed corn, dry and reasonably clean, but not good enough for No. 1.

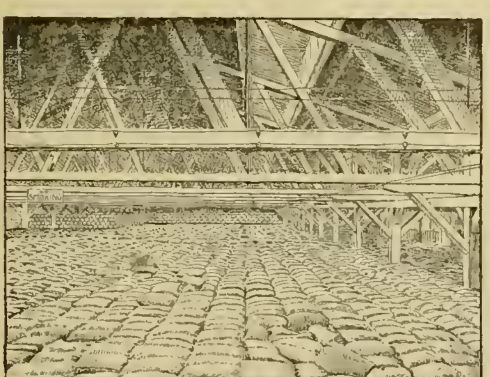

Fig. 511. View of the interior of a grain warehouse on the Pacific coast, showing the grain in bags.

No. 3 Corn.—Shall be mixed corn, reasonably dry and reasonably clean, but not sufficiently sound for No. 2.

No. 4 Corn.—Corn that is badly damaged, damp or very dirty, shall be graded no higher than No. 4.

It will be observed that these rules are very brief and rather indefinite and are thus capable of liberal interpretation, and it must rest with the chief inspector as to just what shall constitute the actual grade limits. The deputy inspectors are therefore guided in their judgment by the chief inspector,

Fig. 512. View of the interior of a large terminal elevator, showing the spouts leading from the scale hoppers on the floor above to the bins below.

and he is usually guided by the commission or committee which has the matter in charge at each market. When either party to a transaction in which a grain grade is involved is dissatisfied with the decision rendered, it is usually possible to appeal from the deputy inspector's decision and secure a ruling from the chief inspector or from a board of appeals. These appealed decisions constitute the unwritten law of the grain inspection department.

Importance of grading and inspecting.—The chief function of grain grades, and consequently of grain inspection, is to permit price quotations on grain and to permit trading for future delivery. Were grain grades not in use it would be difficult to quote prices that had any meaning, and also to make transactions for future delivery of grain, and consequently grain inspection and grading is a very important feature of the grain business, since both transactions are a very large part of it. It is customary to establish in each market a certain grade for each important cereal that is known as the "contract grade," and in all deals and price quotations this grade is the one used, unless otherwise specified.

Inspection tests and methods.—In order to be most efficient, grain inspection must be exact and uniform, and every effort is made by those in control of this work to secure the greatest accuracy and uniformity possible. Many attempts have been made to provide for more accurate methods of inspection and grading than those now in use. A chondrometer, or apparatus for determining the weight per bushel of grain, has been in common use with inspectors for many years. More recently, the inspection of flax has been greatly improved by a system of percentage grading, by which the foreign material and imperfect grains are separated from a sample and their percentage determined by weight. Still more recently, various attempts have been made to determine accurately the percentage of moisture in corn, since it has been found that moist corn deteriorates rapidly in transit and storage, and it is difficult to estimate its moisture content accurately when it is either frozen or very cold, which is often the case. In grading barley for brewing purposes, attempts have been made to determine the percentage and uniformity of germination of samples, since this is one of the most important factors in determining its value to brewers. Owing to the fact that the grain trade demands rapid inspection and grading, so that the grades of the previous day's receipts may be available in time for the day's business, it has not been practicable to use many of the more accurate tests that are known for determining quality in grain.

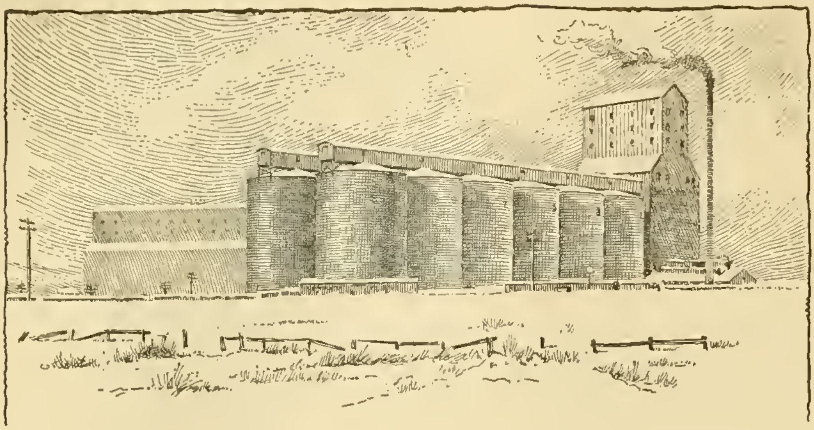

Fig. 513. Grain elevator built entirely of steel, consisting of a series of tanks, with the transfer-belt sheds above and the hoisting and cleaning machinery in a structure at the end.

On the Pacific coast grain is handled almost entirely in bags, instead of in loose bulk. This necessitates some different methods of work in inspection and grading and different types of storehouses and ways of handling grain. For purposes of inspection, it is customary to draw a sample from each bag and base the classification on the composite sample resulting. The term "grading," as applied to grain, has a different meaning on the Pacific coast from what it has in the eastern part of the country. In the West it is applied to the practice of mixing together grain of different qualities to produce a mixture that will meet a certain prescribed standard. This practice has also given rise to other trade customs, particularly to the use of type samples, which are furnished by traders who have grain to sell, and serve as a basis for transactions, instead of the commercial grades, as used elsewhere. A type sample in very common use is what is known as the "F. A. Q. sample," which means Fair Average Quality sample, which is made up early each season after the crop is ready for the market by getting representative samples of grain from the different parts of the producing regions, and this sample or grade is used as a basis for price quotations and future delivery sales, very much as the so-called contract grade is used in the prevailing eastern markets.

Storing and storehouses.

The storehouses used for grain on the Pacific coast have not been so highly specialized as those in the Mississippi valley and eastward. The sacked grain is stored in cheaply constructed warehouses and moved from place to place or loaded and unloaded by hand trucks. (Fig. 511.)

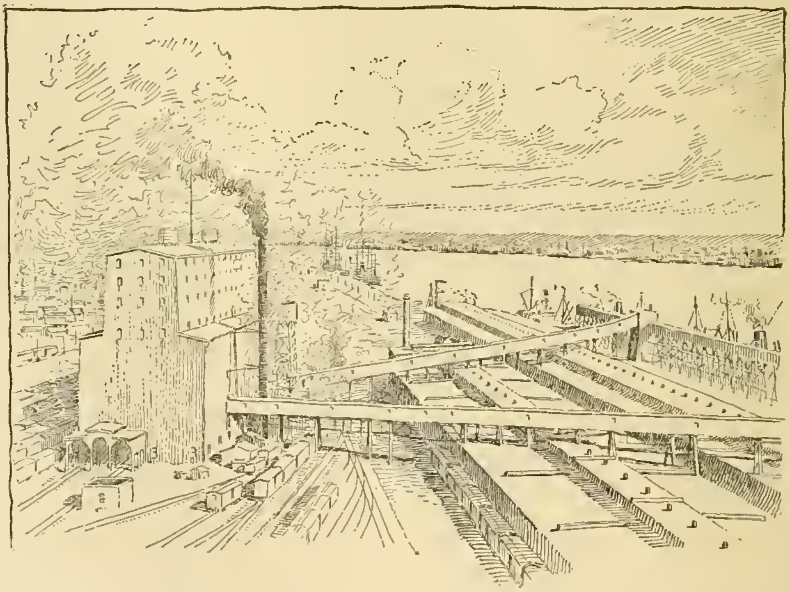

Fig. 514. View of a large terminal elevator, showing the long sheds leading from the elevator to the water front. These sheds shelter large transfer-belts which carry grain from the elevator to the loading chutes.

The warehouse, or elevator, as it is called, in which loose bulk grain is ordinarily stored east of

Plate XII. Three important grasses of the northeastern region—timothy, June-grass, and Canada blue-grass (the last, *Poa compressa*, being the small stiffer panicles in the lower left-hand corner) the Rocky mountains, is a highly specialized type of building. (Figs. 512–514.) It consists essentially of a series of bins set close together, with hoisting, weighing and distributing machinery located above, and with cleaning machinery and loading devices below. Formerly these elevators were built almost entirely of wood, often covered with corrugated metal. More recently they are being built of steel, of concrete and of tile, so as to render them more nearly fireproof.

When grain is received at an elevator it is hoisted at once to the top, usually by means of long belts which carry iron buckets or scoops. These buckets dump the grain into receiving bins, from which it is drawn into the hoppers of scales for weighing. The weighing of grain in elevators has been developed to a very high degree of accuracy, so that it is possible to weigh a thousand bushels at a time with an error of less than one-tenth of one per cent. After the grain is weighed, it is drawn from the scale hoppers into the storage bins, which stand below the scales; or, in some of the modern storehouses, as, for example, the one shown in Fig. 513, it is drawn out onto a broad transfer belt, which is simply a rubber-coated canvas belt, from three to four feet in width, which runs over concave pulleys in such a way as to carry grain on its upper surface. When it is desired to clean grain or to load it out of an elevator, it may be drawn out of the storage bins from the bottom; if it is desired to move it from one part of the elevator, it is drawn out on the transfer belt, which runs below the bins, and is carried from one point to another, to be hoisted again and emptied into another bin at the top. In this way bulk grain is handled very rapidly and very cheaply. It is possible, for instance, to move 15,000 to 20,000 bushels of grain in an hour over a single transfer belt fifty inches wide.

From the standpoint of their relations to the public, there are two general types of elevators,—the so-called public warehouses and the private warehouses. In view of the fact that grain in storage represents an investment of capital that is not active or bearing interest, it is often desirable to use it as a basis for loans of money. In order that the amount and quality of the grain thus stored may be given an official guarantee, there are, in the larger grain markets, registered or public warehouses in which any person may store grain of any grade that will not deteriorate during a reasonable period of time. The grower, owner or broker may receive from the elevator manager a certificate of storage which states the amount and quality of grain stored, and this may be certified to by an official, representing the local grain trade organization or, in some cases, the state grain commission, and when so certified this certificate serves as collateral for loans. In this way, stored grain is relieved from bearing at least a part of the interest on the investment which it represents. Elevators in which the grain is stored merely for cleaning purposes or for immediate transfer are not registered and they are known as private warehouses.

Literature.

The reader should consult Lyon and Montgomery, Examining and Grading Grains (1907), Ginn & Co., for student laboratory methods; Hunt, Cereals in America (1904), Orange Judd Co.; Cobb, Grain Elevators, Department of Agriculture, Sidney, New South Wales, Miscellaneous Publications, 452; Bulletin No. 41, Bureau of Plant Industry, United States Department of Agriculture, The Commercial Grading of Corn, by the author. See also references to literature under the specific grain crops.

GRASSES. *Poaceæ* or *Gramineæ.* Figs. 515–565.

By *A. S. Hitchcock.*

Annual or perennial herbs with characteristic narrow leaves and round or flattened, jointed, usually hollow stems. In the bamboos, the stems are woody and may reach the height of one hundred feet or more. The stems or culms are solid at the nodes or joints and usually hollow between, but may be pithy, as in the Indian corn and other large species. The basal part of the leaf envelops the stem, forming the sheath. The blades are parallel-veined. The flowers are inconspicuous, solitary or several together in spikelets, and these spikelets variously arranged in spikes or panicles. The flowers have no proper perianth but are included between scales in two ranks. A spikelet consists of a short axis bearing at the base two empty scales or glumes (empty glumes of some authors); above these are one or more flowers, each in the axis of a scale called the lemma (flowering or floral glume of some authors); between the flower and the axis is a two-keeled scale, the palea.

The flower consists of a pistil and usually three stamens. The pistil consists of a one-celled ovary and two styles and feathery stigmas. The seed is usually grown fast to the pericarp, forming a grain, and it may also be closely united with the lemma and palea, as in the oat. The spikelet is one-flowered in Agrostis and Phleum, several-flowered in Póa and Triticum. In some genera, such as Panicum, the lower lemma is empty or contains only stamens. The spikelet appears then to have three empty glumes. The inflorescence or flower-cluster is a spike in wheat and a panicle in the oat, while in timothy (Phleum) the panicle is so contracted as to appear as a spike. The glumes and lemmas may bear bristles or awns on the tip or back, as in barley. The staminate and pistillate flowers are in separate parts of the same plant (monœcious) in corn, and may even be in separate plants (diœcious), as in Buffalo grass and Texas blue-grass.

Plants often produce creeping stems below the surface of the ground, by which they spread and form a sod. These rootstocks resemble roots but are jointed like stems and bear scale-like leaves. Familiar examples are Johnson-grass and blue-grass. Perennial grasses which do not bear rootstocks tend to grow in bunches or tussocks, and are known as bunch-grasses. Orchard-grass is of this kind.

This article is restricted to a botanical discussion of the grasses. In some cases reference is made to special articles on the individual grasses for the cultural notes. For cultural notes on all others the reader should consult Spillman's article on *Meadows and Pastures*.

KEY TO GENERA

A. Spikelets dorsally compressed, with one perfect flower, sometimes a staminate flower below the perfect one, falling from the pedicels entire, either singly, in groups or together with joints of an articulate rachis:

- Flowers unisexual; staminate spikelets in a terminal panicle, pistillate spikelets in axillary fascicled spikes more or less enveloped in large bracts (husks):
  - Pistillate spikes compound; grains in several to many rows about a thickened axis (cob) . . . . . 1. **Zea**
  - Pistillate spikes simple, breaking into joints at maturity . . . . 2. **Euchlæna**
- Flowers perfect, or staminate and pistillate together in same inflorescence:
  - Glumes hardened; lemma and palea very thin:
    - Spikelets all perfect, enveloped in long hairs, forming a dense silky panicle . . . . 3. **Saccharum**
    - Spikelets of two kinds,—the perfect sessile, with a staminate one pedicellate on either side . 4. **Sorghum**
  - Glumes thin, lemma and palea hardened; spikelets all perfect:
    - Spikelets not sunken in notches of the axis:
      - Involucre none:
        - Inflorescence spicate:
          - Spikes digitate; spikelets lanceolate . . . . 5. **Syntherisma**
          - Spikes racemose; spikelets nearly circular . . . . . . 6. **Paspalum**
        - Inflorescence paniculate: . . . 7. **Panicum**
      - Involucre of bristles below the spikelet:
        - Grain enclosed in lemma and palea at maturity . . . . . 8. **Chætochloa**
        - Grain globose, forcing open lemma and palea at maturity 9. **Pennisetum**
    - Spikelets sunken in notches of the flattened corky axis . . . . . 10. **Stenotaphrum**

AA. Spikelets laterally compressed, one to many-flowered, the rachilla usually articulated above the glumes which remain on the pedicel after the florets have fallen; (glumes deciduous in *Oryza, Alopecurus* and *Holcus*).

- Spikelets not disposed in alternate notches on opposite sides of a flattened rachis:
  - Stamens 6; glumes minute . . . 11. **Oryza**
  - Stamens 3; glumes more than half as long as florets:
    - Perfect floret 1 in each spikelet:
      - Fertile floret awnless, with 2 sterile lemmas below, falling attached to it:
        - Sterile lemmas minute, awnless 12. **Phalaris**
        - Sterile lemmas larger than the fertile one, awned . . . . . 13. **Anthoxanthum**
      - Fertile floret awnless; a staminate, awned one below, not falling attached . . . . . . 14. **Arrhenatherum**
      - Fertile floret awned or awnless, no sterile floret below:
        - Inflorescence a dense cylindrical spike-like panicle:
          - Spikelets small; glumes longer than the very thin lemmas:
            - Glumes abruptly aristate; lemma awnless . . . . . 15. **Phleum**
            - Glumes not aristate; lemma awned on the back . . . 16. **Alopecurus**
          - Spikelets about 1 cm. long; glumes and lemma chartaceous, sub-equal . . . . . . 17. **Ammophila**
        - Inflorescence an open panicle . 18. **Agrostis**
        - Inflorescence of slender spikes, digitate at summit of culms . 19. **Cynodon**
    - Perfect florets two to many in each spikelet:
      - Plant velvety; spikelets falling from the pedicel entire . . . 20. **Holcus**
      - Plant not velvety; glumes persistent on the pedicel:
        - Florets exceeded by the papery, striate glumes . . . . . . 21. **Avena**
        - Florets not exceeded by the glumes:
          - Spikelets flattened, in dense, one-sided clusters at the ends of the few panicle branches . . . . 22. **Dactylis**
          - Spikelets not in one-sided clusters:
            - Inflorescence a dense spike; spikelets of two forms, the fertile surrounded by sterile ones . . . . 23. **Cynosurus**
            - Inflorescence an open or narrow panicle; spikelets all alike:
              - Lemma keeled; awnless, often cobwebby at base . 24. **Poa**
              - Lemma convex; never cobwebby:
                - Apex of lemma entire; acute or awned . . . . 25. **Festuca**
                - Apex of lemma two-toothed, awned just below the apex or awnless; grain adherent to the palea . . . . 26. **Bromus**
- Spikelets sessile in alternate notches on opposite sides of a flattened rachis, forming slender or dense spikes:
  - Joints of the rachis with one spikelet each:
    - Placed edgewise on the rachis; glume 1 . . . . 27. **Lolium**
    - Placed with one side against the rachis; glumes 2:
      - Glumes bristle-like, one-nerved . 28. **Secale**
      - Glumes lanceolate to ovate; several-nerved:
        - Rachilla not articulated; florets persistent; lemma ovate . . 29. **Triticum**
        - Rachilla articulated above the glumes and between the florets, which fall separately; lemma lanceolate . . . . . 30. **Agropyron**
  - Joints of the articulate rachis with 2 or 3 spikelets each; glumes bristle-like . . . . 31. **Hordeum**

1. **Zea** (Latin name for spelt). A genus of grasses represented by a single American species known only in cultivation. Flowers monœcious, the staminate borne in large terminal panicles (the tassel), and the pistillate borne in the axils of the leaves in several rows on a thickened axis (the cob), and enclosed in several large foliaceous bracts, the whole constituting the ear. The greatly elongated styles project from the tip of the ear and form the silk.

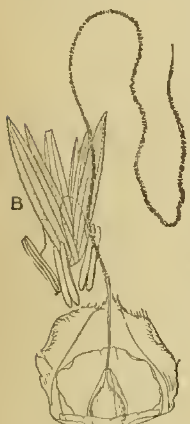

Fig. 515. Indian corn (*Zea Mays*). A, Pistillate spikelet, opened, with second glume cut off to show lemma (flowering glume), palea and ovary; B, staminate spikelet.

Mays, Linn. Indian Corn. Maize. (Fig. 515.) A well-known, large, annual grass with broad leaves, extensively cultivated for forage and grain. The origin of the cultivated varieties of corn is uncertain but must be American, and was probably in the tableland of Mexico or Central America where it has been cultivated longest. It has been suggested that it may have originated from *Euchlæna Mexicana*, which it much resembles in habit, but differs from in having the several pistillate spikes united in a compound inflorescence or ear. [See *Maize*.]

Fig. 516. Teosinte (*Euchlæna Mexicana*).

2. **Euchlæna** (Greek, *eu*, well, and *chlaina*, mantle, alluding to the large glumes). A genus of grasses represented by a single Mexican species. Flowers monœcious, the staminate in panicled racemes terminating the stalks, the pistillate in jointed spikes fascicled in the leaf axils, each spike more or less enveloped in foliaceous bracts. Zea (Indian corn) differs from this chiefly in having pistillate flowers arranged in several rows on a single axis or "cob." The varieties are recognized by some authors as species.

Mexicana, Schrad. (*Reana luxurians*, Dur.). Teosinte. (Fig. 516.) A tall annual with long, broad leaves, resembling Indian corn in habit, native of Mexico and Central America, and cultivated in the southern states for forage. [See *Maize* and *Teosinte*.]

3. **Saccharum** (Greek for sugar). A genus of grasses containing about a dozen species, all but three of which are confined to the tropics of the Old World. Tall grasses with usually large, terminal, spreading panicles, the small spikelets surrounded by long silky hairs. Spikelets usually in pairs at the joints of the articulated rachis, one sessile and the other pediceled, one-flowered, with a sterile lemma below the fertile flower.

officinarum, Linn. Sugar-cane. (Fig. 517.) Stem tall and stout, panicles ample, silky. Cultivated in all tropical countries for the production of sugar. Native country unknown, but probably southwestern Asia. Propagated by cuttings of the stem, as the flowers very rarely produce seed. [See *Sugar-cane*.]

4. **Sorghum.** A genus of about thirteen species of grasses, including the cultivated sorghum and allied forms, many of which are considered as distinct species by some authors. Spikelets in threes in a panicle; the central spikelet sessile, containing a single perfect flower with a sterile lemma above the glumes; the lateral spikelets pediceled and staminate or neuter.

Halepense, Pers. (*Andropogon Halepensis*, Brot.). Johnson-grass. (Fig. 518.) A coarse perennial with extensively creeping rootstocks; stems usually 3 to 5 feet high; leaves one to two feet long, one-half inch wide; panicle open and spreading, six to twelve inches long. Native of the warmer parts of the Old World but well established in the southern half of the United States, where it is cultivated for forage. In many parts of the South it has become a pernicious weed, especially in the black lands of Texas. This species is thought to be the original of the cultivated sorghum.

Fig. 517. Sugar-cane (*Saccharum officinarum*).

Fig. 518. Johnson-grass (*Sorghum Halepense*).

vulgare, Pers. (*Andropogon Sorghum*, Brot.). Sorghum. (Fig. 519.) Differs from the preceding in its larger size, annual roots without rootstocks, and usually large fruit and seed. The panicle varies much in shape in the different varieties. This is the species usually referred to as "millet" in China. [See *Sorghum*.]

5. **Syntherisma** (Greek, crop-making). A genus of grasses of about forty species, mostly tropical,

Fig. 519. Sorghum (*Sorghum vulgare*).

Fig. 520. Crab-grass (*Syntherisma sanguinalis*). A very common weedy grass.

Fig. 521. Water-grass (*Paspalum dilatatum*).

Fig. 522. Para-grass (*Panicum molle*).

with spikelets similar in structure to those of Panicum but arranged in one-sided, more or less digitate spikes. Considered by many as a section (Digitaria) of Panicum.

sanguinalis, Dulac. Crab-grass. (Fig. 520.) A well-known annual weed common in cultivated soil, especially in the South. A native of the Old World. The stems reach a height of three feet and are branching. They are prostrate at the base and root at the lower nodes.

Fig. 523. Guinea-grass (*Panicum maximum*).

6. **Paspalum** (Greek name for some grass, probably millet). A genus of grasses containing about one hundred species, in the warmer regions of both hemispheres. Spikelets one-flowered, plano-convex or flattened, elliptical or circular in outline, sessile or short-pediceled, arranged singly or in pairs in a one-sided spike. Lower glume small or obsolete, upper glume and sterile lemma similar in length and texture, membranaceous; fertile lemma indurated. Spikes single or in pairs at the apex of the long peduncle, or racemosely distributed along the upper part.

dilatatum, Poir. Water-grass. (Fig. 521.) A rather coarse, leafy perennial, growing in clumps two to five feet high; spikes two to ten; spikelets hairy. Produces many succulent basal leaves. A native of Brazil, from whence it was introduced into this country; now well established in the gulf states, where it is looked on as a native grass.

7. **Panicum** (Latin name for *P. Italicum*). A large genus of annual or perennial grasses, containing probably 500 or 600 species, mostly tropical, represented in the United States by about 130 species, particularly abundant in the southeastern states; a few occur as far north as Canada. Spikelets one-flowered, usually awnless, in one-sided spikes or in more or less diffuse panicles; lower glume usually small; upper glume and sterile lemma membranaceous, the latter sometimes with stamens; the fertile lemma and palea indurated.

molle, Sw. Para-grass. (Fig. 522.) A rather coarse, reed-like perennial, four to six feet high, with hairy nodes and narrow lax panicles, six to eight inches long; producing extensively creeping woody runners which root at the nodes. Native of South America, where it is cultivated as a forage grass. It is also cultivated in the West Indies and Mexico and to a limited extent in southern Florida and Texas.

Fig. 524. Hog or broom corn millet (*Panicum miliaceum*).

maximum, Jacq. Guinea-grass. (Fig. 523.) A coarse perennial, growing in dense tufts to the height of as much as ten feet, and producing creeping rootstocks. Inflorescence a large, loose panicle; lemma transversely wrinkled. Native of tropical Africa, but extensively cultivated in tropical America as a forage plant. Somewhat grown in Florida, but will not withstand frost. This should not be confounded with Johnson-grass, which it resembles somewhat in appearance. It is not so hardy as Johnson-grass, and is less troublesome. It furnishes much of the roughage found on the markets in the West Indies.

miliaceum, Linn. Broom-corn Millet. Hog Millet. (Fig. 524.) A rather coarse annual, two to four feet high, with hispid sheaths and large, drooping panicles. A native of the Old World, where it has been cultivated since prehistoric times. Cultivated in Europe and Asia for forage and also for the seed, which is used for food. In this country it is cultivated to a limited extent for forage. This is the true millet of the Old World. In the United States the name millet is given to *Chætochloa Italica*. (Because of its quick growth it is adapted to the North, and is grown somewhat extensively in the Dakotas. It is much more drought-resistant than the other millets.) [See *Millet* and *Meadows and Pastures*.]

Crus-galli, Linn. Barnyard Grass. (Figs. 525 and 526.) A common annual weed probably introduced from Europe, though some forms are native in the United States. Differs from the other species in having awned spikelets, for which reason some authors refer it to the genus *Echinochloa*. Inflorescence a raceme of short spikes. Certain forms of this species are sparingly grown in this country under the name of Japanese barnyard millet. These and the form cultivated in Asia for the grain are sometimes known as *Panicum frumentaceum*, and are shorter-awned than the common forms.

8. **Chætochloa** (Greek, bristle-grass). A genus of annual or perennial grasses of about forty species, found in the warm regions of both hemispheres. Spikelets with the structure of Panicum, but interspersed with roughened bristles which usually extend beyond the spikelets. Inflorescence a dense, cylindrical spike. Also known as *Setaria*. Several species are common weeds in cultivated soil, e. g., *C. viridis* and *C. glauca* (Fig. 527), foxtail or pigeon-grass.

Italica, Scribn. Millet. Hungarian-grass. (Fig. 528.) A coarse annual with thick green or purple spikes, cultivated for forage, especially in the region of the Great Plains. Native of the Old World. Also called Bengal-grass. [See *Millet* and *Meadows and Pastures*.]

9. **Pennisetum** (Greek, feather bristle). A genus of annual or perennial grasses comprising about forty species, found in the tropics of both hemispheres, but more especially the eastern. Spikelets as in Panicum, but surrounded by a cluster of bristles which fall from the axis with the spikelet (except in the cultivated form). Inflorescence a raceme or spike.

spicatum, R. and S. (*Pennisetum typhoideum*, Rich.; *Penicellaria spicata*, Willd.). Pearl millet. (Fig. 529.) A tall, coarse, annual grass, resembling sorghum, but having a dense cylindrical inflorescence six to fourteen inches in length and an inch or less in diameter. The origin of pearl millet is unknown, but it has been cultivated in tropical Africa and Asia for an indefinite period for forage and for the seed, which is used for food. It is now cultivated in the United States to some extent for forage, and the seed is sometimes sold under the name of Pencilaria and Mand's Wonder forage plant. For further account, see United States Department of Agriculture, Farmers' Bulletin, No. 168. [See *Millet*.]

10. **Stenotaphrum** (Greek, narrow trench, alluding to cavities in the rachis). A genus of grasses of three or four species, found in the tropical regions of both hemispheres. Spikelets as in Panicum, but sunken in the cavities of the one-sided broad axis, forming short spikes.

secundatum, Kuntze (*S. Americanum*, Schr.). St. Augustine Grass. (Fig. 530.) A creeping grass with flat stems and obtuse leaves, found in the southern states, mostly near the coast, as far north as South Carolina. The flowering stems may be as much as a foot high. The plants root readily at the nodes and form a thick sod, and hence the grass is especially valuable for lawns or for holding embankments, both in sandy and in mucky soil. The American plant is considered distinct from the Asiatic (*S. dimidiatum*, Kuntze). It is known locally as Charleston lawn grass and mission grass.

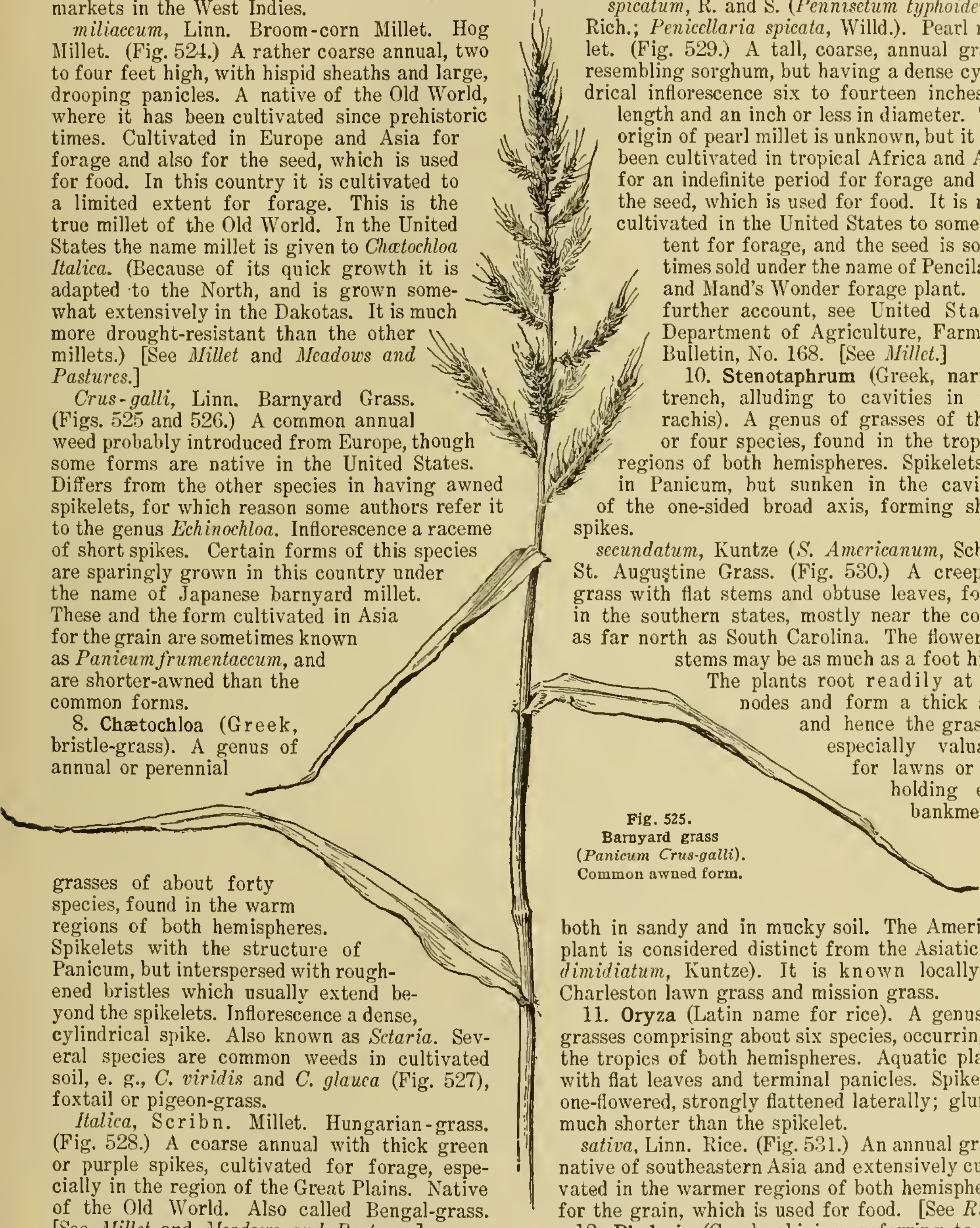

Fig. 525.
Barnyard grass
(*Panicum Crus-galli*).
Common awned form.

11. **Oryza** (Latin name for rice). A genus of grasses comprising about six species, occurring in the tropics of both hemispheres. Aquatic plants with flat leaves and terminal panicles. Spikelets one-flowered, strongly flattened laterally; glumes much shorter than the spikelet.

sativa, Linn. Rice. (Fig. 531.) An annual grass, native of southeastern Asia and extensively cultivated in the warmer regions of both hemispheres for the grain, which is used for food. [See *Rice*.]

12. **Phalaris** (Greek, shining, referring to the seed). A genus of grasses of about a dozen species, mostly in southern Europe, but five in North America. Inflorescence a spike-like panicle. Spikelets one-flowered, strongly flattened latterly, artic-

Fig. 526. Japanese barnyard millet (*Panicum Crus-galli*).

Fig. 528. Common millet or Hungarian-grass (*Chætochloa Italica*).

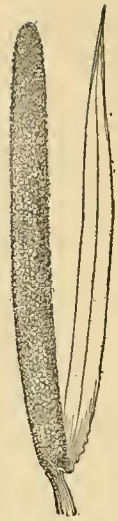

Fig. 529. Pearl millet (*Pennisetum spicatum*).

Fig. 530. St. Augustine grass (*Stenotaphrum secundatum*).

Fig. 527. Yellow foxtail (*Chætochloa glauca*).

ulated above the usually wing-keeled glumes. Below the lemma are two narrow or bristle-formed scales, which represent rudimentary flowers or sterile lemmas. Fertile lemma hard and shining in fruit and closely enveloping the grain.

arundinacea, Linn. Reed Canary-grass. (Fig. 532.) A perennial grass from a creeping rootstock, growing to the height of two to four feet, with a narrow, branched panicle. Native in the northern half of the United States and also in Europe and Asia, where it occurs in wet meadow land. It is an important hay plant in the northern part of the Great Plains region and to the eastward perhaps more especially. A variety with striped leaves is cultivated for ornament under the name of ribbon-grass.

Canariensis, Linn. Canary-grass. (Fig. 533.) An erect annual, with a compact, ovoid spike or head about an inch long. A native of the Old World, but introduced in waste places in America and also occasionally cultivated for its seed, which is used for bird-food.

13. **Anthoxanthum** (Greek, yellow flowers). A genus of three or four species of European grasses, one of which is occasionally cultivated in this country as a forage grass. Spikelets one-flowered, with two unequal glumes, two narrow scales representing rudimentary flowers or sterile lemmas, and a perfect flower with a lemma shorter than the glumes. Aromatic annual or perennial grasses, with contracted, spike-like panicles.

odoratum, Linn. Sweet Vernal-grass. (Fig. 534.) A perennial sweet-scented grass, native of Europe, but now introduced and widely distributed in the northern half of the United States. It is rarely grown in mixtures for meadows; it imparts a sweet odor to the hay. It is an inferior fodder plant.

14. **Arrhenatherum** (Greek, *arrhen*, masculine, and *ather*, awn, referring to the awned staminate flower). A genus of six species of perennial grasses native of the Old World. Spikelets two-flowered, the lower staminate, the lemma bearing a twisted and geniculate dorsal awn, the upper perfect and short-awned or awnless. Inflorescence a narrow panicle.

elatius, Beauv. Tall Oat-grass. (Fig. 535.) A tufted grass, two to five feet high, sparingly cultivated for hay.

15. **Phleum** (Greek name for a kind of reed). A genus of annual or perennial grasses native in the temperate regions of both hemispheres. Spikelets one-flowered, laterally compressed-keeled, the thin lemma shorter than the glumes. Inflorescence a a dense cylindrical spike-like panicle terminating the culm.

pratense, Linn. Timothy. (Fig. 536.) Native of Europe and extensively cultivated in the cooler parts of North America as a forage plant. A short-lived perennial with erect stems and bulbous, thickened base. In New England this is often known as Herd's-grass.

16. **Alopecurus** (Greek, fox-tail). A genus of annual or perennial grasses of about twenty species, found in the temperate regions of both hemispheres. Spikelets one-flowered, laterally compressed, ciliate along the keels of the glumes, lemma awned from the back; palea usually none. Inflorescence a dense cylindrical or ovate, spike-like panicle.

pratensis, Linn. Meadow Foxtail. A hardy perennial grass from a creeping rootstock, with leafy stem and cylindrical panicles. Occasionally grown in meadow mixtures on wet land in northeastern United States.

17. **Ammophila** (Greek, sand-loving). A genus of grasses of one or two species, occurring on the

sandy seashore of Europe and America. Spikelets one-flowered, rather large and chartaceous; rachilla prolonged as a bristle behind the palea. Inflorescence a narrow, spike-like panicle.

arenaria, Link. Beach-grass. (Fig. 537.) A coarse perennial with rigid culms, long, tough, involute leaves and extensively creeping rootstocks, native along the sandy shores of the Great Lakes and on the Atlantic coast as far south as North Carolina. Much used in Europe to bind shifting sand, and recently used for the same purpose in this country, notably at Golden Gate Park, San Francisco, and on Cape Cod. Propagated by transplanting young plants. [For further information, see United States Department of Agriculture, Bureau of Plant Industry, Bulletins Nos. 57 and 65.]

18. **Agrostis** (Greek name for a kind of grass). A genus of grasses including about one hundred species, mostly perennials, distributed over the entire globe in the cooler parts. Spikelets one-flowered, the lemma shorter than the glumes and often awned from the back; palea small or wanting. Inflorescence a panicle, varying from contracted and spike-like to very open and diffuse.

alba, Linn. Red-top. (Fig. 538.) An upright perennial with short rootstocks and moderately open and spreading panicles. Palea one-half to two-thirds as long as the lemma. This species is variable. One form (var. *vulgaris*, Thurb.; *A. vulgaris*, With.) is more tufted and has more delicate culms and panicles. This form is more frequently found in lawns and open woods. It is sometimes awned. A variety of *A. alba*, with more contracted panicles and with extensive stolons, is cultivated as a lawn grass under the name of creeping bent. It is especially useful in the Middle Atlantic states, where it is too warm for blue-grass and too cold for Bermuda. In England, *A. alba* is called Fiorin and bent-grass; in parts of the South it is known as Herd's grass.

canina, Linn. Rhode Island Bent. (Fig. 539.) A delicate perennial resembling the smaller awned forms of *A. alba vulgaris*, but the palea is wanting. Much of the seed sold under this name is *A. alba vulgaris*.

19. **Cynodon** (Greek, dog-tooth). A genus of four species of perennial grasses in the tropical regions of both hemispheres. Spikelets one-flowered, awnless, sessile, in two rows along one side of a slender axis, forming unilateral spikes which are digitate at the apex of the culm.

Dactylon, Pers. (*Capriola Dactylon*, Kuntze). Bermuda-grass. (Fig. 540.) Stems extensively creeping and rooting at the nodes, or in cultivated or sandy soil forming stout flattened rootstocks. On poor soil the leaves are short and the growth low, but in moist, rich soil it may grow tall enough for hay. Very common in the southern states, where it is the most valuable grass for summer pastures. It is also useful for lawns and for holding embankments. In cultivated fields it becomes a pestiferous weed, and is then often called wire-grass or joint-grass.

20. **Holcus** (Greek name for a kind of grass). A genus of annual or perennial grasses containing eight species in Europe and Africa. Spikelets two-flowered, the lower perfect and awnless, the upper staminate and awned. Inflorescence a dense terminal panicle.

lanatus, Linn. Velvet-grass. (Fig. 541.) Velvety-pubescent throughout. It is generally considered a weed, and finds use as a forage crop only in parts of the Pacific northwest, notably about Puget Sound.

21. **Avena** (Latin name for oats). A genus of about fifty species of grasses in the temperate regions of the Old World, a few in America. Spikelets large, two- to six-flowered; glumes membranous, longer than the flowers; lemma with a dorsal, twisted awn (or in cultivated forms straight or absent). Inflorescence a spreading panicle.

Fig. 531. Rice (*Oryza sativa*).

Fig. 532. Reed canary-grass (*Phalaris arundinacea*).

Fig. 533. Canary-grass (*Phalaris Canariensis*).

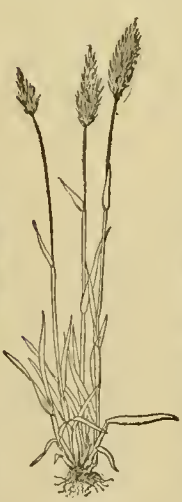

Fig. 534. Sweet vernal-grass (*Anthoxanthum odoratum*).

Fig. 535. Tall oat-grass (*Arrhenatherum elatius*).

Fig. 536. Timothy (*Phleum pratense*).

GRASSES


Fig. 537. Beach-grass (*Ammophila arenaria*).


Fig. 538. Red-top (*Agrostis alba*).


Fig. 539. Rhode Island Bent-grass (*Agrostis canina*) with spikelet showing awn.


Fig. 540. Bermuda-grass (*Cynodon Dactylon*).


Fig. 541. Velvet-grass (*Holcus lanatus*).


Fig. 542. Oats (*Avena sativa*).


Fig. 545. Crested dog's-tail (*Cynosurus cristatus*). Cluster of sterile and fertile spikelet enlarged.


Fig. 546. Texas blue-grass (*Poa arachnifera*), pistillate plant. Staminate panicle and pistillate spikelet enlarged.


Fig. 543. Wild oats (*Avena fatua*).


Fig. 544. Orchard-grass (*Dactylis glomerata*).


Fig. 547. Canada blue-grass (*Poa compressa*).


Fig. 548. Wood meadow-grass (*Poa nemoralis*).

sativa, Linn. Oat. (Fig. 542.) An annual with nodding spikelets and many-nerved glumes, the awns of the persistent lemmas straight or wanting. A common grain thought by many to have originated from the wild oat (*A. fatua*, Linn., Fig. 543), which differs in having a geniculate and twisted awn, and a deciduous lemma more or less covered with red-brown hairs. The wild oat is abundantly introduced on the Pacific coast. A variety (*A. fatua glabrata*, Peterm.) is cut for hay in Washington, and this and an allied species (*A. barbata*, Brot.) are used for pasturage in California. [See *Oats*.]

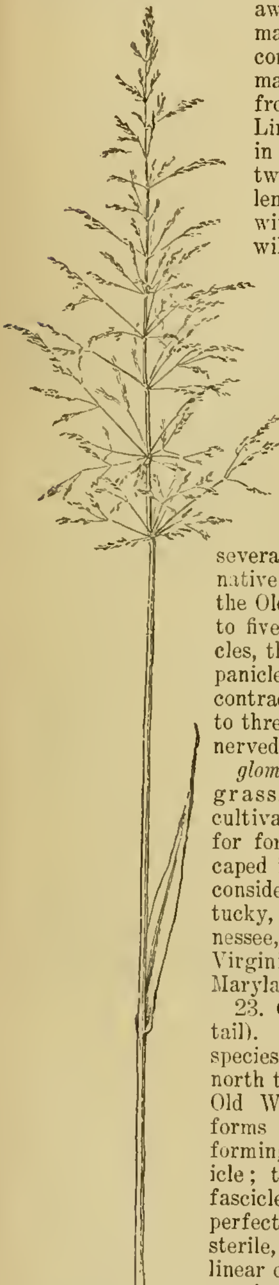

Fig. 549. Blue-grass or June-grass (*Poa pratensis*).

22. **Dactylis** (Greek, finger). A genus of grasses comprising one species or several closely allied species, native in the northern part of the Old World. Spikelets three- to five-flowered, in dense fascicles, these forming a glomerate panicle, spreading in flower but contracted in fruit. Glumes one- to three-nerved, the lemma five-nerved.

glomerata, Linn. Orchard-grass. (Fig. 544.) Commonly cultivated in the northern states for forage and extensively escaped in waste places. It is of considerable importance in Kentucky, southern Indiana, Tennessee, North Carolina, western Virginia, West Virginia and Maryland.

23. Cynosurus (Greek, dog's-tail). A genus of four or five species of grasses found in the north temperate regions of the Old World. Spikelets of two forms in small fascicles, these forming a dense, spike-like panicle; terminal spikelets of the fascicles two- to four-flowered, perfect, the lower spikelet sterile, consisting of many linear one-nerved glumes.

cristatus, Linn. Crested Dog's-tail. (Fig. 545.) A perennial grass, one to two feet high, with fine and chiefly radical leaves. Occasionally sown in grass mixtures but without much forage value.

24. Poa (Greek, for fodder). A genus of about 125 species of grasses, chiefly in the cooler regions of both hemispheres. Spikelets two- to six-flowered, the uppermost flower more or less imperfect; glumes one- to three-nerved, keeled; lemma keeled, five-nerved, awnless. Inflorescence a more or less spreading panicle. Annuals or perennials.

arachnifera, Torr. Texas Blue-grass. (Fig. 546.) A diœcious perennial grass with running rootstocks. The staminate and pistillate panicles are distinctly different in appearance, owing to the fact that the lemmas of the staminate spikelets are smooth while those of the pistillate spikelets are densely long woolly, which character at once distinguishes this species.

compressa, Linn. Canada Blue-grass. (Fig. 547.) A perennial with scattered, flattened stems, six to twenty inches high, from creeping rootstocks which form a strong turf. Panicle comparatively small and narrow. Because of the characteristic shape of the stem it is called flat-stem in the middle Alleghany region. In New England and in some other localities it is known as blue-grass, but this name should be restricted to *Poa pratensis*. It is also sometimes called wire-grass. The foliage has a peculiar blue-green color. It is a native of Europe and of the northern part of America.

nemoralis, Linn. Wood Meadow-grass. (Fig. 548). A tall perennial (one to three feet) with open spreading panicle, four to six inches long; spikelets mostly two- to three-flowered, lemma webby at base, keel and marginal nerves pubescent, intermediate nerves glabrous and obscure; ligule very short. This European species is occasionally cultivated as a meadow grass or in mixtures, and has escaped in the northeastern states. It is adapted to shaded situations. Probably not native.

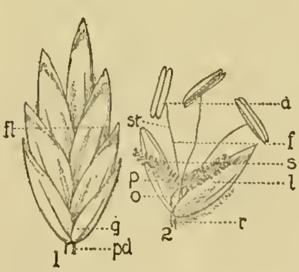

Fig. 550. Detail of blue-grass flower (*Poa pratensis*). 1, spikelet; 2, floret opened; *fl*, florets; *g*, glumes; *pd*, pedicel; *st*, stamen; *a*, anthers; *f*, filaments; *s*, stigmas; *p*, palea; *l*, lemma; *o*, ovary; *r*, rachilla.

Fig. 551. Kentucky blue-grass or June-grass (*Poa pratensis*).

pratensis, Linn. Kentucky Blue-grass. (Figs. 549–551.) A perennial grass growing in tufts, but producing abundant rootstocks by which it soon forms a firm sod. Panicles spreading but not diffuse, two to five inches long. Spikelets mostly three- to five-flowered; lemma much as in the preceding, but the intermediate nerves more prominent. A valuable grass, native in the northern part of both hemispheres and widely cultivated for pasture and lawns. It does not thrive in the South.

triflora, Gelib. (*P. serotina*, Ehrh.). Fowl Meadow-grass. (Fig. 552.) This grass closely resembles *P. nemoralis*. It usually grows taller and has a larger panicle. Probably the best character to distinguish between the two is the ligule, which in *triflora* is about three millimeters (one-eighth inch) long,

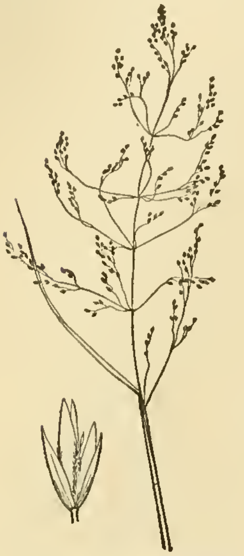

Fig. 552. Fowl meadow-grass (*Poa triflora*) and enlarged spikelet.

Fig. 553. Rough-stalked meadow-grass (*Poa trivialis*) and enlarged spikelet.

Fig. 554. Meadow fescue (*Festuca pratensis*).

while in *nemoralis* it is scarcely measurable. This species is native in the northern part of America as well as in Europe. It has been incorrectly referred to *P. flava*, Linn. Sometimes known as false red-top.

trivialis, Linn. Rough-stalked Meadow-grass. (Fig. 553.) In general appearance much resembling *P. pratensis*, but usually with a larger and more spreading panicle. It differs in the absence of well-developed rootstocks, in the sheaths rough to the touch (hence the common name), and in the glabrous marginal nerves of the lemma. Occasionally grown in mixtures for meadows. A native of Europe but escaped from cultivation in the northeastern states. It is adapted to shaded situations.

25. **Festuca** (Latin, straw). A genus of about eighty species of mostly perennial grasses, scattered over all parts of the globe but chiefly in temperate regions. Spikelets several-flowered, glumes narrow and acute; lemmas rounded on the back, or keeled at apex, often awned from the tip, faintly three- to five-nerved, rather hard in texture. Inflorescence from a narrow raceme to a spreading panicle.

elatior, Linn. Tall Fescue. A tall grass (three to four feet) with large flat leaves, large but rather narrow panicle and large, five- to ten-flowered, awnless spikelets (about one-half inch long). Native of Europe and cultivated for forage. Frequently escaped from cultivation. A smaller form (var. *pratensis*, Gray (Fig. 554); *E. pratensis*, Huds.), with narrower panicle of fewer spikelets, is more commonly cultivated under the name of meadow fescue, and is a more valuable agricultural grass. Sometimes called Randall grass. The tall fescue makes a ranker growth than the meadow fescue.

ovina, Linn, Sheep's Fescue. (Fig. 555.) A low tufted perennial without rootstocks having numerous very narrow, wiry basal leaves, narrow panicles, and short-awned lemmas. A variable species, native of temperate regions of the northern hemisphere. Much valued in Europe as a pasture grass, especially for sheep, but little grown in this country. Varieties or closely allied species of this go under the names of various-leaved fescue (*F. heterophylla*), hard fescue (*F. duriuscula*), and fine leaved or slender fescue (*F. tenuifolia*).

rubra, Linn. Red Fescue. (Fig. 556.) Resembles *F. ovina*, but usually larger and with a more spreading panicle. Distinguished chiefly by the presence of short rootstocks or creeping bases of the stems, which are often red in color. Some varieties are native along the Atlantic coast and in the western mountains.

26. **Bromus** (Greek name for oats). A genus of about one hundred species of annual or perennial grasses, mostly of the north temperate zone. Spikelets several-flowered; lemmas rounded on the back or sharply keeled, five- to nine-nerved, two-toothed at the apex and awned from between the teeth, or sometimes awnless. Inflorescence a panicle of rather large, erect or pendulous spikelets. Leaves flat. Our native species are all perennial. Several annuals introduced from Europe are troublesome weeds, such as cheat or chess (*B. secalinus*).

Fig. 555. Sheep's fescue (*Festuca ovina*).

Fig. 556. Red fescue (*Festuca rubra*).

Fig. 557. Brome grass (*Bromus inermis*).

inermis, Leyss. Russian Brome grass. (Fig. 557.) An erect perennial two to five feet high, with strong creeping rootstocks and a loose, open panicle four to six inches long. Spikelets scarcely flattened, erect, about an inch long, awnless. Native of

Europe, but recently introduced into this country and proving a valuable forage grass in the Northwest, from Kansas to North Dakota and Washington. Called also smooth, Hungarian, Austrian and awnless brome grass.

secalinus, Linn. Chess. Cheat. (Fig. 558.) An annual, one to three feet high, with open panicle, smooth sheaths and short-awned spikelets. A common weed introduced from Europe but cultivated for forage in Oregon and Washington. A closely allied species (*B. racemosus commutatus*) is common and can be distinguished by the pubescent sheaths and the less rigid and turgid lemma, especially in fruiting spikelets. The idea that chess may turn into wheat is now one of the curiosities of agricultural tradition.

Fig. 558. Chess or cheat (*Bromus secalinus*). Common in wheat fields. It was once supposed that wheat turned to chess.

unioloides, H. B. K. Rescue-grass. (Fig. 559.) A tall annual (one to three feet) with an open panicle of broad, much-flattened, nearly or quite awnless spikelets. Native of South America. Cultivated in the southern states for winter forage. Also called arctic-grass, Schrader's brome-grass, Australian brome and Australian oats.

27. **Lolium** (the old Latin name). A genus of six species of grasses in northern Europe and Asia. Spikelets several-flowered, solitary and sessile on alternate sides of the rachis, placed with the edges against the axis, forming a two-rowed spike.

multiflorum, Lam. (*L. Italicum*, A. Br.). Italian Rye-grass. (Fig. 560.) A short-lived perennial or scarcely more than a biennial. Spikelets with awns about as long as the lemma. On the Pacific coast sometimes called Australian rye-grass.

perenne, Linn. Perennial Rye-grass. (Fig. 561.) Similar to the preceding, but somewhat more persistent and with awnless spikelets. Long cultivated in England, where it is highly esteemed as a forage grass.

28. **Secale** (Latin name for rye). A genus of grasses containing two species, one of which is widely cultivated. Native in the Old World. Spikelets two-flowered, solitary and sessile, alternate on opposite sides of a continuous rachis, forming a dense terminal spike. Glumes narrow and pointed; lemmas keeled, five-nerved, long-awned from the apex.

Fig. 559. Rescue-grass (*Bromus unioloides*).

cereale, Linn. Rye. (Fig. 562.) A well-known cereal in common cultivation in all cool climates. [See *Rye*.]

29. **Triticum** (Latin name for wheat). A genus of ten or twelve species of the Mediterranean region. Spikelets two- to five-flowered, solitary and sessile, alternate on opposite sides of the rachis, forming a dense terminal spike. Glumes ovate, three to many-nerved. Annuals.

sativum, Lam. (*T. vulgare*, Vill.). Wheat. (Fig. 563.) A common grain, long cultivated and existing in well-marked races and numerous varieties. The spikelets may be awned (bearded) or awnless (smooth). [See *Wheat*.]

30. **Agropyron** (Greek, wheat-grass). A genus of about thirty-five species of perennial grasses, distributed in all temperate climates. Spikelets three- to several-flowered, solitary and sessile at each joint of the axis, forming a terminal spike. Glumes narrow and pointed. Differs from *Triticum* in the shape of the glumes and in having the lemma deciduous with the grain to which it ad-

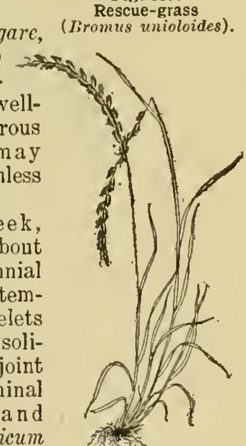

Fig. 560. Italian rye-grass (*Lolium multiflorum*).

heres. Commonly called wheat-grasses. In native meadows in the Northwest several species are utilized, especially *A. occidentale*, Scribn., called blue-stem and blue-joint in the Rocky mountain region (not the blue-stem of the prairie states, *Andropogon furcatus*, Muhl., nor of Minnesota, *Calamagrostis Canadensis*), and the slender wheat-grass of Montana and Washington (*A. tenerum*, Vasey). The seed of the latter is now a commercial article.

Fig. 561. Perennial rye-grass (*Lolium perenne*).

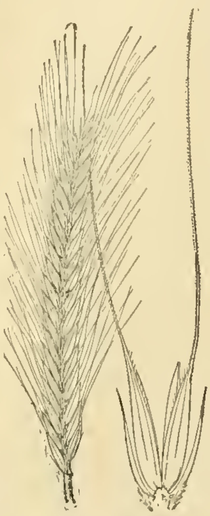

Fig. 562. Rye (*Secale cereale*).

Fig. 563. Wheat (*Triticum sativum*).

repens, Beauv. Quack-grass. (Figs. 159, 564.) A perennial with a creeping, several-jointed root-stock. Culms may reach four feet in height. Leaves numerous and linear; spikes six to twelve inches long, erect; spikelets on opposite sides of a jointed and grooved rachis, erect, four- to eight-flowered. Glumes acute or short-awned; lemmas smooth; palea acute or slightly rounded. Also called couch-grass, twitch-grass and quitch-grass.

31. **Hordeum** (Latin name for barley). A genus of about sixteen species of grasses in both hemispheres. Spikelets one-flowered, two to three together at each joint of the articulated rachis, forming a dense terminal spike. Glumes two, narrow or bristle form.

vulgare, Linn. (or *H. sativum*, Jess.). Barley. (Figs. 287, 565.) A well-known cereal cultivated in all cool climates. There are normally three spikelets in a group at each node, each with its pair of awn-like glumes; each lemma also long-awned. If all three spikelets are developed and form grains, six- or four-rowed barley is produced, according as the lateral spikelets on each side form two distinct rows or are coalesced into one. In two-rowed barley the lateral spikelets are staminate and do not form grains. The grain in most varieties adheres to the lemma in threshing, but in the naked barleys it falls out. Beardless barley is a form in which the awns are short and much distorted. [See *Barley*. Authorities differ in practice as to use of the two specific names; either is allowable.]

Literature.

The following is a list of the more important recent works treating wholly or in part of North American grasses. In addition, there are numerous local floras, monographs and technical articles in botanical journals that are not readily accessible to the general reader. Manuals and general works: Beal, Grasses of North America, Vol. II, 1896; Britton, Manual of the Flora of the Northern States and Canada (1901), Second edition, 1905; Britton and Brown, An Illustrated Flora of the Northern United States, Canada and the British Possessions, Vol. I, 1896; Chapman, Flora of the Southern United States, Third edition, 1897; Coulter, Manual of the Botany of the Rocky Mountain Region, 1885; Gray, Manual of the Botany of the Northern United States, Sixth edition, 1890; Hackel, The True Grasses, translated from the German by Scribner and Southworth, 1890; Small, Flora of the Southeastern United States, 1903; Watson, Geological Survey of California, Botany, Vol. II, 1880 (the grasses are by Thurber); Monographs and special papers, United States Government publications: Hitchcock, North American Species of Agrostis, Bureau of Plant Industry, Bulletin No. 68, 1905; Hitchcock, North American Species of Leptochloa, Bureau of Plant Industry, Bulletin No. 33, 1903; Merrill, The Native Species of Chætochloa, Division of Agrostology, Bulletin No. 21, 1900; Merrill, The North American Species of Spartina, Bureau of Plant Industry, Bulletin No. 9, 1902; Piper, North American Species of Festuca, Contributions from National Herbarium 10, No. 1, 1906; Scribner, American Grasses, I, Division of Agrostology, Bulletin No. 7, 1900; II, Division of Agrostology, Bulletin No. 17, 1901; III, Division of Agrostology, Bulletin No. 20, 1900; Shear, A Revision of the North American Species of Bromus Occurring North of Mexico, Division of Agrostology, Bulletin No. 23, 1900; Vasey, Illustrations of North

Fig. 564. Quack-grass (*Agropyron repens*).

Fig. 565. Six-rowed barley (*Hordeum vulgare*).

American Grasses: Vol. I, Grasses of the Southwest, 1891; Vol. II, Grasses of the Pacific Slope, 1893, Division of Botany, Bulletin Nos. 12 and 13.

HEMP. *Cannabis sativa*, Linn. *Urticaceæ*. Figs. 566–571. [See also *Fiber plants*.]

By *J. N. Harper*.

An annual diœcious plant, reaching a height of ten feet and more, grown for its long bast fiber, and for its seeds. Staminate flowers drooping in axillary panicles, having five sepals and five stamens; pistillate flowers in short spikes, with one sepal folding about the ovary. Leaves digitate, with five to seven nearly linear, coarse-toothed leaflets. Hemp is probably native to central Asia.

Fig. 566. Hemp. Staminate flower-cluster: *a*, pistillate and *b*, staminate flowers; *c*, pistillate flower cluster at left.

History.

Hemp has been cultivated for centuries as a fiber plant. It was grown by the early Greeks and probably by the ancient Egyptians. It has been grown in this country for about 130 years, the seed having been brought from France. During this time, its cultivation has been confined chiefly to about twelve counties in central Kentucky, in what is known as the blue-grass region. For the last forty or fifty years, however, the industry has spread into a number of other states, notably Missouri, Illinois, Nebraska, Oklahoma, Minnesota, New York and California. Notwithstanding this extension of the industry, nine-tenths of the hemp crop of America is still grown in Kentucky.

During the years it has been grown in Kentucky, probably no other crop has brought an equal revenue. A few years before the Civil War it contributed more to the wealth of central Kentucky than all other crops combined. At that time, Kentucky produced annually 38,000 tons, with a gross receipt of $2,280,000. During the war the industry declined but revived a few years later, and again declined owing to the use of iron and jute in the bagging of cotton. Hemp is now used largely for making burlap, twine and carpet warp.

Production.

According to the Twelfth Census there were in 1899, 964 farms producing hemp, with an average acreage of 16.6 and a total acreage of 16,042. The average production per acre was 732 pounds, worth $34.06, or 4.6 cents per pound.

The figures for hemp in the Twelfth Census (1900) are as follows:

	Acres	Pounds	Value
Arkansas . . .	1	420	$20
California . . .	500	620,000	45,000
Illinois	783	515,400	21,784
Missouri	10	2,000	100
Kentucky . . .	14,107	10,303,560	468,454
Nebraska . . .	638	305,400	10,752
Pennsylvania . .	3	3,850	228
	16,042	11,750,630	$546,338

Culture.

The soil.—While hemp will grow on almost any land containing a large amount of humus, it does best on well-drained silurian limestone soils. In Minnesota it thrives on drift soils. The moisture content is the important factor. The soil should be prepared thoroughly by breaking with a turning plow, plowing about six to eight inches deep, and by repeated harrowings and rolling.

Hemp grows so tall and dense that it kills weeds by smothering them better than any other farm crop. A good growth of hemp is effective in killing even Canada thistle and quack-grass. It leaves the soil in excellent condition for any succeeding crop.

Seeding.—The best results are secured by sowing with a seven-inch wheat drill, running it both ways. The seed is sown at the rate of one bushel per acre. It is sown about two inches deep. After sowing, the land should be rolled. Hemp should

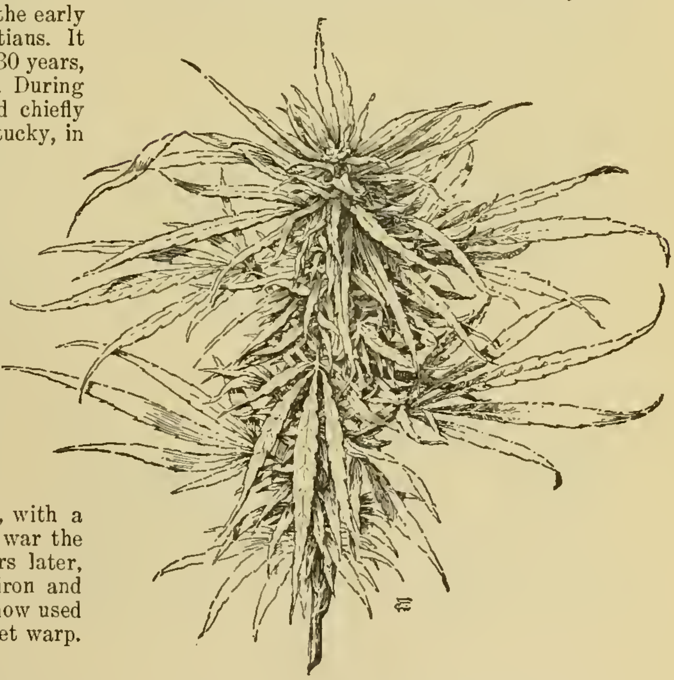

Fig. 567. Hemp: pistillate or seed-bearing part.

not be sown very thick, because in thinning itself it will crowd out many plants and the size of the hemp stalks will not be uniform. The best fiber is obtained from stalks about one-half inch in diameter; if a thin stand is secured, the stalks frequently will grow to be three-fourths of an inch in diameter. Hemp drilled in gives a much more uniform stand than when sown broadcast, because all of the seeds are placed at a depth to have sufficient moisture to insure immediate germination, and the young plants get an even start. Repeated experiments have shown that it does not pay to till hemp that is intended for fiber.

Fig. 568. Hemp; staminate flowers indicate time for harvest.

The earlier the seed is planted in the spring the more assurance there will be of a good crop. Hemp requires a large amount of moisture and should be high enough to shade the ground and thus conserve all water that may fall in the early summer. The average time of planting for eight years at the Kentucky Experiment Station was April 25. The young plants began to come up in about one week's time.

It has been found by long experience that the seed that gives the best results is secured from China. The Kentucky Experiment Station has tested the value of a number of Japanese varieties, but none has given as good results as those from Chinese seed. The first year the imported seed is planted the yield is much less than it is in succeeding years. Growers say that after the Chinese hemp has been grown for a number of years it degenerates and they seek newly imported seed. There are no well marked varieties.

Fig. 569. Shocking hemp.

Seed-growing.—The hemp that is planted for seed is sown on the river-bottoms. A narrow strip along the Kentucky river produces nearly all of the hemp grown in America for seed purposes. About two quarts per acre are sown. This is often planted in hills, seven feet apart, in rows six to eight feet apart. About four stalks are permitted to grow to the hill. This hemp is carefully cultivated and kept free from all weeds and grasses. The seed is used in the making of oils for paints, for bird and poultry food, and various other purposes. The yield of seed is fifteen to thirty bushels to the acre. As much as forty dollars per acre is often realized from hemp seed. The seed must not be stored in bulk or it will heat.

Fertilizers.— The Kentucky Station has experimented for a number of years on the use of commercial fertilizers on hemp, and the results show that, by the use of 160 pounds of nitrate of soda per acre, three to four hundred pounds more fiber can be grown to the acre than on unfertilized land. When 160 pounds of nitrate of soda and 160 pounds of muriate of potash are used together, at least four to five hundred pounds more fiber are secured than on the unfertilized areas. Acid phosphate does not show a material increase. Nitrate of soda gives better results than does sulfate of ammonia or dried blood. The prime requirement is for nitrogen, and it should be furnished by applying commercial fertilizers, or by barnyard or green-manures. A leguminous crop can be alternated with the hemp, and in parts of the South this can be done in the same year.

Fig. 570. Stack of hemp.

Cutting and handling.

The first blossoms appear about the first week in July, and hemp sown April 25 will be ready for cutting about the first of September. Most of the hemp grown in Kentucky is still cut by hand by means of a knife made especially for this purpose. However, much has recently been cut by especially designed machinery. The yield from the handcut field is greater than that from the machinery-cut field, and some farmers maintain that there is enough difference to make up for the greater expense. The heaviest fiber is found on the internode next to the ground, and if the stubble is left any length, a great quantity of fiber is lost. It usually costs about one dollar per acre to cut by machinery and three dollars per acre to cut by hand.

After the hemp is cut, it is spread evenly over the ground, the butts being placed down the hill if there is a slope. The stalks are placed in parallel lines. In about one week it is sufficiently dry to rake up into small bundles. These bundles are tied with small stalks of hemp and are placed in shocks (Fig. 569) or stacks (Fig. 570). The Kentucky Experiment Station has shown that it pays to stack the hemp, as the loss of fiber is not so great and the quality is much improved. Stacked hemp rets more evenly and makes a much better fiber than when shocked. In the latter case, too much of the outer layer sunburns and over-rets. The shocks are liable to blow down, greatly to the damage of the crop. The shocked hemp, however, is much less expensive to handle and can be spread out at different periods, so that the quantity retted at one time can be controlled.

If the hemp is allowed to remain on the ground too long after cutting, it will sunburn and the quality will be destroyed. It requires considerable judgment to stack hemp to avoid the sunburn. Care should be taken not to stack it before it is sufficiently dry, as it will heat in the stack with much injury to the quality.

Retting.—About the middle of November or the first of December, the hemp is taken from the stack and spread over the ground as before stacking, to ret, a process which separates or liberates the bast. If the weather conditions are favorable, it will ret in about two months sufficiently to break. Ideal weather conditions for retting are alternate freezing and thawing, with an occasional snow that does not remain long on the ground. Early and late retting are not so good as winter retting; and hemp retted during heavy freezes is much better than when rain-retted. After the hemp has retted sufficiently to allow the fiber to break readily from the hards (or "hurds"). it should be placed in shocks to prevent further retting. The artificial methods of retting have never been completely successful.

Breaking.—The fiber is removed or extracted from the other tissue by the process of breaking. Most of the hemp of Kentucky is still broken by the old-fashioned hand-brake that has been in use for more than one hundred years. Large sums have been spent in trying to devise machinery for this operation, but so far most of the attempts have failed. Within the last year or so, however, machines have been designed that promise successfully to break the hemp.

Marketing.

After being broken in the field, the hemp is tied up in hanks of six to eight pounds. These are put in about 150-pound bales, which are taken to the market, where the hemp is rehandled by the dealer. The rehandling consists in running the hemp through hackles of various degrees of fineness. The hackled hemp is shipped directly to the twine manufacturer. The best hemp fibers, which are water-retted, come from abroad, especially from Italy and France.

Returns per acre.

Sufficient seed to sow an acre costs about $3; the breaking of the land costs $1.25; harrowing, 50 cents; breaking and rolling, 50 cents; drilling the seed, 50 cents; cutting, $3; tying and shocking, $1.25; spreading, 50 cents; taking up and shocking, 50 cents; putting in stacks, $1; breaking, $1 per hundred, or about $15 per acre, thus making the total cost $27 per acre. Twelve hundred pounds is considered a good crop, and 1,800 pounds is often produced. The average price is about five cents per pound, making a gross income of $60 to $90 per acre, or a net income of $33 to $63 per acre.

Enemies.

The hemp plant is subject to few enemies. There is a parasitic plant that is causing a great deal of damage to the crop in central Kentucky. This parasite belongs to the broom rapes. It has been discussed in several bulletins issued by the Kentucky Station. Cutworms and a small fly (*Pegemyia fusciceps*) sometimes damage it seriously.

Methods employed in Nebraska, California and Minnesota.

At Havelock, Nebraska, where hemp follows hemp or a crop leaving the soil in equally good condition, the land is prepared and the seed sown and covered at one operation. A traction engine draws a gang of plows followed by a harrow, then a special drill and a second harrow to cover the seeds and settle the soil. The hemp is cut with

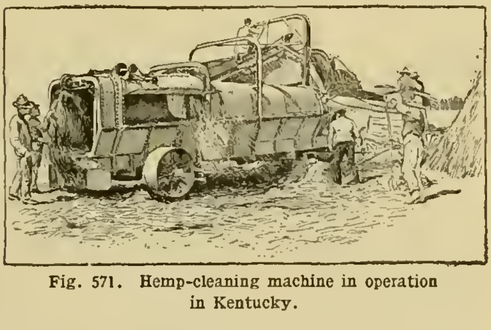

Fig. 571. Hemp-cleaning machine in operation in Kentucky.

ordinary mowing machines with an attachment to throw the stalks smoothly in the direction the machine is going. The stalks lie where they fall until retted. They are then raked up with horse-rakes and taken to the power brake, consisting of fluted rollers followed by beating wheels, which prepares the fiber in the form of long tow. In California hemp is cut with special self-rake reapers, bound and set up in shocks, until conditions are favorable for retting. It is then spread for dew-retting and afterward broken on the Heaney hemp brake, similar to the one at Havelock, making long tow. At Northfield, Minnesota, hemp is cut by self-binders of special construction and, after curing in the field, is water-retted in tanks and broken by machinery, producing a light yellowish fiber somewhat like Italian hemp.

Literature.

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HOPS. *Humulus Lupulus*, Linn. *Urticaceæ.* Figs. 572–576.

By *Jared Van Wagenen, Jr.*

A perennial twining herb producing burs or "hops" that are used in the making of beer. It has long shoots often reaching twenty-five to thirty feet in a season; rough hairy, the stems having minute prickles pointing downward; leaves ovate or orbicular-ovate in general outline, deeply three-lobed (sometimes five- to seven-lobed), or the upper ones not lobed; margins strongly and uniformly dentate; petioles long; staminate flowers in panicles two to six inches long; hops (mature pistillate catkins) oblong or ovoid, loose and papery, straw-yellow, often two inches or more long, glandular and odoriferous. The hop has a tough, fibrous inner bark and a colorless juice which makes an indelible stain on white fabrics. The stems climb as much as thirty feet high by the beginning of the flowering period, lengthening from a well-marked terminal "head," and normally twining by rotating spirally around their supports, "clock-wise" or "following the sun." The hop is diœcious, i. e., the pistillate and staminate flowers are borne on separate plants. The fruit may be regarded as a compact catkin, largely made up of the axis together with the large foliaceous bracts, each of which is covered at its base by a yellow, granular, resin-like material called lupulin. This is the essential principle in the hop, and imparts the bitter taste to beer. There are also a few seeds, although seed-production is irregular and scanty, a large proportion of the fertile flowers failing to mature seed. The plant is unusually drought-resistant and grows most rapidly in extremely hot weather, sometimes increasing in length as much as a foot a day. The stems cling closely to a pole or string and, when once well started, will follow it with very little trouble. The growth is almost wholly increase in length until the beginning of the flowering period (mid-July in New York), after which short compound lateral branches are thrown out from the axils of the leaves, on which the flowers appear and the plant ceases to "run." Botanically, the hop is closely related to hemp and is included in the great nettle family.

Fig. 573. Hop. Pistillate flowers in clusters or catkins, and an individual flower.

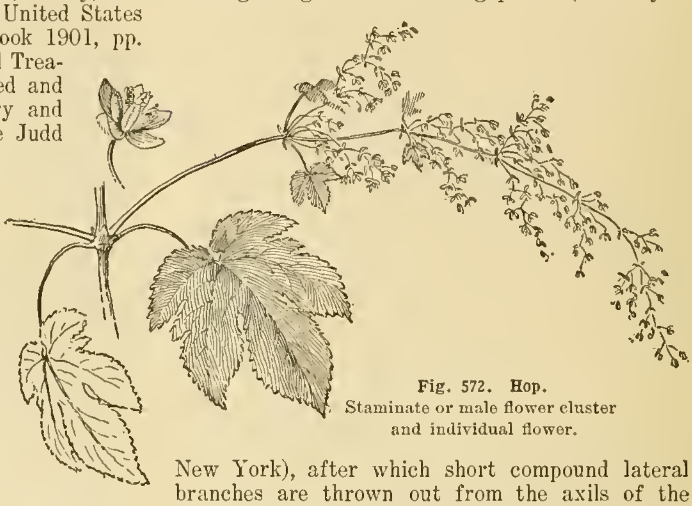

Fig. 572. Hop. Staminate or male flower cluster and individual flower.

Geographical distribution.

There are few plants that are more widely grown than the hop. It is native in Europe and is reported from practically every European country and from Canada, Australia, New Zealand, Tasmania and other countries. In the United States, where it has been an important crop in certain sections for at least a century, its commercial production is limited to four states, in the order named: Oregon, California, New York and Washington, although at times it has been grown in Wisconsin, Michigan and Vermont. The relative importance of the crop in New York seems to be on the decline while it is increasing in the West, owing to the better climatic conditions and cheaper methods of production. The wild form of the plant, which differs considerably from the cultivated hop, although easily recognizable, is found along certain alluvial creek-bottoms of the northeastern United States.

The United States Department of Agriculture makes no official estimate of production, but by the best obtainable statistics, in the five years ending with 1905, the total production of the United States has ranged between 39,000,000 and 51,000,000 pounds. In the same series of years about 20 per cent of the crop has been exported. The United States returns less than one-fifth of the world's total production.

Culture.

Soils.—The hop seems to adapt itself readily to a wide variety of soils, provided only that they are well drained. In parts of the East it is grown extensively on rich alluvial creek-bottoms and on poor sandstone hills. A rich sandy loam that is moist, but not wet, is preferable. The commercial value of the cured hop depends very largely on its color, a bright straw-color being the ideal, and this will not be secured on soils in which nitrogen is too abundant. A slight elevation, protected from north and northwest winds, and sloping toward the east or southeast, is preferable.

Manures.—In starting a hop-yard in the East a liberal dressing of twelve to twenty tons of farm manure per acre is frequently applied. After the crop is established, the general method of manuring is by applying a good-sized forkful of stable manure on the crown of the plant in the fall, thus serving the two-fold purpose of fertilizing and a protective mulch. In the spring it is worked into the soil about the hill. Sometimes manure is used between the rows with good results. The large amount of nitrogen in farm manure has sometimes caused excessive leaf-growth and a green, undesirable hop. This has led some of the best growers to alternate the manure with applications of commercial fertilizers, especially those containing a large percentage of potash, as wood-ashes. So far as quality is concerned, it is wisest to depend at least partially on commercial manures. Good quality has been secured from broadcasting one ton per acre of wood-ashes in the fall, and applying 500 pounds of ground bone at the first hoeing in the spring. The largest yields, however, seem to follow the application of the manure to the hills in the fall, assisted by an application of commercial fertilizer at the first hoeing in the spring. Possibly the highest yield per acre and the best market quality are not compatible. In the richer and newer soils of the West little attention is yet paid to fertilizing.

Propagation.—Hops are always propagated from cuttings of the underground stems, called "roots." These are grubbed from the runners of established hills and cut into pieces having two to six "eyes" each, and four to eight inches long. They are set out in spring as early as possible, at the rate of two to four pieces in a hill, the pieces being six to eight inches apart in the hill. Some growers set the cuttings upright in holes punched with a bar. This method is more difficult, but is said to give more compact hills with a better root system. The tops are brought even with the surface of the ground, and they are then hilled up two or three inches. The cutting must not be allowed to dry out completely. Sometimes, especially in the warmer parts of the West, it is necessary to plant the cuttings as soon as they are made, or "heel" them in on moist ground. The hills are usually placed about seven feet apart each way, which gives 700 to nearly 900 hills per acre. Many growers have found it advisable to set out about one per cent male plants to cause seed production, thus increasing very appreciably the weight of the crops. In other cases, no attention is paid to the sexes. Roots are commonly sold in the East by the bushel, but sometimes by the hundred "sets." Their price fluctuates very widely and may form a considerable item of expense in establishing a new yard.

Since the hop yields no crop in the East until the second year, it is the universal custom to plant it with some other crop. Corn is sometimes used, letting a hill of hops take the place of every alternate hill of corn in each alternate row. Objection has been offered to corn for this purpose on the ground that it shades the hops too much. Potatoes and beans are used in the same way. This permits clean cultivation and good care of the young plants. Sometimes the hops are planted as usual and then the field is sown with oats, a method that has nothing to commend it. The hop is a plant that requires clean and exacting cultivation. This companion-cropping does not apply in California, where the plants get an earlier start, being set out in January and February, and produce a fair crop the first year.

A yard commonly attains its best condition two to four years after setting, and by careful attention and replanting of hills when necessary, it may be maintained for ten, and, occasionally, fifteen years. Probably six to twelve years may be taken as the average profitable life of a yard when good care is given. There is difficulty in getting a new plant to grow in the place where an old one has died, and when the entire field is plowed up and replanted, care must be exercised to have the new rows occupy the land between the old ones.

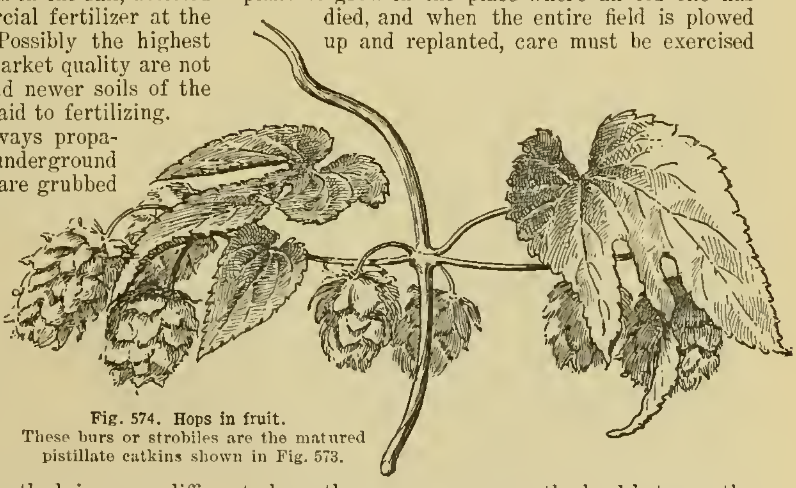

Fig. 574. Hops in fruit. These burs or strobiles are the matured pistillate catkins shown in Fig. 573.

Pruning.—The roots of the plant require pruning, or "grubbing," as it is sometimes called, each year. The first pruning is given about a year after the plants are set out. The dead stump remaining from the previous crop, together with about one inch of the crown, is cut off clean. The shallow runners are also cut off and removed. This operation exposes the poor or worthless roots, which may be taken up and replaced with healthy ones.

Cultivation.—So far as cultural implements are concerned, no very special tools are required. The yard is usually shallow-plowed in the early spring with a small one-horse plow, and after that is kept clean until midsummer by surface cultivation. Various types of cultivators are used. As the season progresses, the earth around the plant is gradually ridged or mounded up into well-marked hills. Some growers assert that high hills aid in overcoming the damage from the hop grub. At any rate, high hills are a protection to the crowns in the winter. There is considerable variation in cultural method, but the best growers agree that it should be thorough and continued as late as possible. A new yard should not be neglected the first year, but given the same care as later.

Training.—One of the most important steps in hop-growing is the training. There has been an evolution of methods of training. A generation ago, when poles were plenty and cheap, the common method was to have two good poles to each hill and use no twine. A system of stakes about seven feet high, with twine strung from one to the other horizontally across the yard in both directions, was also extensively adopted. In the West is employed a method of running twine directly from the hills to heavy overhead wires carried on strong poles or masts, the so-called "trellis" system. A system of setting one tall pole to each hill, and then running two strands of twine from a point about five feet from the ground to the top of neighboring poles, has been rather generally adopted in the East. This is known as the "umbrella" system.

Poles are preferably of cedar and should be twenty to twenty-four feet long. They cost about fifteen cents each delivered. They are set in the ground in holes about two feet deep, which are punched with a special form of bar. It is important that this setting be well done, so that the poles do not blow over with the load of hops. Usually the poles are set as soon as the frost is out of the ground, although on some soils they may be set the previous autumn. The young vines must be started up the poles by wrapping them around the poles with the spiral curve in the proper direction and tying loosely in places. In bright, warm weather they will cling and care for themselves after having been started, but in cold, wet periods they make much trouble by slipping back and refusing to run. They cling to twine and follow it very readily if it is nearly perpendicular, but if the slope is greater than 45° they will need constant training. The tying is largely done by women.

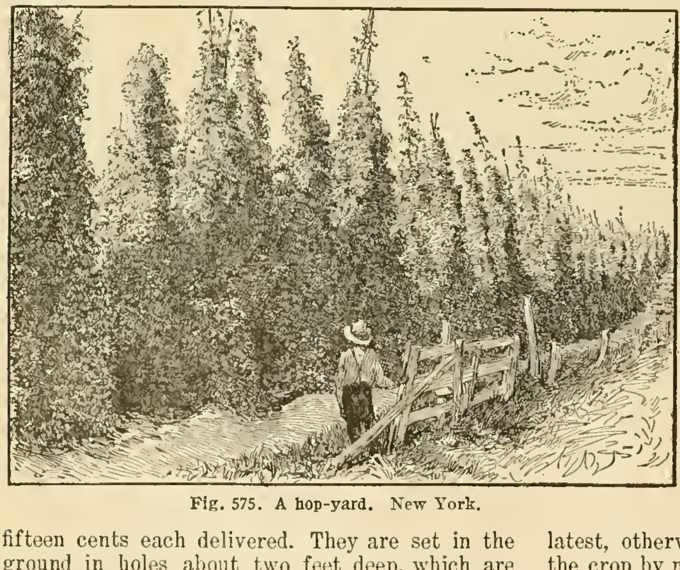

Fig. 575. A hop-yard. New York.

The question of how many vines to tie to a hill is open. The number varies among growers from four to perhaps fifteen or more. Successful growers recommend six as most desirable,—two up the pole and two up each string. Too many vines shade the hops and produce an inferior crop. The most promising vines are selected from the center of the hill.

Varieties.

Hops are so strictly a local crop, and the literature on the subject is so limited, that the question of varieties is not in a satisfactory condition. Individual plants vary, and a rigid selection is not practiced. However, three or four distinct types are recognized in New York. The most usual and desirable is English Cluster, in which the hops are rather small and are borne in compact clusters on rather short, branched laterals. Pompey is perhaps a local name for a type in which the hops are much larger and more four-sided, with a tendency to be borne more scattering or singly. These two forms merge into each other. Humphrey Seedling is a variety maturing ten days earlier than the standard sorts, valuable chiefly to those persons having a larger area than can be harvested in the regular season. Canada or Canada Red is a name given to a late, hardy, rough-vined sort. There is no doubt that careful, systematic selection would do much to improve the vigor and desirable characters of the strains now grown.

Harvesting.

Hops should be picked when some of the seeds become brown and solid, when the end of the cone closes, and the hop feels solid and somewhat papery-like. The danger of loss from mold may make it advisable to begin harvesting before the best condition is reached. Picking generally begins the last week in August and should be finished by September 20 at the latest, otherwise there may be serious damage to the crop by mold.

Hops are gathered very largely by women and children, one man, the "box-tender," taking down the poles, "sacking" the hops and waiting on four pickers. The size of the hop box varies, but usually holds either ten or twelve bushels. A picker should gather two to five boxes per day. It is very important that the hops be picked reasonably clean, i. e., the large, coarse leaves kept out and the clusters separated. The cost of picking averages about seventy-five cents per hundred pounds of green hops.

Drying and baling.

A hop-house or dry-house is a tight building with a large heater or furnace, fourteen to twenty feet above which is a slatted floor covered with open-meshed cloth. On this the hops are spread in a layer one to three feet deep, and kept at a temperature of 125° to 200° until sufficiently dry, a process that commonly requires about twelve hours. Ventilation is provided above for the removal of the moisture. During the early part of the process, sulfur is burned beneath the hops to bleach out the green shade and to bring them as nearly as may be to a straw-color. The sulfur also acts as a preservative. One pound of sulfur will bleach one hundred pounds of green hops. The hops are occasionally turned in order that the drying may be uniform. The proper curing of hops requires considerable experience and good judgment.

Fig. 576. Scene in hop-yard at picking time. New York.

From the kilns the hops are removed to the cooling-room, where they are "sweated." Then, by means of a hand press they are made up into hard, solid bales, about twenty inches square and five feet in length, which are sewed up in cloth, and which should weigh about one hundred and ninety pounds each. A box of hops should weigh thirteen to eighteen pounds when ready to bale. Two thousand pounds of cured hops per acre may be considered a maximum crop, although half this is a satisfactory yield.

Uses.

The almost exclusive use of hops is in the brewing of malt liquors, although in this they have many substitutes. It is said that there should be used about two pounds of hops per barrel of beer. Low-grade and very old hops are sometimes "extracted," i. e., a decoction or extract of the hops is made and shipped in barrels. A few factories have been established for this purpose. In the old cookery, a decoction of hops was used with flour or corn-meal in the making of yeast.

Enemies.

Weeds.—Hops have no special weed enemies beyond those common in other cultivated crops. In some soils under careless cultivation, quack-grass or couch-grass gains a foothold in the hills, but neither this nor the annual weeds are a menace to the careful grower.

Diseases.—There are three serious fungous troubles, the more important of which is the universal black mold. It is nearly always present to some extent, and in hot, damp weather it may spread with amazing rapidity, turning the inner part of the hop to a black, moldy mass and ruining the crop. There is no remedy beyond planting yards in breezy, well-drained places, avoiding too much nitrogenous manure, and in harvesting the crop promptly when it is reasonably mature.

The red rust discolors the outer part of the hops, causing the cured product to look badly, but not greatly injuring the quality. This trouble is not so common nor so serious as the mold.

Mildew (*Sphærotheca castagnei*) attacks the leaves, forming white patches on both sides. In damp weather it spreads rapidly over the leaf. It sometimes is found on the cones late in the season. It is controlled by spraying with standard fungicides or dusting sulfur on the leaves. It is not regarded as a serious pest in the East.

Insects.—While many forms of insect life abound on hops, yet only two can be considered troublesome pests. The hop grub (*Hydrœcia immanis*), does great injury by working in the large succulent roots that form the crown of the hill, often greatly weakening if not entirely killing the plant. The eggs are laid on the tips of the new plants, and the larva eats into the vine, causing the end to drop. Later the larva drops to the ground and works up in the stem. There is no satisfactory remedy, but it is considered a good thing to encourage skunks around the yard, as they burrow for the grub. They may be gathered from the ends of the young plants and destroyed. In extreme cases it is advised to put ammonia phosphate or wood-ashes about the roots before hilling up.

The hop-aphis (*Phorodon humuli*), is always present, often in enormous numbers, but generally appears so late in the East that the crop is nearly mature before much damage results. It is very remarkable, however, that in 1885 the aphis appeared in the East much earlier than usual, practically destroying the crop in New York state. It is an interesting example of how an insect, ordinarily not serious, may cause the total destruction of a crop. The presence of the aphis and the prevalence of the mold seem to have some connection with each other. Spraying with whale-oil soap, kerosene emulsion, strong soap-suds or a tobacco solution is effective; but this treatment is not practiced in New York.

Value and cost.

Hops are generally sold directly to representatives of jobbers. They are remarkable above all other agricultural products for wide and violent fluctuations in prices. In 1882, hops were sold by growers for at least one dollar and twenty-five cents per pound, and at other times they have been almost without a quotable value. The general estimate of the cost of growing and harvesting is about ten to twelve cents per pound, of which harvesting is one-half. For the five years ending with 1904, the price of "choice" New York state hops in New York city, as quoted in the trade journals, ranged between twelve and one-half and forty-one cents per pound, these years representing a comparatively stable and prosperous period of the industry.

Hop-growing requires a considerable investment and working capital. The main items of expense are the hop-house, poles, twine, wire (when the trellis system is used), fuel, sulfur and baling cloth. A large force of dependable labor is required during the harvest season, although thousands of itinerant workers of varying degrees of worth drift into the hop districts during this time.

Literature.

Myrick, The Hop: Its Culture and Care, Marketing and Manufacture, Orange Judd Co., New York city; Hop Culture in California, Farmers' Bulletin No. 115, United States Department of Agriculture; Hops, Nevada Experiment Station, Bulletin No. 35.

KAFIR AND DURRA. *Andropogon Sorghum*, Brot., or *Sorghum vulgare*, Pers. *Gramineæ*. Figs. 577–582.

Strong-growing plants, somewhat resembling corn, used for forage and for the grain which is borne in the panicle or head. They belong to the same species as broom-corn and the sweet or syrup sorghums (not sugar-cane), but differ in the less saccharine juice and also in characters of the head and seed. [See article on *Sorghum* for further botanical discussion and classification, and also for comparative economic notes.]

Although belonging to the same species, kafir and durra represent two groups, quite as distinct as dent corn and flint corn. The methods of cultivation and handling, however, are very similar, and they are therefore treated in a single article to avoid much repetition. The kafir group includes three varieties: White, Blackhull and Red kafirs, with small oval spikelets in erect, cylindrical heads. The durra group includes three varieties also: Yellow milo (usually known merely as "milo"), Brown durra and White durra, the last often called Jerusalem corn, rice corn or White Egyptian corn. These are characterized by compact, ovate or elliptical heads, mostly pendent or goosenecked, and large, obovate or nearly round spikelets.

Unfortunately, there is no one common name that can be used generically for these maize-like plants. "Kafir" is apparently becoming popular, but it is loosely used. These plants are botanically all sorghums, but with farmers the word "sorghum" is understood to mean the syrup-producing kinds. Sorghums are of two kinds,—the sweet or saccharine, and the non-saccharine. The non-saccharine sorghums are the kafirs, durras and broom-corn. The common word "corn" has been transferred from maize or Indian corn to these kafirs and durras in some regions, and confusion has resulted. For this reason, the compound word "kafir-corn" is not used in this article, and it would seem to be advisable to discourage its use generally. Furthermore, the word maize itself has been transferred from the true maize or Indian corn to some of these plants as a contraction of "milo maize." The farmers of western Texas, and probably of other parts, reported "milo maize" as "maize" to the Census of 1900. It is said that a considerable part of the "milo maize" crop was thus reported as "maize." In this article, and subsequently in this Cyclopedia, the word milo will be used for "milo maize."

Fig. 577. Blackhull kafir.

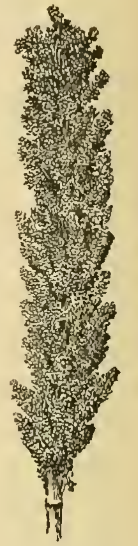

Fig. 578. Typical head of Red kafir.

The kafirs come from Natal and the coast region of east-central Africa, and the name kafir has come with them. Although originally a proper name, it now becomes a common class-name and must lose its connection with a locality or a people; therefore it is treated here as a common-language term by being printed without a capital initial. Peach is a comparable instance; also timothy, and other words. Two varieties of kafir were exhibited by the Natal government at the Centennial Exposition at Philadelphia in 1876. At least one of them was secured by the State Department of Agriculture of Georgia, and was grown and selected for several years by Dr. J. H. Watkins, and was distributed by the Georgia Department of Agriculture, from which the United States Department of Agriculture early secured the seed.

The durras come from northern Africa, from Morocco to Egypt; also from southwestern Asia, from Arabia to Turkestan. The durras are much less grown than the kafirs. In Egypt, the word which is here rendered as durra (rendered by others as dura, durrah, durrha, dourah, doura, dhurra, dhoura, dhura) is applied to all tall-growing succulent crops, whether maize, sorghum, or others, and subordinate specific names are used with it to designate special kinds. The word milo is a corruption of the Latin *milium*, a name that has long been applied to various plants that are commonly known as millets.

Cultivation of kafir and durra.

By *E. G. Montgomery* and *C. W. Warburton.*

Kafirs and durras all come from rather dry, or semi-arid regions. All are considered drought-resistant, are similar in general appearance, and are cultivated principally as forage crops. While the kafir is principally grown for forage, it unquestionably has great value as a grain crop in semi-arid regions. In Kansas, in 1899, about one-seventh of the acreage was grown for grain, the remainder for forage.

Habits of growth.

The plants average four to seven feet in height, are erect, with rather thick and short-jointed stems, and very compact heads ten to twelve inches in length. The roots do not extend so deep as those of maize, but the root system is somewhat more dense in the upper eighteen inches of soil. Few of the roots are more than three feet deep. Kafir extracts soil moisture to a greater extent than maize, because of its long-continued growth in the fall. A valuable characteristic of the plant in dry regions is its ability to cease growth and remain dormant for several weeks during a period of drought. When hot, dry winds come, the leaves will roll up and the plant may remain with-

Fig. 579. Brown durra.

Fig. 580. Yellow milo (or "milo").

out growth for weeks. When rains come again, growth is resumed normally. If the crop is cut the stalks will sprout again, in the South, and produce a second and perhaps a third crop.

Distribution.

The growing of kafir and durra in the United States is very recent, at least to a commercial extent. The culture has had rapid development in Kansas, Oklahoma, Texas and California. Kafir and durra are peculiarly adapted to the drier sections of these states, owing to their ability to withstand hot summer winds and long droughts. They have not proved popular north of the 42d parallel, as none of the varieties mature satisfactorily that far north, while in the more humid regions east of the Mississippi river other forage crops seem more desirable.

The culture of kafir probably reaches 1,500,000 acres at present. Its development was especially rapid in the period from 1893 to 1899, when somewhat dry conditions prevailed in the Great Plains region. In that period the production increased in Kansas, which has always been its greatest producer, from 46,000 acres in 1893 to 618,000 acres in 1899.

Two state experiment stations have made careful tests of the grain and forage produced in comparison with maize, with the following results:

Place	Red kafir		Maize	
	Bus. grain per acre	Tons fodder per acre	Bus. grain per acre	Tons fodder per acre
Manhattan, Kansas, 7 yrs. average, 1889-1895	55.01*	4.71	39.13*	2.41
Stillwater, Oklahoma, 4 yrs. average, 1900-1903	30.1	2.21	11.1	0.94

*Average for six years, 1894 being excluded.

The above results were obtained under conditions too dry to be favorable for maize, as is indicated by the yields. Under conditions most favorable to maize, the kafir is usually at a disadvantage. The weight of a bushel of kafir is fifty-six pounds.

Varieties.

The three principal varieties of kafir are Red, White, and Blackhull. The principal difference in appearance is in the color of seed and hulls, from which the names are derived. White kafir usually averages four to five feet in height under fair conditions. Red kafir grows six to eight inches taller, and yields more fodder and grain. The seed-coat, however, has an astringent taste, making it less desirable for stock-food than grain from the white variety, which is not astringent. Blackhull kafir produces a yield of grain and forage about equal to the Red kafir, and the grain is not astringent, and therefore is considered by many to be the more desirable.

The leading varieties of the durra group are the Yellow milo, Brown durra, White durra or Jerusalem corn (rice corn, Egyptian corn).

Yellow milo is grown rather extensively in some sections, especially in western Oklahoma and the Panhandle of Texas. It matures in about two weeks less time than kafir, and hence can be grown at higher altitudes and farther north than can that crop. The grain of Yellow milo is larger and more brittle than kafir, and hence is more easily masticated by stock. This crop is cultivated in every way the same as kafir. It is seldom grown for hay, soiling or silage, being used almost exclusively for grain and fodder. The fodder is usually considered less valuable than that of either sorghum or kafir, as the stalks are less leafy, and the crop is generally much more mature when cut. It is rather more difficult to harvest than kafir, as the heads often turn down and the stalks are not uniform in height. Thick planting is advisable, using at least five pounds of seed to the acre, as the percentage of goosenecked heads will be reduced, and the time of maturity will be more uniform. If planted thinly, Yellow milo stools and branches vigorously, and the heads on the various suckers do not ripen at the same time as the main head. It is most useful in the western part of the states of Texas, Oklahoma, Kansas and Nebraska; eastern Colorado; and in New Mexico and Arizona. In the warm, dry parts of the small grain-growing sections, milo is an excellent crop to plant after the cereals are harvested. It may prove of value in eastern Oregon and Washington, especially if earlier strains can be developed.

Fig. 581. Field of Red kafir.

The so-called White milo is an inferior, tall-growing true kafir.

Brown durra is grown rather extensively in California under the name Egyptian corn, although this latter name is applied to other sorts, especially to White durra. It is very similar in many respects to Yellow milo, but the grain is darker in color and the heads are rather more uniformly goosenecked. The crop is less valuable than Yellow milo, as the grain shatters readily when ripe. Its cultivation is in every way the same as that of kafir and Yellow milo.

White durra or Jerusalem corn is little grown in this country. The heads are very compact, usually turn down, are frequently injured by insects and fungous diseases, and the grain shatters badly. Any of the three preceding varieties will prove more satisfactory than will this sort. Either kafir or Yellow milo usually proves more satisfactory than White durra.

Culture.

Soils.— Kafir is capable of considerable adaptation, and seems to do equally well on a good clay or on a loam soil. It succeeds much better on a poor soil than many other crops, but does proportionately better on rich land.

Soil-preparation and seeding.— Land is prepared for seeding in much the same way as for maize. If the kafir is to be grown for grain, the land is often plowed early in the spring, thoroughly worked down with harrow and disk and planted with a corn-planter, using the drilling attachment. Listing, however, seems to be a more popular method in the West, especially on warm soils and in late planting. To prepare for listing, the land should be disked early in the spring to conserve the soil moisture. At planting time furrows are thrown out with a lister, and the seed drilled in. The rows should be three to three and a half feet apart, and the plants three to five inches apart in the row. Three to six pounds of seed will plant an acre.

When kafir is grown for forage the land is prepared and planted in the same way, except that the plants should be about one inch apart in the row. However, a great deal of kafir forage is raised by sowing either broadcast or with a press drill at the rate of one to two bushels of seed per acre.

Kafir should be seeded when the weather is warm and settled. If the ground is cold the seed may rot. The seed should be kept in a dry place over winter, and not in bulk, to avoid heating, which destroys the germinating power. Seed from long, rather compact heads is preferred.

The after-care of the crop is essentially the same as for maize. Because of the shallow root system, the cultivation should not be deep. The first one or two cultivations may be given with the sled cultivator or with the spiketooth harrow. Later plowings may be given with any of the shallow-running shovel, sweep, or disk cultivators. Kafir is frequently planted on freshly broken sod, and in that

Plate XIII. Kafir, as grown in Kansas

case it is seldom cultivated more than once, if at all. Under these unfavorable conditions, a good crop is frequently made. The crop requires 120 to 140 days in which to mature.

Harvesting.

The grain should be allowed to get fairly mature before harvesting ; the stalks may be cut with the corn-binder and shocked like corn, or the heads may be removed from the standing stalks with a header or a sharp knife. If cut in either of the latter ways, they should be stored in small piles or spread in thin layers until thoroughly cured, as the grain heats readily if at all moist. After the heads are removed, the stalks may be cut with the corn binder for stover, or they may be pastured. If the stalks are cut before heading, the heads may be removed when the fodder is thoroughly cured by laying the bundles on a block and cutting off the heads with a sharp knife, broadaxe or saw. When the heads are thoroughly dry, the grain may be threshed out by running the heads through an ordinary grain thresher. The grain may also be threshed out while the heads are still on the bundles, by inserting the ends of the bundles in the thresher and withdrawing the stalks when the grain is removed. The more improved separators have a circular saw attached, which removes the heads and drops them on the feeding table. If the kafir is desired for seed, a part of the concaves should be removed from the machine, to prevent cracking the grain. A fair yield of grain is twenty to forty bushels to the acre, although yields of over one hundred bushels have been reported ; the fodder crop ranges from one and one-half to four tons to the acre.

Ten Eyck writes as follows on the harvesting of kafir : "There are several ways of harvesting kafir, the value of each method depending largely on how the crop is planted, the condition of growth and what is desired of the product. Where kafir is grown on a large scale, as in some of the western states, it is often harvested with a wheat header, the heads being drawn directly to the thresher or piled in narrow ricks and threshed later. This, perhaps, is the best way to handle the crop on a large scale, if labor is costly and the fodder cannot be used to advantage in the feed-lot. Kafir does not need to be harvested at an exact time, as is the case with many crops, as the leaves remain green and the seed is retained for a considerable time after it has matured. Some farmers have a home-made implement for cutting the heads from the standing crop in the field. This machine consists essentially of a gear attached to the hind wheel of the wagon and connected with an upright shaft, at the top of which, in a horizontal plane and flush with the top of the wagon, a spindle wheel revolves. The arms of this wheel catch the kafir and draw it toward the edge of the wagon-box, where a sharp knife is fixed so as to cut off the heads, which fall into the wagon-box. There are several machines made for heading kafir in the field. They are simply attachments to any ordinary wagon-bed something after the pattern of the home-made attachment described above.

"If the fodder is desired for feed, the crop should be cut and shocked the same as corn. It is usually satisfactory to use the ordinary corn harvester. Make the bundles small and do not tie them too tightly. Place in small shocks (twelve to fifteen bundles) so made that free ventilation will be allowed underneath. The shock should be firmly tied around the top to prevent the bundles falling over, which they are very likely to do, as nearly all the weight is at the extreme top. The kafir may be left in these small shocks until required for feeding throughout the fall and winter. Good results have been secured by feeding kafir whole and on the stalk, but it is considered preferable to feed the grain and fodder separately."

Composition.

Kafir contains a higher percentage of starch than maize, but less oil and protein. The following table, giving the composition of kafir, is compiled from Farmers' Bulletin No. 37, of the United States Department of Agriculture :

Food Constituents in Kafir.

	In fresh or air-dry material						Authority
	Water	Ash	Protein	Fiber	Nitrogen-free extract	Fat	
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	
Kafir (whole plant, green)	76.13	1.75	3.22	6.16	11.96	0.78	Pennsylvania Station
Kafir (whole plant, green)	76.05	1.44	2.34	8.36	11.41	0.40	New York Cornell Station
Average	76.09	1.60	2.78	7.26	11.69	0.59	
Kafir fodder (whole plant)	10.94	5.48	3.31	30.37	47.40	2.50	North Carolina Station
Kafir fodder (without heads)	8.67	7.14	4.89	28.02	49.75	1.53	Kansas Station
Kafir (mature head)	16.23	2.02	6.92	6.79	65.18	2.86	North Carolina Station
Kafir seed	9.31	1.53	9.92	1.35	74.92	2.97	Kansas Station
Kafir flour	16.75	2.18	6.62	1.16	69.47	3.82	North Carolina Station

Uses and value.

In Africa the grain of kafir is used as human food. In the United States, however, it is little used in this way, most of it being fed to stock, either as grain or as forage. Working horses may be fed the grain threshed or in the head, but for idle horses and colts better results can be obtained by feeding grain and stalks together. The grain

Fig. 582. Blackhull kafir. Planted June 13 on flooded ground. Photographed 101 days later. First rod of four rows here shown averaged 79 stalks per row. Kansas.

should be threshed and ground for feeding as a fattening ration to cattle, but for dairy cows and young stock the fodder may be used. The meal is much used with skim-milk for feeding to calves. For hogs, the grain should be ground and fed in troughs, using water or skim-milk to moisten the meal. Best results may be secured by feeding the meal with alfalfa hay or skim-milk, or by feeding when the hogs are on alfalfa pasture. For sheep, the whole grain, ground grain, or fodder may be used. The whole grain is excellent for poultry.

The grain is similar in composition to corn, but is slightly higher in starch content and lower in protein. In feeding tests it has never been found quite equal to corn. The fodder is considered equal to corn stover.

Care must be exercised in feeding the young growth, as it has been found that prussic acid develops when the growth is checked. Under certain conditions, young growths of all sorghums may be poisonous. Frost and extreme drought are supposed to develop the poison by checking the growth, resulting in the action of an enzyme on a glucoside normally present in the plant.

Literature.

Farmers' Bulletins Nos. 37 and 288, United States Department of Agriculture; Kansas Experiment Station, Bulletins Nos. 56, 93, 127; Nebraska Experiment Station, Bulletin No. 77; Oklahoma Experiment Station, Bulletin No. 35.

KALE FOR STOCK-FEEDING. *Brassiea oleraeea,* var. *aeephala,* DC. *Crueiferæ.* Figs. 583, 584.

By *H. W. Smith.*

The kales (or borecoles) are leafy, headless forms of the cabbage species. Some of them are grown in vegetable gardens for "greens." The purple and curled-leaved kinds are very handsome plants. The stock-feeding or forage kinds are mostly taller, with heavy, rank foliage. Kales are little grown in this country for forage. It is doubtful whether they will ever attain great prominence here.

The thousand-headed kale furnishes a large quantity of very nutritious fodder for fall and early winter, helps to prolong the season for green fodder, is a good soiling crop, and partially replaces silage in the early winter. It is hardier than most varieties of the cabbage family and less subject to disease and insects. In this respect it differs from the Scotch and curled varieties, which are really kitchen-garden subjects.

Culture.

Kale will grow on any soil of normal fertility, but it does best on warm, well-drained soils, such as sandy loams. The application of manure and fertilizer, especially nitrogenous fertilizer, will profitably increase the yield on most soils. To get the best results with the application of nitrates, two or three applications should be made during the season. Kale is a rank feeder, and does well on land that has been heavily manured the previous season.

The culture is similar to that of the large varieties of cabbage (which see). At the North, for garden use the plants may be started in the hotbed and transferred to the coldframe, not only to lengthen the growing season but to enable them to escape the attacks of the cabbage root-maggot. The plants should be set in rows three feet apart and about two feet apart in the row, depending on the variety. For forage, the seeds would need to be planted directly in the field. Thorough cultivation and clean culture during the early growth is essential, but later the plants cover the ground and require no further attention.

Storing.

The young plants are sensitive to severe frost, but the old plants will withstand a heavy freeze. Thus they can be left in the field till winter sets in and can be kept through the winter like cabbage. The writer has found the following method of storing very satisfactory with a small quantity: Tight barrels are filled with the plants, which should either be run through a cutter or be cut up partially with a sharp spade so that they pack closely in the barrel. Salt is sprinkled in with the plants, and when they are thoroughly packed water is added to fill any spaces; the barrel is then covered. Kale thus packed will be well preserved if kept cold. For feeding, they would better be used green, as gathered from the field, or else stored loosely in a shed.

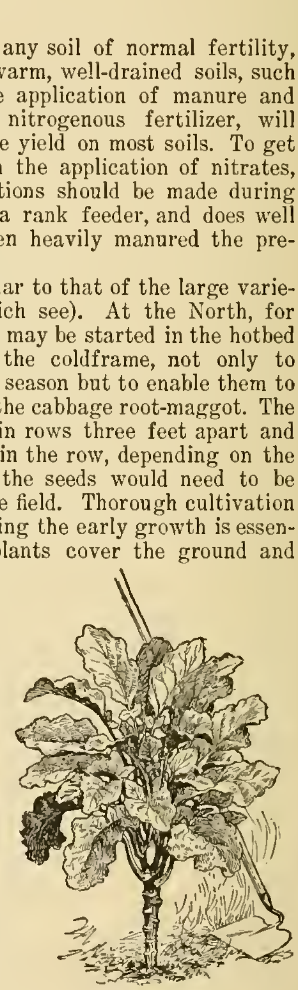

Fig. 583. Thousand-headed kale.

Because of the high nutritive value of these plants, they should be fed carefully and never be used to make the bulk of the ration. All kinds of stock are fond of kale. Remarks on the feeding value of kohlrabi (see succeeding article) apply more or less closely to kale.

Enemies.

The cabbage root-maggot is the worst pest in the growing of kale, and, indeed, of any of the cabbage family. When this fly is abundant, it is sometimes advantageous to sow a few cabbages in the field or transplant them to the field before setting out the main crop; then when the fly has deposited her eggs on these, they may be destroyed by applying kerosene oil directly to the plants and soil. The writer has found that thousand-headed kale is not so seriously attacked as curled kale or cabbage.

The cabbage worms, as a rule, do not seriously attack this crop, but when they do they are easily destroyed by spraying on a warm, dry day with a solution of pyrethrum.

Jersey kale. Fig. 584.

A tall-growing collard, grown in the island of Jersey for stock feed, from which place it has been introduced into California. At the California station it produced green feed at the rate of sixteen tons per acre, and started again quickly after cutting. It seems to have value as a summer and fall feed for poultry as well as for stock. It requires an abundance of moisture, and does well under irrigation. It is hardy, and will thrive for several years if the ground does not freeze in winter. The leaves frequently attain a breadth of twenty-eight inches. There is very little available experience with this plant in North America.

In the island of Jersey, the leaves are broken from the main stem for feeding to pigs and cattle, leaving pronounced scars on the stem. It is the third year, often, before the plant blooms, and by this time the stiff stem may be ten feet or more high. The stems are much used in the Channel islands for the making of canes and sticks to sell to tourists.

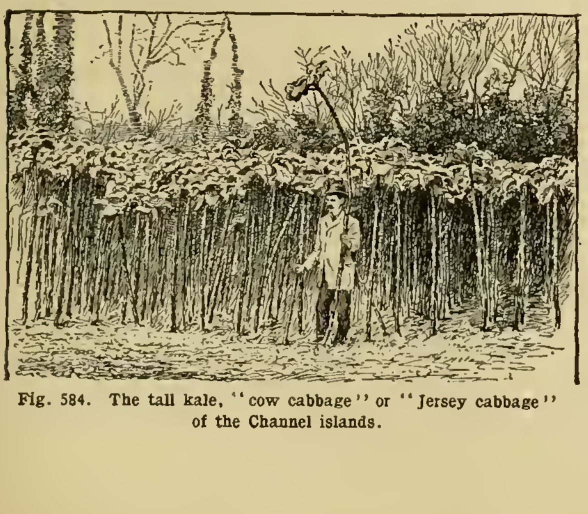

Fig. 584. The tall kale, "cow cabbage" or "Jersey cabbage" of the Channel islands.

KOHLRABI FOR STOCK-FEEDING. *Brassica oleracea*, var. *caulorapa*. *Cruciferæ*. Fig. 585.

By *J. W. Gilmore.*

Kohlrabi is valuable for stock-feeding, not only because it contains a considerable amount of nutrients, but because these nutrients are in a highly palatable and digestible form. In the latter respect

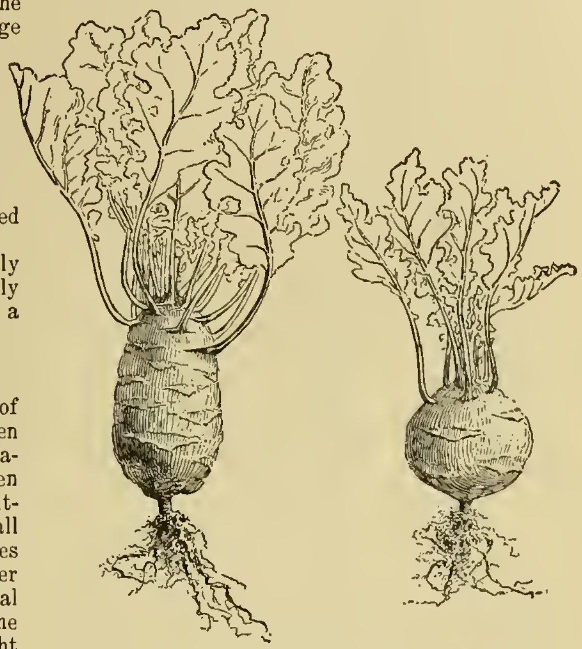

Fig. 585. Kohlrabi. On the left, tankard form and coarse top; on the right, globe form and short top.

the dry matter which it contains compares favorably with concentrated feeds from cereals. As an offset to these qualities, however, are the facts that it is rather high in water content, thus necessitating feeding it with dry grains or roughage; and that it is more expensive to grow per unit of area than corn.

Kohlrabi for stock-feeding may be considered as a concentrate from the standpoint of the high digestibility of its nutrients and the large amount of net available energy derived from them. But, in common with other food products of this class, as mangels, turnips and rutabagas, it is so watery and succulent that it can not be fed in sufficient quantities to supply the amount of nutrients required. Hence it is a part of rational practice to feed it with grain of sufficient quantity and quality to make up a balanced ration for the purpose for which it is fed. It is not, therefore, the intention to recommend kohlrabi as a substitute for silage, or even to be fed with it, but it may be desirable to grow and feed it when conditions of soil and climate prevail that do not permit the production of corn. It is extremely desirable that all domestic animals have some form of succulent food, especially in the winter, and kohlrabi is one means of supplying this need.

The American farmer has an antipathy for that kind of labor which brings into action and strain the muscles of the back. For this reason, the tendency to grow kohlrabi for stock-feeding where corn and some of the roots can be grown is not strong. However, kohlrabi does fit into into a cropping system for this purpose very admirably where it may be grown also for market purposes. If our system of agriculture becomes more intensive, perhaps kohlrabi will find a more welcome place in the rotation.

Composition and yield.

The composition of kohlrabi is very much the same as that of mangels, as shown by the following table compiled from results of analyses in Norway, where these plants are grown extensively for stock-feeding:

	Kohlrabi (average 38 samples)		Mangels (average 46 samples)	
	Composition	Yield per acre	Composition	Yield per acre
	Per cent	Lbs.	Per cent	Lbs.
Dry matter . . .	11.67	4,300.00	14.31	7,416.16
Protein	1.26	464.44	1.35	699.64
Fat	.20	73.72	.15	77.74
Crude fiber . . .	1.18	434.95	.96	497.52
Ash	.65	239.60	.99	513.07
Sugar	5.94	2,189.48	8.35	4,327.39
Other substances .	2.12	781.43	2.52	1,306.09

Yield per acre: kohlrabi, 18.43 tons; mangels, 25.914 tons.

It will be noticed that the kohlrabi is deficient in two essential matters, namely, yield per acre and dry matter content. Both of these are serious defects, as they embody the main qualities for which any forage crop may be grown. Dry matter content is the most important consideration, yet in kohlrabi this is above the general average of the production of dry matter in corn in the New England states. At the Cornell station, several varieties of kohlrabi for three years yielded a minimum of 3,570 pounds of dry matter per acre, a maximum of 4,540 pounds, and an average of 4,040 pounds. The yield of grain from flint corn in the same seasons was about two thousand pounds per acre, while the yield of dry matter in silage from dent corn was about four thousand pounds per acre. Thus it is seen that the yields are satisfactory, but the principal drawback remains in the large amount of hand labor required in its production.

Varieties.

Not many varieties of this crop have been developed, and those which have been grown are mainly for table use. The three varieties grown recently at the Cornell station for stock-feeding have given the following statistical results:

	No. of seeds per lb.	Yield per acre	Yield dry matter per acre	Dry matter
		Tons	Tons	Per cent
Carter's Model . .	129,200	23.0	2.10	9.13
White Vienna . .	113,700	21.6	2.40	11.10
Goliath	. . . .	18.1	1.61	8.91

Other varieties which have given good results in Canada are Purple Vienna and Short-top White.

Cultural methods.

Soil.—Kohlrabi will grow and develop on a great variety of soils and under varying conditions of rainfall. In general, however, loams with a good supply of organic matter and good drainage, insuring a constant supply of moisture, are best adapted. In 1905, at Cornell, a rather stiff clay produced 21.5 to 23.7 tons per acre for different varieties. Especially essential is a well-prepared seed-bed in order that germination may be quick and uniform, and that the plants may be invigorated by a good supply of moisture and plant-food.

Seeding.—Good seed is of prime importance. At present most of the seed is imported at a cost of about two dollars per pound, while in England it sells for one-half to one-fourth that price. A germination test should be made early in the season. The seed is sown at the rate of four or five pounds per acre.

Early sowing is necessary. In one year the three varieties mentioned above were sown on May 9 and again on June 14. The results were in favor of early sowing by about three tons of fresh substance, and about one-fourth ton of dry matter per acre. Kohlrabi, like its relative the cabbage, requires a long growing period for a maximum yield, though such might not be desirable when grown for table use. The seed should be sown in drills twenty-four to thirty-six inches apart, similar to the manner of sowing turnips. Rows wide apart facilitate much in the use of horse implements in tillage.

Fertilizing.—If by weakly plants or tardiness of growth the food supply seems to be lacking, this may be added along the row in the form of nitrate of soda or guano. On most soils the plant responds well to rotted manure applied before planting, or to a complete fertilizer rather rich in phosphoric acid and potash, at the rate of 300 to 500 pounds per acre.

Subsequent care.—It is during the early stages of growth that most labor and care must be expended on the crop. When well up, the plants should be thinned by chopping to eight or ten inches in the row. After the plants are well established and weeds are destroyed, it is necessary only to cultivate shallow at intervals of a fortnight or so for the purpose of stirring the surface and keeping the land in good tilth.

Harvesting and storing.

Kohlrabi is usually allowed to remain in the field until frost, as light frosts do not injure it and during the latter part of summer and early fall it grows some and ripens. Sometimes, however, it is pastured in the field by swine or sheep. The fact that it stands out of the ground gives it an advantage for this purpose. If pulled, however, for immediate feeding, the leaves should be left on, as these are nutritious and palatable and add two to five tons per acre to the yield. If it is to be stored, the leaves should be removed, and the roots also if they cannot be freed from dirt.

Kohlrabi may be stored either in a cellar or a pit. The essentials of a good storage cellar are drainage, ventilation and that it be frost-proof. With these supplied, kohlrabi is not hard to keep. If stored in a pit, the pit should be located on a well-drained piece of ground. Two layers of straw should alternate with layers of earth for covering. Ventilation should be arranged at intervals in the top of the pit. The pit should not be opened for any length of time on warm days after the winter has set in.

Enemies.

Kohlrabi is attacked by the same enemies as cabbage, which see.

Feeding.

The product should be fed early in the season. If left until late, it dries, becomes pithy, stringy and sometimes hollow. For ordinary feeding, kohlrabi should be cut into pieces or slices; for pigs and poultry, however, it may be fed whole. It is most economically fed with grain. Thirty to fifty pounds make one feed for a thousand-pound animal. There is no record of its having given a flavor to milk when fed to cows, but it should not be about the milk-room at milking time. No trials are reported of its having been fed to horses.

Literature.

From the kitchen-garden or horticultural point of view, many of the gardening books may be consulted. [For American forage-crop experiments, see Cornell Bulletins Nos. 243, 244.]

LEGUMES. (Figs. 586–592).

The leguminous plants have lately come into great agricultural prominence because of the power that some, perhaps all, of them have of fixing the free atmospheric nitrogen contained in the soil, and thereby enriching the land in this valuable element when they decay, to the great advantage of plants that do not possess this power. These are plants of the great natural family, Leguminosæ, which contains several thousand species in all parts of the world, some of them being great trees, as mahogany, locust, Kentucky coffee-tree. Some of them bear very gaudy flowers, placing them among the most showy of all plants, as, for example, the royal poinciana of the tropics. The essential botanical characteristic that distinguishes the Leguminosæ from other plants lies in the structure of the fruit. It is the kind of fruit known to botanists as a "legume," being a simple pistil ripening into a dry pod that opens on both sutures and bears a row of seeds on the ventral side. The bean (Fig. 586) is a typical example. The most typical of the Leguminosæ have a papilionaceous or butterfly-like flower, as in the peas and beans, the corolla having an upper mostly broad and ascending part called a standard, two side-pieces called wings, and two other petals below, united into a keel (Fig. 587). The stamens are usually ten, and in the greater part of the common species these form a tube about the pistil, one of them, however, being free. The Mimosa or acacia sub-family has regular (not papilionaceous) flowers and few or many stamens, but it agrees with the other members of the family in the legume. The leaves of practically all legumes are compound; but in some of the acacias they are reduced, on mature plants, to phyllodia (expanded petioles).

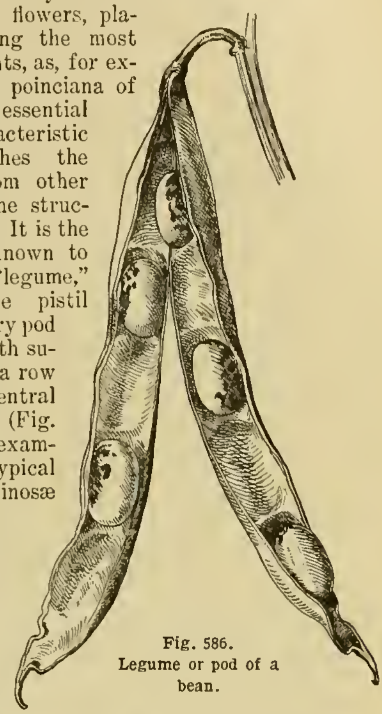

Fig. 586. Legume or pod of a bean.

The field crops belonging to the Leguminosæ may be found in this Cyclopedia under the articles alfalfa, beans, beggarweed, berseem, clover, cowpea, forage, lespedeza, lupine, medic, melilotus, pea, peanut, sainfoin, serradella, soybean, spurry, velvet bean, vetch. Other leguminous plants are mentioned in the articles on cover-crops, dyes and medicinal plants; also on meadows and pastures. Many species are grown in greenhouses and open gardens for ornament. The most popular is the sweet-pea. The everlasting flowering pea is an old favorite.

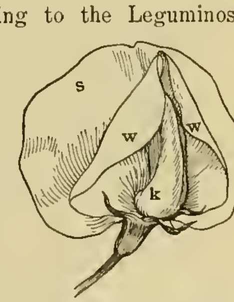

Fig. 587. A papilionaceous flower (sweet-pea). *s*, standard; *w*, *w*, wings; *k*, keel.

Legume Root-tubercles. (Figs. 588–592.)

By *George F. Atkinson.*

The legume root-tubercles, or "nodules," are small galls on the roots of leguminous plants, which are caused by the activities of minute bacteria present in the soil wherever leguminous plants grow. The galls vary in form on different species or genera, being oval on the red clover, rounded and slightly lobed on the soybean, cylindrical or club-shaped, simple or branched once or twice, on the vetch (*Vicia sativa*), or many times dichotomously branched into a rounded mass, as in *Medicago denticulata.* They are whitish or of a pale flesh-color, sometimes sordid brown in age. They occur on the roots of nearly all leguminous plants, but are absent on some, as, for example, on the honey locust (*Gleditschia triacanthos*).

Fig. 588. Root nodules. Red clover (*Trifolium pratense*). One and one-fourth times natural size.

History of the study of root-tubercles.

While the history of the study of these root-tubercles of leguminous plants is extremely interesting, reference can be made here only to a few of the diverse views which have been entertained as to their nature, origin and significance. Some of the early observers thought that they were galls produced by insects, or by eel-worms. By others they were regarded as lateral roots with dwarf growth, or swollen lateral root organs for the purpose of absorbing food, while others held that they were lenticels which played some physiological rôle in the life of the plant. They were also thought by others to be imperfect buds which could reproduce the plant. They were classed as fungi of the genus Sclerotium by some, or as pathological outgrowths. Since Woronin, in 1866, discovered in the nodules bacteria-like bodies, which he thought to be the cause of their formation, the theory has been generally accepted that they are galls produced by the presence of fungi or bacteria, which enter through root-hairs and stimulate the tissues of the root to the production of an abnormal rootlet, which is called the tubercle or nodule.

Fig. 589. Root nodules of alfalfa (clustered on small side rootlets in this case). Two-thirds natural size.

The organism enters near the tip of the root-hair and stimulates the latter to curl into the form of a shepherd's crook. It travels down the interior of the root-hair in the form of a homogeneous strand, as seen in fresh preparations. In sections of young galls this strand is seen branched through the tissues from its point of entrance from the root-hair. These strands pass through the cell-walls by minute perforations and then enlarge again in the cell-lumen. Often the strand swells into a large body in the cell, with irregular projections, which led some to think that the bacteria-like bodies found in abundance at a later stage were budded off from these swellings. These strands present in the young tubercles led a number of students to believe in the fungous nature of the organism, perhaps related to the smuts; but especially by some it was considered to be one of the slime-molds similar to the *Plasmodiophora brassicæ*, which causes the "clubfoot" of turnip, cabbage, radish and certain other cruciferous plants. For this reason Schrœter, a German botanist, named it *Phytomyxa leguminosarum*, and this seems to be the earliest scientific name. More recent investigations seem to show that the organism is one of the bacteria. Many bacteria form gelatinous masses of individuals, which take on various shapes often characteristic of the species. Especially on cultures on solidified artificial media are these colonies of various shapes very characteristic. These gelatinous masses are known as zoöglœa. These strands, then, which are so characteristic of the younger stage of the tubercles, are zoöglœa. Frank, another German botanist, was one of the first to demonstrate this feature of the organism, and it is now generally accepted, although different views are held as to the morphology of the bacterium. He named the organism *Rhizobium leguminosarum.*

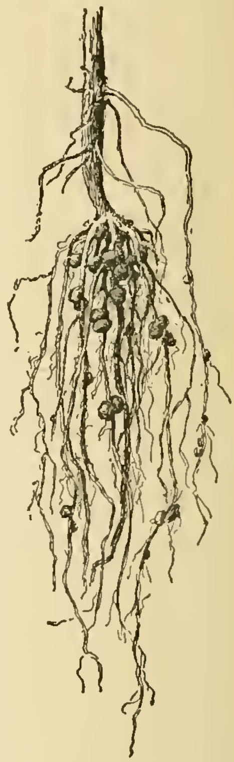

Fig. 590. Root nodules. Soybean (*Glycine hispida*). One-half natural size.

The study of the organism in pure culture began with Beijerinck in 1888, who named it *Bacillus radicicola*, thus discarding the earlier specific name. He discovered, beside the rod-like form which is abundant in the old tubercles, and previously named "bacteroids" by Woronin, a very minute motile form. These two forms of the organism are now generally recognized. The minute motile form is about 1 μ long by 0.2 μ in width (μ is a micron or $\frac{1}{1000}$ of a millimeter). This is the form which enters the root-hairs, multiplies and travels in the strand-like zoöglœa into the root where the gall or nodule is stimulated. Because of this motile

Fig. 591. Root nodules. Black medic (*Medicago lupulina*). Two and one-half times natural size.

form, Moore has recently changed the name to *Pseudomonas radicicola*, though the relation of the cilia to the organism is not very clearly known, in consequence of which there may be some uncertainty as to the appropriateness of this name. The larger rod-like form is 1.5 μ to 5 μ long by 0.6 μ to 2.5 μ in width. These are the "bacteroids." They are usually rod-like, but often branched forms occur which are Y- or X-shaped, or even sometimes more complicated in form. These bacteroids or rods which are found in such large numbers in the old tubercles are abnormal, or involution forms. It is thought by some that the Y and X forms are the result of branching, perhaps a false branching caused by division of the rods, several rods being held together within a gelatinous sheath. It is well known that these "bacteroids," or dead involution forms of the organism, are rich in proteid matter. The host plant, which is the legume, has the power of dissolving these and of absorbing the nitrogenous matter from the tubercles and using it as food. When the tubercles die, some of them are emptied into the soil, and the minute motile form also escapes, thus keeping the soil inoculated with this organism where legumes are growing.

Why legumes are valuable in soil-enrichment.

It has long been known that certain leguminous crops like peas, clovers and alfalfa, were better crops for the enrichment of the land in nitrogenous food when plowed under than the cereals or grasses. A series of investigations, notable among which may be mentioned those of Hellriegel and Willfarth in Germany, Lawes and Gilbert in England, and Nobbe, Hiltner and others in Germany, led to the clear demonstration that (1) in a soil possessing all the constituents of plant-food except nitrogenous substances, if the soil were sterilized and then inoculated with a filtrate from garden soil, legumes would flourish and produce an abundance of seed, and the tubercles would be present on their roots; (2) in similar sterilized soil, not inoculated with a filtrate from garden soil, legumes would develop no tubercles and the plants would develop only so far as the nitrogenous food stored in the seed permitted them; (3) in a similar soil, even if inoculated with a filtrate from garden soil, the cereals and grasses would make only a feeble growth; (4) in similar soil, inoculated with pure cultures of the legume tubercle organism, the tubercles are formed, which demonstrates that the tubercles are caused by the bacteria; (5) there was an increase in nitrogen in the plants with tubercles over those with no tubercles; the soil also increases in nitrogenous content where legumes with tubercles are grown; (6) races of the bacterium occur, since inoculations from pure cultures of the bacterium from pea tubercles will not produce tubercles on cytisus, robinia, trifolium, serradella and others, while they will on the pea, lupine and others, and vice versa.

The fact that the nitrogen content of soils poor in nitrogenous plant-food is increased by the growth of leguminous plants, was used in support of the early theory that green plants assimilate the free nitrogen of the air, a theory which was shown to be unfounded by Boussingault more than sixty years ago. The fact that all other green plants except the legumes could not fix the free nitrogen of the air, and the latter could fix it only when the tubercles were present, led Frank to assert that the presence of the bacteria in the tubercles stimulated the legumes to assimilate the free nitrogen from the air through their leaves. It has since been shown that this is not the case, that when the tubercles are present on the roots, and the roots are supplied with air deprived of free nitrogen, no nitrogen is fixed by the legumes. On the other hand, it has been shown by Mazé and others that under proper cultural conditions the tubercle bacteria on artificial media fix (by assimilation) free nitrogen from the air. That they do fix free nitrogen from the air, when in the tubercles of the legumes under normal conditions, is abundantly proved,

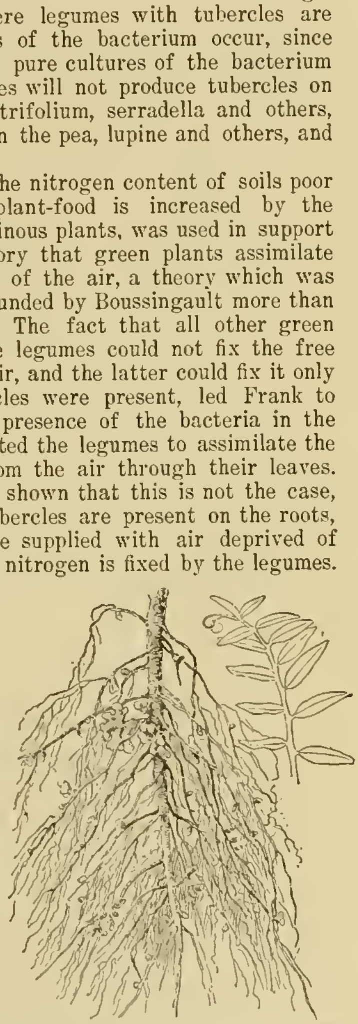

Fig. 592. Root nodules. Vetch (*Vicia villosa*). Two-thirds natural size.

thus confirming the results of empirical observations, that leguminous plants grown in soils poor in nitrogen flourish and sometimes have a larger content of nitrogenous substance at maturity than they could have obtained from the poor soil; that soils poor in combined nitrogen are enriched in this substance when crops of legumes are grown on them, even though the crop of vines and seed is removed, because of the large amount of fixed nitrogen in the bacteroids still within the tubercles in the soil; while with the cereals and grasses the nitrogen content of the soil is decreased. This explains why it is that leguminous crops are more important for green-manuring than the cereals and grasses when there is need of an increase of combined nitrogen.

Races of nodule bacteria.

While the nodule bacteria are widely distributed in the soil, the fact that there are several different races which dwell in the roots of certain genera of hosts, which cannot attack the roots of others. explains why it is that the bacterial races to which certain genera of legumes are susceptible, are not present in all soils, especially in soils where these hosts do not grow, while other races are present in those soils. This is shown in the case of the pea and lupine organism, which will not attack the roots of cytisus, robinia, trifolium, serradella and others, as shown above. It is also shown by experiences with the soybean from Japan. When the seed of this bean was planted in America and Europe, no nodules were developed on the roots. It was only when soil from Japan, in which the soybean had grown, was imported and mixed with soil in which the soybean was planted, that the nodules were developed. This organism of the soybean nodules was thus considered by Kirchner to be a different species and was named *Rhizobacterium Japonicum.*

Besides the distinct races which cannot infect certain genera of hosts, there are probably subraces or initial races which can infect a wide range of genera, but, by being confined to a limited number or to single genera for several years, infect certain genera much more readily than others.

Soil inoculation.

This leads to an important method in practice, i. e., the inoculation of soils with the specific organism to which the legume which it is desired to grow on the particular plot of ground is susceptible. This method has been developed by the United States Department of Agriculture, especially through the work of Moore and Kellerman, and by some of the experiment stations. It consists in obtaining pure cultures of the needed different races on a medium poor in nitrogen compounds so as to create a state of nitrogen hunger in the organism, which makes it more likely to attack the roots of the legumes than organisms which have a nitrogen surfeit of food. Pure cultures were distributed, after being dried on cotton, or other suitable material, to the planters, who place them in a quantity of liquid nutrient media for a day or so in order to multiply the germs. This liquid is then scattered on the soil, or, better, the seed is sprinkled with the infusion before being planted. Under certain conditions this practice, or some modification of it, promises good returns, especially in soils poor in nitrogen, where the crop in question has not grown for several years or where for any reason the specific organism for the specific crop is absent, or present in small numbers. When the specific organism is present in quantity or in soils already rich in nitrogenous plant-food, the increase in the crop is slight or nil as a result of inoculation of the soil.

A method has not yet been perfected for supplying and applying cultures of the germ which is reliable under all circumstances, due to deterioration or contamination of the organisms in cultures, either because of fault, careless or unscrupulous methods on the part of manufacturers, or to imperfect methods of multiplying the organism at the farm and of inoculation of the seed and soil. With some crops it is now a practice to transport the organisms with the soil in which the specific crops have been grown, for inoculation of soils. In this method, however, there is danger of the transportation of the germs of fungus and bacterial diseases, which may be present in the soil. [Soil inoculation is fully discussed by Lipman, Vol. I, pages 447–450.]

Relation between nodule bacteria and their host.

The relation which exists between the nodule bacteria and their host is an interesting one. The bacteria can live in the soil for several years without the presence of the legume host,—how long is not known. Nor is it known what permanent benefit the organism derives from its association with its host. There is at least a temporary gain by the rapid increase in the number of bacteria which are formed within the nodule, but the larger number of these become surcharged with the nitrogen which they fix, pass into abnormal and involution forms and die. It may be, however, that the living ones which escape again into the soil form an increase over what the increase would be in the soil, and also that the association with the legumes may give them new vigor. The host benefits by the association from the increased nitrogeneous substance placed at its disposal. This is abundantly shown by experiment where there is an increase in size and product when the organism is present over that under the same conditions when the organism is absent. The few cases which have been observed under experimental conditions where the bacteroids assume a firm condition so that they cannot be dissolved by the host, cannot be taken as proof against the general and almost universal benefit derived by the host from the association with the bacteria, except when the soil is already very rich in nitrogeneous plant-food. Even under these conditions, although the number of nodules is smaller than in nitrogen-poor soil, there may be an increase of nitrogen in the plant, though no increase in the crop. It cannot be denied, therefore, that there is a mutual benefit derived from this association of the bacterium and the legume in the nodules. The bacterium lives within the nodular root, and thus the nodules are endotrophic mycorhiza.

This relationship of the bacterium and the legume is a good example of what is ordinarily called symbiosis, a living together. The term is now generally applied to those cases of symbiosis where there is a mutual benefit to the symbionts. This special kind of symbiosis is often called mutualistic or reciprocal symbiosis to distinguish it from those cases of symbiosis existing between a strict parasite and its host, which is called antagonistic symbiosis. Disjunctive symbiosis has reference to the relation of flowers and insects in pollination, while contact symbiosis has reference to the relation between the bacterium, *Clostrydium pasteurianum*, and certain low, blue-green algæ in the soil, the algæ supplying the bacterium with carbohydrates. These carbohydrates supply the Clostrydium with the energy which enables it to assimilate free nitrogen.

Some have raised an objection against the use of the term symbiosis applied to the relation of the nodule bacterium and the legume, on the ground that the bacterium is a parasite, that certain cells in the tubercle are destroyed, and that it is difficult to see what benefit the host can derive from an association with a parasite which destroys some of its cells. It is beyond contradiction, however, that leguminous plants do benefit from this association, in the fixed nitrogen which they are able to absorb from the dead bacteroids in the nodule, except perhaps in soils already rich in nitrogenous plant-food, under which condition it is known that few nodules are formed, while in soils poor in nitrogenous plant-foods many nodules are formed and the legume profits to a great extent from the symbiosis. The parasitism is confined to the nodular roots or mycorhiza. This nodule serves a useful purpose for the legume, and the fact that its formation is caused by a parasite, and that some of its cells die, does not necessarily lead to the conclusion that the legume does not benefit by the association. Other normal organs of the plant, as leaves, perform special and important work for the plant, and later die. But the good they have served the plant more than balances the loss of the part or the death of its cells.

It has also been recently stated that since the early relation of the bacterium in the nodule is that of a parasite, this relation cannot be symbiosis in the sense in which DeBary used the term. Now, DeBary distinctly says in his "Die Erscheinung der Symbiose," 1879 (the following is a translation), "The best known and most exquisite phenomenon of symbiosis is complete parasitism, i. e., that arrangement by which an animal or plant goes through its entire vegetative process on or in another organism belonging to a different species. The latter serves the parasite exclusively as a dwelling place and furnishes it with its entire food material; it is in every sense of the word its host."

Literature.

H. Marshall Ward, some recent publications bearing on the question of the sources of nitrogen in plants, Annals of Botany, 1, 325–357 (1888); Atkinson, The Biology of the Organism Causing Leguminous Tubercles, Botanical Gazette, 18, 157–266, plates 12–15 (1893); Moore, Soil Inoculations for Legumes, Bulletin No. 71, Bureau of Plant Industry, United States Department of Agriculture (1905); Pfeffer, Physiology of Plants, 1, 393–403 (1900). The literature referred to in these works will supply other references. Germ life in the soil is discussed at length in Vol. I, Chapter XIII, of this Cyclopedia, and should be read in this connection. Additional references to literature are given there.

LESPEDEZA. *Lespedeza striata*, Hook and Arn. *Leguminosæ*. (Japan clover, Japanese clover, King-grass, Hoopcoop.) Figs. 593, 594.

By *Samuel M. Bain.*

An annual forage plant with stems diffusely branched, decumbent, or erect when crowded, three inches to two feet or more in height, subpubescent; leaves three-foliolate, leaflets oblong-obovate, petioles very short; peduncles very short, one- to five-

Fig. 593. Japan clover (*Lespedeza striata*).

flowered; flowers appearing singly in axils of leaves; corolla purple; pod small, little exceeding the calyx. In the vegetative state the plant is easily confused with *Trifolium procumbens* (low hop-clover). They may be readily distinguished when in flower, however, as the latter produces much smaller yellow flowers in true heads.

Distribution.

Lespedeza, or Japan clover, as it is more commonly known, is supposed to have been introduced accidentally into South Carolina, where it was first observed in 1849 near Charleston. It came from China or Japan. It spreads rapidly, and has already made its way over the entire South, as far north as Kentucky and Virginia, westward to Arkansas and eastern Texas. It is especially adapted to the Gulf and South Atlantic states, as it requires a warm climate and a long season of growth; it has not succeeded north of the Ohio river. It is vigorous, and will hold its own against weeds, and is said to crowd out Bermuda-grass and nut-grass. It should not be allowed, therefore, to gain a foothold in permanent grass-lands. On the other hand, it causes no trouble as a weed in cultivated areas.

Chemical composition.

Its chemical composition as found in Mississippi (Tracy) and Alabama (United States Department of Agriculture) is as follows:

	Water	Crude protein	Fat	Nitrogen-free extract	Crude fiber	Ash
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Mississippi	13.99	12.62	2.64	40.76	24.44	5.55
Alabama	9.13	13.70	3.99	47.52	21.55	4.11

Related species and varieties.

Two species of Lespedeza, aside from *L. striata*, have been tested in this country, namely, *L. bicolor* and *L. sericea*. The former was introduced in recent years by the United States Department of Agriculture. It is less branched than *L. striata*, and more erect, reaching a greater height. Its usefulness has not yet been determined, but it gives promise of having much value under special conditions. Besides these, a number of other species occur in various parts of the country, and contribute largely to the value of the native pastures, especially in thin upland soils not too densely wooded. McCarthy (North Carolina Bulletin No. 133) found a large-leaved variety of Japan clover (*L. striata*, var. *lata*) to be superior in some respects to the common form.

Culture.

Soil.—Lespedeza is successful on a wide range of soils, but does best on argillaceous lands. It is notable for its ability to thrive on all kinds of soil under greatly varying conditions. It prefers a moist situation but not a wet one.

The extent of soil preparation may vary widely. The seeds will germinate and establish themselves on hard ground. Very often shallow stirring of the soil is all that is needed to secure a crop. Careful preparation, however, makes a large crop more certain. Potassium fertilizers are said to aid the growth of the crop in the more northern regions of its production.

Seeding.—Japan clover is not commonly sown, as it has become naturalized throughout a considerable part of the South, and comes in of itself by dropping its seed, which germinates the following spring. It may be seeded to advantage, however, and in parts of Louisiana and elsewhere sowing is the practice when it is desired to secure a stand of lespedeza. It is sown at the rate of ten to twenty pounds per acre in the spring after all danger of frost is past, though it is occasionally fall-planted. The latter is not to be advised except in the extreme South, as the plant will not stand frost. A stand may be secured by scattering the manure of live-stock fed on the hay or green forage containing ripe seed. The same result is secured by allowing stock the free range of an adjoining field which it is desired to seed. It will generally be most satisfactory to sow the seed when a hay crop is desired. If the hay crop is to be continued on the same land, disking the meadow and re-seeding is sufficient. If the crop reaches maturity, enough seed may shatter out to insure the next crop.

Fig. 594. Harvesting lespedeza hay.

The seeding also may be done in the spring in any of the small grains, and preferably harrowed in; and the seed has been used successfully in grass mixtures for pastures.

Lespedeza should occupy the land for two to four years. It can follow cotton or any other late fall crop.

Harvesting and uses.

Hay.—For hay, Japan clover should be cut before it is over-ripe; a good practice is to mow when about half of the lower crop of seed has matured. This provides for reseeding the next year on the same field, or by spreading the manure as above suggested. When the saving of seed is no object, the plants should be cut when in full bloom. On good land one to three tons of hay per acre will be secured. The hay may be cocked after thorough wilting on the day it is cut; one or two days in cocks is sufficient before final storage. It should be handled carefully to prevent loss of leaves. Tracy found lespedeza, with cotton seed as the grain feed, to be the cheapest milk-producing ration. The hay commands a ready sale in the market. On the hill lands near Baton Rouge, Louisiana, it is one of the leading hay crops.

Seed.—For seed production, half-ripe hay may be threshed with a loss of value to the hay, or the seed may be gathered from siftings of the hay. To get the most seed, however, the crop should stand until a large part of the seeds are ripe. The self-rake reaper is used for harvesting, although the mower can be used when the stems are sufficiently erect.

Pasture.—Lespedeza affords valuable pasturage for cattle, horses, hogs or sheep, though they must be accustomed to it in order to relish it. By some it is considered the best pasture plant for the poorer clay soils of the cotton-belt. As it will not start till the soil is warm, the pasturage will seldom be available before May. Under favorable moisture conditions it will continue until frost. It can be planted to advantage in all permanent pastures, where it will reseed itself if not pastured too closely.

Soil renovation.—Lespedeza is a valuable renovator of poor lands, ranking with the other legumes in this regard. It is frequently used to fit poor, waste lands for exacting crops.

Enemies.

Lespedeza is almost devoid of serious enemies in the way of weeds, insects, or parasitic fungi. It combats successfully almost all the weeds. A species of *Colletotrichum* (a fungus) has been found on it in Tennessee, but as yet it has caused no serious injury.

Literature.

Dodson, Louisiana Station, Bulletin No. 72, Second series, 1902; McCarthy, North Carolina Station, Bulletin No. 70, 1890, and No. 133; Shaw, Clovers, New York City; Tracy, Mississippi Station, Report No. 1, 1888; Report No. 3, 1890; Bulletin No. 20, 1892.

LUPINE (*Lupinus*). *Leguminosæ*. Fig. 595.

By *H. N. Vinall.*

A large group of leguminous plants mostly confined to western North America, a few species occurring in eastern United States, in the southern states and in the Mediterranean region, some of them valuable for green-manuring and forage. Upwards of one hundred species are found in the western United States. Most of the species are herbaceous annuals or perennials, although a few are shrubby. The agriculturally valuable species are

Fig. 595. Yellow lupine (*Lupinus luteus*).

all annuals. Those most cultivated are native of the Mediterranean region. All are showy plants with conspicuous flowers in terminal racemes or spikes, borne on long peduncles. The flowers are blue, white or yellow, or a union of these, papilionaceous and free-blooming. The leaves are usually digitate, with five to seventeen entire leaflets.

Lupines are grown primarily as a green-manure crop. Their great value for this purpose depends on their ability to thrive on poor sandy soils and on their high nitrogen content. In Europe, large tracts of sandy soils have been brought into condition for profitable cultivation by green-manuring with lupines and fertilizing with phosphates and potash salts. As a forage crop, the cultivated lupines are of no great importance, and are but little used for this purpose. All of the species are rather coarse for fodder.

Lupines are but little cultivated in the United States. In Europe and North Africa there are four species in cultivation, namely, the white (*L.*

albus), the yellow (*L. luteus*, Fig. 595, adapted from Botanical Magazine), the blue (*L. hirsutus*), and the Egyptian (*L. termis*). Of these, the yellow lupine is used most extensively, the blue and white lupines being next in importance. In parts of the West, a number of species, notably *L. leucophyllus* and *L. sericeus*, grow wild in great luxuriance and are cut for hay. The numerous American native species are of considerable value on the ranges, many of them being eaten readily both by sheep and cattle. Some danger attends the feeding of this hay, especially to sheep, owing to the presence of a poisonous alkaloid in the seed. [Consult Vol. III.]

The cultivated lupines have been tested at many of the American experiment stations, mostly with decidedly unsatisfactory results. Only on the Pacific coast have the cultivated lupines appeared at all promising as green-manure crops, and even there other legumes are more satisfactory. Up to the present time, none of the species has become especially valuable in the United States. It is not at all unlikely, however, when it shall become profitable to build up some of the sandy soils in the West, that one or more of the European species may prove valuable. One of the species, native to California (*L. affinis*), has been grown there as a green-manure crop and compares favorably with the European species.

Culture.

Soil.—A sandy, well-drained soil is essential, as the plants will not grow on wet land, and are particularly averse to limestone soils. Their greatest value is on poor, sandy soils that will not grow anything else. On the other hand, it was found at the California station that lupines would tolerate much more lime on clay soils than on sandy soils. It is said that the large blue lupine (*L. pilosus*, var. *cæruleus*) and the pink lupine (*L. pilosus*, var. *roseus*) are adapted to limestone soils.

Fertilizers.—Potash salts give the most beneficial results, although the addition of phosphates with the potash is profitable. Superphosphates have given detrimental results and should not be applied to the soil on which the lupines are to be sown.

Seeding.—Lupine seed is usually sown at the rate of eighty to one hundred pounds per acre in drills ten to fifteen inches apart. If broadcasted, nearly double this quantity is required. The seed should be sown after the ground is warm, the early part of May or June being the usual time. The plants grow rapidly and are ready to plow under in the early part of August, by which time they will have developed seed and will contain the maximum amount of nitrogen.

Place in the rotation.—If used in a rotation, especially on lands that are being built up, it is preferable to follow lupines with winter rye. In this case, at least a month should be allowed to elapse after the lupines are plowed under, before the rye is sown.

Utilizing the crop.

The native American species are pastured throughout the growing season. If cut for hay, it should not be harvested until the pods have ripened and burst open and scattered their seed. This occurs the latter part of August or first of September.

The seed of the cultivated species is very rich in protein and is used in Europe to some extent as feed. The feeding value is much lessened by the presence of a bitter alkaloid which is injurious to animals, especially to sheep. Before feeding the seed, it is necessary to remove some of the alkaloid by soaking or boiling. One method is to boil the seeds for one hour and then to wash them for twenty-four hours in running water. This results in a loss of about one-sixth of the dry, principally non-proteid matter. The disembittered seed is then fed in much the same way as oil cake.

MAIZE, OR INDIAN CORN. *Zea Mays*, Linn. *Gramineæ*. Figs. 596–648.

By *John W. Harshberger.*

Maize or Indian corn is a grass that is grown both for its grain and its herbage, which are used for food. The grain is used whole or ground, and in various preparations for both human and stock-food. The herbage is a forage used for soiling, silage or as dried and cured fodder. Various manufactured products are made from maize. The plant is annual, dying each year, even in its original semi-tropical home in Mexico. It is the most important and most distinctive American crop. The word "maize" is derived from the Haytian word "mahiz," the name by which Indian corn or maize was called when Columbus found it growing on the island of Hayti. Mahiz, or marisi, is said to be an Arawak Indian word of South American origin. In North America the word "corn," used generically in England for bread grains, more particularly for wheat, is employed specifically for maize. The word has no other application than to maize in this country. It is common, however, to speak of the plant as Indian corn.

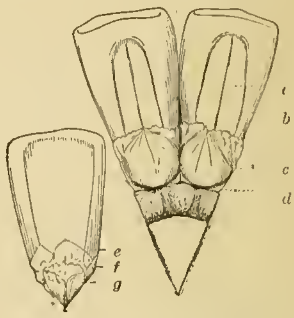

Fig. 596. Botanical parts of the kernel of maize and its integuments. *a*, embryo; *b*, mature ovary; *c*, second glume; *d*, first glume; *e*, palea; *f*, lemma; *g*, sterile palea.

Origin of maize.

The writer has presented elsewhere the proofs of the Mexican origin of maize [see Literature, page 427]. Maize relates itself botanically to a native Mexican grass, teosinte (*Euchlæna Mexicana*, which see), and fertile hybrids of this grass and maize are known, producing a plant described by Watson as *Zea canina*. From the peculiar behavior of these hybrids, the writer has suggested

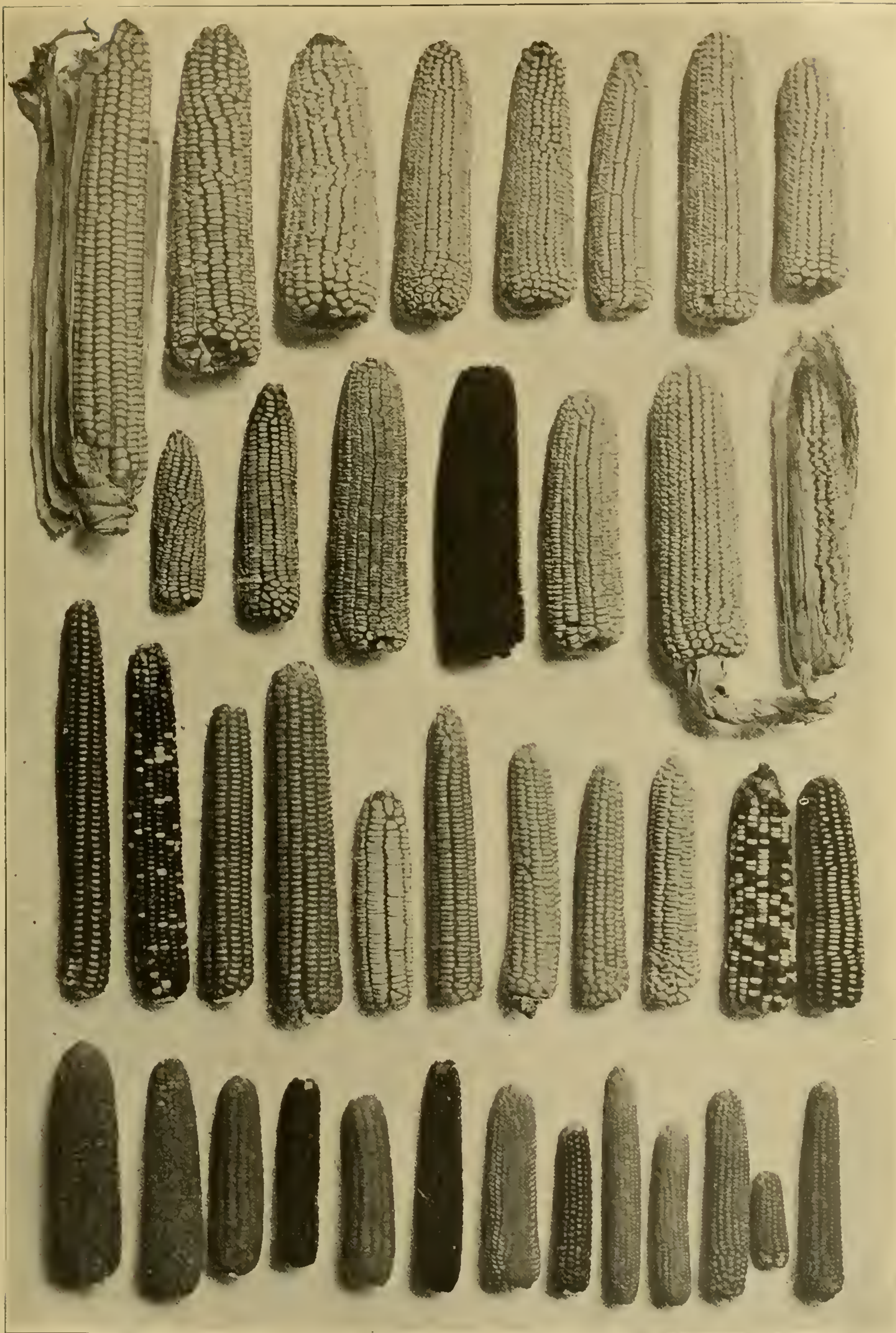

Plate XIV. Types of maize

Upper row, left to right—Maiz Gigante from Mexico, Large-cobbed Coarse Yellow Dent, Cob-pipe, Reid Yellow Dent, Leaming Yellow, Riley Favorite, Boone County White, Minnesota 13. *Second row*—North Dakota Golden Dent, Golden Ideal, Golden Eagle, A Red Dent, Hybrid 120, Hunter White Dent, Pod-Corn. *Third row*—Flesh-colored Flint, Variegated Flint, Yankee Corn, Sturges' Hybrid, Hickory King, Triumph Flint, White Flint, Gehu, Early Tuscarora, Variegated type of Mexican June, Northwestern Dent. *Bottom row*—Stowell Evergreen, Country Gentleman, Crosby, Black Mexican, Quincy Early Market, Red Rice Pop, White Rice Pop, Blue Pop, two strains of White Pearl Pop, strains of Yellow Pearl Pop (last three).

that our cultivated maize is of hybrid origin, probably starting as a sport of teosinte, which then crossed itself with the normal ancestor, producing our cultivated corn. This is speculative, but there

Fig. 597. Types of kernels of corn. 1, 2, White dent kernels of poor shape; 3, end view of thin and thick kernels; 4, edge view of thin and thick kernels; 5–7, flour corn of Peru; 8, Tuscarora or flour corn; 9–12, sweet corn; 13, Golden Pearl popcorn; 14, white rice popcorn; 15, white flint; 16, 17, yellow flint; 18–23, white dent; 24–28, yellow dent. Long, wedge-shaped kernels like 9 and 25 permit of much grain in proportion to cob. (Hartley.)

cannot be any doubt that the close relationship of maize and teosinte points the way to the determination of the botanical characters of the original wild corn plant. Recently, Montgomery has suggested a theory as to the nature of the maize ear, in which, in conclusion, he states "that corn and teosinte may have had a common origin, and that in the process of evolution the cluster of pistillate spikes in teosinte were developed from the lateral branches of a tassel-like structure, while the corn ear developed from the central spike. It is probable that the progenitor of these plants was a large, much-branched grass, each branch being terminated by a tassel-like structure, bearing hermaphrodite flowers." [See literature references at end of article.]

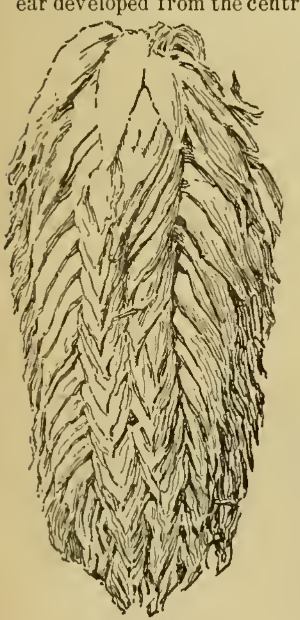

Fig. 598. Pod or husk corn.

The *Zea canina* of Mexico (first described in 1890, by Watson) is of great interest in studying the origin of corn. Bailey experimented with this plant and made hybrids with forms of cultivated maize. Without committing himself as to the origin of *Zea canina* itself, he made the following observations (Cornell Bulletin No. 49, 1892) on its possible relations to Indian corn (subsequent experiments have not been published):

"It may be worth while to inquire whether this Canina corn still retains a specific identity, whether it really is a distinct species from the common corn, *Zea Mays*. For myself, I am strongly of the opinion that it is not a distinct species. I am rather inclined to think, with the native Mexicans and Professor Duges, that it is the original form of *Zea Mays*, or at least very near it. It explains many points in the evolution of Indian corn. Some varieties of sweet corn occasionally produce rudimentary multiple ears, and this Canina seems to tend to lose them under cultivation. The tendency of cultivation in all plants is to develop some fruits or some organs, rather than all fruits or all organs. The suckering habit has been discouraged in the selection of corns. The tendency to sucker, the tendency to produce tassels on the ends of ears, the profuse drooping tassels of many little-improved varieties, the predominance of flint corns northward and of dent or pointed corns southward, the occurrence of many curious and aboriginal corns in the Aztec

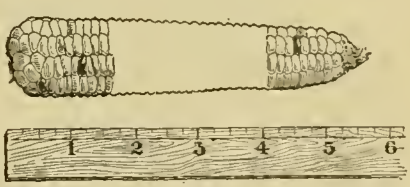

Fig. 599. Swan river corn, grown at Minitonas, Manitoba.

region—all these become intelligible if *Zea canina* is the original of Indian corn."

Botanical characters.

Roots.—The roots of maize are of two kinds: (1) Those that are formed when the kernel germinates, which develop into the strong underground feeding roots; (2) those that develop in a circle from the lower nodes of the stem, and serve primarily as prop or supporting roots. Before these adventitious aërial roots reach the soil, they are covered by a copious mucilaginous material, which probably prevents dry air and dry winds injuring the important growing apex. Later these air roots absorb water and plant-food from the soil into which they penetrate.

Stem.—The stem of corn, known botanically as a culm, is divided into nodes (knots) and internodes (straight stem parts). The internodes differ from those of most grasses by being solid instead of hollow. The basal part of each of the lower leaf sheaths is provided with a ring of soft tissue, which consists of cells capable of rapid growth. Hence the base of the sheath is ready at any time to grow, and if the plant is blown over by the wind, growth takes place, and the plant is thus assisted into an upright position. Another point of interest is that a number of the internodes are alternately grooved or flattened. Those persons who have made a "corn-stalk fiddle" will remember that it was this peculiar flattening, which accommodates the ears, that rendered possible the manufacture of the crude musical instrument. The sap bundles of the corn stem are isolated and of the closed collateral type.

Leaves.—The leaves of corn are two-ranked; that is, they alternate on opposite sides of the stems. Each leaf may be divided into three parts,—a sheath, which is open along one side, a ligule, or

Fig. 600. High northern corn. Cross between large yellow flint and Improved Leaming corn: four years crossing. Wakefield, twenty miles north of Ottawa, Canada.

membranous outgrowth at the top of the sheath, and the blade. The ligule has been appropriately called the rainguard, as it acts in such a way that rain-water with dust particles held in solution, which runs down the grooved surface of the leaf, runs off on either side on reaching the ligule and does not run into the space between the stem and sheathing base, where dirt might otherwise easily accumulate. The folds in the margin and base of the leaf, which are formed because the edge grows more rapidly than the middle, are ingenious natural or mechanical contrivances to ease the strain on the leaf-blade when the wind blows. If a microscopic section is made of the leaf-blade, peculiar fan-shaped cells are found distributed in the upper epidermis between the prominent parallel veins. These are bulliform cells and in ordinary weather absorb water and keep the leaf-blade perfectly flat. In hot, dry weather, water is lost from these cells and the leaf-blade rolls up and thus protects itself against

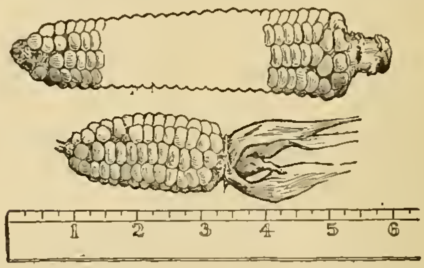

Fig. 601. Ears from the stalks shown in Fig. 600.

desiccation and controls the normally high rate of transpiration, or water loss.

Flowers.—The flowers of maize are arranged in clusters in two different parts of the plant. The male (staminate) flowers together form the terminal tassel of the plant, while the female (pistillate) flowers (Fig. 515) are placed on the cob, surrounded by the husks in the axils of the lower, or usually the middle leaves of the stem. The staminate flower cluster is known as a panicle of spikelets. Each ultimate division of the tassel (panicle) is a spikelet. Each spikelet consists of two dry scales (lower glumes) subtending two flowers of three stamens each. Each staminate flower is surrounded by a flowering glume (lemma) and a palea on the inside. When the anthers are mature, they dangle at the ends of long filaments, and thus the dry, smooth pollen-grains are consigned to the wind. The pistillate flowers are placed in even-numbered rows on the fleshy axis known as the cob. Each spikelet on this axis consists of two flowers, subtended by two glumes more or less horny or leathery. One pistillate flower is abortive and is represented solely by a flowering glume and a palea, while the other pistillate flower, with subtending, flowering glume and palea, has an ovary surmounted by a long, hairy style, showing, under the microscope, two longitudinally directed vascular bundles. Each style, or thread of silk, is hairy, to entrap the round, smooth pollen-grains, which

Fig. 602. Early-maturing low-growing corn adapted to North Dakota and the northern states. It may yield forty or more bushels per acre. (Hartley.)

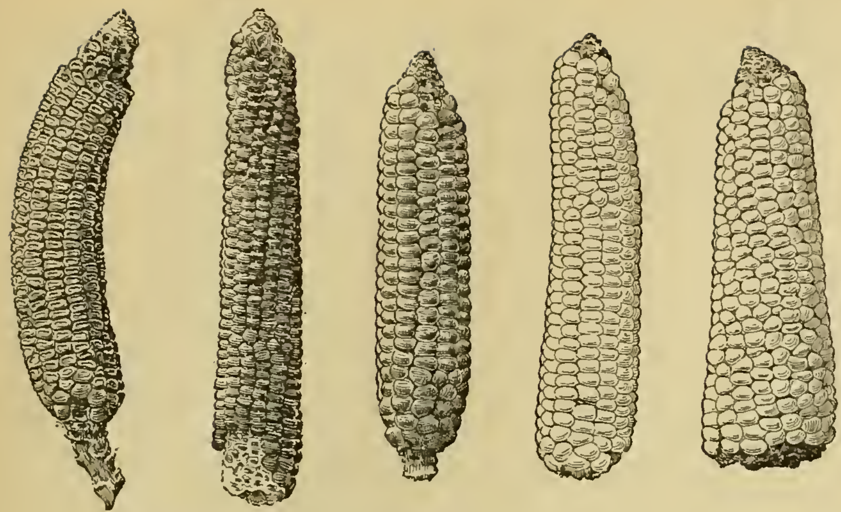

Fig. 603. Hopi corn grown by the Pueblo Indians. (From specimens in the United States National Museum.)

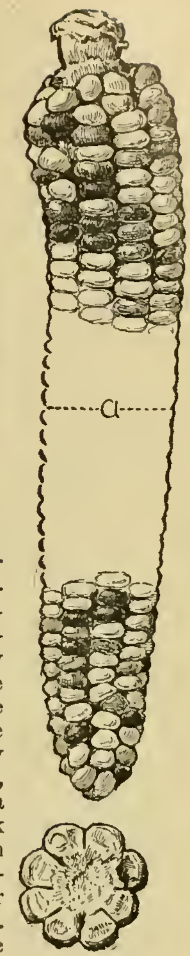

Fig. 604. Squaw corn grown in Manitoba. Section at *a* shown below.

are produced in very great numbers, as many as 18,000,000 by a single plant. The pollen begins to be shed one to three days before the silk emerges from between the husks, and continues to fall for eight days, more or less, although the silk is pollenized usually on the first day of its appearance.

The egg apparatus in the ovule of maize consists of three cells, and in the center of the embryo-sac is an endosperm nucleus. The fertilization of the egg cell results in the formation of the corn embryo, while the double fertilization of the endosperm nucleus by the second sperm nucleus produces an immediate effect on the color of the reserve food stored about the embryo. This immediate effect of the pollen on the offspring kernels is called xenia.

Fig. 605. The sexes; pistillate spike or ear, staminate panicle or tassel.

Fig. 606. Ears too high on the left; on the right, ears well placed.

Kernels. — The caryopses or kernels of corn (Fig. 596), resulting from the act of fertilization, are arranged in even-numbered rows on the fleshy axis, or cob, surrounded by the husk. Each husk represents the sheathing leaf base and the outer ones are usually tipped by a green, rudimentary leaf-blade, which occasionally displays a ligule. The outer, innermost husk is two-keeled, like a sled with runners, and thus it accommodates itself to the flattened or hollowed-out stem surface. Occasionally smaller ears are enclosed by the outer husks, so that the ear together with the husks is to be regarded as a short, axillary, branch bearing reduced leaves and flowers.

Each caryopsis has two distinct coats, viz., the ovarian wall and the seed-coats. On microscopic section, the cell layers composing the ovarian wall, or pericarp, and the extremely thin seed-coats are distinctly visible. The reserve food in corn is horny proteinaceous material and mealy starch, while the embryo itself contains the largest amount of oil. The proteinaceous and starchy reserve foods comprise the albumen, which touches the embryo on the whole of one side, where the scutellum is found. The corn embryo, chit or germ, consists of the radicle surrounded by a root-sheath, or coleorhiza, a short hypocotyl from which arises the sucking organ, or scutellum, and a single cotyledon that surrounds several tightly-rolled plumular leaves. The epidermal cells of the scutellum secrete an enzyme which transforms the reserve food into a usable form when the embryo begins to grow.

In germination, the radicle protrudes first by breaking its way through the coleorhiza, which remains as a circular collar about its upper part, and then the plumule elongates. The cotyledon remains yellowish green and membranous, while the leaves enwrapped by it elongate and assume a bright green color. Coincident with this development of the plumule, a considerable number of secondary adventitious roots arise, so that the primary root soon loses its identity.

Classification of species-groups or "agricultural species."

Several well-marked agricultural races of Indian corn may be distinguished. The asterisk (*) indicates Mays understood. The classification is that of Dr. E. L. Sturtevant:

(1) *Zea canina*, Watson. Maiz de Coyote, a reputed wild form from Mexico. The writer has abundantly proved that this so-called wild species is a hybrid of the fourth or fifth generation produced by crossing teosinte and the black Mexican corn.

(2) *Zea * tunicata.* Pod Corn. In this group each kernel is inclosed in a pod, or husks surround it, and the ear thus formed is inclosed in husks. Originally it was probably derived from Argentina in South America. (Fig. 598.)

(3) *Zea * everta.* Pop Corn. This species-group is characterized by the excessive proportion of the corneous endosperm and the small size of the ear and kernel. The best varieties have the corneous endosperm throughout, which gives the property of popping. Probably cultivated by the Indians.

(4) *Zea * indurata.* Flint Corn. A species-group recognized by the occurrence of a starchy endosperm, inclosed in a corneous endosperm, which varies in thickness in different varieties. First mentioned by Cartier in 1535 and Heriot in 1588.

(5) *Zea * indentata.* Dent Corn. A group recognized by the presence of corneous endosperm at the sides of the kernel, the starchy reserve food extending to the summit. By the drying and shrinkage of the starchy endosperm, an indentation is formed. Cultivated as poketawes by the Powhatan Indians.

(6) *Zea * amylacea.* Soft Corn. These corns are recognized by the absence of a corneous reserve food. The mummy corns of Chili and Peru belong to this class.

(7) *Zea * saccharata.* Sweet Corn. A well-defined species-group characterized by the translucent, horny appearance of the kernels and their more or less crinkled, wrinkled or shriveled condition. The first sweet corn cultivated in America was derived from the Susquehanna Indians in 1779 by Captain Richard Begnall, who accompanied General Sullivan on his expedition to subdue the Six Nations.

(8) *Zea * amylea-saccharata.* Starchy-sweet Corn. The external appearance of the kernel is that of a sweet corn, but examination shows that the lower half of the kernel is starchy, the upper half horny and translucent. May it not be due to xenia? This species is based on three varieties found in the San Pedro Indian collection of Dr. Palmer, sent to Dr. E. L. Sturtevant in 1886.

Maize is exceedingly variable in every part. Therefore it adapts itself to great numbers of uses and to wide ranges of territory. Some of the forms of it are shown in the half-tone plate and also in Figs. 597–613.

Maize-Growing.

By *C. P. Hartley.*

The corn crop is preëminently the most valuable crop of the United States. Through this crop there is derived each year from the soil of the United States a value of more than a billion dollars. If

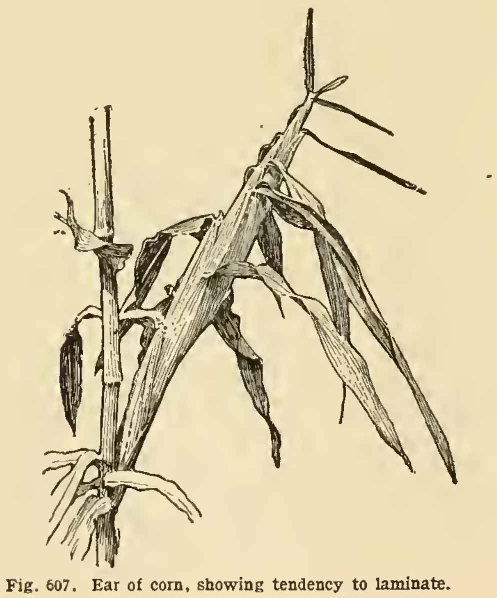

Fig. 607. Ear of corn, showing tendency to laminate.

Fig. 608. Corn triplets.

Fig. 609. A large, heavy ear.

the hay crop, though made up of crops of several distinct plants, be considered as a single crop, it is but one-half as valuable as the grain alone of the corn crop. Corn holds first place in the list of crops, hay second, cotton third and wheat fourth. North America produces four times as much corn as the remainder of the world. As continents, Europe stands second, South America third and Africa fourth. As a corn-producing country the United States has no rival; Argentina stands second, Hungary third and Italy fourth.

If the corn crop of the United States for 1906 had been placed in wagons, fifty bushels per load, and allowing twenty feet of space for each wagon and team, the train of corn would have reached nine times around the world at the equator.

Below are arranged the states of the United States in the order of the total amount of corn each state has produced in the five years 1902 to 1906, and again arranged according to the average yield per acre for the ten years 1897 to 1906. The figures are averaged from the reports of the Bureau of Statistics of the United States Department of Agriculture:

Average Corn Yields for Five Years, 1902–1906.

	Bushels
Illinois	342,115,835
Iowa	301,666,176
Nebraska	239,835,262
Missouri	210,082,426
Kansas	183,490,628
Indiana	165,666,854
Texas	123,454,407
Ohio	112,675,444
Kentucky	91,957,099
Tennessee	78,578,391
Indian Territory	53,216,199
Pennsylvania	52,337,590

Fig. 610. A good short, erect ear.

Average Corn Yields for Five Years, 1902–1906—Continued.

	Bushels
Wisconsin	49,339,658
Arkansas	47,665,325
Oklahoma	47,548,686
South Dakota	45,942,636
Georgia	45,565,769
Minnesota	43,101,849
Michigan	42,549,489
Virginia	42,537,934
Alabama	39,531,578
North Carolina	39,263,224
Mississippi	35,000,660
Louisiana	23,543,048
Maryland	20,934,903
South Carolina	20,777,740
West Virginia	20,404,238
New York	18,138,662
New Jersey	9,422,171
Florida	6,259,542
Delaware	5,577,944
Colorado	2,496,071
North Dakota	2,462,990
Connecticut	1,920,575
California	1,795,668
Vermont	1,764,520
Massachusetts	1,518,261
New Mexico	945,294
New Hampshire	803,60C
Oregon	449,199
Maine	432,140
Utah	320,660
Rhode Island	317,845
Washington	250,283
Arizona	188,428
Idaho	151,417
Montana	85,842
Wyoming	58,001

Average Production of Corn Per Acre for Ten Years, 1897–1906.

	Bushels
Connecticut	36.00
Massachusetts	35.55
Maine	35.13
Pennsylvania	35.04
Ohio	34.91
New Jersey	34.60
Vermont	34.53
Indiana	34.47
Illinois	34.02
Wisconsin	33.64
New Hampshire	33.56
Iowa	32.49
Maryland	32.26
Michigan	32.05
Rhode Island	31.83
New York	30.37
California	29.72
Minnesota	29.44
Missouri	27.98
Idaho	27.83*
Nebraska	27.71
Delaware	27.63
Indian Territory	27.21*
South Dakota	26.55
West Virginia	26.40
Kentucky	25.98
Wyoming	24.91
Utah	24.53
New Mexico	24.50
Oregon	24.34
Oklahoma	23.78*
Arizona	23.48*
Tennessee	22.43
Kansas	22.08
Montana	22.01
North Dakota	21.87
Virginia	21.30
Washington	21.07
Colorado	19.86
Texas	19.03
Arkansas	18.78
Louisiana	16.76
Mississippi	15.22
North Carolina	13.70
Alabama	12.99
Georgia	10.56
South Carolina	9.81
Florida	9.43

*Average production of corn for six years, 1901–1906.

The following table of corn production in Canada is taken from the Canada Year Book for 1905. It is for the census year of 1901, being the crop of 1900. It is seen that very little corn is grown except in the province of Ontario. Quebec stands second, far behind Ontario, but much in the lead of the other provinces, where corn is unimportant.

1901	Acres	Bushels in the ear
Canada	360,758	25,875,919
British Colnmbia	51	1,849
Manitoba	62	1,944
New Brunswick	259	12,509
Nova Scotia	177	9,358
Ontario	331,641	24,463,694
Prince Edward Island	37	834
Quebec	28,506	1,384,331
The Territories	25	1,400

From the statistics of the last four census years it is seen that the production of corn is rapidly increasing. The figures are for all Canada:

1871	3,802,830 bus.
1881	9,025,142 bus.
1891	10,711,380 bus.
1901	25,875,919 bus.

History.

In the early writings and history of both North and South America, the importance of maize is recognized and frequent mention is made of it. However, these early writings mention it as a well-known plant, so that descriptions of it are few and nothing positive appears regarding its origin or the character of the plant when it was first utilized by the native inhabitants of America. We know that there were different kinds of maize in America at the time of its discovery. It is probable that such different kinds of corn as pod, flour, flint, dent, sweet, and pop of various colors, existed at that time. It is certain that by seed selection, preservation and cultivation the settlers of America have improved these different types.

Fig. 611. A well-formed ear of dent corn.

De Candolle states positively as follows : "Maize is of American origin and has been introduced into the Old World only since the discovery of the New." Edward Enfield, in his book on Indian corn, published in 1866, is positive that maize is of American origin and states, "If any further evidence were wanting on this point, it may be found in the impossibility that a grain so nutritious, prolific and valuable, so admirably adapted to the wants of man, could have existed in the eastern world before the discovery of America without coming into general use and making itself universally known. Had this cereal existed there at that period, it would have made its own record too clearly and positively to leave any doubt on the subject." Harshberger states, "The evidence of archæology, history, ethnology and philology points to southern Mexico as the primal habitat of this great New World cereal." [See preceding article.]

The earliest explorers and settlers of all parts of the New World found maize in a state of cultivation and the principal food of the Indians. Thus, in Pickering's Chronological History of Plants this statement is made : "About 1002 A. D., Thorwald, brother of Leif, wintered in Vinland . . . and on an island far westward saw a wooden crib for corn." Columbus, in a letter to Ferdinand and Isabella, dated May 30, 1498, speaking of his brother, says, "During a journey in the interior he found a dense population entirely agricultural, and at one place passed through eighteen miles of corn-fields."

In Prescott's Conquest of Mexico, mention is made that Cortez, on his march to the city of Mexico in 1519, passed "amidst flourishing fields of maize." The historian, Torquemada, has extracted the particulars of the yearly expenditures of the Mexican Palace. One item is 4,900,300 fanegas, or 490,030,000 pounds, of maize.

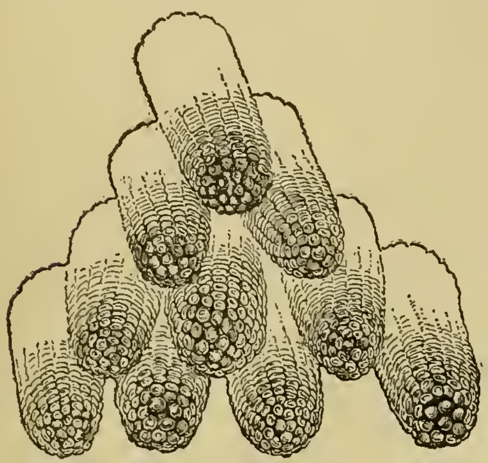

Fig. 612. Good corn tips. The nose or end is well covered with kernels.

In 1539, De Soto, in Florida, speaks of Indian villages surrounded by extensive fields of corn. In one instance he narrates that his army passed through continuous fields of maize for two leagues. In one place they found 500 measures of ground maize, besides a large quantity of grain.

The Puritans, in King Philip's War in 1675, "took possession of 1,000 acres of corn, which was harvested by the English and disposed according to their direction." In 1680, La Salle found stores of corn in Illinois that the Indians had placed under ground for seed and subsistence. In his expedition against the Seneca Indians, Marquis de Nouville says, "On the 14th of July, 1685. . . . We remained at the four villages of the Senecas ten days. All the time we spent in destroying the corn, which, including the old corn that was in cache, which we burned, was in such great abundance that the loss was computed at 400,000 minots, or 1,200,000 bushels." This was in Ontario county, New York.

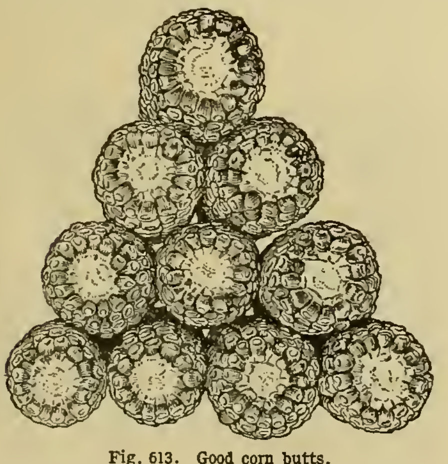

Fig. 613. Good corn butts.

Place of corn in American agriculture.

From the time of the early settlements, when maize saved the colonists from starvation, till the present, this crop has held an important place, not only in American agriculture, but in the development and progress of this country. Other crops are of vital importance in certain limited sections; so is the corn crop; but in addition to this it is of considerable importance in almost every part of America. To a greater extent than perhaps any other plant, it has become adapted to various environments. For the various latitudes from Canada to the equator there are strains more or less perfectly adapted which lend themselves readily to further improvement and better adaptation. Suited to the short seasons of the far North are strains that mature in seventy or eighty days and grow but three or four feet tall (Fig. 602), while in the southern part of the United States (Fig. 626), in Mexico, Central America and South America, there are strains that reach a height of twenty feet or more and require half a year in which to reach maturity.

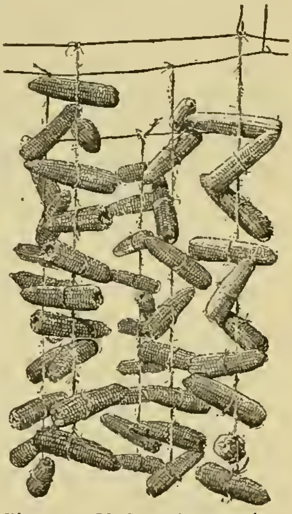

Fig. 614. Method of supporting seed corn in storage. (Holden.)

The hard, smooth flints, mostly yellow flints and sweet corns, are generally grown in New England, the small early yellow dents and reddish dents in the northern states, large-eared white and yellow dents of the one-ear-to-stalk strains in the central states, and white dents partly of the strains that produce two or more ears per stalk in the southern part of the United States.

Because of the need of a cultivated crop that can be used in rotation with small grains, corn is now extensively grown in Minnesota, North Dakota and elsewhere, where but a few years ago all attention was given to the growing of small grains, and corn-growing considered impracticable and unprofitable. The soils of the Pacific slope are also showing the exhaustive effect of one-crop farming, and corn for rotation is meeting with favor. Crop rotation is sure to replace the practice of summer fallowing, or resting the land. By early planting, some of the earliest maturing strains can be grown to maturity before the dry season has continued sufficiently long to prevent growth.

Although produced so much more extensively than other grains, corn does not figure so prominently in our export trade. Nearly all of it is fed to stock on the farms where it is produced. Only 4 per cent of the amount grown in the United States is shipped to other countries as corn and corn meal. It is used for the most part on the farms for fattening cattle and hogs for exportation and home use. It is well for the future of American farming that this custom prevails so generally. A removal of the corn from the farms would much more quickly deplete their fertility. The feeding of it on the farms is the chief means of retaining their fertility.

Fig. 615. Examining the germination box to see how the corn is sprouting. It is not enough that the kernels simply sprout; they should show strong germination. (Holden.)

Consideration of the seed.

In order to produce a successful corn crop it is necessary that attention be given to the selection of seed the fall previous to the year in which the good crop is expected. The opinion is rather prevalent that if a good stand is obtained, it matters little by what method the required number of stalks is secured. The stand is sometimes obtained by planting a larger number of kernels per hill than the number of stalks desired. This method is not advisable for two principal reasons: First, such a method is sure to result in an uneven distribution of the plants in the field; and second, if the seed germinates poorly, so that it is necessary to plant more than the number expected to grow, it is certain that the seed that does grow will have been reduced in vitality by the same conditions that caused the other grains to fail.

One endeavoring to produce successful crops of corn must bear in mind that within each kernel is a partially developed corn plant differentiated into the part that grows into the stalk and that which develops into the roots. This partially developed plant necessarily endures the condition to which the seed ears are subjected during the winter. The best condition under which it maintains its vitality is that of dryness and an even temperature. It is not sufficient to make sure that the corn is once dried in the fall and then placed in a position where it will be subjected to damp atmosphere and extremes of temperature. If but a few bushels of seed are required, a very convenient method of drying it thoroughly is by means of twine and a well-ventilated loft or shed in which to hang the strings of ears. About a dozen or twenty ears can be tied on one string, placing the ears several inches apart on the string so they will not touch. (Fig. 614.) If such strings can be hung in a place that will remain dry and at a comparatively uniform temperature, they may be left in this position until planting time approaches. However, rather than subject such strings to the atmosphere of damp days and changes in temperature, it is better to take them down after the ears are thoroughly dry and place them in an attic or living-room of a dwelling or some building in which the temperature will remain rather constant and the atmosphere dry.

If it is necessary to dry large quantities of seed ears, gently sloping floors or shelves made of one-and-one-half- or two-inch slats, with an inch and a half between the slats, can be constructed in a dry room heated by stoves so arranged that the warm air will ascend between the slats and escape by means of ventilators provided near the roof. The object of the sloping floors is to provide an easy means of moving all of the ears by withdrawing a part of them from the lower ends of the floors, causing the others to roll down a little distance. Such movement enables the ears to dry on all sides. On these floors the seed ears are put only one or two ears deep.

Seed corn should never be placed in tight boxes or barrels until thoroughly dry or until the moisture content is reduced to 10 per cent or less. When dried to this extent, seed can be tightly boxed with safety, provided the boxes are kept in a dry place. In order to guard against the weevil and the grain moth, it is well to place about a pound of naphtha or moth balls with every bushel of ears. Well-dried seed has been preserved in this way for four years without impairing its germination to any extent, while equally well-dried seed

Fig. 616. Six kernels taken from each of three ears of corn and tested in the germination box. No. 1, three swelled but sent out neither root nor stem sprouts; other three sent out weak stem sprouts but practically no root sprouts. No. 2, all six kernels gave strong, even germination; this is a good seed ear. No. 3, all weak germinators; such ears should never be planted. (Holden.)

suspended in sacks in a loft has deteriorated greatly in that length of time.

At the present time, germination tests of each ear to be used as seed are being advocated very strongly by experiment stations and corn-breeders, and the practice is being followed by the most enterprising and successful corn-growers. There can be no doubt that there is great benefit in testing each ear to be used as seed, provided the supply of seed did not mature properly or has not been preserved in the best way. By means of a large number of germinating boxes, the germinating power of individual ears can be tested without much expense of money or time. It should be remembered that a good-sized ear of corn will plant a tenth to an eighth of an acre, and each ear that is found to germinate feebly saves the planting of that much ground to seed that would be sure to return but a small yield.

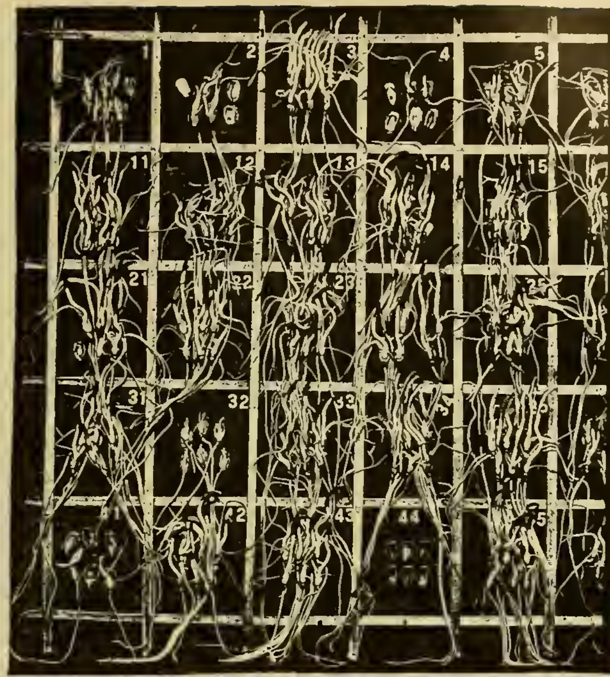

Fig. 617. Germination box ready for examination. Notice the contrast between the kernels from ears 1 and 3; also between 32 and 34. (P. G. Holden, Iowa.)

It is a fact that the average corn-grower plows, harrows, plants and cultivates one-fourth to one-third of his corn acreage without receiving anything for his labor. This is because of the vacant hills, and hills that do not contain the number of stalks that the fertility of the soil demands. By not making sure of the perfect germination of every ear of corn used as seed, corn-growers not only are losing the use of one-fourth of their land, but are expending labor on the land without any returns. Many have become so accustomed to seeing very poor stands that if three-fourths of a proper stand is obtained they are of the opinion that they have secured a good stand of stalks.

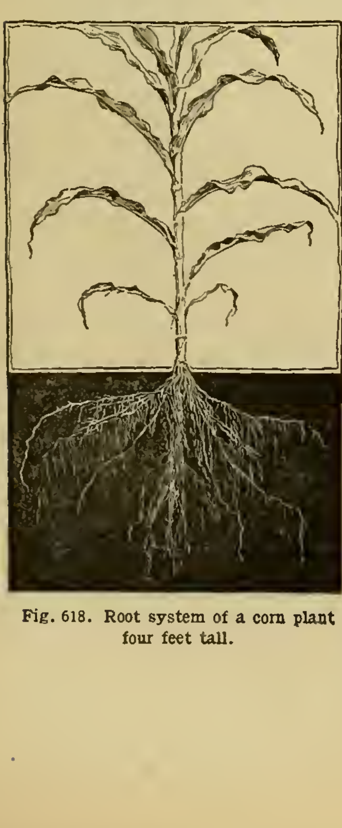

Fig. 618. Root system of a corn plant four feet tall.

The testing of each individual ear must not be taken as a remedy for the neglect of seed preservation. No amount of seed-testing in the spring can make good seed of that which has been poorly preserved. Although there may be found in a lot of poorly preserved seed certain ears each kernel of which will grow, it should be remembered that the same conditions that have caused other ears of the lot to fail to germinate, have weakened the vitality of those that do germinate. They do not germinate so strongly nor produce so well as they would have done had they been better preserved. Some tests of well-preserved seed in comparison with that kept in cribs have shown that the one factor only, of preservation, is responsible for a difference in yield of sixteen or more bushels per acre. The important feature of these tests consists in the fact that the increased production of well-preserved seed is not due to its better germination or a better stand of stalks in the field, but to the fact that the stalks are more vigorous. While a test of the germinating power of each individual ear is very profitable, with a supply of seed containing some ears that do not germinate perfectly, it is more profitable to select and preserve the seed in such a way that it will contain no such ears. Of course, as a safeguard, it is advisable to test one hundred or more ears of seed selected and preserved in the best way possible, but as it is usually found that the seed so preserved germinates perfectly or nearly so, it is often found useless to make the test of each ear of the lot.

Another very important factor in securing the proper stand of stalks is the grading of the seed ears. They should be selected or graded to a uniform size of kernel, and this is readily done before the ears are shelled. No corn-planter can drop the proper number of kernels in each hill unless the kernels are uniform. The ears should always be nubbed, that is, the very small kernels at the tip and the large, thick kernels at the butt should be discarded. It is advisable, even when large quantities of seed are needed, to shell the seed by hand and in a small receptacle where the kernels from each ear can be examined before they are placed with the general supply. If the corn is variable as to width of kernel, it is best to divide the seed into two or more lots and change the adjustment of the planter in changing from one lot of seed to the other. No careful corn-planter will begin planting his crop until he has ascertained that his planter works satisfactorily on the grade of seed that he expects it to plant.

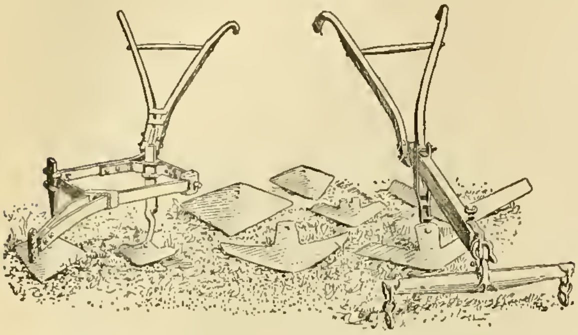

Fig. 619. "Sweeps" used in cultivating growing crops—one-horse cultivators. It is necessary to drive across the field two or more times to cultivate one row. (Hartley.)

Culture.

Choice of land.—A very large part of the land at present planted to corn in the United States is too poor for profitable corn-growing, and should not be planted to corn until improved. The planting of such land to corn keeps both the land and its owner in an impoverished condition. If corn-growing must be practiced in a section having such a poor soil, it is better to withhold the planting of corn until the land can be improved by the application of humus and the growing and plowing under of green crops, preferably legumes. The planting of corn year after year on the same land is a bad practice in any section, even though the ground be very fertile. River bottom that overflows occasionally, and on which sediment is deposited, is the only kind of land that will stand continuous cropping with corn, and even here it may sometimes be inadvisable.

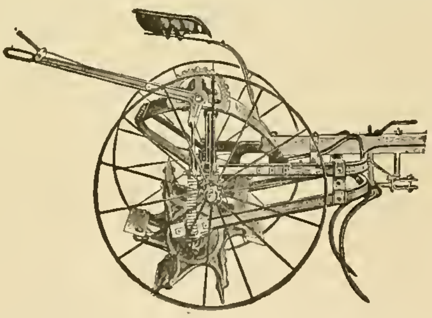

Fig. 620. Steel frame stalk-cutter.

Maintaining soil fertility.—For good results, the corn plant requires a fertile soil, a soil of greater fertility than that required by many other farm crops. Good seed, good land and good culture are the essentials of a good corn crop. Unless nature has supplied the farmer with a fertile farm, the easiest of these three essentials to obtain is good seed, and unfortunately it is the essential in which most growers make the greatest mistake.

New lands are usually good corn soils, and they are generally well supplied with humus or vegetable matter. Lands that have been cropped continuously for years, most of the humus having been destroyed, become hard and the soil particles pack together closely. Such a condition indicates that the soil requires humus or vegetable matter, and the conditions of such a soil can be very greatly improved by the application of coarse manures and the plowing under of large quantities of vegetable matter in the form of corn stalks, grain stubble, clover, and the like. The addition of such material to soil almost invariably increases the yield of corn. Ten to twenty tons of farm manure per acre each year or two will retain most soils in a condition that will make possible the growing of good corn crops. Excessive applications of farm manure may result in decreased yields the first year after the application, especially if the season is dry.

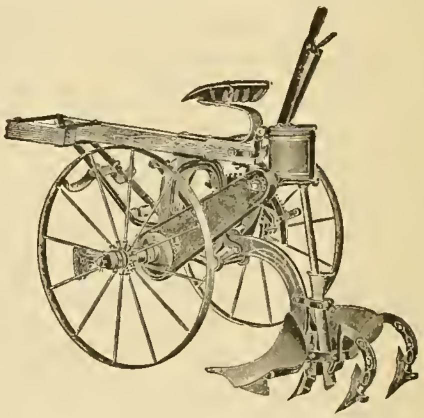

Fig. 621. Combined sulky lister and planter.

Most impoverished soils respond to a greater or less extent to the application of commercial fertilizers composed of phosphoric acid, nitrogen and potash. The proportion of these elements must be varied to suit the requirements of the particular soil to which they are applied, and the most satisfactory way of determining the requirements of the soil is by actual field tests. Much of the impoverished soil of the eastern part of the United States responds readily to applications of phosphoric acid. There are peaty swamp soils which, though apparently very fertile, produce two or three times as much corn per acre by the application of potassium chlorid. With the exception, however, of particular cases in which the application of a few elements to the soil in rather moderate quantities greatly increases the corn crop, the production of corn on impoverished soils by means of commercial fertilizers is not profitable.

It is usually advisable to apply the commercial fertilizers to a small grain crop grown in rotation with corn. Such an application of fertilizers will usually assist in obtaining a good stand of clover or grass which is to follow the small grain crop. Whenever possible, the land should be kept busy growing legumes or grasses that can be plowed under, and, briefly speaking, this is the best fertilizer for corn crops. When corn is to follow wheat, it is usually advisable to sow with the wheat or in early spring clover or some similar crop that can occupy the land from the time the wheat is removed until it is ready for corn. Some of the most successful farmers always sow clover with their winter wheat, when the land is to be planted in corn the next spring.

If found advisable to use commercial fertilizers for corn, it should not be placed in the hills with the kernels. It may be injurious to the germination of the kernels or, at any rate, it is not at the base of the stalks that the feeding roots of the corn plant are found. At the time of tasseling and silking the roots of the corn plant are well distributed throughout the soil to a width and depth of three or four feet. For soils that are very porous, or when very soluble fertilizers, such as sodium nitrate, are used, it is thought best to make the application but a short time before the plants begin to tassel and form ears. (Fig. 618.)

Fig. 622. Cultivating young corn with a two-horse cultivator. (Hartley.)

Preparing the seed-bed.—Whenever possible, and it should be made possible in most cases, it is advisable to have the corn crop follow a hay crop. With a very few exceptions the sod should be broken in the fall. Double cultivators, two-row cultivators, or implements especially designed for the work can be used in the spring to tear up the decayed sod and place the seed-bed in a well-pulverized condition. Disk-harrows are often used to advantage for this work. Fall-plowed land is usually found in the spring to contain more moisture and yet have a drier surface than other soils.

For very level land, and land that is likely to remain very wet during a part of the growing season, a method of preparing the seed-bed should be adopted that will permit of some drainage for the young plants. A very good method for such soils is to throw up the land by back furrowing into beds about eight feet wide. When pulverized, the rows can be planted four feet apart, placing a row on either side and near to the water furrows. In this way the young plants will have drainage and the surplus water can remain in the water furrows. For very sloping or hilly land, the plowing and planting should be done along the hillside or around the hill. In fact, if the soil is inclined to wash, permanent terraces should be maintained at intervals along the hillsides, so constructed as to maintain the same level throughout the field. No soil can be improved in fertility or kept in a fertile condition if much erosion is permitted.

Fig. 623. The right way to cultivate—shallow and not too near the stalks at this stage.

Planting.—The method of planting must be adapted to the section of country in which the work is done. It is well recognized that for sections where very dry weather is likely to prevail during the growing season, listing is best. This method consists of planting the corn in the bottom of a deep furrow or ditch. In many cases the entire process of planting is performed by one operation, and without any previous preparation of the land. It is usually best to prepare the land by means of thorough plowing and then adopt some method of listing that will place the young plants in a furrow, so that the soil can be gradually worked to them as they grow. Some corn-planters accomplish this by marking off deep furrows and running their drills or check-rowers in the furrows. A simpler method is to attach to the check-rower or corn-planter disks which will throw out the

Fig. 624. The wrong way to cultivate—too close and deep. Deep cultivation injures the roots and lessens the yielding ability.

furrow just ahead of the shoe of the drill which places the kernels in the soil. On heavy lands in wet climates, it may be best not to plant in furrows.

There is but one principal plan to be considered in deciding whether the corn should be planted in checks, so as to admit of cultivation in two directions or dropped one kernel in a place. This consideration is that of keeping the corn free from weeds. On river-bottom land and land that is foul with weed seed, it is usually best to plant in checks, otherwise hand-labor will be required in hoeing out the weeds. As the corn roots distribute themselves through the soil for a distance of three or four feet, there is no great advantage in having the plants stand one in a place.

Repeated tests have shown that for middle Georgia the best time for planting is March 15 to 20; for central Illinois, May 11 to 18; central Indiana, May 1 to 11; central Kansas, the first week in May; South Dakota, May 10 to 20; but these dates are only the average for a number of years, and the advancement of the season must each year be taken into consideration and the planting done when the soil can be put in good condition, and when it has become warm enough to insure prompt germination of the seed. The old saying that it is time to plant corn when the oak leaves reach the

Fig. 625. Corn smut. (Page 414.)

size of a squirrel's ear or the dogwoods are in blossom, is as definite a date as it is possible to establish.

The rate of planting is also a point that must be settled for each locality and each particular soil. For very fertile soil the usually adopted distances are $3\frac{1}{2}$ x $3\frac{1}{2}$ feet, with three kernels per hill. When planted at this rate, the stand in the fall should average at least two and one-half stalks per hill, and, with this stand, yields of one hundred bushels and more per acre are possible.

Fig. 626. Late-maturing, tall-growing corn, characteristic of the southern states. (Hartley.)

The amount of moisture as well as the fertility of the land are matters that must be considered in deciding the rate of planting. If the stalks stand thickly in the rows the crop will suffer more from dry weather than if there is a thinner stand. In some sections where the soil is light, and dry weather is usual during the growing season, best results are obtained by having the rows four feet apart, with one stalk every three feet in the row. When such thin planting as this is necessary, it is preferable to plant the corn-rows far enough apart so that peanuts, cowpeas, or some other such crop can be planted between the rows. In the leading corn states, where the greater part of the land planted to corn is rather fertile, the mistake is made of planting the corn too thickly on the poor land. Experience has taught the corn-growers that live in localities where all of the soil is light, that thin planting is necessary, and the mistake of planting too thickly is not so common as in sections where the greater part of the land is fertile. The result of planting too thickly is to reduce the size of the ears and the production of grain, and to increase the amount of forage.

The rate of planting field corn varies from six quarts to one bushel. For silage, nine to eleven quarts are planted.

Cultivation.—Two principal results to be attained in giving corn good cultivation are, first, the prevention of the growth of weeds, and, second, the retention of soil moisture.

It is always much easier and more satisfactory to prevent the growth of weeds or destroy them soon after the seeds germinate than it is to attempt their destruction after they have attained a firm foothold. Wide weeders and harrows with slant-back teeth are very good implements for preventing weeds getting a start ahead of the corn. As they are rather light, and it is not desirable that the teeth penetrate the ground more than an inch, very wide ones can be used and a good deal of land passed over in a day.

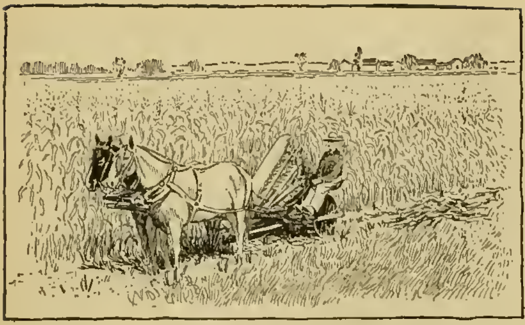

Fig. 627. Corn-harvesting scene near Belleville, Kansas.

Weeders are most advantageous on light lands between the planting and the time the corn comes up. When the corn reaches a height that will not permit of the use of weeders or harrows and it becomes necessary to use cultivators, fenders should be attached to the cultivators so that the young plants will not be covered by clods or injured. In many sections, surface cultivators are used very successfully. These cultivators have horizontal knives that scrape only about an inch under the surface of the ground and cut off any weeds that have started. In some instances, when the corn is young and the ground has become water-soaked by excessive rains, it is advisable to give deep cultivation to facilitate the aëration of the soil. As nearly as possible a thorough shallow cultivation should follow every heavy rain. If the ground is left in a crusted condition the moisture passes rapidly into the air, while the formation of a dust-blanket will retain the moisture for the use of the plants. The mistake is often made of delaying the cultivation until a large part of the moisture has escaped. If the ground has become hard, and crusted and dry, it is usually better to defer cultivation until a rain occurs, as a cultivation when the ground is dry and hard will cause it to break up in large hard clods and will hasten evaporation rather than prevent it. The writer has seen many fields of corn ruined by being cultivated at the wrong time that would have produced good crops if the cultivation had been given at the proper moment. Even after the corn has become too large for the use of the double cultivator, it is often advisable to restore the dust mulch by means of one-horse cultivators.

Fig. 628. Cutting corn with the harvester with bundle-carrier attachment. Louisiana.

Harvesting.—In the northern and north-central parts of the United States, where corn is grown extensively, a large part of it is harvested by means of corn-binders or corn-shockers. In the extreme northern part, where the stalks make but a very short growth, wheat-harvesters are sometimes used for harvesting the corn, but such a practice is not to be advised, because the binder is not made for such heavy work. On very rich soil in the southern states the stalks grow too tall to admit of a satisfactory use of corn-binders, and such corn is usually cut by hand or the ears jerked from the stalks. For many years it has been the custom in the southern United States to obtain forage by stripping the blades by hand from the standing stalks (Fig. 629), but the scarcity of manual labor makes this practice unprofitable.

In the leading corn-growing states, the great bulk of the corn is husked by hand in November and December. Large quantities are husked from the shocks in the field, while a greater quantity is husked from the standing stalks and thrown into wagons that precede the huskers in the field. A high sideboard or throw-board is placed on one side of the wagon-bed to catch the ears and cause them to fall into the wagon.

Implements.

There has been a gradual evolution in regard to the machinery used, both in cultivating and in harvesting corn, and the tendency is to advance to larger and more effective machinery that takes the place of manual labor. From one-horse cultivators that require that the field be crossed at least twice for the cultivation of a single row (Fig. 619), an advance was made to the double cultivator or two-horse cultivator, which completes a row each time the field is crossed (Fig. 622). At the present time two-row cultivators are used very satisfactorily in connection with corn planted by

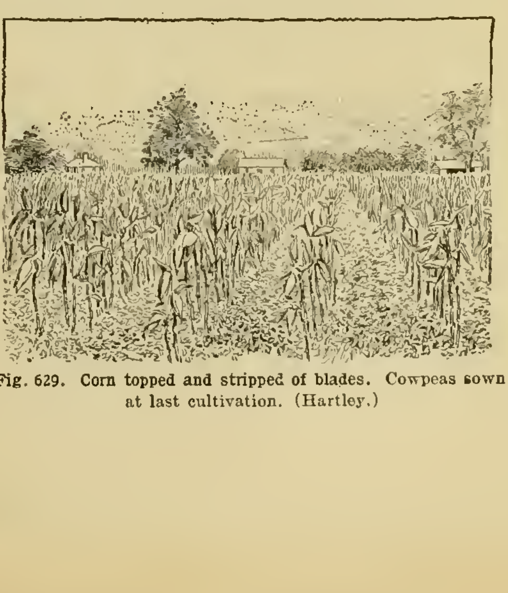

Fig. 629. Corn topped and stripped of blades. Cowpeas sown at last cultivation. (Hartley.)

two-row corn-planters. When so planted, each pair of rows is at every point the same distance apart, so that a man can cultivate two rows as easily as one. For cultivating listed corn, three-row disk-cultivators are sometimes used, which completely cultivate three rows each time the field is crossed, four horses being used. These cultivators are provided with sufficient play so that the disks of the cultivator are guided by the ridges made at the time the corn was planted.

Corn-huskers and shredders are now growing in favor, which strip the husks from the ears and at the same time tear or chop the fodder into very fine particles. In this condition the fodder is fed with less waste. Corn-picking and husking machines designed to gather the ears from the standing stalks, husk them and deliver them into wagons driven by the side of the machine, are used to some extent and will probably be improved so that they will be more generally employed.

Corn products.

To a very slight extent compared with the amount of corn grown, the parts of the corn plant other than the grain are used in making various manufactured products. The silks are used as a filter, husks for the making of mattresses, the pith of the stalk for the packing of coffer-dams of battleships, the outer part of the stalks for the making of pyroxylin varnish and paper, cobs for the making of corn-cob pipes. The leaves and husks are ground finely and mixed with corn oil-cake to form a feed for chickens and cattle. So varied are the products obtained from different parts of this plant that one factory alone manufactures forty-two distinct products.

Corn oil as extracted from the germs, usually by hydraulic pressure, is one of the most valuable products obtained from corn. It is used for culinary purposes and is vulcanized as a substitute for India rubber. About 75 or 80 per cent of the corn oil manufactured in this country is exported. In 1903 the United States exported 3,778,935 gallons of corn oil, valued at $1,467,493; the next year the exportation amounted to 3,222,875 gallons, valued at $998,613; in 1905, 3,108,917 gallons, valued at $890,973; for 1906 the exports of this product reached a value of $1,172,206.

Some of the leading products made from the grain of maize other than those mentioned are glucose, dextrine or American gum, alcohol and whiskey, starches, both edible and laundry, grits, hominies and a great variety of table products.

Enemies.

While this crop is preyed on by numerous enemies, such as rodents, crows, insects and fungous diseases, there are but few that sometimes destroy the whole crop.

Root-worm.—The corn root-worm is one of the most injurious corn pests. At times its depredations become very apparent and entire fields are destroyed, but generally its injuries are moderate and widely distributed, so that the corn crop is cut short by millions of bushels and the cause not known or realized. The larva of the corn root-worm that does injury in the southern states is a slender, thread-like, yellowish white worm with a brownish head. It is about one-half inch long. Plants injured by this root-worm usually show one or more small round worm-holes just below the surface of the soil near the upper whorl of roots. Because it often begins its destruction as soon as the young plants begin their growth, it is commonly called the "bud-worm."

The corn root-worm of the leading corn-producing states differs slightly from the southern corn root-worm. The larva is smaller, four-tenths of an inch long. The eggs hatch in the soil and the worms mine longitudinally either up or down through the corn roots. The adult does not possess the twelve black spots of the southern root-worm but is of a uniform grass-green color, and feeds mostly on the pollen and silks of the corn plant. While the green beetles do some damage by gnawing on the silks, it is in the larval stage that this

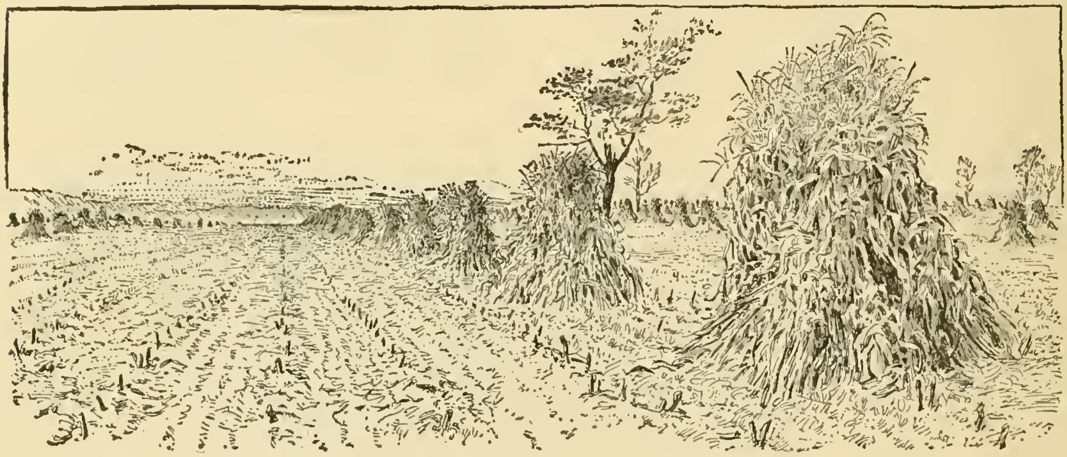

Fig. 630. Corn harvest scene in the middle West. Preparing for wheat.

insect destroys the corn crop to the greatest extent.

Cutworms.—There are many different species of cutworms, and the life-history of the different kinds differs considerably. They destroy some young corn plants in almost every corn-field and occasionally destroy entire crops. Such destruction is most likely to occur when old meadows or pastures are plowed in the spring and planted in corn. Early fall-plowing is very effective in preventing destruction of corn by cutworms. They can be poisoned by scattering about the field bran to which has been added Paris green and molasses in about the proportions of thirty pounds of bran, one pound of Paris green, two quarts of molasses and enough water to moisten the bran. Succulent clover or alfalfa can be sprayed thoroughly with Paris green, then cut and scattered in small quantities where the worms are most destructive. Often when the entire field is severely attacked it is best to disk or till the ground, then wait a week or two and plant again. The writer has seen fields treated in this way in which the first planting was entirely destroyed and the second planting uninjured, resulting in a big yield of corn.

Webworms.—If the destruction is the work of sod webworms, it is not advisable to plant the field a second time till late in May, on the 40th parallel, as the worms begin to pupate at that time. Webworms are easily distinguished from cutworms by being much smaller, about one-half inch long. They eat the young plants but usually do not cut them entirely off as do cutworms. Like the cutworms, they pass the days under clods near the base of the young plants. They are enclosed in a silken web, the web having small particles of earth attached.

Chinch bugs and grasshoppers often enter corn-fields in great hordes from adjoining fields. When wheat is harvested, chinch bugs may enter adjoining corn-fields in sufficient numbers to destroy the corn crop. If the work is begun in time, they can be trapped successfully as they are about to enter the corn. A strip ten feet or more wide should be plowed, disked and harrowed into a dusty condition. Through this strip one or more dusty furrows or ditches should be made by dragging a log back and forth. If well made, the dusty sides of the ditch will prevent the bugs from escaping, and the digging of holes at intervals in the ditch will cause them to be caught in large quantities in the holes. They can then be killed by pouring kerosene on them. Should a rain interfere with the preservation of the dusty trenches, a strip of coal-tar can be substituted to prevent the bugs entering the corn. [See page 42.]

If begun in time, grasshoppers can be prevented entering the corn by frequent use of wide catchers. These are drawn rapidly around the field or over adjoining meadow or stubble. Early morning is the best time. As the grasshoppers take wing, the canvas comes in contact with them and they fall into the pan. They can be caught in large quantities and furnish good food for poultry, especially turkeys. If used for this purpose, water, rather than kerosene, should be placed in the pan of the catcher.

Fig. 631. Husking corn in the field by hand. The old way, and still followed in very many parts of the country.

Crows take warning readily and will not trouble a field for several days after a few of them have eaten grains of corn that have been soaked in a strychnine solution. Alcohol dissolves strychnine more readily than does water. The corn should be soaked in the strychnine solution for a day or two and placed about the field soon after the corn is planted and before the crows begin pulling up the young plants.

Corn smut (*Ustilago zeæ*) does some injury to almost every corn-field. It reduces the total yearly corn production of the United States by perhaps 2 per cent, or, in other words, reduces the income from our farms twenty million dollars each year. Treatment of the seed is of no avail. The brown or black spore clusters that form in huge masses on different parts of the corn plant contain millions of spores which do not affect other plants directly, but which carry the fungus through the winter and grow in manure or decaying vegetation, forming other spores which start the disease in the next year's crop. They gain entrance at any point where the tissue is tender and growing, and especially easily where the tissue is broken. The best known means of prevention is burning the infected plants and crop rotation. Corn-stalk manure should not be applied in the spring to land that is to be planted with corn that season. (Fig. 625.)

Remedies.—It is very fortunate that crop rotation and fall-plowing, two of the leading features of good soil treatment, should also be the best-known methods of preventing depredations from the most destructive corn pests. Depredations from cutworms, webworms, corn root-worms, wireworms, the corn root-louse, stalk-borers, corn bill-bugs, and corn smut are prevented successfully by crop rotation and fall-plowing.

Maize-Growing for the Silo. [See also *Silage.*]

By *Jared Van Wagenen, Jr.*

The ensiling of cattle foods may be defined as the preservation of green or moist forage products by packing them in bulk in such a way that the subsequent heating shall expel the air and check the processes of decay, so that the forage will remain green and succulent and wholesome, and be practically unchanged after the first fermentation has run its course. The success of the process depends partly on the fact that the heat of the initial fermentation is so great that many of the germs of decay are killed, and partly to the oxygen, which is entangled in the mass, being replaced by the carbonic acid gas that is formed and that acts as a bar to further changes.

Fig. 632. A harvest of 10,000 bushels of corn, on farm of H. B. Woodbury near Cawker City, Kansas. The product of 200 acres.

The history of ensiling in Europe and America affords an excellent example of the evolution of agricultural methods. At times the practice has been subjected to sweeping condemnation and at other times it has suffered from over-zealous friends. The idea has been prominently before the agricultural world for twenty-five years, and ensiling may now be said to have become a settled practice in all dairy-farming, and to a less extent in beef- and sheep-feeding operations. Its highest development has been reached in those dairy communities which lie in the northern part of the corn-belt.

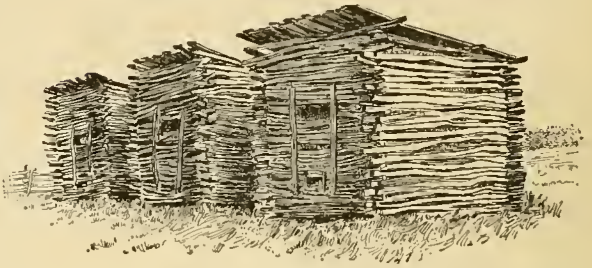

Fig. 633. Old-fashioned rail corn-cribs.

Corn as a silage crop.

The corn plant, with its large, solid, succulent stalks which do not air-dry easily but which ensile very readily, is preëminently the silage plant, and throughout the great dairy sections of the North most of the corn is handled through the silo. At one time or another ensiling has been recommended as a method of handling all the following crops: Corn, clovers, alfalfa, meadow grasses, cowpeas, soybeans, Canada field-peas, sorghum, sunflower, millet, and, in fact, all crops used for forage, apple pomace, beet pulp, and canning-house refuse of various kinds. These have been ensiled with more or less success, but never with advantage over corn. Sometimes some of them are used to advantage with corn, as the last cutting of alfalfa. But corn has been and is likely to continue to be the peer among crops for the silo. It loses somewhat in feeding value when put in the silo, but with proper care the loss need be very little,—4 to 8 per cent of the dry matter. In any event, it is less than when the fodder is cured in the field.

Silo construction.

It is of interest in this connection to mention briefly the evolution of silo construction. In its earliest development in Europe, the silo took the form of stacks of wet grass or ricks covered with earth. In the United States it was first a walled pit in the earth and later a masonry structure above ground, and it was thought essential, after filling, to weight the mass very heavily, often with stones or barrels of sand. These methods have now only historical interest. The wooden silo may be said to have passed from a square or rectangular structure, built like a barn frame, having double boarding with tarred paper between, to a cribbed-up hexagon or octagon, and then to a structure of thin boards bent around a circle of studs, every board forming a hoop,—the so-called Wisconsin idea. Now the silo almost universally has taken the form of a tank-like vessel built of wooden staves, usually two inches thick, tongued and grooved and drawn tight together by round iron hoops fitted with devices for shortening them as may be necessary. There is every indication that this represents the final step in the evolution of the silo, and that in its essential character this will remain the permanent form. Possibly as the years go by, the difficulty in securing suitable lumber may result in the general adoption of concrete, built in cylindrical form, with heavy wire or light iron rods laid in the mold to strengthen it.

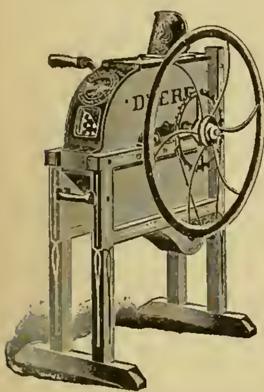

Fig. 634.
One-hole corn-sheller.

Hemlock, pine, cedar and cypress are all used extensively in silo construction. The cypress is doubtless best, but its price is rapidly making it almost prohibitory. We have not as yet much data regarding the life of the stave silo, but even hemlock endures for as much as fifteen years, providing the silo stands empty during the warm months, in a dry, airy place. When filled and kept for summer feeding, thus remaining damp, its life is greatly shortened.

Cultural methods.

Varieties and quantity of seed.—The best varieties of corn and the thickness of planting for silage are a somewhat different problem from when the ripe grain is the only object. When the crop is intended for the silo, the feeding value of the stalks is no less important than that of the grain, and the question really resolves itself into: What varieties and how much seed will afford the greatest quantity of digestible nutrients per acre? In general we may say that the best condition of the crop for the silo does not demand complete ripeness, so that it is advisable to use one of the larger and later varieties of corn even in the North, as this will give greater tonnage. Thus, near the northern limit of the corn-belt, where only the flint type of corn is raised for grain, it is generally best to plant one of the dent varieties for the silo. Usually it is best to plant the largest variety of corn that will become reasonably mature in the locality.

The same line of reasoning applies to the question of the thickness of the stand. Many more stalks will be advisable for silage than when the crop is raised for the grain alone. In fact, the Illinois station arrived at the conclusion that the greatest amount of nutrients would be secured when the corn was planted so thickly that the ears were choked down to not more than half their natural size. Under Illinois conditions the most sound grain was secured by a seeding of about ten thousand stalks per acre, but for silage purposes at least twice as many are advisable, or say a stalk every seven inches when planted in rows three and one-half feet apart. This number would be supplied by seven to nine quarts of seed per acre, provided germination were perfect and no plants were destroyed; but the writer, after considerable experience in growing corn for the silo on high lands in eastern New York, has arrived at about eleven quarts of seed per acre, preferring to err on the side of too thick planting rather than long unoccupied spaces. This, of course, provides for a considerable margin for poor seed, and the cutworm and the crow.

Method of seeding.—Corn for silage is usually drilled in with a regular one-horse corn drill, one row at a time, or with a common eleven-hoe grain drill, with all the hoes but two removed. This implement will do very satisfactory work, planting two rows at a time, about forty-two inches apart.

Manuring.—The silo is an outgrowth of the dairy industry, and wherever it is found large quantities of stable manure are available. The almost universal practice is to grow corn on sod ground—old meadows—to which manure has been applied in the preceding winter months.

Rotation.—Generally the special dairy-farmer employs a rotation of corn for the silo, oats and grass, the seeding being made with the oats, and the mowing kept for two or more years.

Companion cropping.—It has long been realized that the most serious defect of the corn plant is that it carries too small a percentage of protein to give the best results in feeding, and efforts have been made to grow other crops in combination with the corn to be cut into the silo with it. Cowpeas in the South and soybeans in the North have sometimes been planted with the corn, and they have resulted in an increase of the total food constituents per acre and at the same time have given a product of greater value for milk production. This is a very suggestive field for experimentation.

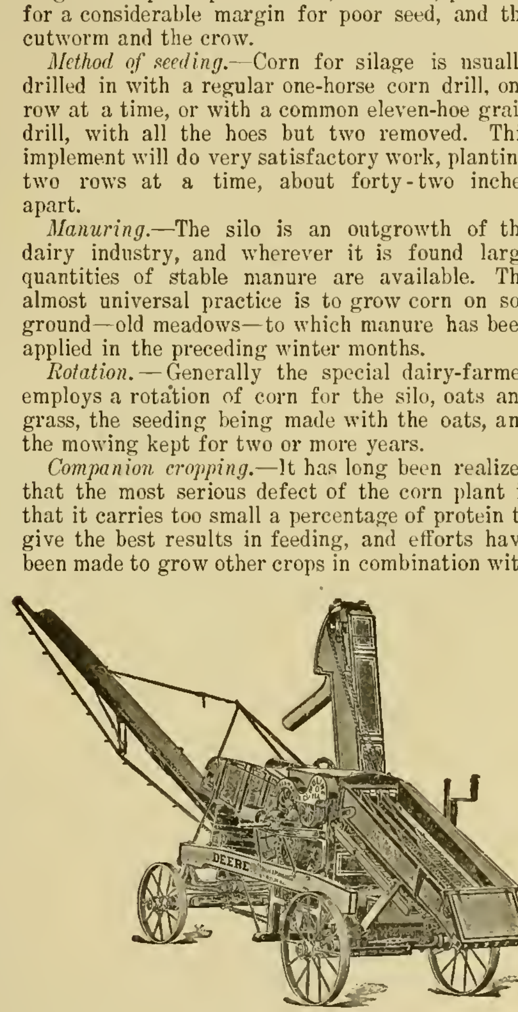

Fig. 635. A mounted corn-sheller.

Subsequent care.—The subsequent culture of corn for silage is essentially the same as when the crop is grown for ripe grain. Inasmuch as more seed per acre is used and it is planted in drills instead of hills, greater use can be made of such cultural devices as the smoothing harrow and the various weeders, because the destruction of an occasional corn plant is a less serious matter.

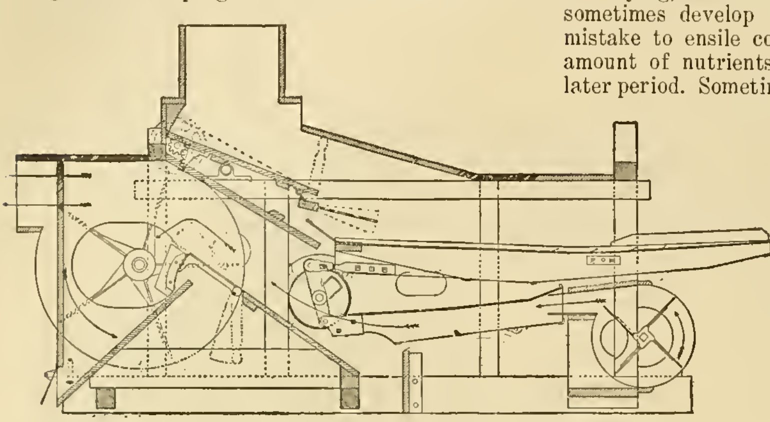

Fig. 636. Skeleton view of a corn-cleaner.

Harvesting and ensiling.

Corn should be put into the silo a few days before complete maturity. In general, the proper stage will have been reached when the lower leaves of the plant are turning yellow and some of the earlier ears are dented. It is possible to make good silage from corn that is fully ripe, but the coarser parts of the stalks are less palatable and the grain may be so hard that much of it will pass through the animal undigested. On the other hand there is no other stage in the growth of the corn plant when the quantity of nutrients is being increased so rapidly as during the ten days just preceding full maturity, and the ensiling of corn too early results in very serious loss. Probably it will be better to err on the side of too great maturity than to put the corn in the silo too green.

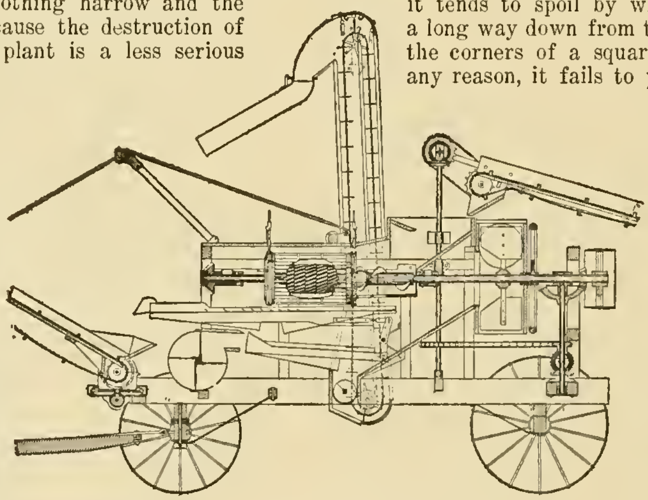

Fig. 637. Sectional view of a cylinder corn-sheller.

While there is doubtless one best time to put corn into the silo, yet there is fortunately a considerable range of conditions within which corn may be ensiled with excellent results. If put in very immature and without partial drying, it will become excessively acid and will sometimes develop disagreeable flavors. It is a mistake to ensile corn in this condition, for the amount of nutrients is very much less than at a later period. Sometimes, however, it may be necessary to handle late corn in this condition when frost is at hand. For example, south of Pennsylvania, in the trucking and canning sections, excellent crops of silage corn are often secured after a crop of garden peas, but the corn may lack maturity when frost comes. Corn that is over-ripe or even badly frosted and dried will make good silage if there is a fair amount of moisture remaining. The less water in the corn when cut, the more serious the surface loss will be. When very dry, silage is almost free of acid, but it tends to spoil by white mold. It molds a long way down from the surface and near the corners of a square silo, or where, for any reason, it fails to pack tightly.

Corn has occasionally been put into the silo without any shredding, by laying the stalks compactly, shingle fashion. It is possible to make a very fine quality of silage in this way, but the care and difficulty, both in putting in and in feeding out, has led to the abandonment of the practice. The corn is nearly always cut or shredded into the silo. Ordinarily, the finer it is cut the better the results, owing to the more intimate mixture of the grain and leaves and the more compact settling.

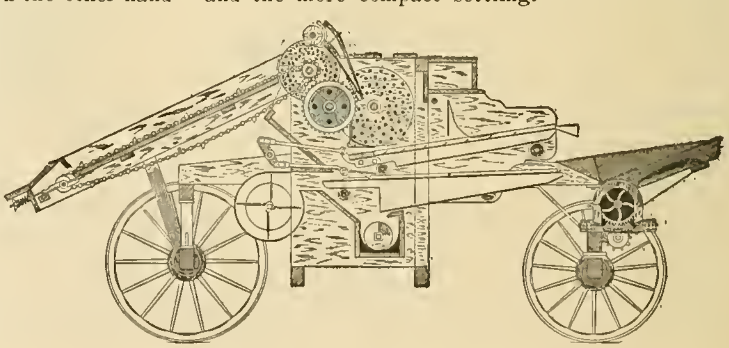

Fig. 638. Skeleton view of combination force-feed sheller.

It is not a vital matter whether a silo is filled hurriedly in a day or two, or more gradually in a week or ten days. A silo which has been filled very quickly will begin to settle rapidly almost at once, and in the next ten days or two weeks will go down perhaps 20 per cent of its total depth. Hence the slow filling, giving an opportunity for the silage to settle, results in getting much more food in the same cubic space.

Covering.—The best way to cover a silo is to begin to feed out of it the day it is filled. In this way, surface loss will be almost wholly avoided. When this method is not feasible, it will be necessary to cover the silage with some material, otherwise the upper foot or more will spoil. Any kind of straw or chaff well wet down, swamp grass, green buckwheat-straw or even sawdust, will do nicely. Possibly it will be just as well to snap off the ears of the last two or three loads of corn and let the stover act as a cover. Sometimes no covering is put on, but instead the top layer is thoroughly wet down. This results in the rapid fermentation of the surface few inches, making an air-tight covering for the silage below. The watering is done at the rate of two to two and one-half gallons per square foot of surface.

Harvesting machinery.— The corn harvester or binder in its present form has been in use about ten years, and its use is becoming well-nigh universal in handling the crop for silage. It is drawn by two or three horses. It cuts the corn and binds it into convenient sized bundles for feeding into the cutter. Under favorable conditions a machine should handle five to eight acres per day. In a recent season the writer used 118 pounds of twine, worth say $13, in binding an estimated crop of 300 tons of silage. The harvester, on the whole, is exceedingly satisfactory in its operation. By a system of carrying chains and devices for straightening up the stalks, it is able to cut and bind corn even when it is badly lodged and tangled. The advantage lies not only in the labor saved over cutting with corn-knives, but to an even greater extent in the subsequent loading on wagons and feeding into the cutter.

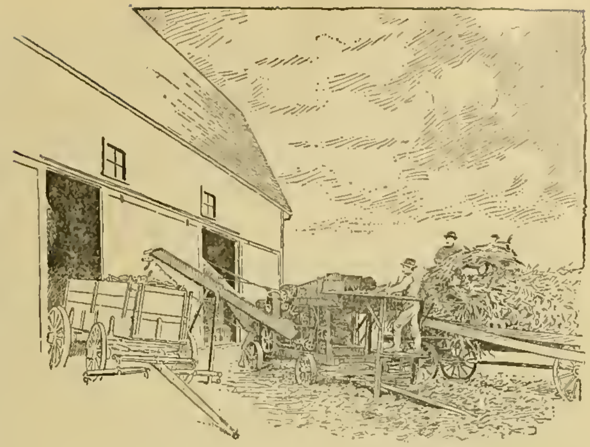

Fig. 639. Corn husker and shredder at work.

Fig. 640. Use of conveyor in making silage.

The machinery for cutting silage and elevating it into the silo is of two distinct types. In one, the cut material is elevated by means of a running elevator of sprocket chains, bearing wooden slats or sheet-iron buckets, which carry the corn away from the knives. The other type is known as the blower or pneumatic elevator, in which the cut forage is blown into the silo through a sheet-iron pipe by a very powerful blast of air, generated by a fan or by blades fastened to the head to which the knives are bolted. The first type is the earlier one. Its disadvantage is that to set up and adjust the slat carrier for a tall silo is rather difficult. Its advantage lies in the fact that it can be operated with much less power and at greatly varying speeds. A six or eight horse-power engine will generally be ample. The advantage of the blower type lies in the fact that it is very much more quickly set up, and that the corn can be taken care of in the silo more easily, as it is a more uniform mixture of the leaves and heavier parts of the plant. Its disadvantage is that very much more power is required and the speed must not fall below a certain minimum or the machine will clog. The blower type is steadily becoming the more popular in silo districts.

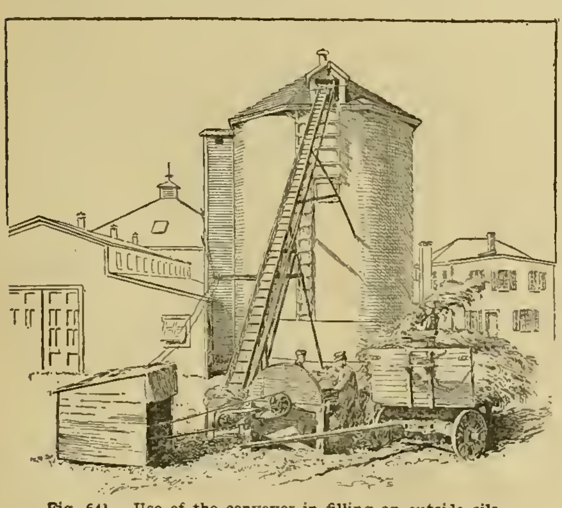

Fig. 641. Use of the conveyor in filling an outside silo.

Place of silage in the ration.

The question of feeding silage belongs more especially to the domain of animal nutrition. However, it may be said in passing that about fifty pounds daily may be regarded as the maximum ration of silage for a cow, and this amount is rather more than is usually fed. The writer thinks that a silo filled with good corn in the month of September offers by far the most satisfactory solution of the problem of feeding a cow during the months of summer drought. If the dairyman has in mind some summer feeding to supplement the pastures (and he should expect to do this to some extent), he will need about five tons of silo capacity for each cow. The tables of capacity provided by manufacturers are fairly dependable. Under ordinary field conditions, the yield of silage will range from eight to twenty tons per acre. Silage may make up the larger part of the roughage, but some hay should be provided in addition. It is now an established fact that liberal rations of good silage are not incompatible with the health of the herd and with milk of the very highest standard of purity and flavor. It is not easy to over-emphasize the usefulness, not to say the virtual necessity, of the silo in successful dairying. Its greatest advantage in feeding lies not in the fact that animals do better on silage than on dry corn fodder, but more especially in the saving of labor. The silo ranks with the centrifugal separator in its effect on dairying.

Popcorn. *Zea (Mays) everta. Gramineæ.* Figs. 642, 643.

By *J. G. Curtis.*

The popcorns are a special group of flint corns used for "popping," as the name suggests, for eating out of hand or in confections. They are characterized by the small size of the kernels and their excessive hardness, and by the excessive proportion of the corneous endosperm or horny substance contained in the kernels, which in turn contains a large percentage of moisture and gives the kernels the property of popping or turning almost completely inside out on the application of heat. In structure and composition popcorn varies but little from ordinary flint and dent corns, but since it yields so much less it is never grown for market as a stock-food. The stalks of popcorn are considerably smaller than those of field corn and vary in height from four to twelve feet, with a general average of about eight feet. In color they are usually rather lighter green than the flint corns, but may vary through all the shades of green, and even to a very dark red in some instances.

The actual popping of the kernels has been shown to be due to the expansion of moisture in the starch-cells, the application of heat converting the moisture into steam, making the cell-walls give way and causing an explosion with sufficient force to alter the entire form and texture of the kernel.

The value of popcorn lies almost wholly in its tendency to pop completely into a large, irregular, flaky mass, since this is the only form in which it has a sufficient value as an edible product to make it worthy of cultivation. While in popping it loses in weight about 10 per cent, due to the evaporation of moisture by the heat employed, it should increase in bulk in the ratio of at least sixteen to one, and under the best conditions as high as twenty to one. There are several factors which control this result, such as the even application of heat and the condition of the corn. It may be too damp or too dry for best results, and since the moisture content is high when the corn is harvested, it is usually held over one season before marketing.

Distribution.

Popcorn is grown successfully throughout the northern half of the United States wherever other corn can be grown, and to a small extent on the heavier soils of the Piedmont section of the southern states. However, there has been a wide change in the methods of production within the last quarter-century, and whereas it was at one time planted in nearly every garden throughout New York and the New England states, it has gradually come to be a sort of special farm crop grown in a commercial way by men who have found it profitable and have made the growing, handling and marketing of the crop a special study. This change is also coincident with the development of certain parts of the Middle West which, because of soil and climatic conditions, have proved especially adapted to the growth of the crop. The great bulk of the crop is now grown in Iowa, Michigan, Illinois, Wisconsin and Nebraska.

Some idea of the magnitude which the business has attained in certain favored localities can be gained from the statement that from one shipping point in Iowa in 1905 there were shipped more than three hundred car-loads of popcorn.

Varieties.

There are about twenty-five different varieties of popcorn, but these are simply variations of the two distinct types or classes known as rice corn and pearl corn. (Fig. 643.) The rice corn has kernels more or less pointed, with the outer coat, where

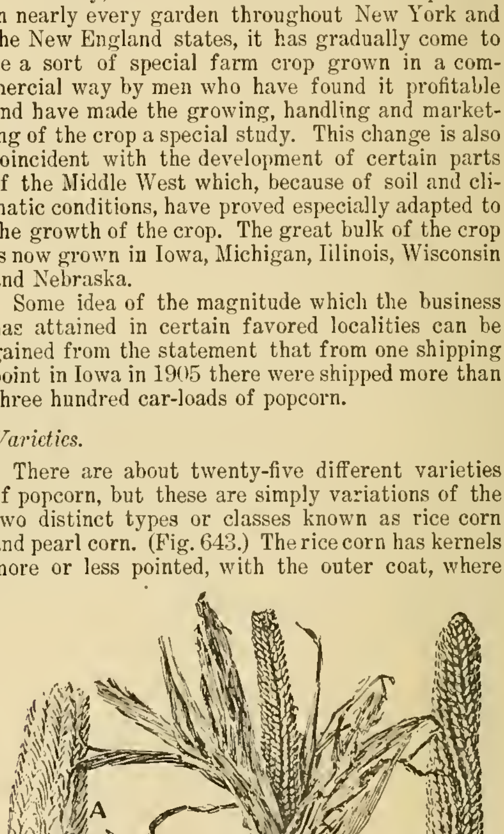

Fig. 642. Three stages in the possible development of rice popcorn from the wild Mexican podcorn. A, Wild Mexican podcorn; B, stage of partial development; C, modern white rice popcorn.

the silks were attached, continued into a sort of spine, which may either stand almost erect or may be depressed by the crowding of the husk on the ear. The pearl corn has kernels rounded or flattened over the top and very smooth, the point of the attachment of the silk being lower down on the same side of the kernel as the germ. These two classes may be divided into early, medium and late, and these again into white, yellow, and colored (not yellow).

All of these varieties cross with each other so readily that it is difficult under ordinary methods to keep a variety strictly to any given type. The different varieties of both the rice and pearl corn may vary as to color through the several shades of white, amber, yellow, red and black, also red and white striped.

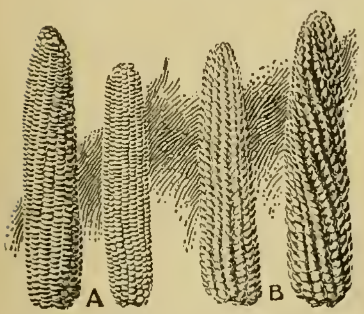

Fig. 643. Popcorn. A, Typical ears of white pearl; B, typical ears of white rice.

Some of the best known white rice varieties are the Monarch Rice, Snowball and Egyptian. Of the white pearl varieties, the Common White Pearl, Mapledale Prolific and Nonpareil are standard varieties. Of the yellow pearl varieties, the most valuable are the Queen Golden and Dwarf Golden, each of which has a yellowish color when popped and has the taste peculiar to yellow corn. The black varieties are grown only in a small way as novelties, and the same may be said of the Golden Tom Thumb, which is a dwarf yellow variety that is so small that it has no value except as a curiosity.

Two typical varieties or groups may be described as follows (Illinois Experiment Station, Bulletin No. 13): White rice: Stalk 7 to 8 feet high, rather short-jointed, leafy, dark green; tassel long, slender, with few branches, drooping; suckers many, growing to about half the size of the parent stalk; very few husk blades. Ear 3 to 5 feet from the ground, strongly tapering, dull white, with a white cob 5 to 7 inches long, 1.3 to 1.75 inches in diameter; cob .65 to .8 inches thick; kernels rounded over the butt of the ear and usually filling out the tips; rows of kernels fourteen to twenty, regular pairs of rows not very distinct. Kernel pointed, the tip being continued into a spine which is either depressed or nearly erect, .15 to .2 inches wide, .3 to .35 inches deep. White rice corn was ripe enough to cut in 132 days from planting. A single plot yielded in 1889 at the rate of 86.3 bushels per acre. This differs from Monarch rice in having a shorter ear with a greater number of rows of kernels, and the kernels more slender.

White pearl: Stalk 7 to 8½ feet high, rather large; blades large, dark green; tassel long, with few branches, drooping; suckers many, reaching about three-fourths of the size of the parent stalk. Ear 3.5 to 4.5 feet from the ground, nearly cylindrical, clear white, with a white cob 6 to 8 inches long, 1 to 1.4 inches in diameter; cob .55 to .65 inches through; kernels even at the butt; tip usually well filled; rows of kernels ten to fourteen, regular. Kernel .2 inches broad, .25 inches deep, very smooth, somewhat flattened over the top. One plot of white pearl with 88 per cent of a full stand yielded forty-one pounds of ears, or at the rate of 46.1 bushels per acre. The ears are long, slender and smooth. It differs from the common white in having longer and more slender ears and in making a much smaller growth of stalk. It was ripe enough to cut in 125 days from planting.

Culture.

Soil.—Any well-drained fertile soil, except a low peat or muck soil, is suitable for the growth of popcorn. A muck soil usually has an excess of nitrogen during the warm weather in the latter part of the season, which tends to cause too much growth of stalks at the expense of well-developed ears. This, of course, can be overcome to some extent by liberal applications of potassic and phosphatic fertilizers, which will furnish the plant a better balanced food-supply; but since this tendency to run largely to stalk is general with popcorn under the best conditions of fertility, it is obvious that planting it on muck soil would increase the fault.

Fertilizers.—Whether the soil is sand, gravel, loam or clay, it must have a sufficient quantity of available plant-food elements to give the best results. In furnishing any or all of these, one should remember that they are not needed to grow any specific crop, but rather to overcome deficiencies of available plant-food in that particular type of soil. All of these types of soil are usually lacking in available nitrogen unless well supplied with humus, and it should be supplied in large applications of organic matter, either in stable manure or by the use of cover-crops; and even then there will be a deficiency of available nitrogen early in the season, which should be supplied by a broadcast top-dressing of nitrate of soda, at the rate of one hundred to two hundred pounds per acre. The application is made when the corn is two or three inches high.

For best results, the mineral elements, phosphorus and potassium, should also be applied at the rate of 400 pounds of acid phosphate (14 per cent available) and 100 pounds of sulfate of potash (50 per cent actual) per acre; these to be mixed together and drilled into the soil with the fertilizer drill three or four inches deep before planting.

Seed.—In the growing of popcorn on a commercial scale, the selection of seed has more to do with success or failure than any other one factor. It is said that a man is the sum of his ancestors, and so is every plant that is propagated by means of a seed. It is not enough that we go through the field when the corn is ripe and select ears for seed from fine, healthy, productive individual stalks; we must try to guard against the possible chance that any of the kernels on the ear which we select for seed could have been fertilized with pollen-grains from the tassel of another plant that may be either poorly developed or entirely barren. In other words, we must breed up our seed corn to the special type best suited to our needs, for the same reason that we breed our animals for special purposes;

and the same general principles seem to underlie the process in either case and the results are equally satisfactory when intelligently employed.

The breeding of popcorn for seed purposes can best be done by growing the seed corn in a part of a field by itself that can be given a little extra fertilizing and care. The seed with which it is planted should be from typical ears that are as uniform in size, shape and color as possible, since they are to be the foundation stock from which the future strain of seed corn is to be developed.

After planting the breeding plot, the only extra work necessary is to go through the plot just before the tassels begin to shed their pollen and remove the tassels and ears from those stalks which are barren or otherwise inferior. Then, when the corn is ripe, by careful selection of seed ears from the best of those remaining and with proper handling and storing the results are sure to follow.

Place in the rotation.—When grown in a regular rotation of crops, popcorn usually takes the place of the ordinary field corn and for much the same reasons, although frequently it is grown in place of one of the "money" crops, such as potatoes. This is often the case when the soil is too heavy for potatoes. The rotation then has to be arranged so that the popcorn and field corn are not grown in adjoining fields, as the pollen is carried by the wind and they become mixed very easily, which affects the quality and appearance of the popcorn.

Planting.—For the main crop the seed should be planted about May 25 to June 5 in the latitude of central New York, or as soon as danger of frost has passed and the ground has warmed up so that the seed will germinate and not rot. The seed-bed should be thoroughly harrowed and pulverized. The planting should be done with a corn-planter or an ordinary grain drill, making the rows three and one-half feet apart and dropping the kernels every six to eight inches in the row.

Subsequent care.—The field should be rolled immediately after planting; and it should be gone over cross-wise of the rows with a light slant-tooth harrow or weeder every five or six days until the corn is six or eight inches high. This will tear out a little of the corn, but more than was needed has been sown to allow for this. It is a large number of well-developed ears rather than stalks that we are trying to obtain. This work with the harrow or weeder will save the expensive hand labor with a hoe. The horse cultivator should now be used at least every ten days, and oftener if necessary to break up a crusted surface after a rain. This should be kept up as long as practicable; it should be shallow, not over two inches deep, unless after long-continued rains, when it is sometimes advisable to cultivate deep to get air into the compact soil quickly.

Popcorn ripens in one hundred to one hundred and thirty-five days from planting, according to the variety, weather conditions, climate and other factors. The maturity can be hastened to some extent by using an abundance of phosphatic fertilizer; on the other hand, it is retarded by the use of large quantities of stable manure, which gives an excess of nitrogen late in the season. It is especially important that popcorn should ripen before frost comes, since if it is injured for popping it has little value for anything else. Nevertheless, the custom is general among growers in the eastern states to allow it to stand after ripening until the first frost comes before cutting it, as it is thought that the frost hardens it and improves its popping qualities.

Harvesting and storing.—It is harvested either with one of the improved corn harvesters or else by hand with the old-fashioned corn knife; in either case it is stood up in loose shocks in the field and tied with stalks or twine and left to dry and cure before husking. It is husked by hand. Where four cents per bushel of ears is paid for husking field corn, six cents per bushel of ears is usually paid for husking popcorn, as the ears are so much smaller.

After husking, if the corn is to be stored it is immediately placed in well-ventilated cribs in which it is protected from squirrels, rats, mice and other vermin. This is usually accomplished by lining the inside of an ordinary corn-crib with woven wire netting (one-fourth inch mesh) and having the crib built up on posts, each one of which has an inverted milk pan or some similar contrivance on top to keep the mice from climbing the posts and gnawing holes through the floor of the crib.

The great difficulty in keeping popcorn from one season to another without having it destroyed by rats or mice is the chief reason why the business has gradually come into the hands of a small number of growers, who are especially equipped for handling it successfully. Again, after a grower has supplied a certain trade for a few years with popcorn that will pop, the dealers come to have confidence in his corn and will hesitate to buy of a new man, which, of course, tends to discourage the new man. In some sections it is a common practice to hasten the curing of popcorn by kiln-drying in order to take advantage of the Christmas market the same season that it is harvested.

Yield.

A bushel of ears of popcorn when husked weighs 38 pounds, but when cured one season the standard weight is 35 pounds. There are 7 pounds of cobs in each bushel of ears, so that two bushels of ears (70 pounds) make one bushel of shelled corn (56 pounds) after shelling and removing the 14 pounds of cobs. Sixty bushels of ears per acre is considered a good yield, although several growers have bred up their seed until with liberal feeding and careful cultivation they are able to get between eighty and ninety bushels per acre.

Enemies.

Diseases.—The only serious disease that affects popcorn is the corn smut, which is caused by a fungus known as *Ustilago Zeæ*. The smut itself consists of the brown spores of the fungus. It injures the crop in two ways: First, by destroying the ears, causing practically a total loss; second, by absorbing the nutrient juices of the plant and thus preventing full growth, especially of the ears. The loss resulting from this one disease is estimated as about two per cent of the corn crop of the entire country. There is no known remedy that is entirely satisfactory. [See page 414.]

Insects.—In Virginia and other southern states, the corn worm (*Heliothis armiger*) is a serious pest and makes the growing of popcorn in some sections an impossibility. Wireworms and corn root-worms sometimes affect the plant, but not more seriously than they do the ordinary field corn. [See pages 413, 414.]

Marketing.

Popcorn is marketed in many different ways. The western grower usually raises it on contract at so much per pound shelled, or sells the entire crop to one of the several large dealers in the West who supply the wants of the trade throughout the country. In this case he ships it on the ear in barrels or shelled in bags, or packed in one-pound boxes for the retail grocer trade. At first the small boxes were very popular, as there was no waste for the grocer who had it on his shelves, instead of in a basket on the floor; it was soon learned, however, that it dried out too much in the boxes and would not pop so well as when left on the cob until wanted for popping. It seems that there is always moisture enough in the cob to keep the chit end of the kernel from becoming too dry and hard.

The eastern growers usually sell it to the grocers in their near-by towns at about one dollar per bushel of ears, and the grocers retail it out in small lots at five to eight cents per pound. Some of the larger growers ship their entire crop in barrels to wholesale grocers and commission merchants in the large cities, where it is sold on account.

Manufacture.

The bulk of that which goes to the large cities eventually finds its way to the confectionery manufacturers, where it is made into sugared popcorn balls, popcorn squares, prize packages and numerous other confections. There are several manufacturers whose entire output consists of popcorn confections. These are generally a mixture of popped corn and molasses, or sugar syrup, flavored with one of the fruit syrups and pressed into bricks or squares. Frequently the popped corn is ground fine and mixed with freshly ground cocoanut and sweetened with syrup, then pressed into small cakes and sold under different names, such as honey corn, fruit corncakes and the like.

The Breeding of Maize. Figs. 644–648.

By *Cyril G. Hopkins.*

Corn improvement should embrace both quantity and quality. But, because of the great importance of increased yield per acre, all selection looking toward improvement should be based first on yield, this to be followed, so far as practicable, with efforts which aim toward higher standards of quality. It is with these ideas that the following methods for corn-breeding are arranged.

Physical selection of seed corn.

The most perfect ears obtainable of the variety of corn which is to be bred should be selected. In making the selection for desirable ears, as judged from the physical characteristics, the larger the number of ears examined the better can be the selection. If the breeder wishes to improve the quality (chemical composition) of the grain, as well as the yield and type of his corn, it is recommended that he choose at least 200 ears of the desired physical type to be further examined as to quality.

Chemical selection by mechanical examination.

The method of making a chemical selection of ears of seed corn by a simple mechanical examination of the kernels is based on the fact that the kernel of corn is not homogeneous in structure, but consists of several distinct and readily observable parts of markedly different chemical composition. For our particular purpose of judging from the structure of the kernel as to its composition, we need consider but three principal parts, namely:

(1) The darker colored and rather horny layer lying next to the hull, principally in the edges and toward the tip end of the kernel. This part, while chiefly starch, is fairly rich in protein and contains one-half to two-thirds of all the protein of the kernel. (Fig. 644.)

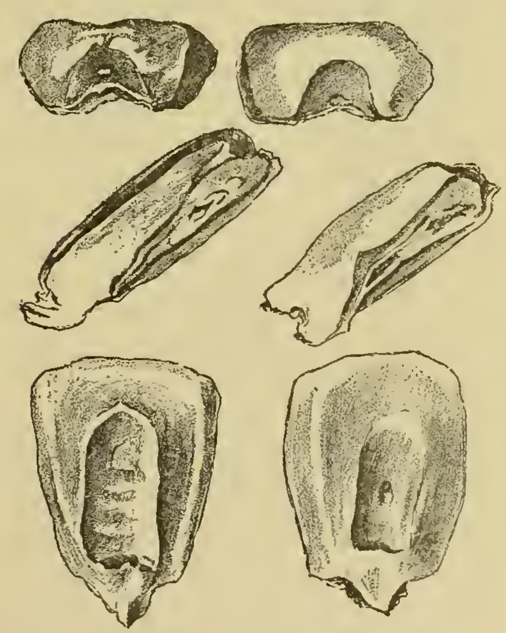

Fig. 644. Kernels of corn. On the left, high-protein kernels (much horny part, little white starch); on the right, low protein kernels (little horny part, much white starch).

(2) The white starchy-appearing part occupying the crown end of the kernel and usually also immediately or partially surrounding the germ

This part is poor in both protein and oil, consisting mainly of starch. (Fig. 644.)

(3) The germ itself, which occupies the central part of the kernel toward the tip end. This is very rich in oil. More than four-fifths of the entire oil of the kernel resides in the germ. It is also rich

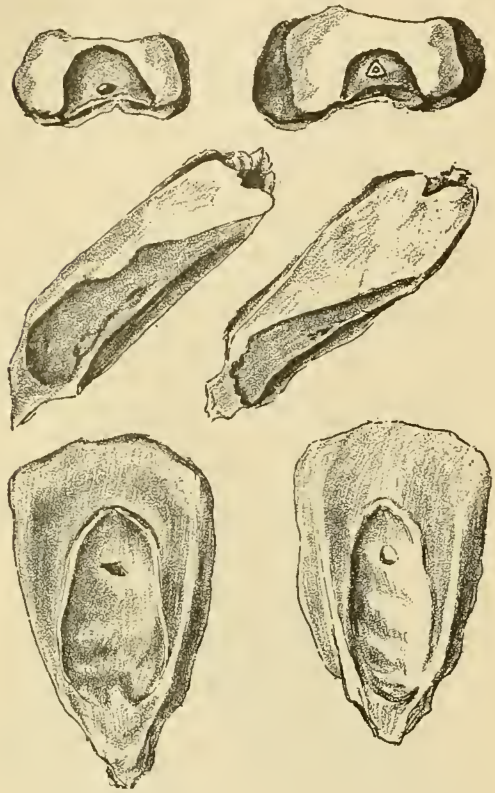

Fig. 645. Kernels. On the left, high-oil kernels (large germs); on the right, low-oil kernels (small germs).

in protein, containing nearly one-fifth of all the protein in the kernel, although the germ itself constitutes only about one-tenth of the weight of the kernel. (Fig. 645.)

In selecting seed corn by mechanical examination for improvement in composition, we remove from the ear a few average kernels, cut them into cross-sections, preferably near the tip end of the kernel (see longitudinal sections), and examine these sections as they are cut, usually simply with the naked eye, selecting for seed those ears the kernels of which show the qualities desired.

Samples for analysis.

In order that the breeder may know what he has accomplished in his work of mechanical selection, he should have an analysis made of two composite samples representing each of the two lots of ears; that is, the selected lot and the rejected lot. One composite sample should be made by taking ten average kernels from each of the selected ears (ninety-six ears preferred) and another sample by taking ten average kernels from each of the rejected ears (100 ears or more). Each of these two samples should be put into a separate sack, properly labeled, and sent to the chemist for analysis. Of course, if the breeder desires to breed for physical type and increased yield only, then no chemical analysis is needed, and all that is necessary to begin work is to select the ninety-six most nearly perfect ears obtainable for the breeding plot.

Size of breeding plot.

The best number of ears to use in a breeding plot is as yet an unsettled question. There are several conflicting factors entering into the consideration. On the one hand, the smaller the number of ears, the choicer can be the selection of the seed; while on the other hand, the larger the number of breeding rows, the better can be the selection of seed for the next crop. Then, again, there is undoubtedly some danger of evil effects from too close inbreeding by the use of too small a number of ears. From our present knowledge, however, we think that ninety-six ears is a safe number to use, so far as inbreeding is concerned, and this is the number that we suggest in these directions, it being understood that alternate rows are to be detasseled and all seed corn selected from detasseled rows.

Planting by the row system.

The ninety-six selected seed ears are planted in ninety-six separate rows. These rows should be at least one hundred hills long, but they may well be forty rods long, as the quantity of seed will usually permit this. It is recommended that these ninety-six seed ears be numbered[1] from 1 to 48 and from 51 to 98, the numbers 49 and 50 being omitted; also, that ears 1 to 48 be planted in one-half of the plot and ears 51 to 98 in the other half, preferably end-to-end with the first half, leaving one hill unplanted to mark the line between the halves, and also leaving one row unplanted to mark the line between rows 24 and 25 and between rows 74 and 75, that is, between quarters. In this way, row 51 (planted with seed from ear 51) is a continuation of row 1 (planted with seed from ear 1), and the two rows may well extend eighty rods across a forty-acre field. The breeding plot can be planted with a corn-planter, although it will require some time and patience, and if the planter is an edgedrop it will be necessary to put a suitable cone or inverted funnel in each seed box to keep the small quantity of corn to the outside. Place the shelled corn from ear No. 1 in one box and from ear No. 2 in the other; drive to the middle of the plot, thus planting rows 1 and 2; clean out the boxes; move forward one hill; put in the corn from ears 51 and 52; use the foot-trip till the corn begins to drop; then drive on and plant rows 51 and 52. Turn at the end; clean out the seed boxes; put in ears 53 and 54; plant back to the middle; clean out, put in ears 3 and 4; and then plant on back to the beginning line, thus continuing until the breeding

[1] These numbers would be 101 to 148 and 151 to 198 the first year, 201 to 248 and 251 to 298 the second year, etc. [See under Register number, page 425.]

plot is all planted. The planting may then be continued for the commercial field, using the same variety of corn, which should be of similar breeding, finishing, perhaps, with the multiplying plot on the side of the field opposite from the breeding plot.

Each one of the breeding plot rows should be numbered to correspond with the "register number" of the ear from which it is planted, as will be explained under the heading of "Register number." The breeding plot should be well protected from foreign pollen, by being planted as far away as possible from other varieties of corn.

Detasseling.

Every alternate row of corn in the breeding plot should be completely detasseled before the pollen matures, and all of the seed corn to be taken from the plot should be selected from these forty-eight detasseled rows. This method absolutely prohibits self-pollination or close-pollination of the future seed. By self-pollination is meant the transfer of pollen from the male flower (tassel) of a given plant to the female flower (silk) of the same plant; by close-pollination, as here used, is meant the transfer of pollen from the male flower of one plant to the female flower of another plant in the same row, both of which grew from kernels from the same seed ear. It is recommended that no plants in any of the rows which appear imperfect, dwarfed, immature, barren or otherwise undesirable, be allowed to mature pollen. Occasionally, an entire row should be detasseled because of the general inferiority of the row as a whole. These are only precautionary measures needing further study, while the value of detasseling to insure cross-pollination is an established fact. Detasseling is accomplished by going over the rows as many times as may be necessary and carefully pulling out the tassels as they appear. Indeed, great care should be exercised in this part of the work in order not to injure the plants and thereby to lower the yields. The tassels should not be cut off, as this produces an external injury and at the same time the stalk is often deprived of several undeveloped leaves. But the tassel should be allowed to develop far enough so that it can be separated alone at the top joint by a careful pull. It is now determined that the detasseling of the breeding rows is necessary. This insures cross-pollination and markedly increases the yield of succeeding crops.

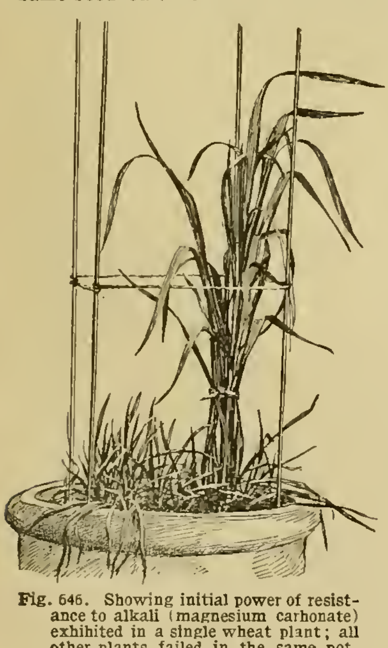

Fig. 646. Showing initial power of resistance to alkali (magnesium carbonate) exhibited in a single wheat plant; all other plants failed in the same pot. (Illinois Experiment Station.)

Selection of field rows and seed ears.

As the crop matures, the corn from each of the detasseled breeding rows is harvested. First, all of the ears on the row which appear to be good and which are borne on good plants, in a good position, and with good ear shanks and husks, are harvested, placed in a bag, with the number of the row, and finally weighed, together with the remainder of the crop from the same row. No seed ears should be taken within two or three rods of the inside ends of the rows. The total weight of ear corn which every detasseled row yields should be determined and recorded, for the yield is the primary factor in determining the rows from which all of the ears for the next year's seed selection must be taken. Each lot of ears from each of the detasseled rows, and each single ear of the ninety-six ears ultimately selected for seed, is kept labeled with the number of the row in which it grew, and finally with its own ear number also, and permanent records are made of the number and the description of the ear, the performance record of the row, and the like, so that, as the breeding is continued, an absolute pedigree is established, on the female side, for every ear of corn which may be produced from this seed so long as the records are made and preserved. It should be the plan to record every fact that bears on the question of efficiency of the plants. We also know absolutely that we have good breeding on the male side, although the exact individual pedigree of the males cannot be known and recorded.

Fig. 647
Showing hereditary power to resist alkali (magnesium carbonate): third generation of resistant plants compared with ordinary plants growing in the same soil. (Illinois Experiment Station.)

Planting for cross-pollination.

In order to insure cross-breeding to the greatest possible extent, the plan given in Table I should be adopted, varied, perhaps, to meet the necessities of individual cases. The greatest care should be given to the lay-out.

Table I. Plan for Planting the Breeding Plot to Avoid Inbreeding.

The numbers given in the "Guides" designate the field rows from which the seed ears are taken. (All even-numbered rows are detasseled.)

Field row No.	Guide system for even years	Guide system for odd years	Model example for an even year	Field row No.	Guide system for even years	Guide system for odd years	Model example for an even year
1	76	78	76	51	2	4	4
2	2	2	4	52	52	52	52
3	80	82	84	53	6	8	10
4	6	6	10	54	56	56	58
5	84	86	90	55	10	12	16
6	10	10	16	56	60	60	66
7	78	76	80	57	4	2	8
8	4	4	8	58	54	54	56
9	82	80	86	59	8	6	14
10	8	8	14	60	58	58	60
11	86	84	92	61	12	10	20
12	12	12	20	62	62	62	68
13	78	76	80	63	4	2	8
14	2	2	4	64	52	52	52
15	82	80	86	65	8	6	14
16	6	6	10	66	56	56	58
17	86	84	92	67	12	10	20
18	10	10	16	68	60	60	66
19	76	78	76	69	2	4	4
20	4	4	8	70	54	54	56
21	80	82	84	71	6	8	10
22	8	8	14	72	58	58	60
23	84	86	90	73	10	12	16
24	12	12	20	74	62	62	68
25	52	54	52	75	26	28	30
26	26	26	30	76	76	76	76
27	56	58	58	77	30	32	36
28	30	30	36	78	80	80	84
29	60	62	66	79	34	36	42
30	34	34	42	80	84	84	90
31	54	52	56	81	28	26	34
32	28	28	34	82	78	78	80
33	58	56	60	83	32	30	38
34	32	32	38	84	82	82	86
35	62	60	68	85	36	34	46
36	36	36	46	86	86	86	92
37	54	52	56	87	28	26	34
38	26	26	30	88	76	76	76
39	58	56	60	89	32	30	38
40	30	30	36	90	80	80	84
41	62	60	68	91	36	34	46
42	34	34	42	92	84	84	90
43	52	54	52	93	26	28	30
44	28	28	34	94	78	78	80
45	56	58	58	95	30	32	36
46	32	32	38	96	82	82	86
47	60	62	66	97	34	36	42
48	36	36	46	98	86	86	92

In this plan, the breeding plot is considered by quarters. Each quarter contains twenty-four rows and each row is planted with corn from a separate seed ear. All even-numbered rows are detasseled and seed for the next year's breeding plot is taken from the six best-yielding detasseled rows in each quarter, four ears being taken from each selected row, making ninety-six ears in all.

For convenience we use the term "sire seed," or "sire ears," to designate the ears that are to be planted in odd-numbered rows to produce tassels (the male flowers) and to furnish pollen; and we use the term "dam seed," or "dam ears," to designate the ears to be planted in the even-numbered rows to produce future seed ears. Of the four seed ears taken from each selected field row, two are used for sire seed and two for dam seed.

In the column headed, "Guide system for even years," is given a key or guide by which to work out the actual plan for planting in all even-numbered years; and under the heading, "Model example for an even year," is given an actual plan which has been worked out, using four seed ears from six selected rows from each quarter of the breeding plot.

In the guide system, for the sake of simplicity, we use four seed ears from each of the first six even-numbered rows in each quarter, a selection which would probably never occur in actual practice. It will be observed that the dam seed ears for each quarter are ears which grew in the same quarter, while the sire seed is always brought from another quarter. For the first quarter (rows 1 to 24), sire ears are brought from the fourth quarter. For the second quarter, sire seed is brought from the third. In each of these cases sire seed is carried diagonally across the breeding plot. For the third quarter sire seed is brought from the first quarter, and for the fourth, from the second, the sire seed being carried lengthwise of the breeding plot in these cases.

It will also be observed that there is a definite order of planting for "even years" and another definite order for "odd years." Thus, in the first quarter, the even-numbered rows are planted in ascending order with dam seed selected from rows numbered : 2, 6, 10, 4, 8, 12, 2, 6, 10, 4, 8, 12. The alternating even numbers are repeated in sets of three and six. The odd-numbered rows are planted with sire seed selected from rows numbered : 76, 80, 84, 78, 82, 86, 78, 82, 86, 76, 80, 84. This is the same order as for the dams except that the two sets of three are reversed in the second set of six. The only change required for odd-numbered years is to transpose the two sets of six in planting the sire seed. Exactly the same system is used in each quarter of the breeding plot.

Arranging seed ears for planting.

By referring to the "Model example for an even year," it will be seen that it becomes an easy matter to follow the "guide system" in arranging seed ears for planting. Suppose, for example, that in 1905 the best six rows in the first quarter of the breeding plot are 4, 8, 10, 14, 16, 20. Then for the dam seed for planting the first quarter in 1906 these numbers in ascending order are to be substituted for the numbers 2, 4, 6, 8, 10, 12, which are given in the "guide system." Thus : For 2, substitute 4 ; for 4, substitute 8 ; for 6, substitute 10 ; for 8, substitute 14 ; for 10, substitute 16 ; for 12, substitute 20.

Arranging these for planting the field rows, we have :

Row Number	Guide system	Actual plan
2	2	4
4	6	10
6	10	16
8	4	8
10	8	14
12	12	20
14	2	4
16	6	10
18	10	16
20	4	8
22	8	14
24	12	20

If the best six rows in the fourth quarter of the 1905 breeding plot are 76, 80, 84, 86, 90, 92, then for the sire seed for planting the first quarter in 1906 these numbers are to be substituted in regular order for the numbers 76, 78, 80, 82, 84, 86, which are given in the "guide system." Arranging these by threes as indicated in the "guide system," we have the order for planting the odd-numbered rows in the first quarter : 76, 84, 90, 80, 86, 92, 80, 86, 92, 76, 84, 90. Thus we have both the dam and sire seed ears for the first quarter, arranged exactly as shown under the heading, "model example" in Table I. The seed ears are arranged for each quarter of the breeding plot in a similar way by following the "guide system" and substituting in regular ascending order the actual numbers of the best-yielding rows for the numbers given in the "guide system" in Table I.

With this selection of best rows, as given in the "model example," we would take the best four seed ears from row No. 4 (1905) and plant two as dam ears in rows 2 and 14 and the other two as sire ears in rows 51 and 69 (1906); we would take the four best seed ears from row No. 84 (1905) and plant two as dam ears in rows 78 and 90 and the other two as sire ears in rows 3 and 21 (1906).

In arranging seed ears selected from the 1906 breeding plot for planting the 1907 breeding plot, we are to follow the "guide system" for odd-numbered years, again returning to the system for even-numbered years for 1908.

Fig. 648.
A productive hill of corn.

Multiplying plot.

Seed for a multiplying plot of ten acres or more should be taken only from the selected rows of the breeding plot, and may include all good seed corn which is not required for the breeding plot. This seed should be well mixed together. The corn in the multiplying plot should be protected carefully from foreign pollen, and all inferior stalks may be detasseled, to eliminate their influence on neighboring plants. The exact yield of the multiplying plot should be determined and registered.

Commercial field.

The seed for the commercial field should comprise only the very best obtainable seed corn from the multiplying plot. The exact yield of the commercial field should always be determined and registered. From the commercial field the finest ears may be selected and sold to the trade as registered seed corn.

Description of individual ears.

Register number.—As soon as any ear of a given variety and strain is selected to be planted in a breeding plot by a given breeder it is given a register number, which must, of course, represent that particular ear only and for all time. By using a certain system of numbering, we not only are able to designate the ear but can show at the same time the year of its breeding or the number of its generation, and the field row in which it is planted. This we do by starting the first year in the 100 series, numbering the ears to be planted in succession from 101 to 148 and 151 to 198, and the second year starting the 200 series, running from 201 to 248 and 251 to 298, and so on, as far as may be necessary, starting each succeeding year with a higher hundred.

Breeder________________
Variety________________
Strain________________

CORN REGISTER OF EARS PLANTED AND ROWS HARVESTED IN SEASON OF 1905.

Distance between hills______
Number of hills in row______

	Description of individual seed ears																Performance record of field rows							
	Register No.	Dam No.	Annual ear No.	Length of ear	Tip circumference of ear	Butt circumference of ear	Number rows of kernels	Number kernels in row	Weight of ear	Weight of cob	Tip circumference of cob	Butt circumference of cob	Per cent protein in grain	Per cent oil in grain			Planted in field row No.	Per cent of stand	Corn, pounds per row	Corn, bushels per acre	Number of ears in row	Per cent protein in grain	Per cent oil in grain	
Average																								

Remarks:

Average yield multiplying plot:
(Year 1905)__________
(Year 1906)__________

Average yield commercial field:
(Year 1905)__________
(Year 1906)__________
(Year 1907)__________

Dam number.—The "dam number" is the "register number" of the parent ear and is useful in tracing the pedigree record from year to year back to the source.

Annual ear number.—In order to designate the two hundred or more ears selected from the field, each one is given an "annual ear number," which runs in a series from one up to two hundred or more. This number is only temporary, to serve while working on the corn for the final selection of seed ears, and when the seed ears are selected to be planted, each is given a permanent "register number," as explained under that heading.

If desired, a record may be kept of certain physical and chemical properties, as length, circumference and weight of ear and cob, per cent of grain, number of rows of kernels on the ear and the average number of kernels in the row, and percentage of protein or oil if determined.

Performance record of field rows.

The field row or breeding row numbers should correspond, for the sake of convenience, with the register numbers of the ears planted. For example, ear Register No. 101 should be planted in Field Row No. 1. The percentage of stand and the yield per acre of each field row should be determined and recorded.

On the same sheet with the complete year's record of the breeding plot appear the records of the multiplying plot for the same year, and for the next year following, and also the records of the commercial field for the same year and for the next two years. If the record sheet is for the breeding plot for 1905, it is important finally to record on the same sheet the record of the multiplying plot for 1906 and of the commercial field for 1907, and for convenience and comparison it is well to record on the same sheet the yield of the multiplying plot for 1905, and the yields of the commercial field for 1905 and 1906. If a breeding plot were started in 1905, the breeder could have both a breeding plot and a multiplying plot in 1906, and a breeding plot, multiplying plot and commercial field in 1907; and from the 1907 crop on the commercial field he could sell seed corn with a registered pedigree of three years, one year in the breeding plot, one year in the multiplying plot and one year in the commercial field. In 1910, he could sell seed corn from his commercial field with a registered pedigree of six years, four years in the breeding plot (1905, 1906, 1907 and 1908), one year in the multiplying plot (1909), and one year in the commercial field (1910).

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MAPLE-SUGAR AND MAPLE-SYRUP. Figs. 649–658.

By *J. L. Hills.*

The making of sugar from the sap of one or two species of maple trees constitutes a peculiarly American industry. It is commonly associated with the "customs" of New England and other northern states.

Like every other farming industry, maple-sugar-making has changed greatly within a generation. The practices of the first half of the last century were in some respects hardly in advance of those which the Indians employed. To be sure hot stones were no longer dropped into the sap, nor was it concentrated by successive freezings; but the rude bark vessels, the huge potash kettles, the unsightly slashes on the tree trunks were still used and the product was dark, strong and tangy. There was little or no attempt to grade the sugar or improve its quality, and cleanliness, in the modern acceptation of the term as applied to sugar-making, was unknown. This was not a very serious matter in those days, as maple-sugar did not then enter into commerce. It was a home-made, home-consumed commodity, and the cane-sugar of the tropics was rarely seen in the farm pantry in the maple regions. Beginning about fifty years ago, however, the status of the product began to change, in part owing to the lowered price of the cane- and beet-sugar. The maple became less of a necessity and more of a luxury; less was eaten at home and more sold on the market. There is more incentive to improve a money crop than one which the family uses, and hence the industry developed rapidly. Processes were made more economical and labor-saving and the products more toothsome and cleaner. But, oddly enough, while quality was enhanced to the last degree, no larger crops were harvested. The situation was and is an anomalous one. The consuming population of 1907 is thrice that of 1850, its purchasing power much greater and its per capita expenditure for food larger than ever before. The demand for maple products is many times the supply ; a good grade brings remunerative prices, the work is done at a time when other farm work is not pressing, the crop is perennial, the draft on the soil slight, the material used of little value, the cost of apparatus once obtained but slight ; and yet the supply is short.

The reasons for a diminishing supply in the face of an increased demand are two. One is avoidable, the other unavoidable. They are adulteration and the weather. Prior to the passage of the pure food law it was aptly and probably truly said that there was ten times as much maple-syrup made in Chicago as in Vermont. The Chicago brand is made of glucose or cane-sugar, perhaps flavored with a little of the lowest grade and strongest tasting maple and perhaps not. The weather, however, is an all-controlling and uncontrollable factor, in that it may favor a long-continued flow or cause only brief and irregular runs. A day may make or mar the success of a crop. If the right sort of weather comes at just such a time, provided the wrong kind of weather has not preceded it, an average crop or better may be gathered. But, if seasonal conditions do not favor, the product may be but a half or a fourth of a crop; and nothing can be done to remedy this condition.

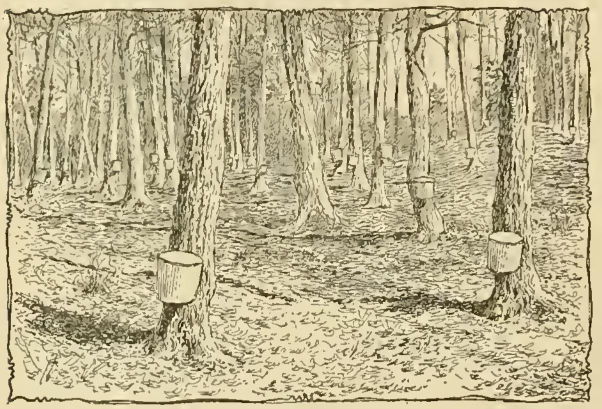

Fig. 649. The sugar-bush at the close of the season. Vermont.

Nature of the maple grove. (Fig. 649.)

There are several sorts of maples known to botanists, but only two are of importance as sugar-producers,—the sugar or rock maple (*Acer saccharinum*, Fig. 452) and the red maple (*Acer rubrum*), the former being the more common one in the East. [Unfortunately, the specific name *saccharinum* has been revived recently by some botanists for the silver maple (*A. dasycarpum*) which is not a prominent sugar-producing species, thus restoring, to no purpose, a confusion of the earlier botanists.] The sugar maple is a stately forest tree, at home on the cool uplands and rocky hillsides of western New England, the Adirondack region in eastern New York, the Western Reserve of Ohio and along the Appalachian region as far south as the Carolinas. In all these regions it is a commercial tree, either as a source of sugar, of timber, or of both. The red or swamp maple grows along stream borders and on the lower lands, particularly if not well drained, and is more common west than east.

The sugar-maker's forest is variously called a grove, orchard, place, works and bush, the last being in many sections the colloquial term. The groves are of all sorts and sizes. The small boy taps the roadside maple in the spring-time and hangs an empty tin pail on a rusty nail to catch the slowly dropping sap ; and the great Adirondack camp, with its railroad system winding among its 40,000 trees, does no more except on a larger scale. Some of the groves stand on level land, some on slopes, some crown ridges, some are of first-growth,—there are not many of these left,—and more are of second-growth trees. Some are nearly clear maple forests, while in others are mingled with the maples such trees as the birches, beech, basswood, spruce and hemlock.

The ideal sugar grove contains the largest number of trees to a given area consistent with a full development of the top, a reserve of smaller growth, however, coming on to replace the failing or fallen maple monarchs. Its soil is well covered with a humus layer, a litter of leaves, grassless and weedless. It is not the number of trees that is important, but the amount and vigor of the foliage; the spread of the tree rather than its trunk, for the leaves are the sugar factories and the sunlight their source of power. The chlorophyll or green coloring matter of the leaf under the influence of the sunlight welds the carbonic acid gas of the air and the water of the sap into starch, which is stored throughout the tree, the next spring to pass as sugar in the sap to the buds for the building of the new leaf structure as well as for the making of the new wood. A small leaf area or one that is so crowded in a dense growth as to be but poorly exposed to the sunlight cannot lay up much starch, and lack of starch means lack of sugar. The thick humus layer on the forest floor is only second in importance to the foliage expanse, for it is the water reservoir of the forest. Indeed, so vitally essential is this soil cover of leaf-mold to the well-being of the industry that many sugar-makers think that the forest trees yield more sugar than do those in the open and exposed on every side. Careful experiments, however, indicate that the sap yields, other things being equal, bear a direct relation to the size and exposure of the tree-top.

Maple-sugar weather.

Ideal sugar weather is met in the late winter or very early spring, when it begins to warm up, when the days are sunny and the nights still frosty. The gradual northern spring in which the ground yields up its frost but slowly is more likely to provoke the repeated sap-flows, which make a successful season, than the more frostless seasons of more southern latitudes. Whatever the real cause of sap-flow, temperature fluctuations from points below to those above the freezing point, slight though they may be, excite the gas tension in the wood-cells if they occur before the leaf-buds get well started. After that yearly episode in the life of the tree, little or no sap flows, whatever the vagaries of the thermometer.

If at this time the tree-trunk is tapped with an auger, an inch or two in depth, preferably on the south side, and a sap-spout driven into the hole, the sap flows. Convenience and economy alike dictate tapping at breast height. The flow is erratic, often exasperatingly so. It may run for some time fairly continuously, but commonly the flow is broken up into several distinct periods, or "runs" as they are called, until the over-warm weather of advancing spring swells the leaf-buds and the "season" is over. Sap runs in the daytime, rarely at night, and to any extent only on good sap days.

The sap.

The sap as it first flows is crystal clear and faintly sweet, carrying not only sugar but also minute quantities of mineral matters, albumens and gums; as the season advances the flow lessens, the sap clouds up (owing to exterior contamination of the pail or tap), becomes slimy at times and the quality becomes impaired. Hence "first run" sugar or syrup makes the best product. While highly variable, the sap averages 3 per cent of sugar, together with some other dissolved substances that are a nuisance to the sugar-maker. The sap is all through the tree at this time, except in the dead heart-wood. It is in twig and trunk, root and branch, and wherever the tree in tapped the wound bleeds, if the weather serves.

Gathering the sap.

The collection of the sap is no small task. Roads or paths are broken out in the snow among the trees, along which men and teams travel in gathering the sap. There are several systems in use. The shoulder yoke is common in the smaller bushes, but the gathering-tank or barrels on a bob-sled or stone-boat are more often used, sometimes in conjunction with the shoulder yoke. When topography favors and the size of the plant justifies it, the pipe-line system is used, a series of open troughs, or, sometimes, galvanized iron pipes running through the various sections of the bush to the sugar-house or to large storage tanks. The most advanced type of gathering device is employed in a large Adirondack camp, tapping, doubtless, the largest number of trees under any one management, where a train of tank cars runs on a narrow-gage railway winding among the trees, past storage-tank stations to which pipe lines lead from several sections of the forest.

The evaporator.

When the gathered sap arrives at the sugar-house it passes into the storage tank, from whence it flows into the evaporator. This, the most costly and elaborate implement of the sugar-maker's art, is an outgrowth of the shallow iron pan which began to replace the old-fashioned iron kettle some fifty years ago. The original form was a single shallow pan about two and one-half feet wide by six to ten feet long, set on a fire-box of brick. The sap was concentrated to a thin syrup, which was poured out and the process repeated. By the use of this device a more rapid evaporation of the water was maintained, less wood was used and better goods made. The lack of continuity and the necessary interruptions of the process were an obvious disadvantage. Necessity evolved the continuous evaporator, into which a steady stream of cold sap enters, passes through a devious course, boiling furiously, and from which, periodically, the hot syrup is drawn.

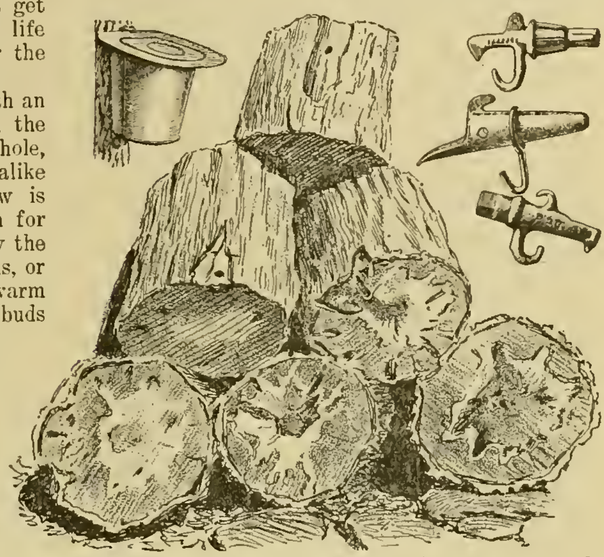

Fig. 650. Ill effect of too much and too deep tapping. Also, a covered sap pail; and current forms of sap spouts.

The evaporator sits over a roaring wood fire burning in a long brick stove or iron fire-box which the sugar-maker terms the "arch." In some large plants steam evaporators are in use. [An evaporator is discussed in detail in the succeeding article.] As the product leaves the evaporator it is not, as a rule, in salable condition. It is usually safer to draw the syrup from the evaporator before it gets concentrated enough to sell. So it undergoes further boiling in a special deep pan until the temperature is about 219° or until it weighs eleven pounds to the gallon, when (after the separation of the "niter" or "sugar sand,"—an impure malate of lime—by filtration or sedimentation) it is sealed, usually hot, in tin cans.

The sugaring process.

Sugaring used to be conducted in the open, and it still is in the more southern maple regions. But in the North the sugar-house is always in evidence. It is commonly a small, rather rough shanty-like affair, large enough to house the evaporator, and perhaps the "sugaring-off" outfit, and to roof over the wood-supply. It is placed usually at the edge of the bush, at such a point as is most convenient for the delivery of the sap.

The "sugaring-off" process is an interesting one. The thin syrup from the evaporator is boiled to a much greater density in the concentrating pan used in syrup-making. Marketable syrup carries 60 to 65 per cent of sugar; marketable sugar, 80 to 90 per cent. The former boils at about 219°, the latter at 234° to 245°, or more. The boiling fluid foams and bubbles furiously over the quick fire and, now and then, is on the point of boiling over, when by a dash of a few drops of cream, skim-milk, water even at times, lard, a bit of salt pork,—anything to break the surface tension of the foam,—instantly it ceases and is gone. Care needs to be exercised here to prevent this loss as well as to obviate scorching. The fluid is adjudged done by the thermometer's testimony, or by the way the stuff "hairs," or "aprons," or simply by the dictates of experience and judgment. The pan is then swung from the fire and the quiescent, brownish, viscid fluid stirred vigorously until graining begins, when the semi-solid mass is poured into molds, tubs or boxes to harden.

The output.

The annual crop in this country approaches fifty millions pounds, valued at over four millions of dollars. Six states — Vermont, New York, Ohio, Michigan, Pennsylvania, New Hampshire—furnish over 90 per cent of the output. Much is made in Canada, but none south of Tennessee, west of the Missouri river, or in any European country. It is the product of limited areas of territorially a very small part of the world, and the foreigner who has seen or tasted it is rare indeed.

Many car-loads, particularly of the last run goods, the dark and inferior sugar,—the blacker and stronger the better,—are picked up by sugar buyers and shipped, mostly west, to the mixers or blenders. Hundreds of tons of such material are used in the manufacture of chewing tobacco, a trade which is said to be eager for all the maple-sugar that it can get.

Statistics are rather unreliable, but it is probably not far from the fact to say that half the total crop is made into syrup and half into sugar, the proportion of syrup to sugar rapidly increasing. Syrup properly put up and stored keeps well, but sugar keeps better. The former sells at retail at ninety cents to $1.50 a gallon, the latter at seven to twenty cents a pound, according to quality and quantity, time of year, size of crop, and other factors. Early or first run sugar, light in color, fine in flavor, in small cakes, sells at fancy prices early in the season; but the main crop, good, bad and indifferent, is likely to bring a low price, which at times has been below the cost of production. The tobacco men and the sophisticators sometimes pay high prices for the strong-tasting goods of more or less uncleanly antecedents; but except for these special purposes, speaking broadly, the light-hued goods of mild and delicate aroma are preferred to the darker ones of more decided flavor, and command better prices.

Centralization in maple-sugar-making.

The latest step in the evolution of the maple-sugar industry is the inevitable one toward which all forms of human endeavor seem destined,—that of centralization. The making of the thin syrup at the individual plants still continues, but buyers contract for the entire supply to be shipped to some central point for grading, reworking, concentration and sale. These central plants are sometimes co-partnerships of private individuals, sometimes supply houses for individual wholesale grocery firms, and sometimes associations of sugar-makers, such as the Vermont Sugar Makers' Market at Randolph. The manifest advantages of such centralization are a greater uniformity of product and better control of sales. They doubtless afford a desirable sales market for many small makers; but the well-informed, well-equipped owner of a considerable sugar-bush can generally do better to complete and to sell his own products.

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Maple-syrup-making from Ohio Experience.

By *W. I. Chamberlain.*

There is no better way of setting forth the principles involved and the methods employed in the making of maple-syrup and maple-sugar than by describing the practice in one of the foremost maple-sugar-producing sections in the country. The discussion that follows is based on sixty years of observation and personal experience, chiefly in northern Ohio.

The old ways and the new.

The old way, still remembered, was to "box" the tree with an axe, cutting a deep "carf," or a sort of pocket, boring up into it with a three-fourths-inch auger, putting in a long elder spout, catching the sap in a wooden sap-trough hewn out of a soft-wood half-log some sixteen inches in diameter, and boiling it in a huge iron kettle on a pole resting on two crotched posts. The boxing soon killed the trees, but trees were plentiful. Then came the improvement of hanging three large kettles, each on a long, strong pole hung like a gate or a well-sweep, so as to raise or lower the kettles or swing them from over the fire. The three kettles were swung into a row, two large logs were drawn up, one on each side for a sort of "arch," and smaller wood was jammed and criscrossed around the kettles. Smoke, coals, ashes and dirt fell in, the sap scorched on the kettles, and the syrup was dark.

The next improvement in boiling is shown in Fig. 651. Five large iron kettles were set in a crude stone arch with chimney and open mouth, and wood about ten feet long was thrust under the kettles. Such an arch fifteen feet long, and holding five large kettles, would boil into thin, dark syrup

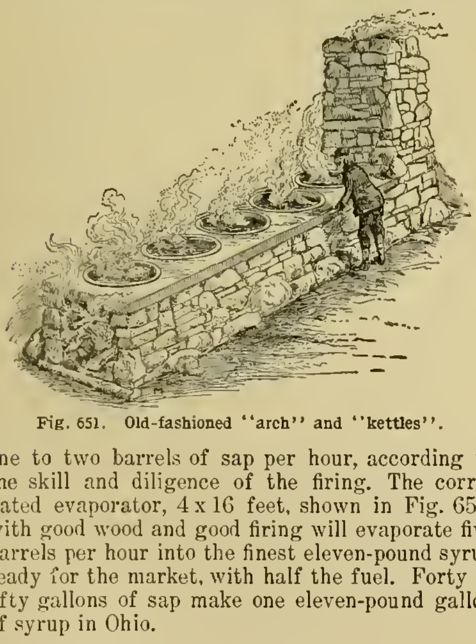

Fig. 651. Old-fashioned "arch" and "kettles".

one to two barrels of sap per hour, according to the skill and diligence of the firing. The corrugated evaporator, 4 x 16 feet, shown in Fig. 652, with good wood and good firing will evaporate five barrels per hour into the finest eleven-pound syrup ready for the market, with half the fuel. Forty to fifty gallons of sap make one eleven-pound gallon of syrup in Ohio.

Details of the sugar-making processes.

Spouts.—The forms of spouts used by writer, after trials of many sorts, are the conical (Fig. 653), made of heavy tin, and the flanged (Fig. 654). Spouts are on sale at hardware stores in the maple regions and are advertised in agricultural papers. The spout in Fig. 653 is cheaper in first cost, but the one in Fig. 654 is more durable and offers less obstruction to the flow of the sap. The writer uses the spout in Fig. 653 in a three-eighths-inch hole the first half or third of the season, then rims the holes with a one-half-inch curve-lip Cook bit and uses the spout in Fig. 654. The rimming freshens the drying hole and increases the flow of sap, and does not wound and injure the tree as boring a new hole; and the partly soured spout is removed. In Ohio, the tapping should be-

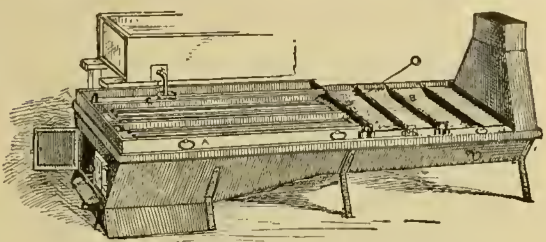

Fig. 652. A modern evaporator and iron arch.

gin the first bright, warm day after February 15, and the season lasts sometimes until April 10, or as long as frosty nights or snow-storms are followed by warm days; hence the need of freshening or rimming the holes and removing the partly soured spouts. The spout shown in Fig. 653 has now been made heavier and longer, so that it answers for seven-sixteenths and one-half inch retapping.

Buckets.—The buckets should be of "IX" tin, very slightly smaller at the bottom than at the top so as to "nest" into each other, in nests of twenty or more, for convenience in handling. They should hold twelve quarts each. Each bucket should have a three-fourths-inch hole punched through the tin close under its wire rim, to slip over the spout to hang the bucket firmly on and against the tree. The bucket should be covered tightly, to exclude rain, insects, dirt and the like, and to prevent the sap freezing on cold nights and souring on warm days.

Covers.—The cheapest and best covers, all things considered, are home-made, of boards 12 x 12 inches square, planed on both sides and all edges, and painted. Home-grown lumber and winter work reduce the cash cost. By painting one side red and the other side white and reversing each cover as the sap is gathered from the bucket, mistakes and omissions in gathering are avoided and when two men are gathering much time is saved from useless travel. If a tree is missed, the (wrong) color of its bucket cover reveals the mistake; and two trips need never be taken to the same bucket, in doubt as to whether its sap has been taken. The writer knows of no one thing more essential to the production of first-class syrup in the variable Ohio climate than covers, and the bi-colored covers are a great convenience in gathering, washing buckets at the trees, and in other ways.

Fig. 653. Conical tin spout.

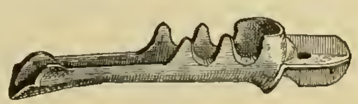

Fig. 654.
Flanged galvanized-iron spout.

Gathering.—Gathering should begin each "sugar day" as soon as there is a quart or more of sap in each bucket. The sooner and the faster the sap is boiled after it leaves the tree, the better is the syrup.

Gathering-tank and sled.—The tank is of galvanized iron, three feet in diameter and three feet deep, stands on end and holds four barrels. The

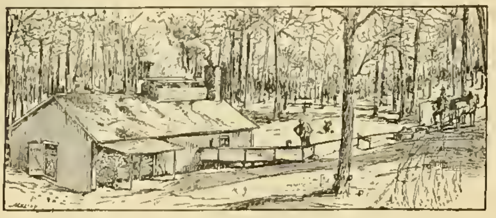

Fig. 655. A sugar camp in Ohio.

sled, commonly known locally as a "stone-boat sled," has heavy runners six inches wide, two cross-beams and two raves, and a flexible pole. The tank has a two-inch galvanized-iron tube, three feet long, attached by a piece of rubber hose to the bottom of one side. In gathering, its outer end is hooked up to the top of the tank to prevent leakage. In emptying, it is unhooked and dropped into the funnel-shaped receiver of the long three-inch tin conductor, and runs the sap into the store-troughs, shown in Fig. 655. The funnel-shaped receiver is shown in Fig. 656.

The can and sled are drawn by a team among the trees in gathering. In emptying the sap, the man stands facing the bucket, holds the gathering-pail in his left hand, holds the bucket cover under his left arm, grasps the bucket rim with his right hand, revolves it on its spout as a pivot, empties it, returns the cover (reversed), carries and empties the sap into the near-by gathering-tank, and goes to the next bucket or tree. Neither the cover, the bucket, nor the pail should ever touch the ground, nor the bucket leave its spout. It saves much time and backache, and dirt in the sap.

From the time the sap is lifted and poured into the gathering-tank human muscle does not handle it again. It runs down the slope (Fig. 655) through an automatic float-regulator and into and through the evaporator (Fig. 652), and runs as finished syrup from the chimney end of the evaporator.

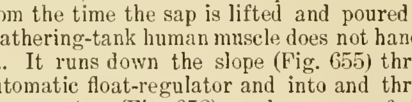

Fig. 656. The funnel-shaped receiver of the sap-conductor.

Sugar camps are usually on rolling land, and there is no trouble but great advantage in locating the sugar-house on a slope. If the slope is slight, the two store-troughs may be placed end to end up the slope and connected by a tall siphon, and a rather long conductor used from the gathering-tank to the first store-trough. The essential feature is that the bottom of the last store-trough shall be a little higher than the top edge of the evaporator, inside the sugar-house. The store-troughs should be wholly outside of the sugar-house, except the mere end plank of the lower one, lest the heat and steam inside slightly sour the sap and hurt the quality of the syrup. And the store-troughs should have covers, like the buckets, to protect from heat (sometimes cold), and to keep out rain, insects, and the like. The writer prefers painted wooden store-troughs to galvanized iron ones, as wood is a non-conductor and excludes heat and cold, which would sour or freeze the sap.

Evaporator.—The evaporator should be of heavy four-plate tin. Galvanized iron is rougher, does not solder so well, and, worst of all, from the action of the sap the galvanizing material, in boiling, is likely to give the syrup a sort of "vanilla" flavor, foreign to the real, delicate, natural maple flavor.

After trying several sorts of pans and evaporators for sixty years, father and son, the kind the writer now uses is the kind shown in Fig. 652. It rests on a heavy sheet-iron "arch" or furnace, which is lined with fire-brick for the fire-box and a little back of it. The writer uses a regular brick "arch" on solid foundation, with tall brick chimney, and the fire-box lined with fire-brick. Such an arch and chimney on solid stone and grout foundation will last twenty-five years or more, and does not heat the sugar-house to discomfort on warm days as does the iron arch.

Some of the advantages of this type of evaporator are the corrugations, the siphons, and the interchangeable rear pans, shown indistinctly in the bottom of the pan in Fig. 652. The corrugations increase the surface exposed to the heat. The bottom of the pan is crimped by machinery, up obliquely about one and one-fourth inch, then horizontally one inch, then down one and one-fourth inch obliquely, then horizontally, and so on. This fully doubles the bottom surface exposed to the fire, and nearly but not quite doubles the boiling capacity on the principle of the tubular boiler.

Siphons in an evaporator permit the operator to cut off and renew at will the flow of sap from one pan or section to the next. Fig. 657 shows the kind of siphon used. It is made of heavy tin, with a cup soldered under and one-fourth inch from the bottom of each "leg," to permit the downward pressure of the air to hold the siphon full when it is lifted from the sap and set on any level surface, and returned to the sap later. It was found that when the siphons, even with the return cups, stood with both ends in the violently boiling sap or syrup, the air from the bubbles would sometimes rise in the siphon, gradually fill the horizontal part and stop the flow. This endangered the burning of the sap in the further pans thus cut off from the sap-flow. So a tin compartment or "cup" was soldered firmly to the outside corner of each pan at the place of transfer. These cups connect with the sap by openings close to the bottoms of the two pans connected by each siphon. The cups rise higher than the sap ever rises in the pans, so as to prevent overflow. The sap or the syrup in the "cups" is always calm, not boiling, and the siphon connection is perfectly secure. To fill the siphon, set both legs in sap enough to cover the return cups (*b* and *c*. Fig. 657), open the small stop-cock shown at the top, and suck through the rubber tube above until the siphon is full; then shut the stop-cock and the flow begins toward the lower level. In sucking up boiling sap through the small rubber tube above the stop-cock, the mouth was sometimes burned. To overcome this, a small, oval, glass bulb (*a*, Fig. 657) was inserted, with a small rubber tube above and below attached to the stop-cock. When the sap rises to the bulb it may be seen, the stop-cock shut, and no injury to the mouth results.

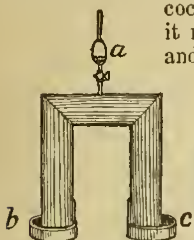

Fig. 657. A good siphon.


Fig. 658. The heater.

Heater (Fig. 658).—This is a deep tubular pan, with sap all around the tubes. It is set at the chimney end of the arch and the flames must all pass through the tubes. The idea is to utilize more of the heat. But it is hard to clean, the sap must be carried by a tube to the front end of the evaporator, and altogether it gives so much trouble that it is less used now than formerly, most farmers preferring to utilize the heat by means of a longer evaporator.

Interchangeable pans.—Two of these, each with two compartments, are shown at the chimney end of the evaporator (Fig. 652). The "niter" settles and hardens on the bottom of the rear section, or, at the most, the last two sections. When it reaches the eleven-pound syrup it is held only in suspension and slowly settles on the bottom of any pan where such syrup is boiling. There it burns or hardens on, retards the boiling and, if left on too long, gives the syrup a burnt or sort of caramel flavor and color. It is hard, and is removed with chisels, which injure the pan. This takes time, and the boiling must stop. But, if the fire is slackened a little, the siphons can be removed and in a moment two men can interchange the last two pans (four sections). Then the boiling at once proceeds and the thinner, sappy syrup soon removes the sediment. This interchangeable feature seems to be valuable for this reason. The rear pans are not corrugated, as flat bottoms are better for syrup, which boils with less fire, and they are more easily cleaned of their hardened sediment.

Boiling.—The cold sap enters immediately over the fire from the store-troughs, through an inch rubber hose or tube. Its rapidity of flow is exactly adjusted to any rate of boiling, no matter how variable, by an automatic float-regulator, a little device that sits in the sap at the front corner of the evaporator and never fails to do its work well. The writer's evaporator, 4 x 16 feet, has two corrugated pans which are together ten feet long, instead of one, and there are three narrow syrup pans, six feet in all, each with three compartments, instead of two with two compartments each. The sap thus enters at one corner (right-hand corner in the writer's), and is pushed slowly forward by the incoming sap under the force of gravity as it lowers toward the rear by evaporation. It passes thus, in the writer's evaporator, back and forth through fifteen different compartments and four siphons until it is drawn out at the left-hand rear corner as finished syrup. The writer strains this syrup through flannel or felt to take out all the malate of lime still held in suspension, and then it is canned air-tight in self-sealing, gallon tin cans. Some persons think that it retains its peculiar flavor better if canned at boiling heat, but it does not seem so to the writer and hence he usually cans it cold.

A saccharometer or a pair of scales tests the thickness of each gallon drawn off. If a full gallon weighs ten and one-half pounds when hot, it shrinks in cooling so that a full gallon when cold weighs eleven pounds. The experienced syrup-maker's eye at once tells. When it "aprons off" from the edge of a dipper (empty except the drippings) in drops nearly an inch wide, it is ready to draw off for syrup.

"*Cleansing*" *the syrup.*—A careful sugar-maker does not cleanse the syrup; he keeps the syrup clean from first to last, and there is not the least need of "cleansing" it with milk or eggs, as in the old times. The bucket covers, gathering-cask or can, covered store-troughs and straining as it enters them, exclude practically all dirt, and the skimming while boiling, and straining the syrup take out any that might remain.

Color of the syrup.—The very best and most delicate flavored syrup is a very light amber color, as light-colored and clear as white clover honey. The writer gathers as soon as the sap is fairly out of the tree and boils it all rapidly before stopping for the night. All buckets are washed usually about once a week, and always as soon as the least white film of sourness begins to form on the bottom. Hot water is drawn around to the trees, and the buckets are washed and wiped. The spouts are pulled and scalded, or new and clean ones are used, and the holes are rimmed every two or three weeks. This keeps the sap sweet and the syrup light-colored and delicate-flavored through the entire season. Sap soured so that it has even a slight filmy whiteness makes dark-colored, rank-flavored syrup, greatly inferior to the best in flavor and in price. By washing buckets and spouts and freshening the holes whenever they need it, it is possible to make fancy "first-run" syrup the entire season until the buds begin to swell. At this time the syrup, though often of very light color, has a "buddy," sickish flavor, very different from the rank taste of the dark syrup made from souring sap. Then the season is over for making first-class syrup, although in Ohio there is sometimes another excellent run. Soft maples bud and spoil the sap much earlier than the hard maples, and are seldom tapped in Ohio.

Quality.—Only the very best syrup pays a good profit. Maple sweets can never compete in cheapness with the refined sugars and syrups made from sugar-cane and sugar-beets for simple sweetening purposes. But for syrup as a table luxury there is nothing to compare or compete with it. For a strictly fancy article, in the writer's opinion, the price will increase year by year because population and wealth increase and the maple-groves diminish, and are not being much replanted, though they might well be. Some twenty-five years ago the writer planted about two hundred young trees along the roadsides, and now they are nearly large enough to tap; and, with clean turf to the edge of the stone pike, they make a beautiful boulevard out of a common country road.

Closing up.—At the close of the season all vessels and utensils should be scalded, washed and wiped, and stored "in the dry," the buckets not "nested," so that they will not rust. Then the large shed should be filled with fine wood for the next season's boiling. Thus stored, old rails, limbs and partly rotten wood, unfit for sale, will do very well with a little sound wood. Such wood dried ten months under cover makes the most rapid boiling and the best quality of syrup.

Utilizing the product.—Nearly the entire Ohio crop is made into best syrup with apparatus much like that described above, and is sold as a luxury costing the consumer $1 to $1.40 per gallon. Perhaps one-tenth of the crop is made into "maple cream," a delicious, almost white, soft, creamy candy, that sells at twenty to thirty cents per pound. It is made by boiling best-grade syrup a little less than it is boiled to make the hard, coarse-grained cake sugar. While hot it is rapidly stirred till it comes to a thick, whitish, creamy condition and is poured into molds when as thick as it will pour. It never becomes very hard and brittle, and dissolves quickly in the mouth with a most delicious flavor.

MEADOWS AND PASTURES. Figs. 659–675.

[See, also, article on *Grasses.*]

By *S. Fraser.*

Meadow is land devoted to crops which are to be made into hay. The word is from the Anglo-Saxon *mæd* = meadow. Frequently land which is too low and wet to be used for other purposes is retained as meadow. Pasture is land devoted to crops which are to be grazed. The word is derived through the old French from the Latin *pastura*. The plants most commonly used for these purposes include the clovers and the true grasses, and plants of many other species, frequently weeds, and all are generally spoken of collectively as "grass" and the land as "grass-land."

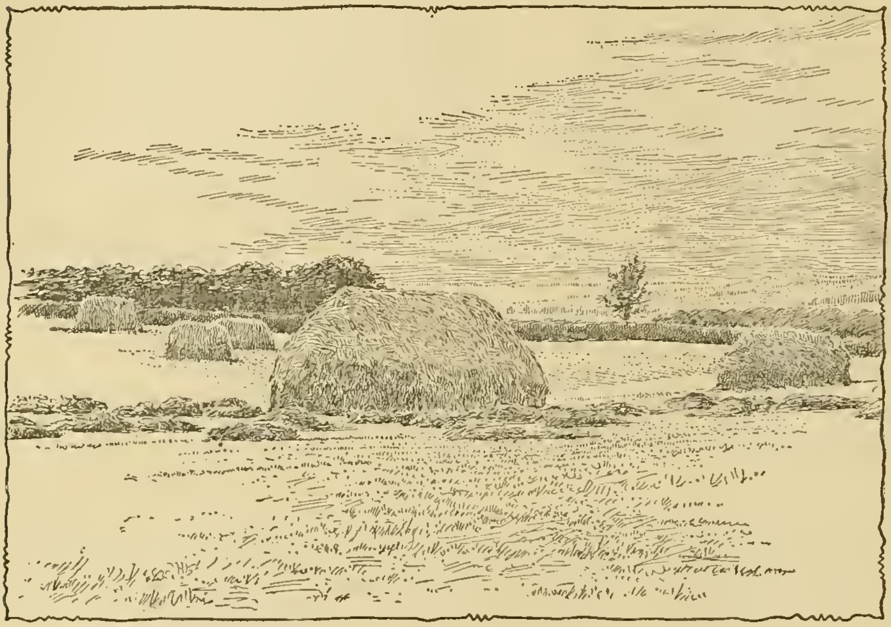

Fig. 659. The making of hay, where hay is cheap; it is a wasteful method.

Meadows and pastures may be permanent or temporary in duration. When permanent, the land is seldom or never plowed; when temporary, grass is grown for one to four years, usually as part of a rotation of crops.

The end in view, whether meadow or pasture, permanent or temporary, will materially aid in deciding the seeds which should be sown on grass-land. For example, in a meadow the aim is to have all the plants at their best at one time, viz., when they are to be cut for hay. In a pasture the aim is to secure plants which will give a uniform amount of feed throughout the season, from spring to fall; thus far, the advice given to secure this is to sow a number of different species of plants which are at their best at different times, and which will survive climatic conditions.

For temporary grass-land it is necessary to sow seeds of plants that are not costly, that arrive at maturity quickly and that give a good yield the following year. On the other hand, in the case of permanent grass-land, cost of seed and the time taken to reach maturity are secondary to duration and adaptability of the plants when established.

Plate XV. Meadow work. Side-delivery rake; hay-loader in distance. Illinois

Permanent and temporary grass-land.

Land may usually be kept permanently in grass on

(1) Hillsides subject to washing.

(2) Upland at a distance from market, and where labor is scarce or high.

(3) Lowland subject to flooding.

(4) Rocky or stony land.

(5) Swamp land.

(6) Heavy clay soils that can be tilled only at considerable expense.

Sometimes it is profitable on high-priced land which could readily be tilled if desired.

Temporary grass-land is especially suited to sandy or light soils where grass and clovers will not hold for more than one or two years, and is of especial value in almost any rotation. Some of the advantages accruing from its use are:

(1) Usually a larger yield of produce is secured per acre; and when leguminous crops are grown the crop-producing power of the soil is increased.

(2) The introduction of grass crops into a rotation reduces the labor bill.

(3) It furnishes an opportunity for improving the texture of the soil when the humus has been exhausted by several years of tillage, by adding humus from the mat of roots and stubble.

Whether temporary or permanent grass-land should or should not be adopted on any particular farm depends entirely on the conditions, and must be decided by the farmer himself.

If temporary grass-land is adopted, it may be accepted as a general rule for the grass-growing region of the New England and northern central states, that the clay and heavy soils may be left longer in grass, with profit, than the lighter soils. Whenever permanent grass-land, especially pasture, is the aim, it is well to remember the English adage, "To make a pasture will break a man, but to break a pasture will make a man." Making permanent pasture is slow work. Once the land is

Fig. 660. Hay-field of Geo. M. Clark, Higganum, Conn. The result of intensive methods.

seeded it should never be plowed, and wherever there is great difficulty in retaining a sod, intelligent care being given, it may be accepted as evidence that conditions, climatic or otherwise, are such that it is better to adopt a system of temporary grass-land.

A poor pasture is unprofitable, and yet a large proportion of the pastures of the eastern part of the United States are poor. This is due, largely, to lack of knowledge and general indifference. To grow good grass is the fine art of agriculture, and no farm crop is grown on higher-valued land. In Italy the best irrigated grass-land is valued as high as $3,000 per acre; and those parts of England most famous for their pastures and meadows are the most highly prized. The European farmer has given much more attention than the American to growing good grass. The present article reflects the English point of view as adapted to American conditions, for the writer's first experience was gained in England.

Fig. 661. The old way.

Valuing grass-land.

The general method of estimating value is to consider the yield per acre, without any special reference to the feeding-value of the crop. In the case of hay grown for sale, this method may be the correct one, but it is not necessarily so in the case of a pasture. The true value of a pasture is based on the amount of "net available nutrients" which it produces per acre; or, in other words, the influence of the herbage on the animal that consumes it. By this method of valuing, the pasture which produces the most beef, mutton or milk, would be ranked as of the most value.

The following are some of the factors that have a direct influence on the value:

(1) The character and condition of the soil. Certain soils, owing to their peculiar properties, are eminently fitted for the production of good quality grass. One of the most important of these properties is the ability to hold sufficient moisture.

(2) The method of management. Manures and fertilizers influence the total yield and quality of the herbage and the time of growth. They may prolong the period of growth of a short-lived pasture. They tend to reduce the variation

in yield due to favorable and unfavorable seasons. At Rothamsted, England, during a period of twenty years, the yields of hay from unfertilized grassland varied from 4,368 pounds per acre in the most favorable season, to 892 pounds per acre in the least favorable one. On well-manured grassland, alongside, the yields varied from 8,960 pounds to 4,480 pounds during the same period. Mismanaged land does proportionately worse in unfavorable years when produce is high. In other words, land in good condition gives more uniform yields and the good farmer is more independent of seasonal variations than the poor farmer.

By intense cultivation and heavy fertilizing and seeding, Mr. George M. Clark, of Higganum, Connecticut, reports enormous yields of hay (Fig. 660). He says:

"Last year (1906) my timothy and red-top field contained eleven acres, and the alfalfa field three and one-half acres. The eleven-acre field produced in two crops eighty-one tons of well-dried hay, and the three-and-one-half-acre field produced twenty-one tons in four crops, making one hundred and two tons from the fourteen and one-half acres. The seven-eighths-acre piece is a part of the eleven-acre field, and produced its usual crop of over eight tons, in two crops, each year, or one hundred and forty-seven tons in seventeen years, at one seeding."

(3) The number and character of the plants per acre. Although it is not known how much emphasis can be laid on these factors, it is conceivable that they are of some importance. It is certain that an animal must not have to travel too far to secure its food if we would have it fatten, and that a certain number of plants must be maintained per acre for profit.

As to the character of the plants necessary for a good pasture, there is little data. Investigations conducted in the United Kingdom, by Drs. Fream and Carruthers, for the Royal Agricultural Society of England, show that there is not necessarily any relationship betweeen the botanical composition of the herbage of a pasture and its feeding value. In some of the best pastures the cultivated grasses might constitute as little as 11 per cent of the herbage or as much as 100 per cent; legumes might constitute 38 per cent or be absent; miscellaneous plants, so-called weeds, might be absent or constitute 89 per cent by weight of the total yield. Two pieces of grass-land may have the same grasses

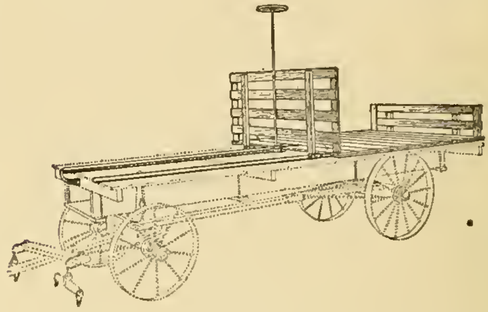

Fig. 663. A recently advertised wagon-loader. The platform is run to the rear to receive the hay; then it is pulled to the front by means of the hand wheel, leaving the rear of the wagon rack to receive the remainder of the load.

in the same proportion and yet the feeding value be very different. On the other hand, two pieces may have entirely different kinds of grasses and yet the feeding value be about the same.

Individual plants of the same species vary to a remarkable degree in duration, yield and other characters, and it is readily conceivable that the variation in feeding value is as marked as it is in other characters. The selection and propagation of desirable individuals is now attracting the attention of plant-breeders.

Although we have over 1,000 species of grasses growing in this country, not more than a score are in general cultivation, and these are sown on various types of soils and under very dissimilar climatic conditions. The sowing of grass seed at all is modern, not having been in common practice either here or in England two hundred years ago, previous to which time land was allowed to seed itself as best it could.

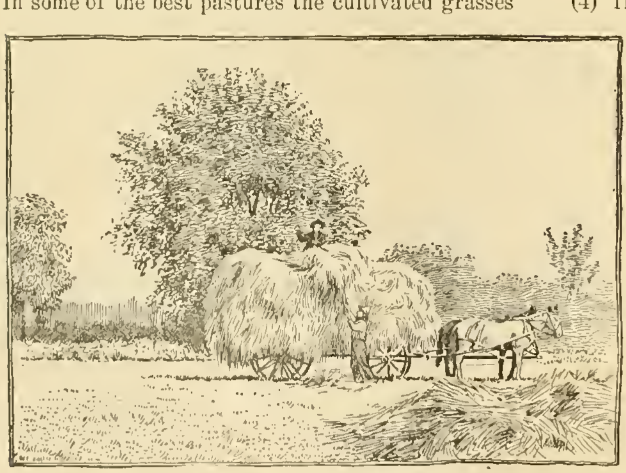

Fig. 662. Loading hay by hand.

(4) The earliness and persistency of the herbage; its ability to carry stock throughout the season. As already stated, a succession of grasses is generally advised for pasture. Taking the period of bloom as indicative of maturity, the order would be as follows, in New York:

May (end): Meadow foxtail, orchard-grass, Kentucky blue-grass.

June: Meadow foxtail, orchard-grass, Kentucky blue-grass, tall oat-grass, red clover (some plants), white clover, alsike clover (some plants), hard fescue.

June (end): Meadow fescue, timothy, awnless brome, alsike and red clover, Canada blue-grass.

July: Red-top, Canada blue-grass.

Not all of the above grasses could be maintained on the same land for a long period of time. The following brief notes are suggestive; all dates refer to New York conditions:

Meadow foxtail thrives on damp, rich land, and on such furnishes feed from early May on. Its period of succulent growth and bloom extends well

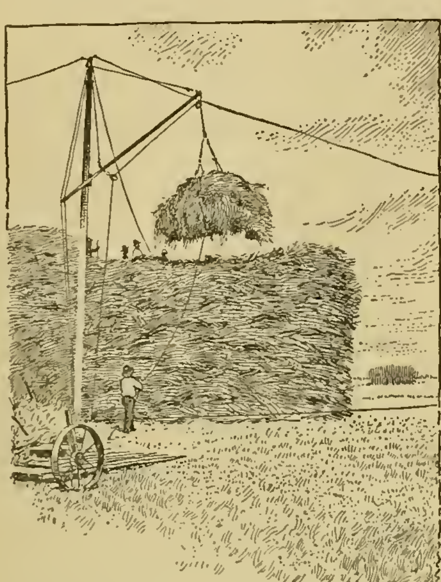

Fig. 664. Use of hay sling in field stacking.

into July under such conditions, some individuals not blooming until the latter date. It is relished by all stock.

Meadow fescue is considered to be one of the best hay and pasture grasses. It is relished by all stock, but will not thrive unless the land is in good condition. It is suited to permanent grass-land only, since it takes two or three years to attain its highest productivity.

Both meadow foxtail and meadow fescue are little known to American farmers, but they are much prized in England and merit attention here.

Orchard-grass is readily eaten by all stock during May and early June. It withstands drought well, but becomes coarse during July. If mown, the aftermath is readily eaten.

Kentucky blue-grass is relished by most stock if grown on land in good condition; if spindly and poor, it is not readily grazed. If well grown, few grasses are better for permanent pasture.

Tall oat-grass is not readily eaten by stock, except in small areas.

Red and alsike clovers are readily grazed by all stock and are used for hay. They furnish feed throughout the season if there is sufficient moisture, but are not long-lived plants in the eastern United States. They are used for temporary grass-land.

White clover is used entirely for pasture.

Timothy is the great hay grass. It is the grass for one- to three-year leys in the eastern United States. Some plants are adapted to grazing, and opinions differ accordingly as to its value as a pasture grass.

Awnless brome grass (*Bromus inermis*) is comparatively new. Its place seems to be that of a pasture grass, where land is to be retained for a term of years as pasture. For permanent pasture its value is undetermined.

Red-top is used for permanent and temporary grass-land, both as meadow and as pasture. It shows great power of adaptation and much variation.

Canada blue-grass is esteemed as a pasture grass in parts of New York and Canada. It is adapted to heavy clay soils, which have been badly eroded and will grow nothing better.

Among other grasses of less importance are crested dog's-tail, which is of little value as a pasture grass; perennial and Italian rye-grass, which, although useful in England, have not proved of general value here. Sweet-scented vernal grass is of little or no value. Quack, although a valuable grass for pasture and meadow, is almost never sown, because of its weedy tendencies.

(5) The quality, digestibility and palatability of the herbage and of the different grasses evidently vary widely, but there is still insufficient information.

The grasses to sow.

From the foregoing it is evident that in seeding grass-land the following points warrant consideration:

(1) Choose grasses that yield heavily under the local climatic and soil conditions. This is best determined by growing the different grasses separately on plats and noting the results during a term of years.

In the eastern states the following grasses do best on moist soils: red-top, fowl meadow-grass, meadow fescue, meadow foxtail, Italian rye-grass.

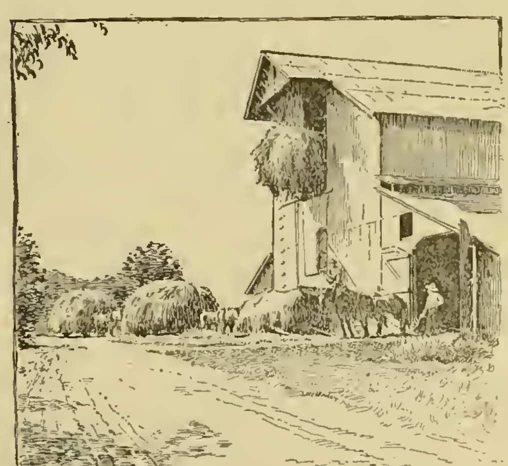

Fig. 665. Hay fork in use.

For clays and heavy loams, alsike clover and timothy do well for hay, while Kentucky blue-grass, Canada blue-grass, white clover and a little meadow fescue should be added if the land is needed for pasture. Awnless brome is also doing well where it has been tried, but its use is still in the experimental stage. On average good land, red clover, red-top, timothy and Kentucky blue-grass are probably the least fastidious, orchard-grass and meadow fescue being a little more exacting.

(2) Choose grasses that animals like. If the plats be sown as suggested and animals allowed to graze them, their choice will be apparent. On the Dunkirk clay loam soil at Cornell University, Ithaca, New York, dairy cows ranked the grasses in the following order: awnless brome, red and alsike clover, meadow fescue and timothy, orchard-grass, Kentucky blue-grass and red-top, the last mentioned grass being shunned wherever it occurred. On the Dunkirk clay in the Genesee valley, New York, fattening steers ate Canada blue-grass, Kentucky blue-grass, *Danthonia spicata* (which is rather prevalent), equally well, while red-top and timothy were left. Horses and sheep are more partial to orchard-grass than are cattle.

Seeding grass-land.

In seeding temporary grass-land, select seeds of plants which mature quickly; it is wasteful to sow seeds of Kentucky blue-grass, meadow fescue or meadow foxtail, since it takes two or three years for these plants to attain full growth. Red and alsike clovers, timothy, red-top and orchard-grass suggest themselves as being desirable for this purpose. For permanent grass-land there is a greater variety at our disposal. In addition to those already mentioned, alfalfa, meadow fescue, meadow foxtail, Kentucky blue-grass, hard fescue, Canada blue-grass and others may be used.

For a meadow a few kinds of grasses are usually sown, and these are generally the tall, strong-growing species, as timothy, red-top, tall fescue, alsike and red clover. Almost invariably when maximum yields are secured, only one or two species are grown, it being much easier to furnish the ideal conditions for the best growth of one or two species than it is for twenty species.

Whenever the herbage of grass-land is diversified, and comprises twenty to forty different species of plants, the yield per acre is low. In seeding a permanent pasture, however, not only do we sow several species of grasses to secure a continuous "bite" throughout the season, but also because conditions change; some of the grasses being slow in occupying the land, early-maturing species are sown with them to fill the land and to exclude weeds, thus ensuring larger yields. Some of the grasses should furnish abundance of leaves and but few stems, thus giving a close, dense turf; among such grasses are Kentucky blue-grass, hard fescue and some strains of timothy. Certain grasses are useful because of their stoloniferous habit of growth, which enables them better to withstand the treading of stock and to live and reproduce below ground. Such plants include Kentucky blue-grass, red-top, white clover and many kinds of timothy.

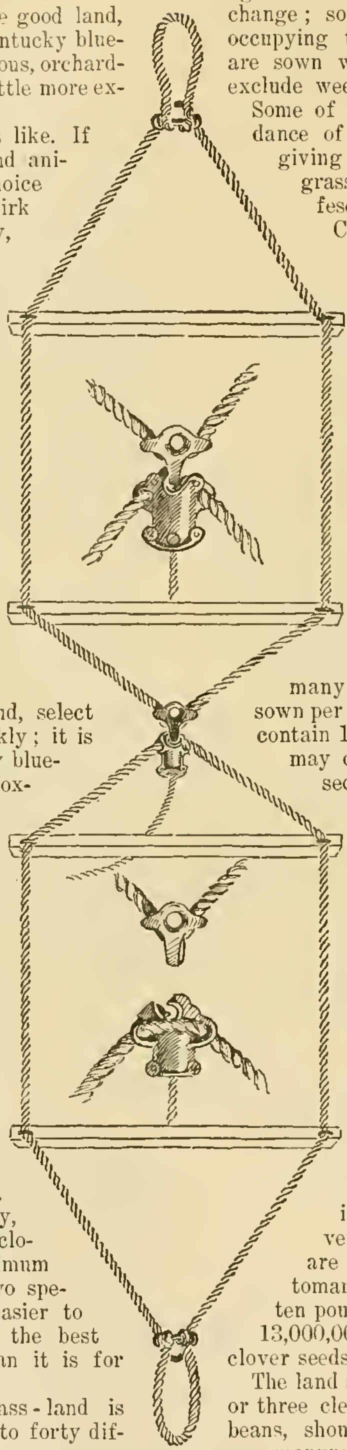

Fig. 666. Center trip hay sling and locks.

Purchasing seed and sowing.

Seeds of different species should be purchased separately and samples taken for examination for purity and germinating power. [For advice on seed-testing, see page 140.] The true basis for purchasing and sowing seeds is not how many pounds per acre, but how many millions of viable seeds should be sown per acre. A pound of timothy seed may contain 1,300,000 seeds; a pound of red-top may contain 6,000,000 seeds; hence, to secure an equal number of plants per acre would require a much less weight of red-top than of timothy.

The number of seeds which should be sown per acre depends on the soil, climate, the kind of grass and the object in view. The number of grass plants found on an acre of old meadow in England was over 78,000,000 when irrigated and about 18,000,000 when not irrigated. A common estimate is to sow 20,000,000 viable seeds per acre, which is about 450 per square foot. For temporary grass-land, where one-third of the seeds are legumes, 8,000,000 to 10,000,000 seeds is ample in many places. On the Cornell University farm when timothy and clover are sown to remain one year, it is customary to sow ten pounds of timothy and ten pounds of red clover per acre, or about 13,000,000 timothy seeds and 2,250,000 clover seeds, a total of 15,250,000 per acre.

The land should be well fitted. If weedy, two or three cleaning crops, as corn, potatoes and beans, should be taken and the land well manured for these crops. Fertilizers and lime may be applied and harrowed in before the seed is sown, if found to be desirable.

A fine, firm seed-bed is necessary, and the sub-surface must be compact to ensure the upward passage of moisture. This point will bear emphasis, many failures occuring from not having the seed-bed sufficiently compact.

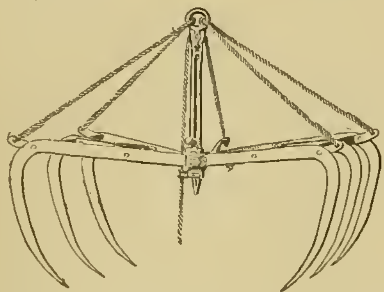

Fig. 667. Six-tine grapple fork with spear. Open.

If sown in fall it is usually advisable to sow not later than September 1. Spring sowing should be done as early as the ground will permit. Clover is usually sown in spring when the snow is still on the ground. This is a good practice because it is found that clovers germinate best under the low and steady temperature which is then maintained. Kentucky blue-grass, however, germinates best when subjected to a temperature alternating between 68° and 86° F.; hence, if it is sown in fall, on or near the surface, these conditions are secured. Thus each kind of grass has a certain temperature or range of temperatures which are best suited for its germination.

Under ordinary circumstances and with temporary seedage, the sowing of the grass with a grain crop is advisable because it economizes the use of the land. It is well to mow the grass early the first year, even if it is to be used as a pasture. This prevents the grasses going to seed and thus weakening themselves. It may not be advisable to seed with a grain crop when an expensive seed mixture is used in seeding permanently, when the land is very rich — the grain crop would lodge — nor when it is so poor in condition that it could not carry both crops.

Number and weight of grass seeds and amount to sow.

It is hardly possible to give the exact formulæ for seeding land to grass. The following notes are merely suggestive and may need modification to meet varying conditions. As already stated, various authorities have asserted that 10,000,000 to 20,000,000 viable grass and clover seeds should be sown per acre, the lesser quantity when the clovers constitute a large proportion of the seed mixture or the land is seeded for but one or two years, and the larger quantity for permanent grass-land. The following table has been adapted from "The Best Forage Plants," by Stebler and Schroeter, and from it calculations may be made. The actual number of grains in a pound will frequently vary 20 per cent either way; for example, in recleaned fancy seed there are fewer grains to the pound, while in an uncleaned sample free from chaff, but containing many small seeds, the number will be greater. The recleaned seed weighs heavier per bushel. The uncleaned seed may contain a large proportion of chaff and in such case the number of seeds per pound of material may be very low. The numbers given are per pound of pure seed. The percentage of germination of average samples of seed is frequently but half, and even less than half, of that given in the table. The germination of the rye grasses given in the table is a little higher than ordinarily found in the United States, even with imported seed. Low germinating power may be due to lack of uniformity in ripening the seed; to part of the seed on a plant being mature before the remainder, frequently seen in meadow foxtail; or to poor methods of harvesting, as in Kentucky blue-grass.

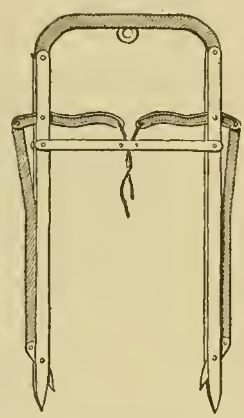

Fig. 668. Double harpoon fork, with twenty-five-inch tine. Closed.

Name	Number of grains in one pound of pure seed	Amount to sow per acre, if sown alone. Standard quality	Good percentage of germination	Weight per English bushel	Weight of 10,000,000 grains. Size as per column 1
		Pounds		Pounds	Pounds
Awnless brome grass . .	137,000	30–50	75–90	13–14	72.99
Kentucky blue-grass . .	2,400,000	15–20	80–90	14–32	4.17
Orchard-grass	579,000	20–35	80–95	12–23	17.25
Perennial rye-grass . .	336,800	25–40	95–98	18–30	29.7
Italian rye-grass . . .	285,000	30–45	95–98	12–24	35.1
Meadow fescue	318,200	30–35	75–95	12–30	31.42
Sheep's fescue	680,000	25–30	60–75	10–25	14.85
Tall oat-grass	159,000	20–30	80–90	10–16	62.89
Meadow foxtail	907,000	20–25	60–90	6–14	11.02
Red-top	6,030,000	8–16	90–95	12–40	1.65
Timothy	1,170,500	10–16	95–98	45–48	8.54
Alsike clover	707,000	10–13	95–98	60–64	14.14
Red clover	279,000	10–16	95–98	60–64	35.8
White clover	740,000	10–12	95–98	60–64	13.51
Alfalfa	209,500	15–30	95–98	60–64	48.56

Testing seed.

In testing the seed for germination power and purity it is more satisfactory to weigh out a sample of the seed, separate the chaff and inert matter, weigh it, and then proceed to make a germination test of the remainder. For example, if a sample of awnless brome grass contain 10 per cent of dirt and chaff, and 75 per cent of the pure seeds are viable, the actual germination power of the sample is 67.5 per cent, or

$$\frac{75 \times 90}{100} = 67.5$$

Mixing seed.

It is important that each kind of seed be purchased separately in order to permit an examination for purity. When satisfied that the seeds are as desired, the different ones may be mixed for

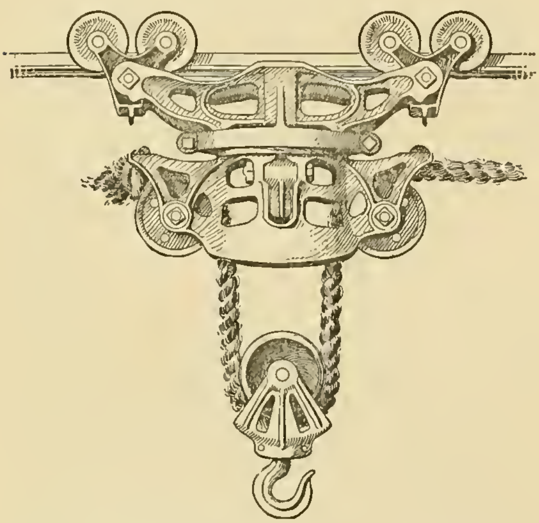

Fig. 669. Wide-mouth engine truck, swivel and reversible steel track carrier for hay fork.

seeding. It is desirable that seeds which are of a similar size and character should be mixed and sown together; for example, it is much better to mix timothy seed with any clover which is being sown, provided that both are being sown at the same time, than to mix it with chaffy seeds, such as Kentucky blue-grass, meadow fescue or orchard-grass. If there are two compartments on the seed barrow, then clover and timothy should be mixed and sown in one, and the chaffy seeds, such as meadow fescue, Kentucky blue-grass, orchard-grass, rye-grass, should be sown in the other compartment. Awnless brome grass is better sown by itself, since it requires different treatment. It not only requires much larger holes in the seed drill or barrow, but it is necessary to cover it much better than most of the other grass seeds.

In mixing, take the seed of which there is the greatest bulk and empty it on a tight floor, a good cement barn floor or something of a similar nature being desirable; empty the next largest quantity on top, and so on, putting the seed of which there is the least amount on the top of the pile; with scoop-shovels proceed to turn over the pile, putting it on a new base. A skilful man will give the shovel a twist by a mere turn of the wrist which will insure very good mixing of the different seeds. When the bulk of the pile has been made on the new site, the remaining seeds should be swept toward the new pile and the operation repeated. Four or five turnings will probably be necessary to secure a complete blending of the different seeds, and the process should be continued until a perfect mixture has been secured.

Examples of seed mixtures which would furnish 20,000,000 seeds, and the weight of same:

	No. of seeds	Weight of pure, viable seed. Lbs.
For hay and fall pasture. Heavy land. Short duration.		
Timothy	13,400,000	11.44
Alsike	3,300,000	4.66
White clover	3,300,000	4.46
	20,000,000	20.56
For hay and pasture.		
Timothy	10,000,000	8.54
Kentucky blue-grass	2,000,000	0.82
Orchard-grass	1,400,000	2.42
Alsike	3,300,000	4.66
White clover	3,300,000	4.46
	20,000,000	20.90
For hay and pasture.		
Timothy	8,000,000	6.84
Kentucky blue-grass	2,400,000	1.00
Orchard-grass	2,000,000	3.46
Meadow foxtail	1,000,000	1.10
Alsike	3,300,000	4.66
White clover	3,300,000	4.46
	20,000,000	21.52
For hay. Heavy loam.		
Red clover	2,790,000	10.00
Alsike	2,121,000	3.00
Timothy	7,089,000	6.06
Red-top	8,000,000	1.32
	20,000,000	20.38

For pasture, for two years' duration, the Ontario Agricultural College sows per acre: 7 lbs. red clover, 2 lbs. alsike clover, 4 lbs. timothy, 5 lbs. orchard-grass. If wanted for hay, the orchard-grass is omitted.

For permanent pasture the same authorities advise: 4 lbs. orchard-grass, 4 lbs. meadow fescue, 3 lbs. tall oat-grass, 2 lbs. timothy, 2 lbs. meadow foxtail, 5 lbs. alfalfa, 2 lbs. alsike clover, 2 lbs. white clover, making 24 lbs. per acre in all.

For wet land in New England for meadow, L. R. Jones, of Vermont, suggests, per acre, 10 lbs. timothy, 6 lbs. alsike clover, 4 lbs. recleaned red-top, 10 lbs. fowl meadow-grass, in chaff. Sow in midsummer without a nurse crop.

For meadow in a shady place, the same authority suggests, per acre, 1 bus. orchard-grass, 6 lbs. timothy, 3 lbs. meadow fescue or Kentucky blue-grass, 8 lbs. red clover, 2 lbs. alsike clover, and 2 to 4 lbs. of meadow foxtail if obtainable.

For pasture in Vermont the same authority recommends, per acre, 8 lbs. timothy, 4 lbs. recleaned red-top, 7 lbs. Kentucky blue-grass, 2 lbs. orchard-grass, 2 lbs. meadow fescue, 3 lbs. red clover, 3 lbs. alsike clover, 4 lbs. white clover, and 1 or 2 lbs. meadow foxtail if obtainable.

In western New York the writer is using, for sowing on old pastures, a mixture of 2 to 3 lbs. timothy, 2 lbs. red-top, 4 lbs. Kentucky blue-grass, 3 lbs. meadow fescue, 2 lbs. meadow foxtail, if good seed is obtainable, 2 to 3 lbs. red clover, ¾ to 1 lb. alsike clover per acre. On heavy clays, 2 lbs. Canada blue-grass might be included.

North Carolina Experiment Station (Bulletin No. 168) used the following mixtures, per acre, for one crop of hay and then to be pastured for 2 or 3 years: 10 lbs. tall oat-grass, 5 lbs. orchard-grass, 1 lb. red-top, 2 lbs. Kentucky blue-grass, 7½ lbs. red clover. Another mixture used was, per acre: 14 lbs. orchard-grass, 7½ lbs. red-top, 7 lbs. Kentucky blue-grass, 5 lbs. red clover, 2½ lbs. white clover, ¼ lb. alsike clover. Another year the following was used, per acre: 10½ lbs. orchard-grass, 7 lbs. Kentucky blue-grass, 10½ lbs. tall oat-grass, 5¼ lbs. meadow foxtail, 7 lbs. Canada blue-grass, 3½ lbs. red-top, ¾ lb. white clover, 4 lbs. red clover.

For southern states for hay sow 3 lbs. per acre of Bermuda-grass, good imported seed, at any time the ground is moist or likely to continue so for some time. This grass is generally started by planting pieces of sod or cuttings of the underground stems, owing to difficulty in securing good seed. Texas blue-grass (*Poa arachnifera*) is usually started from cuttings in the same way as Bermuda-grass, although seed is sometimes sown. Rescue-grass or Schrader's brome grass is sown at the rate of one bushel per acre in August or September. One-half bushel of rescue-grass and a few pounds of bur-clover make a good hay crop.

For pasture in Mississippi, Lloyd suggests carpet-grass and lespedeza for the sandy valleys; awnless brome grass, crab-grass and Mexican clover for the upland; and turf oats and hairy vetch for winter and early spring grazing. Orchard-grass is also a useful plant. For wet and seepy land sow red-top and alsike clover.

For pasture in western Nebraska, Professor Lyon suggests, per acre, 4 to 6 lbs. orchard-grass, 6 to 10 lbs. awnless brome grass, 8 to 14 lbs. meadow fescue, and a small amount of alfalfa, Kentucky blue-grass and white clover. The amount of meadow fescue may be increased in the southern part of the state and the brome grass in the northern part.

For hay for two years and then pasture, alfalfa may be sown with awnless brome grass, meadow fescue or orchard-grass, sowing 20 to 25 lbs. of alfalfa and 15 to 20 lbs. of the grass seed per acre. The alfalfa will occupy the land for the first year or two, after which the grasses come in.

Machines for sowing grass seed.

In northeastern United States it is customary to sow the timothy in the fall at the time the land is sown to wheat, an extra hopper being provided on the grain drill for the purpose. If clover is used on such land, it is generally sown in the spring either with a seed barrow, which frequently is made ten to fourteen feet wide and pushed by hand, or by means of one of the hand-seeders of the Cyclone or other type, which consists merely of a revolving disk which scatters the seed; or it may be sown by hand. In many cases it is desirable lightly to cover the seed; the weeder with a seed-box attached is an admirable tool for such work. This tool is mounted on two wheels, which furnish the drive for the seeder and enable the operator to ride. [See pictures of seeding tools, pages 133, 137.]

Why grasses "run out."

The same plant cannot occupy the same piece of land for an indefinite period of time. Grasses, like other plants, live and die; they tend to run out or disappear. Farmers find it necessary to reseed more or less often if they wish to maintain the grass on the same land. There are several reasons why grasses run out:

(1) The plant may live its normal life and then die. The duration of life of most grasses is not understood and little is known regarding the influence of grazing or cutting on their lives.

(2) When a plant dies the tendency is for some other plant to take its place; just as oaks may follow hemlock or pines, so weeds take the places of grasses unless prevented by the farmer.

(3) The changes in the texture or condition of the soil influence the herbage. When land is newly seeded certain grasses may thrive which will not do so when the soil becomes more compact. The treading of animals further compacts the soil and it is not so well "aërated." The air space in the soil is partially maintained by the death of plants and decay of their roots.

In the Genesee valley on Dunkirk clay soil, when it has been eroded, Canada blue-grass, oxeye daisies and white clover constitute the bulk of the herbage, but if grazed for twenty or thirty years, the land improves sufficiently so that Kentucky blue-grass begins to come in and in two or three decades more the herbage consists largely of Kentucky blue-grass, meadow fescue and white clover.

(4) Climatic conditions are important. Late spring frosts kill early-growing or early-maturing grasses, as orchard-grass and meadow foxtail; but if such are protected by manure, or even cut straw, they may survive similar conditions. Favorable spring weather may enable such grasses to develop unusually well, and crowd out later-growing species.

Changeable autumn and winter weather, freezing and thawing, and even heavy rains are more injurious to some grasses than to others. On the heavy clay lands of New York the chief factor in determining the life of alsike, red clover and even timothy is the winter. In changeable winters many of the plants are heaved out and their places are later taken by oxeye daisies, live-for-ever and other weeds.

Drought injures grass-land in several ways. It not only reduces the water content of the soil, because of which some grasses suffer more than others, but it causes the soil to bake and crack and so injures the roots. Under such conditions, deep-rooted grasses, as tall oat-grass and awnless brome, may survive; and grasses having narrow, bristle-like leaves, such as sheep's fescue, tend to increase, while such grasses as red-top, which have flat leaves, will lose ground. Thus the changing seasons may be one of the prime causes for changes in the herbage of a pasture.

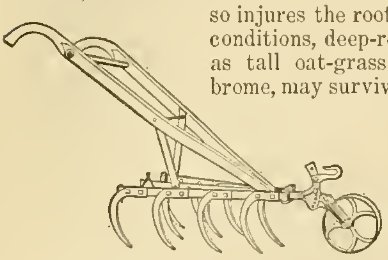

Fig. 670. Root digger or grass-hoe. Sometimes used for destroying weeds.

(5) Injudicious management. Timothy may be ruined by too early cutting, time not having been given for food to be stored in its thickened stem, which would tide the plant over the summer droughts. Grazing too close has the same effect, especially if done late in the fall. Grasses may be pulled up by animals or the land may be poached by the stock if they are turned on when it is too wet.

Certain grasses, such as timothy, are perennial by means of stolons. The stolons are formed about the same time the seed is developed. Anything which prevents the formation of the stolon causes the death of the plant and a bare spot in the pasture.

Renovation of worn-out meadows and pastures.

One of the best ways to renew grass-land or to maintain it in good condition is to fatten cattle or sheep on it, feeding the animals concentrated feeds and, in some cases, hay and forage in addition. Sheep are most highly esteemed, because they eat so many weeds and because their droppings are scattered uniformly over the land. In the case of cattle or horses, the droppings should be distributed every two or three months by running a chain harrow or a weeder over the land.

The application of barnyard manure, lime or fertilizers is profitable in many cases. Barnyard manure has a more lasting influence than most fertilizers. To determine which is the most profitable fertilizer to use, a fertilizer test should be made and maintained for a term of years. Lime may be applied at the rate of 1,000 pounds per acre, once in every three to five years. In addition to the above, the pasture should be harrowed in the spring or fall as soon as it shows signs of becoming thin or sod-bound, the disk-harrow being an excellent tool for the purpose, although the spring-toothed or spike-toothed harrows may be used in some cases. The weeds should be mown either once or twice a year before they bloom, and liberal applications of grass seed made every two or three years, in spring or fall after the harrowing. Under such management, not only may land that is now good meadow or pasture be maintained as such, but much of the poor meadow and pastures of the country may be converted into good ones.

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Grasses and Clovers Used in Meadows and Pastures.

By *W. J. Spillman.*

The number of American grasses is well-nigh countless. It is not the purpose of this Cyclopedia to consider all of them. The best that can be done is to set forth the more important features of those that are of leading economic importance, and to suggest to the reader their uses and range of adaptation. The present article treats chiefly of the cultivated grasses and clovers. The succeeding article considers native meadows and pastures for the ranges.

Place in the cropping system.

With reference to the position occupied by the grasses in the cropping system, we may divide the United States more or less arbitrarily into six divisions. The first and most important of these divisions comprises in a general way those states in which timothy and clover and blue-grass are the principal constituents of arable grass-lands. This region lies north of a line from Virginia to Kansas, and east of a line from Kansas to eastern North Dakota. In the Appalachian region, and in the limestone soils of central Tennessee, are found southern extensions of the area, while New England, for the most part, should be considered separately. Outlying areas are found more or less generally distributed in the northern half of the Rocky mountain states and the northern half of the Pacific coast states. In this region, which we may appropriately call the timothy region, the type of rotation which prevails very generally on farms where rotation is practiced is corn, followed by small grain (usually wheat in the southern part and oats in the north), with timothy and clover sown with the small grain. On the best farms the grass is cut for hay one or two years and is sometimes pastured one or two years more before being broken up for corn. On poorly managed farms, which are by far the more numerous, the grass is left down for an indefinite number of years until weeds especially adapted to meadow lands creep in, rendering the hay of inferior quality and greatly reducing the yield. Because of this practice, the average yield of timothy and clover hay in this country is only about a ton and a quarter per acre, whereas it could easily be made two tons by a proper system of rotation, combined with the best use of farm manures.

In New England we find a marked modification of the rotation type prevailing generally over the timothy region. On many of the best New England farms the small grain is omitted from this rotation, the grass seeds being sown directly in the corn at the last cultivation. This operation in New England is called "stocking" the land. On good New England dairy-farms it is customary each year to plow up about a third or a fourth of the grass-land which most needs renewing. This plowed land is then fertilized, planted to corn (sometimes peas and oats or other cereal crops), and then restocked with grass at the earliest opportunity.

A different modification of the prevailing rotation of the timothy region is found in certain parts of the Pacific Northwest, mainly in western Oregon, and, to some extent, in western Washington. In that section, instead of following grass-lands by a cultivated crop, it is more usual to sow small grain in the spring, especially oats. This is followed the next year by a cultivated crop, after which fall grain is sown. Timothy is sown with this fall grain and clover added in the spring. The reason for this arrangement of crops is found in climatic conditions. Sod land cannot be broken up and sown to corn in the spring because of the absence of summer rains. It would be too dry during the summer. The sod, therefore, must be broken in the fall. Land being thus made available for early spring operations, it is the logical place to sow oats. Because of the absence of summer rains, the oat land cannot be prepared for wheat in the fall. On the other hand, it has been found that wheat can be sown after a cultivated crop in the fall, with excellent results.

In those sections where alfalfa is the principal meadow and pasture crop, as it is in all irrigated sections of the West and is rapidly becoming so along the eastern edge of the Plains region, rotations, when they are used at all, are arranged with reference to this crop. The land is usually left in alfalfa for a period of three to five or more years. When first broken up it is devoted either to a cultivated crop or a small-grain crop. This is usually followed by sugar-beets or potatoes (sugar-beets are not grown the first year after alfalfa because the large roots of the alfalfa interfere with their cultivation). The land is then again devoted to small grain, with which alfalfa is sown. There are numerous variations of this general type of rotation in the section in question.

In the South rotation of crops is almost unknown. In a few instances it is beginning to be practiced. One of the best rotations in any part of the country is widely adapted to conditions prevailing in the South. It consists of cotton, followed by corn, with which cowpeas are sown. This crop is followed by a winter crop of oats and a summer crop of cowpeas. This gives four crops in three years, leaving two blank spaces to be filled by cover-crops or green-manures, namely, between the cotton and the corn and between the cowpeas and the cotton. In this rotation permanent or semi-permanent grasses have no place. When live-stock-farming becomes general in the South, and Johnson-grass has spread over all the territory to which it is adapted, which it ultimately will do, there is a type of rotation including Johnson-grass which will be good. It closely resembles that just outlined and, in practice, may be identical with it, but with the Johnson-grass added. It will consist of cotton followed by corn and cowpeas, these by a winter crop of oats. After the oats are harvested, the Johnson-grass is allowed to come up, and furnishes two crops of hay the first year. The next year it furnishes three cuttings. If then it is used another year for pasture without disturbing the soil, its rootstocks come very near the surface and it can be broken up for cotton and got rid of almost as easily as Kentucky blue-grass in the North. In breaking up the sod for cotton, however, it is of the utmost importance not to plow over four inches deep, for if the rootstocks be buried deeper there is great difficulty in eradicating the grass. On farms where the first type of southern rotation is used there is always more or less permanent grass-land usually devoted to Bermuda.

I. The Timothy Region

As already intimated, the principal grass crop of the timothy region consists of a mixture of timothy (*Phleum pratense*), Fig. 536, and red clover (*Trifolium pratense*), Fig. 671. This crop usually follows wheat or oats and precedes corn. The mixture is left down by different farmers from one year to an indefinite length of time. In the shorter rotations on well-managed farms, two tons of hay per acre are usual and the very best farmers secure three and a half to four tons per acre. The longer the grass remains down under ordinary management the lower the yield. After three or four years the yield usually falls below one ton per acre and the hay consists largely of weeds.

Timothy is usually sown in the fall with wheat or other fall-sown grain. It may be sown at the same time as the grain, from a special grass-seed compartment on the grain drill, in which case some farmers allow the timothy seed to fall in front of the grain hoes so that it will be covered by the drill; others allow it to fall behind the drill hoes, either covering the seed later by means of a light harrowing or brushing of the land or leaving it to be finally covered by rain. The quantity of timothy seed usually sown under such circumstances varies from four to twenty pounds

Fig. 671. Red clover.

per acre, although few farmers sow less than eight or more than sixteen pounds. One peck (eleven pounds) is perhaps about the average.

The clover is added in the spring. There are two general methods of sowing the clover. In the eastern two-thirds of the timothy belt and rather generally in the western third, it is customary to sow the clover seed in late winter or early spring, usually in February or early in March, either on light snow or at a time when the ground is lightly frozen and cracked "honey-comb" fashion, leaving the seed to be covered by natural processes. This method has been fairly satisfactory, though it is thought not to be as reliable as the following. In the western third of the timothy region the better class of farmers wait until the ground is in condition to harrow before sowing clover. The seed is then sown and the ground harrowed.

The quantity of clover seed sown on timothy and wheat in the spring in this manner is, generally speaking, about the same (by weight) as the quantity of timothy seed sown in the fall. Some farmers sow more clover than timothy per acre; others sow less. The average quantity sown is probably about twelve pounds per acre. This is six quarts of clover seed, while it would require a little more than eight quarts of timothy seed to weigh twelve pounds.

Because of the prevalence of the idea that timothy must be sown in the fall with grain, less timothy is grown than formerly in some of the best agricultural sections of the West where wheat has been largely abandoned. It has been shown in recent years by the practice of some of the most successful farmers in the country that, except along the western edge of the timothy region, one of the most satisfactory practices is to sow timothy and clover together on well-prepared land in late summer (not early fall), though some farmers sow as late as the middle of September. This is considered late sowing by farmers who practice this method. When sown thus without a nurse-crop, a full crop of hay is produced the next year, while if sown as first above outlined, a crop of hay is not taken until the second summer. In the western edge of the timothy region this method has not been found to be entirely satisfactory. There is too much danger of severe drought in late summer. In that section a few progressive farmers have found that clover at least may be sown in corn at the last cultivation, and that a good stand can be assured by this method with perhaps more certainty than with any other method. In some instances in southwestern Missouri, the better class of farmers sow timothy alone in the early fall and add the clover in the spring after the land is in condition to harrow. This method has proved very satisfactory where it has been tried, furnishing a moderate crop of hay the first year.

It is known that timothy may be added to a clover sod at any time by sowing the timothy in the early fall and harrowing it in. Likewise, clover may be added to a timothy sod at any time by sowing it fairly early in the spring and harrowing the sod. As already stated, timothy and clover are sown very generally in corn at the last cultivation in New England, with excellent results. In that section corn is grown mostly for silage. This leaves short corn stubble, which is harvested with the hay the first year; but since on good farms this hay is fed on the place, the corn stubble is not very objectionable, as it makes a convenient bedding when left in the feed-racks by the cattle. [See *Clover*.]

Other meadow ingredients.

Red-top. (Fig. 538.) In some parts of the timothy region red-top is frequently sown in the mixture. This is particularly true in New England, New York and Pennsylvania. Occasionally it replaces timothy entirely, for instance in a considerable section of poorly drained prairie land in southern Illinois, where most of the red-top seed of the country is grown. Generally speaking, however, red-top is considered a weed, and its presence in hay on the markets results in a lower grade for the hay. At the same time, it is more nutritious than timothy and is said to be especially desirable for horses when they can be taught to eat it readily.

Red-top is especially valuable in low, moist to swampy places, and may be used on such areas in meadows and pastures. It will endure flooding for a considerable time. It is suggested, also, that it does best on acid soils. It is not adapted to quick rotations, as it does not become well established under two years. It has creeping stolons, and makes a good bottom grass. When used with bunch grasses it fills in the open spaces and makes a good sod. In the South it makes a fair growth through the winter, if the weather is not too severe, and in the spring grows rapidly.

The quantity of red-top seed used in mixtures with other grasses varies widely, from perhaps one pound of recleaned seed to eighteen or twenty pounds. The recleaned seed is the most satisfactory, as less of it is required. It does well with timothy, orchard-grass and alsike clover. Twelve to fifteen pounds of recleaned seed are ordinarily sufficient for a good stand. It is also much used in lawn mixtures in the north Atlantic states. Ordinarily, the seed on the market contains a large amount of chaff, and in order to get the same result it requires three or four times as much of this as of recleaned seed. The weight of the market seed varies with its purity, but ten to twelve pounds per bushel is a fair average. The recleaned seed weighs about thirty-five pounds. The seeding is made in the spring generally, although it may be in the fall with timothy.

Alsike clover (Fig. 335) is rather generally used in small quantity in the meadow mixture and its use is becoming more prevalent than formerly. This clover succeeds well on land where red clover formerly succeeded, but now fails. Heretofore about two pounds of alsike have been used in the mixture in place of four pounds of red clover, but in recent years the quantity of alsike has been increased. In middle Tennessee and in western Oregon, alsike is rapidly replacing red clover entirely, because of the prevalence of diseases to which red clover is subject and alsike is not. [See *Clover*.]

Pastures in the timothy region.

Timothy and clover meadows are more or less generally used for pasture purposes throughout the timothy region. The aftermath is very frequently pastured after hay is cut, and it is a common practice to use the meadow exclusively for pasture after the first or second year. The only other pasture grass of great importance in this section is blue-grass (Figs. 549–551), more commonly known in the southern parts of its territory as Kentucky blue-grass and in the northern parts as June-grass (*Poa pratensis*). In the quality of the forage it furnishes, blue-grass is hardly surpassed by any other grass in this country. In yield, however, it is inferior to many other grasses. It furnishes most abundant feed from early spring to early summer and again in the fall after the heat of summer is past. In some sections blue-grass invades meadow lands and becomes well established by the time the clover begins to disappear, which is usually in two years. This is especially true on soils to which blue-grass is particularly partial. In other sections blue-grass is added to the meadow land at the time the clover is sown and becomes established within two or three years. Ordinarily this grass is very slow to start and in some sections farmers, particularly those whose principal business is the production of beef cattle, are loath to plow up a good blue-grass pasture because of the difficulty of starting it again. Blue-grass is usually sown in the spring. The quantity of seed varies greatly because of the difference in quality as it is found on the markets. Twenty-five pounds per acre of the best quality is sufficient for a good stand, although it would require seventy-five pounds of much of the seed on the market.

Mixtures of other grasses than those here discussed are so rarely met with in the timothy region that they cannot be considered within the space available for this article. A few other grasses, however, deserve brief mention.

Position of other grasses and clovers in the timothy region.

Orchard-grass (Fig. 544) is of importance in only a few sections which lie on the margin of the timothy region. An exception consists of two or three counties in Kentucky, below Cincinnati on the Ohio river, and one county opposite in Indiana. Most of the orchard-grass seed of the country is grown here. [Bulletin No. 100, Bureau of Plant Industry, entitled "Orchard Grass."] In some parts of Virginia, North Carolina, Tennessee, northern Arkansas, southern Missouri and eastern Kansas, orchard-grass is grown considerably both for hay and for pasture. It is usually seeded in the spring on well-prepared land with or without clover. Twelve to twenty-five pounds of seed are used per acre, according to the quality of the seed and the condition of the seed-bed. With good seed and a well-prepared bed twelve pounds makes a very satisfactory stand, especially for seed-growing.

Orchard-grass has two serious faults. In the first place, it grows in bunches and makes a very rough sod. In the second place, it must be cut very promptly at blossoming time or within a few days thereafter, in order to make a good quality of hay.

Brome grass (*Bromus inermis*). Figs. 557, 672. This grass will be more particularly mentioned in dealing with the Plains region. Because of its larger yield of forage and its excellent quality this grass deserves more attention, especially as a pasture grass, than it has formerly received in the northeastern quarter of the United States. [See page 452.]

Fowl meadow-grass (*Poa triflora*, Gelib.; *P. serotina*, Ehrh.). Fig 552. This is an important grass on wet lands in some parts of New England and is frequently recommended for wet lands throughout the timothy region, though it has made no headway except in New England. Very little of it is on the markets and little is known concerning the quality of the seed or the amount required for sowing. As is the case with most grasses which are not standards, and the seed of which occurs in the markets in small quantities, the seed is usually not of very good quality.

Japanese millet (*Panicum Crus-galli*). Barnyard grass. (Fig. 526.) This grass has become somewhat

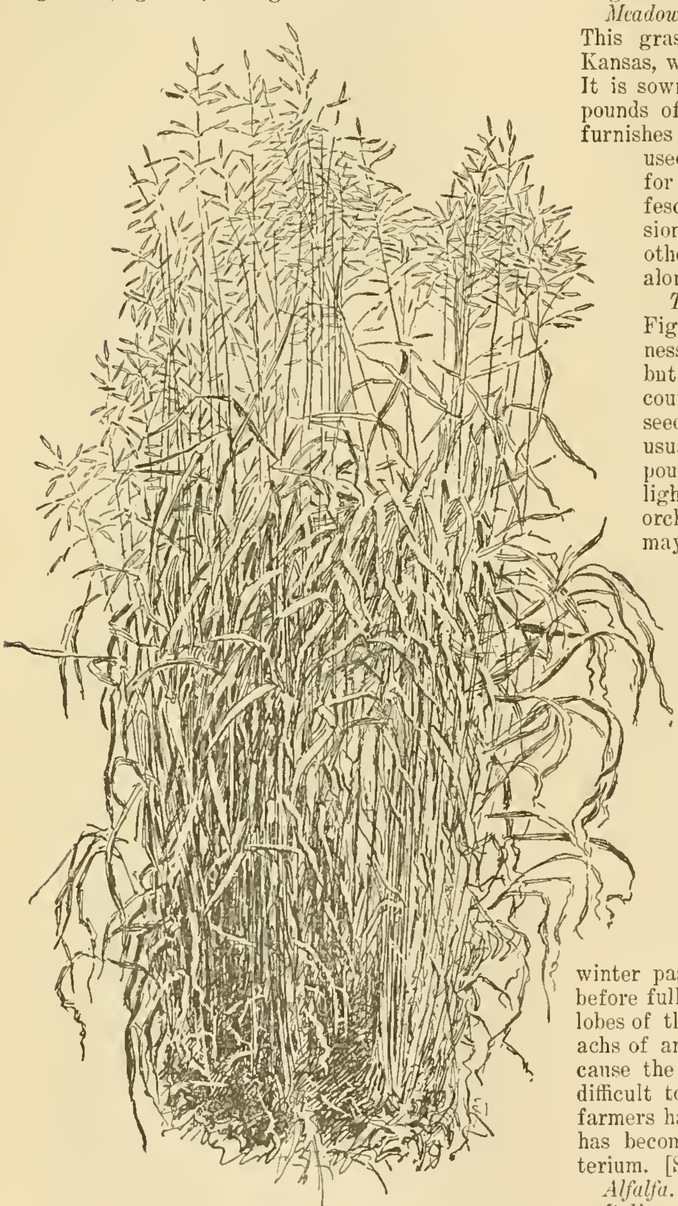

Fig. 672. Brome grass (*Bromus inermis*).

important in parts of New England. It may be sown for soiling and silage purposes at any time from late spring to midsummer. When cut at the proper stage, it is greatly relished by cattle. It is very difficult to cure as a hay and is ordinarily used only for soiling or for silage.

Barnyard grass prefers a rich, moist soil. The seed is lighter than that of most of the millets. It may be broadcasted, but drilling is preferable. One to three pecks to the acre is sufficient when sown for hay. It is deserving of more attention than it has received, for it yields heavily. It produces a large amount of seed. [See *Millet*.]

Meadow fescue (*Festuca pratensis*). Fig. 554. This grass has assumed importance in eastern Kansas, where it is known as English blue-grass. It is sown in spring at the rate of about twelve pounds of good seed per acre. The first year it furnishes considerable pasture. Thereafter it is used for pasture, for seed production or for hay. Elsewhere in this country meadow fescue is seldom met with, being found occasionally on the Pacific coast and rarely in other parts of the timothy region, especially along the southern border.

Tall oat-grass (*Arrhenatherum elatius*). Fig. 535. This is found occasionally in Tennessee and on the northern Pacific coast, but is practically unknown elsewhere in this country. It requires about thirty pounds of seed per acre and the high price of the seed, usually twenty-five to thirty-five cents per pound, makes it almost prohibitive. It is a light yielder, ripens at the same time as orchard-grass, with which and red clover it may be sown. It makes a fair quality either of pasture or of hay, which, however, is not at first readily eaten by stock.

Crimson clover (*Trifolium incarnatum*.) Fig. 338. This winter annual has become established, in recent years, along the Atlantic seaboard, and is occasionally met with in the middle South. On the north Atlantic coast, as far north as Freehold, New Jersey, it may be sown at any time from June to October first. Ten to twenty pounds of seed per acre are used, usually the smaller amount. It is frequently sown in corn at the last cultivation; also after a crop of potatoes has been harvested. Its principal use is as a green-manure and cover-crop, but it is also valuable as winter pasture, a spring soiling crop, and, if cut before full bloom, as hay. If cut later, the barbed lobes of the calyx form "witch balls" in the stomachs of animals, sometimes in such quantity as to cause the death of cattle and horses. The crop is difficult to grow except in a few localities where farmers have learned its peculiarities and the soil has become inoculated with its appropriate bacterium. [See *Clover*.]

Alfalfa. [See Pacific coast region, page 452.]

Italian rye-grass (*Lolium multiflorum*), Fig. 560, is the leading hay grass of England and the continent of Europe. It has never been popular in the United States except in mixtures for lawns, where its rapid, early growth soon gives a green coat to the soil, and as a hay and pasture grass in the

Pacific Northwest. In the latter section it is very frequently found in meadows and pastures. Although practically a biennial, it is very early, and the seed falls readily when mature, so that it reseeds itself freely. It is usually grown with clover in western Washington, and gives good yields of hay or silage. This grass is occasionally sown in the South, in which section it behaves as a winter annual. Most of the seed of this grass obtainable on our markets is the refuse of the European crop, and is very unreliable. If good seed could be had, fifteen or twenty pounds per acre would give a good stand. Of ordinary market seed, twice as much usually gives a poor stand.

Perennial rye-grass (*Lolium perenne*), Fig. 561, does not differ essentially in its culture from Italian rye-grass. It grows best on stiff, wet soils, doing very well in marshy situations, where it will persist for several years.

Sheep's fescue (*Festuca ovina*). Fig. 555. This grass is not suited for hay, as it makes a too light growth, but it has value for pasture in the cooler and drier parts of the country. It does well on sandy soils. It may be seeded at the rate of three bushels per acre.

Red fescue (*Festuca rubra*), Fig. 556, is occasionally cultivated for lawns or in pasture mixtures, and is adapted to shady places. It grows on dry sandy soils and sterile uplands, making a fine, close sod. When seeded alone it is used at the rate of two and one-half bushels per acre. In grass mixtures it is used in small quantities. The seed weighs fourteen pounds to the bushel.

Rhode Island bent-grass (*Agrostis canina*), Fig. 539, is similar in habit of growth and adaptations to red-top, and much of what has been said regarding that grass applies to this. It is especially valuable for lawns. Most of the seed is grown in Rhode Island and Connecticut.

Canada blue-grass (*Poa compressa*). Fig. 547. This grass has value for pasture in the North, particularly in the northeastern states, but is not a heavy yielder. It succeeds best on clay soils and is better adapted to sterile knolls and barren fields than any other cultivated grass. It also does well on sandy soils and withstands drought. It should be sown in mixtures with other grasses when used for hay or pasture. The seed is a common adulterant of Kentucky blue-grass seed. [See pages 143, 144.] The plants can be distinguished by the flat stem of the Canada blue-grass ; and the latter has a bluer color and does not grow so tall.

Weeds in timothy and clover meadows.

When short rotations are practiced, the meadow being left down only one or two years, there is seldom any trouble from weeds. When the grass is left down for longer periods certain weeds become very abundant. In New England, quack-grass (*Agropyron repens*), Figs. 159, 564, white daisy (*Chrysanthemum Leucanthemum*), buttercup (*Ranunculus bulbosus*), and orange hawkweed (*Hieracium aurantiacum*), Figs. 156, 157, are the most troublesome, quack-grass being worse than the other three combined. In the middle states, red-top (*Agrostis alba*), Fig. 538, creeps into the meadows and is considered a weed. Another weed known as white-weed (*Erigeron Philadelphicus*) is very prevalent in old meadows. Quack-grass is beginning to appear in that section and ultimately will probably be as prevalent as it is in New England. On the Pacific coast west of the Cascade mountains, velvet-grass (*Holcus lanatus*), Fig. 541, is the most prevalent weed in meadow lands. It may be exterminated by cutting for hay before seed is formed, and disking the land repeatedly during the dry summer. This will exterminate the velvet-grass by the latter part of August, when any crop desired may be planted.

Velvet-grass is used locally in parts of northwestern United States for forage. It yields about a half ton of very light hay per acre, that is nutritious but not palatable. The seed matures early and shatters badly, and in addition is easily windborne, so that it is readily scattered.

Quack-grass is a widely distributed and troublesome weed in Europe and in southern Canada and the United States. Its extensively creeping rhizomes enable it to spread rapidly. It has some value as a forage, particularly in permanent meadows or pastures. It is both nutritious and palatable. A permanent sod must be gone over with a disk-harrow occasionally to loosen the sod. It is most useful as a soil-binder because of its persistent rootstocks. Quack-grass may be eradicated (according to Beal) by plowing late in fall, or very early in spring, regardless of weather conditions, and then using a shovel-toothed cultivator every three days till the middle of June. All green leaves must be persistently kept down. The harrow must cut off the stems below the surface of the ground to be effective. It is not worth while to plow deep or to rake out the rootstocks. The plant can be eradicated faster by thorough work in the spring growing season than later in dry weather. A cultivated crop should first be used on the land, and all of the grass that comes up persistently chopped out with a hoe. The only cure is entirely to rid the soil of the roots and seeds.

II. The Cotton-belt

Cowpeas. (Fig. 371.) The most important hay crop in the cotton-belt is cowpeas. When sown for hay they are usually sown alone after a crop of small grain. The yield is seldom less than a ton per acre and sometimes as much as three tons, or even more. Two tons, however, may be considered a good yield. The hay is most excellent, especially when the seed-pods are numerous and well filled. Cowpeas are somewhat difficult to cure for hay. A method more or less generally used is to bunch the hay on poles set in the ground and extending to a height of five or six feet. Two cross-pieces about four feet long are nailed to the poles about six inches from the ground. The hay is then piled on until it tops the stake. In this way cowpea hay may be cured in any kind of weather. Cowpea hay may be readily cured by the use of hay caps made of No. 10 ducking cut forty inches square, attaching a small weight to each corner.

Cowpeas are frequently sown in corn in the South at the last cultivation, either broadcast or in drills, at the rate of two pecks of seed per acre in the latter case. Most of the cowpea seed of the country is gathered by hand from peas thus sown. In a few instances, after the corn is gathered the corn-stalks and cowpea vines are cut together for hay. More commonly the vines are left on the ground for their renovating effect. This crop is very frequently sown alone, to be plowed under in renovating worn-out lands. This is an excellent practice, although where stock is available it would be more profitable to harvest the crop, feed it, and return the resulting manure to the land. When a heavy crop of cowpeas is plowed under, it is usually wise to wait until the following spring before planting the land to another crop. [See *Cowpea*.]

Satisfactory grasses are much needed for the South. Only two grasses have thus far been found that are generally adapted to the cotton-belt, and both of them are more or less objectionable because of their weedy nature. They are Johnson-grass and Bermuda.

Johnson-grass (*Andropogon Halepensis*, Brot. *Sorghum Halepense*, Pers., Figs. 518 and 673). Known locally in South Carolina and parts of Georgia as Means' grass. Johnson-grass was introduced into this country from Turkey about seventy years ago. It was hailed as a great hay grass for the South, and spread rapidly for a number of years before its weedy character was realized. It is probably the most productive hay grass in this country, and it is certainly one of the worst weeds. The weedy character is due to the remarkable development of its system of rootstocks, every joint in which is capable of producing a new plant. It is thus exceedingly difficult to eradicate when once established. When once started on a farm, it sooner or later spreads over the entire farm. It is distributed more or less generally throughout the cotton-belt. Northward its distribution is limited by cold. It does not spread into sections where the soil freezes to a depth of three or four inches in an ordinary winter. In recent years it is becoming established on irrigated lands in the Southwest, where it is giving a great deal of trouble, particularly in vineyards, where it is difficult to fight.

Johnson-grass will grow on almost any kind of soil, but it does best on rather heavy, moist land. It spreads ordinarily from the seed, but in cultivated land small bunches of the grass are spread more or less from the rootstocks, which are dragged about the field in tillage operations. In some sections it is unlawful to sow the seed of this grass. No very definite statement can be made concerning the quantity of seed required for a good stand. The seed weighs about forty-five pounds per bushel, and the quantity sown varies from a bushel to a bushel and a half per acre.

Johnson-grass yields, in ordinary seasons, three full cuttings of hay. All kinds of stock prefer the hay to timothy, and it is somewhat more nutritious than the latter. Because of its rather laxative nature, it is not well adapted to feeding livery horses that are liable to be driven to the limit of endurance immediately after a full feed. For ordinary work horses and for cattle, the hay is entirely satisfactory. Like all of the sorghums, however,

Fig. 673. Johnson-grass (*Sorghum Halepense*). By some, all the sorghums are included in the genus Andropogon.

it is somewhat lacking in protein, and should be fed with other materials rich in that material.

When it is desirable to utilize a stand of Johnson-grass for the production of hay, it is necessary to plow the land every two or three years in order to keep the meadow productive. The best time to plow for this purpose is just after the last crop of hay is harvested, or in spring before the growth has begun. The yield of Johnson-grass may be increased by sowing some winter legume, such as bur-clover or the common vetch, and pasturing the legume off during the late winter and early spring.

The fact that livery stable men do not find Johnson grass hay a satisfactory feed, and the fear of introducing Johnson-grass through the hay in sections where it is not already established, greatly limit the market for this crop. There is a fair market in some sections where the grass is well established and in regions where the lumbering industry is important.

Recent studies by the United States Department of Agriculture have resulted in discoveries that render the complete eradication of Johnson-grass comparatively easy. The underground stems live only one year. After passing through the winter, these stems have only one mission, and that is to throw up branches to the surface. These new branches, on reaching the surface, form crowns and produce new plants. About blossoming time these new plants send out a new growth of underground stems, which, if the top is left uncut, grow to great size and length, frequently penetrating the soil to a depth of four feet. But if the top is cut back promptly every time it heads out, these new rootstocks develop very late in the season, are very slender and remain very near the surface. If the grass be cut close during a season, then by plowing just deep enough to turn up all the rootstock, say three to four inches deep, the grass can be eradicated about as easily as Kentucky bluegrass. The succeeding crop should be a cultivated one, such as corn or cotton. A little better cultivation than usual will exterminate the pest when it is treated as here outlined.

Bermuda-grass (*Cynodon Dactylon*), Fig. 540, is distributed throughout the cotton-belt, and throughout the Gulf coast region, where cotton is not important. It is decidedly difficult to eradicate and hence is rather generally considered a weed. It can be held in check by growing densely shading crops such as sorghum, millet, cowpeas, velvet beans and the like. By smoothing down the land and allowing a perfect sod to form, the grass may be killed by shallow plowing followed by thorough tillage in dry, hot weather in summer. In the northern part of its territory an old sod may easily be killed by shallow plowing in late fall or in the winter. The resulting exposure of the roots to cold effectually kills the grass.

When grown for hay, Bermuda may be cut two or three times in a season. On good, fairly moist land it will yield two or two and one-half tons of hay per acre. In one instance, on James island, near Charleston, S. C., where vetch volunteers in the fall on a Bermuda sod many years old and is allowed to die down in the spring, two crops of Bermuda hay yielding four tons per acre are cut. This field has been handled in the same way for twenty-five years, with excellent results. It is heavily fertilized every spring with phosphoric acid and potash.

Bermuda is the best pasture grass of the South. Its carrying capacity is perhaps greater than that of any other pasture grass in the country. In the early part of the season, while the grass is young and tender, it is highly palatable. In late summer it becomes more or less wiry unless carefully handled, and is not so satisfactory. Unlike Johnson-grass, it will bear any amount of trampling, on the heavier class of soils at least, apparently without injury. On light, sandy soils it is rather easily driven out by other grasses, especially near the Gulf coast by carpet-grass (page 451).

Bermuda pastures and meadows are usually started from small pieces of sod incorporated in the soil. The seed of this grass is rather unreliable and usually costs not less than seventy-five cents a pound. By giving the seed-bed special preparation, fining it by means of the harrow as much as possible, and sowing the seed after the ground is thoroughly warmed, three or four pounds of seed will usually give a good stand, if it comes at all. A very good way to set land to Bermuda is to tramp into the ground while it is muddy small pieces of Bermuda sod. Another way is to drop pieces of sod two or three feet apart in every second or third furrow while the land is being plowed three or four inches deep. Still another very good practice is to put the land in good condition by plowing and harrowing, scatter pieces of sod broadcast and then roll them into the land.

Paspalum dilatatum. Water-grass. (Fig. 521.) This grass is found more or less widely scattered in the cotton-belt, and by many is thought to be of considerable value for hay and pasture, though its value is really not well established. It has a long growing season, starting early in spring and remaining fresh and green till fall. It is hardy and will grow on a wide range of soils, but prefers moist situations. It stands pasturing. The seed has recently found a place on the market. The seed is attacked by a fungous disease, which renders most of it useless. It should be gathered either very early in the season or very late to avoid this fungous disease. Little is known concerning the quantity of seed required or the best method of seeding. [See page 451.]

Cereals. The cereal grains are much grown for hay and for winter pasture in the South. Oats is by far the most important. They are all more or less valuable for both of the purposes mentioned.

Crab-grass (*Syntherisma sanguinalis*). Fig. 520. This grass is abundant throughout the cotton-belt and beyond. It is very frequently cut for hay, which is of fair quality, and is much pastured. As the grass comes up volunteer on land which is cultivated in the early part of the season and left undisturbed in midsummer, it is a cheap source of feed. It furnishes an important part of the hay crop, but is seldom sold off the farm where it is produced. The yield is half a ton to a ton and a half per acre, the smaller yields being usual; three tons per acre may be secured under the best conditions. The seed is never sown, the growth being entirely volunteer. It reaches its best growth in moist lands. The main difficulty is to cure the grass properly. When curing is well done, the forage is nutritious and palatable.

Japan clover (*Lespedeza striata*). Fig. 593. This useful plant was first observed about 1850 at Charleston, S. C. Since that time it has spread throughout the cotton-belt and as far north as the Ohio and Missouri rivers. It is found rather generally along roadsides and in waste ground. It frequently comes up in old deserted fields, in all of which situations it furnishes a considerable amount of valuable pasture. It is available for pasture from early summer till late in the fall. It seeds abundantly and when once established, although it is an annual, it is more or less permanent. The hay is said to be of excellent quality. [See *Lespedeza*.]

Fig. 674. Saccharine sorghum, grown for fodder.

Sorghum (Fig. 674) is very largely used in the South, in late summer, as a green feed for all kinds of stock. It is not infrequently sown thick and cut for hay. It is planted like either corn or wheat. In the former case one-half a gallon to a gallon of seed is used; in the latter case, half a bushel to two bushels. [See *Sorghum*.]

St. Augustine grass (*Stenotaphrum secundatum*), Fig. 530, is adapted to a wide range of soils, but seldom succeeds except near the coast. It is propagated readily by root-cuttings or pieces of the sod. Roots are formed wherever the joints touch the ground.

Texas blue-grass (*Poa arachnifera*), Fig. 546, is a native of Texas, but it is now grown somewhat widely in the southern states. It makes a good sod, which remains green the year round. It makes its principal growth during the winter, beginning in October and furnishing pasture until April or May. The seed is matured in April. In the summer months it makes little growth.

This grass would undoubtedly be more generally grown if it were easier to propagate. It produces an abundance of seed but is difficult to start from seed. Cuttings of the rootstocks are used almost entirely. They should be set about twelve inches apart each way. The creeping rootstocks soon occupy the ground. It does best on a rich loam, well prepared and having good drainage. Planting may be done either in fall or spring, September and October being preferable. If seed is used, it should be drilled in, in rows about twelve inches apart.

Rescue-grass (*Bromus unioloides*), Fig. 559, does best on a rich loam. It should be seeded in August or September, at the rate of thirty to forty pounds per acre. Farther north, where the summers are not so warm, it may be seeded in the spring and be used for summer and fall pasture. When fall-sown in the South, it grows rapidly and may furnish pasture in December or January. The seed will mature in March or April. If the conditions are right, two cuttings may be had in a season, the first one in the spring. If the seed is allowed to mature in the spring, it will fall to the ground and remain dormant until fall. In this way a permanent stand may be secured, and the land may be plowed and used for a summer crop during the dormant period.

III. The Gulf Coast Region

This is one of the most distinct agricultural regions in the United States. No distinct cropping systems are developed, although agriculture is more diversified in that section than in any other part of the South. Cotton is relatively of small importance. Truck-growing perhaps stands first. Sugarcane is important. Some phases of fruit-growing, especially in the southern part of the region, are prominent. More live-stock is found in the Gulf coast region than in any other southern territory. This is especially true of southern Texas and of central and southern Florida. In these sections, however, live-stock is not strictly farm animals but is run on ranges where the native grasses furnish more or less abundant feed.

The section has four more or less valuable hay and pasture plants of identical habits. Three of these are found mainly in the eastern gulf region, the fourth almost wholly in the western. The three in the east are crab-grass, beggarweed (*Desmodium tortuosum*, also given as *Meibomia tortuosa*), and Mexican clover (*Richardsonia scabra*). These all come up volunteer on land that is cultivated in spring and left undisturbed in summer. Frequently two or three of them are found together. Colorado grass, which is found principally in south-central Texas, has the same habits. It is of no importance except on alluvial soils, where volunteer crops sometimes furnish two or three tons of hay per acre. The hay is hard to cure because of its rank growth, but is of excellent quality if cut before it is too ripe. Crab-grass has already been discussed (page 449). It is perhaps more important in the Gulf coast region than it is in the cotton-belt. One farmer in Florida makes a business of producing seed of this grass. Beggarweed (Figs. 305–307) is used mostly for pasture and as a cover-crop, though it is sometimes cut for hay and for silage. The silage is said to be of unusually fine quality for dairy cows. [See *Beggarweed*.] Mexican clover has gradually spread over the eastern half of the

Gulf coast region. It is grown only as a volunteer crop. Horses relish it green, but cows do not. All kinds of stock, however, eat the hay readily. In some localities it is an important addition to the forage resources. [See *Mexican clover*, page 309.] All of these crops produce feed that costs nothing but the harvesting, and in most cases the stock may do that.

Velvet bean (*Mucuna utilis*). This crop is not much grown outside of Florida, but it is important there. It occupies the whole season, and is a very rank grower, the vines sometimes reaching sixty feet in length. It is difficult to handle as hay, but a good deal of hay is made from it.

The hay is of good quality and the yield is large. If left in the field, the vines and immature pods after they are frosted are eaten with relish by all kinds of stock. When the ripe pods have softened by contact with the ground, the seeds are readily eaten by cattle and hogs. About a peck of seed is used per acre, and the price of seed is usually about a dollar a bushel. It is doubtful whether this crop would satisfactorily replace cowpeas north of Florida. [See *Velvet bean*.]

Carpet-grass (*Paspalum compressum*). This grass is found from Florida to central Texas and north to Arkansas. The stems grow very close to the ground, sending up leaves two to six inches high. It is greatly relished by all kinds of stock, and its habit of lying flat and rooting at the joints enables it to bear closer cropping than any other good grass. On light sandy soils, when this grass is closely cropped it will drive out all others. It is not confined to sandy land, however, doing well on good upland loams. It is seldom cut for hay, but is one of the best pasture grasses in the country so far as quality is concerned. Its carrying capacity is hardly known because so little effort has been made to utilize it under farm conditions. Its seed is not on the market. The tall, bare stems are frequently cut and scattered where the seed is wanted. The seed could easily be gathered by hand or perhaps with a stripper similar to that used in harvesting blue-grass in the North.

Paspalum dilatatum. This grass was referred to above (page 449). In one section of southwestern Georgia it has become known under the name Dallis grass, from the name of a progressive farmer who has made considerable use of it for hay and pasture. In eastern Australia it is by far the most important of the grasses. It is known there as paspalum grass. It grows five or six feet high in Australia and is used mostly for pasture, remaining green the year round. It has been little tried in the Gulf coast region, but as it thrives in a corresponding latitude in Australia, it would appear that it is worthy of trial in northern Florida. It is not well adapted to sandy lands, which may account for its scarcity in the Gulf coast region.

Japanese cane. A variety of sugar-cane known as Japanese cane is somewhat frequently grown for forage in northern Florida and along the Gulf coast as far west as Louisiana. The stalks are smaller and more numerous than those of ordinary sugar-cane and the plant remains green longer in winter. It produces enormous yields of good forage and is much appreciated by dairymen. It lasts several years longer from one seeding than does the ordinary sugar-cane.

Cassava (Figs. 323, 324). An account of the forage crops of the Gulf coast region would not be complete without a mention of cassava. A few years ago this crop was exploited in that region and it became rather popular, although interest in it has waned greatly in recent years. In the Gulf coast region the roots are frequently used as feed for cattle and hogs, taking the place of corn, for which purpose they are valuable. It is difficult to secure a perfect stand of the crop. This may be done, however, by sprouting the stem-cuttings in coldframes before planting. An effort is now being made by the United States Department of Agriculture to propagate this crop from seed, with a fair degree of success. [See *Cassava*.]

Three recent introductions.

Guinea-grass (*Panicum maximum*), Fig. 523, the great forage plant of Cuba, is getting a foothold in Florida and along the Gulf coast to Texas. It does best on lands that are not wet, furnishes five or more cuttings a year and yields an immense quantity of excellent soiling material. It is best cut every four weeks, otherwise it becomes large and woody. It is very sensitive to cold, and if the ground freezes at all the roots are killed. It is used chiefly as a soiling crop. For the best results it must be planted in rows about five feet apart and cultivated. It produces seed at Biloxi, Mississippi, and volunteers freely from this seed. Little is known of its seed habits, as it is usually propagated from root-cuttings. It lasts several years from one setting.

Para-grass (*Panicum molle*), Fig. 522, is a bad weed in wet lands in tropical countries. It first sends out long runners (twenty or more feet) with internodes two feet long. From the joints it takes root and sends up branches three or four feet high. It is decidedly a wet-land grass. Because of its vigorous growth it is difficult to eradicate, but yields remarkable quantities of hay or pasture. It is fairly well relished by stock. It is propagated by cuttings of the creeping stems, which live through the winter. It does not mature seed in this country to any extent. The cuttings are best planted just before the rainy season, about six to twelve feet apart each way. It is not adapted to rigorous climates, and must not be cut too late in the fall. Time should be allowed after the last cutting to produce sufficient growth to protect the roots during the winter. It is a heavy grower, and may be cut every six weeks during the summer. The first cutting is made about June 1. It is grown in a few localities in Florida and in southern Texas. It has been known to carry three head of cattle per acre all summer and to keep them in good condition.

Natal grass (*Tricholaena rosea*) is a third recent introduction. It was introduced into Florida about 1890 by S. M. Tracy. It is well established there in the wild state in a few localities. It seeds abundantly and is spreading. Very little is known of its forage value. It grows two to five feet high and may be worthy of more attention than it has received. In the Hawaiian islands it is a rather serious weed in the cane-fields.

IV. The Plains Region

The eastern edge of the Plains region may be considered in two divisions, namely, the north and the south. In the north, brome grass (*Bromus inermis*, see page 445) is the most important perennial hay and pasture plant. It takes the place in that section occupied by both timothy and blue-grass farther east. It is usually sown in the spring, either with or without a grain crop, at the rate of about twenty pounds of seed per acre. Home-grown seed is much superior to the imported, largely because imported seed is the refuse from the European seed trade. The first year it yields large quantities of excellent hay. If cut for seed a good crop will produce 500 to 700 pounds of seed per acre. Later the grass becomes sod-bound, and unless broken up, and rolled and harrowed into condition again, it no longer yields profitable crops of hay or seed. It is, however, a good pasture grass for a number of years. It is beginning to be grown in rotation in that section much as timothy is grown in the East.

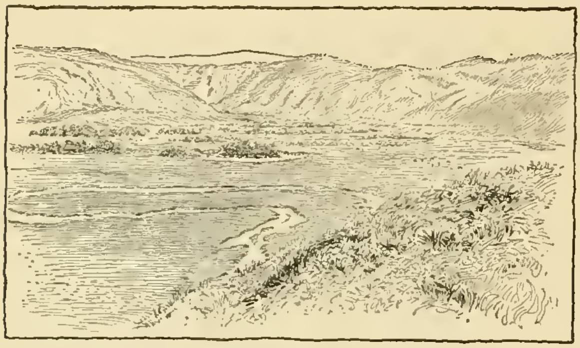

Fig 675. Native pasture. Pottain Ranch on south fork of Humboldt river, Elko county, Nevada. Looking down stream.

Millet is important in the same region. This is true both of the foxtail millets and of the broom-corn millets. Brome grass extends as far south as northern Kansas, but does not succeed south of central Kansas. The millets, especially the foxtail varieties, extend to central Texas.

The eastern edge of the Plains region is the only section in which millets are of first importance. It will be noticed more later. [See *Millet*.]

Foxtail millets. There are many varieties of this group, the most common being Common millet, or Hungarian-grass, and German millet. Common millet is grown most largely in the Northwest, German millet mostly in the South. The seed of German millet is largely grown in one locality in central Tennessee. Hungarian-grass is grown more or less throughout the country, being frequently found in small areas on dairy-farms in the North, even in New England.

Broom-corn millet. There are several varieties of broom-corn millet grown in the Dakotas. The seed is several times larger than that of the foxtail millets. It is sown after the manner of wheat, mostly for its seed, which is used as feed for all kinds of stock.

Sorghum. The several varieties of sorghum, both saccharine and non-saccharine, find their most important development as farm crops in the Plains region, especially from Nebraska southward. The ordinary sweet sorghums are grown largely for hay and for fodder. These crops are all resistant to drought and are relished by all kinds of stock. In Kansas and southward kafir (Figs. 577, 578) is largely grown both for grain and fodder. A variety of sorghum closely related to kafir, known variously as milo, dwarf milo and yellow milo, is of special value in the Panhandle region of Texas. [See *Kafir* and *Sorghum*.]

Alfalfa is the most important hay plant of this region. It will be noticed more particularly below.

In this region large quantities of wild prairie grasses are cut for hay. The hay is found on all the western markets, where it usually sells at about half the price of timothy hay.

V. The Rocky Mountain States

In this section alfalfa is by far the most important hay and pasture plant. It is grown mostly on irrigated land in the mountain states and to the west.

Timothy and clover, orchard-grass and the cereals, especially wheat and oats, occupy more or less important places in the economy of the farm in this section. In some of the mountain parks an excellent quality of wild hay is secured. In one of these, South Park, Colorado, a species of rush (*Juncus Balticus*) is extensively cut for hay, and this hay on the Denver market outranks timothy as a feed for horses. In northern Montana, in the Milk river valley, a wild grass, known locally as blue-stem (*Agropyron occidentale*), is grown extensively for hay, and it is generally considered as superior to timothy for horses. This same grass prevails more or less generally in Colorado and the Dakotas, and, when present in considerable quantity in the native hay, adds greatly to its feeding value. It is especially adapted to wet lands and irrigated areas. It is nutritious and palatable, and relished by horses. Slender wheat-grass (*Agropyron tenerum*), which is a bunch grass, also does well on dry land and is very hardy against cold. It is a promising forage grass in the Dakotas and the Canadian Northwest, where it may be considered a standard grass.

VI. Pacific Coast

Alfalfa. In this section alfalfa outranks all other grasses and forage plants. It is almost the only hay crop grown on irrigated lands. We may fairly state that aside from maize it is the most valuable forage plant known to man. Many fields are reported that have yielded satisfactory crops for a quarter of a century or more. It succeeds generally on irrigated soils throughout the West and on good non-irrigated prairie soils in the Plains region from the Dakotas to southern Texas. Farther east it is more choice of soils, being difficult to grow except on rich alluvial soils or on upland soils heavily charged with lime. It is becoming well established on alluvial lands along the Red river in Louisiana and Arkansas and along the Mississippi river as far north as southeastern Missouri. It may be grown readily on good prairie soils in Missouri, Iowa, southern Minnesota, southern Wisconsin and northern Illinois. In central New York it has long been established on a peculiar limestone soil. Perhaps one of the best alfalfa soils in the country is that found in what is known locally as the Cane Brake in Alabama and Mississippi, a narrow strip of prairie land heavily charged with lime, running across the central part of the state of Alabama and turning northward into northeastern Mississippi. In the localities mentioned, this crop is not difficult to start, though in some sections inoculation with alfalfa bacteria is necessary when the crop is first introduced. When this crop is difficult to grow, it is well to sow the seed from the middle to the latter part of August in the North, from the middle of August to the middle of September in middle latitudes, and either in September or March for the South. The number of cuttings increases southward, being three in a season in the northern states, four in the latitude of southern Missouri, four to six in northern Louisiana, eight to nine along the Rio Grande river, and eight to eleven in southern California.

Aside from its use for dairy and beef cattle, alfalfa is perhaps the best hog pasture in this country. The feeding value of the hay is such that brood sows can be wintered on it without other feed very satisfactorily. It is also an excellent pasture for horses and mules. Because of its tendency to cause bloat, cattle and sheep should not be pastured on alfalfa except with great caution. [For further information, see the article *Alfalfa*, page 192.]

On non-irrigated lands the cereals, especially wheat, are grown for hay very largely on the Pacific coast. Wild oats (Fig. 543) are a bad weed in that section. It is customary to cut those sections of wheat-fields for hay in which wild oats are most prevalent. Barley and oats are also used extensively in some localities for hay. In western Oregon and western Washington timothy and clover occupy much the same place that they do in the timothy region of the East, but in that section orchard-grass and Italian rye-grass, particularly the latter, are much more appreciated than they are in most other parts of the country. Meadow fescue is also frequently met with in western Oregon. Along the northern Pacific coast, especially on sandy and peaty soils, velvet-grass is almost universal. It is generally regarded as a pest because of its low yield of hay and because stock will not eat it until starved to it. However, they can be made to acquire a taste for it, after which they will thrive on it. It yields about half a ton of hay per acre.

Native Meadows and Pastures of the Plains and Ranges. Figs. 676, 677.

By *P. Beveridge Kennedy.*

The native or unsown meadows and pastures, existing on unbroken or wild land, extend over such a vast extent of country, with such varied characteristics of soil and climate, that only the larger phases of the subject can be treated in a discussion of this nature. Some of the leading species comprising the grazing flora may be mentioned. The native hay lands and grazing lands are not necessarily tenanted by grasses and clovers alone, as we shall see.

The Southwest.

The greater part of Arizona, New Mexico and Texas is included in this region. Poplars and willows are abundant along the rivers, while mesquit and creosote bush cover large stretches on the sandy and gravelly mesas. The native meadows in the northern part consist largely of saccaton and saltgrass, which furnish forage of a poor quality. Farther south there is an open prairie country. In some sections of New Mexico and Texas on the mesa lands, the grama-grasses furnish considerable summer and winter pasturage. In the extreme southwest, in the Texas prairie section, the wheat-grasses, blue-stems, gramas, wild-rye, mesquit-grass, switch-grass, needle-grass and buffalo-grass furnish considerable native pasturage in seasons of good rains.

The important grasses entering into the composition of the native meadows and pastures are, the western wheat-grass (*Agropyron*), feather and bushy blue-stem (*Andropogon*), three grama-grasses (*Bouteloua*), Arizona millet (*Chætochloa*), wild-rye (*Elymus*), everlasting grass (*Eriochloa*), curly mesquit (*Hilaria*), wild timothy (*Muhlenbergia*), white-top (*Triodia*), galleta or black grama (*Hilaria*), alkali saccaton (*Panicum*), needle-grass, (*Aristida*), buffalo-grass (*Bulbilis*), bunch drop-seed grass (*Sporobolus*), and saltgrass (*Distichlis*).

Fig. 676.
A Sage-brush. One of the Artemisias.

The following plants, other than grasses, are of great importance on the ranges for forage: Mesquit beans (*Prosopis*, p. 308), screw-bean (*Prosopis*), lupines (*Lupinus*), milk-vetches

(*Astragalus*), saltbushes, winterfat (*Eurotia*), plantains, alfilaria, Stolley vetch, tallow-weed (*Actinella*), tall tallow-weed (*Amblyolepis*), beggarweed, wild bean. Prickly pear and other cacti have been used for forage in this section by burning off the spines (page 226).

The Great Plains region.

The native grasses and forage plants of this region do not play such an important part in agriculture as formerly. There are still, however, immense tracts of open prairie from which large quantities of native hay are cut. In wet and swampy places, slough-grass (*Spartina*), if cut when young, furnishes a supply of coarse hay. Several blue-stems together with switch-grass (*Panicum*), side-oats grama (*Bouteloua*), and western wheat-grass, supply the bulk of the native hay. All of these are also valuable for pasturage, but the two chief pasture grasses are buffalo-grass and blue grama. Other grasses of importance are wild rye, wild timothy, reed canary-grass, and needle-grass (*Stipa*). Two native forage plants, other than grasses, which have come into prominence because of their forage value are the wild vetch (*Hosackia*; see the article on *Vetch*, page 658) and Beckwith's clover (*Trifolium Beckwithii*). The former occurs more or less abundantly throughout the prairie region, while the latter is common in low meadows along the upper Sioux valley and other places in South Dakota. As elsewhere on the open ranges of the country, much harm has been done by over-stocking

The Rocky mountain region.

The cultivated crops grown in this region are insignificant compared with the millions of cattle, sheep and horses that subsist on the summer mountain ranges and the winter desert feeding-grounds. The Red Desert of Wyoming alone is estimated to winter 300,000 to 500,000 sheep. In Wyoming some alfalfa is grown, but the bulk of the hay is made from the native grasses. The native meadows are composed chiefly of blue-grasses (*Poa*), wheat-grasses (*Agropyron*), brome-grasses (*Bromus*), rye-grasses (*Elymus*), blue-joint, needle-grass, hair-grass, mountain timothy (*Phleum*), mountain foxtail (*Alopecurus*), sedges and rushes. In the foothills bordering on the Great Plains region, blue grama is abundant and important. Sheep's fescue and snow-grass (*Festuca*) are also important on the high mountain ridges.

Two native species of clover, Rocky mountain and Beckwith's, add greatly to the nutritive value of the meadow hay in some places. There are very many other plants, both annual and perennial, as well as a large variety of shrubs, which are of value from a forage standpoint, but cannot be here enumerated.

Fig. 677. Mountain or bunch-grass pasture in the far west.

The Great Basin region.

This region is bounded on the west by the Sierra Nevada mountains, extending northward to include parts of Oregon and Idaho, and southward to northern Arizona. Sagebrush and rabbit-brush (*Chrysothamnus*) are the prevailing plants, except where alkali is present, when the vegetation changes

Plate XVI. Permanent pasture. This is the noted "Roberts' Pasture" at Cornell University, laid down by Professor I. P. Roberts about twenty-five years ago, and still in prime condition to iodine weed (*Suæda*), greasewood (*Sarcobatus*), saltgrass (*Distichlis*), and saltbushes, according to the percentage of injurious mineral salts in the soils. In the central part of Nevada, along the Humboldt river, there are immense tracts of wild native hay and pasture lands. The stock is allowed to roam in the hills during the summer and in the autumn is turned into the meadows after the hay is all stacked, when they feed among the tules (*Typha*) and other places inaccessible to the mower. The hay consists largely of wild wheat-grass (*Elymus*). It is sold at so much per day for range stock being fattened for market. In the desert regions there are numerous mountain valleys irrigated by the melting snow from the mountains. These produce an abundance of native hay and pasturage, comprised largely of blue-grasses, clovers, sedges and rushes. Giant rye-grass (*Elymus*), when young and green, is cut in considerable quantities and left in bunches where the cattle feed on it in winter when other forage becomes scarce. There are hundreds of other plants of considerable value that are browsed on throughout the year to a greater or less extent.

Pacific slope region.

In this region might be included the states of California, Oregon, Washington, Idaho and the territory of Alaska. It may be divided into the following geographical sections, each with its characteristic climate. (*a*) Pacific coast; (*b*) upper Pacific coast; (*c*) interior valley of California; (*d*) the Inland Empire; and (*e*) Alaska.

(a) *Pacific coast.*—This section is characterized by low hills of usually poor soil, although in a few places the coast line has been eroded and has formed fertile flood plains. On these bottom lands one acre to a cow is usually sufficient, and stock is on pasture for nine months of the year. The native pasturage consists of oat-grass (*Danthonia*), red fescue, hair-grass (*Deschampsia*), blue-grass (*Poa*), and about ten wild clovers (*Trifolium*), while mixed with these to a greater or less extent are a number of introduced species, such as the perennial and Italian ray-grasses (*Lolium*), velvet-grass, soft chess, white clover, bur-clover (*Medicago*), black medic and alfilaria.

(b) *Upper Pacific coast.*—This section includes northern California and the western parts of Oregon and Washington. The pastures consist mainly of tufted hair-grass (*Deschampsia*), white-top, meadow barley-grass (*Hordeum*), oat-grass, prairie June-grass (*Kœleria*), California fescue, reed-grass, slough-grass (*Beckmannia*), melic-grass (*Melica*), sheep's fescue, blue-grasses and several needle-grasses (*Stipa*). Adding greatly to the nutritive value of the hay and pastures are about fifteen species of native clovers. The mountain ranges also support an almost endless variety of plants of forage value, such as the vetches, wild lupines, sunflowers, wild carrots, Indian potato and many others. To the detriment of the native plants, three weedy brome-grasses, velvet-grass, small barley-grass and squirrel-tail grass have become naturalized. Hogs are usually turned into the woods, where they find plenty to eat almost the entire year round, feeding on acorns, nuts, manzanita berries, bulbs and tubers, together with grasses and clovers.

(c) *Interior valley of California.*—This section includes two immense valleys, which form a huge basin in the central part of California. Locally the basin is divided into the San Joaquin and Sacramento valleys, named after the rivers which run through them. The flood waters of these rivers extend during the spring months over hundreds of square miles of land, making it worthless except for pasturage, and then only in the late summer months. As the waters recede, a strong dense growth of tules (*Scirpus*) is produced, which, together with sedges, rushes and water-loving grasses, provides forage for large numbers of stock.

(d) *The Inland Empire or Columbia Basin.*—This includes parts of eastern Washington, northeastern Oregon and northern Idaho. In the Palouse country of eastern Washington, wheat and wild oats are largely grown for hay. Those sections of the Empire having a rainfall of less than ten inches are devoted largely to grazing and the production of alfalfa by irrigation. Large areas have been overstocked and the native meadows are being replaced by cultivated crops. Some of the grasses of special importance growing indigenously in the meadows and bottom lands are western and false wheat-grass, white-top, water foxtail, blue-joint (*Calamagrostis*), oat-grass, hair-grass (*Deschampsia*), saltgrass (*Distichlis*), wild rye, meadow barley-grass, melic-grass, manna-grass and blue-grasses. On the dry hills in the ravines and among the sagebrush, the following are of considerable importance; bunch wheat-grass (*Agropyron*), mountain rye-grass (*Elymus*), sheep's fescue, needle-grasses (*Stipa*) and false oat-grass (*Trisetum.*)

In addition to the above there are about ten native clovers, nearly all of which are very nutritious and well liked by stock. The sedges and rushes are also extremely abundant and enter largely into the composition of all the native meadows and pastures. As in other regions devoted to grazing, the vetches, milk-vetches, lupines, sunflowers, saltbushes and wild peas play an important part in the production of forage.

(e) *Alaska.*—Only a small part of this new territory has been investigated from a forage standpoint. The chief literature describing the meadows and pastures is to be found in the annual report of the office of Experiment Stations for the year 1904, Bulletin No. 82 of the Bureau of Plant Industry, and the publications of the Alaska Experiment Station. The following extract from Bulletin No. 82 will give some idea as to the present conditions: "Live-stock husbandry in Alaska will have to depend primarily on the native forage plants, supplemented in time, perhaps, by such additional ones as experiments shall indicate may compete with the native plants, or which on cultivated land will yield heavily enough to be profitable."

Blue-top, beach rye, Kentucky blue-grass, silver-top, Siberian fescue, various sedges, Alaska lupine and fireweed are mentioned as being the best native forage plants.

MEDIC. *Medicago* species. *Leguminosæ.* Figs. 678, 679.

The one great medic is alfalfa. This plant, once thought to be adapted only to semi-arid regions, is now grown extensively in many parts of the humid East, where it is specially valuable to dairymen. In recent years, eastern dairymen have depended on nitrogenous by-products to balance home-grown rations, which consist largely of corn silage and timothy hay. Alfalfa is adapted to saving a part of this expenditure, as is shown by the following table based on analyses and digestion experiments of American Experiment Stations:

Comparison of Hays on an Average Tonnage Per Acre.

	Yield per acre	Digestible nutriments per acre	Digestible protein per acre
	Tons	Pounds	Pounds
Alfalfa	2.3	2,461	506
Common red clover	1.1	1,027	150
Timothy	1.1	1,091	62

While alfalfa hay, on account of its bulky character, can only be a partial substitute for concentrates from grains or manufactured nitrogenous by-products, it may also on account of its productiveness, where successfully grown, be a profitable substitute for other hay crops. Since it is perennial it reduces the labor and care for a given area of land to the minimum.

The medics are plants of the genus Medicago, some fifty in number, some of which are grown for forage. With the exception of alfalfa, which is *Medicago sativa*, the species are of very secondary agricultural value, and are practically unknown to the farming people of this country. Medicago is closely allied to Trifolium (the clovers), from which it is distinguished chiefly by the twisted or coiled pods [see Fig. 274, in the *Alfalfa* article]. With the exception of one shrubby species, the medics are herbs, annual or perennial, mostly with clover-like habit, rather small leaves of three leaflets, and flowers purple or yellow in small heads, short spikes or racemes. They are native in Europe, Africa and Asia. Several species have been tried at experiment stations and more or less recommended for special purposes. Seeds of some species are used as adulterants in other seeds [see page 141]. The best known medic (aside from alfalfa) in this country is the hop or black medic (*Medicago lupulina*, Fig. 678), which looks like a small-headed yellow-flowered creeping clover. It is now a weed in many parts of the country, although not particularly troublesome. It is said to afford good forage and has been recommended for special places now and then, but it appears to be of little value as compared with several other plants that thrive under similar conditions. It is an annual wiry pubescent plant, lying close to the ground. *Medicago media* is the Sand lucern mentioned on page 193.

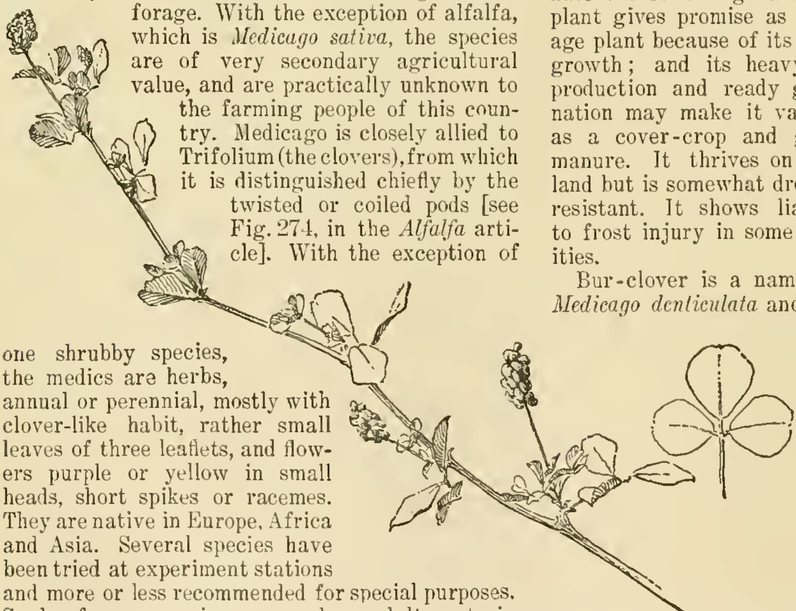

Fig. 678. Black or hop medic (*Medicago lupulina*).

A medic that has recently received attention is Snail clover (*Medicago turbinata*, Fig. 679). It is native in southwestern Spain, introduced into California as a winter forage plant. The seed starts as soon as the fall rains come, and the plant grows vigorously through the winter and spring. The heavy crop of seeds is matured in early summer, after which the plant shrivels up. It volunteers from year to year, so that direct seeding is not necessary after the crop is established. The pods, which are large and smooth, lie on the ground after the plant has withered, and are easily gathered. If they are allowed to remain, the seeds will germinate the following fall. The plant gives promise as a forage plant because of its heavy growth; and its heavy seed production and ready germination may make it valuable as a cover-crop and green-manure. It thrives on moist land but is somewhat drought-resistant. It shows liability to frost injury in some localities.

Fig. 679. Snail clover (*Medicago turbinata*).

Bur-clover is a name applied to two medics, *Medicago denticulata* and *M. maculata*. The former is a weed on the Pacific coast, but furnishes much forage in dry summer pastures. The spotted clover, or southern bur-clover, *M. maculata*, is recommended for the South, particularly for winter pasture in the sandy soils of the pine-woods regions. Various other medics are mentioned in experiment station and other literature, but they are not of sufficient importance to warrant discussion here. The economically important species in this country at present, aside from alfalfa, are *M. denticulata* and *M. maculata*.

MEDICINAL, CONDIMENTAL AND AROMATIC PLANTS. Figs. 680–691.

By *R. H. True*, and others.

The growing of medicinal, condimental and aromatic plants in the United States has at present hardly passed beyond the experimental or garden stage, the demand for articles of these classes being in general met where possible by importation. Nearly all native drug products are now obtained from wild plants. The threatened disappearance of some of the most valuable has led the government and private experimenters to make efforts to put some of these kinds under cultivation, e. g., golden seal, ginseng, echinacea, Seneca snakeroot, *Cascara sagrada* and others. Drug-plant cultivation on a small scale has long been practiced in a few places by the Shakers and others. At present, beginnings in this line have been made in several places. Ginseng to a total value of about a million dollars is grown in New York, Ohio, Kentucky, Missouri and other states in the eastern half of the country. Golden seal is grown sparingly over a similar area. In California, some success has been reached in growing insect flowers (Pyrethrum species) on a commercial scale.

Botanical source.

For medicinal, condimental and aromatic products in America, many botanical families are drawn on. The orchid family furnishes vanilla pods; the crowfoot family provides chiefly medicinal products, as aconite, golden seal and larkspur; the potato family is represented by drugs, as belladonna, jimson weed, tobacco, and among the condiments by red pepper and paprika; the mint family furnishes a considerable number of products used in medicine and also as flavoring agents, such as sage (Fig. 680), marjoram, basil, peppermint, spearmint, hyssop, thyme, savory and pennyroyal. Catnip, belonging to this family, has a medicinal value only. The laurel family is especially rich in aromatic principles, and hence forms the group from which many spices are obtained, notably allspice, sweetbay, cloves and cinnamon. Sassafras and camphor, products of this family, are of especial medicinal value. The parsnip family shares this tendency toward aromatic products which are frequently used for both purposes: caraway, anise, fennel, lovage and coriander. The mustard family is also usually characterized by products of an aromatic or spicy nature, as mustard, white and black. The spurge family is characteristically the source of medicinal principles, usually purgative, as castor-bean and croton seed. The great group of the composites includes a variety of products, such as dandelion, tansy, wormwood, elecampane and camomile to represent the medicinal group, and tarragon to represent the condimental use.

Parts of plants used.

Nearly all parts of the plant are made use of in obtaining medicinal, condimental and aromatic substances. The entire root is used in dandelion, burdock, belladonna, yellow dock, lovage, licorice ipecac, valerian and Seneca snakeroot; the bark of the root only in some cases, as in sassafras and cotton-root bark. The entire herb, excluding larger stems, is used in a number of small plants, as lobelia, pennyroyal, thyme, peppermint, spearmint and catnip; the leaves in belladonna, henbane, stramonium and foxglove; the flowers only in camomiles; the unopened buds in cloves; the fruits complete, as in red peppers, chillies, allspice, caraway, coriander, anise, fennel, black pepper

Fig. 680. Sage plant one year old (adapted from 1903 Yearbook, United States Department of Agriculture).

and vanilla pods; the seed freed from the seed vessel, as in mustard, poppy seed, castor-beans and fenugreek.

Time of harvesting medicinal, condimental and aromatic products.

In general, root products are usually collected at the close of the growing season, when the plant has filled the roots or rhizomes with reserve products, thus giving them a full appearance which makes them more acceptable than the shrunken material collected in the growing season. Early spring, before the reserve products have been used up, is also a good season to harvest. Some dealers assert that the shrunken roots of some sorts are preferable as containing a greater quantity of the active principle than fall-dug roots. Perennial roots are sometimes preferred at some special stage of growth; e. g., belladonna root gives the best yield of alkaloids when two to four years old; if too old it becomes woody and the alkaloidal content decreases. Marshmallow root is preferred when about two years old.

Leaves and herbs are, as a rule, collected when the plant is in full flower. Many tests have shown that at that stage the desirable principles, whether alkaloids or volatile oils, are most abundant. In the case of biennials, the leaves of the two years are often not of equal value; e.g., foxglove leaves are taken the second year when the plant is in flower.

Flowers are sometimes collected in the bud stage, as in insect flowers, or soon after the flower has well opened, as in camomile. Calendula flowers are harvested at this stage by pulling off the bright-colored ray flowers, which alone make up the drug. Fruits are frequently collected a little before they are thoroughly ripe in order to secure a bright appearance in the crude article, as in conium, coriander, anise, fennel and American wormseed. Others are allowed to ripen thoroughly, as red peppers and chillies. Some fruits are collected and allowed to dry before the seeds obtained from them are separated, as opium poppy, stramonium and castor-beans.

Methods of preparation.

Usually the products of medicinal, condimental and aromatic plants are not used when fresh, but have to be got into a condition permitting storage or shipment so that they may be used at a distance or at some later time. The homeopathic school of medicine makes it a strong point to use plant drugs in a fresh condition or preserved by immersion in alcohol. In general, the preservation of these products is brought about by simple drying. When dry many of them retain their most important properties for use. The live roots are carefully cleaned by washing, and if not too large for easy drying are merely spread out in some airy place. If too large, they are cut up, frequently into characteristic forms. Leaf products are dried in the shade with natural heat or over a gentle artificial heat, about 125° Fahr. In order to secure a bright green color, pains must be taken to keep the leaves from taking up moisture at any stage. When dry they should be stored out of strong light. Barks are usually "rossed" before drying, i. e., the dead outer corky parts are scraped off. In the case of some drugs, as cascara bark, a more or less prolonged period of storage is necessary before use. Flowers and fruits are best when dried as promptly as possible without raising the temperature to a point likely to drive off more of the volatile substances than is necessary. Nearly all drug and condiment products leave the hands of the growers in the form of the crude, dry products, which are worked up by the manufacturers into the proper forms for use.

Medicinal, condimental and aromatic plant importation.

The sources of our crude drugs and condiments are very widely separated, depending in large part on climatic conditions. Common drug plants belonging to the temperate zone, such as digitalis, burdock and caraway, are in very large part produced in northern and central Europe, frequently in more or less localized regions. Caraway comes chiefly from Holland, in small quantities from Norway, east Prussia and southern Germany. Fennel is cultivated in Saxony, Galicia, Macedonia and Italy. Digitalis leaves and belladonna reach the market from northern Germany, Austria, Belgium, Holland and England. Peppermint oil is produced chiefly in Japan and the United States. Other plants demanding tropical conditions are obtained from regions in which their culture has been undertaken. Cinchona bark, from which quinine is obtained, came formerly from the slopes of the Andes. Cultivation of this plant in India, Java, and other parts of the Orient has succeeded in so far as to cause the practical disappearance of the wild barks of South America from the market. Ipecacuanha, likewise a native of northern South America, is apparently repeating this history. Black and white pepper are chiefly produced in southeastern Asia, coming on the market through Singapore and Penang. Cloves are in large part supplied by Zanzibar, where the crop constitutes one of the royal monopolies. Some products are derived from still more localized regions, as buchu leaves from the vicinity of Cape Town, South Africa, and aloes from South Africa, the island of Socotra in the Red sea, and the Barbadoes islands. Some are cultivated, as may be seen in numerous cases cited above, and some are wild products. Camphor until recently has been derived from an essentially wild tree growing in Japan, China and Formosa. The great depletion of the natural forests has led the Japanese government to make extensive plantings. Several African sorts of the red peppers of the market are collected by natives from the wild plants and brought long distances to market.

The quantity of drugs and condimental products imported into the United States may be learned from the customs report, which shows a total of $16,414,868.37 for the twelve months ended June 30, 1906.

DESCRIPTIVE NOTES

It is not intended to present here a discussion of all the plants used for medicinal, condimental and aromatic purposes. A few of the more common and useful ones only are discussed in detail.

Anise (*Pimpinella Anisum*, Linn.). *Umbelliferæ.* (G. F. Klugh.)

Anise is an annual herb, two to three feet high, with smooth, twice-pinnate leaves, small yellowish white flowers in large terminal umbels, followed by short, somewhat curved, ribbed fruits ordinarily seen in pairs fastened together along their straight sides, narrowed toward the upper end, with a pleasant aromatic odor and taste.

Anise is widely cultivated for the aromatic fruits and the volatile oil distilled from them. Russia is the largest present source, with a considerable quantity grown in other European countries, especially on the Mediterranean sea. The plant has been grown in America only on a small scale, chiefly in gardens. Considerable heat seems to be required to mature the crop.

The plant grows readily from seed drilled in a good loamy soil, at such distances as may be best fitted to the method of cultivation, whether by horse or by hand. Planting should be done in the early spring. The fruit matures in the fall. Since a bright, clean appearance is desired, the fruit is collected before fully ripe. It is threshed off, dried and stored. The peculiar sweetish, aromatic taste is due chiefly to the volatile oil located in the ribs of the fruit.

The fruits are rarely used for flavoring, the oil obtained by distillation being preferred. The usual yield of oil is about 2.5 per cent. The material remaining after distillation is used in some parts of Europe as a stock-feed. One investigator in Siam reports that the leaves are grown there and distilled instead of the fruit.

Belladonna (*Atropa Belladonna*, Linn.). *Solanaceæ.* (G. F. Klugh.) Figs. 681, 682.

A coarse, herbaceous plant, with a fleshy, perennial root system, a branching, spreading and often straggling stem, reaching a height of three to five feet, bearing ovate, entire, nearly smooth leaves, three to six inches long, and numerous bell-shaped, dull purple flowers that occur either singly or in pairs; the fruit is a purple, very juicy berry of a sweet and not unpleasant taste. All parts contain atropine or related alkaloids and are poisonous. The leaves and roots are used in medicine.

Belladonna occurs wild in the United States occasionally, but is native in Europe and occurs

Fig. 681. Leaves of belladonna (*Atropa Belladonna*).

there abundantly both wild and under cultivation. The demand of the American drug market is in part satisfied from England, Germany and Austria, where the plant is cultivated or collected wild. Recently its cultivation in the United States on a commercial scale has been begun. It seems to thrive as far north as New Jersey and does well at Washington, D. C. Vermont seems to be too far north. It is probable that Virginia and the Carolinas offer a favorable type of climatic conditions.

The soil should be a rich garden loam, moderately light and sandy, since a heavy soil gives a poor return in plants, a light yield of leaves and roots, and favors winter-killing of the roots in severe winters. A complete fertilizer is recommended, containing phosphates, potash and nitrogen. The plants may be started in the field or in seed-beds and grown in three-foot rows, about twelve or fifteen inches apart in the rows. The seed may be sown in the fall or early spring in the field and barely covered with soil, germination taking place in March, when conditions are most favorable for the growth of young seedlings. One to four pounds of seed are needed to sow an acre.

Fig. 682. Root of a two-year-old belladonna plant, two feet deep. Grown at Washington, D. C.

Cultivation should be frequent and shallow to keep the soil in good tilth and free from weeds. The leaves are picked when the plants are in full bloom, dried carefully in the shade, and then kept in a dry place. One crop may be gathered the first year, and two or more the second and later years, if the stalks are cut after each picking of leaves. The roots are dug at the end of the second year, washed, cut into four- or five-inch lengths and dried.

The yield that may be expected on good soil is about 500 pounds of dried leaves per picking and 1,500 pounds of dry root at the end of the second year per acre.

Camphor (*Camphora officinalis*, Steud.). *Lauraceæ.* Fig. 683.

A large evergreen tree, native in Asia, having a wide-spreading top, a thick, much-branched stem, alternate, entire, evergreen, leathery leaves, broadly lanceolate to ovate in form, axillary clusters of small, yellowish flowers which are followed by small, blackish berries, in size and appearance not very unlike the fruit of the native small black cherry (*Prunus serotina*). The tree is cultivated in Florida, along the Gulf strip and as far north along the Atlantic coast as South Carolina.

The tree yields the gum camphor of commerce, as well as camphor oil used in liniments and the like. These substances are present in varying quantity in all parts of the tree, being especially

Fig. 683. Camphor leaves (*Camphora officinalis*).

abundant in the dead heart-wood of old trees. They are also present in the leaves and other parts. Experiments by the United States Department of Agriculture have shown that camphor gum of high quality can be distilled from the leaves by steam, and further experiments are now in progress in the hope of utilizing this source or method for camphor products.

Caraway (*Carum Carui*, Linn.). *Umbelliferæ*. (G. F. Klugh.)

Caraway is usually a perennial herb, having an enlarged, fleshy root; erect, slender, somewhat branching stem, reaching a height of two feet, bearing pinnately compound leaves, the segments of which are very narrow, almost filiform; the small white flowers form a flat-topped umbel; the fruits, the so-called "caraway," are narrow, ribbed, pointed at the ends, and have the characteristic caraway flavor due to the volatile oils contained in them. It is a native of Europe but is widely introduced into the United States, occurring wild or in kitchen gardens. Attempts are being made to produce it commercially in the United States to supply the large demand now satisfied from abroad, chiefly from Holland and middle Russia.

It grows well on heavy soils, but a moderately light soil gives larger yields and is supposed to give a grade containing more oil. The seed should be sown about the first of April in three-foot drills, at the rate of about eight pounds per acre, or in sufficient quantity to give a stand of plants about three inches or less apart. After the plants come up the soil should be cultivated shallow and weeds killed regularly until late summer the first year and early spring of the second year. Weeds left in the field at harvest time will contaminate the product when the seeds are harvested and reduce the value.

The seeds ripen about the middle of June the second year, and may be cut with a mower, threshed out and cleaned. The seeds should be light brown if cut just after the first seeds are ripe and before the stalks are dead. Cutting at this time makes a good salable product and avoids waste by shattering of the seeds. An acre should yield about 1,000 pounds of seed.

On distillation with steam the fruits yield a pleasant volatile oil with the odor and taste of caraway. According to the geographical source and conditions of soil and climate, caraway fruits yield 3 to 6 per cent of their weight in oil.

Catnip (*Nepeta Cataria*, Linn.). *Labiatæ*. Catmint. Fig. 684.

A perennial-rooted herb having a branching, erect or somewhat decumbent square-cornered stem, three to four feet high, bearing cordate or broadly ovate petiolate leaves with crenate margins, softly woolly surfaces and veins sharply marked on the pale under side; the small nearly white flowers are collected in terminal spikes, flowering late in the summer or early fall. It is a frequent garden plant, and has also escaped over a wide area.

Catnip is propagated by seeds or by root division. It likes a moderately rich garden loam, but does well on a variety of soils. The seed should be sown about the first of March, or as early as possible in the spring, in drills three feet apart, at the rate of one to two pounds per acre. After the plants are four or five inches in height, they should be thinned out to stand about eighteen inches apart in the rows. Shallow cultivation to keep the soil loose and conserve soil moisture will incidentally kill the weeds and produce a healthy growth. The plant will flower the first year in August or September and in subsequent years in June. The flowering tops are used. They should be picked free from large stems and dried carefully in the shade to preserve their green color. The yield of tops per acre is about 2,000 pounds under good conditions.


Fig. 684. Catnip (*Nepeta Cataria*).

Fennel (*Fœniculum officinale*, All.). *Umbelliferæ*. (G. F. Klugh.)

Fennel is an herbaceous perennial of the parsnip family, native to the Old World, grown for its aromatic fruit, and in India and Japan for its edible root. It is grown in central Europe and in the Mediterranean countries as well as in Japan and India, and sparingly in the United States as a garden herb. The fleshy root-stem of fennel gives rise to stout, smooth, succulent stems reaching a height of three feet, which bear the dark green, finely dissected aromatic leaves and numerous very small yellow flowers in branching, umbel-like, terminal clusters; the fruits, ripened in late summer, are about one-third inch long, conspicuously ribbed and have the pleasant fragrance characteristic of plants containing anethol.

Fennel does well on a moderately rich, well-drained loam or sandy loam, a heavy wet soil giving too much leaf and stem and too little fruit. It is sown in three-foot drills as soon in the spring as the ground is ready for garden planting, about five pounds of seed being used per acre. It is cultivated as an ordinary garden crop. The fruit ripens in the fall and is gathered at once in order to preserve a fresh, bright appearance. It is less desirable for the market if allowed to turn dark. After it is dry it can be cleaned of the immature fruit, some of which is unavoidably collected, since all fruits do not mature simultaneously.

The aromatic flavor is due to a volatile oil present in the ribs of the fruits. This oil is obtained by distillation with steam, a yield of 4 to 5 per cent being obtained. The fruit remaining after distillation is used in some parts of Germany as a food for cattle.

Foxglove (*Digitalis purpurea*, Linn.). *Scrophulariaceæ.* (G. F. Klugh.) Fig. 685.

Foxglove is a tall biennial herb with fibrous root system, and in the second year a straight stem bearing a long, unbranched raceme of large, two-inch long, showy, bell-shaped to funnel-formed flowers, purplish with darker spots in the throat, or nearly white, and a luxuriant development of alternate, sessile, woolly leaves, with venation conspicuous on the under side, crenate margins, largest toward the base of the stem, decreasing upwards to the base of the flower-bearing part of the stem. The dry seed-pods contain a multitude of minute seeds. The flowers open in the early summer of the second year. At the end of the first season's growth a strong rosette of radical leaves is seen. Leaves of the second year's growth form an important article in crude drug commerce. The demand of the United States is at present satisfied from English, German and Austrian sources chiefly, where the plant is cultivated for the purpose or occurs wild.

Fig. 685. Foxglove (*Digitalis purpurea*).

Since the seeds are very small, they require good conditions of germination to produce a good stand of plants if sown in the field, but they may be grown where they are to stand or in seed-beds and transplanted. The soil most adapted to the growth of foxglove is a good garden loam containing a liberal amount of sand and humus, but the plant will do well on heavier soils if transplanted. Good drainage is essential to keep the plants from damping off in hot weather and freezing out in winter. The rows should be three feet apart, the plants being fifteen to eighteen inches apart in the rows. A garden drill may be used to sow the seed, two pounds being required per acre. If planted too deep the seed will remain in the soil until turned up by subsequent cultivation. Early spring, as soon as the soil can be worked, is the best time for planting.

Frequent cultivation is desirable during the growing season of both first and second years until the plant flowers in June of the second year. The leaves around the bases of the flowering stalks are then picked and dried in the shade to preserve their green color. The yield of leaves from an acre of good soil well fertilized and cared for will be about five hundred or six hundred pounds. The relation of fertilizers to yield and content of active principle is an open question here as with other drugs.

Fig. 686. Golden seal (*Hydrastis Canadensis*).

Golden seal (*Hydrastis Canadensis*, Linn.). *Ranunculaceæ.* (G. F. Klugh.) Fig. 686.

A low, perennial-rooted herb with a stout, strongly-rooted rhizome of a golden yellow color when broken, sending up a slender stem about a foot high, which bears one or two alternate, five- to seven-lobed leaves, the leaves with a short petiole, the upper sessile, and a large basal leaf of similar general outline ; the single, whitish, inconspicuous flower is borne terminally above the upper leaf on a short peduncle ; the fruit is somewhat pulpy when ripe and in general appearance is suggestive of a small red raspberry. This plant is a native of the rich woods of the Appalachian region, Ohio valley and northward to southern Wisconsin. It has long been used in medicine and in recent years to an increasing degree. As a result it has become relatively rare in commercial quantities and its cultivation has been made a subject of investigation by the United States Department of Agriculture. The culture of golden seal is now widely practiced in small gardens.

The soil should be loose and loamy, well supplied with humus and shaded to keep it moist and cool. Plastering laths nailed to 2 x 4-inch pieces at the rate of four to the running foot give a proper degree of shade. These 2 x 4-inch pieces run across others nailed to the tops of eight-foot posts set two feet in the ground. The soil may be worked up without making beds. The planting may be in rows twelve inches apart, the plants being set six inches apart in the rows. Beds about four feet wide, made of ten-inch boards, and filled with soil are easier to keep clean of weeds but are more expensive in the beginning. Plants may then be set eight inches apart each way. A mulch of leaves or similar material three inches deep spread on after planting furnishes humus and keeps down weeds. Two hundred pounds each of acid phosphate and kainit in addition to the mulch will supply the necessary fertilizer. Walks about a foot or a foot and a half wide made between the beds make it possible to weed the beds without tramping out the plants.

The best method of propagation consists in dividing the root-crowns of old plants. These may be divided each year, doubling the number at each division, or, if desirable, more and smaller plants may be made according to the number of buds produced, since a bud and a part of the rhizome is necessary to produce a new plant. The tops die in early fall and the roots may be divided and planted again while they are dormant. Small plants are formed on the fibrous roots of old plants and may be cared for separately or with the other part of the crop. Seeds are a practicable means of propagation, being stratified in sand till the following spring when they are planted in the seed-bed. Several years are required to grow the plants to marketable size. The plants from crown division should be dug while dormant about the third year after planting, the large roots sorted out, washed and dried for market, and the smaller ones planted again with those made from crown division for a new crop. The yield per acre is 2,000 pounds, or more, of dried root.

Fig. 687. Liquorice plant (adapted from 1903 Yearbook, United States Department of Agriculture).

Liquorice (*Glycyrrhiza glabra*, Linn.). *Leguminosæ*. Fig. 687.

A smooth, perennial-rooted plant, with herbaceous top, bearing on the sparingly branching stems alternate, once-pinnate, compound leaves of eight to fourteen paired leaflets and one terminal member; leaflets entire, obtuse, oblong or elliptical; the small, numerous, papilionaceous, lilac- to violet-colored flowers borne in a rather loose, pedunculate spike. The underground parts are wide-spreading through the long, slender rhizomes which run out on all sides and constitute the chief part of the Spanish and smaller sorts of liquorice-root. The larger sort, the so-called Russian liquorice of southeastern Europe, consists of the larger, more irregular underground parts of the variety *glandulifera*, Reg. & Herd.

The chief sources of liquorice at present are Asia Minor and the Caucasus, where the plant grows wild, and Spain, Italy and England, where it is cultivated. The plant can be grown from the seed, but usually is propagated by planting the younger parts of the rhizomes bearing the buds. The crop is harvested in the fall by digging, the cuttings then removed being placed perpendicularly in the ground in a deep, rich, loamy soil. The crop is harvested every third year. The fresh root is washed, dried and sold. At present the United States Department of Agriculture is experimenting with several commercial sorts in several of the warmer states. Aside from the medicinal use, liquorice is largely demanded in the tobacco industry.

During the year ended June 30, 1905, the following importations of liquorice products were made: Liquorice extracts, etc., 751,646 pounds, valued at $90,508; root, 106,457,889 pounds, valued at $1,780,485.

Fig. 688. Lobelia (*Lobelia inflata*).

Lobelia (*Lobelia inflata*, Linn.) *Lobeliaceæ*. Indian Tobacco. (G. F. Klugh.) Fig. 688.

A small, branching, hairy herb, six inches to two feet high, bearing ovate or elliptical, roundly toothed leaves, and a slender spike-like raceme of small pale blue flowers, and later much inflated bladdery capsules containing a large number of small brownish seeds. It is found wild on dry hillsides and in pastures from New England to Georgia. Both the green herb and the seed are collected for the crude drug market. Recently the United States Department of Agriculture has undertaken its cultivation.

It likes a moist loam containing a fair percentage of sand and humus. Owing to the smallness of the seed and young seedlings, conditions suitable for germination must be unusually good. The seeds cannot be buried at all, but germinate early in April if planted in late fall or early spring on the surface of the soil. Freedom from weeds and thorough cultivation are essential to its growth. One-half to one pound of seed should be sown to the acre, the rows being two feet apart, to facilitate cultivation, and the plants left thick in the drill. The whole herb should be cut when in full flower and dried in the shade to preserve the green color. Good soil should yield about 1,000 or 1,200 pounds of dry herb per acre.

Lovage (*Levisticum officinale*, Koch.). *Umbelliferæ*. (S. C. Hood.)

An aromatic perennial of the Parsley family, characterized by a system of thickened, fleshy, aromatic roots, having the odor of celery, a tall smooth stem bearing twice or thrice divided leaves, segments wedge-shaped at base; yellowish flowers in umbels; seed three-ribbed and also aromatic. The large root is used both as a condiment and for medicinal purposes.

Lovage is an old garden plant introduced from Europe, and is grown as a crop in certain parts of the West and in New England by the Shakers. It is easily propagated either by root division or by seeds, but since the seeds grow so readily it is probably cheaper to use them. Planting should be done in fall in light soil, in drills eighteen inches apart. Heavy fertilization with stable manure should not be used, since it causes the plant to produce too much top. Cultivation consists in keeping the crop free from weeds. The plants will flower the second year and supply a large amount of seed, which also has a market value. The root should be gathered in the late fall and be well washed and cut into slices about one-half inch thick. These are then dried by heat at about 125° Fahr. When dry, they are ready for market.

Opium Poppy (*Papaver somniferum*, Linn.). *Papaveraceæ*.

A tall, smooth, somewhat branching annual, of grayish green color, reaching a height of about five feet, bearing large, ovate leaves with irregularly cut margins and clasping base. The large, solitary flowers are borne at the ends of somewhat elongated stems. The flowers vary in color from pure white to a striking magenta or purplish color, petals usually with a spot of darker color at the base. The fruit capsules are roundish in outline, somewhat elongated, or sometimes oblate. Some forms bear valves near the top, which open at maturity and permit the seed to escape; in others the valves do not open. The capsules, when scored superficially, yield abundant milky juice; in India, China, Persia and Turkey this is collected and dried to form opium, the crude gum from which the alkaloids morphine and codeine are separated. The white seeds are used under the name of "maw" seed in bird-seed, and as a source of a pleasant bland oil used for food purposes. The blue-seeded form is prized for culinary purposes in making the "Mohn Kuchen" of Germany and Austria, and in other forms of bakery. The oil is used for burning, in soap-making, and as a salad oil, either under its own or under some other name. Experiments being conducted by the United States Department of Agriculture have in view the cultivation of the poppy in the United States for the seed and for the alkaloids. Opium-making is not encouraged.

The commerce in products of the opium poppy for the fiscal year ended June 30, 1905, is as follows:

Crude opium . . .	456,563.79 lbs.	$913,770
Prepared for medicinal purposes . .		723
Prepared for smoking	144,997 lbs.	1,316,096
Morphine and its salts	21,290 oz.	41,734
Seed	38,399.25 bu.	76,779
Poppy seed oil . .	3,491.45 gal.	1,892
Total value		$2,350,994

Pennyroyal (*Hedeoma pulegioides*, Pers.). *Labiatæ*. (G. F. Klugh.)

A low, annual, erect, branching herb, six to eighteen inches high, with hairy, angled stem, and hairy, oblong or ovate leaves bearing short petioles, margins obscurely and bluntly serrate, glandular, especially on underside; flowers pale blue, crowded into loose terminal spikes. A native herb found wild in open woods along fences, usually in somewhat shaded places.

It grows on a variety of soils but is best in a garden soil where it makes an unusual growth. The seed should be sown in late fall in three-foot rows, at the rate of two pounds per acre. It should be cultivated as a garden crop and cut when in flower. The dried herb may be sold to drug dealers or the plants may be distilled, green or dry, with live steam for their volatile oil. The yield of dry herb per acre on good soil should be about two tons.

Peppermint (*Mentha piperita*, Linn.). *Labiatæ*. American mint. Fig. 689.

A perennial herb, usually one and one-half to three feet high, having a fibrous root system, many running rootstocks by means of which it is rapidly propagated, a thick growth of upright or ascending, branching, square stems, opposite leaves with entire margin, acute apex, short petioles, punctate with pellucid oil-glands; flowers purplish in loose, interrupted terminal spikes on the main stem and branches formed by the whorled clusters of flowers at the nodes. Characteristic when wild of wet places. Introduced from Europe.

Mentha piperita, var. *officinalis*, Sole., the so-called "white mint," is a smaller plant, having light green stems and foliage. It is grown chiefly in England.

Mentha piperita, var. *vulgaris*, Sole., the so-called "black mint," is like the species in stature, with large leaves, generally two to three inches long. Entire plant dark in color, due to the presence of a purplish pigment in leaves and stems. The varieties are of European origin, and although both have been introduced into the United States the white mint has not been grown extensively. The black mint is the most generally used. In America it has proved hardy and very productive.

Peppermint-culture is practiced in England, Japan, Germany and some other countries on a small scale, but extensively in the United States.

Perhaps 2,000 pounds will cover the amount of English and German peppermint oil distilled yearly. These countries import most of their oil from the United States. Michigan, northern Indiana and Wayne county, New York, are the most important regions. The Japanese peppermint oils are obtained from a different botanical source, *Mentha arvensis piperascens*, Malinvaud, and *Mentha arvensis glabrata*, Holmes.

Fig. 689. Peppermint (*Mentha piperita*).

Peppermint-culture is practiced in Michigan on black muck land, obtained by the draining of swamps and marshes, after it has been thoroughly subdued by previous cropping. After fall-plowing, the land to be used for peppermint is harrowed in the early spring and provided with furrows about three feet apart, into which the slender roots are thrown so as to make an unbroken row of plants. The soil is drawn over the roots and made firm by treading. The young plants are carefully hoed during the first season to remove weeds which injure the crop, partly by contaminating the oil. By fall the peppermint runners so nearly cover the ground as to interfere with further use of the hoe. Horse cultivation may be made use of until fall, when the runners will practically cover the ground.

In August or early September, when in full bloom, the herb is mowed usually with a scythe, dried until only enough moisture remains to prevent the falling of the leaves, and hauled to the distillery. The distilling apparatus consists essentially of a boiler from which live steam is obtained; large circular wooden vats connected with the boiler, into which the herb is thrown for steam treatment; a condenser, consisting of a tight tube surrounded by cold water, through which the vapors from the wooden vats are conducted and cooled; and a receiver into which the condensed water and oil flow from the condenser. [See article on *Oil-bearing Plants*.] The oil is separated from the water and stored in tin or glass containers, and the exhausted "hay" is sold for fodder for stock or allowed to rot for fertilizer purposes.

Peppermint oil, when frozen, separates into two parts,—a crystalline solid, menthol, and a clear oily residue having the taste and odor of peppermint. Menthol is present in an especially large proportion in Japanese oil. It is used in solution in combination with other remedial agents in sprays and other forms of medication, and, being a local anæsthetic and disinfectant, is molded into the form of pencils or cones or as loose crystals for inhalation or external use in headache, neuralgia and similar troubles. The oil is used as a flavoring in most varied kinds of products, such as candies, soaps and various drinks. The United States is a large exporter of peppermint oil. It has varied in price from seventy-five cents to three dollars and fifty cents per pound in the last ten years.

Red Pepper (*Capsicum* species). *Solanaceæ*. (T. B. Young.) Figs. 690, 691; also Fig. 95.

In the United States these plants, belonging to *Capsicum annuum*, Linn., and varieties, *Capsicum frutescens*, Linn., and varieties, and perhaps still other species, are annuals, although where they are not killed by frost the latter series of forms are perennials.

C. annuum is a very variable member of the family *Solanaceæ*. It has a fibrous root system, a smooth, branching, herbaceous stem, one to three feet high, bearing entire, ovate or nearly elliptical, smooth, acuminately-pointed leaves and whitish flowers singly or in small groups at the nodes. The fruits vary widely in size, shape, color and pungency.

C. frutescens is a perennial shrub reaching, in warm climates, a height of several feet, with branched and spreading tops, sometimes decumbent; leaves broadly ovate, fruits most various in shape, size and color, but usually small and very pungent, borne on long peduncles.

Paprika type. (Fig. 690.) A sweet red pepper, mild in pungency, grown especially in Hungary, coming into the world's commerce through the port of Budapest chiefly. The plant resembles in general appearance the ordinary red pepper of the garden, the fruit varying from a narrow, truncated-conical form to a slender pointed form. It is grown to a limited extent in South Carolina, where it seems best suited to a rich, loamy soil. It has come on the market in small quantities from California.

In the South, the seed should be sown in a well-prepared seed-bed by March 1, and covered very lightly. The plants should be ready for transplanting to the field by the last of April. A rich, loamy soil suitable for garden purposes is desirable. It should be put in good tilth by April 1, when the plants are ready for the field. When necessary, any good combination of fertilizers may be used. A mixture of 8 per cent phosphoric acid, 4 per cent ammonia, and 4 per cent potash has been found beneficial. Stable manure is good.

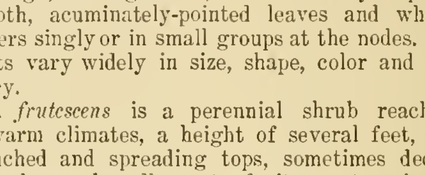

Fig. 690. Paprika peppers. Whole dried fruits as they appear when ready for market. (Yearbook, 1905.)

The plants are set in rows three to four feet apart, and twelve to eighteen inches apart in the rows. Cultivation is given as for other field crops. In July the pods begin to ripen. They are picked at about weekly intervals and dried in special drying houses by low, artificial heat. They are sold in this condition or after the removal of the stems. The seeds may also be removed and sold separately.

Cayenne type. A variety of types of small peppers from various geographical and botanical sources, characterized by a high degree of pungency, come on the market as cayenne pepper. The culture method depends on the geographic

Fig. 691. Branch of Japan chilli pepper, showing the clustered arrangement of the fruit. (Yearbook. 1905.)

source of the sorts used; some are from tropical and subtropical situations, others from temperate regions. Some forms resembling the Japanese chillies (Fig. 691) and Japanese capsicum of the market are grown on a small commercial scale in the southern and southeastern states. The methods of propagation and cultivation here are similar to those used in growing paprika peppers. These peppers are often perennials in a warm climate and produce during a long season, hence localities which offer these conditions are preferable. The so-called "bird peppers" belong to the general class of fruits used in producing the "cayenne" pepper of the market.

Sassafras (*Sassafras officinale*, Nees.). *Lauraceæ.* Fig. 2256, Cyclopedia of American Horticulture.

A tree of moderate size (fifty to ninety feet); bark rather finely checked longitudinally and ridged, dark grayish brown; twigs greenish yellow; leaves with moderately long petioles, smooth when mature, ovate in form, entire to three-cleft, with smooth margin; flowers greenish yellow, in clusters, appearing with the leaves; buds and twigs mucilaginous; bark spicy and aromatic, especially the bark of the root. The bark and wood of the root are distilled for the oil of sassafras used in perfuming soaps and for flavoring purposes. The bark of the root and the pith are used in medicine. The distillation has been practiced in the mountains of eastern United States.

The bark and wood of the root, after being chopped up and split, are distilled by steam in an apparatus not differing in principle from the usual sorts of apparatus used for distilling volatile oils. [See general introduction.] Sassafras is a well known common tree, interesting in its habit and very marked characteristics of bark, branding and foliage. It is partial to sandy lands.

Seneca snakeroot (*Polygala Senega*, Linn.). *Polygalaceæ.* (S. C. Hood.)

A native herb with a rather thick, perennial, branching, light-colored root supporting a rather extensive crown, from which a large number of erect, unbranched stems are given off, bearing numerous, alternate, oblong or lanceolate-ovate, very short-petioled leaves. The stem terminates in a close spike of small white flowers, in general appearance suggesting the papilionaceous type seen in the legumes. The plant is found in rocky woods of New England, to the plains of Manitoba, and northward and southward. It is much in demand for medicinal purposes both for domestic and foreign use. In view of its commercial value and threatened scarcity, its cultivation is receiving attention from the United States Department of Agriculture and other experimenters.

Since the commercial supply of Seneca snakeroot has been derived wholly from wild root, the plant cannot as yet be called an agricultural crop. Its cultivation, although not difficult, has so far been confined to certain experimental gardens. The soil should be light and well drained, and should be made rich with leaf-mold well worked in; stable manure is not advisable. The plant is propagated from seed, which must be gathered in the early summer as soon as ripe. Care must be taken not to let the seeds dry. They should be mixed with moist sand, placed in earthen pots and buried two to three feet deep in the ground. They should be dug up the following spring and planted in the field in drills eighteen inches apart, and the seed covered very lightly. Seedlings should appear in two to three weeks. Cultivation consists simply in keeping clean of weeds. The first year the plants are not more than two to three inches high and are not matured for gathering for perhaps five years. Plants will begin to seed when three years old. No winter covering is needed if the soil is well drained. Plants may be harvested in about four or five years from the seed.

The native range of this plant is chiefly the northern half of the United States as far west as the Rocky mountains and northward throughout Canada.

Tansy (*Tanacetum vulgare*, Linn.). *Compositæ.* (G. F. Klugh.) Figs. 2463, 2464, Cyclopedia of American Horticulture.

A common perennial-rooted herb of waste places, kitchen-gardens and waysides, sending up from a strong crown a clump of upright stems, one to three feet high, bearing smooth, dark green, pinnately compound leaves made up of sharply toothed leaflets, the blade of the leaf running down from the petioles; yellow flowers, reaching a diameter of one-half inch, occur in terminal, branched, flat-topped clusters. It is a rank-smelling herb, used in a dry condition in medicine. It contains a volatile oil.

It likes a rather heavy soil, doing best on a clay loam, but after having become established on a heavy clay it makes a good growth. It may be propagated either from seeds or by dividing the crowns in early spring. The plants are grown in the seed-bed or in the field, the seed being sown in March. The plants are set in three-foot rows, eighteen inches apart in the row; if seeds are used instead of plants, they are sown at the rate of two to four pounds per acre and thinned to eighteen inches when the plants are established. Seed sown in the field should be barely covered with soil. Cultivation is as for ordinary garden crops. The dried flowering tops and leaves are used in medicine. An acre should yield about 2,000 pounds of tops.

Thyme (*Thymus vulgaris*, Linn.). *Labiatæ*. (G. F. Klugh.)

A low, shrub-like perennial, eight inches to one and one-half feet high, forming a dense clump of slender upright stems, bearing many small, sessile, ovate to oblong, entire, pale leaves with many oil-bearing glands; flowers small, lavender-colored, in short, spike-like terminal groups. It is a common plant of kitchen-gardens used for flavoring purposes. The herb is distilled for oil, from which the disinfectant "thymol" is obtained.

It likes a mellow, loamy soil, and grows well from seed. Planting is done about the first of March in three-foot rows, at the rate of about one or two pounds per acre; the plants are left thick in the drill. The grower should cultivate thoroughly, and cut the plants at the end of the growing season for distillation. An acre should yield five or six tons of green herb the first year, which will give about twenty pounds of oil. Plantings in Washington, D. C., have been winter-killed after being cut down to the ground, while bushes left uncut lived over.

Valerian (*Valeriana officinalis*, Linn.). *Valerianaceæ*. (S. C. Hood.) Fig. 2632, Cyclopedia of American Horticulture.

Valerian is a perennial herb with a stout, horizontal or ascending rootstock, bearing fibrous roots; stem one and one-half to three feet high, somewhat branching above, with a few short hairs; lower stem-leaves pinnately divided or lobed into many lanceolate or oblong leaflets; flowers small, closely crowded into terminal clusters, lilac or lavender in color, fragrant. It is a common ornamental known as "garden heliotrope." The underground parts are dug, sliced and dried to form the valerian of the crude drug market.

Valerian root has been grown in certain sections of New York and New England, and as this is the form known as English valerian the quality is very fine.

The soil should be light and well dressed with stable manure. Soil not well drained or having much clay should be avoided, because the plant does not do well, and also because of the difficulty in cleaning roots grown on this soil. The land should be plowed in the fall, and very early in the spring should be harrowed until very fine. In some sections it is the custom to spade the soil by hand with a fork and pick out all lumps.

The plant is propagated by root-divisions of the previous year. The plants are left in the ground until wanted, when they are dug and the divisions made. A good plant should give six to eight divisions. These divisions should be planted in rows two feet apart, and ten inches apart in the row. They should root at once and send up a rosette of leaves in two weeks. The crop must be well cultivated throughout the entire summer and kept free from weeds.

The roots are ready to be dug about October 1. The masses of roots are usually washed in running water to remove the soil. They are then cut so that drying will be even. The drying is done in a specially constructed kiln with artificial heat, usually at 125° to 150° Fahr. When well dried the root may be packed in barrels for market. The yield should be about 2,000 pounds of dry root per acre.

Wormseed, American (*Chenopodium anthelminticum*, Linn.). *Chenopodiaceæ*. (T. B. Young.)

An annual, branching, unsightly weed characteristic of waste grounds, having a large fibrous root system (which under favorable conditions may live over winter in the South) and a stout, straggling, smooth stem, two to four feet high, bearing smooth leaves, various sinuately cut and lobed or almost entire, and long, dense, nearly leafless spikes of inconspicuous flowers, followed by small, shining black seeds enclosed in a green calyx. It occurs wild in eastern and southern United States. It has long been used in medicine for its anthelmintic properties, a quality due to the volatile oil which is distilled from the tops and fruits. Its cultivation has been practiced experimentally in South Carolina by the United States Department of Agriculture. The center of wormseed production in this country, of oil as well as seed, has been Westminster, Maryland.

Loamy soils are best suited to the plant, but it grows well on any type of soil, and develops an abundant crop of herbage and fruit in the fall. Fertilizers with a liberal amount of phosphates, nitrate, and organic nitrogen and potash, are the most satisfactory to the plant.

The seeds are sown directly in the field in rows three to four feet apart. When the plants are up they are thinned out with a hoe to a distance of about eighteen inches. The cultivation is not unlike that given to other crops of a similar kind. A flat cultivation is best, as the crop has to be mowed. About July, before the seeds begin to turn brownish, the plants are cut with a mower and allowed to remain in the field a day to dry, and are then housed. Then the seeds are threshed, sieved clean and sacked, ready for market.

A fair yield per acre of seeds is about 1,000 pounds. The plant yields on distillation 0.3 to 0.6 per cent of volatile oil, the fruits being the parts richest in oil. Wormseed oil is pale or yellowish and has a penetrating, disagreeable odor. It has the property of killing intestinal parasites.

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MELILOTUS (*Melilotus alba.*) *Leguminosæ.* (Sweet, Bokhara, Stone and Large White Clover, and White Melilot.) Fig. 692.

By *J. F. Duggar.*

Melilotus is a genus of leguminous plants, usually biennial, occurring commonly as weeds. One form, *Melilotus alba*, is of value as a green-manure, forage and bee plant.

Plants of the genus Melilotus are erect herbs with three-foliate leaves, dentate leaflets, and mostly white or yellow flowers in slender racemes. The most important species are *M. alba*, Desv., and *M. officinalis*, Lam. Both are generally regarded as weeds except in the prairie region of Alabama and Mississippi, where the former serves a useful purpose for forage and for soil renovation. *Melilotus macrostachys* is promising by reason of its being less bitter than most other species. *M. Indica*, All., is an introduced weed in the western part of the United States. Its yellow flowers are smaller than those of *M. officinalis*. At the Arizona Experiment Station, *M. Indica*, locally known as "sour clover," proved to be a most satisfactory winter cover-crop for orchards, seed sown in October affording an immense mass of green material to be plowed under in April. Britton states that there are about twenty species of Melilotus, natives of Europe, Africa and Asia. A number of species have been tested at the California Experiment Station, some of them affording large yields of green material of untried feeding value. In California, *M. officinalis* is a pest in grain-fields because it imparts its odor to threshed grain and to the flour made therefrom, which is very objectionable to bakers. The price of such "clover-scented" grain is reduced by buyers.

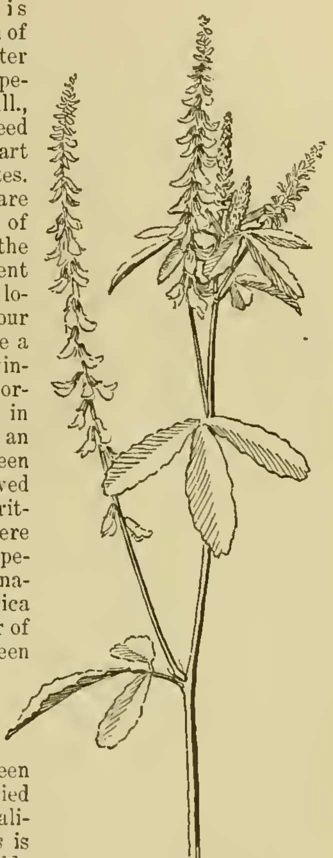

Fig. 692. Sweet clover (*Melilotus alba*).

Melilotus alba is an erect, branching plant, three to nine feet tall, bearing small white flowers in racemes. It is biennial, rarely blooming the first year. Like other members of the genus, it has a bitter taste and a characteristic pleasant odor when bruised. The chief need for improvement in the plant is to decrease this bitter principle. In general appearance this plant bears a close resemblance to alfalfa, up to the time of the appearance of blooms, but the stems of the former are coarser and less leafy.

This plant is widely distributed over the United States and Canada, growing freely along roadsides, in vacant city lots, and in other waste places. It is hardy, holding its own against weeds and even against Johnson-grass, with which it is sometimes sown. It is recognized as a weed throughout the greater part of its habitat and is especially liable to give trouble in alfalfa-fields in the first year or two after the first sowing of alfalfa. To prepare land that has been in melilotus for alfalfa, it should be devoted for at least one year to some hoed crop, preferably cotton, or the melilotus plants should be completely plowed under with a disk-plow before seed has formed. Large sharp plows are required to cut the tough roots of the sweet clover.

Composition.

The following analyses of *Melilotus alba*, show great variation in composition dependent on stage of maturity:

	Month harvested	Moisture	Protein	Ether extract	Nitrogen-free extract	Publication
Hay, air-dry		7.43	13.37	3.32	45.08	Massachusetts State Experiment Station, 10th Report
Hay, air-dry		9.30	11.75	2.70	27.70	Canada Experimental Farms, Report 1893
Hay, dry matter of . .	May	0.00	22.96	5.38	48.20	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	June	0.00	30.54	4.00	32.34	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	June	0.00	22.19	3.09	37.74	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	June	0.00	17.85	3.61	43.80	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	June	0.00	15.20	1.77	36.56	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	Aug.	0.00	18.32	5.97	42.34	Mississippi Experiment Station, Report 1895
Hay, dry matter of . .	Oct.	0.00	19.45	3.83	46.28	Mississippi Experiment Station, Report 1895

The average of analyses made at the Mississippi Experiment Station show that the composition of the dry matter of the above-ground part of the plant is protein, 20.93 per cent; fat, etc., 3.09 per cent; nitrogen-free extract, 42.46 per cent; crude fiber, 25.21 per cent; ash, 8.87 per cent. At the Massachusetts State Experiment Station, the air-dry, above-ground part contained 7.43 per cent moisture, 1.95 per cent nitrogen, 1.832 per cent potash, 0.558 per cent phosphoric acid.

Culture.

Propagation.—Sweet clover does best on a shallow, calcareous soil with a rotten limestone subsoil. It is never fertilized or manured. It is propagated from seed, two to eight pecks of unhulled seed per acre being sown on a well-prepared seed-bed. In the South the sowing is done in February or the early part of March, or by nature in August. The seed is frequently broadcasted among growing plants of small grain, and usually covered with a harrow.

Place in the rotation.—The field is left for two years in melilotus, or, if very poor, for four years, reseeding occurring at the end of the second year if the crop is allowed to stand till seed is formed. The crop immediately preceding sweet clover is usually oats or cotton and the succeeding crop is usually corn, after which cotton, alfalfa and other crops may be grown.

Harvesting.—When sown on land that is poor or poorly prepared, the growth of the first season is usually insufficient for mowing, and is unused or utilized as pasture in late summer and fall. On rich or well-prepared calcareous land in the South, two cuttings are secured the first season, aggregating one and one-half to three tons per acre. The second year, growth from the old roots begins early in March, and the first cutting is made about May 1, and a second and sometimes a third cutting is made the second year, the total yield aggregating two to five tons of hay. The crop is cut when it is about eighteen inches high.

Uses.

As a green-manure.—Through the loosening effect of its large and deeply penetrating roots and the decay of the roots and above-ground parts, sweet clover serves as a fertilizer for succeeding crops, often doubling the usual yield.

As a forage.— While chemical analysis shows that sweet clover hay is practically of the same composition as alfalfa, the former is decidedly inferior because of its want of palatability, its coarseness, and its tendency to shed its leaves in curing. Melilotus hay is at first refused by live-stock, but in time it is eaten fairly well and sustains the animals in good condition. Likewise, in time animals become accustomed to melilotus as a grazing plant, but continue to give preference to other forage plants. When used as a pasture plant for hogs, melilotus should be mowed occasionally, thus causing a new growth of tender shoots to be produced. The forage value of melilotus is practically unrecognized in California and other parts of the West.

Enemies.

Sweet clover seldom suffers seriously from disease or insect injury. The leaves are occasionally attacked by leaf-spot.

Literature.

In agricultural writings very little has appeared on the subject of melilotus, except brief notes and reports of chemical analyses, occurring chiefly in the reports of the Massachusetts State Experiment Station. Brief notes are found in Alabama (Canebrake) Experiment Station Bulletins; Illinois Experiment Station, Bulletin No. 94; Mississippi Experiment Station, Bulletin No. 20; United States Department of Agriculture, Farmers' Bulletin No. 18; Wilcox and Smith, Farmer's Cyclopedia of Agriculture, Orange Judd Company; Shaw, Forage Crops, and Soiling Crops and the Silo, Orange Judd Company.

Plate XVII. Foxtail millet (*Chætochloa Italica*)

MILLETS. Figs. 693–702.

By *M. A. Carleton.*

The millets are cultivated varieties of certain small-seeded cereal and forage grasses, which, in a strict sense, belong to the genus *Panicum*, or to closely allied genera. Because of a resemblance in the seed the name is also applied to other grasses of different genera in this country, while in Europe and Asia even the sorghums are classed as millets.

The millets are among the most ancient of food grains. There is historical evidence of their cultivation in China since 2800 B.C. They are still of the greatest importance in oriental countries, both as food grains and forage plants. In India the annual acreage for all millets (including sorghums) is comparable with that of wheat in the United States. The prosos predominate in India, while in Japan the foxtail millets are the most common. In these countries and in China an enormous amount of seed is used annually for human food. For many years the proso millets have constituted one of the important crops of Russia, and at present the annual production, over eighty million bushels, is probably greater than in any other country.

In this country millet is generally grown as a supplementary or catch-crop. It is also found to be valuable in certain kinds of rotations. It is profitably employed in the case of a failure of some other crop, such as corn, or may be substituted for corn where the latter crop is not adapted. Millet may often be grown in place of a summer fallow, giving extra returns without materially lessening the chances for the following crop. It is also excellent for restoring to a good condition land that is foul with weeds.

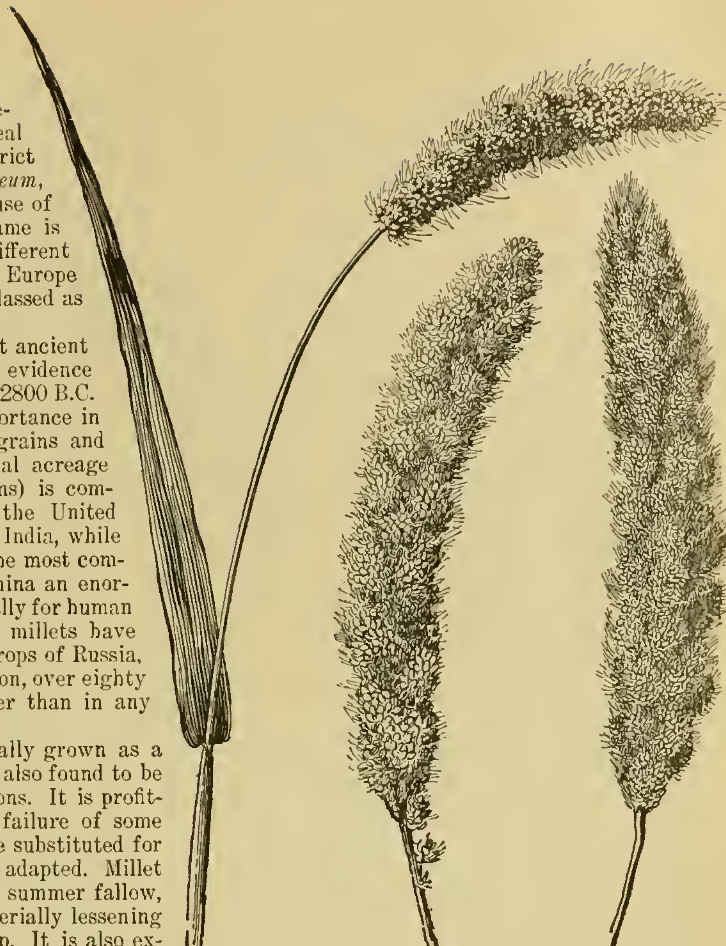

Fig. 693. Red Siberian millet. Fig. 694. Common millet. About three-fourths natural size. Fig. 695. German millet. About one-half natural size.

Groups and varieties of millet.

Of the millets that are fairly well known in this country there are three principal groups: the foxtail millets (*Chætochloa Italica* and var. *Germanica*), the barnyard millets (*Panicum Crus-galli*), and the prosos (*Panicum miliaceum*).

Fig. 696. Aino millet. One-third natural size.

Foxtail millets. (Figs. 693–698.)

The seeds of these millets are closely compacted into a club head, varying much in size, and either cylindrical or tapering at one or both ends. According to the most common classification, there are two principal sub-groups of the foxtail millets, separated chiefly on the basis of the size of head, and which may be called the large or common millets, and the small or Hungarian millets. To the sub-group having the large heads belong the common (Fig. 694), the German (Fig. 695), the Aino (Fig. 696) and the Golden Wonder millets. The type of the second sub-group is the Hungarian millet (Fig. 698). In each of these sub-groups there is great variation in the length and color of the beards and color of the seed, and on the basis of these variations the further classification into varieties is made.

The seed of both the German and common millets is yellow, but that of the former is slightly the smaller, while the head of the German is much the larger. Both varieties are bearded, the beards often turning dark brown or purple in color. The Golden Wonder, a variety much advertised, has a head still larger than that of the German and is almost beardless. The seed is small and yellow Our common millet is not the common one in Europe, although what is known on that continent as California millet is this variety.

The name Japanese has often been applied to a form of foxtail millet that is usually considered identical with the German. On careful study the writer is forced to conclude that this is rather distinct and he has given it the name of Aino millet. The name Japanese is very confusing, as it is applied to various groups of millets. This variety is grown by the Ainos, a prehistoric race of Japan. The spikes are longer and more open in proportion to thickness than in the German millet. It is not well known in the United States, but may prove to be important.

The Hungarian millet, or Mohar, is a small-headed millet, with large seeds, which vary in color from yellowish to purple-brown. In typical Hungarian millet there appears to be a large percentage of dark seed. The heads have dark brown or purple beards. This is the common foxtail millet of central and south-eastern Europe and is often called there German millet, but it is not the German millet of this country. This variety is very persistent after being once seeded, and in careless farming may become a weed. It is fairly drought-resistant, although as a result of many trials it does not appear to be so good in that respect as the common millet.

The Early Harvest millet is of the common millet type. The New Siberian and the Korean millets are not yet sufficiently studied, but may be distinct varieties.

Barnyard millets. (Fig. 699.)

The barnyard millets are so called because of their development from the wild species, *Panicum Crus-galli*, which is known in this country as barnyard grass, and is common throughout the country (Fig. 525). The native grass is a coarse plant, with thick spreading stems and broad leaves, but is exceedingly variable in all characters. The heads vary in color from green to purple-brown, may possess strong beards or none, and there is much variation in habit of growth of the entire plant. These variations make the development of different varieties a comparatively easy matter.

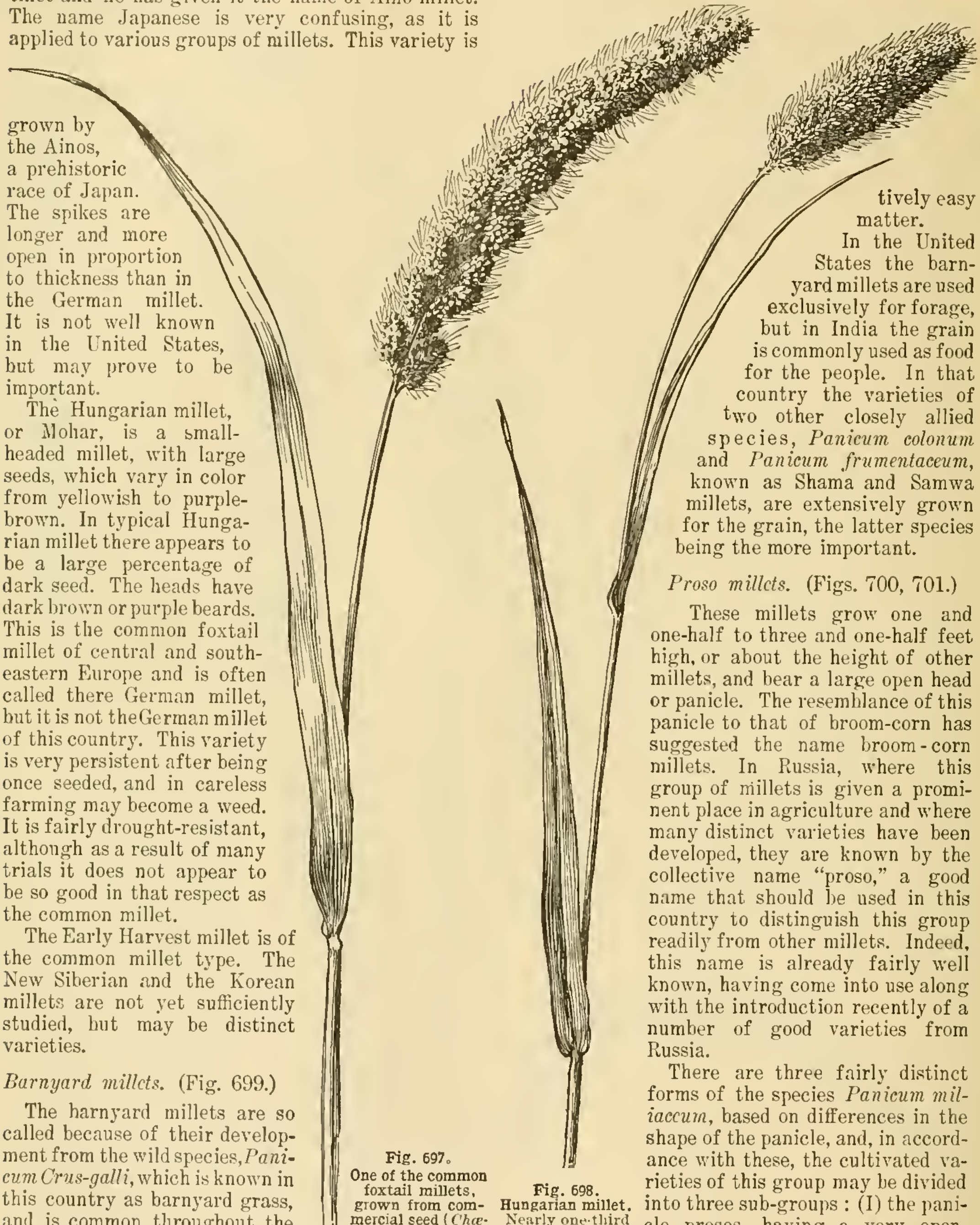

Fig. 697. One of the common foxtail millets, grown from commercial seed (*Chætochloa Italica*).

Fig. 698. Hungarian millet. Nearly one-third natural size.

In the United States the barnyard millets are used exclusively for forage, but in India the grain is commonly used as food for the people. In that country the varieties of two other closely allied species, *Panicum colonum* and *Panicum frumentaceum*, known as Shama and Samwa millets, are extensively grown for the grain, the latter species being the more important.

Proso millets. (Figs. 700, 701.)

These millets grow one and one-half to three and one-half feet high, or about the height of other millets, and bear a large open head or panicle. The resemblance of this panicle to that of broom-corn has suggested the name broom-corn millets. In Russia, where this group of millets is given a prominent place in agriculture and where many distinct varieties have been developed, they are known by the collective name "proso," a good name that should be used in this country to distinguish this group readily from other millets. Indeed, this name is already fairly well known, having come into use along with the introduction recently of a number of good varieties from Russia.

There are three fairly distinct forms of the species *Panicum miliaccum*, based on differences in the shape of the panicle, and, in accordance with these, the cultivated varieties of this group may be divided into three sub-groups: (1) the panicle prosos, having a very open, erect panicle; (2) the clump forms, having a panicle shaped particularly like that of broom-corn, and drooping; and (3) the compact prosos, having the panicle compacted almost into the form of an actual head, similar to that of kafir. Each of these sub-groups is made up of a number of varieties, differing in the color of the plant, shape and hairiness of the leaves, color of seed and other features. Within each sub-group more importance is usually given to the color of the seed, but even this character varies considerably in the same variety. The seed is always considerably larger than in any other millets. The colors of seed generally recognized are white, yellow, red, brown, gray, and black.

There is much variation in different varieties, also in the height of the plant, the time of maturity, and drought-resistance. The best varieties with respect to the last two qualities have been introduced only recently from Russia. Until recent years little attention or study has been given to this group of millets in this country, and naturally no distinction of varieties has been recognized. The principal definitely-named varieties at present known to us are the Early Fortune, Manitoba, Black Voronezh, Red Voronezh, Red Russian, Tambov, Red Lump and Red Orenburg. Even some of these are very similar to each other, and may be identical. All but the first two have been imported from Russia since 1897. Several so-called varieties making up our stock known previous to this period, and imported largely from Germany, Austria-Hungary, China and Japan, may be distinct, but have not yet been thoroughly studied.

During the last six years there has been a great revival in the cultivation of these millets in this country, largely through the influence of the introduction of new and better

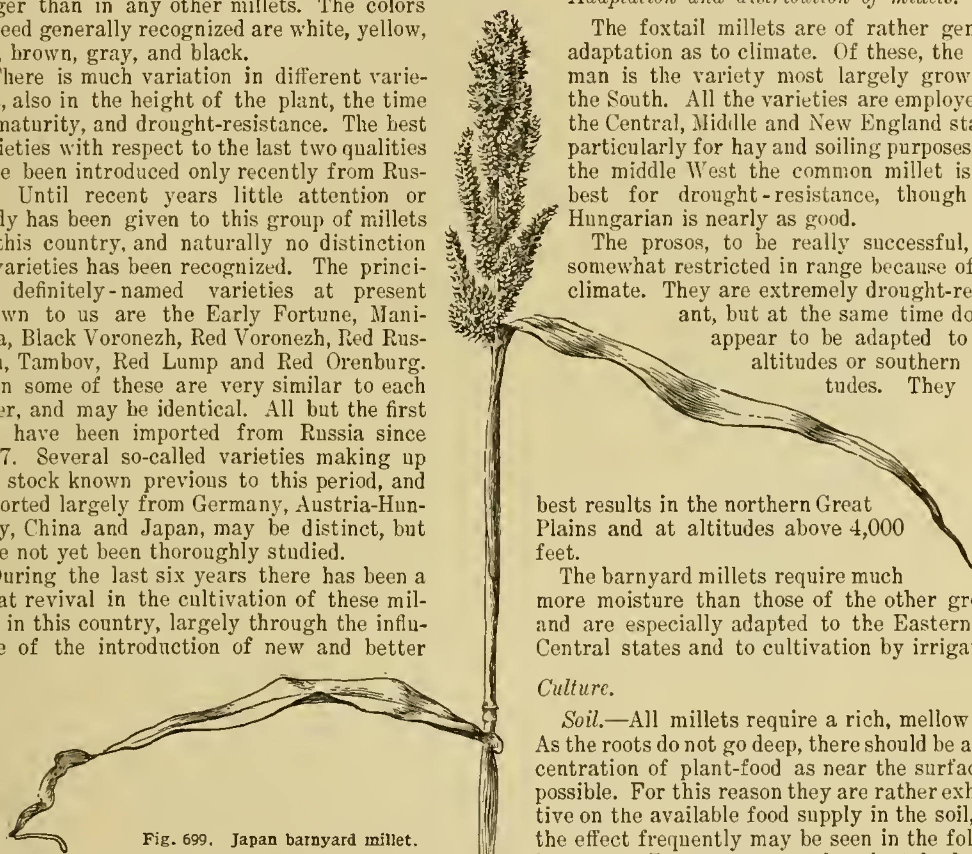

Fig. 699. Japan barnyard millet.

varieties by the United States Department of Agriculture.

Pearl millet. (Fig. 702.)

In addition to the above-described groups, which alone may be considered as the true millets, another grass, of the species *Pennisetum spicatum*, known best as pearl millet, has lately attracted much attention and should be mentioned here. Various other names have been applied to this plant, such as penicillaria, cat-tail millet, Egyptian millet, and Mand's Wonder Forage Plant. It is an erect, succulent annual, growing to the height of six to fifteen feet, and bears its seeds in a compact, slender, cylindrical "head" or spike, six to fourteen inches long. There is at present much difference of opinion as to the usefulness and, therefore, the importance of this plant. It is certain that it yields an enormous amount of forage per acre, and may be cut two or three times during the season, on an average. It is very succulent when young, but rapidly becomes woody at time of heading, and, therefore, should be cut early for hay. On the other hand, because of its succulence it is difficult to cure for this use. It is apparently most useful for pasturing or soiling, and for the latter purpose should be cut very young.

Adaptation and distribution of millets.

The foxtail millets are of rather general adaptation as to climate. Of these, the German is the variety most largely grown in the South. All the varieties are employed in the Central, Middle and New England states, particularly for hay and soiling purposes. In the middle West the common millet is the best for drought-resistance, though the Hungarian is nearly as good.

The prosos, to be really successful, are somewhat restricted in range because of the climate. They are extremely drought-resistant, but at the same time do not appear to be adapted to low altitudes or southern latitudes. They give best results in the northern Great Plains and at altitudes above 4,000 feet.

The barnyard millets require much more moisture than those of the other groups and are especially adapted to the Eastern and Central states and to cultivation by irrigation.

Culture.

Soil.—All millets require a rich, mellow soil. As the roots do not go deep, there should be a concentration of plant-food as near the surface as possible. For this reason they are rather exhaustive on the available food supply in the soil, and the effect frequently may be seen in the following crop. To concentrate the plant-food near the surface, it may be desirable in some districts to apply special manures to be determined by the nature of the soil in the particular locality. The foxtail millets and prosos, as a rule, should have a rather heavy clay loam that will hold moisture well, when grown in dry districts, and a lighter sandy loam if there is much rainfall.

Millet is often made a catch-crop after rye or some other early-maturing crop or when crops have been destroyed. In such cases, if in a humid district, it is well to plow immediately after harvesting the other crop, and then the soil can be put in excellent condition for the millet. If in a dry district, the ground is better simply double-disked without plowing, after which it should be harrowed and the millet drilled; or if the soil has remained unplowed already for a long period it may be plowed after the double-disking. The first treatment produces a surface mulch of the stubble and weeds, which absorbs moisture and checks evaporation; if later it is plowed under, the under soil is thus put in a more compact condition and will not "dry out" easily. Summer fallow, or land plowed late the previous fall is, of course, already

Fig. 700. Proso. Two-thirds natural size.

likely to be in excellent condition for millet and needs only to be lightly disked and harrowed before drilling.

Seeding.—As a rule, millets should be sown with a drill, particularly in the dry districts. When grown in humid areas, where the condition of the soil for resisting drought is not important, and especially if the crop is to be pastured, broadcasting may be better. A usual rate of seeding is two to three pecks per acre for the foxtail and proso millets, and one to two pecks for the barnyard millets. In very dry areas the rate may be considerably less. Millets are sown at about the same time that corn is planted, but the period may be extended to August 1. For soiling purposes, several crops may be planted at different dates.

Millet is one of the best crops for immediate planting on new land or first "breaking." Unless the sod is very stiff the crop can be sown soon after the former is turned over.

Harvesting.—This feature, of course, varies, depending on the purpose for which the crop is to be used. In this country the foxtail millets are used exclusively for forage, and, therefore, should always be cut before the seed begins to ripen unless it is intended to sell the seed. For hay they should be cut even earlier, about the time most of the heads have appeared. The barnyard millets are also rarely used for the grain, and, for early hay or soiling, should be cut at about the blooming period. It is even more essential to cut the prosos in good time if intended for forage, as these millets are coarse and their forage quality diminishes rapidly toward the time of maturity.

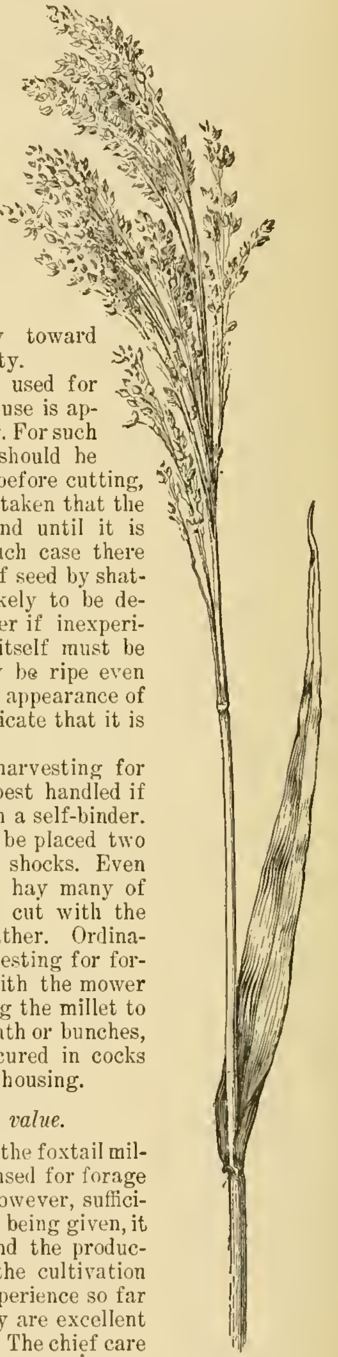

Fig. 701. One of the prosos, sold as White French (*Panicum miliaceum*).

Proso is largely used for the grain, and this use is apparently increasing. For such purpose the seed should be allowed to mature before cutting, but care should be taken that the crop does not stand until it is over-ripe, as in such case there will be much loss of seed by shattering. One is likely to be deceived in this matter if inexperienced. The seed itself must be examined. It may be ripe even though the general appearance of the crop would indicate that it is yet green.

In all cases of harvesting for the seed, millet is best handled if cut and bound with a self-binder. The bundles should be placed two by two in narrow shocks. Even when intended for hay many of the millets can be cut with the binder in dry weather. Ordinarily, however, harvesting for forage is best done with the mower or self-rake, leaving the millet to cure dry in the swath or bunches, after which it is cured in cocks before stacking or housing.

Uses and nutritive value.

As before stated, the foxtail millets are generally used for forage in this country. However, sufficient attention is not being given, it seems, to soiling and the production of silage in the cultivation of these crops. Experience so far indicates that they are excellent for these purposes. The chief care to be taken is to feed sparingly and in combination with other foods because of the laxative action of these crops, when green, on the digestive organs. If cut late, when the seeds are well formed, the feed has an injurious effect on the kidneys of the horse. The millets may also be of much value in pasturing, especially for supplementing exhausted pastures.

Proso is not so good as the other millets for forage, though it is used considerably in this way. It is much more valuable for the seed. An increased amount of seed is being used for feeding to stock each year. Seed should be ground. In this way proso even acts as a substitute for corn where that crop will not succeed and the sorghums will not mature. These millets have been found so well adapted for hog-feeding that they are often called hog millets. They are also excellent poultry food, and in North Dakota are profitably fed to sheep. Because of the large percentage of protein the seed contains, proso should be well adapted for feeding to dairy cattle.

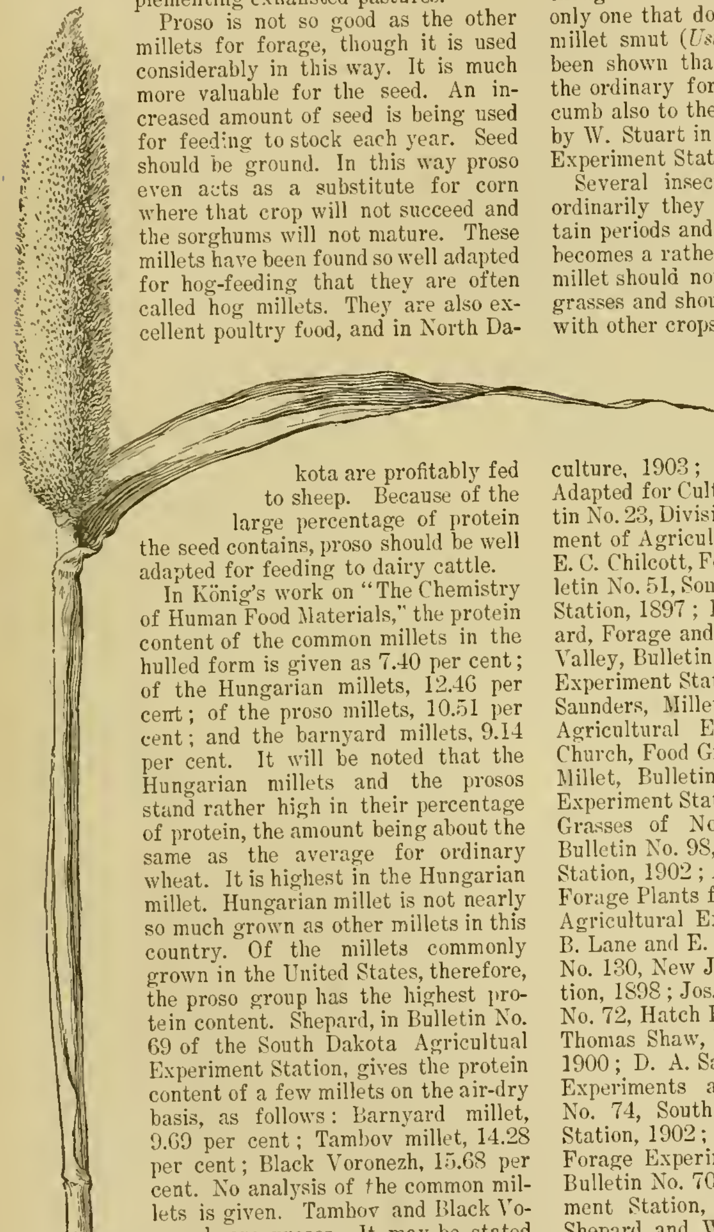

Fig. 702. Pearl millet (*Pennisetum spicatum*). One-fourth natural size.

In König's work on "The Chemistry of Human Food Materials," the protein content of the common millets in the hulled form is given as 7.40 per cent; of the Hungarian millets, 12.46 per cent; of the proso millets, 10.51 per cent; and the barnyard millets, 9.14 per cent. It will be noted that the Hungarian millets and the prosos stand rather high in their percentage of protein, the amount being about the same as the average for ordinary wheat. It is highest in the Hungarian millet. Hungarian millet is not nearly so much grown as other millets in this country. Of the millets commonly grown in the United States, therefore, the proso group has the highest protein content. Shepard, in Bulletin No. 69 of the South Dakota Agricultual Experiment Station, gives the protein content of a few millets on the air-dry basis, as follows: Barnyard millet, 9.69 per cent; Tambov millet, 14.28 per cent; Black Voronezh, 15.68 per cent. No analysis of the common millets is given. Tambov and Black Voronezh are prosos. It may be stated also that the Black Voronezh has so far proved to be much the best of the prosos in South Dakota. According to these analyses, the protein of proso in South Dakota runs very high. In Russia and Oriental regions the seed of these millets is one of the most common food grains not only for stock, but also for man.

Enemies.

The millet crops are apparently fortunate in being less subject to attacks of insect and fungous pests than probably any other cereal crops. Although several fungi may be found on millet, the only one that does any considerable damage is the millet smut (*Ustilago Crameri*, Korn.), and it has been shown that this smut can be prevented by the ordinary formalin treatment. It seems to succumb also to the hot-water treatment. [See report by W. Stuart in the annual report of the Indiana Experiment Station, 1901. See also Index.]

Several insects occasionally attack millet, but ordinarily they are of little importance. At certain periods and in certain districts the chinch-bug becomes a rather serious pest. In such cases the millet should not be planted in proximity to other grasses and should be grown in complete rotation with other crops.

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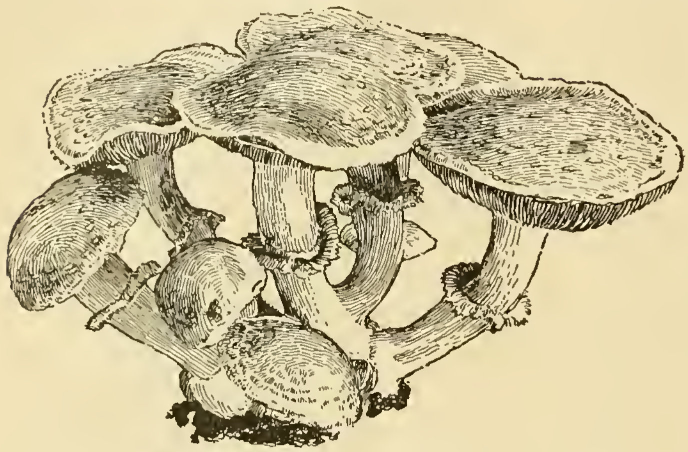

Fig. 703. *Agaricus campestris.* An edible, purple-brown-spored agaric.

MUSHROOMS and TRUFFLES. Figs. 703–713.

By *B. M. Duggar;* illustrations of mushrooms from photographs by G. F. Atkinson.

The native or wild mushrooms supply a source of food that we cannot afford to neglect, and it is the purpose of this article to call attention to them and to give advice as to their utilization.

The term mushroom, as the term fruit, is of very broad application. It may be applied to any one of the several hundred fleshy fungi which may be found in a particular region. Unfortunately, there is a popular belief that a "mushroom" and a "toadstool" are two things which are very distinct one from the other in some mysterious way, the one being edible and the other poisonous. This is practically synonymous with saying that those which have been found to be edible will be regarded as mushrooms, and those which have been found to be inedible, or which are supposed to be inedible, will be termed toadstools. This leads to endless confusion, since no two laymen would agree as to what forms are edible and what are not. The best usage, therefore, sanctions the use of the term mushroom to include all the fleshy forms, and we may, therefore, with propriety speak of edible, inedible, or poisonous mushrooms. In a commercial sense, "the mushroom" refers to a particular species, *Agaricus campestris* (Figs. 3, 703), or to a group of species closely related to this one, several of which are cultivated as varieties of this form.

The utility of mushrooms.

Mushrooms are an important article of food in many parts of the world. They cannot in any sense, however, replace the staple articles of diet. Pound for pound of the fresh product, they are not rich enough in proteids or nitrogenous materials to replace meat, nor are they so rich in carbohydrates as to replace such foodstuffs as rice and potatoes. Nevertheless, they are, from a chemical point of view, as valuable as many of our vegetables. From a physiological point of view their value cannot be estimated. This is due to the fact that they belong to that class of foods which should be known as condimental foods. The part which they play, therefore, is analogous to that of many of our fruits, and sometimes more important because of the fact that they serve the purposes of relishes taken with other foods.

In considering the economic possibilities of mushrooms, the distinction between wild and cultivated mushrooms should be borne in mind. It is not possible to form an estimate of the total output of cultivated mushrooms, although it is a product which, to a very large extent, is grown for the market. Therefore, it would be wholly impossible to estimate the consumption of wild mushrooms, for the latter constitute a product a relatively small part of which is marketed. While *A. campestris* and its allies are the chief cultivated mushrooms, it should be said, however, that other species are cultivated, in a sense, in particular regions. Truffle-growing [see *Truffle*, following] is for all practical purposes an industry in sections of southern France. In Japan, the Shiitake (*Collybia Shiitake*) is an article of commerce, and probably this same species is likewise grown in China.

Extent of mushroom-culture.

During the season of 1901, the estimated quantity of the cultivated mushroom product which passed through the Central Markets of Paris was nearly ten million pounds. The market of Paris is the chief market of the world for the cultivated mushroom, and much of the product finally sold in London and continental cities may be traced to Paris. Nevertheless, mushroom-growing is an industry in England and in other European countries. In the United States the cultivated mushroom is a product of importance only in the neighborhood of some of the larger cities, and the best markets are unquestionably New York, Philadelphia, Boston and Chicago. It is safe to say, however, that markets of these and of many other cities could support a much larger quantity of the cultivated mushrooms than is sold during any season. The price paid in this country may vary from twenty-five cents a pound to more than a dollar, and an average price would probably be about fifty cents per pound. This is nearly twice as much as is paid for cultivated mushrooms on the markets of Paris, and it is evidence of the fact that the mushroom is still a luxury. It is safe to say that although mushroom production has doubled in the United States within a period of five years, the markets could take twice the quantity now being received without very materially affecting the value of the product. Moreover, the demand for the cultivated mushroom is increasing very rapidly, and many of the smaller cities which now receive none of this product could dispose of it in small quantity.

The cultivation of mushrooms is an horticultural operation, and is therefore not discussed in detail in this place. For the benefit of prospective growers, however, it may be said that the market possibilities have not by any means been attained and that the price at present paid for the fresh product makes it a paying business where the conditions are favorable and where good care and the best cultural intelligence are brought to bear on the work.

Wild mushrooms.

The wild mushroom product, being dependent on the season, is very variable. In the United States the wild mushrooms which reach the market may, for all practical purposes, be said to consist only of *A. campestris* and its allies, and the food value of the vast number of other common edible forms is appreciated by an individual only here and there. In Europe, more than in any other country, perhaps, the wild mushroom is a sub-staple article of food. In many instances there are municipal or state regulations governing the species which may be legitimately sold. Generally as many as six species are legitimately sold, and in extreme instances the list may run as high as forty species. From France to western Russia, or from Scandinavia to Italy, during the mushroom season, one may find one or more species of wild mushrooms on the market of both village and city. A knowledge of common forms is, therefore, well disseminated. Nevertheless, even in those countries, mistakes are made, and cases of poisoning, among the peasantry particularly, are from time to time reported. This is not surprising, however, when one finds that some of the more ignorant classes pay no attention whatsoever to the possibility of poisoning except from one or two well-known species.

Fig. 704. *Coprinus comatus.* An edible black-spored agaric.

Writing in 1876, a French botanist reported the sale of more than seventy thousand pounds of wild mushrooms on the market of the small city of Nantes. In 1901, the sale of wild mushrooms in the vegetable markets of Munich amounted to about two million pounds, and this does not include the amount dried and sold out of season. Of the amount last mentioned, it is true, however, that about six species (or groups of related species) furnished practically nine-tenths of the total product. Some of the important species of this market will be referred to later.

Fig. 705. *Coprinus atramentarius.* An edible black-spored agaric.

How to distinguish the mushrooms.

It has been stated that there is no one mark by means of which an edible mushroom may be known from a poisonous species. In order to use the wild forms of the cultivated mushroom, or to cultivate the wild forms which may be of value, it is necessary to know something of the form and appearance of the important groups of these plants. Unfortunately, the child seldom grows up with such knowledge of these plants as it has attained in the case of the birds or snakes which it may also have seen in field or forest. The cultivated mushroom (*Agaricus campestris*) is perhaps best known, and its general appearance may therefore be described, before attempting to compare with it the wild edible species.

The general umbrella form of the plant is familiar to all. In its different varieties the color may vary from almost white to deep brown or even sometimes to purplish brown, so far as the cap, or upper expanded part, is concerned. Moreover, the plant consists of a centrally placed stipe, or stem, three or more inches high, bearing the expanded cap. Toward the upper end of the stem, in the mature plant, there is attached a small ring, or annulus, and in the early stages this ring is in the form of a veil, that is, a structure connecting the edges of the cap, technically known as the pileus, with the stem. This veil protects on the under side of the cap certain plate-like radial structures, which reach practically from the stem to the periphery of the cap. These plate-like structures are known as the gills, or lamellæ, and in young specimens of this genus they are invariably some form of pink, but on the breaking away of the veil and exposure to the air they soon become brown and eventually brown-black. These characters enable one to distinguish this species with absolute certainty from any injurious form. The umbrella shape, the annulus, and the gills are common to many species and even to genera; but the umbrella shape coupled with the presence of an annulus (no other appendages being present on the stem) and with the pink gills becoming brown-black, cannot be confused with those of undesirable forms. It should be borne in mind, however, that there are differences in the color of the varieties of this species. Again, there may be slight differences in the form of the annulus, in the shape of the stem, and other features. However greatly these varieties may differ one from another, there is a general resemblance which is constant.

Fig. 706. *Volvaria bombycina.* An edible red-spored agaric.

Agaricus campestris, as a wild plant, is usually found during the late summer and autumn, although in sections of the country where the winters are light and the spring of some length, they may appear in some quantity during June. This refers only to general conditions, for in special localities, as, for example, in California, the mushroom may occur in greatest abundance after the beginning of the winter rains, coming in abundantly in early January.

One should not be content to use merely this one group of mushrooms, but should gradually acquire a knowledge of other groups concerning which there can be no question of edibility and no possibility of mistake. As the interest increases, definite knowledge of species will be acquired, and one will find himself able to utilize a number of the more valuable species as readily as he may utilize the berries of the field or the game of the woods. Attention may therefore be called to a few groups of mushrooms to which the amateur might first give consideration, and also to a few forms which it is well at the outset entirely to avoid.

For home consumption there is no group of fungi more easily secured than certain species of the Ink Caps, belonging to the genus Coprinus. The characters of the Ink Caps, in general, are the umbrella shape, a very slight indication of an annulus, gills becoming black, and, best of all, the gills, and sometimes the whole plant, becoming deliquescent with age, so that, as the plant matures, the gills break down from the edges of the pileus toward the center, and the whole plant may eventually disappear in an inky mass. The two more common species of this group are, the one named Coprinus (*C. comatus*, Fig. 704), sometimes known as Shag Mane, a plant which attains a height of six to nine inches, with an oval or oblong pileus and shaggy surface, becoming gradually deliquescent. It is large and fleshy, with excellent flavor. It can be found in lawns and meadows, and in grassy places anywhere, and is usually most frequent during the spring months. The plants are more or less solitary, or in loose groups. The other species, which is important because of its size and flavor, is the true Ink Cap (*Coprinus atramentarius*, Fig. 705). As a rule, this species is found in similar situations as the above, but in closer tufts, and usually it is more frequent. The life of the plant above the surface of the ground is at most but a few days, when it also disappears in the manner of other members of this group.

From what has been said, it is evident that the Coprini are not to be used for market purposes. When found they should be immediately used. The flesh is not so firm as that of other species, therefore care must be used in the preparation of these for food in order that they may be most appetizing.

There are other brown or brown-black spored forms which are desirable, and so far as at present known, no species is poisonous. The more desirable forms, however, should be learned by gradual experience.

Among the Agarics which have white spores, there is a genus which contains several highly poisonous species. The general characters of the group may be briefly indicated. The plant is umbrella-shaped. There is an annulus borne in the characteristic fashion near the upper end of the stem, and, in addition, there is an appendage of the stem, known as a volva, which is to be found at or near the base of the stem in the form of a definite ridge or sheath. In either case it is what remains about the stem of the universal veil which inclosed the young plant before it assumed its definite umbrella form. Sometimes the whole plant breaks through this sheath and no markings of the universal veil are left on the cap. Again, to the surface of the cap the veil is adherent, and, as the cap expands, it may be broken up into scales or floccose patches. The gills are white in the poisonous species. The two species which every one should learn to know are the Fly Agaric (*Amanita muscaria*, Fig. 245) and the Destroying Angel (*A. phalloides*, Fig. 246). In Europe, the Royal mushroom (*Amanita Cæsarea*, Fig. 707) is regarded as one of the most delicious wild species. It was even regarded as the chief delicacy among the mushrooms, aside from the truffles, in the times of the Romans. That is, it is this species, probably, which in Latin literature is referred to under the name "Boletus," a term now unfortunately applied to a very different group of fungi, as subsequently mentioned.

Closely related to the genus Amanita there are field mushrooms of the genus Lepiota, which resemble fairly closely the Destroying Angel in every way except in the absence of the universal veil, or volva, at the base. It might not be advisable, however, at the outset to use even these.

Another group of the Agarics to which the amateur may turn his attention with no fear of harm, is that which includes the oyster mushroom (*Pleurotus ostreatus*) and its allies. These fungi grow in the form of clusters of shelving plants, which may be found on old stumps and logs or on exposed roots where decay has set in. The clusters may attain a diameter of a foot or more, and an examination of the individual plants which constitute the cluster will show that the stem is attached excentrically, or at one edge of the pileus, in some instances the stem being greatly reduced. The gills are white and white spores are produced. The surface of the pileus varies from white to yellowish with age, or it may even be grayish purple in different forms and species. In most species the gills are decurrent, coursing downward on the stem, gradually losing themselves in mere surface lines. These fungi are found abundantly in most regions of the United States from July to early winter. In the southern states they are not infrequently found at any season so long as the moisture is sufficient.

In the family of pore-bearing mushrooms the more widely distributed edible forms are found in the genus Boletus (Fig. 247). These species consist of fleshy plants of the characteristic umbrella shape. The stem is central, and frequently the whole plant is highly colored. In place of bearing gills on the lower surface of the pileus, the surface consists of a compact layer of vertically-placed small tubes or pores, and it is over the surface of these that the spores are borne. *Boletus edulis*, commonly known as the Edible Boletus (called in French, cèpe, and in German, Steinpilz), is a common article of food throughout Europe, and it probably represents in this country a chief source of waste, so far as edible fungi are concerned, since it is very seldom used. An idea of the amount of this waste is suggested by the statement that this species and two or three closely related forms were sold on the market of Munich in 1901 to the extent of about one million pounds, representing a value of nearly two hundred thousand dollars. *Boletus edulis* is a plant with a pileus usually red-brown on the upper surface, with a lower surface yellowish becoming greenish, slightly discoloring when bruised, white flesh, and with a fleshy stem, yellowish buff in color. Among the Boleti there are several injurious species. General characteristics, by which they may be avoided, are a red color of the margins of the pores, the gills or flesh changing color markedly when exposed or injured, and an acrid or peppery taste.

It is safe to say that among the peasantry of Europe, *Boletus edulis* is almost as common a food product as our well-known vegetables. From the time of its appearance in the early summer until the cold weather of autumn, it is sought everywhere in the moist woods, and while highly prized in its fresh condition, it is also cut into pieces and dried for winter use. No small amount is canned and exported, the principal exported product being from France, and therefore bearing the name commercially of *cèpe*. It would appear that it was this species that constituted, during the time of the empire at Rome, the greater bulk of what were

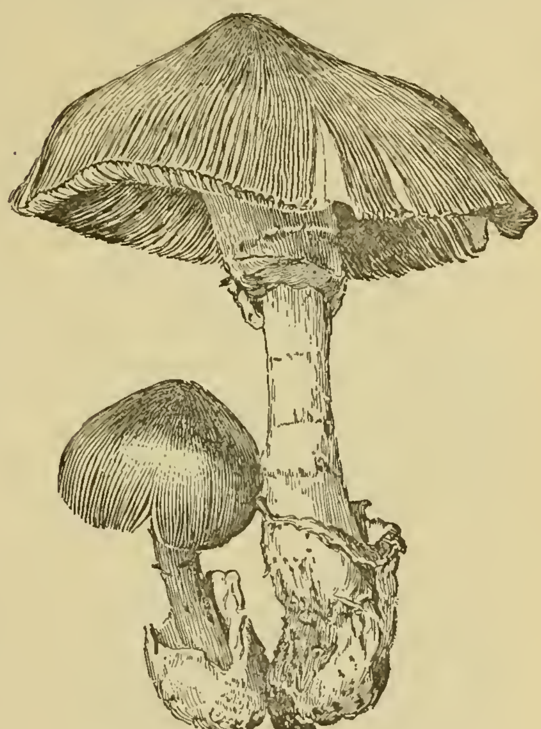

Fig. 707. *Amanita Cæsarea*. An edible white-spored agaric.

known as *fungi suilli*, not the most highly prized, but yet the fungi eaten by the multitudes.

In the woods of north temperate regions throughout the world, and especially abundant in the moist mountain regions, there are found delicate branched fungi, commonly known as Stag-horn mushrooms, Fairy Clubs and others. These species grow on the ground, frequently among the mosses, even in boggy regions. All of the species which are somewhat delicate or of sufficient size are edible and no mistake can be made in appropriating them at will. The larger and more fleshy species are fortunately rather common and of inviting color. They vary from light buff to golden yellow, and the delicate appearance of the plant is unmistakable. The species more commonly used are *Clavaria formosa*, *C. aurea*, and *C. botrytes* (Fig. 708).

Somewhat like the preceding in general appearance are a few toothed fungi, which grow on

Fig. 708. *Clavaria botrytes.* Edible.

decaying trunks or limbs. These plants belong to the genus Hydnum, and they are found only in wooded regions, usually in the presence of abundant moisture. The fungus body may consist of a very much branched structure, the branches ultimately terminating in teeth. The characteristic species are cream white and they are of good texture. The best known forms are the Coral Hydnum, *H. coralloides*, and the Satyr's Beard, *H. erinaceus*. There are also two important members of this genus which have an irregular umbrella shape, the lower surface of the pileus in these cases being studded with teeth (Fig. 709). Both species are edible and of good flavor. They are frequently found in unusual abundance in mountain woods, in situations favorable for the Clavarias above mentioned, in the late summer and early autumn.

If there is one group of the fleshy fungi well known to all who have had opportunities to know the products of the pasture and meadow, this group is that of the puffballs. The puffballs are all edible, and many of the larger species are some of the most valuable of our fleshy fungi. If collected and used when the flesh is white, discarded always when old, or when the flesh has begun to change in color, no suspicious or injurious qualities can be assigned to this group. The larger species are sometimes very abundant, and a single plant may furnish a delicate accessory dish for a whole family. Among the valuable species several may be mentioned. *Calvatia cyathiforme*, the beaker-shaped puffball, is common in pastures throughout the United States. It is a plant of the early autumn, and is most abundant when the season is moist and cool. It is a favorite food of insects, but since the latter are comparatively inactive during cool weather, that is the season when they are to be expected in greatest profusion. This puffball is at first white and later may become purplish brown, or white with a slight tint of brown. The flesh is firm and pure white even until full size is attained. The plant may attain a diameter of as much as five or six inches. With age it becomes spongy, and the plant differentiates into a mass of purple-brown threads and spores; this gradually wears away, leaving a purple-colored basal cup or beaker, which may be found in the pastures for months after the spores have blown away. The Giant Puffball (*Calvatia gigantea*) is also found in pastures, but it may appear in gardens and meadows as well. It has been found of a diameter of more than two feet, and can frequently be had sixteen to eighteen inches across. Thus far it has not been possible to cultivate any of these species of puffballs, but in recent years the use of these plants has become very much more general, perhaps because of the recognition of the very definite characters of the group. Even the smaller members of the puffballs may be used when the flesh is white and tender.

An entirely different class of mushrooms, and one which indeed includes the truffles and terfas, is of further economic importance as furnishing, in practically all north temperate regions of the

Fig. 709. *Hydnum repandum.* Edible.

earth, some of the most highly prized of the mushrooms, namely, the morels. There are several species of the morels, the chief one being *Morchella esculenta* (Fig. 710), the common morel (in German known as *Morchel*, and in French as *Morille*). In the United States this plant may pass under the name of "sponge mushroom," this fittingly describing the general appearance of the plant, for the morel is of a sponge-like color, and consists of a stem bearing a cap or head, which is thrown into folds or wrinkles, also suggesting very much the structure of a sponge. The plant is two to five inches in height and of very neat appearance. It is found chiefly in open woods, though it may also extend into grassy places and orchards. Its season in the United States is from late April to early June, and in a particular locality it may come and disappear within a single week. It must therefore be sought as the earliest edible mushroom. With the exception of the truffle, moreover, it is considered by the French the greatest delicacy among mushrooms, and it commands on the markets of Paris a price several times that of the cultivated mushroom.

Fig. 710. *Morchella esculenta.* Edible.

Truffles and other subterranean forms.

Truffles are the fruit bodies, or sporophores, of subterranean fungi belonging to the family *Tuberaceæ*, of the class *Ascomycetes*. There are only six or seven species which, because of size and quality, may be considered of economic importance. These are all classed in the genus *Tuber*, as are also many small species.

The black or winter truffle (*Tuber melanosporum*, Fig. 711) is particularly abundant in France. It is preëminently the truffle of commerce, and constitutes most of the best exported product. It is sometimes known as the Périgord truffle, and has made famous the markets of Périgord and Carpentras. This species has a wonderful aroma and flavor. *Tuber æstivum*, the summer truffle, occurs also in southern France, but chiefly in parts of central France. The next important species is *T. magnatum*, a large species with alliaceous flavor, highly prized and abundant in Italy. Any of these species may vary in size from plants smaller than hulled walnuts to those larger than an orange, in extreme cases. The majority of truffles are dark brown or black, with a peculiar warty surface, but *T. magnatum* is smooth and light in color, somewhat resembling a spherical yam.

In the United States no truffles of economic importance have thus far been found. One or two small species have been found during a single season in Minnesota, and small forms are also known in California. It is thought that none of the larger edible species are native in this country. There seems to be no reason why truffle-growing may not succeed in parts of some of the southern states. The introduction experiments thus far have been of no consequence.

Truffles are found in lime-containing clay soils, and are thought to be absent from all sandy soils. They are seldom found at great distances from the roots of certain trees, and it is thought that the mycelium is, in part at least, parasitic on living roots. *T. melanosporum* is more commonly found under oaks, particularly *Quercus Ilex*, the live-oak (*Chêne vert*) of southern Europe, *Q. coccifera*, a scrub live-oak of the Mediterranean garigues, and *Q. sessiliflora*.

Properly speaking, truffles are exploited rather than cultivated; nevertheless they are cultivated in the sense that many areas in which truffles did not grow are now yielding an abundance of this

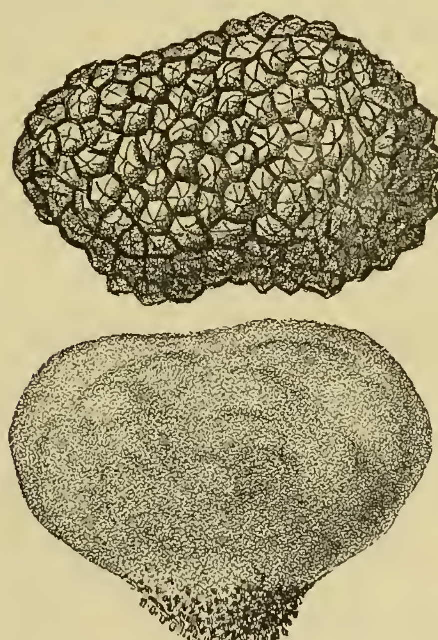

Fig. 711. The black truffle above (*Tuber melanosporum*, var. *à grosses verrues*). Terfa (*Terfezia leonis*) below. (From "La Truffa," by Ad. Chatin, Paris.)

fungus. Truffle production has been made possible in such areas by planting the necessary shelter trees, providing for proper soil drainage and shutting out predatory animals. Sometimes, moreover, the soil from truffle regions has been spread on the land, thus securing a sowing of the spores. A double economic purpose has thus been accomplished,—reforestation and the encouragement of truffle-growing.

Terfa. Terfeziaceæ. Fig. 711.

The terfas, or kamés, are fungi which in general appearance resemble the white truffle of southern Europe, but because of well-marked characters they are placed in another related family, the *Terfeziaceæ.* They were among the earliest known edible fungi, and were greatly prized by the ancient Greeks. At present the terfas are abundant in parts of Asiatic Turkey and Persia, particularly near Smyrna and Babylon, also in the Libyan Desert of northern Africa and in the semi-desertic regions of southern and southwestern Algeria. They are highly prized by the Arabs, and wherever they occur in quantity they constitute an important food product. These fungi are found, as a rule, under certain species of *Cistaceæ,* although they occur associated with the roots of other plants. They are found more readily than truffles. They mature in the spring after the heavy rains, and as they develop rapidly, they break or raise the soil slightly, so that the locations may be detected, although subterranean. They occur in lime-containing, sandy soils, mostly in the flood plains of small streams. The production of these fungi is very evidently dependent on sufficient winter rainfall, or inundations at some time in the winter months.

Fig. 712. Truffle hunting (above) with a dog in the garigues of southern France. Truffle hunting (below) with a pig in an "orchard" of oaks, southern France.

Fig. 713. A broken tuckahoe. Much reduced.

Tuckahoe. (Indian Bread, Indian Loaf. Okeepenauk of the early Indians.) Fig. 713.

The American tuckahoe is now considered to be inedible. It is unquestionably the sclerotial stage of some fungus, very probably of a pore-bearing mushroom (supposedly of a Polyporus). The form and size of this sclerotium is not unlike a coconut. The exterior is also rough and bark-like. The interior, however, when mature, is hard, white and friable. The tuckahoe has been found in various parts of the South and Southwest. It has received tentatively the name *Pachyma cocos.*

Among other pore-bearing mushrooms which may produce a somewhat similar sclerotial stage, one of the most interesting is *Polyporus Mylittæ.* The sclerotium of this fungus is known as "Native Bread," and is said to be eaten by the native inhabitants. *P. Sapurema,* found in Brazil, produces a sclerotium weighing many kilos. In Italy, *P. tuberaster,* produces a sclerotial mass of mycelium. This mass will produce the edible sporophores of the Polyporus until the stored-up nutriment is exhausted. The sclerotial mass is therefore sought in the open and brought in, so that none of the mushrooms may be lost as produced. No form of tuckahoe or allied structure is cultivated so far as can be ascertained.

Literature on mushrooms.

Atkinson, Mushrooms, Edible, Poisonous, etc., first edition, Andrus and Church, Ithaca, N. Y. (1901); second edition, Henry Holt & Co., New York City (1903); B. M. Duggar, The Principles of Mushroom-Growing and Mushroom Spawn Making, Bulletin No. 85, Bureau of Plant Industry, United States Department of Agriculture (1905); W. G. Farlow, Some Edible and Poisonous Fungi, Bulletin No. 15, Division of Vegetable Physiology and Pathology, United States Department of Agriculture (1898); Wm. Hamilton Gibson, Our Edible Toadstools and Mushrooms, and How to Distinguish

Plate XVIII. Yellow Bellflower apple trees in fruit. Santa Cruz county, California

Them, Harper & Bros., New York (1895); Nina L. Marshall, The Mushroom Book, Doubleday, Page & Co. (1901); Charles McIlvaine, One Thousand American Fungi, Bowen-Merrill Co., Indianapolis, Ind.; Charles H. Peck, Reports of New York State Botanist in the Reports of the New York State Museum of Natural History, 1879 to present.

NURSERIES.

The special development of nursery agriculture is recent. Nurseries were in existence in North America a hundred years and more ago, but they were isolated, relatively unimportant, and few in number. In 1900 there were 2,029 nursery farms (establishments in which nursery stock constitutes at least 40 per cent of the products) in the United States, comprising 165,780 acres; and in 1901 there were 1,561 acres devoted to nurseries in Canada. The nursery business is understood in this country to be devoted to the raising for sale of woody plants and perennial herbs, and does not include the raising of florists' plants and vegetables, although an establishment or place in which any plant is reared for sale or transplanting is properly a nursery. Aside from the commercial nurseries, there are city park departments, cemeteries, florist establishments and private estates that rear vast quantities of plants.

The total value of the commercial nursery products in the last census year (1899) in the United States was $10,086,136. The states returning a product of more than a half million dollars are: New York, 237 establishments, $1,703,354; Iowa, 104 establishments, $636,543; Illinois, 126 establishments, $610,971; Ohio, 147 establishments, $538,534; California, 141 establishments, $533,038; Pennsylvania, 95 establishments, $515,010. The average size of the nursery farms was 81.7 acres, and the average value per acre of the land was $84. In Canada, by far the larger part of the nurseries are in the province of Ontario. From the other provinces the acreage is returned as follows: Quebec, 193; Manitoba, 90; British Columbia, 72; Nova Scotia, 37; New Brunswick, 35; Prince Edward Island, 17; The Territories, 20.

As a type of farm organization and management, the nursery business has received no careful study in this country. It differs from all other forms of agriculture in many of its fundamental features, particularly in its business organization. A high-grade nursery presents perhaps the most perfect division into departments of any agricultural business; to illustrate this feature, a rather full discussion of an organization for a $50,000 nursery business is presented in the following pages.

Inasmuch as nursery farming is not the raising of a single crop, or even a single series of crops, and as the various nursery crops are treated in the Cyclopedia of American Horticulture, the crop-practice phases are not discussed here. The nursery business is characterized by the relatively small equipment in machinery, and the great outlay for labor. In 1899, the labor outlay in the nurseries enumerated in the census was considerably more than one-fifth of the total value of the products. On the other hand, the outlay for implements was only 5 per cent of the products, and for fertilizers it is surprisingly small, being only $139,512 as against $2,305,270 for labor. This low fertilizer cost is the result of the custom of growing trees on land that has not been "treed," especially fruit-stock, which must attain a certain size and appearance at a specified time. There has been much speculation as to the reason why trees do not succeed well after trees; but this should be no more inexplicable than similar experience with other crops. Rotation is no doubt as necessary in nurseries as in other kinds of farming. No rotation systems have been worked out, however, and nursery production is to that degree not conducted on a scientific basis. Great attention has been given to developing skill in propagating the plants and in tilling and handling the stock, but little is known of the underlying soil and fertility requirements. Experiments have demonstrated (see Roberts and Bailey, for example, in Cornell bulletins) that the failure of trees to succeed trees with good results is not due to lack of plant-food alone.

Although certain kinds of nursery farming may be classed with the intensive agricultural industries, as a whole the average returns per acre are not remarkably large for a special i dustry. The census shows the average value per acre of the product not fed to live-stock (comprising by far the greater part of the total product) to have been $60.84 for the whole United States, being about six times the acreage value for all crops. The average value from flower and plant farms, however, was $431.83. The distribution of the property in nursery-farms is mostly in land and its improvements exclusive of buildings, this item being for the United States $6,841, in a total average valuation of $9,436 per farm. In buildings there were invested $2,101 to each farm, in implements $266, and in live-stock $228. Each nursery farm averaged $4,971 in the value of its product.

The American nursery grows such a different class of products from the European establishment that organization studies of the two are not comparable. The American nurseries grow relatively large quantities of fruit trees, and these are not trained to special or individual forms. The business is conducted, for the most part, in a wholesale way, with a consequent small value for each piece in the product. As the country fills up and special tastes develop, and as new or untreed land is more difficult to secure, a new line of studies will need to be made of the economics of nursery agriculture.

There is no good separate literature on the nursery business, although there are books on nursery practice, as Bailey's "Nursery-Book," Fuller's "Propagation of Plants," and chapters in the leading fruit books. The American Association of Nurserymen publishes annual proceedings, and there are special journals. In Vol. I of this Cyclopedia (page 193) is a discussion of the capital required for establishing an up-to-date nursery. Following is advice on the equipment needed for an average nursery, by E. Albertson and W. C. Reed, of Indiana (comprising the remainder of this article):

As to the equipment, the wagons, harness, teams and tools used on a good, well-equipped farm for preparing the soil,—such as breaking plows, harrows, rollers and crushers—are all needed in the nursery; while for cultivating, the same tools as used on the farm for corn, potatoes and garden truck can be used to advantage. To these may be added the small bar plows, some finer tooth cultivators, and double cultivators with extra high arches. Drags or floats, both single and double, are needed to follow the cultivators to crush the clods and pack the soil, especially in dry weather, and hand weeders to use in place of hoes except in very hard ground or for heavy work.

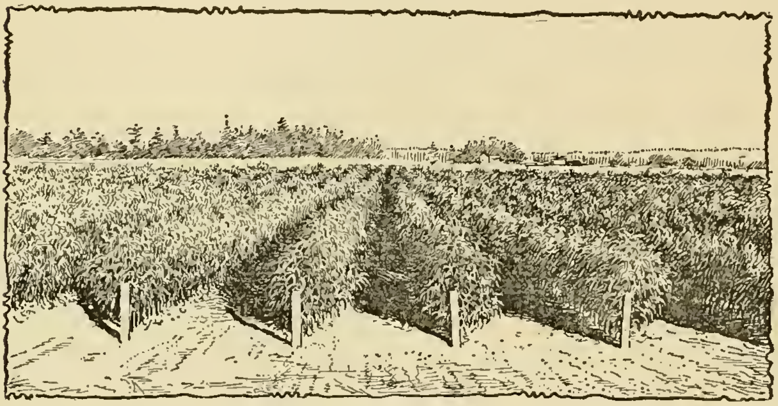
Fig. 714. A peach-tree nursery. Oregon.

Planting tools will also be needed. For small plants the dibble may be used to good advantage, but for the planting of most small stock the light spade is preferable. Machines are now made for opening up the ground and pressing back the dirt after the plant has been inserted, proving to be a great saving of expense and labor where large plantings are made, but they would hardly pay the small planter.

Sheds will be needed and water barrels should be provided to keep on hand plenty of water for puddling everything before planting. If the nurseryman is to grow largely of seedlings, seed-sowing machines adapted to the seed to be planted should be provided. For large blocks of peach trees, a peach-seed planter should be had, the best of which costs about $125.

One of the most important parts of the equipment is the spraying outfit, which should always be ready and often used from early spring till the latter part of summer. This should be adapted to the amount of service needed. Very small areas can be covered with the knapsack, while for a few acres the tank on a cart with a hand pump will be needed; in large tracts, the power sprayers will be found to be more economical. The cost of these outfits will range from one to five hundred dollars.

Pruning, grafting and budding knives must be provided, stakes for marking varieties, raffia or other material for tying buds, shears for cutting off stocks, grafting threads and wax and calipers for measuring the trees. Good, heavy digging spades will be needed. The equipment will not be complete without a power tree-digger and attachments for hitching at least ten horses.

After preparations are made for planting, cultivating and digging, the nurseryman must prepare to handle and care for the stock properly after it is dug, and for this there should be suitable packing, storage and work rooms. A work room for grafting, making cuttings, grading and counting seedlings and cions, will be needed. The room for storage of grafts, seedlings and cuttings for planting, should be separate from those used for storing and packing trees; if possible, a separate building is preferable. The writers would advise that all buildings, whether called cellars or not, be made above ground and of only one story. The room for seedlings, cions and grafts should join the work room on the same level, both having dirt floors. The room for storage of trees should be separate from all others; adjoining this should be the packing rooms, where the planters' orders are sorted, and where all box and bale goods are prepared for shipment, bulk shipments being loaded directly into cars from the storage room. A switch into or alongside of this packing room will be a great convenience. All these rooms should be frost-proof, excepting the packing room, and if that is also frost-proof it will be of great advantage for grading, counting and tying stock taken up late, as this work can then be done when the stock could not be handled outdoors.

These buildings may be constructed of any material most convenient and economical, but the principle of insulation must always be carefully considered. If the buildings are of brick, stone or concrete, this insulation may be secured by air-chambers in the walls and roof; if the buildings are of lumber, paper may be used for insulation, making three or four air-chambers, and protecting the paper outside and inside with lumber. This makes one of the cheapest and most satisfactory buildings, although the brick, stone or cement is more durable. Gravel roofs and good air spaces in the roofs may be recommended.

To meet the requirements of the laws of many of the states, a fumigating house or room must be built. This should be separate from other buildings and constructed according to approved plans, and may cost from fifty dollars up.

Plenty of water should be at command at all times. If it cannot be had from city waterworks, private supplies should be installed, by engine or windmill, with sufficient tank capacity to insure a constant supply; and this should be so distributed as to be accessible in every part of the buildings. Packing material, rye-straw and lumber for boxes must be supplied in liberal quantities. Moss, excelsior, straw, and shavings are used for packing.

The storage and work rooms may be built at a cost of $1,500 and upwards, depending on the volume of business contemplated. Small office room may be secured by cutting off part of the work room, or in a separate building, the expense being governed by circumstances.

In addition to the above, provision has to be made for the nursery-stock or seed that is to be planted and grown. This will be governed entirely by the nature of the business contemplated, location and other factors, and must be considered separately for each individual case. One can very soon succeed in investing $5,000 or $10,000 in the nursery business, and then find that he has not very much of a nursery. Yet there are many large nurseries that were started on much less cash capital than this, but which, with good judgment, energy and grit, soon found the capital to enlarge and extend the business as circumstances warranted.

Organization of a Commercial Nursery Business.

By *M. McDonald.*

The purpose of this article is to show the proper distribution of capital to equip, operate and maintain a nursery to cover 200 acres of land, to be planted complete in three years, starting with a capital of $50,000. In the organization of a commercial nursery of such size, sufficient capital should be provided to plant 140 acres and operate the growing department for the first two years, or during its non-productive period, and also to erect suitable packing, storage and office buildings; and, after the first year, to establish and operate a complete sales department.

After organization has been effected and capital provided, if an incorporated company, the stockholders meet and elect directors, who in turn elect officers whose business it is, with the advice of the directors, to arrange the permanent plans and business organization of the company. Usually, in case of a corporation, a general manager is appointed, who may be one of the officers or directors or may be chosen from outside because of personal fitness for the work in hand. Again, the directors may act as an advisory board or executive committee, resting the responsibility from the different departments directly on themselves, and directing the affairs of the company without the assistance of a general manager; or, in case of an individual owner, he may himself assume the position of general manager and direct the work of the different departments, receiving the reports from the heads of each division.

Whether it be general manager, advisory board, executive committee or individual owner on whom devolves the responsibility of the working organization, such person, or persons, must be thoroughly conversant with the intricacies and have a practical knowledge of all details of the nursery business in both field and office, so that he may economize time and lessen cost without detracting from the efficiency of the forces under him or lower the standard of quality of the article produced.

The man on whom rests the responsibilty of the management of a commercial nursery should be a general in every sense of the word. It has been well said, "To the active participant, the commercial battles on the field of modern business are no less picturesque than the struggles for military supremacy. The powers of command, the routes of authority, the training and distribution of men in the field of action and the regulation of the forces, may not improperly be compared to those of an army."

The nursery farm now under consideration is presumed to have the entire acreage planted in three years. The seventy acres set aside for the first year's planting should include a complete line of nursery products that will thrive in the section in which the nursery is located, containing fruit trees, seedlings to be budded or grafted later of all the varieties desired to be propagated, together with a full line of ornamental trees, shrubs, vines, roses, and the like. This first planting should be duplicated the second year, leaving sixty acres to be planted the third year to complete the two hundred. The reason why it is not necessary to plant so large an acreage the third year as the first and second, is because of the slower-growing kinds, especially in ornamental trees and shrubs, as these classes contain many kinds that are carried in stock for a number of years, while the fruit-tree stock is disposed of in two or three years. The surplus shown in the stock book at the end of the second year will indicate the classes and varieties left over after the first year's sales, and will be the guide for the third year's planting.

The field men organization.

Organization of the nursery forces should be effected at the very inception of the business, and a correct system of daily and weekly reports installed, so that the cost of any given class of trees and plants may be arrived at by the management at any time. The highest standard of grade, thrift and health, produced at the least possible cost, should always be aimed at; this can be accomplished only by a close check on labor employed at all times.

Superintendent of nurseries.—Second in authority and reporting directly to the general manager should be the superintendent, who necessarily must have a practical knowledge of all the details connected with the growing department of a commercial nursery. He should be selected for his wide experience in the business, together with his ability to manage men and direct the forces in the field.

Division foremen. — Under the superintendent are the field foremen, whose business is to take charge of and direct the men from day to day in the field work. In any well-regulated commercial nursery, there should be at least three foremen who are responsible for the amount and kind of work done in their departments. First would be the foreman in charge of the cultivating department, which should include, in addition to plowing and cultivating, the care of horses, tools, and the like. Next would come the foreman of grafting, budding and the general work of growing and digging. In addition to these two, there should be a foreman in charge of spraying, which work is now acknowledged to be very important to the thrift and health of the trees and plants, as well as necessary in keeping the stock free from all insect pests and diseases. This, at the present time, is one of the most important points in connection with the nursery business, as it is impossible to ship nursery stock from one point to another unless it is free from pests and diseases.

Daily report from field foremen to superintendent. — The system established should include daily reports from each of the field foremen to the superintendent, showing in detail the amount and kind of work each man performed during the day. The daily reports should be arranged to accommodate the various kinds of work in which one man may be engaged during the day, although it might be changed every hour. These reports will be a guide to the foremen as to the value of individual men and help to form the basis for arriving at the cost of stock in any given block, enabling the management to fix the price at which a tree can be sold and a profit made.

Superintendent's weekly report. — The foremen's daily reports should form and be made a part of the superintendent's weekly reports to the general manager, which should include a general review of the work done in the different departments and the nurseries generally, with recommendations for changes or new equipment required.

General managers' monthly report.—If a corporation, the general manager may use the superintendent's weekly reports, together with the foremen's daily reports, in a monthly report to the officers and directors of the company.

Office organization.

After planting the seedling stock the first year, the erection of suitable office buildings must be considered. These should be large and roomy, with a view to increased business from year to year, great care being given to proper lighting, heating and ventilation.

Sales department.— In the organization of the office force, the sales department must be given first consideration, for on the management of this department will depend largely the success or failure of the entire structure. Whether the stock is to be sold by wholesale, retail, or by both methods, great care should be exercised in laying a foundation on which to build a sales structure to accommodate daily balances between stocks and sales, and weekly reports from the salesmen, together with the weekly and monthly reports to the general manager. The retailing of nursery stock through the medium of traveling salesmen being the most generally in favor with nurserymen, these remarks will apply more particularly to that system, although the same principle will apply to any other system of selling.

The sales manager.— The sales manager is the man on whom rests the responsibility of disposing of the products of the nursery farm. He should have a general and practical knowledge of the nursery business and be able to organize, manage and direct a selling force, which work, in itself, requires unusual skill, perseverance and tact. He should also have a personality that will gain the confidence of the salesmen working under him, and have sufficient aggressiveness to inspire the men to put forth their best energies in the advancement of the mutual interests of the nursery and of themselves. The sales manager must also be able to install an accurate system of accounting or aggregating of stock sold and balance in surplus to be disposed of.

The aim of the successful sales manager must always be to dispose of those kinds and varieties of trees, shrubs and plants that are grown in the nursery farm, and to avoid as much as possible the sale of varieties that are not produced in his own nursery; this can best be accomplished by keeping an accurate record of sales made from week to week. This, when checked against stock grown, will show remainder yet to be disposed of. The salesmen's weekly reports, together with a general review of the work accomplished during the week, may form the basis of the sales manager's report to the general manager, which report should include condensed comparisons with corresponding periods in previous years, together with general information affecting the business.

Accounting, delivering and collecting departments. —In addition to the sales department, the office force should be organized into accounting, delivering and collecting departments, each of which will report periodically as desired by the general manager.

The stock-buildings and organization.

It is important and necessary, in establishing a commercial nursery, that suitable buildings be erected to store the stock during the operation of packing, and as a protection from the elements between the time when the trees and plants are taken up and the time they are sent out to customers. These buildings should be arranged for receiving, storing, packing and shipping, and should be grouped conveniently so that the stock will pass from the receiving floor to the storage, billing and shipping departments with the least expense in handling. Special attention must be given the storage cellar to insure a low and uniform temperature as a protection to the stock from extremes of heat and cold, it being important that stock be held in a perfectly dormant condition for late spring shipments.

Superintendent of packing department. — The superintendent of this department fills a very important part in the work of the nursery, and must be a man of experience and ability, quick to decide and accurate in his judgment of men and of nursery-stock.

Packing-house foremen.— Under the superintendent and reporting to him there should be foremen over the different divisions of the packing houses, whose business it is to direct the men and keep an accurate account of the kind and amount of work performed by each during the day. Verbal reports from the foremen to the superintendent daily during the busy season, will greatly facilitate the work.

Distribution of the investment.

The approximate distribution of capital in the nursery under consideration would be as follows:

Capital stock		$50,000
Annual rental for 200 acres of land at $6 per acre for two years . .	$2,400	
Horses, tools, etc.	1,500	
Cost of seedling stock, planting and cultivation of nursery-farm for two years	25,000	
Office equipment, management (including commission advanced on sales for one year)	15,000	
Packing and storage buildings . .	6,100	
		$50,000

OATS. *Avena sativa*, Linn. *Gramineæ*. Figs. 715–721, also Fig. 542.

By *A. L. Stone.*

A grass grown for its grain, which is used both for human food and for stock, and also for its straw. It is the only species of the genus that is of great agricultural importance. *Avena fatua*, the wild oat (Fig. 543), from which the domestic oat may have sprung, is a serious pest in many parts of the world.

The flowers of the oat are borne in a panicle which consists of a central rachis or flower-stem from which small branches extend in various directions. The panicles are nine to twelve inches in length, and the branches are arranged in whorls at intervals along the flower-stem. There are usually three to five or more whorls, which bear sixty to eighty florets, or spikelets. (Fig. 715.) Each one of these spikelets is composed of two or more flowers, but it is seldom that more than two of them mature, and of these one grain is invariably larger than the other. In many varieties but a single grain reaches full size and the oats are called "single" oats; in others two grains mature, and the oats are called "twin" oats. The flower itself is placed in two outer, light, netted-veined glumes which enclose the flowering glume and palea. When there are two flowers on the pedicel, the flowering glume of the lower flower generally encloses that of the upper flower to a greater or less degree. Within the flowering glume and palea are the organs of reproduction, which consist of three filaments and anthers, closely set about an ovary bearing two feathery stigmas. These stigmas surmount the ovary and spread out as the flower expands. The filaments bearing the anthers grow very rapidly and push themselves outside the palea. The anthers are so arranged that the growth of the filaments changes their position enough to subvert them and allow the pollen to fall on the stigmas. The flowers bloom in morning or afternoon.


Fig. 715. Oat spikelet in bloom.

Distribution and yield.

The exact nativity of the oat plant is not positively known, but the evidence would indicate it to be Tartary in western Asia, or possibly eastern Europe. No record of it has been found in the literature of China, India or other parts of southern Asia. Neither is it mentioned prominently in the early histories of Asia or the Holy Land. Certainly it has never been of such importance to the human race as wheat, corn or rye, all of which figured largely in the early nurture of the race.

The great oat-producing regions of the world lie almost wholly within the north temperate zone and include Russia, Norway and Sweden, Germany, Canada and the north-central part of the United States. Large quantities of the grain of very good quality are grown in Australia and the neighboring islands, and more recently limited quantities have been grown in Africa and South America, but the great bulk of any season's crop is produced in the first mentioned territory.

Russia and its provinces, Poland and Northern Caucasia, produce the greatest quantity of oats of any country in Europe or America, or in fact the world. Of the more than two billion bushels produced in Europe in 1904, Russia furnished 1,065,088,000 bushels. The oats grown there are high grade and many of the most valuable varieties now being grown in America are importations from Russia, largely from the southwestern provinces.

The following tables from the 1904 Yearbook of the United States Department of Agriculture, giving the yields of the various grains in the principal regions where each is grown, will give some idea of the comparative importance of the oat crop:

Yield of Oats by Continents.

	1900	1901	1902	1903	1904
North America	963,738,000	906,285,000	1,193,194,000	991,508,000	1,097,423,000
Europe	2,129,316,000	1,884,945,000	2,324,439,000	2,240,970,000	2,342,015,000
Asia	40,905,000	28,439,000	43,511,000	71,694,000	54,948,000
Africa	6,750,000	6,750,000	10,479,000	7,500,000	8,116,000
Australasia	25,293,000	32,110,000	25,613,000	29,979,000	33,677,000
Total	3,166,002,000	2,858,529,000	3,597,236,000	3,341,651,000	3,536,179,000

YIELD OF CORN BY CONTINENTS.

	1900	1901	1902	1903	1904
North America	2,193,938,000	2,225,254,000	1,641,600,000	2,622,906,000	2,364,388,000
South America	81,185,000	66,647,000	113,418,000	98,078,000	162,711,000
Europe	405,990,000	465,102,000	562,194,000	424,090,000	492,957,000
Africa	33,207,000	27,350,000	32,350,000	32,350,000	32,350,000
Australasia	9,780,000	10,025,000	10,168,000	7,847,000	5,615,000
Total	2,724,100,000	2,794,378,000	2,359,730,000	3,185,271,000	3,058,021,000

YIELD OF WHEAT BY CONTINENTS.

	1900	1901	1902	1903	1904
North America	588,360,000	850,693,000	777,194,000	733,786,000	640,827,000
South America	120,546,000	87,417,000	75,984,000	118,876,000	140,598,000
Europe	1,507,596,000	1,513,553,000	1,817,602,000	1,828,419,000	1,726,177,000
Asia	331,266,000	395,574,000	381,879,000	478,515,000	519,505,000
Africa	42,872,000	41,428,000	51,931,000	50,523,000	50,606,000
Australasia	50,111,000	56,610,000	43,927,000	20,461,000	84,627,000
Total	2,640,751,000	2,945,275,000	3,148,517,000	3,230,580,000	3,162,340,000

It will be seen that in the number of bushels oats exceeds both corn and wheat; but it is really less than either when the total number of pounds is considered. The average annual yield of oats for the world at large from 1900–1904, inclusive, has been 3,499,866,000 bushels. While the yield per acre is high, the value per acre is less than that of any other of our common grains.

The average yield of oats per acre varies in the different oat-growing regions of the world, as will be seen by the following table, also taken from the 1904 Yearbook of the United States Department of Agriculture:

AVERAGE YIELD OF OATS IN CERTAIN COUNTRIES, IN BUSHELS PER ACRE, 1894–1903.

Year	United States	Russia	Germany	Austria	Hungary	France	United Kingdom
	(a)	(b)	(b)	(b)	(b)	(a)	(a)
1894	24.5	21.7	46.8	25.9	30.1	27.2	43.7
1895	29.6	19.9	43.2	26.2	29.6	27.5	39.5
1896	25.7	19.2	41.8	23.1	31.4	27.0	39.2
1897	27.2	15.7	39.9	21.5	24.3	23.1	40.1
1898	28.4	16.5	47.1	27.3	30.2	29.0	43.6
1899	30.2	23.6	48.0	30.2	33.3	27.8	41.8
1900	29.6	19.5	48.0	25.2	28.1	25.7	41.2
1901	25.8	14.0	44.5	25.6	28.1	23.5	40.6
1902	34.5	21.8	50.2	27.6	34.0	29.2	45.9
1903	28.4	17.7	51.3	28.4	34.4	31.6	44.2
Average	28.4	19.0	46.1	26.1	30.3	27.2	42.0

a, Winchester bushels. *b*, Bushels of 32 pounds.

While the yields here given are not strictly comparable, part of them being given in Winchester bushels and part in bushels of thirty-two pounds, it is still evident that the yields are greater in Germany and the United Kingdom, with their moist climates and intensive farming methods, than in this country. Europe produces the greatest quantity of grain in proportion to the area covered, with North America second. The production is increasing more rapidly in North America than in Europe, and as our agriculture becomes more intensive we will undoubtedly exceed the yields of Europe.

Of the history of oats in the United States a writer in the International Encyclopedia says: "Oats have been cultivated in America ever since the advent of the first white settlers. They were sown with other cereals by Gosnold on the Elizabeth islands in 1602; were introduced into Massachusetts bay, 1629, and their cultivation has since extended to every state in the Union." While this statement is literally true and oats are raised in every state in the Union, the greater bulk of the crop is raised in the north-central states. Eleven states now produce four-fifths of the oats grown in the United States, and all except New York and Pennsylvania are in the north-central group. These states in order of production in 1905 were Iowa, Illinois, Wisconsin, Minnesota, Nebraska, Indiana, New York, North Dakota, Pennsylvania, Ohio and Michigan.

The average yield in 1905 was thirty-four bushels per acre. Of the great oat-producing states, Wisconsin leads in yield per acre with 39 bushels, and North Dakota is second with 38.9 bushels. Iowa showed an average of 35 bushels and Illinois 35.5 bushels per acre, the states with the largest total yield not giving the largest yield per acre.

The total acreage for the United States in 1905 was 28,046,746, with a production of 953,216,197 bushels, worth at farm values $277,047,537. Of the vast quantities of oats produced in the United States nearly all are used for home consumption. Oats to the amount of 41,369,415 bushels, worth $12,504,564, were exported in 1900, and 41,523 bushels, valued at $18,360, were imported. Since that time the exports have constantly decreased and the imports increased, so that in 1904 only 1,153,714 bushels, valued at $475,362, were exported, while 170,882 bushels, valued at $57,802, were imported. [Yearbook of the United States Department of Agriculture, 1904.]

Fig. 716. On the left, spreading oats; on the right, sided or mane oats.

This increase is undoubtedly due, as will be mentioned later, to the increasing popularity of oats as an article of human diet in the United States.

The yields of oats in Canada for forty years have been as follows: 1871 the yield was 42,489,453 bushels; in 1881 it was 70,493,131 bushels; in 1891 it was 83,428,202 bushels, and in 1901 it had risen to 151,497,407 bushels. The yield was distributed approximately as follows in 1901: Ontario, more than 88,000,000 bushels; Quebec, 33,500,000; Manitoba, 10,500,000; New Brunswick, nearly 5,000,000; Prince Edward Island, 4,500,000; Nova Scotia, 2,300,000; British Columbia, 1,500,000; The Territories, 6,000,000 bushels.

Classification.

Oats may be divided into two great classes. These are spreading oats, and sided, mane or banner oats. (1) In the spreading oats the branches of the panicle extend in all directions from the rachis. This class comprises the largest number and the most popular of the varieties of oats. (Figs. 716, 717, 718.) (2) In the second class, known as sided or "mane" oats, the branches all hang to one side of the rachis, thus producing the appearance that has caused the name of "banner" oats occasionally to be affixed to them. The terms "open" and "closed" panicles are sometimes applied to the two flower arrangements. (Fig. 716.) A third class, or hulless oats, while classed by themselves, may in fact belong to either of the preceding classes, although sometimes called by a distinct name, *Avena nuda*. The principal agricultural difference is in the hull, which is so loosely attached as to be completely removed by the threshing process, leaving the grain only. There is also difference in the structure of the parts. Because of low yields and other considerations these oats have never become popular and are not extensively grown.

At the Ohio Experiment Station, where seventy-one varieties of oats have been under experimentation for several years, another classification has been made. There the different varieties have been divided into four groups. (1) In the first or "Welcome" group are placed all varieties with spreading panicles, and having coarse straw and short, plump grains. (2) In the second or "Wideawake" group are placed those varieties with spreading panicles which have long, slender kernels and

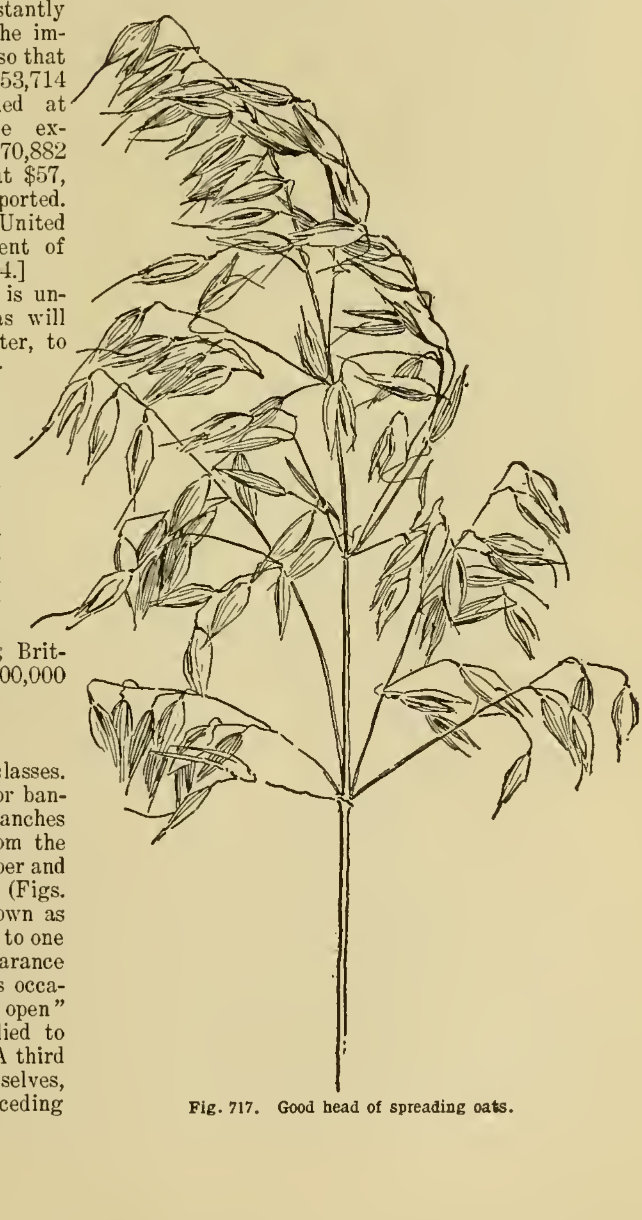

Fig. 717. Good head of spreading oats.

longer straw than the Welcome oats. These varieties take a little longer to mature than the preceding. (3) The "Seizure" or third group contains all the varieties of side oats, those having closed panicles. These take a still longer time to mature. (4) In the fourth or "mixed" group are placed all varieties about the classification of which there is any doubt.

Fig. 718. Spreading oats. Poor head. Compare with Fig. 717 for a lesson in seed selection.

The varieties may be subdivided as to color into white, yellow, red, gray and black oats. The white and yellow oats are grown most largely in the North and are of the greatest economic importance. The red and gray varieties are grown in the South, largely for forage and pasture and may be either winter or spring oats. Black oats are grown in the North but are not considered to be so good as the white oats.

Relative values of different types.

The character of the soil and climatic conditions will largely determine which of these varieties shall be grown in any given locality. Experiments show that in general there is no advantage in yield per acre of oats having the open panicle over those having the closed panicle. The latter varieties are hardier and are undoubtedly better yielders where the growing season is of sufficient length to allow them to mature properly, but greater certainty of a crop is assured through a series of years when the open-panicled, earlier-maturing oats are grown. It has also been found that there is no particular difference in the yields of varieties having short, plump grains and those having long, slender grains, nor is there any appreciable difference in the weight per measured bushel. (Figs. 719, 720.)

Fig. 719. Short, plump kernels of the medium-early varieties of oats. Also illustrates "twiu" oats.

The Illinois Station conducted a five-year test with between thirty and sixty varieties, and came to the conclusion that the long, slender kernels gave a higher percentage of grain to hull, while the Ohio Station with seventy varieties one year found that the short, plump grains gave the higher percentage of grain to hull.

Varieties with the long, slender kernels take longer to mature and in a short season would not fill well. This would result in a larger percentage of hulls and a decrease in weight per measured bushel. The varieties with short, plump grains are early-maturing, and the grains will invariably be well filled, consequently the percentage of hulls will be less. However, in a season long enough to allow the later varieties properly to mature the grains would be well filled and the percentage of hull would be less, so that in general this percentage will be affected more or less by the character and length of the growing season.

Probably a majority of the varieties grown in the United States at the present time are those having short, plump grains. While the yields are not always greater,—in fact may in good seasons be less,—they have the advantage of ripening early enough to escape storms and rust, which often come on a little before harvesting time and tend to lessen the yields or in some cases utterly destroy the crop. The average percentage of grain to hull for American varieties is stated by Hunt in "The Cereals in America" to be 70 per cent.

Variety to sow.

In choosing a variety to sow, the end in view is to secure the highest possible yield of the best grade of grain. To do this a variety must be chosen that is suited to the local conditions. The shorter the season the earlier-maturing must be the variety. There are many well-tried varieties of oats, and with a little care success may be had in growing any of them.

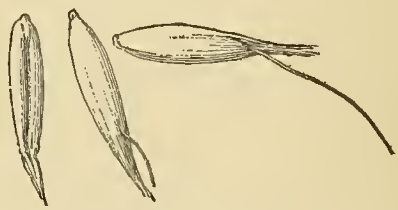

Fig. 720. Long, slender kernels found in the later-maturing varieties of oats. Also illustrates "single" oats.

At the Ohio Station it was found that varieties of the Welcome group, with short, plump kernels and open panicle, gave the highest yields per acre and the heaviest weight per measured bushel. In a ten years' trial the following were found to be the best varieties in the group, ranking in the order named: American Banner, Improved American, Colonel and Clydesdale. Of these, the American Banner has been recommended by ten experiment stations, which is more than can be said of any other variety. Other highly recommended varieties are the Swedish Select, White Bonanza, Lincoln and Siberian. In Wisconsin, the Swedish Select oats have averaged ten bushels more per acre than other varieties grown in the same localities, and have yielded as high as eighty-five bushels per acre in several instances. In Montana, the same oats have yielded over one hundred bushels per acre. These oats would be well suited to any oat-growing section of the United States.

In a series of trials at the Ontario Experiment Station the Siberian proved to be the best of one hundred varieties, and on Canadian farms yielded an average of eighty or more bushels per acre. The yield of oats per acre is higher in Canada than in the United States, one hundred bushels or more per acre being not uncommon.

The Sixty-Day oat is rapidly coming into favor in some regions because of its earliness. It matures six to twelve days earlier than the ordinary varieties. The straw is short and the kernel slender. Its early-maturing qualities make it valuable in sections where the oats are subject to rust, as it matures before the severe attacks of rust come on. Its short straw also prevents lodging to a large extent. The variety known as Kherson is practically identical with Sixty-Day.

New varieties in the United States are largely introductions from European countries. To this also is due the larger share of the improvement in the crop, though many fine varieties have been established by careful breeding and selection.

Oats for the South are discussed for this occasion by H. N. Starnes: "At the North there is a wide varietal range from which to choose, although throughout the south Atlantic and Gulf states the list of available profitable varieties shrinks to a lean half-dozen, or less. This does not mean that all of the northern standard varieties (with the exception of the few above referred to) cannot be grown at the South. In many localities, where climate, soil and special environment chance to be favorable they (or most of them) may be readily grown, some of them very successfully. Yet it may be safely asserted that but two varieties are so vastly superior to all others that they are now grown to the practical exclusion of the others. These varieties are Texas Red Rust-Proof, with its offspring Appler planted almost entirely in the fall, and the Burt for spring planting.

"The two former are vigorous, robust and productive with a heavy head. The Burt is of value only because it will always grow tall enough to be cradled or reaped even on thin, poor land. Its head, however, is very light. Yet even Burt, in common with all other spring oats, must eventually—and probably very soon—be abandoned, since the adoption at the South of the 'open furrow' method of seeding will render spring planting no longer necessary, and Appler will thus remain practically the only representation of the oat at the South."

Culture.

Seed.—In general, the variety is not so important as the care and selection of the seed after the variety is established. Any variety suitable to the locality can be made to yield well with careful selection and grading of seed. Whatever the variety, it is important that the seed be of the highest grade. High-grade seed consists of plump, heavy grain, free from weed seeds and other foul materials and resistant to fungous diseases.

The seed should be run through a good fanning mill to remove weed seeds and dirt, then through the mill again, so set that all light oats will be blown over. At the Ohio Experiment Station it was found that when the light oats were blown out in this way and sown, they yielded 3.68 bushels of grain and 111 pounds of straw less per acre than did the heavy grains secured at the same separation. The heavy grains also yielded 1.54 bushels more per acre than grain sown just as it came from the threshing machine.

Zavitz, of the Ontario Agricultural College, conducted an eleven-year experiment to determine the effect of a constant selection and sowing of heavy-weight, plump grains in contrast to light-weight grain. He found that at the end of the eleven years the yield from the former was seventy-seven bushels, and from the latter fifty-eight bushels per acre. Professor Zavitz expressed his belief that the yield of oats could easily be increased 15 per cent by careful breeding and selection of the seed. The oat crop of the United States in 1905, in round numbers, was 950,000,000 bushels. An increase of 15 per cent would be 142,500,000 bushels. The average price for oats in 1905 was about twenty-seven cents. This would mean an addition of $38,475,000 to the wealth of the farmers of the United States.

The seed should be treated for the prevention of smut. In many fields the loss from smut amounts to 40 per cent or more of the crop. The treatment of the seed for smut is more important than farmers as a rule are willing to believe. In the year 1902, by close inspection of many fields in the state and with the coöperation of graduates of the College of Agriculture, it was found that 17 per cent of the crop in Wisconsin was destroyed by smut. The yield of oats in Wisconsin that year was 95,000,000 bushels, which may be considered as only 80 per cent of a full crop. [See below under *Diseases*.]

The seed should be tested as to its vitality or germinating power. A simple form of seed-tester is shown in Fig. 210 and described on page 141. Another tester is shown in Fig. 391. If the tester is placed where it will be exposed to ordinary room temperature, or 70° to 80° Fahr., a good germination of oats should be obtained in three days. Using one hundred seeds to begin with, the number that germinate will represent the percentage of germination, which should be 97 per cent.

Fig. 721. Oat head affected by smut.

In cases in which the vitality is lower than that, it will be necessary to sow more seed per acre.

There is no question that if care is used in selecting, cleaning and treating the seed, and in the preparation of the soil, oats should grow better in yield and quality from year to year. The ease with which seed can be procured and the lack of knowledge concerning the best methods induces many a farmer to change his seed when by care and industry he might himself produce seed as good as any he buys.

In an effort to teach the young farmers the importance of good seed and the proper methods of selection and grading, many of the agricultural colleges have taken up the study of the grain by the use of score-cards. A thorough understanding and application of all the principles of the score-card will enable any one more intelligently to take up the work of improving the oat crop.

Preparation of the seed-bed.— Oats demand cool weather and abundance of moisture, so that the sooner they can be sown in the spring the better. The amount of water taken from the soil by oats exceeds that used by any other of our important crops. King, at the Wisconsin Experiment Station, found that oats removed from the soil 504 pounds of water to each pound of dry matter produced. Of course a part of this moisture passes from the leaves of the plant through transpiration, and from the soil by evaporation, but the amount is very great and demonstrates the need of getting the grain into the soil as early in the season as possible, while the moisture is still available.

In cases where the ground has been fall-plowed, the stirring of the soil should begin as early in the spring as it is possible for teams to get on the land. The value of early stirring to form a soil mulch and thus prevent the evaporation of moisture was well shown at the Wisconsin Station. Professor King used two plots, side by side, both of which were alike at the beginning. On one the hardened or packed crust was allowed to remain. On the other the stirring process was begun as soon as practicable and the soil mulch carefully preserved. It was found that the evaporation of moisture from the unstirred plot was enormous, amounting to 198 tons per acre in seven days or at the rate of thirty tons per day. Nothing could indicate more clearly the short-sightedness of allowing the land to lie with a packed surface because a little extra time would be required to keep it in proper condition. The extra labor would be well repaid by the increase in crop due to the wise conservation of moisture and the destruction of weeds.

While oats will do well after corn with only a surface disking, increased yields will undoubtedly be obtained when the ground is plowed, especially if the soil is naturally very compact. The seed-bed should be in good tilth. Although oats will produce well on poorer grades of soil than any other of the cereals, a careful preparation of the seed-bed will be amply repaid by increased production. The seed-bed should be compact, and on rather light soils rolling may be necessary. Should the soil be wet, however, rolling is likely to pack it to the exclusion of proper amounts of oxygen, and even to the point where the young plants will be unable to reach the surface. In all cases rolling should be attended with caution ; and a light dragging afterward to preserve the soil mulch is to be recommended.

Fertilizers.—Oats do best on soils that are not too fertile, and the direct application of fertilizers is generally inadvisable, as it is liable to produce lodging of the grain and consequent loss. When oats are grown in a rotation following corn which has been manured, there is no need of manuring the oats, as enough plant-food will still be available after the corn crop has been removed. On soils too poor to raise good crops of oats, the application of barnyard manure at the rate of ten to twenty-five loads per acre, or of a standard commercial fertilizer, would put the soil in good condition. A standard commercial fertilizer, according to Hunt, is "one that furnishes ten to twenty pounds each of ammonia and potash and thirty to sixty pounds of phosphoric acid. This can be obtained by applying 250 to 500 pounds of a commercial fertilizer containing 4 per cent of ammonia, 12 per cent of available phosphoric acid and 4 per cent of potash." On soils, such as some of those in Iowa, Illinois and other states of the corn-belt, and in some of the eastern states, where continuous cropping has lowered the fertility, it may be necessary to increase the percentage of nitrogen in the fertilizer. Commercial fertilizers may best be applied with a fertilizer attachment to the grain drill and at the time of sowing the grain.

All in all, oats need little fertilization. The Ohio Experiment Station (Circular 54) found that while the addition of a complete fertilizer to oats increased the yield, the increase failed to pay for the fertilizer in one case and barely paid expenses in another. It was found, however, that when phosphorus alone was used, a marked increase resulted and at a profit. The fertilizer applied will have to depend on the soil and is largely a matter of judgment.

Depth of seeding.—The proper depth to sow the seed and the best method of sowing will depend much on the soil. Better results have been obtained by shallow sowing. The Illinois Experiment Station in a six years' trial has found one inch to be the best depth at which to sow oats. This was corroborated by the Ohio Experiment Station, where seeding at a depth of one inch gave a yield of 3.56 bushels more per acre than when the grain was sown two inches deep, and 7.73 bushels more than when sown three inches deep. All things taken into consideration, drilling is the best way of seeding when the seed-bed is properly prepared, because the depth of seeding can be made more precise and uniform. No especial advantage has been found in ordinary drilling over broadcasting. Large areas, however, are now drilled on old corn land by using disk drills. Broadcasting in this manner necessitates sowing slightly more seed per acre.

It is well, in all cases, to follow the seeder with a harrow to aid in covering the seed in the case of broadcasting, and to level the soil in any case, as well as to aid in preserving the best soil mulch. A common harrow or drag with teeth set at an angle of 45° makes a good tool for the purpose.

Rate of seeding.—The rate per acre at which the seed should be sown will depend largely on the location and the preparation of the seed-bed. Oats stool abundantly and indications are that a majority of farmers sow too much seed per acre. Experiments at ten experiment stations have led to the recommendation of eight to sixteen pecks to the acre, with an average of ten pecks. When the seed is clean and well graded and the viability is high, ten pecks to the acre should be ample. In the corn-belt, where oats are sown on corn ground with only a surface disking, it is customary to sow four bushels of seed per acre; and in Scotland as high as seven and one-half bushels per acre are sown.

Place in the rotation.—Few crops fit into rotations in all parts of the country as well as do oats. In the West, where wheat is so largely grown, we find the following rotation: Corn, oats and wheat each one year, and clover and timothy two years. In the central states we have corn and oats, each one year, and clover and timothy two years. This rotation predominates also in the corn-belt, but is there liable to variation, such as corn two years, oats one year, clover one year or clover and timothy two years. On many farms in the corn-belt, a three-year rotation of corn, oats and clover is practiced, while some of the more shiftless farmers maintain a two-year rotation of corn and oats. This latter custom in time is certain to deplete the fertility of the land and should be condemned.

Southern farmers use oats in the rotation with corn, cowpeas and cotton. These are combined in various ways, but the most common method is to sow cowpeas with corn the first year, putting the cowpeas between the rows of corn and harvesting them for the grain. Then fall-sown oats are removed in time the next summer to put on a crop of cowpeas which is cut for hay; this crop is followed by cotton one or two years, depending on soil conditions.

Subsequent care.—After the grain is up, nothing further need be done until harvest time in an ordinary season. When, however, moisture is very abundant and the soil fairly fertile it may be advisable to clip back the oats slightly to prevent lodging. This delays the ripening somewhat, but may obviate a heavy loss from lodging. The Iowa Experiment Station found (Bulletin No. 45) that cutting back to the third leaf from the ground when most of the plants had five leaves not only increased the yield eleven and one-half bushels per acre over that which was not clipped, but the grain remained erect after that which was not clipped was badly lodged. The cutting back delayed ripening four days, so that little risk was run in clipping

Harvesting and threshing.

The time to harvest oats is when the grain has just passed from the "milk" into what is called the hard "dough" stage, or a very little later. When cut at this stage and set in round shocks, covered with cap sheaves, the best quality of grain will be obtained. Weather conditions and the environment must always be taken into consideration, and if the season is unfavorable and weeds are abundant in the grain it may be more profitable to set the grain in long uncovered shocks, thus giving the bundles a better exposure to wind and sun. Circumstances and the judgment of the farmer must indicate the best treatment for the grain in the interval between cutting and stacking or threshing, as the case may be.

Many of our farmers still hold to the old régime of stacking all the grain. Oats may be stacked a trifle greener than they may be threshed, as they will stand a pretty severe heating in the stack without injury. If stacked while in proper condition there is no question that grain will be of the very finest quality, other things considered. This method has the advantage that the oats can be taken care of at the proper time, and are not in danger of storms and other injurious influences.

It is rapidly becoming the custom in many parts of the United States to thresh the oats from the field. If the weather is favorable so that the grain becomes thoroughly dried before threshing, this is undoubtedly the more economical method of handling the crop, as it saves time and labor when both are at a premium on the farm. No especial loss in appearance or quality will be suffered unless storms occur during the time while the oats are standing in the shock. In this case there will be a change in color which, while not detrimental so far as feeding is concerned, will injure the market value of the grain. If the storms are severe and the bundles fail to dry out, the grain is liable also to start growing, which will injure it from every standpoint.

There are drawbacks to this system of threshing. Often, to secure the services of machine and crew, the farmer must thresh before his grain is fully dry, or he has to wait too long. In one case, the grain will have to be stirred in the bin or it will heat. In the other, the shocks are exposed to the autumn storms, and the quality of the grain is impaired.

Precaution should always be taken to see that the threshing machine is cleaned thoroughly, so that there may be no mixture of grain. Especially is this true when barley has been the last grain threshed, as we have not yet been able to find a machine which will make a close separation of oats from barley.

Oats should yield on an average fifty to seventy bushels per acre in the northern states. In many of the southern states the yields are as low as ten bushels per acre.

Enemies.

Diseases.—The principal diseases which affect oats are rust and smut. The smuts of oats are of two forms,—the closed smut (*Ustilago lævis*, Jens.), and the loose smut (*Ustilago avenæ*, Jens.). Both forms do serious damage when allowed to develop. The loose smut attacks the entire head of oats and turns it into spores. The closed smut affects only the kernels and is less apparent. Both forms can be completely prevented by either the formaldehyde or the hot-water treatment. The formaldehyde treatment consists in submerging the seed grain for ten minutes in a solution made by using one pint of formaldehyde to thirty-six gallons of water. This amount of solution will treat forty bushels of oats. The hot-water treatment consists in submerging the seed in water at 133° Fahr. for ten minutes. [See under *Barley*.] In either case the seed may be put in baskets, gunny sacks or any vessel which will allow the water to penetrate readily. After removing from the solution or water, as the case may be, pour the grain on the threshing floor and allow it partially to dry. Then by opening the drill or seeder sufficiently to allow for the swelled condition of the grain, it may be sown at the usual rate.

There are two kinds of rust [See *Wheat*] which attack the growing oats. One of these is the "crown" or "orange leaf" rust. It affects only the leaves of the plant. The other is known as the "black stem" rust, and this is the one which does serious damage to the growing grain. The rust spores obtain lodgment on the tender stems of the young plants, penetrate to the interior and there produce new spores in quantities so great as to burst the stem-walls and appear in black lines on the surface. It is often very difficult to distinguish between these two varieties of rust, for each has a red and a black stage. Neither in the red or black stage does the "orange leaf" rust do serious damage, nor does the red stage of the "black stem" rust. It is the later or black stage of the "black stem" rust that does especial harm by sapping the life from the stem and preventing the "filling" of the grains. The damage may extend only to a partial prevention of the filling, or a total failure of the crop may result.

A very moist season furnishes the best condition for the growth and development of the rust spores, and this is the reason why rust is more abundant in such seasons. It also explains why grain in low parts of the field is more seriously affected than is that on the more elevated parts of the same field.

Only by growing varieties of oats which are rust-resistant or which mature so early that the grain fills before the devastating stage of the rust arrives can the loss from the rust be avoided. Varieties of oats are now obtainable which are practically rust-proof, having shown their power to produce well under the very worst rust conditions. Of the varieties of oats which mature early enough to escape serious damage by rust are the Sixty-Day oat previously mentioned, the Early Burt and the Kherson oats. While none of these is as satisfactory as some of the later varieties where the latter will mature, they will undoubtedly yield good crops every year. With the later-maturing varieties there will probably be an occasional failure to get a crop, due to attacks of rust.

Insects.—The oat plant is seldom attacked by insects to any appreciable degree except in occasional seasons when chinch-bugs, army-worms or grasshoppers are abundant. The ravages of the grasshoppers are hard to avoid, but are of so infrequent occurrence as to be a negligible quantity.

Both the chinch-bug and the army-worm when once well established do much damage. They start at one side of the field and move across it, leaving devastation behind. A plowed strip of several feet in width, with a deep furrow into which the bugs or worms will fall, will often prevent their reaching a neighboring field. This may also be made more efficient by scattering tar or some insect destroyer in the furrow, the perpendicular side of which should be toward the field to be protected. In extreme cases it would be well to burn one field to save the remainder. [See page 42.]

The threshed oats are probably less subject to attacks of insects or worms than any other of our grains. This is due to the rather thick, smooth and close-fitting hulls, which seem to ward off all attacks.

Uses.

Until recent years oats have been used mostly as a food for animals, horses especially being very fond of them. Large quantities are also fed to sheep and cattle in conjunction with corn. It has been asserted than there is a stimulating principle in the oat which gives to an animal life and energy, such as is produced by no other cereal. Be that as it may, oats remain preëminent as a food for horses.

In Scotland for many years, and more recently in other parts of the world, including the United States, oats have been used as an article of human food. Their great growth in popularity as a human food undoubtedly explains in a large degree the immense increase in production in the years 1880 to 1890, which, according to Hunt, was from four hundred to eight hundred millions of bushels, an increase of 100 per cent. Certainly none of the breakfast foods on the market today is more nourishing or palatable than properly prepared oat products.

The best grade of oatmeal is made from single oats, with as small a percentage of hull as possible. The plumper and heavier the grain the better will the oatmeal manufacturer be suited, provided the hulls of the grain are thin. The manufacturer will undoubtedly be willing to pay an increased price for oats of this sort, and there is here an opportunity for the farmer who is properly situated, to make a financial gain by catering to the oatmeal trade.

Marketing and market grades.

Other things being equal, the best time to market oats is at threshing time. Then the grain may be hauled directly to the market, which saves the extra handling caused by placing oats in the bin. The market price and the condition of the grain when threshed will determine, in a large measure, whether grain is to be sold at that time.

The price received for the grain will depend on its condition and the use to which it is to be put. To command the best market price any grain must be sound and sweet, free from weed seeds and foul material, and have a good color. Oats of poor color, whether from exposure to storms, molding in the bundle, or overheating in stack or bin, will not command the best prices. Oats that have been overheated in the bin will be "bin-burned" and discolored. They will be injured not only from the marketing but from the feeding standpoint as well. When oats are badly discolored, elevator men often resort to treatment by sulfur to bleach the grain and improve the appearance. This leaves the grain in worse condition than before and is a reprehensible practice.

In spite of the magnitude of the oat crop in the United States and the immense increase in production in the last few years, the exportation of the grain has steadily decreased and the importation increased. It is evident, therefore, that there will be a good market for years to come. It should be the aim of the farmers of the United States, by more scientific growing and care of the crop, not only to supply the home demand but to build up an export trade as well.

Grades.— Every grain-raising state has its grain-inspection rules and regulations. These are very similar in all the states. The Illinois Grain and Warehouse Commission has adopted the following grades for oats:

White oats, Nos. 1, 2, 3 and 4.

White clipped oats, Nos. 1, 2 and 3.

Mixed oats, Nos. 1, 2, 3 and 4.

The rules for grading read as follows:

"No. 1 white oats shall be white, sound, clean, and reasonably free from other grain.

"No. 2 white oats shall be seven-eighths white, sweet, reasonably clean and reasonably free from other grains.

"No. 3 white oats shall be seven-eighths white but not sufficiently sound and clean for No. 2.

"No 4 white oats shall be seven-eighths white, damp, badly damaged, musty, or for some other cause unfit for No. 3."

For clipped white oats the same rules apply except that No. 1 must weigh thirty-six pounds, No. 2, thirty-four pounds, and No. 3, twenty-eight pounds to the measured bushel.

The rules for mixed oats are the same as those for white oats, except that all need not be white. It is very seldom that a carload of oats will grade No. 1. Of the four grades, more of No. 3 are received in the market than of any other, and there are more of No. 4 than of No. 2. There is no reason, except lack of care on the part of the growers, why the major part of the oats shipped should not grade No. 2 at least. Sowing, harvesting and threshing at the proper times will cause many oats that now grade No. 4 to grade No. 2. The market prices generally range from three to five cents higher per bushel for No. 2 than for No. 4 white oats. Thus, a field of eighty acres, producing fifty bushels to the acre, would yield 8,000 bushels of oats. A difference of five cents a bushel would increase the value of the crop $400, an amount which would pay for the extra care and labor involved and leave a fair profit besides.

Literature.

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The "Open Furrow" Method of Seeding Oats. Fig. 722.

By *Hugh N. Starnes.*

The oat is yearly becoming more prominent as one of the staple crops for the southern cotton-belt, its position being strongly emphasized by its entrance as an indispensable factor into the system of "triennial crop rotation" (page 98). In the past, however, oat-culture in the South has been largely influenced and its greater increase checked by two discouraging obstacles: (1) Because of the almost inevitable drought in April and May, spring oats are not successful. On the poor, stiff, red-clay land usually allotted to them, aside from their predisposition to rust under such circumstances, the only variety reaching a height sufficient to cradle or reap is the "Burt," an oat with a lengthy stem but a light head, and therefore unprofitable. "Texas Red Rust-proof," the standard variety, is unfitted for sowing on poor land in the spring by reason of its shorter culm. (2) This necessitates fall-planting; but it is usually impossible for the average farmer to seed down his fall oat plats in time for them to become sufficiently rooted to withstand the freezes of early winter, for his corn occupies the land that should go in oats and it must be gathered before the area is planted. The late seeding which this entails renders broadcast and hand-sown fall oats a most uncertain crop. A large percentage invariably succumbs to the cold. Difficulty has been experienced in the use of the seed drill. Unfortunately, the extremely long awns of the "Texas Red Rust-proof" oat, and of its improved progeny, the "Appler" oat, cause the seed to clog in the delivery tubes and to produce, in consequence, an irregular stand.

The remedy.

The practice of the "open furrow" method of seeding, however, has transformed the uncertainty of a fall-sown oat crop into a reasonable surety. It has been exploited in Georgia for some fifteen years, and although it made slow progress at first, now that its advantages are more fully realized it is being rapidly adopted by the public.

Under this system grain may be seeded as late as the last week in November with the assurance of a good stand and of the crop passing the winter uninjured. Throughout the cotton-belt the loss from the "winter-killing" of hand-sown fall oats ranges from one crop in two to one in three, equivalent to an annual average loss of at least 40 per cent. With the "open furrow" method, an annual average loss of 4 per cent would seem to be an excessive estimate. Moreover, the yield is relatively greater, while its additional cost is comparatively moderate.

Details of the "open furrow" method.

The details of the process are as follows:—The corn land of the previous year is well broken and harrowed, preferably in the first or second week in October. The implement at first used for

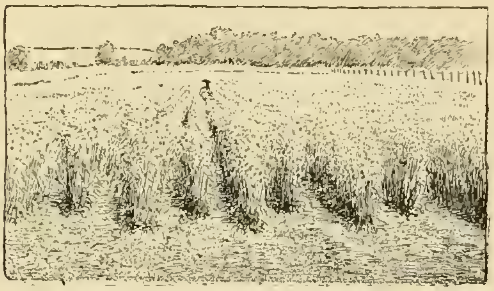

Fig. 722. "Open furrow" oat-growing.

planting was a light, one-horse combination seeder and fertilizer distributer, seeding and at the same time fertilizing only one row at a time. It was provided with a six-inch "shovel" plow-point to open the furrow, into which were drilled seed and fertilizer together from separate hoppers and in any desired quantity. The covering was effected by means of a wheel at the rear of the implement.

An "open furrow" machine, however, has recently been devised by which four rows at a time may be seeded in place of one if the oats are exceptionally well cleaned. The machine will doubtless be still further perfected and eventually supersede the original "single row" implement.

The seeds on germination thus occupy the bottom of an open furrow some four inches deep, where the roots find anchorage in permanent moisture. The sides of the furrow are miniature "bluffs" which serve as windbreaks for the tender grain against the cold northwest winds, while the recurring frosts of winter successively sift the soil into the furrow, almost filling it by harvest time. The rows are run preferably east and west, but their direction is not of serious moment, since the prevailing cold winds of the cotton-belt are from the northwest, and would therefore cross the rows diagonally, even when extending north and south.

By harvest time, which is usually the first week in June or the last week in May, the grain has tillered to such an extent that the rows are barely traceable across the field. Although planting one or even four rows at a time appears to be rather slow work, it is really more expeditious than it seems, while the assurance of securing thereby an otherwise fortuitous crop should more than reconcile the planter to the delay.

With the "open furrow" method liberal fertilization is advisable on planting and also an additional top-dressing of nitrate of soda in early spring.

Adaptation of the method.

Besides oats the process is equally applicable to other small grains, and permits wheat to be sown successfully in the South as late as the middle of December. It also opens up great possibilities for the Northwest along the margin of the belt where fall-sown wheat gives way to spring-sowing. It is possible that the limit of fall-sown wheat may be pushed northward some fifty or seventy-five miles, perhaps one hundred.

Literature.

R. J. Redding, Bulletins Nos. 44 and 72, Georgia Experiment Station and Press Bulletin No. 45 of the same station.

OIL-BEARING PLANTS. Figs. 723-726.

By *R. H. True.*

Under this heading are included two widely different classes of plant products, which will demand separate treatment. The oils of one class are light, readily volatilized, usually marked by a more or less strongly developed odor, and taste frequently pleasant, and are obtained from the plant by the process of distillation with water vapors. The oils of the other class are heavy, thickly fluid at usual temperatures, relatively lacking in odor and taste, and are usually obtained by the forcing out of the oil under heavy pressure. Since these two classes of products are obtained from different sources by very different processes, and are made use of in different ways, it will be expedient to discuss them separately.

Plants Producing Volatile Oils

Botanical source.

The *Labiatæ* (the mint family), the *Umbelliferæ* (the parsnip family), the *Rosaceæ* (the rose family), and the *Compositæ* (the sunflower family), are all rich in volatile oils and furnish a considerable part of the world's supply. This class of products is also widely developed throughout the flower-producing section of the vegetable kingdom, and is found in the *Verbenaceæ* (the verbena family), in many of the evergreen trees, in the family which includes the orange and the lemon (*Rutaceæ*), and also in that which includes the wintergreen (*Ericaceæ*).

Place of production in the plant.

Not only are volatile oils produced by many widely separated members of the vegetable kingdom, but they are contained in the most various parts of the plant. (1) In many cases they are developed in hair-like structures which grow on the leaves and stems of plants, chiefly herbaceous, and give to the herbage of these plants the odor characteristic of them. Peppermint, spearmint, pennyroyal, sage, catnip, lavender and marjoram belong to this class. (2) In many cases the oils are formed in internal glands or secreting structures and there developed and retained. Such accumulation is seen in the fruits (sometimes called seeds) of the *Umbelliferæ*, e. g., anise, caraway, coriander, fennel; in the fruit, rind and the foliage of the orange and lemon trees; in the leaves, bark and wood of the sassafras; in the needles, bark and wood of many of the cone-bearing trees, as the fir balsam, long-leaved pine, white cedar and juniper. (3) In still other cases, the volatile product does not exist in the plant, but is formed by chemical changes following preparatory treatment of the parts involved. In the case of those products in which the development of prussic acid is a characteristic result, the leaves or fruits yielding it must be crushed and thoroughly moistened so as to bring together those substances which by their action on each other cause the development of this acid. Usually a substance belonging to the group of bodies known as enzymes acts on a substance belonging to the group of bodies known as glucosides. When water is present, this reaction results in the formation of prussic acid and also of other less important substances.

This condition of things is encountered in obtaining the so-called oil of bitter almonds, whose chief sources are the kernels of almonds and apricots. Peach kernels contain similar substances and yield this oil also. The same general condition exists also in the green leaves and the bark of the black cherry, which yields this poisonous principle only after such a chemical change takes place. Similar in its general features is the situation in mustard seeds and horseradish, which owe their pungency to a volatile oil that is produced by a chemical change taking place between substances present in the seeds and root respectively. The volatile oil of wintergreen illustrates a similar method of formation.

Thus it is clear that for the production of volatile oils many different parts of plants are used, and also that these are treated in very different ways.

Method of obtaining volatile oils.

The process of obtaining volatile oils consists especially in exposing the oil-containing herbage, seed, wood, or bark to the action of a current of live steam which is then condensed, yielding water and the oil. The most important parts of a distilling apparatus are the following: (1) The boiler which yields the live steam; (2) the distilling chamber in which the substance to be distilled is packed and exposed to the live steam, which is usually admitted at the bottom; (3) the condenser in which the pipes carrying the live steam laden with the vapors of the volatile oil are brought from an outlet near the top of the distilling chamber into an artificially cooled series of tubes from which the condensed steam and oil flow out into some proper receptacle. The oil, usually somewhat impure, floats generally as a superficial layer on the water, from whence it is skimmed or otherwise drawn off for storage or purification. [Fig. 1391, Cyclopedia of American Horticulture, shows a mint still in section; and there is a discussion of peppermints and spearmint, and a botanical account of the cultivated species of Mentha.]

Volatile oil production in the United States.

At the present time the growing and distillation of volatile oil-producing plants are practiced to a limited extent in several parts of the country. The most conspicuous example is peppermint, which is grown in southern and central Michigan, northern Indiana and in Wayne county, New York. Michigan is at present probably the most important peppermint oil region of the world. Japan produces a large quantity of an oil called commercially peppermint oil. England and Germany are smaller producers. Wormwood oil, formerly grown chiefly in France and other parts of Europe, is now grown largely in Michigan, Wisconsin and Nebraska, the United States furnishing a very considerable part of the world's product. Spearmint oil is also produced in small quantity. Spearmint supplies material for mint julep.

Among the volatile oils produced in the United States, some are obtained from wild plants which are collected in the fields and forests for distillation. Sassafras oil is distilled at scattered points in Pennsylvania, Virginia and other parts of the country occupied by the sassafras tree, even as far west as Missouri. Wintergreen oil is distilled in small quantities in Michigan, Connecticut and other regions where the wintergreen plant and the sweet birch (which yields the oil on distillation of the bark) are found abundantly. Perhaps the most important single volatile oil is distilled from the resinous substances which exude from the wounded trunks of the turpentine-yielding pines. The resinous exudate on distillation yields the oil of turpentine of commerce. On the Pacific coast there is a sparing distillation of the leaves of the eucalyptus trees grown so frequently in that region. The kernels of California bitter almonds, and to a much larger extent the kernels of apricots, are also a commercial source of the so-called oil of bitter almonds.

Volatile oil importation.

In addition to the above home production, this country imports volatile oils and products derived from them to no small extent. In the following tables, the report of the National Customs authorities for the year ended June 30, 1905, gives the sorts, values, and quantities of some of the most important kinds of products imported during the period indicated:

IMPORTATION OF VOLATILE OILS INTO THE UNITED STATES DURING THE YEAR ENDED JUNE 30, 1905.

Kind	Quantity	Value
Bitter almonds	13,785 pounds	$10,089 00
Anise seed	39,112 pounds	40,949 00
Bergamot	64,549 pounds	132,114 00
Cajeput	22,082 pounds	8,309 00
Caraway	28,269 pounds	19,464 00
Cassia and cinnamon .	46,473 pounds	31,080 00
Camomile	56 pounds	172 00
Citronella	649,113 pounds	159,564 00
Fennel	8,517 pounds	2,901 00
Jasmine	817 pounds	6,797 00
Juniper	9,989 pounds	5,511 00
Lavender and spike . .	129,832 pounds	175,383 00
Lemon	310,056 pounds	175,852 00
Limes	5,415 pounds	3,060 00
Orange flowers	4,995 pounds	28,957 00
Orange	92,077 pounds	143,555 00
Origanum	6,495 pounds	1,404 00
Peppermint	16,184 pounds	18,733 00
Rosemary	33,050 pounds	16,398 00
Roses, Attar of . . .	88,337 ounces	296,918 00
Thyme	54,607 pounds	39,839 00
Valerian	13 pounds	26 00
All other essential oils and combinations . .	. . . . . .	420,858 00
Total	. . . . . .	$1,737,933 00

IMPORTATION OF SEEDS FROM WHICH VOLATILE OILS ARE DISTILLED, DURING THE FISCAL YEAR ENDED JUNE 30, 1905.

Kind	Quantity	Value
Anise	330,494 pounds	$16,593 00
Caraway	2,275,158 pounds	100,501 00
Coriander	1,037,866 pounds	47,861 00
Fennel	125,858 pounds	5,308 12
Total	3,769,376 pounds	$170,263 12

Uses of volatile oils.

Volatile oils meet with a wide use in the making of perfumery, for which their pleasing odor and high degree of volatility render them especially valuable. They are used not only mixed in proportions designed to produce a given fragrance in the form of solutions seen in the usual commercial perfumeries, but they find their way into many other preparations in which pleasing odor is desired. Soaps alone make a striking illustration. As flavoring agents they play an important part in domestic economy. The "essences" of the kitchen, bakery and confectionary factory are in large part preparations of such volatile oils as give the desired flavors to cakes, ice creams and candies. They are also used in various beverages, liquors and cordials. The French beverage, absinthe, is distinguished by the presence in it of oil of wormwood. These oils and their products are also used in the manufacture of remedies. Menthol, a crystalline substance obtained from peppermint oil by subjecting it to a low temperature, occurs in many preparations because of its antiseptic properties, and in the form of cones or pencils for use externally in headaches, neuralgia and the like. Eucalyptol, obtained from eucalyptus oil, and thymol, obtained chiefly from the oil of thyme, are likewise highly valued antiseptics and enter into many washes, sprays and other medicinal preparations. Some oils of the class here concerned are employed almost solely for medicinal purposes, such as oil of American wormseed. Others have a limited use in various ways in the arts and sciences, e. g., oil of red cedar wood and of white cedar in microscopic work.

Anise. [See *Medicinal, Condimental and Aromatic Plants*, page 458.]

Bitter Almonds (*Prunus Amygdalus*, var. *amara*, DC.). *Rosaceæ.*

The so-called oil of bitter almonds is obtained from the kernel of bitter almonds, apricots and peaches. The kernels are coarsely ground, submitted to great hydraulic pressure to remove the fatty oils present, and the remaining cake after finer grinding is macerated in several times its volume of water and left for twelve hours. The volatile oil does not exist ready formed in the seed, but is developed by the chemical action of bodies present in the kernel. Amygdalin, a glucoside present, when acted on by emulsin, a splitting ferment also present in the kernel, splits up, in the presence of water, into grape-sugar, prussic acid and benzalde-

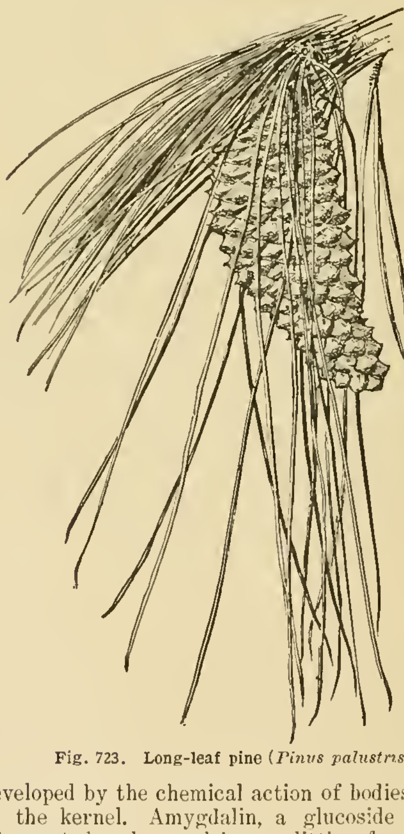

Fig. 723. Long-leaf pine (*Pinus palustris*).

OIL-BEARING PLANTS

hyde. After a sufficient time has elapsed for the oil to form, distillation occurs. California is the chief American source of this very volatile and poisonous oil.

Caraway. [See *Medicinal, Condimental and Aromatic Plants*, page 460.]

Long-leaf Pine (*Pinus palustris*, Mill.). *Coniferæ.* Fig. 723; also Fig. 55, Vol. I.

American turpentine oil consists of the more volatile constituents of the resinous exudate obtained by wounding the trunk of the various species of pine, chiefly the long-leaf pine. The outer living wood is chopped away in such manner as to open a large area of young wood rich in turpentine. During the warm months this pitch exudes and runs down into a pot connected by a spout to the tree or into a "box" cut in the trunk itself, from which it is removed every month or fortnight. The pitch is then distilled, with the result that the more volatile part, the oil of turpentine, is separated from a heavy residue, the resin. This volatile oil is further purified by rectification.

The southeastern states, from North Carolina to Florida, are the chief source of American turpentine oil. Wilmington, N. C., is the chief commercial center for this and related pine products, such as resin and tar. The turpentine supply is threatened in the United States by the destruction of the forests. Synthetic substitutes have not been secured.

Spearmint (*Mentha viridis*, Linn., *M. spicata*, Linn.). *Labiatæ.* (Fig. 1392, Cyclopedia of American Horticulture.)

A low perennial herb (one to three feet high) propagated by numerous running rootstocks, with ascending or reclining, somewhat hairy, square-cornered, green stems, bearing slightly hairy, aromatic, sessile, veiny, oblong leaves, and the dense, narrow, terminal leafless spike of small lavender-colored flowers.

This European plant has been widely distributed over the eastern part of the United States, where it occurs wild in damp fields and waste places. It has been grown in Europe for centuries on a small scale as a garden plant. It has been cultivated on a commercial scale at Mitcham, England, but chiefly in the United States in Michigan and in Lyons county, New York, where its culture is practiced with that of peppermint [see *Peppermint*, page 463]. The methods of cultivation and distillation are similar to those employed in the case of peppermint. The yield is about twenty pounds of oil per acre. The total American yearly output seems not to exceed about 12,000 pounds, which amount makes the American product the determining factor in the world's market. An oil grouped with spearmint oil commercially was formerly produced on a small scale in Thuringia, Germany, but it has ceased to be a factor in the market.

The oil is used as a flavoring agent in confectionery and cosmetics and to a less extent in medicine. Both the dried herb and the oil are official in the U. S. Pharmacopœia. The dried herb meets with a limited demand from crude drug dealers.

Sweet Birch (*Betula lenta*, Linn.). *Betulaceæ.* Fig. 724.

A tree of medium size, reaching a height of seventy-five feet, having a close dark brown bark,

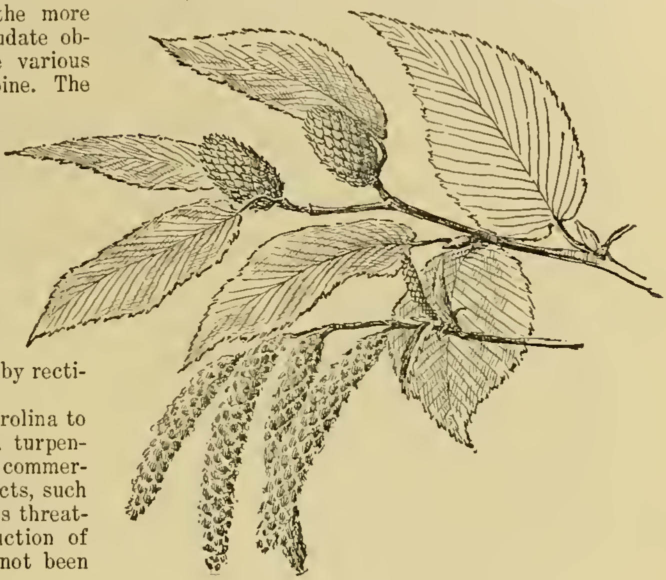

Fig. 724. Sweet birch (*Betula lenta*).

the inner lining of which is sweet and aromatic when chewed. The leaves are cordate, ovate, acuminate at the apex, with finely serrated margins. The flowers are in long, slender catkins. A native tree of rich forests of eastern North America.

The bark of the sweet birch (cherry birch or black birch) yields on maceration and distillation a volatile oil which is frequently known commercially as oil of wintergreen and has practically a like composition. The birch bark from young trunks and branches is removed usually in late summer, cut up into small pieces and macerated for twelve hours with enough water thoroughly to moisten the bark, and distilled with steam. The characteristic substance of the oil is methylsalicylate, formed by the action of the ferment gaultherase (betulase) on the glucoside gaultherin. The yield is about .23 per cent. The oil of sweet birch and of wintergreen is used chiefly as a flavoring agent in candies and medicinal preparations.

Vetiver. *Andropogon squarrosus*, Linn. (*A. muricatus*, Retz. *Vetiveria zizanioides*, Nash.). *Gramineæ.* Vetivere, Cuscus, Khus-khus, Khuschus, Kuskus, Koosa.

Vetiver is a perennial tufted grass, native in rich moist soils in the coast region of India and in Bengal, and also on the plains of the Punjab and Northwest provinces. It is grown for its roots, the filaments of which are used for making scented mats, screens, fans, ornamental baskets and various fancy articles, and are tied in bundles, weighing about two ounces each, which are used for scenting drawers. The latter is the Louisiana utilization of the plants. From the roots (called khas or khas-khas) is distilled a fragrant oil used in perfumery. Vetiver is closely related to citronella (*Andropogon Nardus*), from the leaves of which citronella oil is distilled.

Vetiver has been introduced into southern Louisiana and has become naturalized there, but it has not yet been grown commercially to any extent. It seems to have been introduced here from the West Indies about seventy years ago. There are a few plants in every garden belonging to the native French population of the state. There is one large collection of plants at Shiloh, about sixty-four miles north of New Orleans, and another in St. Bernard parish.

Dr. Le Monnier, who has the garden at Shiloh, has some 700 plants in nine rows, six feet apart, each plant or tuft consisting of a compact mass about a foot and a half in diameter, giving rise to long stems which in September become jointed canes, one-half inch in diameter, and as much as eight feet high. In September or October he burns the plants, and digs up the roots which have then produced great numbers of small roots or filaments about one thirty-second of an inch in diameter and running one to two feet long. These are chopped off close to the central mass, which can then be replanted. The filaments are thoroughly washed in cold water, and, after being dried slowly in a room at a temperature of about 120 degrees, are ready for market.

The grass is propagated chiefly by transplanting the roots. When once established it forms dense, firmly rooted tufts, rather difficult to eradicate, but not spreading or increasing rapidly. It requires for its best development a rich moist soil of rather open texture. In Louisiana it is grown most economically on exceedingly sandy soil, the product from which shakes almost entirely clean.

The period during which vetiver is in active sale in Louisiana is from November to April, after which the stock is mostly exhausted. The wholesale dealers pay for it at forty to eighty cents per pound. The higher price obtains at the beginning of the season. The quantity of domestic product on the market is very small. Almost every constant user of it has one or more plants in her own garden. It has figured in a small way in the importations from France since a very early date. [See Watt, Dictionary of Economic Plants of India, and Dodge, Catalog of Useful Fiber Plants of the World.]

Wintergreen (*Gaultheria procumbens*, Linn.). *Ericaceæ.* Fig. 725.

A slender, creeping, almost woody perennial, with running stems near the surface of the ground and short erect branches, four to six inches high, bearing dark green, leathery, alternate leaves, three to six in number, and small, white, almost egg-shaped axillary flowers, which are followed by round bright berries. It is a native of damp woods in the cooler parts of eastern North America.

Wintergreen herb has been distilled on a small commercial scale for its volatile oil for nearly a century in New England, and for a less time in New York, Pennsylvania, Virginia and other mountainous states of the East, and as far west as Michigan,

Fig. 725. Spring or creeping wintergreen (*Gaultheria procumbens*).

where the plant has been abundant. It seems, however, never to have been cultivated for this purpose. It grows in woods from Canada to Georgia and westward to Michigan and Wisconsin. The leaves or herb are gathered in a fresh state, chopped up, and after moistening with water are left standing for about twenty-four hours to permit the development of the oil, as explained in the introductory paragraph on volatile oils (p. 495). It contains a glucoside, gaultherin, which, when acted on by the splitting ferment gaultherase in the presence of water, yields oil of wintergreen and grape-sugar. It is distilled with steam essentially as described in the general introduction. The usual yield is about .8 per cent.

Wormseed, American. [See *Medicinal, Condimental and Aromatic Plants*, page 466.]

Wormwood (*Artemisia Absinthium*, Linn.). *Compositæ.* (Fig. 2750, Cyclopedia of American Horticulture.)

A perennial-rooted woody herb, two to four feet high, having stout, branching, erect or somewhat decumbent stems; twice or thrice pinnately divided leaves with narrow lobes, pale, finely hairy-woolly, especially beneath; hemispherical flowers in panicles; fruit with hairy pappus. A common escape in waste places or along woodsides.

Wormwood and the oil derived from it by distillation have been known to European medicine for more than a century. It was introduced into the United States at an early date and has been cultivated both in Europe and America on a commercial scale. Formerly France was the chief producer, but in the last fifteen or twenty years the United States has held first rank as regards quantity distilled. The plant is grown chiefly in Michigan, New York, Nebraska and Wisconsin. Good ordinary farm land is chosen for wormwood, and when in good tilth in spring is planted to wormwood seed, usually in rows three feet or more apart for easy horse cultivation, the plants being thinned out in the row to a distance of eighteen inches to two feet apart. The plants grow rapidly and yield a considerable cutting the first year. By proper weeding a wormwood-field will last three to five years before it is plowed up and replanted. Some growers sow the seed broadcast in pasture land and harvest the wormwood, which is avoided by the stock. This secures manuring of the crop. The tops are cut for distillation in an advanced flowering stage and the distillation is carried out as in peppermint. The oil is dark greenish or bluish brown in color and of a heavy consistency. Wooden tubs that have been used in wormwood distillation are not fit for use in distilling other oils. The yield is about one-half per cent of the weight of the fresh herb. In Michigan, in 1902, 90 acres yielded 873 pounds of oil, an average of 9.7 pounds of oil per acre.

Wormwood is the active principle in the French drink absinthe. In the form of this beverage and as an oil it is capable in overdoses of producing serious results resembling epileptic convulsions. The oil distilled in America is in part exported.

Plants Producing Fatty Oils.

Many plants produce fatty oils in a very considerable quantity and store these, usually in seeds or fruits, as reserve food substance. They are used at the time of germination as a source of energy to support the young plant until it can maintain itself. These oils are bland, usually lacking in any very strong taste or odor when obtained in a pure condition, and lack the strong antiseptic properties which characterize the volatile oils. In their chemical relationships, they are closely allied to the common animal fats. In general they are all made up of a mixture containing the same principal substances occurring in differing proportions. In oils having a low melting point, as olive oil, the proportion of olein, the constituent having a low melting point, is large; in firmer oils this substance is present in smaller percentage, and the constituents having a higher melting point, such as stearin and palmitin, are present in large proportion. This is true in the case of most firm fats, such as cocoa butter, palm oil and the commoner animal fats. Thus some vegetable fats are fluid at ordinary temperatures while others are solid.

Botanical source.

Plants yielding fatty oils are widely distributed through the vegetable kingdom. Among those sorts produced on a considerable commercial scale in the United States, there are almost as many plant families represented as there are oils. A few examples will illustrate this: Cottonseed oil is obtained from the seed of the species of cotton, *Gossypium*, belonging to the mallow family, *Malvaceæ;* peanut oil from the seed of *Arachis hypogæa*, the peanut, a member of the pea family, *Leguminosæ;* corn oil from the seed of the common field corn, *Zea Mays*, of the *Gramineæ*, or grass family; linseed oil from the seed of *Linum usitatissimum*, the flax plant, of the flax family, *Linaceæ;* rape-seed oil from *Brassica Napus*, a member of the mustard family, *Cruciferæ*; and castor-oil from the seed of *Ricinus communis*, a member of the *Euphorbiaceæ*, the spurge family. [Refer to the special articles on these crops in other parts of the Cyclopedia for further information.]

Place of production in plant.

As indicated in the above examples, the fatty oils are found in seeds or fruits, where they are stored in great abundance as reserve food products for the use of the seedling during germination. However, they are located in different parts of these structures. For example, in the seeds of the castor-bean, peanut, flax and cotton, the oil is stored in the germ, especially in the cotyledons. The source of corn oil is found in the germ of the corn grain, not in the storage tissue making up the great bulk of the grain. In the olive, the oil is stored in the fleshy pulp, of which the fruit in large part consists, and not in the hard seed which it encloses, therefore, not in the germ, as in the other cases.

Method of obtaining fatty oils.

In order to obtain the oils from the seeds and fruits in which they occur, it is necessary to break open the cells in which they are stored and force them out. This is ordinarily accomplished by the application of high pressure. In some cases, when not harmful to the oil, a moderate degree of heat is employed, rendering the oil more thoroughly fluid, so that it will more readily run out. In some cases, the heat developed by the energy expended in securing a sufficiently high pressure is ample. When the oil is expensive, the oil residues remaining after pressure has been used are extracted by the use of solvents.

The residue left after the expression of the oil is completed may be utilized, in most cases, either as a stock-food, as in the case of cottonseed meal and linseed cake, or as a fertilizer, of which cottonseed meal is an example.

Commercial information and uses.

The production of plant oils of this class (the fatty oils) in the United States on any considerable commercial scale is limited to a very small number of kinds: cottonseed, linseed, peanut, corn, castor and olive oils. The magnitude of the production of these oils or of the stock from which they are derived is difficult to determine with any degree of accuracy.

Castor-oil (*Ricinus communis*, Linn.). *Euphorbiaceæ.*

The cultivation of the castor-oil plant is centered in Oklahoma, Kansas, Missouri and Illinois, in which states, according to the last United States Census, an annual crop of 100,000 to 150,000 bushels of seed is produced. The price is at present about one dollar per bushel. The importation of seeds for the year ended June 30, 1905, was 387,767.86 bushels. This plant is cultivated chiefly in Egypt, Turkey in Asia, India and China. The oil from this seed is obtained by expression, as above stated, after which it is clarified by boiling with water to free it from mucilaginous and other objectionable substances or by leaving it standing in the sunlight to settle. The cake remaining after the removal of the oil is powerfully poisonous, as are also the whole seeds.

Castor-oil is used in a number of ways. When cold pressed, it is used in medicine for its purgative properties; it is mixed with other substances to increase its mobility and used in making sticky fly-paper, according to report; it is valued in some circumstances as a lubricating oil because of its heaviness; it is excellent as a dressing for leather and is used somewhat in making transparent as well as common soaps. This oil, like that from cottonseed and peanuts, is semi-drying in character. [See *Castor-bean.*]

Colza (*Brassica campestris*, Linn.). *Rosaceæ.* [See, also, page 307, and *Rape.*]

Colza oil, strictly speaking, is obtained from the seed of *Brassica campestris*, the rutabaga, but the oil from this plant is probably not distinguished in commerce from that of *B. Napus* and *B. Rapa*, the different sorts of rape.

Colza is cultivated especially in France, Germany and Belgium, in part for the seed and the oil expressed from it. The seeds yield about 35 per cent of their dry weight of brownish yellow oil, which, although odorless when expressed, develops an unpleasant odor and taste on standing. The crude oil is used as a lubricant and in some regions for illuminating purposes, the refined oil being used, it is said, as an adulterant for olive and almond oils. The cake is a recognized stock-food. The importation of products listed as rape during the fiscal year ended July 1, 1905, was as follows: Rape seed, 3,029,948 pounds, valued at $78,344; rape-seed oil, 730,686 gallons, valued at $264,025. Neither rape nor colza is grown in the United States to any considerable extent as a source of oil, being used rather as green forage crops. The seeds of rape and colza, it is said, are used in bird-seed mixtures. [See page 307.]

Corn oil (*Zea Mays*, Linn.). *Gramineæ.*

Corn oil is obtained from the germ of the seed of corn. This part of the seed is practically free from starch, so that in the manufacture of glucose, in which the starchy structure only is of value, the germs are discarded. From this formerly refuse product, a useful oil is obtained in large quantities. The center of the corn oil industry is found in the upper Mississippi valley, where the glucose and starch industries are centered. This is practically an American product and is exported in considerable quantities to Europe, especially to Belgium. In 1905, out of a total exportation of 71,372 barrels, valued at $873,579, Belgium received 51,468 barrels. The "cake" remaining after the removal of the oil is also an article of export.

The oil belongs to the semi-drying oils and is used for the making of soap and as a lubricant. [See *Maize.*]

Cottonseed. (*Gossypium species.*) *Malvaceæ.*

The cottonseed crop, of course, is confined to the southern states. The states bordering on the Gulf as well as the Carolinas and Arkansas are important cotton producers. The crushing and storage of the seed is practiced not only in cities within the cotton-belt but also in centers most readily accessible, such as Cincinnati, Louisville and St. Louis, as well as in the larger commercial centers. The domestic crop of cottonseed may be stated as averaging 5,000,000 tons, of which about 60 per cent is crushed for oil. The average recent oil yield has been about 110,000,000 to 115,000,000 gallons per year.

Crude cottonseed oil is purified by heating with caustic soda and by further treatment with fuller's earth. The clear oil when cooled to 12° below zero, Centigrade, separates into a part used in making oleomargarine, and a clear oil which is used in large quantities as a salad oil and for mixing with olive oil. The impure residue removed by treatment with caustic soda is used by soap-makers. Cottonseed oil occurs very largely in various articles used in cooking as substitutes for lard. [See *Cotton.*]

In both cottonseed- and flaxseed-oil production, the United States ranks as an exporter except under special conditions, when the demand for flax seed may result in importation from Argentina and from British India.

In the preparation of these oils, the residual "cake" is a valuable by-product, which is also an article of export as well as of home consumption.

Flax (*Linum usitatissimum*, Linn.). *Linaceæ.*

In the case of flax seed the crop of the country seems to lie between 20,000,000 and 28,000,000 bushels per annum, grown in large part in Minnesota, North and South Dakota. There is a minor production in Iowa, Kansas, Missouri and Idaho. The important centers of the trade are at Chicago, Minneapolis and Duluth, where store-houses and crushers provide accommodations for the shipper or for the manufacturer of linseed oil. The chief use of linseed oil is found in the making of paints. The desired pigments, finely ground, are mixed with the oil and applied to the surface to be covered. The oil is quickly acted on by the atmosphere in such a way as to harden it, and is classed for this reason as a drying oil. Linseed oil is put on the market as raw oil or as boiled oil. The cake left after the expression of the oil is a valuable stock-feed, and, as such, forms an important article of commerce. [See *Flax.*]

Niger (*Guizotia oleifera*, Cass.). *Compositæ.* Fig. 726.

Niger seed is derived from an erect annual plant reaching a height of about three feet. It has opposite, lanceolate-oblong, serrated leaves, numerous bright yellow flowers one to one and one-half inches in diameter, borne on elongated stems. The seed is formed by the inconspicuous disc flowers.

This plant, native of Abyssinia, is cultivated in Mysore, India, and to a lesser degree in Germany and the West Indies, principally for the pale yellow fatty oil expressed from the seed. The yield is about 35 to 40 per cent. The oil is used for illumination, and in making soap. The higher grades are also used for food purposes. It has a chracteristic pleasant aromatic odor. The seed is used also in bird-seed mixtures. It reaches the European market by way of London and Hamburg, but is not imported in the United States. Its experimental culture here has been recommended.

Fig. 726. Niger (*Guizotia oleifera*).

Olive oil (*Olea Europæa*, Linn.). *Oleaceæ.*

Olive-growing in the United States is practically confined to California and Arizona. The total crop in 1899, according to the United States Census, was about 5,000,000 pounds. The fruit is in part used for pickling and in part for the production of olive oil. The oil is obtained by expressing.

The demand for olive oil is large and is in part supplied from foreign sources, notably Italy and France. In 1904, the total importation was about 1,700,000 gallons. This oil does not readily become rancid. The better grades of the oil are used as salad oil, the poorer for soap-making and in processes connected with the manufacture of tobacco.

Peanut oil (*Arachis hypogæa*, Linn.). *Leguminosæ.*

Peanut-culture in the United States is found chiefly in the South, Virginia, North Carolina, Georgia, Alabama, Florida and Tennessee being the largest producers in the order named. The total crop for the United States in 1899 was about 12,000,000 bushels, valued at sixty-one cents per bushel. In 1904, the United States imported peanuts, shelled and unshelled, to a value of about $148,000. The peanut crop has increased during the last decade to a remarkable degree, due doubtless to the increased use. Aside from its use in a whole roasted condition, the fruit is the source of an oil which is expressed from it.

Peanut oil when expressed cold is pale in color and may be used as a salad oil, although it becomes rancid more readily than olive oil. It is used as an adulterant for olive oil, also in making butterine. The lower grades are used in soap-making. Sardines are frequently preserved in peanut oil. The "cake" remaining after expression of the oil is used sometimes as a stock-feed. [See *Peanut.*]

Sesame (*Sesamum Indicum*, Linn.). *Pedaliaceæ.*

Sesame (bene or til) is an annual herbaceous plant growing two and one-half to seven feet tall. The leaves are variable, three to five inches long, oblong or lanceolate, the lower often three-lobed or three-parted; the corolla is pale rose or white, one inch long, and tubular. The pods are about three inches long.

Bene is planted in April or May, and is ready to harvest about six months later. It is sometimes planted between rows of cotton, and occasionally hoed to keep out weeds. It begins to flower when twelve inches high. As the stems elongate, new flowers appear, and we eventually find ripe capsules below, green ones in the middle, and flowers at the top. The flower-capsules burst and the seed shatters before the others are ripe. The seed may be gathered by shaking into a sheet when the pods are dry.

The seeds are valued for their oil. The seeds yield about half their weight of oil-of-sesame, which is odorless and does not easily become rancid. The oil and seed are used in cooking and in medicine, in the making of confections, soap, and as an adulterant of olive oil.

Sesame has been known from ancient times in India, Greece and Egypt, and is much more used in these countries and in Europe than in this country. It is said to have been brought to South Carolina by the early slaves. It now runs wild in parts of the extreme South, and is cultivated in small patches, chiefly by the negroes.

During the fiscal year ended June 30, 1905, the importation of oil-of-sesame amounted to 1,394,-975 pounds, valued at $91,314. Since the seeds are not itemized in the customs returns, the amount of seed imported is not ascertainable.

Literature.

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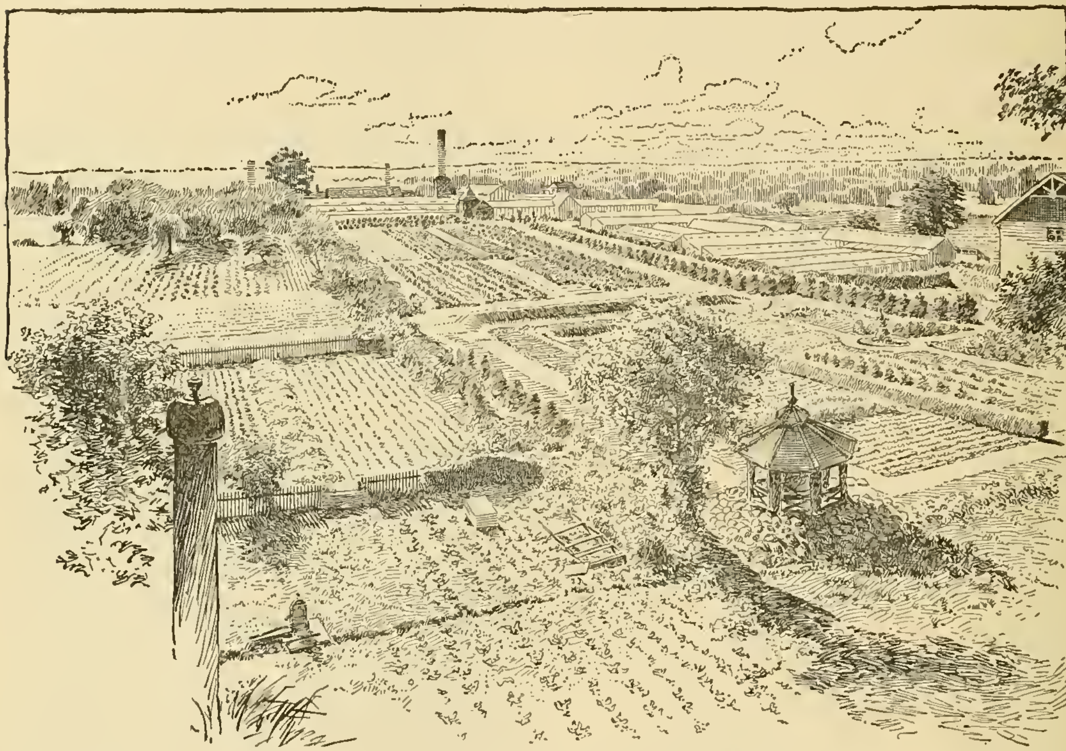

Fig. 727. A flower and plant farm. Rose Hill, New Rochelle, N. Y.

ORNAMENTALS.

While some farmers are growing crops to provide their fellows with food, clothing and shelter, others are reciprocating by growing plants to ornament the home and public places. The growth of the desire for beautiful plants has been very marked in the last half-century. Within that time commercial floriculture has arisen, together with a large part of nursery-farming. [See *Nurseries.*] The growing of ornamental plants, however, is a wider business than floriculture. The business of floriculture is included within it. Floriculture is properly the growing of flowers, including, of course, the rearing of the plants that are to produce the flowers. By custom, also, the term is applied to the raising of many or most herbaceous ornamental plants and all greenhouse ornamentals, whether grown for foliage or habit. Unfortunately, there is no generic term for the growing of all ornamental plants, covering such phases as floriculture and the rearing of trees and shrubs for adornment and for shade.

The extension of floriculture and allied occupations is due, of course, to the rise in taste; but the rise of taste has been promoted and hastened by the increasing effectiveness of the plant-growing business. The business is becoming more effective because a much greater variety of plants is increasingly available, because of the perfecting of the glasshouse, of more expeditious and satisfactory means of transportation and handling, and because the increased demand has made it possible to make a more effective business organization.

The business of floriculture may derive its revenue from (*a*) the selling of cut-flowers (as carnations, roses and violets); (*b*) the selling of pot-plants to the user (as begonias, palms and many greenhouse and window-garden plants); (*c*) the selling of nursery products, more or less wholesale (as small plants of carnations, chrysanthemums, cannas); (*d*) the selling of seeds or bulbs. Flower-farming of one kind or another has now become one of the important agricultural industries, comprising a total in the United States at the last census of 6,159 commercial farms or establishments, with 42,662 acres, a total property valuation of $52,462,419, a total value of products of $18,505,881, and an average value of $431.83 per acre of products not fed to live-stock. Aside from these establishments are many others, as nurseries and truck-farms, that grow and sell flowers as a secondary business. There are numberless private places giving much attention to ornamentals. The glass surface reported by florists (about one-third greater than the land surface on which the structures stand) was 68,030,666 square feet, in 6,070 establishments. More than half this glass was in the north Atlantic states, New York leading with 10,690,777 square feet. and Pennsylvania second with 8,811,711 square feet.

Floriculture is a concentrated and high-class business, notwithstanding the fact that many establishments are shiftless and profitless. The average size of flower- and plant-farms in the census year was less than seven acres. On these farms, the value of land and its improvements was some $28,000,000, while the value of the buildings was above $22,500,000. The implements were relatively low, being only $1,366,887 worth. The amount expended for labor was more than $4,000,000, or about one-seventh the value of the land and between one-fourth and one-fifth the value of the salable product. The labor cost was about $100 per acre.

The risks in floriculture are great because of the perishable nature of the products, the changes in taste, the expensiveness and unsubstantial character of buildings, and the cost of heat and other maintenance. The difference between the wholesale and retail prices is very marked. The business is now largely broken up into specialties, one establishment devoting itself mostly to carnations, another to violets or roses, and the like. Although the number of species of florists' plants runs into thousands, the numbers that are commercially important are relatively few, and, for these specialties, societies of growers are usually organized. The cut-flower industry has made great headway in recent years, with roses, carnations and violets as the leading crops. In the growing of all these specialties, great perfection of manual and mechanical skill has been developed. This skill is constantly becoming more rational and less rule-of-thumb. The workmanship is passing out of the hands of the old-time apprenticed gardener who was trained to grow a great variety of plants for personal or household use. The glasshouses have come to cover acres of land rather than square feet, and they are simple, direct and completely utilizable. The notions of greenhouse building that were current twenty-five years ago are now largely outgrown for commercial establishments (see Figs. 179 to 188). The utilizing of cool storage for some of the products has had great effect. The development of the city flower store, the delivery-wagon system, and the wholesale trade have changed the whole aspect of the business. The breeding of plants in one way and another has long been an important factor in flower-growing. The greater number of authentic historic plant hybrids are between greenhouse and other garden plants. The underlying problems of plant nutrition and of soil fertility and efficiency are yet little studied, however, in their practical applications to the florists' business. The florist makes his soil. He depends little on concentrated fertilizers, but greatly on manure, rotted sod and other humous ameliorators.

The organization phases of floriculture have little relation to the farm management and crop management problems that are the proper theme of this Cyclopedia; the floricultural subjects and plants are discussed in many phases in the Cyclopedia of American Horticulture; therefore the subject may not be further discussed here. The best literature will be found in the trade papers, and the reports of national societies. There are recent good books devoted to special plants, but none devoted to the whole subject of commercial floriculture; in fact, the subject is scarcely homogeneous enough for conspectic treatment. The business of growing ornamental plants is increasing rapidly, and it will continue to increase because the desire for beautiful objects rises with the accumulation of means and the progress of civilization. Every observant person will have noticed that every year greater attention is paid to the care and adornment of home grounds. This practice is beginning to extend far into the open country.

PAPER-MAKING PLANTS. Figs. 728–731.

By *F. P. Veitch.*

The farmer is not called on to grow crops for the purpose of supplying the raw materials used for making paper. The cutting of timber and the sale of straw for this purpose have been incidental to other farm work, filling in the gaps between more profitable work. But conditions are changing: the wild growths and the wastes of other industries heretofore used are supplied at constantly increasing cost, and the time is now come when the farm may be called on to contribute more largely to these supplies, both with its waste materials and with its crops.

Paper can be made from any fibrous vegetable material. The materials commonly used, however, are not numerous, and are obtained from flax, cotton, hemp, esparto, manila, jute, woods, straws of cereals, Sunn hemp, rhea, China grass or ramie, New Zealand hemp, coconut fiber, adansonia, agave, and bark of the paper mulberry. Other materials which are used to a certain extent, or for various reasons may be considered promising, are bamboo, sugar-cane and corn-stalks. There is also a long list of cultivated and wild grasses, rushes of all kinds, reeds, banana fiber, barks of trees, common broom and heather, tobacco- and cotton-stalks, beet-pulp waste, peat, and many miscellaneous materials from which small quantities of paper have been made experimentally.

The woods most used are spruce, poplar, hemlock, cottonwood, balsam and pine. A number of others are now being employed in the manufacture of paper, possibly not in sufficient quantity to require individual mention, but enough to indicate that, as the necessity arises, many other woods will also be used for this purpose. Indeed, there is every reason to suppose that, with proper modifications in methods of handling and treating, most of the woods will make paper. Fig. 728 shows a pulp mill with its accompanying log pond.

Of the standard paper-making plants, cotton, flax, hemp, straws and woods are the only ones produced commercially in the United States. Sugar-cane, corn-stalks, cotton- and tobacco-stalks are produced in large quantities, and vigorous efforts are being made to produce paper from them on a commercial scale.

The best paper-making materials — those that make paper of the highest quality and greatest value — are wastes, derived chiefly from the textile industries, which from their form or condition are of little value for any other purpose. Cotton, flax, hemp, jute and ramie fiber come to the paper-maker in the form of rags or as waste, and as old bagging, canvas, rope cordage and oakum. The coarse fiber from the end of jute stalks is cut off, baled and sold to the paper-maker as "jute butts." Waste paper, new and old, is an important material, which is used in making all grades of paper. Wood, esparto and bamboo are the chief materials now used which are not the wastes of other industries.

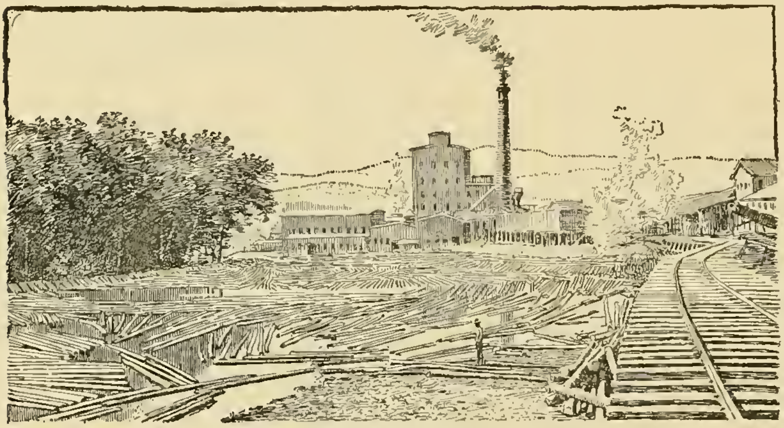

Fig. 728. Pulp mill and log pond.

All plants are made up of certain definite chemical constituents, among which are fats, tannins, lignin, pectose, coloring matters, sugar, starch and cellulose, and, when treated with certain chemicals, according to established methods, a more or less pure cellulose is obtained; and it is on the amount, fibrous nature, softness and pliability of this cellulose that the paper-making value of the plant chiefly depends.

Classification of materials.

With regard to the quality and value of the paper produced, the chief materials may be classified in four general groups: (1) Cellulose from cotton, flax, hemp and ramie; (2) cellulose from jute, manila and chemical wood; (3) cellulose from esparto and straws; (4) ground wood. From the consideration of the nature and the percentage of cellulose in the materials they are classified as, (*a*) simple cellulose: cotton, containing 91 per cent of cellulose; (*b*) pecto-cellulose: flax, cellulose 82 per cent; hemp, cellulose 77 per cent; ramie, cellulose 76 per cent; Sunn hemp, cellulose 80 per cent; manila, cellulose 64 per cent; bamboo, cellulose 50 per cent; sugar-cane, cellulose 50 per cent; straw, cellulose 46 per cent; esparto, cellulose 48 per cent; adansonia, cellulose 49 per cent; (*c*) ligno-cellulose: New Zealand hemp, cellulose 86 per cent; jute, cellulose 64 per cent; pine, cellulose 57 per cent; poplar, cellulose 53 per cent.

Classification of papers.

With regard to the uses to which they are put, papers are divided into several classes:

(1) Writing paper, embracing what are known as bond, ledger, record, linen, bank note, ordinary writing and envelope papers. These are thoroughly sized papers, the best of which are made from rags, hemp and ramie fiber, while the poorer grades contain also a varying amount of wood pulp.

(2) Printing paper, embracing book paper and newspaper. The best grades of the former are made from rags, while the poorer grades contain esparto, straw and wood pulp. Newspaper is almost universally made from ground wood pulp which has not been subjected to any chemical treatment, with a small percentage of sulfite pulp. Some newspapers also contain straw.

(3) Wrapping papers, embracing also paper bags and heavy envelopes. The best grades of these are made from jute, sisal and common rags; the poorer grades may be made in part or entirely from chemical wood pulp, straw, or ground wood. A particularly strong paper, known as "kraf brown," standing between manila and jute papers and wrapping paper made from regular chemical wood pulp, is now made by under-cooking wood by the sulfate process and subsequently grinding the fiber in a special mill.

(4) Blotting and tissue paper. The best grades of the former are loosely made and free from loading; poorer grades contain chemical wood pulp and large quantities of clay. They are not sized. Tissue papers are very thin and should be made from strong fiber, such as hemp and cotton.

(5) Cardboard and pasteboard are usually made of low-grade materials. Strawboard is manufactured from unbleached and imperfectly washed straw. Parchment paper is made of long-fibered material by dipping the finished sheet in sulfuric acid, washing with water, then with ammonia, and finally with water.

Extent of the paper industry.

The quantity, kind, and value of the raw materials and the paper made therefrom in the United

PAPER PLANTS

States, in 1905, are given in the following table, from the report of the Bureau of the Census:

PAPER AND WOOD PULP.

Materials used, by kind, quantity and cost; products, by kind, quantity and value; equipment.

Materials used, total cost	$111,251,478
Wood:	
Domestic—	
Cords	2,473,094
Cost	$15,953,805
Canadian—	
Cords	577,623
Cost	$4,847,066
Rags, including cotton and flax waste and sweepings:	
Tons	294,552
Cost	$8,864,607
Old, or waste paper:	
Tons	588,543
Cost	$7,430,335
Manila stock, including jute, bagging, rope, waste, threads, etc.:	
Tons	107,029
Cost	$2,502,332
Straw:	
Tons	304,585
Cost	$1,502,886
Ground wood pulp, purchased:	
Tons	317,286
Cost	$5,754,259
Soda wood fiber, purchased:	
Tons	120,978
Cost	$5,047,105
Sulfite wood fiber, purchased:	
Tons	433,160
Cost	$16,567,122
Other chemical fiber, purchased:	
Tons	6,278
Cost	$264,678
All other stock	$1,963,066
Chemicals and colors	$8,365,305
Sizing:	
Tons	52,171
Cost	$1,838,035
Clay:	
Tons	201,218
Cost	$2,096,570
All other materials	$28,254,307
Products, total value	$188,715,189
Newspaper:	
Tons	912,822
Value	$35,906,460
Book paper:	
Tons	515,547
Value	$37,403,501
Fine paper:	
Tons	146,832
Value	$22,249,170
Wrapping paper:	
Tons	644,291
Value	$30,435,592
Boards:	
Tons	520,651
Value	$16,959,557
Other paper:	
Tons	366,553
Value	$20,692,140
Ground wood pulp:	
Made for own use, tons	695,576
Made to sell as such, tons	273,400
Value	$4,323,495
Soda fiber:	
Made for own use, tons	66,404
Made to sell as such, tons	130,366
Value	$5,159,615
Sulfite fiber:	
Made for own use, tons	379,082
Made to sell as such, tons	376,940
Value	$13,661,464
All other products	$1,924,195
Equipment:	
Paper machines:	
Fourdrinier, number	757
Cylinder, number	612
Digestors, number	547
Grinders, number	1,357

Paper-making materials of the future.

Inspection of the above table shows that by far the largest quantity of paper, more than half in fact, is made from wood. This enormous demand for 3,000,000 cords per year, when added to the quantities otherwise used, is rapidly decreasing the visible supply of the better-known paper-making woods, the effect of which is already being felt in some localities. Greater difficulty in securing and increasing cost of spruce and poplar suitable for paper-making may be expected. It is highly probable, however, that modern agriculture will be able to meet the demand for suitable substitutes for spruce and poplar; indeed, there is every reason to think that very many other woods are also suitable for paper-making, and with decreasing supplies of the better-known kinds, these will be used more and more. Such use has already begun, as is shown by the very large consumption of hemlock, pine, balsam and cottonwood, and by the fact that yellow pine and chestnut are now being developed as paper-making materials in the South. The high yield of paper obtained from wood, together with the ease with which it is prepared for treatment, its freedom from dirt, the large quantity that can be got into the digester for treatment, have contributed to make wood the cheapest paper-making material. For all but the most exacting purposes, it makes a suitable paper at a minimum cost. Any successfully competing material, therefore, must compare favorably with wood in the final cost of the finished paper and in the quality of the paper, its freedom from dirt, its appearance, strength, durability, and resistance to wear. At present, the price of pulp wood averages about six dollars per cord, and one cord makes approximately 1,300 pounds of good, clean, white paper. Six dollars' worth of any substitute, therefore, must make 1,300 pounds of an equally good paper. A number of factors help to make the cost of paper from other material greater than from wood. Cereal straws, wild grasses, corn-stalks, bagasse and cotton-stalks must be carefully freed from the dirt which they contain, while the high percentage of silica which the straws and wild grasses contain helps to make their chemical treatment somewhat more costly than that of wood. It is doubtful, therefore, whether these materials can yet be delivered at the mills and treated as cheaply as can wood.

Again, a property which discourages the use of sugar-cane, bagasse, corn-stalks and materials of like nature, is that the cellulose which they contain is present in two or more forms having widely different physical properties, and these forms do not behave alike when treated with paper-making chemicals. Thus, the pith, fibrovascular bundles and rind (the latter consisting of highly lignified fiber) of bagasse will be attacked in the order given by chemical treatment, and a treatment sufficient

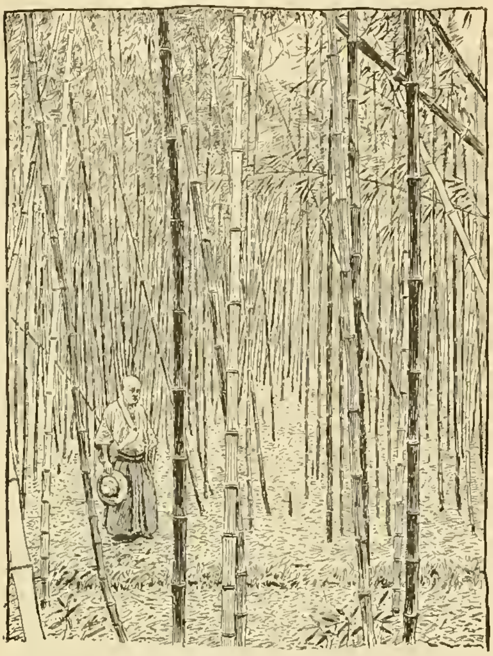

Fig. 729. Paper bamboo. Japan.

to soften the rind is rather too severe for the fibrovascular bundles, and entirely too severe for the pith. Such treatment, therefore, results in low yields, and the resulting pulp is not homogeneous, consisting of long, coarse fibers and of the short pith cells, the latter of which impart parchment-like and objectionable characteristics to the paper.

A material which is suitable for making papers of all grades is the fiber of flax grown for seed. The straw contains 20 to 25 per cent of flax fiber suitable for making the strongest and best paper. Here, again, there are three forms of cellulose present, and it is difficult to separate cheaply the wood of the straw from the true bast fibers. Difficulty, too, has been encountered in removing the seed left in the straw, the oil from which, if it is not removed, appears in the finished paper, giving it a greasy, spotty appearance and spoiling it for any but common papers.

Looking to the time when the cost of wood will encourage a larger use of other raw materials, but little consideration need be given to materials suitable for common papers, such as strawboard, box and cardboard, common wrapping paper, and the like, as it is not probable that the supply of straw, bagasse, corn-stalks, and other low-grade material which, under these conditions will be available, will be reduced in the near future. For the better papers, such as newspapers, strong wrapping, book, writing and record papers, we may expect the demand to be met more largely than at present, under the stimulus of increased prices, by a larger collection of rags, scutching and spinning waste of the textile industries, old rope, paper trimmings and old papers; utilization of other kinds of wood and of the waste woods of other wood-using industries; recovery of the fiber now wasted in flax-straw, of which the product of about three million acres is annually wasted in this country; substitution of the cereal straws, bagasse, corn-stalks, bamboo and many other materials; and, finally, when it becomes necessary, the production of a material primarily for the making of paper.

DESCRIPTIVE NOTES

Adansonia (*Adansonia digitata*). *Malvaceæ.*

Adansonia is the inner bark of the baobab or monkey bread tree. It is obtained from the tropical regions of the western coast of Africa, and is suitable for making a strong wrapping paper having a high finish.

Balsam (*Abies balsamea.*) *Coniferæ.*

Balsam is used in Maine, Pennsylvania, New York, New Hampshire, Minnesota and Wisconsin for sulfite pulp, yielding a pulp of the same general character as spruce.

Bamboo (*Bambusea* species). *Gramineæ.* Fig. 121, Vol. I, and Fig. 729.

These are giant grasses which have long been known as suitable for making paper, but have never been used extensively for this purpose, probably owing to the greater ease of securing wood. Recent experiments have again demonstrated the value of the dwarf bamboos, particularly, for paper-making. Bamboo is native in tropical and subtropical countries, and is used extensively industrially in southern Asia and the Philippines. It has been introduced successfully into the United States. It is the chief paper-making material of China, and owing to the rapidity with which it grows (a yield of six tons of paper stock per season has been estimated), it is a promising material of the future. It makes a soft, white paper, possessing some of the characteristics of paper made from straws, and is suitable for wrapping, newspaper and book papers. The fiber is 1 to 10 mm. long and .015 mm. in diameter. The yield of paper is about 40 per cent.

Corn-stalk (*Zea Mays*) and **Sugar-cane bagasse** (*Saccharum officinarum*). *Gramineæ.*

The former is grown extensively in the United States, the latter in the United States, West Indies, East Indies and Hawaii. They have both attracted considerable attention, as have also cotton-stalks, as paper-making materials. Samples of very acceptable paper have been prepared, and bagasse has been used for some years by several mills in preparing a low-grade wrapping paper. [See *Maize* and *Sugar-cane.*]

Cotton (*Gossypium* species). *Malvaceæ.* Fig. 355.

Cotton is a single-fibered seed hair and is used in the paper industry in the form of fibrous waste from the decortication of the seeds, which, even after ginning, retain on their surfaces about 10 per cent of fiber; by delinting, 1 per cent of a short fiber is recovered. Old and new rags, spinning waste and thread are the chief sources of cotton-paper stock. Large quantities of rags are imported from England, Germany and Egypt. The total quantity of cotton and flax fiber used in the United States for paper-making in 1905 was 294,552 tons. Cotton is largely employed in the finest record, ledger, writing, book and blotting papers, usually mixed with a little linen. The fibers are 20 to 40 mm. long, and .012 to .037 mm. in diameter. The yield of paper from rags is approximately 83 per cent. [See *Cotton.*]

Cottonwood (*Populus deltoides*). *Salicaceæ.* Fig. 449.

Cottonwood is used to a small extent and yields a pulp by the soda process of the same general nature as poplar.

Esparto (*Stipa tenacissima* and *Lygeum Spartum*). *Gramineæ.*

This plant grows wild in Spain and northern Africa. It is gathered, baled and shipped, chiefly to England, where large quantities are used. The fibers of the fibrovascular bundles constitute the paper-making material. The fiber is tough and is particularly suitable for the manufacture of book papers, yielding a soft paper of good quality. The fibers are 1.5 to 2 mm. long and .0125 to .022 mm. in diameter. The yield of paper is about 45 per cent. It has been used for centuries in southern Spain and northern Africa for the manufacture of baskets, matting and similar wares. The leaf, which grows three to five feet long, is used and is stripped annually from the plant by hand. This can be done only in dry weather. The plant must grow ten to fifteen years before the leaf is suitable for paper-making. Its cultivation has not been successful. [See *Fiber plants.*]

Flax (*Linum usitatissimum*). *Linaceæ.* Figs. 405–407.

The bast fiber from the inner bark of the straw is employed in the form of scutching refuse, spinning waste, threads, and new and old rags. The fibers have a length of 25 to 30 mm. and an average diameter of .02 mm. The yield of paper from rags is about 75 per cent. Flax fiber is the most suitable material for the preparation of high-class papers, such as are used for court and other records, which are to be handled a great deal and preserved for many years. [See *Flax.*]

Ground wood.

In addition to the use of wood pulp prepared by chemical treatment, paper is also made from wood pulp prepared by grinding against a stone under a stream of water, such pulp being known as "ground wood" or "mechanical wood." The paper thus prepared has only a temporary value, as the fibers are very short, much shorter than from the same wood chemically treated; and, as the coloring matter and ligneous matter are still in the pulp, the paper darkens and deteriorates rapidly. Spruce is most largely used for grinding. Small quantities of hemlock, pine, balsam and poplar are also used. Ground wood is used chiefly in making newspaper, which consists of about 80 per cent ground wood and 20 per cent sulfite. It is also used alone or in mixture with other materials in making board, cards and cheap wrapping paper.

Hemlock (*Tsuga Canadensis*). *Coniferæ.* Fig. 454.

This wood yields a somewhat coarser pulp of the same general character as spruce, but is reduced with more difficulty. Hemlock is native from the St. Lawrence river to Wisconsin on the west, south to Delaware and Maryland, and in the mountains to Alabama. It is now employed largely in Wisconsin, Michigan, Pennsylvania, New York, Ohio and West Virginia for making sulfite pulp, which is used for the same class of paper as spruce is. The fibers have a length of 1 to 4 mm. and a diameter of .021 to .063 mm.

Hemp (*Cannabis sativa*). *Urticaceæ.* Figs. 566-568.

The bast fiber from the inner bark of the hemp plant is used in the form of scutching refuse, spinning waste, threads, cuttings, rope ends and canvas. As the fiber has great strength, it is used largely in combination with rags for bank note and ledger paper. Unbleached, it is used for wrapping paper and for cable insulation. Hemp is cultivated in Russia, Italy, France, China, Japan, and in the United States. The fibers are about 22 mm. long and .022 mm. in diameter. The yield of paper is about 68 per cent. [See *Hemp.*]

Jute (*Corchorus capsularis* and *Corchorus olitorius*). *Tiliaceæ.* Figs. 392, 393.

The fiber of jute is thin-walled, highly lignified, and contains much coloring matter. It is obtained from the inner bark and is used in the form of threads, butts, bagging and spinning waste. It is used chiefly where strength is of more importance than appearance, as in wrapping papers and heavy envelopes; it is seldom used in white papers. Jute is cultivated commercially in India, Burmah, Japan, China and Formosa and has been introduced into the United States. The fibers are 2 mm. long and .022 mm. in diameter. The yield of paper is 50 per cent. [See *Fiber plants.*]

Manila hemp (*Musa textilis*). *Musaceæ.* Fig. 398.

The fiber of Manila hemp or abacá is obtained from the fibrovascular bundles of the leaf stalks and is used in the form of scutching refuse and old rope. It is cultivated in the Philippine islands and has been introduced into the East Indies. The fibers are about 6 mm. long and .024 mm. in diameter. The yield of paper is about 50 per cent. It is used chiefly for wrapping, cable insulation and heavy envelope papers, which are known as "rope manila." [See *Fiber plants.*]

Mauritius hemp (*Furcræa fœtida*). *Amaryllidaceæ.* Fig. 402.

This hemp is obtained from Mauritius and St. Helena, where it is prepared for export. It is native in Central America. The fiber of the fibrovascular bundles of the leaves is used for small cordage, in which form it is used as paper-making material. The fibers are 1.3 to 3.7 mm. long and .015 to .024 mm. in diameter. Other agaves also yield a suitable paper-making fiber. [See *Fiber plants.*]

Fig. 730. Aspen (*Populus tremuloides*), much used for paper.

New Zealand hemp (*Phormium tenax*). *Liliaceæ.* Fig. 401.

The fiber is obtained from the fibrovascular bundles of the leaves of this plant. It is native in New Zealand and Australasia, and is cultivated in New Zealand, and, to a small extent, in southern Europe. It is used in the form of old rope, twine and yarn, and is suitable for making strong wrapping papers, though it is but little used. The fibers are soft and lustrous, 9 mm. long and .016 mm. in diameter. [See *Fiber plants.*]

Paper mulberry (*Broussonetia papyrifera*). *Urticaceæ.* Mitsumata (*Edgeworthia Gardneri*). *Thymelæaceæ.* Fig. 92.

The inner or bast fibers of these plants are used in Japan for making paper. The fibers are 6 to 20 mm. long and are soft and lustrous, and are not broken or cut in making Japanese hand-made paper. The fiber is prepared for paper-making by scraping, soaking and beating, and in the unbroken condition yields a paper of great tensile strength and softness. By treatment with oils, adhesives and colors, the Japanese make from these fibers papers which in their strength and resistance are ready substitutes for leather and cloth for some purposes. These fibers mixed with others are also used in Japan in making machine-made papers. Mitsumata has been introduced into this country by the United States Department of Agriculture. [See page 72.]

Pine (*Pinus* species). *Coniferæ.* Figs. 459, 462.

Several varieties of pine are used in paper-making. White pine (*Pinus Strobus*), long-leaf yellow pine (*P. palustris*), and grey pine (*P. divaricata*, Fig. 462) are coming into use for the preparation of pulp by the soda process. The fibers are .5 to 4.5 mm. long.

Poplar (*Populus grandidentata, P. tremuloides*). *Salicaceæ.* Fig. 730.

This is the preferred wood for use in the soda process and yields a soft, easily bleached white pulp. The tree is native in southern Canada, westward to the Mississippi river, and south to North Carolina. The fibers are .45 to 1.2 mm. long, and .017 to .035 mm. in diameter. The yield of paper is about 52 per cent. Poplar wood is used chiefly in combination with sulfite and other good materials in making lithograph, book, writing and blotting papers. It is particularly suitable for giving an open texture, soft handle and bulk, resembling esparto in these qualities. Unbleached poplar is used alone or with sulfite, hemp or jute for wrapping and cable paper.

Ramie (*Boehmeria nivea*). China grass. *Urticaceæ.* Fig. 394.

The bast fibers of the inner bark of this plant are used in the form of scutching refuse, spinning waste and rags, and furnish an exceptionally strong fiber suitable for the production of the highest grade papers, such as bank notes, which are subject to much wear and handling. The length of the fiber is 80 to 150 mm. and the diameter .05 mm. The plant is cultivated in China, Formosa and Japan for textile purposes, and recently has received a great deal of attention in India, Africa and in the United States, where it can be grown successfully as far north as Washington, D. C. [See *Fiber plants.*]

Rhea (*Boehmeria tenacissima*). *Urticaceæ.*

This plant yields bast fibers somewhat like those of ramie, and is suitable for the production of strong papers for special purposes. The fiber is stiffer than that of ramie, which is a drawback to the use of the material. The fibers reach a length of 220 mm. in some cases. It is used in the form of scutching waste, spinning waste, and other materials. [See *Fiber plants.*]

Sisal or Henequen (*Agave rigida*, var. *elongata* and var. *Sisalana*). *Amaryllidaceæ*. Figs. 22, 399, 400.

These plants are cultivated in the West Indies, Mexico, Yucatan, Central America and Venezuela. The fibers are separated from the leaf by scraping. The ultimate fibers are 1 to 6 mm. long, white, lustrous and stiff. The material reaches the paper-mill in the form of cordage and old bagging and is suitable for making strong wrapping paper. [See *Fiber plants*.]

Spruce (*Picea nigra*, *P. alba* and *P. rubra*). *Coniferæ*. Fig. 731. [See Fig. 465.]

Spruce is particularly suitable for the production of sulfite pulp made by cooking the wood with a sulfite liquor, and is still the chief source of this pulp. The bark is always removed before making the wood into pulp. Spruce is native in Canada, northern United States and in the mountains as far south as North Carolina. It is also found in northern Europe and Asia. The fibers are 1.5 to 2.5 mm. long and .035 mm. in diameter. The yield of paper is about 50 per cent. It is largely used in combination with other materials for making lithograph, book and other printing papers, and for writing papers. Unbleached, it is also largely used with other materials for making wrapping paper. So-called manilas often consist almost entirely of unbleached spruce fiber.

Straws of cereals. *Gramineæ*.

Until the introduction of wood, rye- and wheat-straws were largely used in the production of newspaper material and other cheap printing paper. Straw is still used in small quantities, even in high-grade papers, to impart to them stiffness and hardness, but is used chiefly for strawboard, which is made in large quantities almost exclusively in the Ohio valley. Barley-, rye-, wheat- and oat-straw fibers are .1 to .5 mm. long and .0125 to .024 mm. in diameter. Rice-straw fibers are .88 mm. long and .0025 mm. in diameter. The yield of paper is about 42 per cent. Of strawboard the yield is about 80 per cent. Rice-straw is not used to any extent, but experimental work indicates that it makes a paper similar to that from other straws and that it is just as suitable for the making of strawboard. The high percentage of silica which it contains (which reduces the quantity of soda recovered) operates against its use for paper-making. Immense quantities of straw are wasted annually. [See articles on the cereal grains.]

Sunn hemp (*Crotalaria juncea*). *Leguminosæ*. Fig. 396.

This is cultivated for its fiber in India and the Sunda islands. It is used chiefly in the form of old rope and bagging for strong wrapping papers. The fibers are 7 to 8 mm. long and .03 mm. in diameter. [See *Fiber plants*.]

Waste paper.

In printing there is considerable waste of paper, due to the tearing of the paper on the presses, to soiling, and to trimming and cutting to desired sizes. Magazines, advertising matter, books and newspapers, after serving their purpose, are collected and returned to the paper-mill, to be again used in making such kinds of paper as they may be suitable for. The quantity of waste paper thus used is very large and might well be much greater.

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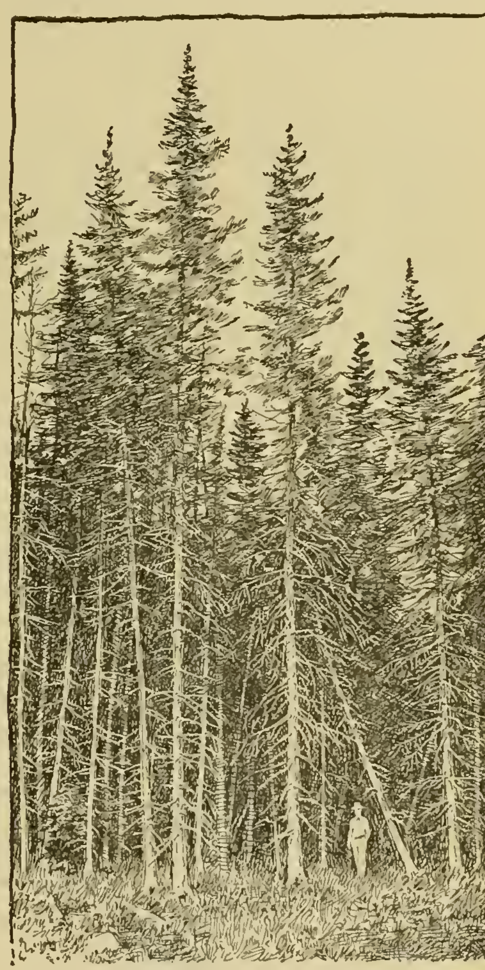

Fig. 731. Spruce timber, used for paper pulp.

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PEA, AS A FIELD CROP. *Pisum sativum*, var. *arvense*, Poir. *Leguminosæ.* Figs. 732–734.

By *J. L. Stone.*

The pea is grown as a field crop for the production of grain for stock-feeding and for the manufacture of "split peas" for culinary use, for canning in the factories, for forage and green-manuring and to supply the seed trade.

The pea is the most important member of the genus Pisum. It is native to Europe, but has been cultivated from before the Christian era for the rich seeds. It is an annual, glabrous and glaucous, tendril-climbing; the stipules are large and leafy; the leaflets are oval or ovate, two to three pairs, the leaf ending in tendrils; the flowers are few, on an axillary peduncle. The field- or stock-pea differs from the garden pea usually in its violet or purple rather than white flowers, its smaller and more uniformly smooth seeds, but chiefly in the less tenderness and sweetness and lower quality of the green seeds.

History.

The pea is generally supposed to be a native of southern climates and was well known both to the Greeks and to the Romans, frequent mention being made of it in the works of old writers on rural subjects. A form of gray pea still growing wild in Greece is supposed by some to be the original form of all the highly domesticated varieties belonging to the species. The pea has been known and cultivated in England for centuries. Most of the early English writers on agricultural topics mention it either as a garden vegetable or as a farm crop. Lydgate, a writer in the time of Henry VI, speaks of peas as being hawked about the streets of London. It seems to have been more extensively used as a garden vegetable in England before the introduction of the potato than during recent years.


Fig. 732. Field-pea.

In the United States the practice of canning green peas, thus rendering them available throughout the year, has led to their being extensively used by the well-to-do classes. The area now devoted to canning peas very largely exceeds that planted to stock-peas.

Distribution.

Peas thrive best in localities having somewhat cool summer temperatures and a rather abundant supply of moisture. For grain and seed production the southern parts of Canada and the northern belt of the United States seem to be best suited. Farther south fruiting is less certain owing to liability to hot weather, though the crop may have value for forage and green-manuring purposes.

Pea-growing has received much attention in Canada, the average annual production of the province of Ontario alone during the last twenty years being nearly 14,000,000 bushels. The greater part of this large crop is fed to live-stock. In the United States the crop has received less attention than it deserves. In Michigan, Wisconsin and Montana great increase in the area devoted to peas has occurred in recent years, while in New York the production of stock- and seed-peas has very materially declined, while the production of canning peas has largely increased.

Peas may be grown successfully for green-manure or forage purposes in many regions where climatic conditions are not favorable for a good yield of seed, and they may be raised successfully for canning or marketing in the green state where, because of insect infestation, the matured seed is of little value. This leads to certain favored localities making a specialty of seed-pea production. Formerly Jefferson county, New York, was the center of the seed-pea industry of the United States. More recently, owing to the advent of the pea weevil and the pea louse, the industry has largely been removed to Michigan, Wisconsin and the state of Washington.

Varieties.

The varieties of peas are numerous and are of two general classes: the field-peas, grown for stock food and for the production of "split peas" of the markets, and the sweet, wrinkled or vegetable peas grown largely for canning and for consumption in the green state. The field varieties in the United States are usually classed together as "Canada field-peas." The Ontario Experiment Station at Guelph has tested many varieties of field-peas, mostly secured from Europe. Among the most successful varieties are the Prussian Blue, Canadian Beauty, Tall White Marrowfat, Early Britain, Mummy and

Golden Vine. The last-named variety is very largely grown and is the one usually met with under the name "Canada pea."

Of the vegetable peas there are many varieties. They differ from the field sorts principally in containing more sugar, which increases palatability, and many of the varieties have wrinkled seeds while the field sorts are smooth. The wrinkled varieties usually produce white flowers, while the smooth sorts have colored (mostly purple) blooms. They vary greatly in habit of growth, being dwarf or large; early, medium or late; and in quality, from moderately to very sweet. Many of the dwarf, early varieties are smooth and only moderately sweet, while the late, large varieties are wrinkled and much sweeter. The varieties named below are grown largely for canning or for marketing in the green state. In a careful test made a few years ago by N. B. Keeney & Son, LeRoy, N. Y., it was found that the number of days from planting to fruit picking was:

Gregory Surprise	49 days
Alaska	50 days
Advancer	59 days
Horsford Market Garden	71 days
Telephone	71 days
Abundance	78 days
Champion of England	78 days
Everbearing	80 days

Some varieties commend themselves to the canners by maturing the whole crop nearly at one time, while other varieties have a long fruiting period which makes them especially desirable for the home garden.

Culture.

Soils.—For whatever special purpose the pea crop may be grown, the general soil and cultural requirements are much the same. The crop succeeds on a variety of soils. Clay loams, especially if well supplied with lime, are best adapted, but excellent crops are grown on stiff clays. Light, sandy and gravelly soils are not so suitable, as they are liable to dry out and become hot. Mucky soils produce a large growth of vine but the yield of grain is likely to be small. While peas require an abundance of moisture for their best development, over-wet soils are wholly unsuited to the crop.

Preparation of the land.—Fall-plowing is to be recommended for peas. This favors early sowing the following spring, which is desirable, and exposes the stiff soils, on which peas are usually grown, to the ameliorating influences of the winter's freezing and thawing. It is desirable that the land be well pulverized, but, since the pea is a hardy and vigorous grower this is not so necessary as for the small grain crops.

Fertilizing.—When grown on poor soils, peas respond well to manure or fertilizers, but on soils of good fertility the manures are usually applied to other crops in the rotation and fertilizers are rarely used. Some growers maintain that if manure is applied it should be plowed under deeply, so that the taproots will reach it during the seed-forming period.

Place in the rotation.—Peas may be assigned any place in the rotation. When properly inoculated they are capable of gathering nitrogen from the atmosphere and consequently are not so dependent as some other crops on nitrogen supplied by decaying grass and clover roots. Still, an inverted sod is found in experience to produce the best of yields, and the pea crop is most excellent to break down the sod and prepare the land for exacting grain crops, such as wheat. The usual practice, however, is to have peas follow a tilled crop, as beans or corn, and then be followed by wheat. A farmer can almost afford to grow a crop of peas for the purpose of fitting the land for wheat.

Fig. 733. Oats-and-peas for forage.

Seeding.—Peas are usually sown with a grain-drill or broadcasted by hand. If the land is very foul with weeds they are sometimes planted in drills twenty-eight to thirty inches apart so as to permit of horse cultivation during the early stages of growth. The grain drill is usually preferred to hand-broadcasting, as it covers the seed more evenly than the latter method. On spring-plowed land the peas are sometimes sown by hand immediately after the plow. The seed falls into the depressions between the furrows and is usually well covered by the harrowing which follows. Some persons have recommended sowing the seed ahead of the plow and turning it under the furrows, but this usually buries it too deeply, especially if the land is rather heavy. The depth of seeding varies from two to four inches, being deeper on the lighter soils.

The quantity of seed required per acre will vary with circumstances from two to four bushels. Rich soils which tend to produce a vigorous growth of vine require less seed than poorer soils. Large-seeded varieties or those producing small vines require more seed per acre than those having small seeds or producing large vines. Usually the canning varieties require heavier seeding than those grown for stock-feeding.

Harvesting and threshing.—Peas are usually cut with a mowing machine. The tendency of the vines to fall on the ground often makes the cutting a difficult task. Sometimes extra long guards of special shape are provided which lift up the vines so that the knives may cut them satisfactorily. Following the mower, men with forks pitch the cut peas to one side in bunches so that they are not trampled on at the next bout.

A pea harvester constructed on the plan of the twine binder has recently been invented. It does not bind the peas, but delivers them at the side out of the way, and thus saves the extra labor of moving them by hand.

If the crop has been matured for seed or grain purposes it is allowed to cure in these bunches, which are turned once or twice to facilitate drying. When dry, peas may be stored in a barn or stack like other grain. As the pea-straw will not shed rain well, stacks should be topped with some finer material to protect the crop from damage.

If the crop is grown for canning purposes it is drawn to the factory immediately after being cut. Formerly it was customary to pick the pods containing the peas by hand-labor in the fields and deliver these only at the factory, but more recently the difficulty of securing sufficient laborers to do this work and the introduction of pea threshers that successfully shell and separate green peas from the vines has led to delivering the whole crop to the factory.

Peas are usually threshed by machinery, though when only a small quantity is grown annually they may well be threshed by using a flail. This avoids breaking the seed. In handling larger quantities, machine threshing becomes advisable. A "bar concave" with most of the spikes removed is best, and the cylinder should be run at a low rate of speed to avoid splitting the peas as much as possible. If the grain is intended for stock-feeding the amount split is unimportant, but when intended for seed or the market the breaking of the grain lessens its value. The regular bean thresher does more satisfactory work on peas than the ordinary grain thresher.

The general method of pea-culture outlined above is applicable whatever may be the intended use of the grain. The varieties to be planted will vary with the purposes for which they are grown.

Uses.

Stock-feed.—The uses of the pea crop are numerous. In Canada it is much more largely grown as a general farm crop than in the United States. The grain has a high feeding value owing to its relatively high content of protein. As part of the grain ration of horses, fattening cattle, milch cows, sheep and swine, peas are unexcelled. When fed to sheep or brood sows in winter, peas do not require to be ground. For all other stock it is advantageous to grind them, though sometimes they are soaked in water for feeding to swine. When intended for stock-feeding, peas are frequently grown with oats. The combined crop will usually have a greater total value than would be produced by either alone. When so grown, about one and one-half bushels of oats should be sown with one bushel of peas per acre. (Fig. 733.)

Pea-straw, if well cured, is more relished by horses, cattle and sheep than the straw of other grain crops. Indeed, if not allowed to become too mature before cutting, nor weather-beaten in the curing, it more nearly approaches clover hay in nutritive quality and palatability than ordinary straw.

Peas sown with oats or barley afford excellent pasturage for sheep and swine, but unfortunately produce best growth at the season when the grass pastures are at their best. For large stock such pasturage is not so satisfactory, as the peas are easily injured by the tramping of larger animals. Sown in this way and cut just before the peas are full-grown, they produce an excellent soiling crop, and are much used to bridge over the interval between the shortening up of grass pasture and when corn is ready for use. By sowing at intervals of ten days, a supply of green forage may be provided for several weeks. Any surplus not needed for green forage may be cut and cured for hay.

In common with other leguminous plants the pea is especially rich in protein, and much of its agricultural value is due to this fact. The following table gives approximately the digestible nutrients in the products named:

	Dry matter	Digestible nutrients		
		Protein	Carbo-hydrates	Ether extract
Pea seed	89.5	16.8	51.8	.7
Pea-vine straw . .	86.4	4.3	32.3	.8
Pea-vine silage* .	27.2	4.71	11.0	.5
Peas and oats (green)	16.0	1.8	7.1	.2
Pea-hull meal (residue from split peas)* . .	89.8	15.9	36.3	.9

*Computed from analyses made by G. W. Cavanaugh at Cornell Experiment Station.

Soil enricher.—Since peas, like other legumes, have the power of obtaining nitrogen from the atmosphere and placing it within reach of other plants, they are much used in some places as a green-manure crop. Some persons assert that land from which a crop of peas has been harvested is richer in nitrogen than it was before the crop was grown. Peas are frequently used for sowing in apple orchards, the common Canada field-peas being suitable for this purpose. The orchard is plowed shallow very early in the season and, when the peas are beginning to ripen, pigs are turned into the orchard to harvest the crop, and the larger the pea crop and the smaller the drove of hogs, the longer will the peas last. The principal growth of the peas is made in spring when there is plenty of moisture. The pea crop is made by the middle of July and does not draw on the moisture supply in the orchard after that date, when the moisture is needed by the apple trees. [See page 506, Vol. I.]

Seed-peas.—When produced for the supply of the seed trade, peas are usually grown on contract, the jobber supplying the planting stock and agreeing to buy the crop at a specified price. The peas are received at the seed houses and prepared for market by recleaning and hand-picking in the same way that beans are prepared.

Split peas.—About half a million bushels of smooth or Canada field-peas are annually required for the production of "split peas," which are used principally in making soups. The hulls, which are removed in the process of manufacture, and the refuse peas are ground together to make "pea meal," which is sold as a stock-food.

Canning.—The canning factories use the garden pea grown as a field crop, not the type known as field-pea. [The subject of canning is discussed in Part II of this volume.] The pods and vines from canning factories are often ensiled, or fed green.

Enemies.

Weeds.—The pea crop, as most others, encounters a number of rather serious obstructions to growth. As a rule, it is not seriously interfered with by weeds, as it starts quickly and makes rapid progress, thus smothering out most weed competition. If, however, the land is infested with the annual wild mustard (*Brassica Sinapistrum*), the crop may be seriously injured. Fortunately this weed may be destroyed when a few inches high by spraying with a solution of about twelve pounds of copper sulfate in fifty gallons of water, while the peas are not materially injured by the solution. This treatment is most effective if the spraying is performed on a bright, hot day. Young mustard plants are much more easily destroyed than those approaching bloom. An ordinary four- or six-row potato sprayer answers well for the work. The metal parts of the sprayer should be brass, as iron is actively attacked by the solution. (Page 118.)

Insects.—There are three insect enemies of the pea crop, each of which is very destructive at times: the pea weevil or "pea bug" (*Bruchus pisorum*); the pea moth (*Semasia nitrieana*); and the pea louse or aphis (*Nectarophora destructor*).

The weevil is a brownish gray, active beetle, one-fifth of an inch long, which emerges from peas in autumn or in spring, leaving a small round hole. The egg is laid on the outside of the young pods and the grub, on hatching, eats its way into the pea. Here it undergoes its transformation, usually not emerging till the peas are sown the following spring. The affected peas are much injured for seed and somewhat for stock-food. Fumigation of the seed stock with bisulfid of carbon is effective as a remedy so far as the seed is concerned, but the few beetles which emerge in autumn and hibernate in barns or fields prevent a complete riddance of the pest. In treating the seed it is usually placed in tight vessels or rooms and exposed for two or three days to the fumes of bisulfid of carbon. One pound of bisulfid is sufficient for about one hundred bushels of peas.

Fig. 734. Brush-and-pan method of fighting pea-louse. (Div. Entomology, United States Department Agriculture.)

The pea moth, in the perfect form, is a small, slaty gray moth, three-eighths of an inch long. The moths, however, are seldom seen, the insect being observed by pea-growers when in the caterpillar state, and is usually called the "worm." They are small, whitish, slightly hairy caterpillars, when full-grown about half an inch in length, which live inside the green pods, attacking the peas by gnawing ragged-edged cavities into them and filling the cavities about them with excrement. This insect is very destructive in eastern Canada and in recent years has become abundant in Jefferson county, New York. The injuries are most severe to late peas. Suggested remedies afford little relief except that by planting early and using early varieties the attack is usually escaped.

The pea aphis is a pale green plant-louse which clusters in enormous numbers at the tips of the shoots and sometimes over the whole plants of field-peas; and it sometimes is found on sweet-peas and clover. These insects appear suddenly in large numbers and sometimes cause great loss over large areas of country. This species is very active and springs from the plant on the slightest touch. This trait has been used for their destruction by planting the seed in drills and using the cultivator to bury the aphids after they have been brushed from the vines.

Literature.

The first two references following have to do with the culture of peas, and the last two with pea enemies: Farmers' Bulletin No. 224, United States Department of Agriculture, Washington, D. C.; Soiling Crops and the Silo, Shaw, pp. 102–110; Yearbook, United States Department of Agriculture, 1898, p. 223; Delaware Experiment Station, Bulletin No. 49. [See, also, the gardening books.]

PEANUT. *Arachis hypogœa*, Linn. *Leguminosæ.* (Earth-nut, Ground-nut, Ground-pea, Goober, Pindar.) Figs. 735-740.

By *L. C. Corbett.*

Of the "nuts" produced in the United States, the peanut is the best known and most universally used. It is perhaps most commonly known as a roasted nut for eating, and in confections; but it has great importance as a soil-renovator and forage. The product is really not a nut, however. It is a ripened pod, with edible seeds, of a plant very like the pea and bean.

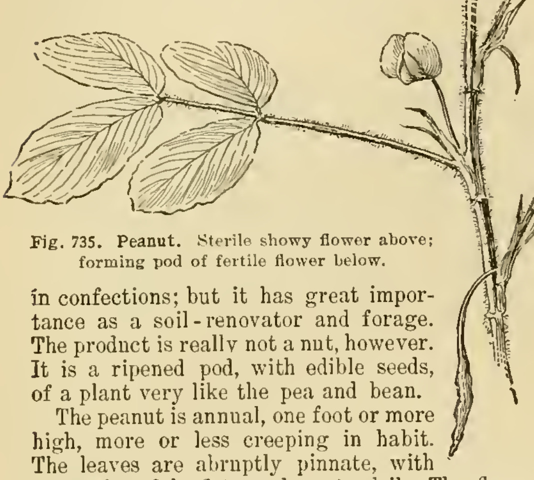

Fig. 735. Peanut. Sterile showy flower above; forming pod of fertile flower below.

The peanut is annual, one foot or more high, more or less creeping in habit. The leaves are abruptly pinnate, with two pairs of leaflets and no tendril. The flowers are of two kinds: the male (staminate) showy, and the female (pistillate) hidden or cleistogamous flowers more or less clustered in the axils of the leaves. The stamens are monadelphous, but the alternate ones are short. The male flowers soon wither and fall away, while the female flowers begin to grow rapidly by the extension of the receptacle and flower stem (stipe), soon curving toward the ground, where they bury themselves and ripen the pod entirely underground.

History.

Little was known of the history or culture of the peanut outside of a comparatively circumscribed area in southeastern Virginia prior to the Civil war. Even now the means of its advent on this territory is not clear. Circumstantial evidence points to the early slave trade as the most likely means by which the nut reached North America. Peanuts were used as staple food for the maintenance of slaves on the voyage across the Atlantic, and it is likely that this traffic was the means of bringing the peanut to this country early in its colonial history. This idea is given additional weight by the fact that the Carolina nut is very different in size from the Virginia or Spanish nut (Fig. 738) and is accredited an African origin. The Virginia nut is probably of African origin also, but from a different section of the country than that from which the Carolina came.

Up to the time of the elder De Candolle, the native home of the peanut was in doubt. It had been very generally disseminated and thoroughly inured to a wide area of the earth's surface. Many botanists held to an African origin for the species, while others accredited it to India and South America. A careful investigation of the case by De Candolle has indicated the natural habitat of the peanut as Brazil, where six or seven other closely allied species are found. If *Arachis hypogœa* were not of American ancestry it would be the only exception in the group, which seems improbable.

Distribution and yield.

Although the peanut was brought to this country in colonial times, its extensive commercial cultivation is of recent development. The knowledge of the crop gained by the soldiers during the Virginia campaigns did more than any other single cause to disseminate the culture throughout the thirty-eight states from which it was reported in the last census. It is now grown in commercial quantities in eight states, but it is estimated that one-half of the crop is produced in Virginia and North Carolina, and that more than one-half of the total marketed product of the United States is cleaned and prepared for the trade in Petersburg, Suffolk and Norfolk, in Virginia.

The magnitude of the peanut industry can be judged from the estimated crop of 1905, which is placed at 14,000,000 bushels, of which Virginia and North Carolina each produced about 4,000,000 bushels, Georgia about 2,000,000, with the remainder scattered throughout the other southern states. The value of the crop that is placed on the market, exclusive of the part retained for planting and for home consumption, is estimated at $10,500,000, practically all of which represents an expenditure for an article now classed as a luxury or confection.

Varieties. (Figs. 737, 738.)

While seedsmen catalogue only two or three varieties of peanuts, there are a number of sorts which are distinct and are known by local names. The so-called Virginia nut varies from a nut of moderate size carrying two kernels to the pod, to the immense jumbo nuts carrying three or more kernels to the pod. The habit of the vine also varies from the broad, decumbent, running plant covering an area three or more feet in diameter to the compact, upright habit of growth in the bush type. In North Carolina there is a type of nut

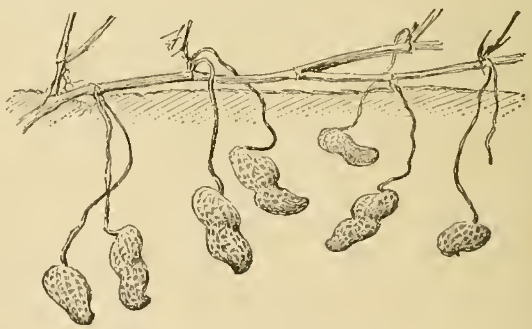

Fig. 736. Peanut, showing procumbent stem and buried pods.

grown extensively and known as the Carolina, which presents also the running and the bush types of plant. The nuts are of smaller size than the Virginia but not so small as the Spanish. The Spanish nuts are small and of the bush type of plant and yield more than any other variety. (Fig. 737.) For agricultural purposes and for the production of forage the bush habit is a very decided advantage, as it can be more closely planted. In Tennessee, two or three varieties of nuts have been developed, one of which is worthy of mention, in that it produces a kernel carrying a very red skin which renders it especially attractive. This is known as the Tennessee Red, but is not generally recognized as a distinct variety or catalogued by seedsmen.

Culture.

Seeds.—One of the most important points in connection with the cultivation of peanuts is the proper selection of seed. Only seed from vigorous, productive plants should be planted. Those persons who give special attention to this point are liberally rewarded for their attention. The result of planting a miscellaneous collection of seed is an indifferent stand and a corresponding yield.

While the general practice is to employ shelled nuts for planting, in some instances Spanish nuts, and the larger varieties as well, are planted in the hulls; but a less uniform stand of plants is secured when this practice is followed. The more perfect stand of vines resulting from the use of shelled nuts is sufficient to warrant the expense and trouble of shelling. This work should be done very carefully, so as not to crack the kernels or to break the thin skin which covers them. The work of shelling is most satisfactorily done by hand, but in recent years a considerable quantity of the seed, of the Spanish variety particularly, is secured from the factories where it is shelled by machinery. To facilitate the work of hand-shelling, a simple device called the "peanut popper" is used. This consists of a piece of tough hickory or oak bent into the form of a miniature pair of tongs.

Soil.—With the exception of low wet soils the peanut will thrive on any good agricultural land. In order to produce high-grade peanuts for market, however, only soil which is of a light color and carrying a high percentage of sand is suited for the work. Heavy land of a dark color, impregnated with iron, is likely to produce stained nuts which do not command so high a market price as do clear-shelled nuts. For agricultural purposes, however, the color of the shell is of no importance and in some instances the largest yields of nuts have been obtained from soils of a rather heavy and somewhat retentive nature, soils carrying a considerable percentage of clay. In addition to the light gray soils already mentioned, chocolate soils, which are more or less abundant in certain parts of Virginia, are considered to be well adapted to the peanut. It is not advisable to use the same land year after year, but the crop fits well into a rotation scheme. It is a good preparatory crop for corn.

Preparation of the land.—The general preparation of the soil for the cultivation of peanuts is the same as that for any other tilled crop. The land should be plowed moderately deep, and if clean, as the result of a previous tilled crop, the breaking of the soil may be deferred until spring. If, however, there is considerable vegetable matter on the land, it is advisable to plow it in the fall and to rework the surface in the spring with a disk-harrow or some type of soil-stirring implement which does not reverse the soil as does the plow. A preparatory tilled crop is a decided advantage, as it helps to rid the land of grass and annoying weeds.

Fig. 737. Single plant of Spanish peanut. Texas.

Fertilizers.—Land which is moderately clean is benefited by a light application of lime, ten to twelve bushels to the acre, and that which is somewhat weedy or grassy should have a more liberal dressing, say fifteen to twenty-five bushels to the acre. After the land has been tilled and limed, it is customary to lay it off in rows two and one-half feet apart, using a turning plow to open a furrow in which is scattered the fertilizer to be used on the crop, after which the cultivator or weeder is run over the area to incorporate the fertilizer with the soil.

If stable manure is to be employed on the area to be devoted to peanut-culture it should be thoroughly rotted, spread on the field in the fall previous to planting the crop and plowed under. It is not advisable to use fresh manure on the land immediately before planting. In addition to manuring and liming the land in the spring, a dressing of plaster is given at the rate of 250 pounds to the acre about the time the plants come into bloom.

Other fertilizers which are suggested for peanuts are acid phosphate 80 pounds, cottonseed meal 300 pounds, kainit 240 pounds. Another formula recommended is acid phosphate 100 pounds, dried blood 185 pounds, muriate of potash 65 pounds. Since the peanut is a leguminous plant, drawing its nitrogen largely from the soil air, the fertilizer used need not be highly nitrogenous, although in each of the formulas given there is much nitrogen ; the cottonseed meal in the first carries a considerable percentage, while dried blood in the last also contains nitrogen. A dressing of 250 to 500 pounds to the acre of either of these mixtures should be sufficient. The North Carolina Department of Agriculture is using a fertilizer analyzing 7 to 8 per cent of available phosphoric acid, 4 per cent potash, and 1 to 2 per cent nitrogen.

Planting.— By the use of a small turning plow two furrows are thrown up in the form of a back furrow or ridge over the line of the furrow first opened, in the method employed in preparing land for the reception of sweet-potato sets. After the ridges are thrown up they are knocked off either by the weeder or by using a board scraper fastened to the back teeth of an ordinary Planet Jr. or Iron Age cultivator. The planter follows on the ridges, dropping the seed at intervals of about eight inches, two seeds in a place, and placing the seeds deep enough to be on the same plane as the general level of the surface of the field. The ridges are brushed down to about two inches in height and the seeds are planted about two inches deep. On soils that are likely to be grassy or weedy seeds are dropped somewhat farther apart, about twelve inches, and two or three seeds in a hill. If the seeding is to be done by hand, the common practice is to employ a wheel-marker with pegs set on the rim of the wheel large enough to make marks in which the seeds can be dropped at proper intervals and depths. Covering is then accomplished by treading on the ridge or scraping the earth in with the foot.

Cultivation. — Cultivation should begin as soon as planting is completed, so as to keep weeds in subjection. The first cultivation can be done with a narrow-toothed cultivator run comparatively close to the vines, so as to kill as much grass as possible. Some growers employ a weeder and run crosswise of the rows after using the cultivator between the rows.

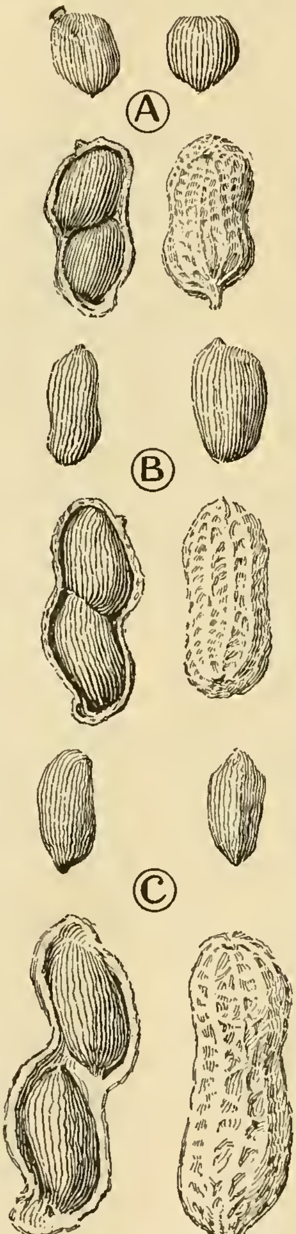

Fig. 738. Three leading types of American-grown peanuts: (A) Spanish; (B) Carolina; (C) Virginia No. 1.

There is objection to this, however, as the young plants are brittle and easily broken, and the weeder frequently does considerable damage. As the season advances and the plants gain size, broader teeth are used on the cultivator and a center tooth of some size is employed to open a water furrow between the plants so as to leave a ridge two to three inches high of loose, friable soil. This is important, for as soon as the plants have shed their bloom the forming nut is thrust into the loose soil for further development. The importance of keeping the soil well up around the plant, as well as loose and friable, is apparent. It is also important that the cultivation should not be close enough to the plant to disturb the roots or the forming nuts. In ordinary practice the plants are not "laid by" until about the last of July or the first of August through the Virginia peanut region.

Harvesting.—In late years, since the value of peanut hay has become more generally recognized, the harvesting of the crop has been pushed forward. The earlier the hay is cut the more valuable it is. If gathering is delayed until frost touches the plants, a large proportion of the leaves are lost and the value of the hay is very materially lessened. It is the practice to begin harvesting sufficiently in advance of the normal date for killing frost to have the crop entirely in shock before such frost occurs. The common method is to throw a furrow away from the row of plants on either side. Men follow with forks and lift the plants out of the ground, gently shake the sand from them, and throw them into heaps, placing five or six rows in one general windrow. Another squad follows the diggers and places the plants in shocks. (Fig. 739.) For these, poles seven or eight feet in height, free from projecting limbs or knots, and sharpened at both ends, are provided. One end of the pole is thrust into the ground eighteen inches or two feet to hold it firmly in position. Around the base of this pole a few cross-pieces are laid on the ground to keep the vines from coming in direct contact with the soil. In some instances a whorl of branches is left on the poles to accomplish this end. In other instances narrow strips of boards are nailed at right angles to one another across the pole to support the vines. The plants with the nuts attached, which are thrown into windrows by the diggers, are taken up, gently shaken and placed with the nuts all inside the heap around the pole, making a narrow, upright shock about two and one-half feet in diameter at the base, and of nearly uniform diameter until near the top, where it is quickly

Fig. 739. Peanut ricks. Curing peanuts in the field.

drawn in and capped with grass or hay. These shocks are about five feet in height. The nuts are allowed to remain in shocks until thoroughly cured or until they are ready for picking. In some instances the shocks are lifted and carried to suitable buildings or sheds where the picking is done, but in the majority of cases the picking is done in the field, this work being accomplished largely by hand (Fig. 740), although in the last few years a number of satisfactory machines have been invented for this purpose.

The nuts are thoroughly cured, and are then placed in sacks and sent to a cleaning factory, where they are put through a number of processes for removing all adhering sand or dirt, blanching the shells of those which are slightly discolored, and polishing those of high grade which are to go on the market for roasting purposes.

Yield.

The average yield of peanuts in Virginia and North Carolina is about forty bushels per acre. Some growers make an average yield of one hundred bushels per acre with select types of large nuts, and yields of one hundred to one hundred and forty bushels per acre are reported for the Spanish nuts.

Enemies.

There are no serious enemies to the peanut crop as yet. Plants are sometimes destroyed by cutworms. The nuts may be attacked by weevils if kept a long time, a trouble that occurs chiefly in warehouses and confectionary establishments.

Uses.

Peanuts are put to a great variety of uses. Every one is familiar with the roasted nuts for eating out of hand. Great quantities are thus consumed. In addition, the nuts are manufactured into a great variety of confections and candies, while the vines, either with or without the nuts, are valuable for stock-feeding, and the growth of the plant is important in soil-renovation.

Peanut butter.—Of late, peanut butter is receiving wide advertising and is finding a ready market. It does not soon become rancid, can be carried to sea and can be had in packages to suit the most exacting demands. While it will probably never become a rival of butter, it has a legitimate use and is likely to become a staple commodity.

Salted peanuts have in late years become an important competitor of the salted almond, and because of the difference in cost the peanut is likely to find a greatly increased use as a confection of this class.

Peanut oil is one of the best known vegetable oils, but because of its high food value, quality and keeping properties, it has found little use in the arts. It is used chiefly as a substitute for olive oil. Marseilles is the great peanut oil factory of the world, the supply of nuts being drawn largely from Africa, India and Spain. This oil is not manufactured in the United States, but the discussion of it here is just now receiving considerable attention. This is due to the fact that the owners of cotton-oil mills recognize the importance of the peanut as an oil-producing plant, in general adapted to the same soil and climatic conditions as cotton. With the oil mills in the field the next step is the production of the nut in sufficient quantity to provide a supply to the mills and at a price which shall be remunerative to the farmer and at the same time leave a margin of profit to the millman. Although the subject is being extensively discussed, only one experiment to demonstrate the profit and loss in the venture has been carried out. This has demonstrated that the work can be done without loss, but it has not been sufficient to show the advantage of careful manufacturing on an extensive scale. [See *Oil-Bearing Plants.*]

As a forage crop.—The peanut vines make hay possessing a feeding value for cattle, mules and horses equal to that of clover hay. The yield of hay when the crop is well manured and cultivated ranges from one to three tons per acre. The value of the forage is each year becoming better recognized, and more careful attention is being given to

Fig. 740. Picking peanuts, separating the nuts from the vines.

harvesting the nuts in such a way as to preserve the hay in the best condition for feeding purposes. For best results the vines should be cut or dug before frost has touched the leaves. If frosted, the food value of the hay is lessened and the yield materially reduced.

The following statement of the analysis of peanut hay in comparison with other standard hay crops shows the great merit of this plant as a forage crop:

Feeding Value of Peanut Hay as Compared with Hay of Other Crops.

	Moisture	Dry matter				
		Protein	Fats	Carbohydrates	Crude fiber	Crude ash
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Peanut hay	7.83	11.75	1.84	46.95	22.11	17.04
Peanut vine	6.25	13.48	15.06	36.28	29.16	6.02
Clover hay	14.30	12.84	2.11	48.31	29.27	7.47
Timothy hay	13.50	7.17	1.97	52.94	33.41	4.51
Cowpea hay	10.29	19.72	4.04	45.15	21.99	9.10
Alfalfa	6.95	16.48	2.02	42.62	31.38	7.49

As roughage, peanut hay compares very favorably with clover hay. The whole plant, vine and nuts, noted as "peanut vine," is superior to alfalfa in fat and almost its equal in protein content. The value of the peanut as a stock- and hog-food is well recognized, and with the increasing interest in swine and cattle through the South a great increase in the acreage of peanuts grown is sure to come. For hogs, peanuts are planted and cultivated and the hogs allowed to harvest the crop. This let-alone method of harvesting has been justified in the commercial results as reported by the Arkansas Experiment Station. As compared with corn, the standard hog-food, one-fourth of an acre of peanuts produced 313 pounds of pork, while a like area in corn produced 109 pounds of pork, a remarkable showing in favor of Spanish peanuts. Cattle, horses and poultry as well as swine, are fond of peanuts and thrive on them. Horses doing normal work have been maintained on whole nuts with as good apparent results as on a ration of corn and hay.

The accompanying summary of the average analyses of various parts of the peanut plant are of interest as they indicate the value of the several parts of the plant for food purposes. While there is considerable variation in the composition of nuts grown in various parts of the world, we cannot do more than call attention to the importance of the variations in nuts for special purposes. There is a range from 26.49 to 35.37 in the protein content of different samples and a range of 41.17 to 55.37 in the percentage of fat. In special-purpose nuts these differences are of great importance.

These tables show the peanut kernel, with an average of 29 per cent of protein, 49 per cent of fat, and 14 per cent of carbohydrates in the dry material, to be worthy of a high rank, and it should be classed with such concentrates as soybeans and cotton seed. The vines are superior to timothy hay and but slightly inferior to clover hay. The food value of the hay is of course higher the greater the percentage of nuts left on the vines in harvesting. The hulls also appear to possess considerable value as a feeding stuff, being richer in food constituents (protein, fat and carbohydrates) than cotton hulls, which are extensively used in the South as a coarse fodder, and about equal to the poorer grades of hay. The ground hulls are used to a considerable extent as a coarse fodder in European countries. Peanut meal (the ground residue from oil extraction) is a valuable feeding stuff, extensively used in foreign countries. It contains about 52 per cent of protein, 8 per cent of fat, and 27 per cent of carbohydrates, and is therefore one of the most concentrated feeding stuffs, ranking with cottonseed meal and linseed meal.

Average Composition of the Food Constituents in Different Parts of the Peanut Plant.

Peanut	Water	In water-free substance					
		Ash	Protein	Fiber	Nitrogen-free extract	Fat	Nitrogen
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Kernels	7.85	2.77	29.47	4.29	14.27	49.20	4.67
Vines cut before blooming	31.20	10.64	12.63	22.32	48.34	6.07	2.02
Vines cut when fully ripe	31.91	12.08	10.81	32.28	39.81	5.02	1.73
Hay	7.83	17.04	11.75	22.11	46.95	1.84	1.88
Vines without leaves	...	8.80	6.25	32.95	49.49	2.50	1.00
Leaves	...	10.90	10.00	21.51	54.09	3.50	1.60
Roots	28.74	9.58	7.63	48.59	31.00	3.20	1.22
Hulls	12.94	3.39	7.22	67.29	19.42	2.68	1.77
Skins (inner coat of kernel)	10.80	5.72	25.11	20.96	26.89	21.52	4.00
Meal	10.74	5.48	52.49	5.93	27.26	8.84	8.40

As a soil renovator.—As a soil renovator, the peanut, like other leguminous plants, is rich in nitrogen and contains considerable amounts of phosphoric acid and potash. The kernels are as

Plate XIX. A form of potato much prized tor household use rich in these constituents as the kernels of cotton seed and the vines are nearly as valuable as a fertilizer as are those of cowpeas. From the analyses it will be seen that the hulls are comparatively poor, while the meal or cake is rather rich, being nearly equal to cottonseed meal as a fertilizer:

This implies that peanuts can be grown in the Orient and shipped across the Pacific more cheaply than they can be produced at home. The nuts can be produced as successfully in parts of California, however, as in eastern United States, and this condition may some day be changed.

FERTILIZING CONSTITUENTS IN DIFFERENT PARTS OF THE PEANUT PLANT.

		In the fresh or air-dry substance				
	Water	Nitrogen	Phosphoric acid	Potash	Lime	Total ash
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Peanut kernels	6.30	4.51	1.24	1.27	0.13	3.20
Peanut vines (cured)	7.83	1.76	0.29	0.98	2.08	15.70
Peanut hulls	10.60	1.14	0.17	0.95	0.81	3.00
Peanut cake (meal)	10.40	7.56	1.31	1.50	0.16	3.97

Importations.

Notwithstanding the magnitude of the crop grown in the United States, a very considerable quantity of peanuts is annually imported. The

Fig. 741. Potato spray and blossoms. Detail shows a diagram plan of flower (dotted lines showing position of sepals), and a vertical section.

Atlantic coast ports report an importation of peanuts during 1904 amounting in value to $65,161, chiefly from Spain, while the Pacific coast ports report for the same year an importation valued at $87,441, chiefly from Japan and China. This gives a total of $152,602 sent abroad for a product which might easily be produced at home. The interesting fact in connection with the peanut supply for various sections of the country is that none of the nuts produced either in the Atlantic or Gulf coast states reach the Pacific coast markets, these markets being supplied almost exclusively from Japan and China.

Literature.

Wm. N. Roper, The Peanut and Its Culture; B. W. Jones, The Peanut Plant; R. B. Handy, Peanuts—Culture and Uses, Farmers' Bulletin No. 25, United States Department of Agriculture; C. L. Newman, Peanuts, Bulletin No. 84, Arkansas Agricultural Experiment Station.

POTATO. *Solanum tuberosum*, Linn. *Solanaceæ*, (Irish, English, Round, White Potato.) Figs 741–762.

By *S. Fraser.*

A farm crop grown for its tubers, which are used largely for human food and for stock-food, and for the manufacture of starch and alcohol. The genus Solanum comprises perhaps 1000 species, in many parts of the world. Some twenty of the described species are more or less tuber-bearing, but J. G. Baker (Journal Linnæus Society, XX) considers that only six of these "possess a fair claim to be considered as distinct species in a broad sense." These six are *Solanum tuberosum, S. Maglia, S. Commersoni, S. cardiophyllum, S. Jamesii, S. oxycarpum.* Of these, only *S. tuberosum* is known agricuturally. It is possible, however, that *S. Maglia* (the Darwin potato) and *S. Commersoni* (Fig. 103) possess value for the cultivator, either directly or hybridized with the common potato. *S. Commersoni* is now receiving considerable attention in Europe. It is native in Uruguay and Argentina "in rocky and arid situations at a low level." *S. Maglia* is native in the coast regions of Chile, while *S. tuberosum* occurs natively in the hill country of the interior of Chile and Peru. Forms of *S. tuberosum* occur in Mexico, and one of them (var. *boreale*) is native as far north as southern Colorado.

Fig. 742. Sprouts arising from the buds, or eyes, of a potato tuber.

The potato is perennial by means of its tubers. Its smooth, generally solid, more or less quadrangular stems attain a height of two to five or more feet. The stems bear compound leaves of oval leaflets and small intermediate leaflets. The flowers are in clusters and have a five-pointed, wheel-shaped corolla, one to one and a half inches in diameter and varying in color from white to purple. (Fig. 741.) Stamens 5; pistil 1, 2-celled. The fine fibrous roots penetrate the soil to the depth of two to four feet, and frequently extend horizontally two feet distant from the stems. The fruits or seed-balls are globular, three-fourths to one and one-half inches in diameter, and green, yellowish or purple in color. (Fig. 762.) The tuber is an underground stem; it bears buds, and, when planted, tends to produce plants similar to its parent; hence tubers are used for perpetuating a variety, and such are generally designated "seed tubers" or "seed."

Varieties vary considerably in composition; an average of many analyses is: Water, 75 per cent; protein, 2.5 per cent; ether extract, .08 per cent; starch, 19.87 per cent; fiber, .33 per cent; other non-nitrogenous materials, .77 per cent; ash, 1 per cent; undetermined, .45 per cent; 85 to 95 per cent of the total dry matter is digestible.

History.

The potato was thought by De Candolle to have been in cultivation in Peru for probably 2,000 years. G. de la Vega found the Peruvians cultivating it in 1542. He sent tubers to Europe. Various importations were made by the Spanish, and the potato became known in parts of Europe before it was introduced into Ireland in 1586 by

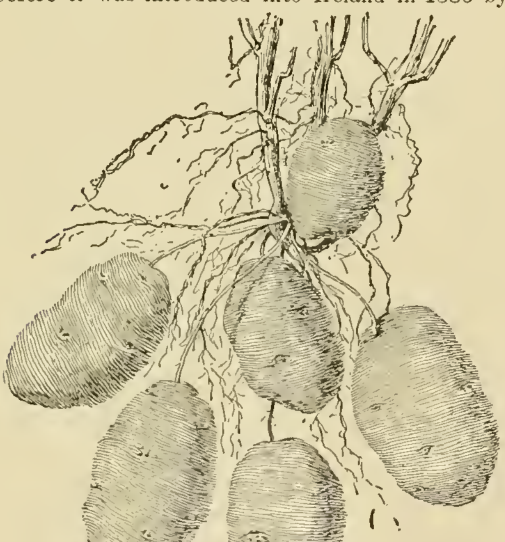

Fig. 743. Potato, to show manner of growth.

Thomas Herriot, who was a member of the expedition sent to America by Sir Walter Raleigh. The Virginian colonists probably secured potatoes from the Spanish, and they soon proved a valuable acquisition.

It is a common opinion that the aborigines of Virginia cultivated the potato at the time of the discovery. W. R. Gerard asserts, however ("Scientific American," September 15, 1906), that the *openauk* of Thomas Herriot (a product much quoted or discussed in the later writings on the potato), supposed to have been the potato, is really the ground-nut, *Apios tuberosa*. He contends that the potato was secured by Raleigh's expedition, under his cousin Sir Richard Grenville, on the return voyage, from a Spanish ship hailing from St. Domingo and captured in mid-ocean. The potato was cultivated in Ireland long before it was known in England. Probably the potato was served as an exotic rarity at a Harvard installation dinner in 1707; but the tuber was not brought into cultivation in New England till the arrival of the Presbyterian immigrants from Ireland in 1718. The potato of Shakespeare was what we now know as the sweet-potato, which derived its name from the aboriginal word *botata* or *batata*; this word or its derivative was later applied to our common or Irish potato. The aboriginal word is still preserved to us in the Latin name of the sweet-potato, *Ipomœa* (or *Convolvulus*) *Batatas*.

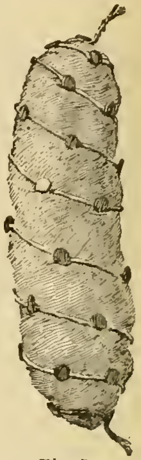

Fig. 744. Phyllotaxy of potato. The inserted tacks show the location of the buds.

Gerarde's Herball, published in 1597, describes the potato, and the edition published in 1636 contains a woodcut of it. Many of the other works of like nature contain descriptions of it. In 1663, the Royal Society of England tried to popularize the plant, especially in Ireland. So late as 1699 Evelyn barely mentioned the potato, and in 1719 London and Wise did not consider the plant worthy of listing in their Complete Gardener. Only two varieties were listed in 1771, yet by the end of the eighteenth century they were numerous.

Potato-culture spread slowly in Europe but more rapidly in the south of Ireland, because the peasants realized that it was a useful food and planted it everywhere; and with this as their commissary they were able to maintain the opposition to English rule. Two and a half centuries of reliance on this crop led to the neglect of other crops, and, when the blight occurred in Ireland in 1846, it was attended by one of the worst famines known in Europe. The potato has been more highly developed in Europe than in America, and much higher average yields are secured in the United Kingdom and northern Europe than in this country.

Geographical distribution and extent.

Next to rice, the potato is probably the most extensively grown and most valuable crop in the world. The annual yield of the world is nearly five billion bushels. The potato crop of Europe in value and volume exceeds the tabulated wheat crop of the world. One acre of potatoes frequently furnishes as much human food as ten acres of wheat, and wherever wheat is a precarious crop, as in northern Europe, potato-growing has been extensively developed. Yields of 1,000 to 1,200 bushels of potatoes per acre containing 10,000 pounds of starch are on record. About 30,000,000 acres of potatoes are grown annually in Europe, and of this area one-third is in Russia, the average yield per acre being about 95 bushels; Germany is second in total area with 8,000,000 acres and a yield of nearly 1,600,000,000 bushels, an average of 200 bushels per acre. France grows between 3,500,000 and 4,000,000 acres, Austria nearly 3,000,000, Hungary 1,500,000 and the United Kingdom 1,250,000. The average yield of England is about 230 bushels per acre, that of Ireland about 150 bushels. The United States grows about 3,000,000 acres, and the average yield for the past ten years is 84.5 bushels. Since the potato thrives best in a cool climate, potato-growing has been developed to the greatest extent in the Northern states. (Fig. 745.) According to the report of the Twelfth Census, the five states reporting the greatest number of bushels in 1899 were New York, 38,060,471 bushels; Wisconsin, 24,641,498 bushels; Michigan, 23,476,444 bushels; Pennsylvania, 21,769,472 bushels; and Iowa, 17,305,919 bushels. Fig. 746 shows the average yield per acre in bushels for the period 1900–1904.

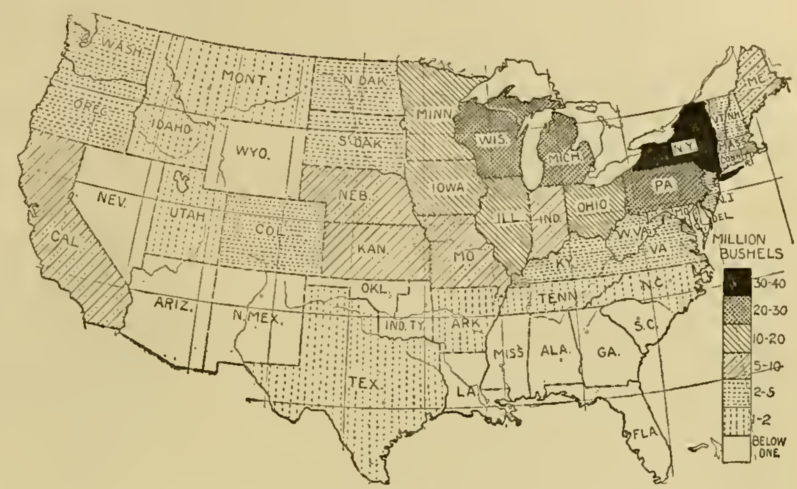

Fig. 745. Potatoes. To show actual yield in bushels by states.

In Canada, the potato crop has always been important, although the output has not shown so great an increase as some other crops, notably oats and wheat. In 1871, the potato crop was 47,330,187 bushels. In 1901, it reached 55,362,635 bushels, raised on 448,743 acres. The production in bushels by provinces in 1901 was as follows: Ontario, 20,042,258; Quebec, 17,135,739; Prince Edward Island, 4,986,633; New Brunswick, 4,649,059; Nova Scotia, 4,394,413; Manitoba, 1,920,794; The Territories, 1,277,793; British Columbia, 955,946.

Culture.

Soil.—The soil usually considered best is a deep, mellow, free-working loam, although crops are raised on lighter or heavier soils, provided the latter are well drained. Fall-plowing is generally advisable, since it facilitates the spring work. It should be as deep as possible, to a depth of twelve inches if the soil will permit. The land is generally left rough-plowed during winter and is fitted as early as possible in spring. The seed-bed should be well prepared by using the disk or acme harrows.

Fertilizers.—An application of ten tons or more per acre of barnyard manure may be made in the fall before plowing, or, if the manure is well rotted, it may be applied in

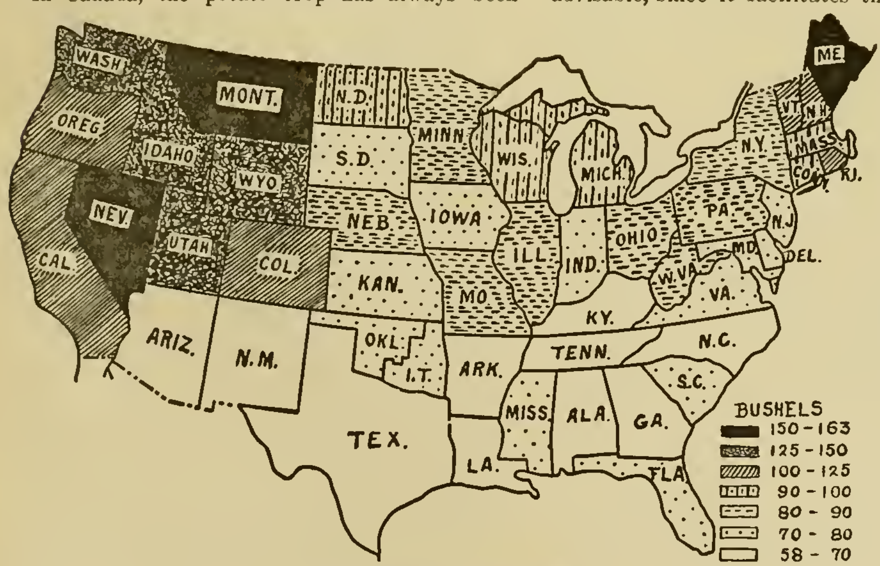

Fig. 746. Potatoes. To show the average yield per acre in bushels for the five-year period, 1900–1904. Compiled from Yearbook United States Department of Agriculture.

spring and disked in. It is important for potatoes that there be plenty of humus, hence the crop is frequently grown after a crop of clover or on a two-year-old sod. It would do well after a much older sod, but there is likely to be trouble from wireworms and white grubs; for this reason, when potatoes are to be planted on such land, it is considered advisable to follow another crop, such as oats or corn, by potatoes, which may then be grown for two or three successive years if desired. If commercial fertilizers are applied, generally a complete fertilizer — containing nitrogen, phosphoric acid and potash—gives best results. Nitrate of soda is a good source of nitrogen for potatoes.

Fig. 747. A "long" potato, with shallow eyes; peels with little waste.

Seed.—The seed tubers may be planted whole or cut; a piece weighing about three ounces, or as large as a good-sized egg, and having at least one good eye, being the most profitable. It pays to dig the heaviest-yielding plants by hand and save their progeny for seed. Heavy-yielding plants will generally reproduce heavy yielders, and vice versa. The tubers used for seed should be sound, free from coarseness and second growth and be true to name. If planted in rows thirty-six inches apart and the plants fifteen inches asunder in the row, it will require about seventeen bushels of seed per acre.

The storage of seed is a very important factor. It should be kept in a cool, well-ventilated place to prevent much loss of weight, until ten or fourteen days before planting time, when it may be spread on the barn floor or in some well-lighted place, which will cause the seed to begin to grow before planting. The shoots made under such conditions will be very small. If the seed is scabby, or from scab-infested land, it may be treated with formalin. [See next page under *Enemies*.]

Seeding.—Planting may be done by hand or machinery, the latter being by far the cheaper way, although still unsatisfactory, because there is no planter, known to the writer which will handle a seed piece of the size required. On sandy loam soils the seed may be planted three or four inches deep, and level culture adopted with profit. Under other conditions, planting two or three inches deep and subsequent drill culture may be good practice. Where irrigation is practiced, rows are often four feet apart, but under other conditions three feet is generally considered ample.

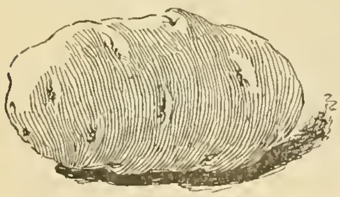

Fig. 748. A "long" potato, difficult to peel economically.

The time of planting depends on whether an early, mid-season, or late crop is being grown. Generally the early crop is put in as soon as settled weather comes and the ground is workable. Care must be taken that the plants are not frosted, as they are sensitive. The late crop is planted in the middle or latter part of May in the North. [The planting dates throughout the country are given in Chapter VII, pages 138–140.]

Subsequent care.—Cultivation begins a few days after planting and consists of harrowing the land with the spike-toothed harrow or the weeder to destroy all weeds before they are well started, a policy that should be rigidly maintained. The weeder may then be used once a week until the plants are seven to ten inches tall. By this time the plants may have been cultivated once, with the cultivator set three or four inches deep; they should receive subsequently about four more cultivations, each one shallower than its predecessor, the second one being not more than two to two and a half inches deep, thus giving a total of about five cultivations at intervals of seven to ten days. By this time the tops will meet in the rows.

Varieties. — In choosing a variety to plant, a number of factors must be considered. Among these may be mentioned:

Fig. 749. A "round" potato, with shallow eyes.

(1) Good cooking quality and flavor. These are partly influenced by the soil, season, fertilizers, ability to mature before frost and other factors.

(2) Yield. This is dependent on adaptation of the variety to its environment.

(3) Ability to resist diseases. No blight-proof variety exists, but some possess more resistance than others.

(4) Color of skin and tuber. Some markets require one color, others another.

(5) The nature of the skin. A netted or rough skin is preferred.

(6) The shape. Some markets discriminate in favor of a particular shape. Varieties are sometimes classified according to shape, as round, flat round, kidney and the like.

(7) Depth and frequency of eyes. Deep and numerous eyes are not economical in peeling.

(8) Time of maturity. In the northern states varieties are classified according to the time taken to form salable tubers; thus, "earlies" are ready to harvest in 70 to 90 days after planting, "second earlies" in 90 to 130 days, while late varieties may sometimes continue to grow for 200 days.

(9) The character of the foliage and top. Straight upright stems bearing thick hard leaves are desired, since such are probably less liable to diseases, and are easier to spray.

(10) The vigor. The variety and the strain secured must be vigorous and not subject to second growth of the tubers.

(11) True to name. The variety should be what it is purchased for.

Many thousand varieties of potatoes have been developed during the past hundred years. Among prominent varieties of today may be mentioned:

Fig. 750. **Beginning of late blight on left.** Right spray good, but showing a few holes made by flea-beetles.

Earlies: Bliss Triumph, Early Ohio, Six Weeks Market, Early Thoroughbred, Bovee, Reliance, Crown Jewel, Noroton Beauty, Burpee Extra-Early, Eureka, Early Rose (some strains). *Second earlies:* Burpee Extra-Early, Eureka, Beauty of Hebron, Polaris, Irish Cobbler, Early Rose (some strains). *Late:* Carmen No. 3, Sir Walter Raleigh, Rural New Yorker No. 2, Vermont Gold Coin, State of Maine, Green Mountain, Freeman, Burbank.

Potatoes sometimes sport or "mix" in the hill, and these bud-sports may be treated as new varieties. Practically all the new varieties of potatoes, however, are produced from seed, for every seedling is likely to be different from the parent. Seed-balls are not produced abundantly on most varieties. If it is desired to produce new kinds, the seed should be saved and treated as tomato seed is treated, being planted the following spring. The first year the plants are small and slender, and the tubers will also be very small. These tubers are saved and planted the next year, when a crop of good-sized tubers may be expected, showing their characteristics. If it is desired to combine features of two varieties, the flowers may be crossed; and the resulting seed will produce hybrids.

Harvesting and storing.—Early potatoes are dug as soon as large enough for sale. Late varieties are left until the vines are dead; should the vines be killed by blight and it is intended to store the tubers, the digging should be delayed, if possible, until ten days after the date the vines died. The grower should harvest when the land is dry, pick up the tubers at once and keep them cool. In storage the tubers should be held between 32° and 40° Fahr., be well ventilated and kept dark.

Potatoes may be stored in the open, in piles covered with straw and earth, in cellars or root-houses according to the climatic conditions. In the northern states the cellar is the most advantageous, since the conditions can be more easily controlled, and the crop may be inspected or sold at any time. The cellar should be kept dark. With sound tubers, the loss in weight in storage may vary between 5 and 20 per cent in the five winter months. Both temperature and the moisture content have an influence, a high temperature increasing and a high moisture content diminishing the loss. Nobbe found that about 75 per cent of the depreciation is loss of the water content.

Enemies.

Diseases.—In the northern and north-central states the two most serious diseases are the early and late blights. The early blight (*Alternaria solani*) is a fungus which attacks the leaves, entering frequently through holes made by flea-beetles. It comes on earlier in the season than the late blight and does not cause rot of the tubers. The late blight (*Phytophthora infestans*, Figs. 750, 751, 752), another fungous disease, injures and often destroys the leaves, stems and tubers, and is probably familiar to most growers. These diseases spread by means of spores which germinate on the potato leaves and stems and produce the fungus that causes the diseased appearance. If the leaves and stems be kept coated with some fungicide, as Bordeaux mixture, it prevents the germination of the spores and helps to check the spread of the disease.

Potato rosette attacks the stem, causing the leaves to grow in clusters. It reduces the yield in many parts of the country. The disease is caused, in part at least, by *Corticium vagum solani* (*Rhizoctonia solani*). One form of this fungus develops scale-like bodies on the tubers, causing the "black scale" of potatoes.

Fig. 751. Shoot killed by blight.

Scab (*Oöspora scabies*) is a fungous disease which appears on the tubers. For treatment, the seed tubers should be immersed for two hours in a solution of formalin of the strength of one pound of formalin to thirty gallons of water. If the seed is not planted at once, it should be spread thinly to dry, and should be planted on scab-free soil.

Dry-rot (*Fusarium oxysporum*).—This disease attacks all parts of the plant below ground and produces a gradual premature death of the plants. Infected tubers rot and shrivel. This fungus causes more or less loss to the potato crop in all sections of the United States.

A good and rather long rotation of crops is of value in combating all of these diseases.

Insects.— The flea-beetle (*Crepidodera* [*Epitrix*] *cucumeris*) attacks the leaves, puncturing them and thus furnishing an easy entrance for spores of diseases. Spraying with Bordeaux mixture as soon as the insects appear is of value. It acts as a deterrent. On the Pacific coast other flea-beetles occur, and for such the use of arsenites alone or in Bordeaux mixture is advised.

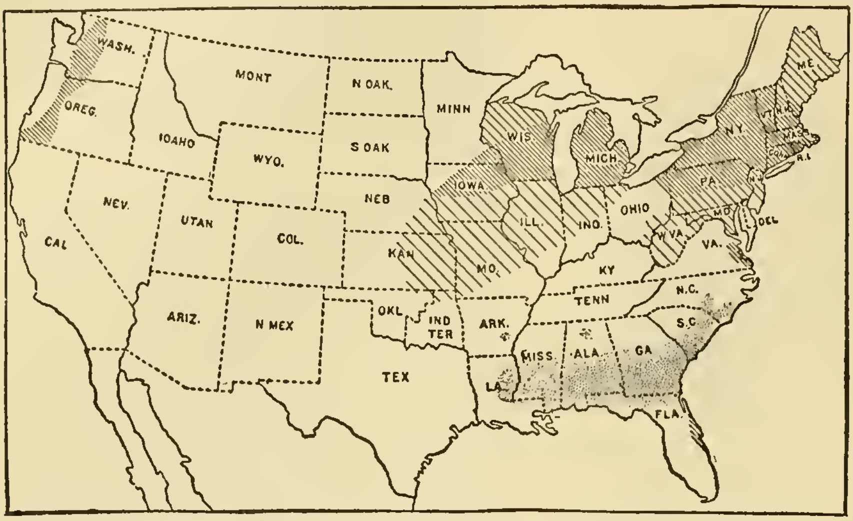

Fig. 752. Distribution of late blight (*Phytophthora infestans*) of potato indicated by lines, and of cotton-wilt (*Neocosmospora vasinfecta*) indicated by dots. Yearbook, Department of Agriculture, 1903.

The potato-bug or Colorado potato-beetle (*Doryphora decemlineata*, Fig. 753), the larva of which attacks the foliage, is destroyed by spraying with Paris green or some other arsenite in a solution, preferably Bordeaux mixture, using one-fourth to one-half pound of Paris green to fifty gallons of solution, and applying 150 to 200 gallons per acre when the foliage is well grown.

The old-fashioned potato-bug or blister-beetle (*Epicauta vittata*) is combated in the same way as the Colorado potato-beetle. It is now rarely seen. The potato-worm (*Gelechia operculella*) is injurious on the Pacific coast. The potato-stalk weevil (*Trichobaris trinotata*) attacks the stems. It is found from Canada to Florida.

Uses.

In the United States, potatoes are used almost entirely as human food, a few million bushels being used for the manufacture of starch. They may be desiccated and in this form can be readily transported. In Europe, large quantities are used for the manufacture of starch and alcohol, the latter being a cheap source of power for motors. Potatoes are also used as a stock-food, either raw, cooked or as silage. [For the making of alcohol, see Part II of this volume.]

Marketing.

Potatoes are sold by the pound, peck, bushel, barrel, cental, sack and car lot. The bushel box is the most convenient package for a home market. The barrel and sack are often used in shipping. The potatoes must be graded before shipment and all small, diseased or ill-shaped tubers sorted out. Eight to 10 per cent commission is usually charged by salesmen in New York, Philadelphia and other markets. When potatoes are shipped any distance by rail, it not infrequently happens that of the price paid by the consumer for a bushel of potatoes about two-thirds is required to defray the cost of transportation and distribution, and one-third is left for the grower.

Machinery. (Figs. 754–760.)

Potato machinery is in a much less satisfactory condition than that used by the grain- or hay-grower. There are no potato planters which will plant all the tubers all the time unless a man sits behind to look after them; 80 to 95 per cent perfect is the best that has been attained automatically. Few of the potato spraying machines carry enough nozzles to ensure the covering of the whole of the plants with the spray. With potato harvesting machinery the aim has been to supply a two-horse machine, and in some cases these are efficient, but in some soils three or four horses are necessary to handle the same machine. The shovel plow is not an efficient tool and is of little value for the commercial grower. The elevator diggers, of which there are several makes, are a distinct advance. There are two types, the high elevator, in which the potatoes and soil are lifted to a height of two or more feet up an inclined plane and shaken meanwhile, and the low elevator, in which the soil and potatoes are elevated very little, but are passed backward over disk-like rollers.

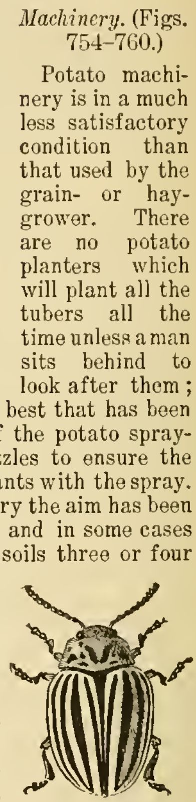

Fig. 753. Potato-beetle (*Doryphora decemlineata*).

In spite of defects, any commercial grower who has ten acres of potatoes needs a planter, sprayer, cultivator and digger of the most approved types. With a good planter a man can open, distribute the fertilizer, plant and cover three to six acres per day, and by changing teams during the day the machine may be run at the maximum figure. A weeder will cover twenty acres a day once. With reasonable facilities for filling, a spraying machine taking five rows should cover one to one and a quarter acres per hour of work, or about ten acres per day, once over. A two-horse cultivator set to take two rows will cover eight to ten acres per day, going once in a row. A man without machinery will dig one-eighth to one-half an acre per day, depending on the crop and the soil, at a cost of two to six and sometimes eight cents per bushel; with a good mechanical digger and three or four horses and eight to sixteen hands to pick up, three to six acres may be dug per day at a cost not exceeding two cents per bushel.

A specific example.

While the average yield of potatoes in the United States is less than ninety bushels per acre, it is wholly practicable, on good potato soil, to produce three to five times that yield. It is doubtful whether it pays to raise less than two hundred bushels to the acre. Whether it pays to raise more than three hundred bushels depends on the price of labor and the ability to secure it advantageously. By superior tillage, the yield may very easily be placed beyond three hundred bushels, if the land is right; but if this requires the keeping of an extra team throughout the year in order to have it when

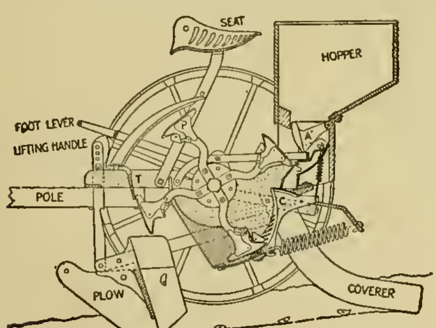

Fig. 754. A potato planter in cross-section.

the potatoes need tilling, it is a question whether the crop would return a profit. The question of farm organization at once arises, for there should be other productive work for the extra teams and men at other times of the year.

The farm methods employed in producing more than four hundred bushels of potatoes to the acre on a particular farm (T. E. Martin, West Rush, New York) will illustrate the discussion in this article. The land (good loam) is in a three-year rotation,—wheat, clover, potatoes. Potatoes is the money crop. The land is underdrained. Plowing has been lowered gradually from six to ten or twelve inches. The plowed land is rolled, and then deeply harrowed three or four times. When necessary, parts of the land are rolled again and worked over several times with harrows. Home-mixed fertilizer is drilled in at the rate of 1,600 pounds to the acre, so mixed as to contain $2\frac{3}{4}$ per cent nitrogen, $9\frac{1}{4}$ per cent phosphoric acid, 15 per cent potash. Counting the mixing, the fertilizer costs about thirty dollars per ton. The soil is considered to be deficient in potash.

The potatoes are planted on a rolled surface in order to secure uniform depth and a good stand. The rows are thirty-six inches apart, seed placed three inches deep, and about eleven inches in the

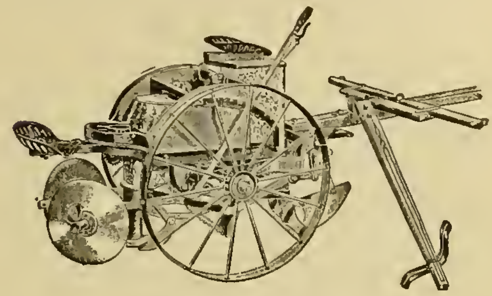

Fig. 755. Potato planter.

row, requiring sixteen to twenty bushels of seed, cut to one or two eyes. Rows are placed at three feet in order to facilitate spraying. On high-priced truck-garden land, closer planting may be advisable. The tubers are planted with an automatic cutting, dropping, furrowing and covering machine.

The fields are tilled ten to fifteen times. With the good preparation of land and efficient tools, this extent of tilling is not laborious nor expensive. Level culture is practiced, but considerable ridges are formed by the time the vines cover the ground. A riding double-row cultivator and one-horse weeder are used. Tillage invariably begins within a week after planting, by following the potato-row lines. The first and second times over, very narrow teeth are used, set deep. The third and fourth tillings are made as soon as the rows can be followed, working deep and very close to the plants. Immediately following the fourth cultivation, the weeder is used, as a rule, running twice over the field, crosswise and lengthwise, the lengthwise treatment pulling the plants up straight so that subsequent working is not interfered with. Seven-inch side teeth are now used on the cultivator, throwing a small, sharp ridge directly on each row, burying the weeds. The fields are hand-weeded once or twice; and, in this operation, all weak, diseased or prematurely ripening potato plants are pulled up, being treated as weeds.

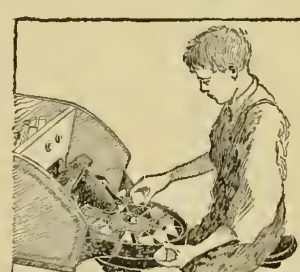

Fig. 756. The platform of one of the planters.

Spraying is accomplished by means of a two-wheeled geared machine, developing sixty to eighty pounds pressure and carrying the nozzles ahead of the wheels. On eighteen acres in 1906, there were used 331 barrels (of fifty-five gallons) of Bordeaux mixture, entailing a cost per acre for spraying of twelve dollars. Careful tests showed that the spraying saved, above its cost, about forty dollars per acre. Spraying began July 2 and was completed September 10. The area required about one ton of sulfate of copper in crystals, and fifteen barrels of stone lime. The formula is six pounds of sulfate, six pounds of lime, fifty gallons of water; also two pounds of Paris green per acre are added. Each application is made in opposite directions, two such sprayings being called a double application. From the time the vines cover the ground, at the beginning of each double application all nozzles are directed to the right, then into the centers twice over and then to the left twice over. This plan requires three double applications, and the spray is directed against the plant from six different positions and angles; at the completion of the sixth spraying, every part of the plant is copper-plated.

The last week in September or the first week in October, while vines are still green, harvesting is

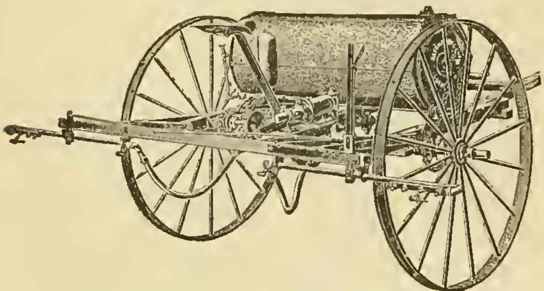

Fig. 757. Four-row potato sprayer.

begun. A four-horse elevator digger is used. In 1906, the crop on eighteen acres was dug and picked up in six and one-half actual days, the total crop being 7,510 bushels, or 417 bushels to the acre. (Fourteen years previous, when Mr. Martin took the farm, the average yield was sixty bushels per acre. A good part of the above crop was hauled directly to the station and sold at forty cents; 136 bushels only were sold as low as thirty-eight cents). The heaviest day's work in the harvesting in 1906 was as follows: Twenty-one helpers, little and big; three and three-fourths acres dug and picked up; three two-horse rigs drew seventeen loads to cars one mile distant, comprising 1,011 crates; digging teams drew 283 crates on trucks to the barn; at six o'clock there were left on wagons and in the field 207 crates; total 1,501 crates. A break-down in the digger caused delay of one hour and loss in handling of 200 bushels.

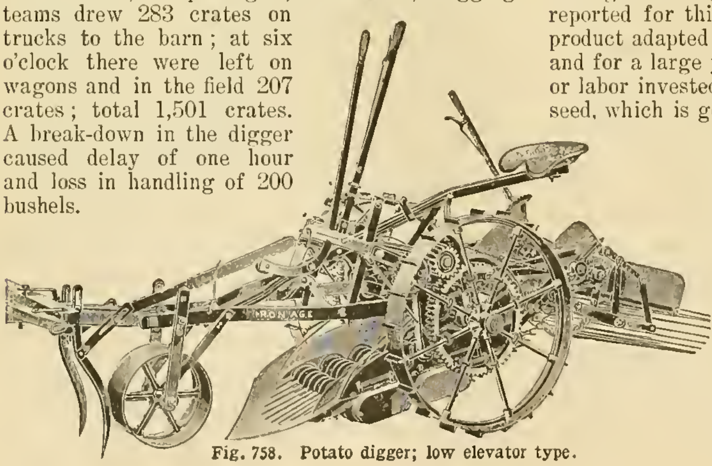

Fig. 758. Potato digger; low elevator type.

Potato tops are all raked and burned immediately to destroy disease. The ground is worked about twice with the spring-tooth harrow and sown directly to wheat, after applying about 400 pounds of

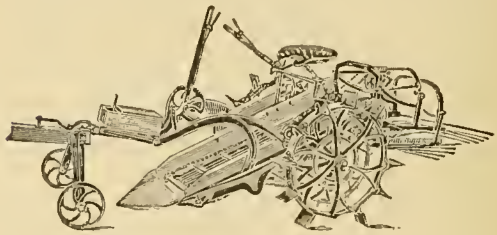

Fig. 759. Potato digger; high elevator type.

home-mixed fertilizer. Eight quarts of choice timothy seed is drilled to the acre at this time. The following spring, clover or alfalfa, or both, is added.

In such high-class potato-growing as this, special attention must be given to the stock seed. A "seed piece" of two acres is grown according to the very best approved methods. This area is planted with the choicest large tubers, and all inferior plants are eradicated as rapidly as their deficiencies become known. Very promising hills are saved for stock seed the following year. This "seed piece" or field supplies the tubers for raising the main potato crops.

European experience.

The potato crop assumes great importance in Europe, partly because the corn plant is not successful, and the potato is the cheap starch-producing plant. It is the standard crop for starch and alcohol factories, is the staple food of the poor, and is much fed to stock. The aim, as compared with American potato-growers (and reported for this article by L. R. Jones), is for a product adapted to one or another special purpose, and for a large yield quite irrespective of the seed or labor invested. Careful attention is paid to the seed, which is generally secured from more northerly countries. The crop from the best northern-grown seed is considered more disease-resistant and more productive. The origination of new varieties has been especially stimulated during the last two decades in Great Britain and Germany, in order to meet the more specialized demands. Seed-balls are more abundant, owing probably to climatic conditions, and hence less difficulty is experienced in crossing varieties. In Great Britain, where potatoes are

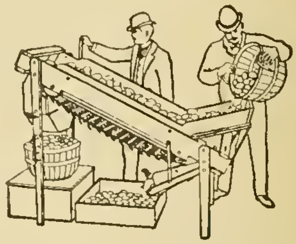

Fig. 760. Potato sorter.

grown primarily for table use, the ideal tuber is white-fleshed, rich in starch, medium size, oval, smooth and with shallow eyes. Much attention is given to securing increased disease-resistance. On the continent the ideal table variety is smaller, yellow-fleshed, relatively poorer in starch and richer in proteids. The breeding of starch-rich varieties for stock-feed and factory purposes has received attention, especially in Germany and Austria.

Potato-growing in the South.

By *H. Harold Hume.*

In recent years the potato, in common with other truck crops, has received an increasing share of attention in the southern states. On the Atlantic seaboard the southern potato territory may be said to extend from Florida to Virginia, the area of greatest production being in northeastern North Carolina and around Norfolk, Va.

Cropping system.

One of the principal differences in the culture of the potato in the North and in the South is that in the South two crops are grown, one in autumn and the other in spring. The spring crop is by far the larger and more important, being grown to supply the northern spring demand for new potatoes, while the relatively small fall crop is disposed of locally. Planting for the fall crop in Florida is made in late September or early October; in the latitude of Savannah, in the latter part of August or early September; and farther north in the early part of August. The spring crop is generally planted in the latter half of January and in February and March, depending on the section. This crop is marketed between the latter part of April and the middle of July.

Culture.

Varieties.—Earliness is the principal consideration in the selection of varieties for the southern crop. If the variety is not early it will not meet the exacting conditions imposed on the culture of the crop by market competition. The favorite variety with Florida planters is Early Rose No. 4, nine-tenths of the seed used being of this variety. In other sections Bliss Triumph (Red Bliss) and White Bliss are grown, though the latter, because of its being a white variety, although equally early, is not so favorably received in the markets.

Seed. — Generally, seed grown in the North (Maine, New York and Michigan) or Virginia second crop is preferable for use in the extreme south, although in the more northerly sections seed from the fall crop will give good results for spring planting. Throughout the whole area seed from the spring crop is used for fall-planting.

Preparation of the land. — The best preceding crop for potatoes in the South is a cover of cowpeas. The land should be broken two or three months in advance of the spring-planting, thoroughly harrowed and ridged slightly. Unless the land is very well drained, ridging is advantageous in increasing the earliness of the crop, and everything which will hasten the growth of the spring-planting must be carefully considered. The rows may be laid off as close as three feet apart if a single planting is to be made, but if corn, cotton or some other crop is to be planted between the potato rows they should be five feet, or thereabouts, apart.

About a week or ten days before time of planting, depending on weather conditions, the commercial fertilizer required for the crop should be distributed on the slight ridge referred to, and a second higher ridge thrown over it.

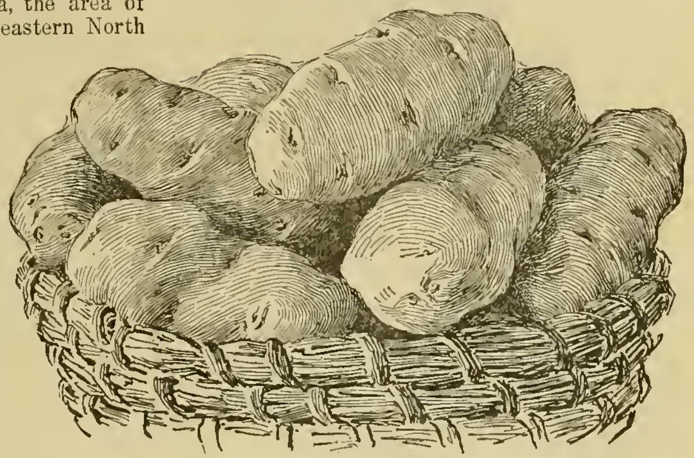

Fig. 761. Lady-finger potatoes.

Fertilizer.—To force the crop, large amounts of fertilizer must be used. There is always a considerable amount which does not become available for the crop during its growing season, and to make up for this a greater quantity must be applied. If the crop could be allowed a longer growing season, much less fertilizer would be required. The amount used, of course, will vary with the previous cropping of the land and the amount of native available fertility; but, in general, 1,000 to 2,000 pounds per acre should be used. Florida planters generally use one ton per acre. While these amounts may seem excessive, the crop does not use all the fertilizer, and the residual supply may be used to good advantage in producing corn, cotton, hay, or some summer truck crop, which should always follow.

A good average fertilizer should analyze 4 per cent ammonia, 6 per cent phosphoric acid and 7 or 8 per cent potash. Both organic and inorganic sources of ammonia may be used. Nitrate of soda is frequently very helpful in starting the crop. It should be used as a side dressing at the rate of 100 or 150 pounds per acre after the plants are two or three inches high. The phosphoric acid is derived almost solely from phosphatic rock. Sulfate of potash, because of its effect in improving the quality of the potato, should be given the preference over other sources of potash.

The fertilizer may be applied in one or two separate applications. On the whole, except possibly on very light soils, where loss from leaching may occur, it is just as well to put the entire quantity in the soil before planting the crop.

Fig. 762. Berries or seed-balls of the potato.

Planting.—The ridge should be split open and the seed dropped on the normal level of the ground or a little above it. It may be dropped by hand and covered with a disk-cultivator, but in all large plantings the potato-planter must be used.

To secure a more uniform stand and stronger plants, the seed should be exposed to strong light (not sunlight) for some time before planting. Seed intended for fall-planting should be spread out under the shade of a tree, covered with pine-straw and allowed to sprout before planting. Only that seed which has sprouted should be used. The potatoes should be cut and planted immediately afterward. Cutting by hand is preferred, as a larger yield is generally secured. The cost of cutting the seed and planting (if a planter is used) is two to two and one-half dollars per acre.

Cultivation.—In normal seasons, all the necessary cultivation can be done with a weeder and disk-cultivator, although if crab-grass gets a start, as it frequently does in wet weather, the hand hoe must be used. Even then the cost of hand-work should not exceed twenty-five or thirty cents per acre. The disk-cultivator puts the middles and sides of the rows in excellent condition, while the weeder can be used to stir the tops of the ridges until the vines are five or six inches high. If the stand is good, the ridge tops will then need little or no further attention. During the season, six to eight cultivations should be given to secure the best yields. When the tops begin to spread, cultivation may be discontinued. If cold weather is approaching when the plants are two or three inches high, they may be covered with the disk-cultivator and allowed to grow out again without uncovering. If larger, they may be partially covered.

Digging and packing.

When the tubers are two-thirds grown, they are ready for digging. A good average yield at this stage of growth is fifty barrels per acre. If the area is large and considerable time is taken in digging, a yield of fifty barrels at the beginning will run up to seventy-five or eighty barrels toward the close of the work, the greater yield being due to the increase in the size of the potatoes.

Many growers prefer to dig by hand, as the mass of green vines and the tender skins of the new potatoes often make the use of a digger unsatisfactory. In digging by hand, the ridge should be barred off on both sides, the remaining part being leveled down and the potatoes exposed, using ordinary prong hoes.

The potatoes should be graded into firsts and seconds as they are picked. Two gangs of pickers in charge of competent foremen should be employed, one gang to pick up the firsts, the other, the seconds. The less handling the potatoes receive the fewer breaks there will be in the skins. The barrels of firsts and seconds should be lined up in separate rows, to prevent mistakes. The pack should be full, well shaken down and the head forced into place with a barrel press. Then the barrels are headed and stenciled.

The barrels should be new, clean and bright. Proper ventilation can be secured by means of one-inch auger holes, fifteen or sixteen in number, bored in the sides.

Potato literature (Fraser).

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PUMPKIN AND SQUASH FOR STOCK-FEEDING. *Cucurbita Pepo*, Linn., and *C. maxima*, Duch. *Cucurbitaceæ*. Figs. 763-764.

By *S. Fraser*.

Varieties of pumpkin and squash are grown for stock-feeding. The Mammoth Chili is one of the large squashes and the Connecticut Field is the standard pumpkin, these being among the best kinds for feeding.

Fig. 763. Staminate flower and leaf of common field pumpkin (*Cucurbita Pepo*).

So long as hand labor was used in working corn it was a common practice to put a few pumpkins in with the corn; but, with the advent of machinery and of tillage until the corn plants are tall, the custom has rightly fallen into disrepute. It is a better practice, in most instances, to plant the crop by itself.

Culture.

A sandy loam soil is preferred. It should be in good condition and be given a deep fall-plowing. It may be marked off in checks 8 x 8 feet or 8 x 10 feet in the fall, and manure applied near where the hill is to be planted; or this work may be done in spring. The manure is covered with soil, and some fertilizer may be added if deemed advisable. About three pounds of seed are planted per acre, and finally three or four plants are left in a hill. Constant cultivation is given until the spreading of the vines checks it.

The crop should be harvested and used or stored before severe freezing. For storage, the fruits should be carefully handled, not cracked or bruised, the stem left on, and kept in a dry and moderately warm cellar. Two or three mature fruits on a vine is considered to be a good crop and may give a yield of thirty or more tons per acre. Since the cost of production is small, this is often a very remunerative crop.

Uses.

Thus far the pumpkin has been viewed as roughage, as competing with silage in the ration. That this is the correct view does not appear to have been proved. The average analysis shows that its percentage composition is, water, 90.5; ash, 0.5; protein, 1.3; crude fiber, 1.7; nitrogen-free extract, 5.2; ether extract, 0.4. About 80 per cent of the dry matter is regarded as digestible. Henry states, "For dairy cows the pumpkin is an excellent fall feed, none being more highly relished; for swine in the first stages of fattening it is useful either fresh or cooked with meal." In feeding value, the pumpkins and squashes should rather be compared with roots and cabbages. It is probable that increased attention will be given to these crops, as more careful feeding practices are developed; at present they are merely incidental crops so far as stock-feeding goes. This brief article is designed to call attention to this class of plants as feeding products.

Enemies.

The striped cucumber beetle may destroy the plants while young and the squash bug is sometimes a serious pest. The former is difficult to combat successfully. Arsenical poisons are effective, but injure the foliage. The best results generally follow the planting of an early trap crop of squash, which is sprayed with arsenical poisons. The main crop is then sprayed with Bordeaux mixture. The squash bug is combated by keeping the fields free from rubbish, trapping with squash leaves and examining daily, and by hand-picking of the old bugs early in spring.

Literature.

Squashes: How to Grow Them, J. J. H. Gregory (1889), Orange Judd Company, New York; Farmers'

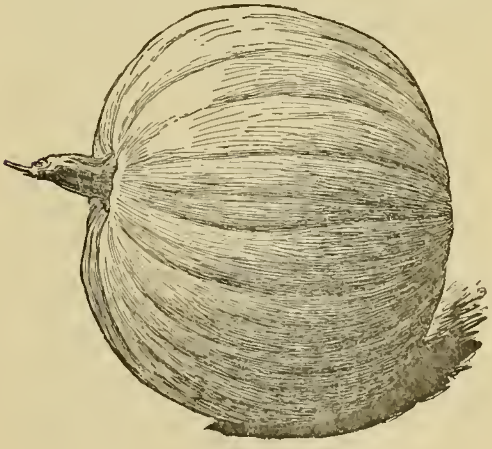

Fig. 764. Connecticut field pumpkin.

Cyclopedia of Agriculture, Wilcox & Smith, Orange Judd Company; Principles of Vegetable-Gardening, L. H. Bailey, The Macmillan Company. For insects and diseases, New Jersey Experiment Station, Bulletin No. 94; New York State Experiment Station, Bulletins Nos. 75, 119; Massachusetts State Report, 1892, p. 225; same, 1890, p. 211. There is little literature on the growing of these plants for stock-feeding; the above references are to horticultural writings chiefly.

RAPE. *Brassica Napus*, Linn. *Cruciferæ.* Figs. 765–767.

By *A. L. Stone.*

Rape is grown primarily for forage and for the manufacture of oil from its seeds; also for bird-seed. It is closely related to the mustard, cabbage, cauliflower, kohlrabi, kale and turnip. In appearance it very closely resembles the rutabaga or Swedish turnip. Unlike the rutabaga, however, the rape plant runs almost entirely to leaves, and its roots, instead of being bulbous like the rutabaga, are fusiform or stringy, and resemble those of the cabbage. The leaves of the rape have the bluish shade characteristic of the rutabaga, and are variously cut and curled. The leaves grow very rank and are sweet, tender and very succulent. The plants grow to be one to four or more feet tall, according to soil and season.

Fig. 765. Dwarf Essex rape, showing growth of two months.

Rape may be either annual or biennial, depending on the variety. The annual or summer varieties are grown almost entirely for purposes of seed production, while the biennial or winter sorts are cultivated for forage purposes. In either case, at flowering time the plant bears large numbers of bright yellow flowers about one-half inch in length and the same in diameter at the crown. The seeds are small and black, with roughened seed-coats, and to the uninstructed are difficult to distinguish from those of other members of the mustard family. The annual varieties are reproduced by seed each year; the biennial varieties, under favorable conditions, live through the winter and produce seed the second season. Bird-seed rape is a good example of the former, and Dwarf Essex rape (Fig. 765) of the latter. Rape must not be confused with colza (page 307).

History.

Rape has been known in England since the sixteenth century, and may possibly be native there, although there seems to be no definite information concerning that fact. As early as the seventeenth century large quantities of oil were made from rape seed in England and on the continent. The quantity has increased, until today rape-seed oil occupies an important position in the trades and manufactures of Europe. The rape plant is now distributed over practically all of Europe, northern Asia, Canada and the United States.

Forage rape has been known and grown for as many years as the bird-seed rape, from which the oil is manufactured. It has long been a strong factor in the feeding practices of English and Scotch farmers, and has been grown in Canada for more than thirty years. Many farmers in the United States have come to recognize its value as a soiling crop, and its production here has rapidly increased in the last ten years.

Whether or not the growing of the German or bird rape is ever practiced to any great extent in the United States will depend largely on the coal-oil supply. If the time ever comes when we need to depend on vegetable oils for illuminating and lubricating purposes, rape oil will be one of the most important.

Culture.

Soil.—Any good, arable soil will produce good crops of rape, but the plant is a gross feeder and the best crops are secured on soils which are very fertile and contain large quantities of humus or vegetable matter. Good sod land, turned over in the fall and given thorough preparation in the spring, makes a good seed-bed for rape, the roots of which will penetrate the sod and make use of all available nourishment. Rape can also be grown to advantage on new land, as it will there produce abundantly and stumps and roots will not prevent stock pasturing it off.

Fertilizing.—Rape can utilize a very large amount of plant-food, and it seems impossible to furnish available nutrients in too great quantities. The best method of applying manure is to spread it on sod in the early fall and plow later. Any soil nutrients that may have leached down will then have been absorbed by the grass roots and held near the surface. Plowing late in the fall will preserve a large share of the fertilizer and at the same time allow the sod to decompose during the winter, and thus assure a good seed-bed in the spring.

It is a custom in some places to follow a grain crop with rape without plowing. In such cases a disk-harrow set to cut well and to lap one-half will provide a seed-bed in which seed may safely be sown. If the season is favorable a good crop of fall pasturage can thus be secured. A corn-field after the last cultivation is sometimes used as a seed-bed, and where the rainfall is sufficiently heavy and the corn not too thick, good crops may be secured. However, the season is an exceptional one in which this method will meet with success, as the corn crop usually makes use of all the sunlight and moisture that are available.

Another method which has proved very successful in some sections is to sow rape with oats. The rape in this case should be sown one to two weeks later than the oats, to give the best results. If the rape is sown at the same time, it is likely to grow as rapidly as the oats, causing great inconvenience in cutting the grain and sometimes producing moldy bundles. Because of the great succulence of the leaves, they are slow in drying. When the rape seed is sown a week later than the oats, it can be harrowed in with a light smoothing harrow without much damage to the oats. The oats thus get well along before the rape starts and at harvest time very few of the rape leaves get into the bundles and no damage results. After the grain is cut the rape comes on rapidly, and in the course of three or four weeks sheep may be turned on it.

Varieties.—There are several varieties of rape, some of which make good forage and others of which do not, so that in ordering rape seed it is necessary to designate the kind. Experiments at various experiment stations, notably at Ottawa (Canada), Wisconsin, Minnesota and Michigan, have demonstrated the Dwarf Essex rape to be the best variety for forage purposes. If seed-growing for purposes of oil production is contemplated, then seed of some annual variety should be sown.

Seed.—The rate at which the seed is to be sown depends on the seed, the soil and the method of sowing. The seed should be well developed and give a strong and vigorous germination. Before ordering the bulk of seed for sowing, it is well to request one or more dealers to send samples of seed. These can then be examined to see whether there are any weed seeds or other impurities in the seed, and germination tests can be made. [See article on Seed-testing, page 141.] Rape seed that will not give a germination test of over 90 per cent should not be purchased. The seed weighs sixty pounds to the bushel and can be purchased in quantities for about five cents a pound.

Seeding.—Rape seed is sown in drills or broadcasted. When broadcasted, the seed should be sown at the rate of three to four pounds to the acre, depending on the physical condition and fertility of the land. It may be sown to advantage with a grain drill, set to sow the proper amount, or with a hand-seeder if the field is not too large.

When sown in drills, rape should be seeded at the rate of two or three pounds to the acre, and the drills should be thirty inches apart. The rape can then be cultivated and its growth will be more rapid. It should be cultivated often enough to keep down the weeds, and after every rain to conserve the soil moisture. The seed should be sown with a hand drill of some kind, or it may be sown with a grain drill by stopping the intervening holes in some way and leaving open those which are the proper distances apart. This is the best method of sowing, as when stock is turned on the rape the tendency is to keep between the rows and much less of the rape is trampled on and wasted. The plants remain upright until nothing but the stem is left, and if the stock is then removed for a time a second growth of leaves appears and often a third growth. This is seldom the case when the rape is broadcasted, as the plants are injured by trampling.

If the land is exceedingly rich, the seed can be sown more heavily than on soils of a poor grade, and this point must be considered in sowing. It is well not to sow the seed too thin in any case, as the forage is likely to be coarse and not so palatable. If rape is to be raised on very low ground, the seed should be sown on raised ridges, leaving opportunity between for good surface drainage. On ordinary soils this has been found to be unnecessary.

Place in the rotation.—Rape can be used almost anywhere in a rotation of crops, taking the place of the cultivated crop, such as corn, roots or potatoes. When grown by itself in this way the land should be free from weeds if the seed is broadcasted. If sown in drills, the land may be kept clean by cultivation. Rape may also be used, when sown broadcast, as a nurse crop for clover, for when the rape leaves are eaten off the clover begins to shoot up. Many good catches of clover have been secured in this way.

Harvesting and handling.

Owing to its great succulence it is impossible to cure the forage or biennial rape satisfactorily, and if it is in exceptional cases well cured it is not palatable and animals as a rule refuse to eat it. As a result, the forage rape is almost never cut for hay or for the silo, but is pastured or cut for soiling.

When rape is grown for seed it may either be cut with knives or be pulled. In either case it must be allowed to cure until thoroughly dry, after which it may be piled up in a barn or stack and threshed, at the convenience of the grower. If stacked outside, care should be taken to handle while damp enough to prevent shelling, and the stack should be covered with some rain-proof substance, such as marsh hay or boards.

Storage of seed.—After threshing, the seed should be stored in not too great bulk. Owing to the high oil content of the rape seeds they are liable to become rancid and to heat to an extent to spoil the germinating power.

The storage of the seed after cleaning is very important. The seed should be put in piles, not over three inches deep unless perfectly dry. When in a perfectly dry condition, the seed may be piled a foot deep in summer, and two feet deep in winter, but must be stirred with a shovel frequently to drive off the moisture which is absorbed in damp weather. When seed is to be dried rapidly, it should be turned twice a day. In all cases the drying bins should be subjected to a good circulation of air.

Cleaning the seed.—Before rape seed can be used for oil manufacture it must be thoroughly cleaned to remove all foul seeds and earthy material. In this cleaning process a six- or eight-sided cylinder is used, set on a slant of three-fourths to one inch to the running foot. This cylinder is composed of a fine screen for two-thirds its length and a coarser screen for the other one-third. The screen revolves at the rate of forty revolutions per minute, requires one-fourth horse-power to run it, and will clean sixty-four to seventy-two bushels of rape seed per hour. The whole apparatus is so set that a strong current of air carries away all dust. When the seed is very dirty the fall per running foot of the cylinder is diminished and the number of revolutions per minute doubled.

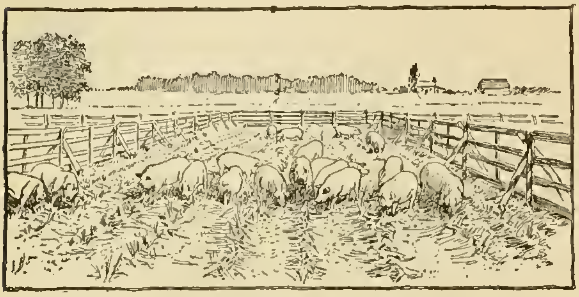

Fig. 766. Fattening hogs on rape. The fence is the hurdle shown in Fig. 767.

Care must be taken in caring for the seed to prevent attacks of mold and must, and the occurrence of rancidity in the oil and rape cake or meal. This can be done by being careful not to pile seed in too deep piles and by proper precaution in refining.

Feeding.

The principal uses of forage rapes are for soiling and pasturage. In the former case the plants are cut with knives or a scythe, and fed to stock in desirable quantities. In the latter case the animals are turned in to harvest the crop for themselves, which, after they become accustomed to it, they do very thoroughly and with a great deal of satisfaction. Rape resembles clover in its composition and should make a good grade of silage, but has not met with success as a silage crop. Whether fed as a soiling crop or pastured, it is a very palatable and valuable feed.

Rape has been shown to be a very valuable feed for fattening lambs and pigs, and has been fed even to dairy cows with satisfactory results, although when so fed it should follow rather than immediately precede the milking period. If fed just before milking, the milk is likely to have the cabbage flavor, and will to a greater or less extent taint the butter.

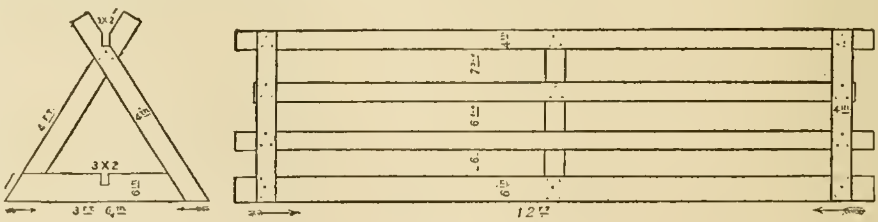

Fig. 767. Sketch of hurdle used in pasturing lambs and hogs on rape. The method of using this hurdle is shown in Fig. 766.

It has also been found impossible to make good cheese from milk obtained from cows receiving rape as part of the ration, and it makes practically no difference whether the rape is fed before or after milking. (Bulletin No. 115. Wisconsin Experiment Station.)

When turning lambs on rape, it is well first to have their stomachs partially full of some drier food, as the great succulence of the rape plant is liable to cause hoven or bloat and often scours, with fatal results. Especially is this true when the rape is still wet from a rain or heavy dew. Swine are not thus affected and can be turned in at will. A good plan is to have the rape-field adjoining a blue-grass pasture in which the sheep can feed for a time before being turned into the rape. After sheep have become accustomed to feeding on the rape they can be turned directly on it without harm.

When small numbers of animals are being fitted for show, a movable fence can be used and a small patch pastured at a time. A diagram of hurdle and panel for such a fence is shown in Fig. 767. In Fig. 766, the hurdle is shown in use. It sometimes happens that stock do not at first relish the rape, but all eventually learn to eat it and when once started eat it voraciously, cases being known when swine have even dug out the roots and eaten them. [For fuller discussion of comparable methods and results, consult the article on *Soiling*.]

It should be understood that, while very fattening, rape cannot be depended on as a single feed properly to fatten animals, but must be used in conjunction with a grain ration. Flesh made by feeding rape alone is likely to be soft and blubbery, and not of the firm handling qualities to suit either the stock judge in the show ring or the butcher on the block. [Further consideration of the feeding value of rape and other products may be expected in Vol. III.]

When cut for soiling, rape should be fed soon after cutting, for if left until badly wilted it loses its palatability. If not cut closer than four inches from the ground, it was found at the Wisconsin Experiment Station that three crops could be secured in a good year, yielding a total of thirty-six tons of feed to the acre.

In a favorable season, stock may be turned on the rape in about six weeks from the time of planting, but more often it takes eight weeks for rape to reach the best or most satisfactory feeding stage.

Manufacture of oil.

There are or have been several ways of crushing the seed for oil, and many machines have been constructed for each process. The early method was by use of a stamping mill in which the seed was run into mortars and crushed by means of stampers. This was a cumbersome process and gave way to the roller system, in which the seeds were run between rolls set at proper distances. The early system of rolling did not crush the seed fine enough and it was necessary to recrush by means of millstones or runners. This method also proved too costly and cumbersome, and was replaced by a machine in which were three sets of rollers. Each set was a little closer than the preceding, and the crushed seed passed from one to the other until, after passing the third set of rolls, it was in proper condition to go into the presses.

It was found later that the extraction of the oil was facilitated by heating the crushed seed before putting it into the presses. Enough of the pulp was placed in a shallow pan to make one cake—nine to eleven pounds. These pans were exposed to heat varying from 167° Fahr. to 176° Fahr., but never to 212° Fahr., as this would have damaged the oil. In the modern process of heating, the pulp is steamed to the required temperature.

Many styles of presses have been used, but all the more modern presses are operated by hydraulic power and are composed of several pans so arranged that pressure can be applied all at once. Experience has shown that a more thorough expression of the oil can be made when cakes are in separate pans than when several cakes are placed one on another in the same press with only the cloths between. The material for each cake is placed in a cloth so cut that the ends when folded overlap, making a perfect case. The cloths are composed of linen on one side and wool on the other, with ropes sewn between the two at intervals, thus giving the scalloped appearance to the cakes. The cakes are submitted to a pressure of 2,840 pounds to the square inch and the process of oil expression requires fifteen minutes. After the pressure is removed, the cakes are taken from the press and the edges trimmed on the assumption that the oil has been completely removed at the center of the cake, but has not from the edges. The material cut from the edges is mixed with a new lot and repressed.

The oil runs into a collecting reservoir from which it is pumped into a 2,000- gallon tank. From here the crude oil is pumped either into barrels for crude oil use or into refining reservoirs. In refining the oil it is exposed first to a heat of 86° Fahr., in an open vat to which $\frac{3}{4}$ per cent to 1 per cent of sulfuric acid is added with continuous stirring. In stirring, a vertical movement is preferable to a horizontal or rotary motion. From the heating vat the oil is run into a tank and washed several times with hot water, and then into a vat where 5 per cent of common salt is added and the oil left until, with the aid of the salt, it has become completely clarified. For the purest oils, suitable for table use, a filtrating process is resorted to in which the oil is run through successive layers of linen tow and moss.

Refined oil should be of a pale yellow color, clear, free from acid and without any rancidity. It should burn with a clear white light without soot or odor. Such oils are used for lights and, when specially treated, for table and cooking purposes.

Lubricating oil should contain as much fat as possible, be clear from acid and mucus and form no sediment. Such is the crude rape-seed oil, and this is its principal use.

By-products.

Rape-seed cake is a valuable by-product of rape-oil manufacture. The cake is broken by means of mills made for the purpose, where the cake passes between toothed steel cylinders. After breaking it may be ground into a fine meal in roller mills. This meal contains 9.23 per cent of oil and 5 per cent of nitrogen, which makes it a valuable feed, when it does not become rancid, and a valuable fertilizer at all times. It has been found that 85 per cent of the protein substances, 88 per cent of the fat substances, and 78 per cent of the non-nitrogenous substances in rape meal are digestible. While a valuable feed, rape-seed meal needs to be used in conjunction with other feeds, for when used exclusively it forms flesh of a soft and flabby and wholly undesirable character.

The high percentage of nitrogen contained in the meal and the amount of phosphoric acid in the ash make rape-seed meal a very valuable fertilizer. Analyses have shown 6.82 per cent of the meal to be ash, and of the ash 32.7 per cent is phosphoric acid. Besides these two valuable soil constituents, the meal leaves a residue of organic matter to improve the mechanical and water-holding properties of the soil. The 5 per cent of nitrogen contained in the rape cake is almost immediately available. In their experiments at Rothamsted, England, Lawes and Gilbert found that 70.9 per cent of the nitrogen in the rape-seed meal was utilized by the crop the season of application. In this it compared very favorably with nitrate of soda, of which 78.1 per cent was found to be immediately available.

Value.

Grisdale, of the Ottawa Experimental Farm, estimates the cost of growing an acre of rape at six dollars and ninety-five cents. The cost will, of course, vary with the locality, price of labor, and other factors. When care is taken, crops of 1,000 pounds of seed per acre are not uncommon. If sold at five cents per pound, the seed would bring fifty dollars per acre. Estimating the growing of the crop to cost ten dollars per acre, the rape would still give a net return of forty dollars per acre. This would surpass a crop of ninety bushels of oats per acre, taking into consideration the straw and the heavier soil-feeding of the rape. Rape may therefore prove a paying crop in some sections.

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RICE. *Oryza sativa*, Linn. *Gramineæ.* Figs. 768-773; also Fig. 531, p. 371.

By *S. A. Knapp.*

An annual plant of the grass family grown for its grain, which is used for human food. The seeds grow on short separate stems radiating from the main stalk, and at maturity stand at a height of two to five feet. The flowers of rice (Fig. 768) are perfect with six stamens, one borne in each spikelet, and usually with rudiments of others; the fruit or grain (Fig. 769) is oblong and obtuse and closely enclosed in the glume or hull, and it falls or shells easily, hull and all. The grain is used in a great variety of ways, and it probably supplies more human beings with food than any other single plant. Rice is extensively cultivated around the world in the tropical and subtropical countries, mostly following the shores. Its culture is very ancient.

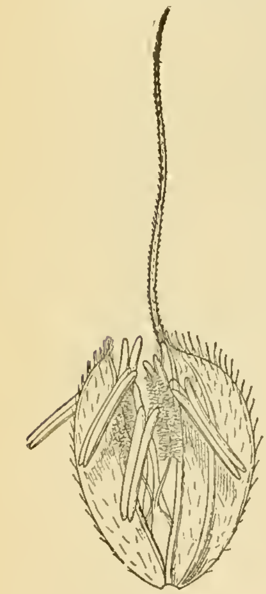

Fig. 768. Rice (*Oryza sativa*). Floret open, showing flower with two stigmas and six stamens. Fig. 531 shows the habit of the plant.

Distribution.

While a tropical plant, rice thrives in subtropical countries. It is known to have existed in India in early historic periods and is doubtless indigenous there. It requires a rich, moist soil, but is of wide adaptation. It thrives better under high temperature than wheat and is more resistant to extreme heat. It has been produced under favorable conditions as far north as 44°, but its production is limited chiefly to about 40° north and south of the equator; hence it is adapted to all of the states south of Pennsylvania, and under favorable conditions may be grown in most of the United States. With increasing density of population it will doubtless become a staple crop in all of the states south of the Ohio river, especially on lands now considered waste by reason of insufficient drainage. Wherever fresh water is found in abundance and can be economically applied to the lands within the rice zone, it will prove a profitable crop and will become staple.

In the United States the production of rice has been limited mainly to the south Atlantic coast states and to the states bordering on the Gulf of Mexico.

Fig. 769. Two types of rice. The common long Honduras on the left, and the short Japanese on the right. The short-kerneled rice does not break so readily as the long, in the polishing.

Development of the rice industry.

Rice was first introduced into America soon after the settlement of Virginia and attained considerable importance in the colonial times. According to the Encyclopedia Americana, the practical introduction of rice took place accidentally in 1694 in lower Carolina. A vessel bound for Liverpool from Madigascar, blown out of her course and in need of repairs, put into Charleston. The captain gave Landgrave Thomas Smith a small parcel of rough rice. This was used as seed; enough was soon grown to provide the needs of the colony, and early in the following century it began to furnish a considerable amount for export. In 1707, seventeen ships were reported as sailing from South Carolina with cargoes of rice. Production gradually increased, and in 1730 it reached 21,153,054 pounds; in 1755 it was 50,747,090 pounds, and in 1770 it had increased to 75,264,500 pounds. This was the product of slave labor and was mostly exported to Europe and the West Indies. During the next seventy years the increase was slight. In 1840 the report was only 84,145,800 pounds, but in 1860 it amounted to 187,167,032 pounds. The civil war practically destroyed the industry. The crop of 1865 was reported at 4,740,580 pounds. It gradually revived till in 1880 it reached 85,596,800 pounds, and in 1893, 237,546,900 pounds, of which amount Louisiana produced approximately 182,400,000 pounds and the Atlantic coast 55,146,900 pounds. In 1905, the total rice crop of the country was 12,923,920 bushels, valued at $12,266,343.

In Louisiana the production of rice began at an early date, but the commercial product was mainly confined to the alluvial lands along the Mississippi till about 1884, when on the prairie region of southwestern Louisiana the rice industry began to be developed along entirely new lines. The wheat machinery of the northwestern states was adjusted to the rice crop; the gang-plow, the force-feed drill, the twine binder and the steam thresher became necessary adjuncts to the rice-farm. This was possible because the tenacious subsoil of the prairies along the Gulf coast becomes firm enough to sustain harvesting machinery in the period that elapses between drawing off the water of irrigation

Plate XX. Rice; showing the panicle, and a rice-field on the Louisiana prairies and the ripening of the grain. These prairies are now a great rice region.

Varieties.

There are a great many varieties of rice, mainly the result of the different climates, soils and methods of cultivation under which rice has been produced through long periods of years. For practical purposes these numerous varieties may be reduced to a few. The three types mainly cultivated in the United States are the Carolina, the Honduras and the Japan. The famous Gold Seed rice of the Carolinas ranks among the best rices of the world for size, richness of kernel, and large yield. The so-called Honduras rice, mainly imported from Mexico, is similar in form of grain and in habits of growth to the Carolina. Of the many varieties of Japan rice, all have the short, fat type of berry, but differ in habits of growth, length of head, date of maturity, strength of straw and other qualities. The Japanese appear to have bred and selected intelligently for certain characteristics that would meet local requirements. Some are storm-resistant, some mature early, some have a straw very valuable for hats, and other varieties are excellent for paper. Thus some valuable characteristics have been made dominant in each variety. All of the leading varieties excel in yield and milling qualities. It is not uncommon for the famous Kiushu rice (Japan) to mill 90 to 95 per cent of head rice; 40 per cent is a good average for Honduras and 60 for Carolina.

Red rice (*Oryza rufipogon*), so called because the grains are red or streaked with red, is a separate species, hardy, of early maturity and great vigor. In foreign countries it is not considered very objectionable, and in some countries, as Porto Rico, where the rice is slightly colored for common use with some harmless vegetable dye, the matter of the color of the grains has no commercial importance. In the United States, however, the demand is for white rice and wherever the red rice invades a field the grade is lowered. Red rice can be eradicated by going through the fields and pulling all the stools of that variety, by late spring-plowing or by rotation of crops.

Wild rice.—The wild rice of North America (*Zizania aquatica*) differs widely from true rice. It abounds in places of shallow water, in marshy places and along the borders of lakes. The grain is about one-half inch long, slender, farinaceous. It shatters easily when ripe. Some tribes of Indians use it extensively for food. Chicago furnishes a market for it at a high price, where it is regarded as a great delicacy. It is not cultivated.

Oriental rice-culture.

In oriental countries the method of production usually followed is to plant in carefully prepared seed-beds, where, after the rice has germinated and is three inches tall, the soil is daily saturated with water till the plants have reached a height of six to eight inches, when they are ready for transplanting to the field. Two objects are attained by this method of growing the rice plants in beds and transplanting them to the fields. A more uniform stand and a larger yield are secured and later planting in the field is permitted, thus allowing time to harvest the winter crop to which the field was devoted. Transplanting is done by running a spade about two inches under the surface, which prunes the roots slightly and renders the plants easily pulled up by the tops. They are then pulled, tied in bundles of five or six, and carried to the field for setting. Previous to this the field is watered by rainfall or artificial irrigation, then spaded or plowed and further worked until the soil is a mass of fine, thick mud, four to six inches deep and covered with an inch or more of water. In this the field hands stand and set the plants in rows eight inches apart by six inches in the rows.

After setting, the field is kept flooded with water till the plants are about twelve to fifteen inches tall. The water is then drawn off, the rice is hoed, and by some growers slightly root-pruned. It is then reflooded and the water allowed to remain till about ten days before the grain is fully ripe. This period is gradually indicated by the head bending over from the weight of the grain.

The grain is universally cut with a reaping hook, bound in bundles about three inches in diameter and hung on bamboo poles or laid on the levees of the fields for curing. The rice grains are then removed by drawing the heads through a hatchell or by pounding them over a log, or by piling the sheaves on a clay floor and driving oxen over them, as the custom of the country may approve. The grain is spread on mats or floors and dried in the sun, and is then stored.

The hulls or husks are generally removed before the grain is sold. The sacks for holding the rice in transit to market are commonly made by the farmer out of rice-straw. [Further discussion of rice-growing in tropical countries is found in Vol. I, Chapter II, pages 108, 119, 124, 125. Figs. 60, 129, 130, 132, 133, 140, 141, and Plates VI and VII (Vol. I) are interesting in this connection.]

Rice-culture in the United States.

The larger part of the rice produced in the United States is grown on the low alluvial lands along rivers, in reclaimed swamps and marshes and tide-water lands, and on level tracts capable of irrigation. The tide-water lands lie back up the rivers above the meeting of fresh and salt water, so that the fields are not liable to flooding with salt water. Next to the river a levee is constructed sufficiently broad and high to keep out the river water. This is provided with tide gates. The field is then thoroughly ditched and drained, and the land is plowed and prepared for a crop.

Soil.—Rice prefers a rich, clay loam soil with the surface thoroughly pulverized at the time of sowing to the depth of three inches. The soil is prepared as for wheat. The soil below should be firm, such as would result from fall-plowing. The clay subsoil should be retentive of water.

Excellent drainage of the soil is an important condition of good rice-farming. Good drainage allows earlier planting, makes possible a more thorough preparation of the soil, insures a better stand, improves the quality of the grain, allows prompt and complete removal of the water of irrigation at harvest-time and provides one of the most important conditions for curing the crop.

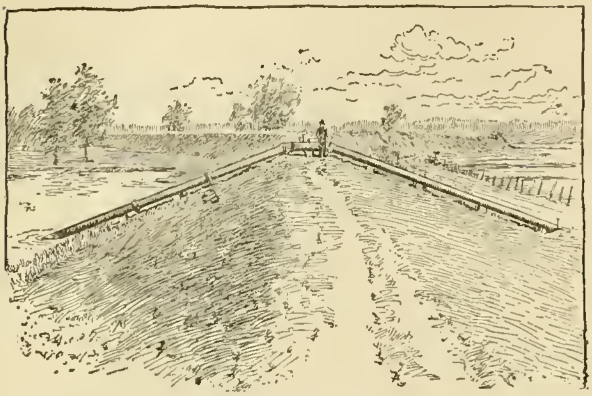

Fig. 770. Taking water from the Mississippi river over the levee by means of a siphon.

The soil of the Gulf coast prairies varies from a sandy loam to a black clay loam and is uniformly underlaid with a clay subsoil more or less tenacious. The soil is generally rich in plant-food; the surface of the land is mainly smooth and falls slightly toward the Gulf or some drainage stream. The numerous rivers flowing through these prairies to the Gulf furnish an abundant supply of fresh water for irrigation.

The rice-fields vary in area from ten to one hundred acres, depending on the variation in the level of the surface. Many of the best rice-farmers do not allow a variation of more than three inches in the total levels.

Planting.—Rice is planted in drills or is broadcasted and harrowed in at the rate of fifty-five to eighty pounds of seed per acre. On land which has been long in cultivation the larger amount of seed is advisable. Rice should not be planted till after the wheat crop is in, as it germinates at a slightly higher temperature. The seeding period extends from March 15 to June 15, but ordinarily the seed should be in by the middle of April.

Watering.—As soon as the rice is up, watering begins. The depth of the water is increased as rapidly as the growth of the plant will permit, till such a depth is attained that the weeds in the field are destroyed.

For watering the rice-fields, surface canals are constructed (with many laterals), running from the river banks across the prairies, and into these the river water is elevated by powerful pumps and distributed to the rice-fields. The elevation of the canals above their water-supply varies from five to sixty feet, with a probable average of twenty or twenty-five feet. Along the Mississippi the water is siphoned over the levee (Fig. 770). In the Carolinas, a different method is followed. After the first water has been applied to sufficient depth to kill grass and weeds, it is then slowly withdrawn and the crop hoed, and a few days allowed for dry growth, when the field is again flooded and kept in that condition continuously till the crop is nearly mature. (Fig. 771.)

A critical period for rice is when it comes into bloom. If heavy showers are frequent at this time they will wash the pollen off, thus preventing fertilization.

Harvesting.—Rice should be cut a few days before it is perfectly ripe, when the straw begins to turn yellow, and should be shocked with a good cap to protect as many grains as possible from the direct rays of the sun, as the too rapid drying may produce sun cracks, causing the kernel to break in milling. The milling quality of the grain is improved by stacking, if the bundles are dry and the stacks are small. In the past the crop was generally cut with a sickle and bound by hand, and it still is to a considerable extent. But the draining of the fields and the using of modern harvesting machinery is a marked advance over the old method and is taking its place wherever practicable. (Fig. 772.)

In the United States considerable rice is marketed with the hull on, because there are no appliances on the farm for removing it, and the kernel is better protected from insect enemies if incased in the hull during the period of storage.

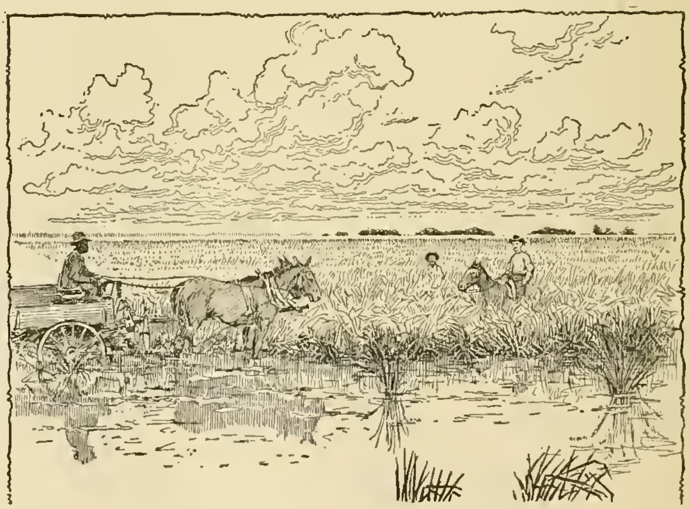

Fig. 771. Rice-field prior to drawing off water for harvesting. Louisiana.

Yield.

The average yield is twenty-five to thirty-five bushels per acre, but products of one hundred and fifteen bushels per acre have been secured. With good soil and seed the average crop may be more than doubled by a thorough preparation of the soil and the proper application of water while the rice is young and during the entire period of growth.

Milling.

Rice mills (Fig. 773) have been perfected until they are a vast network of complicated machinery, taking the grain in the rough, separating the weed seeds and light grains, removing the hulls and then the bran, polishing, grading and placing each grade in sacks of recorded weight, ready for sewing and marking. The capacities of rice mills in the United States vary from 1,000 to 10,000 bushels of rough rice per day of twenty-four hours.

The products of the rice in milling are classified commercially, as follows: Head rice (whole grains), straights (mostly whole grains but a grade slightly below head rice), screenings (broken rice, of which there are several grades), brewers' rice (very finely broken rice used in the manufacture of beer), polish (a highly nutritious flour scoured from the surface of the kernels in polishing, sometimes incorrectly called rice flour, which latter is ground rice), rice bran (the cuticle immediately within the hull), and rice hulls (the outer covering). The approximate milling outturn of 162 pounds of rough rice is 98 pounds of commercial rice, 6 pounds of polish, 28 pounds of bran and 30 pounds of hulls.

Composition of rice products.

The chemical constituents of the products of rice are as follows:

Commercial or polished rice: Total nutrients, 87.15; protein, 7.52; ash, 0.73; fat, 0.38; carbohydrates, 78.05. Rice polish: Protein, 11.06; ash, 8.45; fats, 5.92; carbohydrates, 65.97. Rice bran: Protein, 9.88; ash, 11.55; fats, 9.21; carbohydrates, 52.63. Rice hulls: Protein, 3.50; ash, 18.29; fat, 0.4; carbohydrates, 41.80; crude fiber, 37.50. Rice straw: Protein, 3.31; ash, 14.64; fats, 0.59; carbohydrates, 33.31; crude fiber, 32.01.

It will be noted that rice polish and rice bran remove nearly all the fats from the rice, and consequently rice as sold on the market has little flavor. The retention of the polish, as in oriental milling, would materially increase the flavor, and if the bran were retained rice would be rich in flavor.

Definitions of terms.

The commercial terms used in the United States may be defined as follows: Rough rice, or paddy, signifies rice with the hull on; a sack is an indefinite quantity varying from 160 to 210 pounds; a barrel is 162 pounds of rough rice; a pocket is 100 pounds of milled or cleaned rice.

Enemies.

Insects.—The principal injurious insect is the rice weevil (*Calandra Oryzæ*). It originated in India and has gradually become common in all the rice-producing countries of the world. It is not common in overflowed fields, mainly attacking stored rice. It is readily killed by the use of carbon bisulfid.

The rice grub is the larva of one of the scarabæidæ and looks like the ordinary white grub. It is killed by water.

The rice-stalk borer is the larva of a crambid moth, which lays its eggs in the early summer.

Fig. 772. Rice-field in harvest. Louisiana.

The young larva bores into the stalk, gradually working down to the roots of the plant. In the stalk it is transformed into the pupa state and in five or six days the moth emerges. Stalks affected by the borer turn white, causing a white blast.

The chinch-bug occasionally works on rice in the field, but thorough flooding is, in the main, a protection. In stagnant water, rice-worms occasionally attack the roots and ruin the crop. The remedy is to draw off the water and allow the field to dry a few days, then reflood.

Diseases.—Occasionally a fungous disease attacks the stalk just below the head and penetrates it till the head falls over and the stalk breaks at the point of attack. This is commonly called "neck rot" or "white blast," and can be obviated by the application of lime to the soil.

Smut (*Horrida corona*) sometimes attacks the rice seeds, changing the interior of the seeds to black powder. The affected grains are lighter than sound grains, and will float when the seeds are immersed in water. In this way they may be removed. For treatment, see oat smut, page 491. Another smut, known as *Ustilaginoidea virens*, gives the blasted grains a greenish appearance.

Uses of rice and its products.

As food.—The uses to which the rice crop is devoted are varied and interesting. The rice kernel is the principal food of more than half the population of the earth. Where a dense population depends for food on an annual crop, rice has been selected as a staple if the soil and climate are adapted to its production. Its great yield per acre, its assured returns, its slight drain on the soil and its ease of

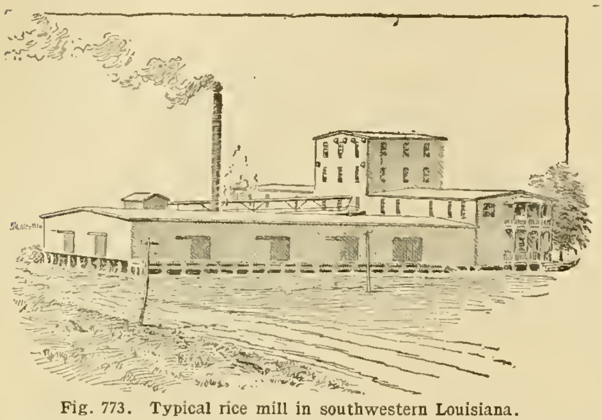

Fig. 773. Typical rice mill in southwestern Louisiana.

digestion have been important considerations. Its slight deficiency in protein is an advantage, because the nutritive ratio is usually balanced by the lean meats, eggs, fish and legumes, ordinarily composing a part of the American diet. When thoroughly cooked, rice is one of the best foods known for supplying heat and energy. The short time required for its digestion, the slight tax imposed on the system in the process and the high percentage digested are all items in its favor for the toiler, the person of sedentary habits and invalids.

There are many ways of preparing rice for food. In the oriental countries it is made into cakes, candy, and infant and invalid foods. A very attractive method of use is popped rice, prepared much like popped corn. In the East Indies rough rice is boiled until about half done; it is then dried in the sun and the hull removed. This makes the so-called brown rice, which includes the polish and the bran. In this form it will keep longer without injury than rice milled in the American way; it has a higher flavor, contains more protein and pepsin, and yields a larger merchantable percentage of human food per bushel milled. Another method of preparing rice in India is to remove the hull and bran, then store the rice for a year before placing it on the market. It is asserted that old rice is more digestible.

There is very little if any difference in the nutritive value of the different grades of rice in the United States. All of our milled rice has less flavor and is of a lower nutritive value than oriental rice because in those countries the polish is not removed from the kernel in milling. The polish contains about fifteen-sixteenths of the flavor of the grain. Commercially, polish is sold to foreign countries as human food; in the United States it is chiefly fed to animals and has a high reputed value for dairy cows and young pigs.

Rice bran contains a high percentage of protein and when fresh is held in great esteem as a stock-food, but, owing to the excessive amount of fat contained, it soon becomes rancid. To overcome this, the oil is sometimes extracted and sold for various uses, leaving the residue for the stock. Another use for rice bran is proposed as follows: Cut equal parts of rice-straw and alfalfa hay, mix with this rice bran and refuse molasses, dry and grind. This would place the by-products of rice and sugar in a very available form for use and transportation.

Rice hulls are largely silicates and so indigestible that they are of little value, if not positively harmful. At first in the rice industry the hulls were thrown out to decay; later they furnished the fuel for the mills and more recently some are used to adulterate rice bran, or sold to perform the same office for wheat bran.

Rice-straw is at present used chiefly in the United States for stock-food. When used as a sole cattle-food, animals will merely maintain weight. Large quantities are burned in the fields as a convenient method of disposal. The loss by this method amounts annually to several millions. Live-stock industry is usually not extensively developed in rice-growing regions.

Miscellaneous.—In Japan, rice is used extensively in the manufacture of a fermented liquor called saki. In China several kinds of wine that are much prized are made from rice. An excellent starch also is made from rice.

Possible expansion of the rice industry.

West of the Mississippi river, in the states of Louisiana and Texas, are at least 10,000,000 acres of land adapted to rice-culture, and, of this, about one-half can be watered by husbanding the waters of the rivers and by sinking artesian wells. In the basin of the Mississippi and her tributaries are 10,000,000 acres that can be watered suitable for rice. In the Gulf and Atlantic states are about 8,000,000 acres, of which three-fourths can be watered. On this estimate there are in the United States about 21,000,000 acres of land adapted to rice that can be watered and are capable of producing an annual crop of 735,000,000 bushels, worth, at sixty cents per bushel, $441,000,000. Most of this land is non-productive at present, but in the near future it will be required for our food supply, and can easily be brought under cultivation. This points to the fact that the rice industry in the United States is in its infancy and has ample room for expansion.

The State of Arkansas has large areas of land with a deep, rich soil, underlaid with a semi-tenacious clay, making admirable conditions for rice culture, when taken in connection with the abundant water supply of that state. Several thousand acres have been planted to rice with the best results. The coast sections of Mississippi and Alabama are in the main better adapted to rice culture than to any other grain crop.

DUTY ON RICE FROM 1861 TO 1897.

	Cleaned	Uncleaned	Paddy	Flour, granulated
	Per pound	Per pouud	Per pound	Per pound
1861 . . .	1	½	. .	. . . .
1862 . . .	1½	1	¾	. . . .
1864 . . .	2½	2	1½	. . . .
1883 . . .	2¼	1½	1¼	20 per cent ad valorem
1890 . . .	2	1¼	¾	¼
1894 . . .	1¼	$\frac{8}{10}$	¾	¼
1897 . . .	2	1¼	¾	¼
1906 . . .	2	1¼	¾	¼

Rice from Hawaii admitted free since 1876.

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ROOT CROPS. Figs. 774–785.

By *S. Fraser.*

The growing of roots for stock-feeding has never taken the place in American agriculture that its merits deserve, largely because of the ease and cheapness with which grain crops can be raised and the amount of hand labor involved in the production of roots. There is every indication that the culture of these forage plants will increase, particularly in the East. The reason why the production of roots is of special interest in the north Atlantic states and in eastern Canada is that these regions raise a comparatively large amount of roughage and a small amount of concentrates, while the north-central states raise a large amount of cereals or concentrates in proportion to hay and forage as shown in the following table. The following table shows the ratio of concentrates to roughage in the north Atlantic and north-central states according to the Census of 1900:

	North Atlantic	North-Central
All cereals except wheat, million tons	4.4	69.2
All hay and forage, million tons . .	15.6	49.0
Per cent of cereals except wheat . .	22.0	58.5
Tons cereals except wheat, per animal unit	.55	1.55
Tons hay and forage per animal unit.	1.95	1.10
Total tons of food per animal unit (of about 1,000 lbs. live weight) . .	2.50	2.65

The significance of this table is further emphasized when the superior feeding value of concentrates is fully understood. For example, experiments made by Zuntz, of Germany, show that when clover hay was fed to horses, 41 pounds were digested out of each hundred pounds of hay fed, while, when oats were fed, 62 pounds were digested, or 50 per cent more. It was found, however, that it required the energy of 24 pounds of the 41 pounds of hay digested to supply energy to chew and digest the hay, leaving the net nutritive value at 17 pounds. On the other hand, it required only 12 pounds of the 62 pounds of oats to masticate and digest the oats, leaving 50 pounds of oats available for producing energy or work. In other words, the oats had three times the value of the clover hay for the production of work in horses. The energy used up in chewing and digesting food is manifested in heat and helps to keep the animal warm, and is therefore not entirely lost when the ration is merely for maintenance. But since in any liberal feeding for the production of work, the production of meat, or of milk, the amount of heat thus produced is sufficient to keep the animal warm, the figures given above may be taken as representing their true food value. Rather extensive Danish experiments indicate that a pound of dry matter in roots is about equal to one pound of the cereal grains, or to three-fourths of a pound of cottonseed-meal, when fed to milch cows. Roots, like the cereals, are highly digestible, perhaps even more digestible than the cereal grains, and herein probably lies their high value. From the standpoint of the results which they produce, the roots may be looked on as watered concentrates. They have apparently a high net available energy.

The yield of dry matter.

One of the objections to roots as a food product lies in their high water content. This limits the quantity which may be fed and becomes of special importance where they are fed in connection with silage. Because of this high water content it will not be practicable to feed a sufficient amount entirely to take the place of the cereals, even should this be desirable for other reasons. The trend of experimental evidence is that the feeding value of the different types and varieties of root crops depends more largely on the percentage of dry matter than any other factor; for example, the percentage of dry matter apparently modifies their feeding value more largely than the percentage of sugar. In comparing these yields with the yields of corn, it must be remembered that it is more difficult to handle a root crop than a corn crop; more hand labor is required per acre and the land must be in good condition. The thorough farmer who manures and fits his land on a timely and intensive system is the one who may succeed in growing root crops.

The following table shows the minimum, average and maximum number of pounds of dry matter per acre which was obtained at the Cornell Experiment Station in 1904, 1905 and 1906, from sowings made in May:

	Minimum	Average	Maximum
Mangels	2,168	5,155	8,453
Half-sugar mangels	5,480	5,880	6,440
Sugar-beets	6,014	7,090	8,090
Rutabagas	3,537	4,331	5,079
Hybrid turnips	2,584	3,694	5,111
Common turnips	1,710	2,680	3,500
Kohlrabi	3,570	4,070	4,540
Cabbages	4,076	4,662	5,588
Carrots	1,878	3,134	4,379
Parsnips	2,080	3,130	3,680

The estimated yield of grain from flint corn the same seasons at the Cornell Station was approximately 2,000 pounds, while the yield of dry matter in silage from dent corn was about 4,000 pounds. It is probable that the season of 1904 was relatively favorable to the production of roots as compared with corn, but this was not true of 1905 and 1906. In the latter years the average yields from roots were better than in 1904, although the land used was conceded by all interested to be less favorable than that used in 1904.

Roots vs. cereals.

The present high price of cereals is a factor in favor of the production of root crops. If corn-meal continues to be worth $20 a ton or more in the East, economy in the production of roots would be indicated, while if the price should fall to $10 a ton, corn-meal would probably be the cheaper source of concentrates. The serious handicap to the raising of root crops is the fact that with present cultural methods a large amount of hand labor is required. The point of view that is desired here to emphasize is that while roots may not be economically raised as a substitute for silage or other coarse fodders, it may be economical to raise them, especially out of the grain regions as a partial substitute for concentrates, particularly the cereal grains.

Literature.

The following literature deals with several root crops and it is most convenient to give it in one place. Thomas Shaw, Forage Crops, Orange Judd Company, New York (1900); L. H. Bailey, Cyclopedia of American Horticulture, Macmillan Company, New York (1900); W. A. Burpee & Co., Root Crops for Stock-feeding and How to Grow Them, Philadelphia, Pa. (1888); Mm. Vilmorin, The Vegetable Garden, Translation by Wm. Robinson, John Murray, London (1885); J. J. H. Gregory, Carrots, Mangold-wurtzels and Sugar-beets, Marblehead, Mass. (1882); Fearing Burr, Jr., The Field and Garden Vegetables of America, Crosby & Nichols, Boston (1863). Exhibiting roots: Edwin Beckett, Vegetables for Exhibition and Home Consumption, London (1899); Dunn, The Horticultural Exhibitor's Handbook, London (1892); Vegetables Grown for Exhibition, New York (Geneva) Experiment Station, Bulletin No. 69 (1894). History and Botany: A. de Candolle, Origin of Cultivated Plants, Appleton & Co., New York (1892); E. L. Sturtevant, History of Garden Vegetables, American Naturalist (1887, 1888, 1890); Improvement of the Carrot, see L. de Vilmorin, Transactions of the London Horticultural Society, Ser. 2, Vol. 2, p. 348; John Percival, Agricultural Botany, London (1900); L. H. Bailey, Botany of Turnips, etc., Garden and Forest, 1897, pp., 321, 322; James Buckman, Science and Practice of Farm Cultivation, London (1865). The most recent studies in this country are by Hunt, Fraser, Gilmore and Clark in Cornell Bulletins Nos. 243 and 244, from which extracts are made above.

THE KINDS OF ROOTS.

The kinds of roots that are most profitable to grow in this country for forage may now be described briefly. To these might be added potatoes and kohlrabi, both treated in separate articles. Cabbage, kale and pumpkin [see separate articles] are also practically comparable with roots as to feeding value.

Carrot. *Daucus Carota*, Linn. *Umbelliferæ.*

The carrot is used as human food and is also esteemed for all classes of stock, especially horses. The leaves are also relished by stock. It belongs to the same order as the parsnip, celery, parsley and several other useful herbs. It is sometimes annual, but generally is biennial. The edible part is made up of parts of the stem and root which have become thickened. A section of carrot shows two well-defined layers, an outer, and an inner layer or core, which frequently vary in color. The proportion existing between the two layers is variable. Since the outer layer is esteemed to be of higher value than the core, the aim in breeding has been to produce "coreless" varieties.

The average percentage composition is, approximately, water, 88.6 ; ash, 1 ; protein, 1.1 ; crude fiber, 1.3 ; nitrogen-free extract, 7.6 ; ether extract, 0.4.

History.

The carrot is known to have been in cultivation for about two thousand years. It is mentioned by Pliny, and the wild carrot was known to the Greek writers 300 B. C. It has received more attention in France than in any other country, and there is reason to think that as early as the first century it was esteemed there. Cultivated varieties were recorded as growing in the gardens and fields of Europe in the sixteenth century and had by that time been introduced and disseminated over the central and northern parts of South America. They were grown in Virginia as early as 1609 and were in Massachusetts twenty years later. The Indians carried them westward, and in 1779 General Sullivan destroyed carrots at Geneva, N. Y.

The influence of environment is marked in this plant. Vilmorin succeeded in developing commercial varieties from the wild carrot, by sowing the seed in well-prepared ground and selecting the best plants for three successive generations.

The carrot is now cultivated or found wild over all parts of the world. It is probably native of Europe, where the most attention is now being given to its improvement. Although it has been grown on this continent, practically as long as the European occupation its culture has not assumed any large proportions in any place.

Varieties.

Varieties are classified according to their shape, as (Fig. 774): (1) Taper-pointed, (2) stump-rooted or premorse and (3) cylindrical. These are characterized as follows:

(1) Taper-pointed. The roots taper uniformly from crown to taproot..

(2) Premorse. The roots end abruptly at the base, the taproot starting from a flat or nearly flat surface.

(3) Cylindrical. The roots are cylindrical for at least two-thirds of their length and then taper.

In both (1) and (2) we may have long, half-long and short varieties, according to the ratio existing between the length and greatest diameter; thus,

> Long = length more than four times the width.
> Half-long = length more than twice, but less than four times the greatest width.
> Short = length less than twice the width.

The cylindrical types are all long. Of these three types the following varieties may be given: Taper-pointed, long: White Belgian, Long Orange, Long Red (grown largely for stock, and have one-third to one-quarter of the root out of the ground). Taper-pointed, half-long: Danvers Half-long, Carter's One Hundred Ton. Premorse, half-long: Early Horn (various synonyms), Lobberick Agricultural Carrot (stock). Premorse, short: Early Frame (various synonyms). Cylindrical, long: Altringham and Japanese varieties. Vilmorin Coreless Long Red belongs in this class. It is stump-rooted. The colors red, orange, yellow and white exist in all types.

The stump-rooted type and half-long varieties should be selected for shallow and heavy soils. The long types may be grown on the deeper and more friable soils.

Culture of carrots.

Soil.—The ideal land for carrots is a deep, sandy loam or an alluvial soil. Carrots grow well on deep, peaty soils and give good crops on light soils if there is a good rainfall, or on clay loams if well drained. The land should be well prepared, deep fall-plowing being recommended. The spring preparation consists of harrowing with the disk or acme harrow and finally with the meeker harrow, the latter being an admirable tool for finishing the preparation of the seed-bed for all root crops.

Manuring.—It is preferable that the land be well manured for the previous crop. If this cannot be done, about twelve tons of rotted manure may be applied per acre in fall and plowed under, or rotted manure may be disked in in the spring. It is important that it be evenly distributed. One important reason for using rotted manure is that carrots are slow in germination and growth and permit weeds to grow apace. Manure introduces many weeds to land, and rotted manure is less likely to contain so many. A complete fertilizer is usually applied, consisting of, per acre, 100 to 200 pounds of muriate or sulfate of potash, applied in fall or spring and harrowed in, although wood-ashes are sometimes used instead; 400 to 800 pounds of acid phosphate, 16 per cent available, or its equivalent, i. e., 64 to 128 pounds of actual phosphoric acid, which is worked into the soil in the spring; and 100 to 150 pounds of nitrate

Fig. 774. Carrot shapes. Beginning at the left, first three taper-pointed: 1st, long; 2d, half-long; 3d, short. Second three premorse: 1st, long; 2d, half-long; 3d, short. Third two cylindrical: 1st, taper-pointed; 2d, premorse.

of soda, which is usually applied in the form of two top-dressings when the plants are growing. Liming the land at the rate of 1,000 pounds per acre is frequently beneficial.

Seed and seeding.—Carrot seed is sometimes partially germinated by mixing it with wet sand and leaving it for a few days, or by merely dampening it and leaving the seeds in a pile. Since carrot seeds, which are really fruits, carry many spines, the method of mixing in sand was formerly of value to prevent their sticking together. Today, seeds from which the spines have been removed may be purchased, and such will readily pass through the drill. The seeds should be sown on or very close to the surface. They take ten to fourteen days to germinate. Six to seven pounds may be sown per acre, although if the seed is of good germinating power four or five pounds will suffice. The rows may be narrow, eighteen to twenty-four inches apart when hand culture is used, or twenty-eight to thirty-six inches apart for field conditions and when machinery is used. In the latter case the plants may be left three inches asunder in the rows, and 55,000 to 60,000 plants should be secured per acre.

Subsequent care.—Shallow cultivation should be given as soon as the rows can be seen and be maintained until the foliage meets in the rows. The plants should be thinned to one in a place as soon as large enough to handle. The crop could well be grown after such a crop as cabbages or potatoes, or any other crop which has been well manured.

Harvesting.—The varieties that have part of the root out of the ground are easier to harvest but are more liable to injury by frost. A plow may be run beside the rows to loosen the ground in the case of other varieties. They are usually harvested before severe frost occurs and stored in root cellars or in pits as are other roots.

Enemies.

The carrot has few troubles. A bacterial soft rot (*Bacillus carotovorus*), for which no remedy is known, gives trouble sometimes. The parsley worm sometimes attacks the leaves.

Hybrid-turnip. *Brassica Rapa*, var. *hybrida*, Fraser. *Cruciferæ.*

A cross between a rutabaga and a common turnip, made with a view to securing a plant possessing the desirable characters of both parents,—for example, to secure the higher dry-matter content of the rutabaga in a plant which will mature in a shorter time. Such hybrids show characters of either parent. Some varieties are highly esteemed, as Fosterton Hybrid, Aberdeen Yellow, Carter Lightning and Commonwealth, Garton Pioneer. [For culture, see *Turnip.*]

Half-sugar mangel. *Beta vulgaris*, Linn. *Chenopodiaceæ.*

A cross between a modern sugar-beet and a mangel, for the purpose of securing a mangel richer in dry matter. Thus far little progress has been made. Culture and management same as for mangel [which see].

Jerusalem artichoke. *Helianthus tuberosus*, Linn. *Compositeæ.*

A hardy perennial, with rough, much-branched stems, six to eight feet high, which bear large, rough, alternate leaves and large yellow flowers. It is usually propagated by means of the tubers, much in the same way as potatoes, the seeds being used for the development of new varieties.

In percentage composition Jerusalem artichoke is very much like the potato:

	Water	Ash	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Artichoke . .	79.5	1.0	2.6	0.8	15.9	0.2
Potato . . .	78.9	1.0	2.1	0.6	17.3	0.1

The plant is native in North America and has been cultivated by the aborigines for centuries. Since the advent of the Europeans it has been neglected, and better varieties are now found in Europe than here. The plant may be grown profitably wherever the potato succeeds, and, since it can withstand considerable periods of drought, it is asserted that it should find a more important place in our agriculture, especially in the northwestern states.

Culture.

The land should be plowed deep, well manured and well fitted. The tubers are planted either in fall or in spring, about two inches deep, eighteen inches asunder and in rows three and one-half feet apart. Six to eight bushels will plant an acre, and since frost does not injure the tubers one planting may be sufficient for two or three successive crops. The crop should be cultivated shallow, as corn or potatoes, and is harvested in the same way as potatoes; or hogs may be turned on the field to root out the tubers. The best method of handling a crop which comes from tubers left in the land over winter is to use the weeder early in spring, and as soon as the plants are well up run the cultivator through in both directions, leaving the plants in hills.

Varieties.

There are several varieties of Jerusalem artichoke, some of much better flavor than others, the Improved White French being considered one of the best. Some varieties are named from the color of their skin, as Red-, Yellow-, Purple- and White-skinned.

Uses.

The tubers are cooked as a vegetable, eaten raw as a salad or pickled like cucumbers. They are also used as stock-feed, principally for pigs, although they are of some value for horses.

Literature.

Consult the Experiment Station Record for references to the experience with Jerusalem artichokes at the various experiment stations. In addition, see Arkansas Experiment Station, Bulletin No. 31; Missouri Experiment Station, Bulletin No. 29; Massachusetts Experiment Station, Bulletin No. 10.

Mangel. *Beta vulgaris*, Linn. *Chenopodiaceæ.* (Mangel-wurzel, Cattle Beet, Field Beet).

The mangel is a root crop used for stock-feeding. It may be annual, is more commonly biennial, and occasionally is triennial in duration. The part used consists of part of the stem and part of the root, both considerably thickened, and so closely united that the exact points of union are not readily recognized. The whole is frequently referred to as a "root." The following names are given to the different parts (Fig. 775):

The stem includes (1) the neck, which supports the leaves and flowers, and with the upper part of the hypocotyl (the shoulders, B) constitutes the crown (C). (2) The hypocotyl (H), used for the storage of food.

The root includes (1) the primary root (R) used for the storage of food and on whose surface are seen the dimples (D), in which arise fine, lateral, fibrous roots. (2) The taproot and its branching fibrous roots, which, like the lateral fibrous roots, may attain a depth of four or five feet.

The neck may be long, medium, short or absent, and since it is of less value than the remainder of the tuber, the aim is to have it as short as possible. In the case of sugar-beets the crown is removed before using them for the manufacture of sugar. When a plant has but one shoot or neck arising from the crown, it is said to be single ; should several shoots arise, the plant is said to have multiple crowns. These are objectionable in all classes of roots, because the small shoots are developed at the expense of the food already stored in the "root." The hypocotyl varies in length in different varieties. In some it is above ground, in others, as in Kleinwanzlebener sugar-beets, it is below ground. It is an observed fact that those plants having the hypocotyl below ground are richer in dry matter and therefore of higher feeding value than those having a large part of the hypocotyl above ground. The primary root appears as a continuation of the hypocotyl ; it should terminate in a single small taproot. Roots with two or more taproots are said to be forked or rough according to the degree of forking.

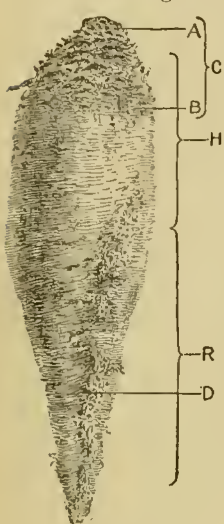

Fig. 775. Mangel parts. A, neck; B, shoulders; C, crown; H, hypocotyl; R, primary root; D, dimple. Taproots and fibrous roots broken off.

They are objectionable because of being difficult to harvest, and because they hold considerable soil and are likely to have coarse and stringy flesh. The dimples (D), usually two in number, are depressions on opposite sides of the root. They should be vertical and not too deep.

The lateral roots should be fine, fibrous and abundant, and should arise only from the dimples, otherwise they increase the cost of harvesting and carry considerable soil, which is objectionable. The fibrous roots springing from the taproot break off when the root is harvested. They are extensive and frequently fill the soil to a depth of four or five feet. The flesh is seldom of a uniform color. A transverse section will show rings of firm tissue alternating with rings of softer tissue. Six or seven or more rings are often formed in as many months of growth. The sap of the soft tissue is often colored, being crimson or golden, or other color, even white.

In the manufacture of sugar from sugar-beets considerable loss was experienced in removing the coloring matter from the sap, and this led to the use of white mangels for sugar production.

History of mangels.

The mangel is regarded as a direct descendant of the chard, which was used by the Greeks 300 B.C. as a vegetable. The roots of the chard were used medicinally and as a vegetable during the first and second centuries A. D. The use of the root for cattle-feeding is recorded as early as the sixteenth century, and beets were introduced into this country by the early colonists. As late as 1783 the only kinds of mangel seed catalogued for sale in England were the red beet and the common long red, and in 1806 the red beet was the only kind listed in America ; in 1828 four varieties were mentioned and today there are probably not over a score in common use. Since 1805, when the manufacture of beet-sugar began, certain mangels have been developed and have produced our present-day sugar-beets.

Geographical distribution.

The wild plant (*Beta vulgaris*, Linn.) may be found indigenous along the Mediterranean and in other parts of Europe. It was originally cultivated for its leaves under the name chard, and this plant is sparingly grown in American gardens. It was later grown for its roots, and about the middle of the sixteenth century we have reports that in Germany and Italy and other parts of Europe the root was grown as stock-feed. The practice of growing it as cattle-feed was later introduced into the United Kingdom, where the industry was rapidly developed and where some of the best varieties are now found. The mangel is sparingly grown in parts of the United States, but to a larger extent in Canada.

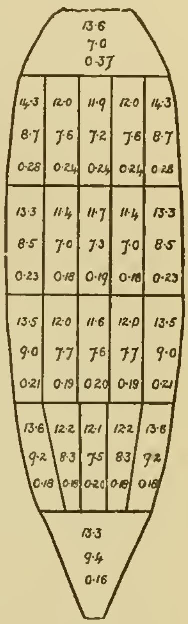

Fig. 776. **Long red mangel.** In each "compartment" the upper figure gives percentage of dry matter, middle figure percentage of sugar, and lower percentage of nitrogen. (Wood & Berry.)

Composition. Figs. 776, 777.

The average percentage composition for mangels, sugar-beets and garden beets usually given is as follows :

	Water	Ash	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Mangel . . .	90.9	1.1	1.4	0.9	5.5	0.2
Sugar-beet .	86.5	0.9	1.8	0.9	9.8	0.1
Garden beet .	88.5	1.0	1.5	0.9	8.0	0.1

Too much emphasis must not be laid on an average. During a recent trial at Cornell University Experiment Station the average amount of dry matter in 125 samples of mangels, embracing ten varieties, was 11.6 per cent, the extremes between different varieties being 7.5 per cent and 16 per cent. The variation between individual roots of the same variety is equally great, being frequently 100 per cent. In another experiment some individuals contained over 20 per cent of dry matter. In the case of sugar-beets, in 1904 the average amount of sugar obtained from one ton of beets by the factories and rasping stations in the United States was 230 pounds. From these data it

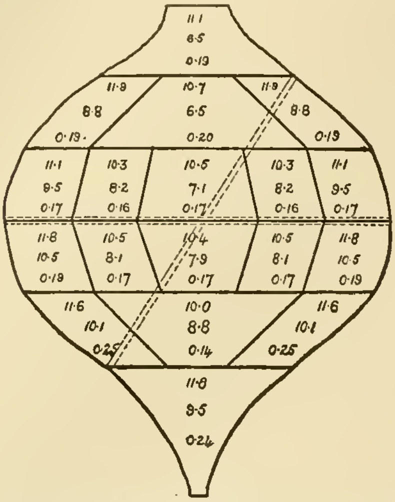

Fig. 777. Yellow-fleshed Globe mangel. In each "compartment" the upper figure gives the percentage of dry matter, the middle figure the percentage of sugar, and the lower figure the percentage of nitrogen. (Wood & Berry.)

is evident that the average percentage of dry matter contained must have been over 2 per cent greater than that given in the above table, and in many states the beets average 18 to 20 per cent dry matter, while 30 per cent with 24 per cent of sugar has been attained with individual roots.

Improvement.

During the past fifty years the amount of sugar which can be obtained from a ton of sugar-beets has been increased from about 100 or 150 pounds to 250 pounds or more, a gain of over 100 per cent. Part of this gain is due to better methods of manufacture and part to better beets. The percentage of sugar in the beets has been increased from an average of between 5 and 10 per cent in 1805, to an average of 14 to 18 per cent, and 24 per cent has now been attained in individual roots, a gain due largely to a right method of selection. In selecting sugar-beets, a high sugar content has been insisted on and the sugar content of "mother beets" has been determined before they were saved for seed production. The use of the saccharimeter and a reliable method of coring have given valuable results.

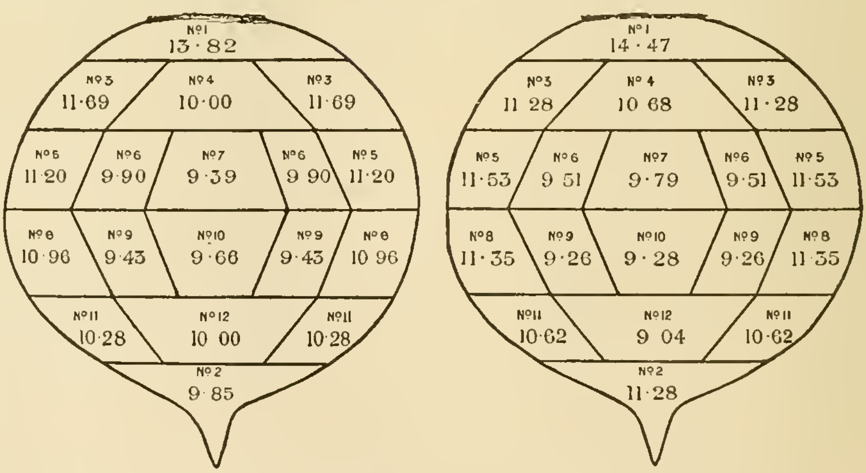

Fig. 778. Green-top Yellow turnip. The figures show the percentage of dry matter. (Wood & Berry.)

With mangels there has been no method of improvement, and roots were selected because of their shape or the color of their skin, no attention being paid to their dry-matter content, although it is for the dry matter that they are grown. To-day, it is urged that all roots that are to be used for seed production should be sampled and the percentage of dry matter determined, and that all roots that fall below a certain standard should be discarded. The determination of the dry-matter content requires the use of a cheese tryer, with which a plug is removed from near the center of the root. (Fig. 779.) This sample is then numbered to correspond with a tag on the root, carefully weighed and dried in a water-jacketed oven or some place where it will not be charred. The loss in weight is water, and the percentage of dry matter may be estimated. The hole in the root may be filled with cotton batting which has been immersed in a solution of formalin. The roots which pass the test should be stored in sand or soil over winter and planted early the following spring three and one-half feet apart each way. It is important that roots saved for seed production should not have their crowns injured.

Varieties of mangels.

Varieties are frequently classified according to shape and color of skin; they may be long, ovoid, tankard, globe or cowhorn (Fig. 780), and have black, purple, red, orange, golden, yellow, pink or white skin. The varieties grown in the United States are nearly all of European origin, and European-grown seed is generally sown. Some well-known varieties of mangels are: Norbiton Giant Long Red, Sutton Long Red, Gatepost, Yellow Leviathan, Yellow Intermediate, Chirk Castle, Golden Tankard, Yellow Globe.

Among half-sugar mangels, i. e., the mangels that apparently result from a cross between mangels and sugar-beets, may be mentioned Vilmorin Half-sugar White and Half-sugar Rosy, and the various kinds of half-sugar mangels of most of the seedsmen.

Among sugar-beets grown for stock-feeding are Lane Imperial, Danish Redtop and Danish Improved, which frequently contain a little higher percentage of dry matter than mangels, and the improved forms of sugar-beets, as Kleinwanzlebener and its several strains, which are the richest in dry matter.

Culture of mangels.

Land.—Mangels may be grown on almost any soil. Deep loams are considered best, and are necessary for the production of heavy yields of the long varieties. The globes and tankards may be grown on the shallower and lighter soils. Deep fall-plowing is advisable to ensure a compact subsurface. Thorough fitting of the surface soil should be given

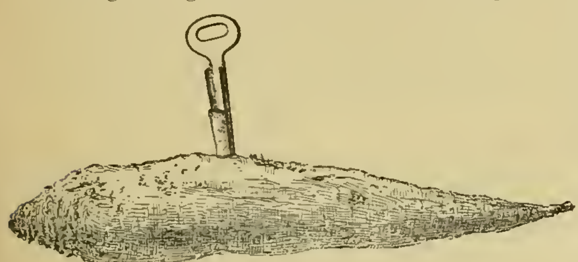

Fig. 779. Sampling a mangel.

in spring. No crop responds more readily to good tillage, and none will be more discouraging to the grower who but half prepares the land. The use of the disk or Acme and the spike-toothed harrows, and then the Meeker harrow to finish the work, is advised.

Mangels do better where there is considerable sunshine, and if there is a good supply of moisture in the soil they will thrive in a warm, dry climate. After the first two months of growth they can withstand drought better than almost any other root crop.

Fertilizing.—Ten to twelve tons of manure per acre should be spread evenly in the fall, previous to plowing, and this should be supplemented with fertilizers in spring. One hundred to 200 pounds of muriate of potash per acre may be applied in the fall or early in spring, and 200 to 500 pounds of acid phosphate with fifty pounds of nitrate of soda per acre in the spring, both to be harrowed in before seeding. If the land has not been limed in the past few years, 1,000 pounds of quicklime per acre will probably be of value.

Seed and seeding.—Six to eight pounds of good seed will be ample, but frequently ten pounds, and, in the case of sugar-beets, twelve to fifteen pounds, are sown. These may be sown about three-fourths

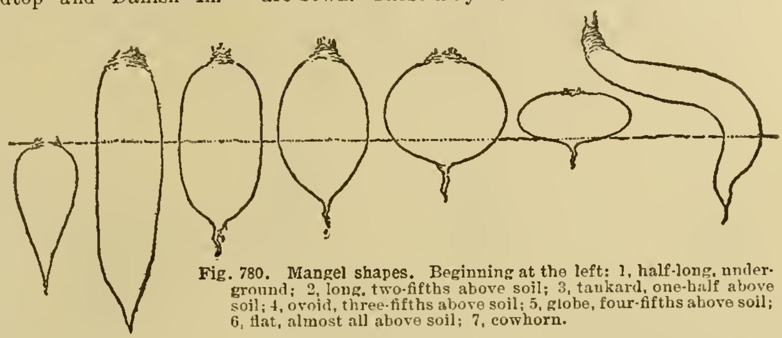

Fig. 780. Mangel shapes. Beginning at the left: 1, half-long, underground; 2, long, two-fifths above soil; 3, tankard, one-half above soil; 4, ovoid, three-fifths above soil; 5, globe, four-fifths above soil; 6, flat, almost all above soil; 7, cowhorn.

to one inch deep, the lesser depth on heavy soils and the greater depth on the lighter soils. The seeding is done as early as possible—the first of May for New York conditions—in rows twenty-eight to thirty-five inches wide. The young plants will appear in ten to fourteen days. A regular beet drill may be used or the seven-inch eleven-hoe grain drill. The part sown is a fruit and generally contains three to five seeds, half of which should germinate. Since two or three plants springing from one seed cause difficulty in thinning, attempts are now being made to breed fruits which contain but one seed.

Subsequent care.—The object of wide rows, twenty-eight inches or more, is to facilitate the use of machinery. Since land is low in price and labor is high, the aim should be to grow the maximum number of plants in a row and have as few rows as necessary to the acre and thus reduce the cost of production to its lowest point per ton. At least 30,000 plants should be grown per acre. The plants should be thinned to one in a place as soon as they have four leaves, or if thinning cannot be accomplished on time, they should be bunched by cutting out all plants except a little bunch every

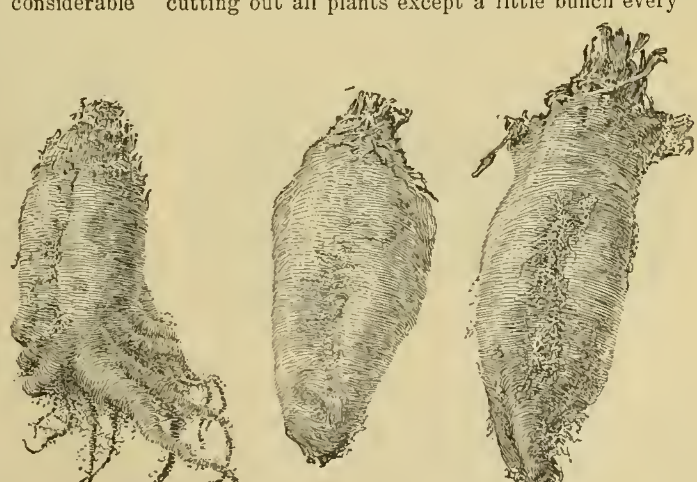

Fig. 781. Mangels. On the left, rough; center, single crown; right multiple crown.

six, eight or ten inches as required, or by running the weeder across the rows. Singling to one plant may be done later. Two plants should not be left close together. The distance asunder varies with the different varieties, globes and tankards requiring more space than the long varieties. Shallow cultivation should begin as soon as the rows are discernible and be maintained every seven or ten days until the tops meet in the rows.

As soon as the plants are thinned they should receive an application of fifty pounds of nitrate of soda, which may be mixed with 200 pounds of salt or with some acid phosphate to give it bulk. This should be applied near the plants, but not on the leaves, since it may burn them, and should be cultivated in. A second application may be given two weeks later.

Mangels do well after clover, or after an intertilled crop which has been well manured, as cabbages or corn, or after a grain crop. Sod land should be plowed one year before growing mangels on it.

Harvesting and storing.—Mangels are usually pulled by hand, the tops twisted off and the roots stored in root cellars or in piles in the field. They should be harvested when dry and should not be roughly handled. Sugar-beets are generally plowed out, or a beet digger is used. When pitted in the field the piles are covered with straw and soil to a sufficient extent to prevent injury from rain or frost. It is important to keep beets cool in storage and see that they are well ventilated. Freshly harvested mangels tend to produce "scouring" in stock, hence it is not advisable to feed them until they have been stored for a few weeks.

Feeding mangels.

Mangels are grown for stock-feeding. The valuable ingredient they contain is dry matter, which is almost entirely digestible and is comparatively easy to digest. The method of feeding them has been to use them as roughage, but owing to their

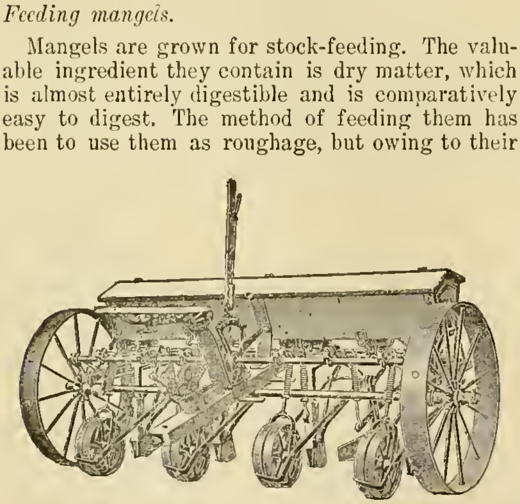

Fig. 782. Beet seeder.

watery nature and the ease with which silage can be produced in many parts of this country, the general opinion is that the latter roughage is the more economical. Recently, certain Danish experiments have shown that mangels can be regarded as concentrated feeds with a large amount of water present, and in comprehensive trials it was shown that for milk-production one pound of dry matter in the form of mangels (equal to about eight pounds of roots) was as good as one pound of corn meal, and that this was true in both cases when mangels were substituted for three pounds and seven pounds of grain in the ration.

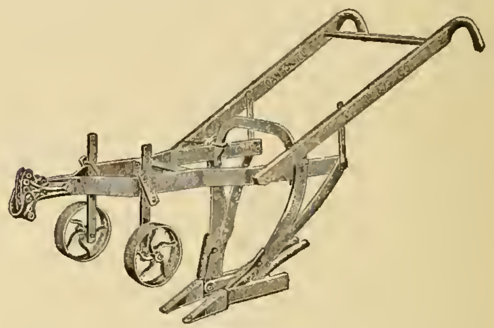

Fig. 783. Beet digger.

When fed to cattle, mangels are usually "pulped" or grated to irregular-shaped pieces about three-fourths of an inch in size. British feeders frequently mix the pulped roots with chaffed hay or straw and let them stand twelve hours before feeding. For sheep they are cut into finger pieces, or else sliced.

Enemies.

Mangels have few troubles, and should any occur which cannot be controlled by good tillage and good rotation, it will be better to abandon the crop. The diseases are the same as those of the sugar-beet [which see].

Parsnip. *Pastinaca sativa*, Linn. *Umbelliferæ.*

This plant is biennial, and is grown for its thickened stem and root, which is used for human food and for stock-feeding.

The parsnip was doubtless known to the Greeks and Romans, and it has figured in most of the herbals written since the sixteenth century, showing that it was well known and was used as food. It was disseminated in the West Indies by 1564, was cultivated in Virginia as early as 1609, and was grown in other colonies later in the same century. The Indians of western New York cultivated it in the eighteenth century. Wherever it has grown readily it has tended to escape from cultivation and become wild. Seedlings from wild plants will assume the characteristics of the cultivated forms under favorable conditions.

The plant is generally considered to be a native of the Old World, but it has been so widely disseminated that it is found wild in many regions. It is grown to some extent in Europe, but is raised only sparingly in this country. Since the root grows entirely below ground, it is difficult to harvest, and being small in comparison with other roots, both in size and in yield, it is not likely to be grown extensively for stock-feeding.

The average percentage composition usually given is water, 86.3; ash, 0.7; protein, 1.6; crude fiber, 1.0; nitrogen-free extract, 10.2; ether extract, 0.2.

The parsnip is grown usually on strong loams and even on clay soils. The details of culture are similar to those given for carrots [which see]. It is important, however, that the seed shall not be more than one year old and that it be sown near the surface. Four to six pounds are required to seed an acre. Since the roots are not injured by frost when left in the ground over winter, harvesting may be deferred until spring, if desired.

At the present time there are a few well-recognized varieties which are embraced in two main types: (1) the long type, which includes the Hollow Crown or Student variety and its strains; (2) the short or round type, which is of comparatively recent introduction. Both of these types are found wild.

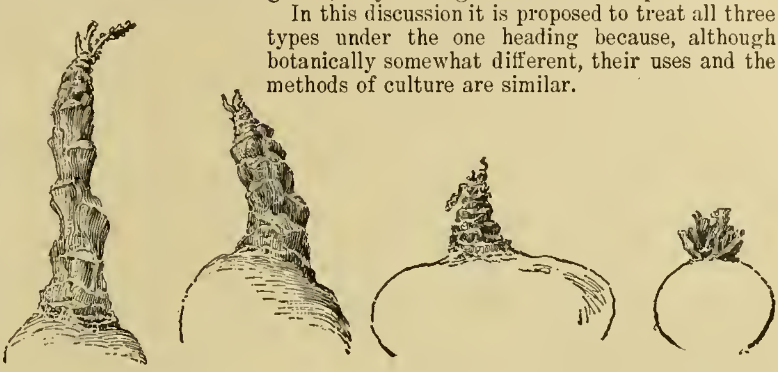

Fig. 784. Turnips, showing necks. Beginning at left, long, medium, short, absent (right.)

Sugar-beet. *Beta vulgaris*, Linn. *Chenopodiaceæ.*

A mangel developed for the production of sugar, and a product of the past century. So far as culture and use as stock-food is concerned, it is similar to mangel. [See separate article on *Sugar-beet.*]

Turnip. *Brassica*, sp. *Cruciferæ.* Figs. 778, 784, 785.

Turnips are grown for their thickened roots, which are formed during the first year of growth and are used as food for stock. The name "turnip" is here used in its widest sense and embraces the common turnip (*Brassica Rapa*, var. *depressa*, DC.), the rutabaga, a Swedish turnip (*Brassica Campestris*,

Fig. 785. Single and multiple crowns on turnips.

var. *rutabaga*, DC.), and the hybrid-turnip (*Brassica Rapa*, var. *hybrida*, Fraser), all of which belong to the same family as the cabbage. Like the mangel they consist of a thickened hypocotyl and primary root, the relative proportions of which vary in different varieties and even in individuals of the same variety, being modified by variations in the plants themselves, the soil and the method of cultivation. As usually grown, they are regarded as biennial plants.

In this discussion it is proposed to treat all three types under the one heading because, although botanically somewhat different, their uses and the methods of culture are similar.

History.

According to De Candolle, the common turnip (*Brassica Rapa*) and the rutabaga (*Brassica Campestris*, var. *rutabaga*) are native of temperate Europe. They were disseminated in Europe previous to, and in Asia after the Aryan invasion. Turnips were introduced from Spain to Mexico as early as 1586, and in 1610 Strachey reported that the Jamestown, Va., colony grew them as well or better than they were grown in England. Mason reported that they grew well in Newfoundland in 1617, and they were grown in New England as early as 1628. With the introduction of the Norfolk four-course rotation of turnips, barley, clover, wheat, into English agriculture in the middle of the eighteenth century, turnips began to be commonly grown for stock-feeding in England, although this practice had then been in vogue in parts of Europe for some time. Thus far Americans have not been much interested in these crops except to a small extent for garden purposes. A large number of the varieties grown are of European, chiefly British origin, and the question may be raised as to whether varieties selected and developed for American conditions might not be much more satisfactory and thereby encourage the greater development of these root crops.

Geographical distribution.

Turnips are grown most extensively in cool climates. They reach their highest development in northern Europe and the United Kingdom and do well in northern United States and Canada.

Composition of turnips.

The average percentage composition usually given is:

	Water	Ash	Protein	Crude fiber	Nitrogen-free extract	Ether extract
Common turnip .	90.5	0.8	1.1	1.2	6.2	0.2
Rutabaga . . .	88.6	1.2	1.2	1.3	7.5	0.2

In regard to the distribution of the dry matter in turnips, Wood and Berry, of Cambridge University (England), report as follows:

"The bulbs [shown in Fig. 778] of green-top yellow turnips from the same field, were each weighed and then cut into horizontal slices. The top and bottom pieces, 1 and 2, were not further divided. The other slices were subdivided; 3 represents a ring around the second slice and 4 the central part of the same slice. Similarly, 5 represents the outside ring of the third slice, 6 a ring inside that, and 7 the inside part of the slice. In this way each turnip was divided into twelve different sections from top to tail and from rind to core. Three other bulbs, representing two different varieties, were divided similarly but in a simpler manner. These gave results in general agreement with what is shown in Fig. 778. In all these samples only the dry matter was determined. The results may be summarized as follows:

"(1) The upper half of a turnip contains a higher percentage of dry matter than the lower half. This is in direct opposition to the common opinion that the under half is the richer.

"(2) The outside part next the rind is richer in dry matter than the inner part. As we proceed from the outside toward the center the dry matter falls. This is true, no matter in what direction we proceed, but the difference from crown to center is greater than the difference found in any other direction.

"This analysis shows that a sample taken from a turnip by boring can represent only approximately the composition of the turnip. In order accurately to obtain its composition, the whole turnip would require to be used, or at any rate a wedge passing through the center from top to tail would require to be taken from it."

Type distinctions.

Some of the differences between common turnips and rutabagas are brought out in the following table:

During the second year both turnips and rutabagas send up a strong stem which bears many branches. The leaves produced at this time are generally bluish green and smooth in both cases. The flowers of the rutabaga type are much like those of the cabbage, being large and creamy yellow, with long claws; those of the turnip type are more like the flowers of the mustards, being small and sulfur-yellow, and short-clawed. Thus far, no one has found any marked distinguishing features of the seeds of these types, although it is now possible to detect seeds of charlock or wild mustard in a sample of turnip or cabbage seed and to distinguish between seeds of turnip and cabbage. For data on this, consult Bulletin No. 29, United States Department of Agriculture, Division of Botany.

As mentioned elsewhere (page 540), a hybrid-turnip, or cross between a rutabaga and a common turnip, may have the characters of either parent blended in any number of ways.

Botanical relations.

In several of the Brassicas, selection of plants for economic purposes has been so long continued that the descendants of an original plant are now so diverse that they may be regarded as distinct species. The original plant from which the rutabaga has been derived is held by some to have been the result of a cross between the wild cabbage and the wild turnip, but such has not yet been proved. This plant (*Brassica campestris*), however, has given rise to several others, among which may be mentioned the colza or rape (*Brassica campestris*, var. *oleifera*), the best oil plant of Europe, annual in duration and developed for its seeds (see under *Oil-bearing plants*); and *Brassica campestris*, var. *rutabaga*, DC., which is biennial in duration and has been developed for its roots for stock-feeding. The same diversification is seen in the case of the wild turnip (*Brassica Rapa*). *Brassica Rapa*, var. *oleifera*, or the thin-rooted turnip, is an annual grown for its seeds to furnish oil, while *Brassica Rapa*, var. *depressa* is grown for its thickened root and is biennial

	Turnip	Rutabaga
First foliage leaves	Rough.	Rough.
Color of leaves	Grass green.	Bluish green, or covered with a bluish white bloom.
Later leaves produced the first year	Covered with rough, harsh hairs.	Smooth.
Neck	Absent.	Present.
Position of leaves	Like a rosette in the center of the upper surface of the "root."	On the neck, which usually shows well-defined leaf-scars.
Period of growth	Usually 60 to 120 days.	Usually 90 to 180 days.
Flowers	Small, usually yellow.	Larger, buff yellow to pale orange in color.
Roots	Usually smooth on the surface and in outline.	Usually rough on the surface and less perfect in form and outline.
Flesh	Soft, usually white to yellow, more often white.	Firmer, white, yellow or orange, more often yellow.
Keeping quality of "roots"	Generally poor; should be consumed early in the season.	Generally good; can be kept until spring.
Dry-matter content	5 to 10 per cent.	7 to 12 per cent.
Average weight of "roots"	3 to 40 ounces.	16 to 50 ounces.
Size of seed	Small; 2 to 3 pounds usually sown per acre.	Larger and darker in color; 4 to 5 pounds usually sown per acre.

in duration. The relationship of these plants to each other and to the hybrid-turnips is shown graphically below :

Brassica campestris. Hairy leaves when young, smooth leaves when older (said to be a cross between wild cabbage and wild turnip).

- *Brassica campestris*, var. *oleifera.* Colza or rape. Annual. Grown for seeds and oil. Best oil plant of Europe.
- *Brassica (campestris) rutabaga*, DC. Rutabaga, Swedish turnip. Biennial. Grown for "roots."

Brassica Rapa. Hairy leaves at all times.

- *Brassica Rapa*, var. *oleifera.* Annual; thin root. Grown for seed and oil.
- *Brassica Rapa*, var. *depressa.* Biennial, normally. Grown for its thickened "root."

Brassica Rapa, var. *hybrida*, Fraser. Hybrid-turnips. Modern. Biennial. Grown for "roots."

Classification of varieties.

Turnips are classified commercially according to their

(1) Shape.
(2) Shape of the upper part of the root.
(3) Color of the upper part of the root.
(4) Color of the flesh.

(1) Shape. Turnips are said to be flat when the width of tuber is one and one-half times the depth; globular when the crown and base are depressed like a globe, but the width is less than one and one-half times the depth; round when spherical in outline in all directions; tankard when the depth is less than two and one-half and more than one and one-half times the width and the sides are parallel; ovoid when the depth is less than two and one-half and more than one and one-half times the greatest width and the sides are not parallel, but taper toward the top and bottom; long when the length is over two and one-half times the greatest width; half-long when the roots taper from the shoulders to the root but the length is less than two and one-half times the width; cowhorn when the roots are twisted like a cow's horn.

(2) Shape of the upper part of the root. They may be "flat-topped" or "round-topped" according to the shape of the upper part of the root and the character of the shoulders. A concave or depressed top is objectionable, since it permits the lodgment of water and encourages diseases.

(3) Color of the upper part of the root. Roots are said to be white-, yellow-, green-, bronze-, gray-, purple-, red- or black-topped. The term "grey stones" is also applied to roots having the upper part mottled with green and purple streaks.

(4) Color of flesh. The flesh is generally white or yellowish. Both colors are found in common turnips, rutabagas and hybrids.

The varieties of turnips used in the garden give too low yield for stock-feeding, although they are sometimes sown broadcast after an early crop of potatoes, peas or other crop. For the latter purpose the Golden Ball, Pomeranian White Globe, Cowhorn or Mammoth Purple Top are frequently sown. For sowing for a main crop some of the cattle turnips grown in Great Britain are recommended, such as Imperial Green Globe, Purple-top Mammoth, Devonshire Grey Stone, Red Paragon, Red Globe, some of which yielded at the Cornell Experiment Station in 1904 at the rate of twenty-five tons per acre in four months after sowing. Among hybrid-turnips well-known varieties are Fosterton Hybrid, Aberdeen Yellow, Carter Lightning and Commonwealth, Garton Pioneer, Dale Hybrid. Among rutabagas, there are many strains of the Monarch or Elephant, the Improved Purple-Top, the Long Island Purple-Top, the Large White rutabaga, Green-top, Bronze-top.

Unfortunately, in turnips, as in mangels, the aim in the development of varieties seems to have been to select for non-essentials. It matters little whether a rutabaga is purple-topped or green-topped. It does matter whether it yields twenty-five tons of roots containing 8 per cent of dry matter or twenty-five tons containing 12 per cent, and it is on this line that future efforts in the development of varieties must be concentrated. As mentioned in the case of mangels, the only method practicable for the improvement of turnips and the selection of "mother roots" for seed production seems to be to take out a core or plug from each individual root, determine the amount of dry matter in the same and retain only those roots which are rich in dry matter. When varieties are valued and catalogued on their performance record, as fast horses and dairy cattle now are, it will be easier to give advice as to the variety which should be grown.

Culture of turnips.

Land.—The best soils are free-working loams, rich in organic matter and in good tilth. Common turnips will thrive on the lighter loams, and the rutabagas will give higher yields on the medium to heavy loams, although, if well supplied with moisture and manure, good crops may be grown on light friable soils. Stiff clays are unsuitable because of the difficulty in securing a fine seed-bed, which is essential; and light, sandy and gravelly soils are objectionable because the yield is low. The root system of turnips is mainly in the surface soil, and the moisture supply at this point in the sandy soils is likely to fail.

Climate.—Climate is of more importance than soil. For perfect development a damp, rather dull climate seems to be best. Unless the rainfall is well distributed throughout the growing period, the plants are likely to receive a check from which they may never recover.

Preparation of the land. [See *Mangels.*]—Emphasis must be laid on the necessity of thorough preparation of the land and securing fine tilth. Phosphatic fertilizers with barnyard manure are generally profitable, 400 to 600 pounds of acid phosphate per acre being applied in addition to ten tons of farm manure per acre.

Seeding turnips.—Large, plump seed produces very strong plants. Two and one-half to five pounds, average four pounds, of seed per acre is usually sown in the case of rutabagas and hybrids; and two to four pounds, average three pounds, per acre in the case of common turnips, when the rows are twenty-seven inches apart. Less would do if we could be sure that the flea-beetles would not kill many of the plants. The seed should be sown at a depth of one-half to three-fourths inch, usually the former, but in a dry season the latter may be better. It can readily be sown too deep. The results obtained during the past two years at Cornell University show that sowing on May 11 gave over 100 per cent better yield than sowing on June 12.

Thinning.—The young plants come up about four days after sowing and are ready for thinning in three or four weeks. The stand of a root crop has great influence on the yield, and to secure more plants per acre it has been urged to make the rows closer. This, however, eliminates the use of horse-power machinery, necessitating hand labor and rendering the crop unprofitable. In the case of rutabagas, 26,000 to 30,000 plants must be grown per acre, and with common turnips rather more. Twenty-seven-inch rows are better than twenty-four-inch, and thirty-inch rows are easier to cultivate than twenty-seven. Some of the distances advocated are considered below:

	No. of plants per acre
23-inch rows, plants 14 inches asunder . .	19,480
24-inch rows, plants 12 inches asunder . .	21,780
27-inch rows, plants 10 inches asunder . .	23,232
30-inch rows, plants 8 inches asunder . . .	26,136
30-inch rows, plants 7½ inches asunder . .	27,878

As with mangels, it is recommended that the effort be made to secure the maximum yield per row, and the use of thirty-inch rows with plants seven to eight inches asunder in the row is suggested. The common turnips may be left five or seven inches asunder. Some of the advantages of wide rows are better air circulation among the plants, which aids in checking fungous diseases, and fewer rows to cultivate and to thin, with a consequent saving in labor. The object is to produce roots at the least cost per bushel. Intertillage should be given every seven to ten days until the foliage meets in the rows.

Harvesting.—The roots are usually pulled by hand, and the necks and tops cut off and left in the field. The roots are stored in root-cellars or pits. Since these roots can withstand more frost than mangels and are usually used earlier in the season, they are stored after mangels are harvested. The roots should be dry when harvested and pitted, and good ventilation and a low temperature should be maintained in the storage. In Great Britain common and hybrid-turnips are frequently consumed in the field by folding sheep or young stock on them. This practice has been used to a small extent in some parts of northern United States.

Uses.

Aside from their value for cattle-feeding, there is sometimes a market for the better quality turnips for human consumption. Late-sown and not too large rutabagas are barreled and shipped to most of the large cities in the North, but for such purposes varieties required by the different markets should be secured.

Enemies.

Clubroot or anbury (*Plasmodiophora brassicæ*), sometimes does considerable injury. For treatment, see Cabbage. A soft rot due to a bacterium (*Bacillus carotovorus*, Jones) has been doing serious injury to the crop in some of the northern states. It is most serious when a crop has reached maturity. Late sowing or speedy consumption of the crop seems to be the only means of combating it. A brown bacterial rot (*Pseudomonas campestris*) frequently ravages the crop when the cruciferous plants are grown too closely together in the rotation.

The flea-beetle (*Phyllotreta vittata*), mentioned under cabbage, frequently destroys the young plants and necessitates resowing of the crop.

Early sowing and plenty of seed, a good rotation, having the soil in the best of tilth, liming, manuring and timeliness in doing the work, will generally put the plants in such a condition that they will safely withstand most of the diseases and insect attacks.

Root Cellars and Storage Houses. Figs. 786–789.

By *L. C. Corbett.*

Well-constructed pits are more desirable for the storage of both fruits and vegetables than house cellars. All offense from decaying vegetables is thus removed from the dwelling, and as a rule a lower and more satisfactory temperature for the storage of such products can be maintained in root cellars than in house cellars. The trifling expense involved in the construction of a satisfactory root cellar and the value of beets, turnips and carrots as stock-food, should command much greater attention for the root cellar from stockmen and dairymen than has been given it in this country.

In view of the character of the products to be stored in a root cellar, cheapness of construction is essential. The less expensive the construction, that at the same time will be convenient, and have a reasonable degree of permanence, the more desirable. Convenience to the feeding place is important because of the bulk and weight of the product to be handled. Barn cellars are as a rule, therefore, when practicable, most convenient though not always least expensive. If roots are to be used extensively in the feeding of dairy herds, and if it is possible to use the bank basement so as to fill the cellar by dumping the roots from the floor above or through an area-way from the outside, a very considerable saving in labor can be made.

Construction.

In the construction of the root cellar, whether it be a part of the basement of the barn or an independent structure, arrangements must be made to provide good ventilation by admitting cold air from without, and by means of flues to carry off dampness and warm air from within. The side walls as well as the floor should be dry, and while it is more desirable that they consist of earth or masonry than of lumber, they should be frost-proof.

These requirements can be attained in several ways, among which may be mentioned the bank-pit or cave construction. This requires the making of an excavation into the side of a hill in a well-drained place. Such excavations should not be too wide to be spanned by a safe arch or covered by poles, or simply with rafters and a ridge pole. When the cellar is wider, it is necessary to use posts and pillars to support the roof, which is undesirable. The length of the cellar will be determined by the quantity of products to be stored or by the nature of the location in which it is to be constructed. A pit eight feet wide and thirty feet long will hold 700 bushels of roots.

Materials.— Now that concrete is so extensively used in all building work, both above and below ground, it is thought that a permanent root cellar, whether an adjunct to the barn itself or an independent structure, can be constructed more economically with this material than with stone or brick. Simple forms for the side walls can be made from rough lumber, and the roof can be built either over rafters set for a flat roof or over a low segment giving an arched roof. The side walls need not be more than six or seven inches thick, and if the span of the roof is not over eight feet and the layer of earth over the concrete is not more than twelve inches, an 8-inch wall over the arch will be sufficient.

A cheaper bank cellar can be constructed by using posts and planks to hold the sides of the bank in place. If the earth is stiff clay, the sides will not require supporting either by concrete or by posts and planks. If posts and boards are used, the roof can be built on top of the posts about twelve inches below the general level of the soil, so as to provide a gutter at the side after the roof frame has been covered with earth and sod. In fact, this arrangement is desirable, no matter what the interior construction.

On level ground in localities where the winters are not severe, root cellars are constructed partly above and partly below the surface. For houses of this kind, concrete, stone, brick and log-crib construction are used. The kind of building will depend, of course, on the use, the material at hand and the cost. Since there are no special features to be provided in these structures, except that they are usually placed two to four feet in the ground, the log-crib building only will be described.

Log-crib building. (Fig. 786.)—"If there is no hillside convenient, a knoll or other dry place should be chosen, and the soil removed over a space a trifle larger than the ground plan of the house, and to

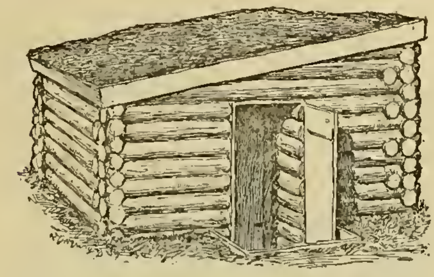

Fig. 786. Root cellar. Crib-construction. After Halsted.

the depth of two feet or more, provided there is no danger that the bottom will be wet. In the construction of the house, select poles or logs of two sizes, the larger ones being the shorter; these are for the inside pen, as it is subjected to greater strain. The ends of the logs are cut flat, so that they will fit down closely together, and make a pen that is nearly tight. At least two logs in each layer of the inner pen should be cut long enough to pass through and fit into the outer pen, to serve to fasten the two walls together, the space between the two being two feet wide on each side. The doorway is built up by having short logs, which pass from one layer of poles to the other, and serve as supports to the ends of the wall poles. This is shown in Fig. 786, in which the house is represented as completed. The space between the two walls is filled with earth, sods being used to fill in between the logs to block the earth. It is best to begin putting in the earth before the walls are completed, as otherwise it will require an undue amount of hard lifting.

"When the walls are built up five to six feet on one side, and about two feet higher on the other, to give the necessary slope, the roof is put on. The latter should be of poles placed close together, well secured to the logs, and covered with sod, eighteen inches of earth, and sodded again on the top. Two doors should be provided, one on the inner and the other on the outer wall, both to fit closely. A filling of straw can be placed between the doors, if it is necessary, in order to keep out the frost. Such a house will last for many years, paying for its moderate cost many times over." [Barn Plans and Outbuildings, B. D. Halsted.]

The "A" construction. (Fig. 787.)—A construction somewhat akin to this is used extensively throughout the Carolinas for storing sweet-potatoes. For this purpose, poles about eight feet long are taken. If of a size to allow splitting in half, so much the better. The ends of the pieces are cut at the same angle that rafters would be cut to give the desired pitch to the roof. A well-drained and somewhat sheltered situation is chosen, the earth smoothed and a slight excavation made in which to place the bases of the poles; the split timbers are then set against a ridge-pole in the form of the letter A. The timbers are fitted as closely as possible, so as to form a comparatively tight side. The ridge is about six or six and one-half feet above the surface of the ground, which, with eight-foot pieces, makes a room about eight feet wide, six feet high and any length desired. If the room is not more than sixteen or twenty feet long, the door is placed in the end, but, if it has a greater length, the door is usually placed in one side and given the same slant as the side of the building. After the framework has been completed, the structure is covered

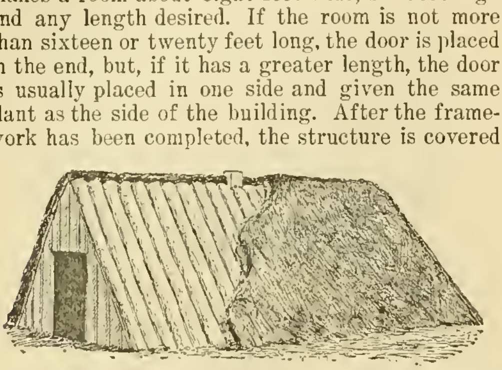

Fig. 787. Root cellar. "A" construction.

with a layer of straw or turf and earth to the desired depth to give the needed protection. Board chimneys six or eight inches square are provided to give ventilation. One is sufficient for a house of any length up to sixteen feet, but another should be used for each additional ten feet. When it is desirable to increase ventilation, or to enable the cellar temperature to be maintained at an unusually low point early in the fall, or late in the spring, tile intake pipes can be arranged to carry the cold night air from the outside to the cellar. The intake pipes should be provided with dampers to exclude the heated air of the day, but opened at night when the temperature falls low enough to aid in cooling the pit.

The interior arrangement.—The interior arrangement of the root cellar will depend on the use to which it is to be put. If for the storage of beets, turnips or carrots for stock-food, it should be arranged to store them in bulk without the construction of bins. If it is desirable to store several kinds of roots in the same cellar and keep them separate, then the construction of bins will be desirable. Usually it will be best to use only earth or concrete floors, the partitions for the bins being made of plank or concrete.

Special types of storage houses.

Besides the types of storage structures already described, there are in use among the producers, as well as dealers in root crops, structures which are designed to carry such products as are injured by freezing through the severe weather of the winter. Preëminent among the crops which are thus stored may be mentioned onions, sweet-potatoes, Irish potatoes and celery.

Houses for sweet-potatoes, onions and Irish potatoes.—In general, the types of construction of storage houses used for the storage of the sweet-potato, onion and Irish potato, are very much the same. They are usually built above ground or as bank structures, part of the basement being beneath the surface of the ground, and so arranged as to be conveniently approached by wagon and by water or railway transportation facilities. Buildings for this purpose are built of stone, concrete or wood, the walls being made as nearly frost-proof as possible. When brick, stone or concrete structures are employed, the walls are so constructed as to carry a dead-air space. In addition to this they are usually furred out and lined with paper and matched lumber. If stone or concrete is used, either hollow blocks or solid walls are built and furred out as above described. In frame construction, 2 x 6 or 2 x 8 studding are employed, and paper is placed between the studding so as to divide the space between the front and back of the studding, so that when paper flooring and ceiling are placed on the two sides a double space is formed. It is customary to place on the outside matched sheeting, a layer of paper and weather boarding, and on the inside matched boards, paper, furring strips, paper and another layer of matched lumber, thus making three dead-air spaces in the wall. Such buildings, built entirely above ground and located in the extreme northern potato regions of the United States, are practically frost-proof. The precaution which is taken in the storage of perishable products in such buildings is to keep the products from contact with the outside walls.

In the case of storage houses for sweet-potatoes which are built much after the manner described, they need not, in the regions in which sweet-potatoes are grown, be provided with so many dead-air spaces. The potatoes are usually stored in bulk in bins which are kept from the outside wall by slat-cribbing placed about eighteen inches from the outside wall. The sweet-potatoes are harvested as soon as the first frost injures the vines. The potatoes are dug so as to dry as thoroughly as possible in the field. They are then carefully gathered into small baskets holding five-eighths to one bushel, and carried, preferably on spring wagons, to the storage house, where they are placed in large heaps in a storage room, which is kept by means of artificial heat at a temperature of about 80° to 85° throughout the harvest period, and for at least ten days or two weeks thereafter. A common practice is to place the potatoes in layers about two feet deep, which may be separated by pine needles or some dry absorbent material which will act as an insulation to the different layers. With these facilities and proper ventilation, provided the tubers are not in contact with the earth or a concrete floor, but rather on a board floor elevated some fifteen or eighteen inches from the earth, and so arranged that cold air shall not be admitted after the curing period has passed, the potatoes can be kept very successfully until February or March, or even on to the bedding period for the next year's crop.

Irish potatoes may be stored in bulk in cribs similar to those described for sweet-potatoes. A more common practice, however, is to store them in bushel crates or in gunny sacks; but bags or gunny sacks are likely to be unsatisfactory. If they are stored in crates they are placed in tiers about five or six crates wide, and as high as the crates can be conveniently placed in the room. If stored in sacks, the tiers are about three to five sacks wide and sometimes ten sacks high. This arrangement provides an alley-way between the different lines of stored material, whether in sacks or in crates.

In the case of onions, false shelving or racks are sometimes provided, which are about six or eight feet wide, on which the onions are very carefully spread, eight to fifteen inches deep, there being sufficient space above the onions to admit of inspection; but the usual practice is to replace the shelving by bushel crates, which are universally used for gathering such products. The crated onions are then stored in perfectly insulated buildings constructed as above described.

The capacity of such storage houses varies from a few hundred to fifty thousand bushels. The practice in some regions where onions are carried over for seed purposes is to spread the bulbs on slat racks in open buildings where they are allowed to freeze at the beginning of winter and remain frozen throughout the whole storage period. Under these circumstances it is very important that the bulbs be protected from all possible injury; even the jarring of the building must be guarded against, otherwise the bulbs will rot at the approach of warm weather in the spring. It is evident, from the nature of the case, that this system can be followed only in regions where the winters are rigorous.

In the storage of Irish potatoes and onions, it is desirable that the products be in contact with the earth if practicable. The moisture of the earth seems to have a beneficial influence on the quality of the product, if it is to remain in storage for a considerable period. Onion bins and crates, when placed directly on the earth, are less liable to jars and disturbances, which cause loss in the stored bulbs, than when made a part of the superstructure.

Storage houses for sweet-potatoes and onions must be provided with flues and ventilating arrangements to remove the moisture and to keep the temperature within the limit of safety. In some cases this involves heating facilities as well as ventilating and cooling apparatus.

Celery pits.—The storage houses or pits for celery are very different in construction and usually consist of a half-cellar arrangement. A well-drained location is chosen, preferably on soil which is of a sandy character. The buildings are so constructed as to give sufficient head room for storing and caring for the crop. Buildings of this description are usually about twelve or fourteen feet wide, and provided with side walls two or three feet high, which are fairly well insulated to protect the plants next to the outside, either by banking at the outside or by the style of construction above described. The roof is then made of boards, usually those used for blanching the early crop of celery in the field. In cases where more permanent structures are desired, the houses may be constructed of concrete and provided with shingle or slate roofs. Sufficient ventilating flues must be provided to govern the temperature inside the pit; windows are also necessary to provide light for those who water and care for the crop during the storage period.

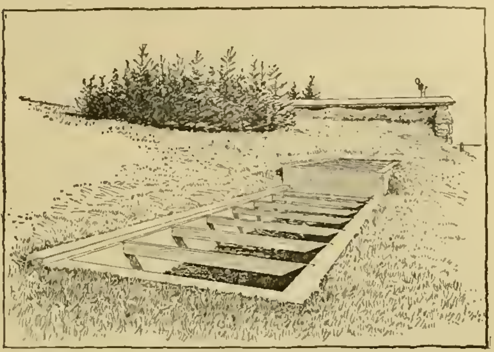

Fig. 789. Concrete hotbeds and masonry root cellar. Side view of cellar shown in Fig. 788.

Example of a general-purpose root cellar.

In Figs. 788 and 789 are shown a front and side view of a well-constructed and very serviceable root cellar at the Farm and Trades School, Boston, Mass. The cellar faces south. The walls are of solid masonry two feet thick, and extending two feet below the level of the earth floor. The front and top only are exposed, the earth bank sloping away from the two sides and the rear. The front wall extends beyond the side walls to retain the earth.

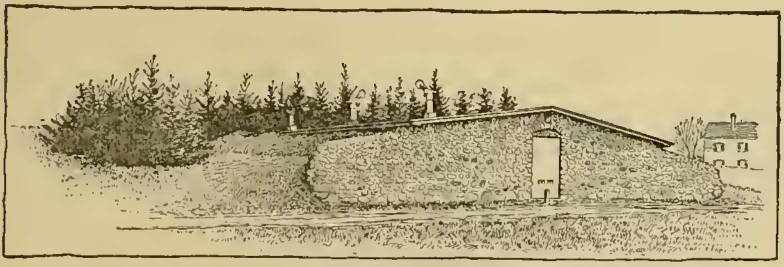

Fig. 788. Root cellar. The spruce trees serve to catch the snow so that it will drift on the roof.

The roof is of two-inch matched spruce, tarred and covered with three-ply roofing-paper. The ceiling is sheathed, leaving a dead-air space. The rafters are 2 x 8 spruce, and the collar-beams the same. Entrance is through an outer and an inner door, each four by seven feet, set in the center of the front wall. There are four automatic ventilators in the roof, also one over the door and one in each door, all regulated from the inside. On the south side of the interior is a brick wall, extending from end to end, six feet from the side wall and three feet high. From the top of this wall to the ceiling is a double-boarded partition, and a door leads from the main cellar into this smaller room. This is for keeping celery banked in sand. The room has two small ventilators in the roof. In the main room are bins and shelves for different vegetables. The cellar is thirty-nine feet six inches long, and twenty-six feet six inches wide. The interior height is seven feet six inches. The cellar is cool and dry, capable of being kept at a uniform temperature, and will accommodate four thousand bushels.

RUBBER, OR CAOUTCHOUC. Figs. 790–798.

By *H. N. Ridley* and *J. H. Hart.*

Rubber, or caoutchouc, is obtained from the milky juice or latex of a considerable number of trees and shrubs, erect or climbing, which inhabit almost exclusively tropical parts, though some are found in sub-tropical regions. These plants belong to the families *Urticaceæ*, *Euphorbiaceæ* and *Apocynaceæ*. For practical agriculture, however, there are only four of these plants which can be utilized in cultivation, viz., *Hevea Brasiliensis* and *Manihot Glaziovii* of the *Euphorbiaceæ*, and *Castilloa elastica* and *Ficus elastica* of the *Urticaceæ*. The big woody climbers, *Landolphia* and *Willughbeia*, of the forests of Africa and Malaya, do not respond to cultural treatment. *Hancornia* and various species of Ficus not mentioned above have given such poor results under cultivation that they are not worth the attention of the agriculturist, though the rubber has value when it can be collected in sufficient quantity. *Mimusops globosa*, a tree which produces "Balata rubber" (or gutta-percha), is indigenous to South America and the British island of Trinidad, and might be cultivated to any extent. It is a slow-growing tree, but to those who can afford to wait it would doubtless be a most profitable investment.

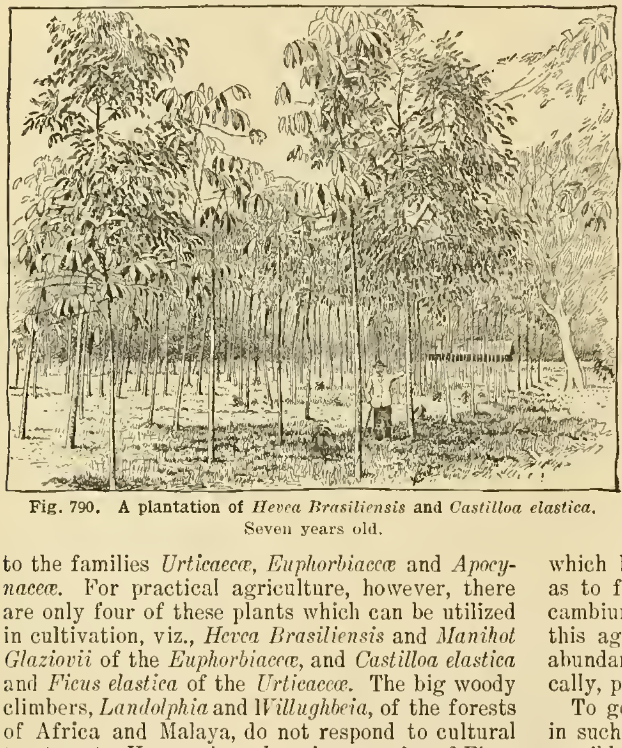

Fig. 790. A plantation of *Hevea Brasiliensis* and *Castilloa elastica*. Seven years old.

In the four species above mentioned, we have plants of which one or another is suitable for cultivation on a large scale and with good profit very widely in the tropical regions. All are trees of considerable size, and, under suitable circumstances, of rapid growth.

The United States is entirely dependent on imports for its rubber. Crude rubber is the third largest of the tropical imports of this country. The imports for the five years, 1898–1902, were as follows:

1898	$25,386,010
1899	31,707,630
1900	31,376,867
1901	28,455,383
1902	24,899,230
Average	28,365,024

It is absolutely essential for the agriculturist who intends planting rubber trees, first carefully to select the kind suited for the climate and soil in which he intends to plant. Much money has been wasted by attempting to plant Ceara rubber in the tropical rain-forest region. Such errors are easily avoidable.

The latex.

The latex, or milk, is a white liquid consisting of water containing proteid matter, sugar and minute globules of caoutchouc or rubber. The art of making the rubber consists in separating the rubber from the water and other constituents of the latex.

The latex occurs in a series of special vessels (the laticiferous vessels) which permeate the bark of the stem and twigs and also the leaves and other soft parts of the trees. A section of the bark of the Para rubber (Hevea) under the microscope shows on the outer surface several layers of hard, thick-walled cells, forming the cork layer; below this lie layers of thin-walled, long cells, the bast layer, through which run the laticiferous vessels, which are of some length and which branch and join each other at intervals so as to form a network. Below this layer lies the cambium or growing layer of the bark, and below this again the wood. The latex vessels are most abundant near the cambium layer, and run vertically, parallel with the long axis of the stem.

To get the latex it is necessary to cut the bark in such a way as to cross as many latex-tubes as possible without unduly injuring the tree. A notion holds that the wound should not penetrate the delicate cambium layer but stop short of it for fear of risking the life of the tree. As a matter of fact, in Para rubber, at least, the risk is small. Many trees have been cut to the cambium and deeper in the Singapore Botanic Gardens, but none have been injured; reports from Ceylon, however, recommend great care in this respect. Less deep wounds heal more quickly, it is true, but as the greater part of the latex vessels lie very close to the cambium, unless the wound is made to this layer not more than half the available latex can be secured.

Although latex occurs in all parts of the tree, that which is found in the upper branches and twigs is weak and of no value commercially. It is therefore from the lower part of the trunk, and, in

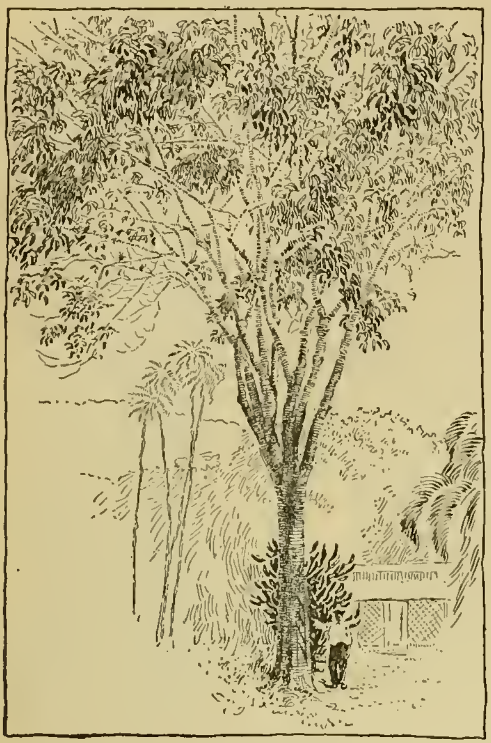

Fig. 791. *Hevea Brasiliensis*, or Para rubber tree, thirty years old.

Ficus, from the aërial roots also, that the rubber is derived.

The value of the rubbers of different trees is by no means the same. That of the Hevea is much the most valued, and consequently this tree is the most extensively cultivated of the four mentioned. This seems to be due to the fact that this rubber contains less resin than do the other rubbers. In Hevea there is also a perceptible difference in the quality and quantity of latex obtainable from different trees.

Culture.

As there are some important differences in the way that each kind of tree requires to be treated, both in the matter of cultivation and preparation of the rubber, it will be advisable to treat of each kind separately. Because of its importance, and inasmuch as some of the practices employed in raising Para rubber apply to all the others, or will serve to illustrate the general principles, this species is discussed at length.

Para rubber (*Hevea Brasiliensis*). Figs. 790–793.

The Para rubber is a native of the tropical forests bordering the Amazon river and its tributaries, where it grows in a damp, hot climate, with a heavy rainfall, and with no distinct dry period. It is therefore suited for those parts of the world which lie close to the equator, and are known as the tropical rain-forest region. It thrives in the West Indies. The temperature at which it grows shows a mean annual of 78° Fahr; mean maximum, 87° Fahr; mean minimum, 69° Fahr; extreme maximum, 93° Fahr; and extreme minimum, 62° Fahr.

The seed.—This tree is nearly always grown from seed, for, although it is possible to raise it from cuttings, this is not to be recommended. The seeds in adult trees are produced more or less throughout the year, but the main crop is ripe in August (in Trinidad always in September and October). The seeds are about an inch long, oblong-rounded, with one side slightly flattened, dark brown marbled with silver. They vary in size, some of the finest trees giving very small seeds. They are produced in a large, woody, three-celled capsule, which when ripe explodes violently, throwing the seeds.

The seed should be planted as soon as possible after it ripens, as its vitality is of short duration, and, unless specially treated, it dies within a week. Seed sent from a distance, which has been long on the way, should be soaked in water for a day before planting.

The nursery (Fig. 792).—Nursery-beds are made in moderately moist, rich soil, carefully worked. The seeds are placed in rows about six inches apart, on the flat side, and pressed into the soil for about half their depth. In some regions they are not covered with earth. It is advisable at first to cover them with a light shade of leaves or branches, about a foot above the ground. The seed germinates very quickly. The plant can be removed to the plantation when it is about a foot tall, which will be six or eight months from the time of planting the seed. However, it may be kept in the nursery till much later, as it is very hardy and bears transplanting at almost any age. It is advisable to

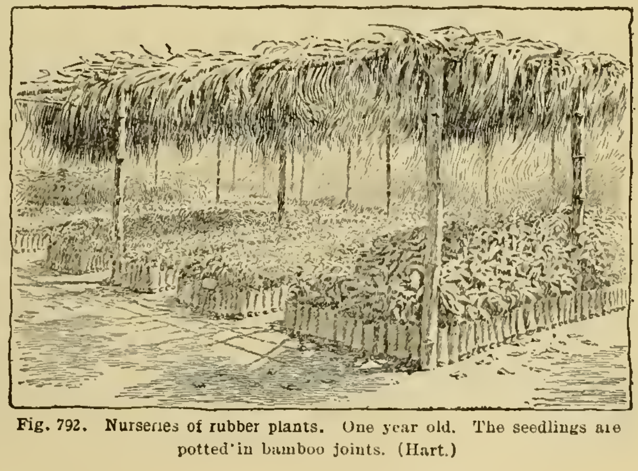

Fig. 792. Nurseries of rubber plants. One year old. The seedlings are potted in bamboo joints. (Hart.)

keep it longer in the nursery when the plantation is liable to the attacks of grasshoppers or slugs, or where deer or other wild beasts are likely to attack the young plant. In such cases the taproot should be cut off, and, if the young plant is over twelve feet in height, the top should also be removed with a clean cut at eight to ten feet from the ground.

Young plants of Hevea should be potted in bamboo joints as soon as they can be safely handled; and the same applies to all the species. In the bamboo pots the young plants can await time or season for planting better than if grown in nursery-beds, and will stand transport better. However, they should not stand too long in these pots, or their roots may become cramped and hinder future growth. (Hart.)

The plantation.—The soil in the plantation should be rich alluvial flat, free from salt-water and well drained. Rocky or very sandy soil should be avoided. The ground should be cleared of trees and bushes by felling and burning, and the young trees should be planted about twenty-five feet apart.

Growth.—The growth in a suitable locality is very rapid, and the young trees should be about fifteen feet tall in a year and a half, and should attain their full height of sixty feet in about eight years. If they grow very tall and slender it is advisable to top them at about eight or nine feet from the ground. For the first few years the ground should be cleared of weeds from time to time; afterward it is less necessary, as the trees will shade out the weeds. No further cultivation is required.

The duration of the life of the tree is not known. The oldest trees in cultivation are about thirty-five years of age and show no signs of weakening; and there are said to be some trees in the Amazon region which have been tapped for eighty years.

It was formerly thought that the Hevea requires swampy river-side lands, but the discovery of forests of it in high lands shows that a moist situation is not essential. That it thrives in gravelly soil and stands drought well has been amply proved. The better the land, however, the better the growth, and on well-drained river-side lands it certainly reaches a larger size than on dry ground. The tree thrives in the open, but grows faster when slightly shaded in its younger stages by trees of similar habit. (Hart.)

The trees should fruit in their fifth year. The flowering season is preceded by the fall of the leaves, which in young trees takes place all at once. Older trees shed their leaves more irregularly.

Tapping.—Many methods of tapping are now in use, and it is probable that as the industry progresses other methods may be found to which those in use will eventually give way. In the original forest the life of the tree is but little regarded, and generally the collector takes all he can, to get which the trees are badly mutilated and usually die. It is evident, therefore, that very careful measures are necessary on cultivated estates, not to injure the trees if continuous crops are to be secured. While the trees have large recuperative power, yet it is certain that excessive wounding for bleeding purposes must tell on them and eventually diminish the yield, if indeed the trees do not succumb altogether. (Hart.)

Tapping may begin in the sixth year with Hevea, but much depends on the size of the stem at that age. The rubber from young trees is weaker and lighter than that from older trees, which is valued more highly. It is watery and contains a considerable proportion of resinous matter, a feature which disappears as age advances.

The most convenient and satisfactory method of tapping the Para rubber tree is the herring-bone system (Fig. 793). A vertical incision is made in the bark from as high as a man can conveniently reach to within a few inches of the ground, and as narrow as possible, as it is required only to conduct the milk to the cup inserted by its edge at the base of the cut. On either side, sloping cuts are made alternately about six inches apart, connecting with the central cut. The milk runs from these side cuts to the central channel and so into the cup. Each day a thin slice is taken off the lower side of each side cut till the milk ceases to flow or till the cut is about one and one-half inches wide, when tapping is stopped and the wound allowed to heal, which it does in about six months. Wounds may be dressed with coal-tar.

Fig. 793.
Para rubber tree, showing herring-bone tapping.

Tapping is done all the year round, and is best performed in the early morning at daylight, or in the evening. The former gives the largest yield. Some growers prefer to tap during wet weather, on the theory that the sap flows faster then, and because the additional moisture delays coagulation and thus facilitates gathering. In dry weather the latex coagulates in the cuts and stops the flow.

The instruments used for cutting the bark are very varied, new ones constantly being invented. Especially in old trees, a mallet and a chisel are perhaps the best and most easily used. The cups for catching the milk are made of aluminum, with a rounded base, and contain four or eight ounces.

The milk runs for half an hour or so and then stops. The cups are collected and their contents poured into jugs or other large vessels to carry to the curing shed. It is advisable to put a little water with a drop of formalin into each cup before fixing it to the tree, to avoid coagulation in the cups, which sometimes occurs. The latices of all trees should be strained through a fine wire mesh to remove the impurities inseparable from the bleeding process.

Preparing.—Rubber may be made in various forms, the best of which are biscnit, crêpe or sheet, and block. For biscuit, the latex, after being strained through muslin or wire gauze to remove any dirt, is poured into enameled iron plates. A few drops of acetic acid are put in each plate, and the milk stirred. The plates are covered and put aside for about twelve hours, when the latex is found to be set, and can be taken out in a cake. It is then put between rollers and rolled flat, and laid away on a rack to dry, in a cool, dry place. The drying usually takes some weeks. When quite dry the biscuits are packed in wooden boxes for shipment. If in drying mold appears, the biscuits are wiped with a rag moistened with formalin.

Some planters do not use acetic acid, but allow the latex to coagulate of itself. The objection is that it takes a much longer time to set, and the latex is liable to suffer from the decomposition of the proteids. Rubber is also sometimes smoked over a wood fire. This accelerates the drying but darkens it and sometimes causes a small reduction in value.

Sheet rubber is made in the same way but in long, flat trays. Crêpe is made in a machine invented in the Malay states, the rollers of which are grooved and tear up and press the soft rubber together again, making it of a lace-like appearance.

There is a slight preference at present for biscuit and sheet rubber over crêpe, but the latter has the advantage of drying more rapidly. Block rubber has recently come into prominence.

Scrap is the waste bits of rubber derived from the cuts when reopening, and any other bits which cannot be made into biscuits. The washings of the cups and splashes of milk, and in fact every drop of latex, collected into a wooden tub and coagulated with acid, go into the scrap.

Returns and profits.—Every well-grown tree of six years (in the Straits Settlements) should give three-fourths to one pound of dry rubber per year, and increase as the tree grows. The price of plantation rubber has been extraordinarily high of late, reaching as much as seven shillings a pound. Although it is difficult to forecast even an average price of the product, at a reduction of one-half of the present value the planter would still gain a large profit. It is estimated in the East that the cost of making the rubber and putting it on the market is five to ten cents Mexican, or one to two pence per pound; in Trinidad it is eight pence to one shilling. The scrap, if tolerably clean, is worth one or two shillings less per pound, but usually brings a higher price than the best African rubber.

Central American or Panama rubber (*Castilloa elastica*). Fig. 794; Fig. 120, Vol. I.

The Central American rubber, a tree allied to the bread-fruit, is a native of the northern parts of South America and Central America, and is more suited for cultivation in latitndes ten degrees north of the equator. It does not seem ever to have been grown successfully along the equator. The area of its successful cultivation lies north of the region for the latter plant. Cultivated trees reach a height of sixty feet, with a diameter of eighteen inches, in twenty years.

The plant is raised from seed in nursery-beds, and when about a foot tall is removed to the plantation. It thrives best when planted not too thickly with other trees. The tree can be tapped in the same way as Para rubber at about eight years of age. A spiral form of cut is often used (see Vol. I, page 108), but is not recommended. With this tree, as with all others, it is best not to tap too early, as such treatment is likely to affect later production. A better quality of rubber is produced as age advances. The latex is coagulated by adding boiling water to it, and, after straining, by adding eight ounces of formaldehyde to a barrelful. Then the creamy mass is washed again and rolled out, or it may be mixed with water in a barrel with a tap at the bottom. This water is drawn off in about twelve hours, and the operation repeated two or three times, when the cream is allowed to coagulate and is then rolled out.

Separation can also be effected by centrifugal action, but the frequent stoppages necessary are an expensive waste of time. By this process the rubber is rapidly brought to the surface of the vessels used, and requires only to be dried. A convenient method of coagulating and drying is by means of the "sand filter," which can be used in connection with either the creaming or the centrifugal process. A centripetal method is now under trial, which is inexpensive and is expected to work with great economy. If the latex is left in the original fluids after straining through a fine mesh, it quickly ferments and becomes putrid; the rubber will then coagulate and float on the surface, and there is but trifling loss. The rubber thus produced is dark in color, but of good quality, free from resinous matter and keeps well. The method, however, is tedious, repulsive, and takes considerable time. (Hart.)

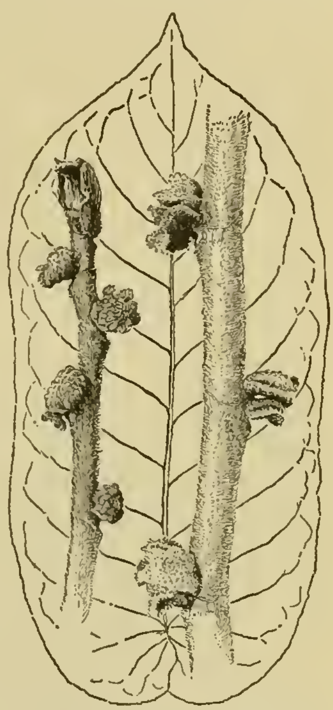

Fig. 794. Pistillate (left) and staminate (right) flowers and leaf of *Castilloa*. (Adapted from Bulletin No. 49, Bureau of Plant Industry.)

The amount of rubber from a tree is variously stated. An eight-year-old tree probably gives about six pounds (or less) a year on an average. The rubber brings a lower price than Para.

Ceara rubber (*Manihot Glaziovii*).

The Ceara rubber, a tree allied to the tapioca plant, is a native of the dry desert regions of Ceara in Brazil, where there is annually a long spell of drought during which not a drop of rain falls and the soil becomes perfectly dry. Though it frequently has been planted in the equatorial forest region it has always failed, as a permanently wet climate is quite unsuited for it; but it might be cultivated with success in sandy regions where there is a fairly heavy rainfall for a few months followed by a spell of absolutely dry weather. Ceara rubber has been but little under cultivation as yet.

It is grown from seed but may be raised from cuttings. The seed is small, rather flat and dark brown. It is borne in a small capsule like that of Para rubber, only much smaller. Because of the hardness of the testa of the seed it germinates slowly, and it is usual to file off the end or grind the angle before planting. The tree grows with fair rapidity, and soon attains a large size in suitable localities. It requires a sandy soil and a dry climate.

It is generally tapped in short cuts and the latex allowed to coagulate on the tree and collected in the form of scrap. However, it can be drawn off in quantity as is Para rubber, and coagulated by means of smoke. The rubber is of a poorer quality than Para rubber, but the tree is certainly worth cultivation in countries where the climate is suitable.

Fig. 796. *Ficus elastica*, or Assam rubber tree, showing tapping system.

Assam rubber (*Ficus elastica*). Figs. 795–798.

The Assam, or India rubber, is a native of Assam and the Malay region, where it is found

Fig. 795. *Ficus elastica*, or Assam rubber tree. Showing habit and the characteristic way it attaches its roots to a log.

growing either as an epiphyte on other trees for part of its life, finally killing its host, or as a rock plant on high precipices. It is well adapted for cultivation in the rain-forests of the equator, but it will also grow farther north than will Para rubber. It is the well-known "rubber plant" of the horticulturist.

Assam rubber can be grown from cuttings, which is the usual method, or from seed. The seed is very small and should be grown in boxes over water, as it may be destroyed by ants. There are 1,000 to 1,200 seeds in an ounce. Cuttings grow rapidly and may be tapped in four years. It grows freely without shade if planted close, but more rapidly under partial shade. The tree sends out aërial roots, some of which are usually removed, leaving only those which in time may become suitable for tapping. Roots and stems are tapped with a V-shaped cut, made with a gage, and a sharp knife is drawn down the center of each arm of the V.

The latex is more difficult to coagulate than that of Para. It can be coagulated by stirring, or by extracting as much water as possible. One system is to allow it to drop on mats below the tree, where it coagulates and is afterwards removed. The amount of latex produced varies greatly. After heavy tapping the tree requires to be rested for a year or two. The value of this rubber is about the same as that of Central American rubber.

Ire or silk rubber (*Funtumia elastica*).

This tree grows to a very large size, and takes many years to come to maturity. When of sufficient size and age it produces rubber of excellent quality, but few can wait the time required for it to mature, which may be given at a minimum of twenty years. It might be planted, however, between quicker-growing kinds, to come in later in case of the exhaustion of earlier-maturing kinds. The tree has attained large size at considerable elevations in the West Indies,

Fig. 797. Tapping rubber trees.

where a lower temperature prevails than on the plains. In Trinidad it grows at elevations of 130 to 500 feet above sea level. Funtumia was formerly known as Kickxia. (Hart.)

West African rubber (*Landolphia species*).

There are several species of this genus which yield rubber of good quality, but which do not respond readily to cultural treatment. They are for the most part high-climbing plants requiring the support of trees. The latex or rubber coagulates almost as soon as it exudes. It may be formed into rubber by smearing on a smooth surface. It is related that in Africa native collectors use their arms for this purpose, cutting off the accumulated material when it becomes sufficiently large to inconvenience their working. It may be assumed with some certainty that Landolphias are unlikely to compete with Hevea, Ficus, Castilloa or Manihot. (Hart.)

Balata gutta-percha (*Mimusops globosa*).

This tree is a native of the forests of Trinidad and South America, and is exported in large quantities, via Trinidad, from the mainland. The tree affords one of the most useful hard-woods known. It is especially valuable for railway sleepers and for building purposes because of its durability. It grows to a large size, both in virgin forest and under cultivation. Its produce is of the nature of gutta-percha and melts in hot water. No attempt at cultivation on a large scale has yet been made. The tree produces a small edible fruit, deliciously sweet, which is sold largely in local markets when in season. The tree takes some thirty or more years to reach full maturity. The seed soon loses its vitality if allowed to become dry. (Hart.)

Literature.

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RYE. *Secale cereale*, Linn. *Gramineæ*. Figs. 799–801, and Fig. 562.

By *Jared Van Wagenen, Jr.*

Rye is one of the minor cereal grains, of relative unimportance in America as compared with wheat, corn or oats. The grain is used both for human and for stock-food, and the entire plant for soiling and, occasionally, as hay. It also finds a place as a cover-crop and green-manure, while the demand for the straw for bedding horses is considerable.

In botanical relationship, physiological characters, manner of growth and method of cultivation, rye is most closely comparable with wheat. The spikelets are two- to three-flowered, two of the flowers being perfect and three-stamened, the flowering glumes long-awned. The straws are much taller and more slender in rye than in wheat, sometimes reaching a length of seven feet on rich soils;

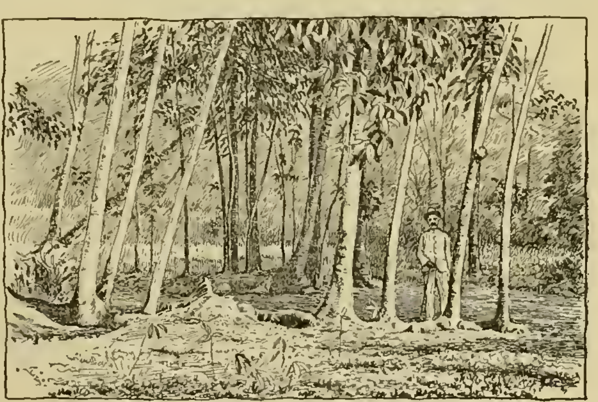

Fig. 798. Layered trees. *Ficus.*

hence, rye tends to droop or lodge more readily than wheat. The heads of rye are rather longer and much more slender and compressed, and the glumes and appendages are so firmly attached that comparatively little chaff is formed in threshing. The individual grains on the head are partly exposed instead of being entirely enclosed within the glumes, as in wheat. They are also somewhat longer, more slender and more pointed at the end which is the point of attachment to the spike. The longitudinal crease or suture, which is so characteristic of wheat, is very much less marked in rye. Rye is darker in color, with a slightly wavy or wrinkled surface and exceedingly hard and tough in texture, requiring more power to mill than any other grain.

Rye "shoots" the spike or head in the spring much sooner than winter wheat, but the time of maturity is usually not more than one week earlier. As the young plantlets emerge above ground they have a distinctly red tinge, which markedly distinguishes them from young wheat plants, and the fall growth is more spreading or decumbent than in wheat, while in spring, before heading, the leaves take on a grayish green that is different from other grains. The flowering glume is always awned or bearded, and the large anthers shed their pollen in great profusion, so that on bright, windy days it may sometimes be seen drifting across the field like puffs of thin yellow smoke. The leaves largely lose their vitality before the grain is mature, and, as in wheat, the stems probably perform the physiological function of leaves. Rye is a more hardy plant than wheat and is grown in more extreme northern latitudes, and yet it seems more tolerant of hot weather also. It is probable that its zone of successful growth covers a wider range of climatic conditions than any other cereal.

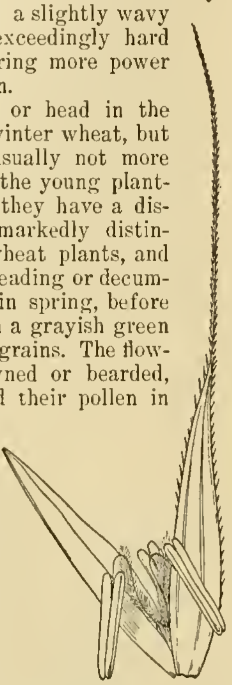

Fig. 799. Floret of rye (*Secale cereale.*) See Fig. 562.

History.

The culture of rye, while more than two thousand years old, is still not so ancient as that of wheat and barley. De Candolle states that its original home was between the Austrian Alps and the Caspian sea. The Greeks were not acquainted with it and Roman writers in the time of Pliny spoke of it as a new plant grown by the barbarian tribes which they had conquered. No rye remains are found in the middens of the Swiss lake-dwellers, while wheat, barley and spelt occur.

According to A. de Candolle, it is doubtful whether rye now exists in the wild state. He held that the wild rye reported by travelers was either plants which were self-sown or a rye-like form of grass of an allied genus. It is certain that under cultivation rye has the power of perpetuating itself by volunteer sowing beyond any other grain.

According to Hackel, however, the original form of rye (*Secale montanum*) grows wild in mountains of the Mediterranean countries and as far east as central Asia. It is perennial, with a jointed rachis, both of which characters have disappeared in cultivation.

Rye seems to be a plant of decreasing importance in the economy of the world. First barley and later wheat have driven it out of the warmer climates. It has always been the bread of northern peoples. In the United States, at least, it is mainly the peculiar value of the straw which still retains for it a place in our agricultural practice.

Distribution.

While rye is of minor importance in America, it is the principal cereal of Russia and Scandinavia. It is estimated that the world's production of rye is equal to slightly more than 50 per cent of the world's wheat crop, and rather more than one-half of this is grown in Russia.

The annual production of rye in the United States for the five years 1900 to 1904 averages a little less than 29,000,000 bushels, and this amount has shown no important increase for twenty years. Pennsylvania, Wisconsin, New York and Nebraska were the only states growing more than 2,000,000 bushels in 1904, but the growing of rye has reached its highest development in New Jersey and in three or four counties of eastern New York. In New Jersey, the production of rye very closely approaches that of wheat, being the only state where this condition prevails. In Canada in 1901 the bushels of rye were 2,316,793, from 176,679 acres. More than two millions of bushels of the crop were produced in Ontario.

Composition.

The composition of rye grain is similar to that of maize and wheat, the following being the average of many American analyses as given by Henry:

Percentage Composition.

	Water	Protein	Crude fiber	Nitrogen-free extract	Ether extract	Ash
Rye	11.6	10.6	1.7	72.5	1.7	1.9
Dent corn . . .	10.6	10.3	2.2	70.4	5.	1.5
Wheat	10.5	11.9	1.8	71.9	2.1	1.8

Rye differs from maize mainly in the less amount of fat; and it has considerably less protein than wheat. So far as mere chemical analysis is concerned, it may probably be considered as satisfactorily replacing corn in a ration.

The composition of rye-straw is almost identical with that of wheat-straw, but it is much tougher in fiber, which gives it a special value as bedding and for some industrial purposes.

Culture of rye.

Soil.—It is true that rye will make a fair growth on soils which are too light and thin for the

Plate XXI. Heads of rye

successful growing of wheat or barley, and this has tended to crowd the crop off of the more fertile soils; but rye will repay good culture and liberal fertilization as well as any other grain. It is unfortunate that rye and buckwheat have achieved the reputation of being the grains of poverty. Rye makes its best growth on soils which contain less clay than some which are adapted to wheat, and it is very important that it have good drainage. Snow protection in very severe weather is scarcely less necessary than in wheat-growing.

The high value of the straw is the only factor which makes it advisable to grow rye on soils which are naturally well adapted to wheat, but this fact has a most important bearing on the case. The writer, living on a farm where both wheat and rye are produced successfully, finds that rye is, on the whole, the more profitable crop to grow, and so it is sown on lands which are rich enough to grow maximum crops of wheat and often to cause it to lodge. Rye here finds its place in a four-crop rotation of corn, heavily manured with stable manure, followed by oats with acid phosphate, this followed by rye with acid phosphate and grass seeded with the rye.

Fertilizers.—The principles of fertilization which apply to the other small cereals hold with rye as well. Too much nitrogen and moisture result in early lodging, discolored straw and very shrunken grain. Applications of phosphoric acid sometimes give most striking benefits by counteracting this tendency. The writer has seen 250 pounds per acre of dissolved phosphate rock make all the difference between a crop which "crinkled" down soon after heading and one that stood up until it was well filled; and the straw remained fairly bright.

Seeding.—While the grains of rye are smaller than those of wheat, the amount of seed used per acre is about the same. In the rye districts of eastern New York it is customary to sow seven to eight pecks of seed per acre, placing the seed one to two and one-half inches deep, depending on the soil. On the poorer soils, and with early seeding, some persons recommend less seed. It can be sown safely earlier than wheat, for it rarely shows any tendency to "shoot" the culms in the fall; it is well known that when this occurs the plant will not survive the winter. In the latitude of Albany, New York, it is sometimes sown as early as the last week in August, while, on the other hand, sowing is sometimes deferred so late that it barely germinates before freezing weather. When rye is sown early it sometimes gives a large amount of fall pasturage and an excellent crop of grain the following summer. Early sowing is very desirable on poor soils, in order that the crop may get well established before winter sets in.

Place in the rotation.—When rye is grown, it generally fills the place in the rotation which would otherwise be taken by wheat. There is certainly no crop better adapted for seeding down with grass. When both are grown, there is a popular idea that a good "catch" of clover is more easily secured with rye than with wheat.

Varieties.—Unlike the other cereals, rye has developed very few varieties, possibly because it cross-fertilizes freely. Yet corn, which cross-fertilizes with perfect freedom and is indeed almost self-sterile, has developed, nevertheless, a very large number of varieties and types. More probably, this lack of varieties in rye arises from the fact that it has less innate tendency toward variation, i. e., it is not a plastic form.

There is a spring and a winter form of rye, the latter being raised almost entirely in America. New York state growers talk of "White" rye and "Common" rye, and a "Mammoth White Winter" has figured in seedsmen's catalogues, but the distinction is not well marked. The grain has not enough commercial importance to attract much attention in the way of selection and improvement by plant-breeders. A number of wheat × rye hybrids have been made, but they seem to have had no especial value.

Harvesting and handling.

Owing to the fact that the culms of rye are so long and slender, a heavy crop is nearly always more or less lodged and tangled, and its harvesting is attended with special difficulties. It should be cut and bound as is wheat. When it is sown on fertile soil and grows thick and stout and seven feet tall, it will severely tax even if it does not go entirely beyond the capacity of the ordinary grain binder. The binder is not especially constructed for that kind of work, and the elevators will clog and the bundles be tied together. Still, if the machine has a rather long table and the straw is dry, it will usually be possible to handle it by using skill and patience and cutting on only two or three sides of the field. This condition obtains only when rye is sown on soils good enough to grow heavy crops of wheat. Such rye is still often cut with a self-rake reaper and bound and shocked by hand. Four active men, accustomed to the work, will bind rye by hand as rapidly as a reaper will cut it. This makes expensive harvesting, but it is sometimes the only way.

Rye grain must be thoroughly dry if it is to be stored in large bulk, as it seems to become musty more readily than other grains. If straw is to sell well, it must be threshed without breaking or tangling and then rebound into bundles before baling. This was done by flailing long after that implement had disappeared for other uses. It is now handled by a special type of threshing machine known as a "beater." This has a cylinder about six feet in length run at a very high speed, and armed with only slight corrugations instead of the usual teeth. The bundles are unbound and fed through this, lying parallel to the axis of the cylinder instead of endwise as is the usual way. In the old style of machines the straw is discharged on a table in shape so that one or two men can rebind it with bands of straw caught up from the bundle. In more modern machines, the binding is done with twine by a modified form of the ordinary binder. The straw is baled in the old type of open-topped box-press, being packed in bundle by bundle and tramped down. This is peculiarly hard, exhausting work, but it seems to be the only acceptable method of baling rye-straw. The bales weigh 200 to 250 pounds each. A hay car will hold about ten tons of baled straw.

Long, clean, bright straw will usually sell at prices approximating that of good timothy hay. The straw must be bright if it is to bring a good

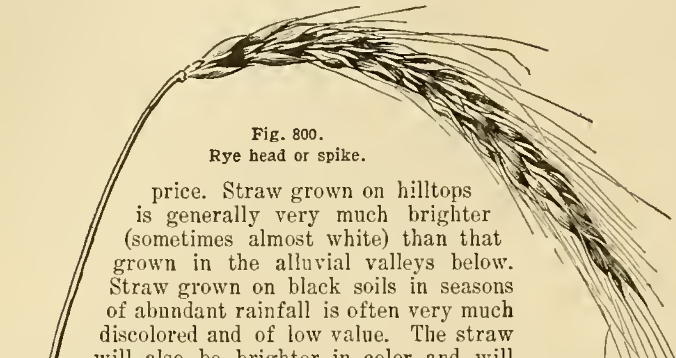

Fig. 800. Rye head or spike.

price. Straw grown on hilltops is generally very much brighter (sometimes almost white) than that grown in the alluvial valleys below. Straw grown on black soils in seasons of abundant rainfall is often very much discolored and of low value. The straw will also be brighter in color and will weigh better if cut a few days before complete maturity. Heavy rains after it has once dried seem to diminish its weight by washing out soluble matter.

Yield.

A ton of rye-straw per acre is accounted a good yield, and the usual thresherman's estimate is sixteen to twenty bushels of grain to each ton of baled straw. The writer in 1905 grew on one measured acre 3,305 pounds of baled straw and twenty-seven bushels and twenty-two pounds of grain, exclusive of scatterings which would probably have made the straw about thirty-five hundred pounds and the grain twenty-nine bushels. This, so far as straw is concerned, seemed to be about all that could possibly grow on an acre. It was on soil rich enough so that in the same field the wheat in spots was badly lodged. While on good land and under favorable conditions the yield of rye is generally less than that of wheat, and while thirty bushels of rye is a very exceptional yield, yet the average production per acre as reported by the United States Department of Agriculture is larger in the case of rye. On the other hand, wheat can be made to produce more to the acre than can rye. For the five years 1900–1904, the average yield of rye per acre was 15.6 bushels, against 13.5 bushels for wheat. This is explained by the fact that most of the rye is grown in the older states where culture and soil preparation are more thorough, while the average yield of wheat is reduced by the great acreage in states where less careful methods of soil preparation and fertilization result in a low average per acre. The average yield of rye in the South Atlantic states is reported as only a little more than seven bushels per acre.

Marketing.

Only one class of rye is recognized in the grain trade, and this grades as Nos. 1, 2, 3, 4, varying from that which is bright, dry and well cleaned down to that which is damp, musty or in bad condition from any cause. The legal weight of a bushel of rye is fifty-six pounds in nearly all the states.

For the five years 1900–1904, the average price of export rye at New York was 56 cents and for wheat 69.2 cents. While the exports of rye are very small as compared with other grains, yet during the five years 1900 to 1904, inclusive, about 25 per cent of the total crop was exported.

Uses.

Grain for feed.—Rye constitutes the main bread grain of more than one-third of the inhabitants of Europe, but in America it is used mainly as a food for animals. The fact that it carries comparatively little protein does not as a rule commend it for feeding dairy cows. Apart from its composition it has, for some reason, a distinctly bad reputation among dairymen, it being averred that it causes cows to "dry up," although there does not seem to be any real scientific basis for this idea.

In the districts where rye is grown, it is often ground and mixed with wheat bran or oats as a feed for horses doing heavy, slow work, and they keep in excellent condition on it. However, owing to the heavy, sticky, viscid mass that ground rye forms when moistened, it should always be fed mixed with some bulky material to lighten it. Used as a food for hogs, especially in connection with dairy by-products, it is always regarded as very satisfactory. Poultry, however, will refuse rye as long as any other grain is available.

Pasturing of rye.—The writer has learned from many years of experience in the fall-grazing of rye that it will force a yield of milk beyond any other food, young wheat only excepted. A herd may be well fed in the fall and be giving good returns, but if turned out on a luxuriant growth of rye for a few days the increase in milk will be astonishing. While such fall-pasturing of rye is an incidental and perhaps not very usual practice, yet there are years when the food thus secured will add very considerably to the total net income secured from the crop. If stock is kept off in very wet times when the ground would poach, and is not allowed to graze it too closely, such pasturing does not appear greatly to reduce the crop. Sometimes in warm, moist falls when the plants have made excessive growth, pasturing may actually be beneficial. Spring pasturing is frequent.

Soiling.—Rye has often been employed as a soiling crop for feeding in the green state, and occasionally it has been cured into hay. Its advantage lies in the fact that it will furnish a considerable amount of green food earlier in the spring than any other forage plant and before the pasture grasses are available.

While green rye is exceedingly laxative, it is generally reported to be satisfactory for milk production. One objection to its use lies in the comparatively short period during which it is available. Before heading, the dry matter per acre is too small to amount to much, and as soon as the grain begins to form the straw becomes hard, woody and unpalatable. Probably ten or twelve days in late April or early May, according to latitude, will cover the period during which it is in really good condition for green forage. When a system of soiling is followed, rye may be succeeded in turn by wheat, clover, pèas and oats and corn. However, a silo full of first-class, well-matured corn silage will usually offer the happiest solution to the problem of summer feeding.

Cover-crop and green-manure.—Rye is used as a cover-crop and for green-manuring. While not a nitrogen-gathering plant, it is perhaps one of the best for producing organic matter on soils of low fertility. When plowed under to be followed with a crop of corn, it should not be allowed to become too mature, for the exhaustion of the soil moisture by the rye before plowing, and the subsequent cutting off of the capillary movement of the soil water by a mat of vegetable material which decays very slowly, may work serious injury to the succeeding crop, especially if the summer proves to be one of deficient rainfall.

Straw.— Rye as a crop is unique in one respect, that is, in the East the straw is commonly about equal to the grain in value. This is preëminently the straw which is sought for bedding by fastidious horsemen, and the outlet for this purpose is very large. Until a score of years ago, it was very largely used in the making of a coarse brown paper for grocers, and for strawboard. Columbia county, in New York state, was once the center of a great rye-growing and paper-making industry. The crop is still very largely grown, but the mills have gone since the trade has changed to wood-pulp manila papers. The straw is also widely used in packing furniture and nursery stock, in making straw goods and in various other industrial.

Flour.—Rye flour carries some of its protein in the form of gluten, and hence, unlike maize, makes a light, porous, but rather dark-colored bread. The American demand for the flour is comparatively small. A century ago, with corn, it entered largely into the dietary of the New England states.

Rye flour is now made by the roller process similar to the methods employed in wheat milling. A few mills in the East make this their specialty. All the milling waste ordinarily goes together into one feed, which contains less protein and ash than wheat-mill products and sells at a lower price. It is often wise to purchase it for swine-feeding.

Liquors.—Some rye is used in the production of alcoholic liquors, but the quantity thus utilized is relatively small. The distillers' refuse from rye is not so rich in protein and fat as from corn.

Enemies.

Insects. —Rye has no very specific insect or fungous enemies. The chinch-bug (*Blissus leucopterus*) will feed on it, and the Hessian fly (*Cecidomyia destructor*) has been reported to infest it in New York. The former is difficult to combat. All rubbish near infested areas should be destroyed and infested grass-fields should be burned over. Grass strips may be planted around the rye-field and turned under when infested with the insects. Crop rotation helps in a measure. Migrations may be prevented and large numbers killed by means of deep trenches or tar strips (page 42). The Hessian fly is controlled by planting resistant varieties, late seeding, burning the stubble after harvest, and sowing a small strip of wheat early for a trap-crop, to be plowed under when infested.

Diseases.— Rye also suffers from at least two kinds of rusts,— one a black rust of the stems and the other a reddish or orange rust of the leaves. These fungi are important economically, because they not only cause shrinkage and light weight in the grain, but they discolor the straw as well. Burning infested stubble and practicing crop rotation are the suggested remedies.

Fig. 801. Ergot, a diseased condition of the grain of rye.

Smut sometimes attacks rye. It may be treated as for oats, which see.

An interesting disease, which is not confined to rye, however, is ergot (*Claviceps purpurea*) or spurred rye (Fig. 801), due to a fungus which attacks the rye grains and causes them to become greatly enlarged with a characteristic appearance. Ergot is important from a physiological standpoint. As a medicine it has long been used in obstetrics, and when fed to animals it has sometimes caused abortion and also gangrene of the extremities. Wide-spread disease and trouble have been reported from its presence in rye used as human food in Europe. Ergot occurs on the seeds of various grasses and wheat as well, but it does not cause the grains of wheat to enlarge, and hence it is less conspicuous. It is said to be very common on rye in Germany, France and Spain, and is frequently reported from Iowa and Nebraska, but it is not usual in the rye districts of New York and New Jersey. The remedy lies in not using infested rye as seed and in not sowing rye on land where ergot rye has grown for two or three years previously.

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SAINFOIN. *Onobrychis sativa*, Lam. *O. viciæfolia*, Scop. *Leguminosæ*. (Esparcet, Esparsette, Saintfoin, Holy Clover.) Fig. 802.

By *C. V. Piper*.

Sainfoin is a long-lived and deep-rooted leguminous forage plant, comparable agriculturally with red clover and alfalfa. The stems are erect or nearly so, one and one-half to two and one-half feet high, and terminated by dense, erect racemes of rose-colored flowers. The leaves are mostly basal and are unequally pinnate, each composed of six to twelve pairs of leaflets with an odd terminal one.

Fig. 802. Sainfoin.

The plant is a native of south-central Asia, whence it was introduced into continental Europe about the fifteenth century and into England in the seventeenth century. In Germany, where it is commonly called esparsette, it was an important forage crop as early as 1716. By some writers it has been supposed that the plant called Onobrychis by Dioscorides and Pliny was identical with the modern sainfoin, but recent investigations have shown conclusively that it was a related species, *Onobrychis Caput-galli*, which is now grown but sparingly.

Distribution.

Sainfoin was introduced into the United States at least 150 years ago and has been tested in an experimental way in most parts of the country. Thus far its cultivation is exceedingly limited. This is due to the fact that it can not compete with red clover or alfalfa in the sections of the country to which these crops are especially adapted. To a limited extent it is being grown on barren soils in limestone regions, and it is probable that it will become important in such regions when its value and cultural requirements have become generally known. It is possible that many of the unsatisfactory results have been due to lack of inoculation, though in some experiments nodules have appeared on the roots where the crop has never before been grown and without the seed having been inoculated. To a limited extent sainfoin is grown in the West on well-drained soils under irrigation, particularly in British Columbia. As a rule, however, alfalfa yields so much more heavily that there is little likelihood of sainfoin becoming much used in this way.

Varieties

There are two varieties of sainfoin commonly cultivated in Europe, the common or small-seeded sainfoin (*Onobrychis sativa*, var. *communis*), which yields only one cutting of hay, the aftermath being composed almost entirely of leaves; and the large seeded or double-cutting sainfoin (*O. sativa*, var. *bifera*), which yields two cuttings of hay. This latter variety flowers earlier than common sainfoin and is somewhat more vigorous.

Culture.

Soil.—Sainfoin is especially adapted for growing on dry lands too barren to produce satisfactory crops of clover or alfalfa. It is quickly killed out on land saturated with moisture. It thrives especially well on calcareous soils. Where the soil is not calcareous in nature, it is best to make heavy applications of lime, for, although sainfoin will succeed with only a small amount of lime, it reaches its maximum productiveness when the lime content is high. In Europe large tracts of barren calcareous lands almost valueless for other purposes are devoted to the cultivation of sainfoin. This is particularly true of the chalk districts of France and England. The soil should be thoroughly prepared, and as free from weed seeds as possible, as the young plants are weak and easily crowded out.

Seed and seeding.—The seed of sainfoin occurs on the market almost entirely in the pod, a bushel of which weighs twenty-six pounds. The seed is usually sown at the rate of four to five bushels per acre, but a considerable proportion fails to germinate owing to the tough hull. Shelling of the seed is difficult because of the toughness of the pericarp and the brittleness of the seed. Hulled seed is rarely found on the market, but if used forty to sixty pounds per acre is sufficient for seeding. Owing to the large size of the seed in the pod, it should be planted rather deep. Wherever possible it is advisable to use a drill, as this places the seed at a more nearly uniform depth so that it germinates better.

When spring-sown, May 15 to June 30, barley or oats is commonly used as a nurse crop, in which case it is usually advisable to cut the nurse crop green for hay. When weeds are a serious factor, especially in the eastern part of the country, sainfoin should be sown in early fall. It is not advisable to mix sainfoin with other forage plants, owing to the weakness of the young seedlings.

Sainfoin is not well adapted for use in rotations owing to its perennial character and the difficulty of establishing it. For this reason it should be planted only where it can be left permanently. Under favorable conditions fields will remain productive for twenty years, and some fields in France are said to have produced continuously for one hundred years.

Harvesting and uses.

Sainfoin is harvested in much the same way as red clover, but it cures out much more readily. To prevent loss of leaves it should be turned as little as possible. It should not be allowed to get too dry before cocking but should cure in the cock some time before stacking. The average yield of hay is one to one and one-half tons per acre. The protein content of the hay is higher than that of alfalfa.

Sainfoin is not well adapted to pasturing, owing to the slowness with which the plant sends out new shoots. It is said that when used as pasture it does not cause bloating, as is the case with most related plants.

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SALTBUSHES. *Atriplex*, spp. *Chenopodiaceæ.*

By *P. Beveridge Kennedy.*

The saltbushes, or saltbrushes, as they are sometimes called, are low, shrubby, much-branched plants, valuable as forage only where the conditions of soil or moisture will not permit of the growing of more palatable crops, such as the grasses, clovers and vetches. They are among the few plants that are tolerant of alkali. Where the winters are cold they are often annual, but in California and the Southwest they are perennial.

Distribution.

Many miles of range country in eastern Oregon, eastern Idaho, Utah, Wyoming, Nevada, Arizona and New Mexico are covered by saltbushes. In fact, a large proportion of the range feed in many of the western states, during the fall and winter months, consists of one or more of the annual or perennial saltbushes. The greater part of this area could not produce any other forage crop, owing to the abundance of alkali in the soil and the scarcity of water.

Experiments are now in progress, notably at the Arizona Experiment Station, to introduce some of the most promising native species on the depleted stock ranges. The efforts are meeting with some degree of success, and it is to be hoped that some sure methods of sowing on the open ranges may be devised.

Native and introduced saltbushes.

The American species of economic value are shad scale (*Atriplex canescens*), Nuttall's salt sage (*A. Nuttallii*), spiny salt sage (*A. confertifolia*), scrub saltbush, Utah saltbush (*A. truncata*) and tumbling saltbush (*A. volutans*). Of these, the shad scale is of most importance [see page 310].

Of the introduced saltbushes, several types are now in cultivation, all native of Australia. These are: the Australian saltbush (*Atriplex semibaccata*), slender saltbush (*A. leptocarpa*), gray saltbush (*A. halimoides*), round-leaved saltbush (*A. nummularia*) and annual or bladder saltbush (*A. holocarpa*). Of these, only the Australian saltbush has attained any large degree of prominence from an agricultural standpoint. So far it has proved of permanent value only in California and, to some extent, in Arizona.

Culture.

Saltbushes are generally raised from seeds, though cuttings may be used. On alkali soils the seed should be sown early, on the surface of the soil and rolled lightly. In such soils, if the seed is covered it usually rots and fails to come up. On non-alkaline soils it may be slightly covered with advantage. One-eighth of an inch deep is sufficient. If the seed is placed much deeper than this the percentage of sprouted seed will be greatly reduced. On the alkali soils in California seeding should be done early in October, before the rains come. It may be an advantage to start the seeds in boxes and transplant to the field in rows about seven feet apart on alkali soils, and four feet apart on light soils, the plants being placed one to four feet apart in the rows.

Uses.

The chief use of the Australian saltbush is for soiling purposes. If it is fed green with straw, stock does fairly well on it. The best method is to change the feed gradually, as animals usually do not care for saltbush until they have acquired a liking for it. At first, only a little of the saltbush hay should be fed with a considerable quantity of meadow hay; then, by degrees the quantity of meadow hay should be diminished until the proportions are about equal.

The dried-up annual species are eaten to a considerable extent during the fall and winter, and the seeds which collect underneath the perennials are liked by both cattle and sheep as a sort of relish.

Although no digestion experiments have been conducted to determine the nutritive value of the saltbushes, yet their chemical composition indicates that they are of good quality.

Literature.

Farmers' Bulletin No. 108, United States Department of Agriculture; Wyoming Experiment Station, Bulletin No. 63; California Experiment Station, Bulletin No. 125; Division of Agrostology, United States Department of Agriculture, Bulletin No. 13, p. 24; Division of Botany, Bulletin No. 27; Arizona Experiment Station, Bulletin No. 38, p. 291; Idaho Experiment Station, Bulletin No. 38, p. 250; South Dakota Experiment Station,

Bulletin No. 69, p. 39; Bureau of Plant Industry, Bulletins, No. 4, p. 17; No. 13, p. 68; No. 59, pp. 51, 56.

SERRADELLA. *Ornithopus sativus*, Brot. *Leguminosæ.* Fig. 803.

By *C. V. Piper.*

Serradella is an annual forage and green-manure plant growing six to eighteen inches high. The leaves are odd-pinnate with numerous leaflets, and the flowers are pale purplish. It has been cultivated in the United States only in an experimental way, and it is not grown extensively in Europe. There it is employed as a combination forage and green-manure plant, particularly valuable to precede potatoes or corn. It is eagerly eaten by sheep and cattle and is comparable in value to the clovers. It has no deleterious qualities whatever, when fed either green as pasture or as hay. At the Massachusetts Experiment Station, where it was cultivated in rows, it was fed in comparison with cowpeas and vetches and gave more satisfactory results than either of these for dairy cows, in this agreeing with the results of European experience. For late pasturage it has given some promise in Michigan, especially on sandy lands. Owing to its relatively small growth and light tonnage it has no place where other legumes will grow, and is not likely to find much use as a cultivated crop in this country, although in limited localities it may be valuable. Good, heavy stands yield ten to twelve tons of green fodder per acre, which will make about two tons of hay.

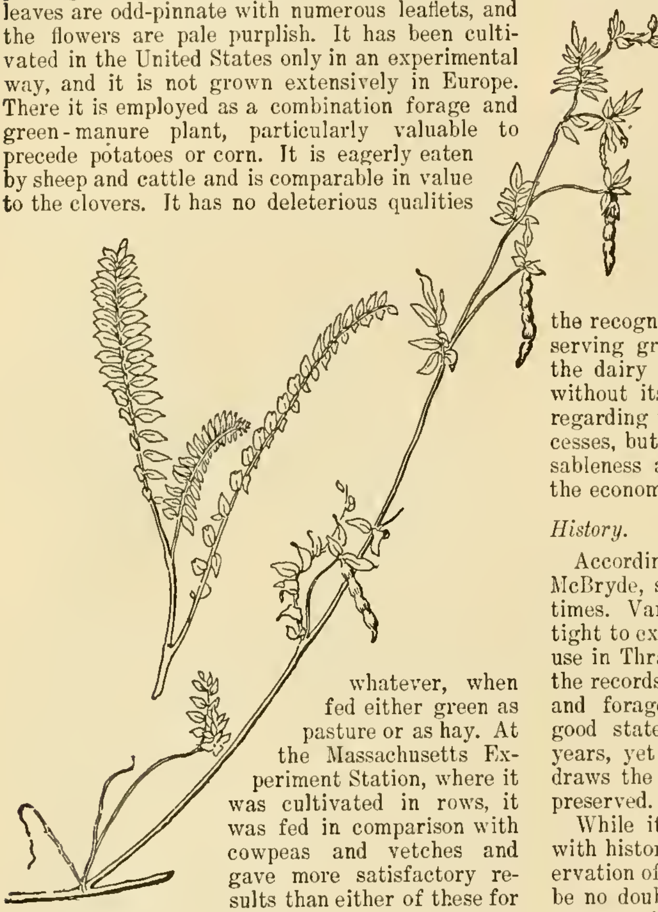

Fig. 803. Serradella (*Ornithopus sativus*).

Serradella is especially adapted to medium light, sandy soils. Even where lime is deficient it thrives. While it is fairly drought-resistant, it makes very small growth under dry conditions. The plant will not withstand severe cold, and therefore should be planted in the spring, at least in the northern states. It may be seeded alone, or in small grain. If planted alone it may be drilled in rows about five inches apart. Forty to fifty pounds of seed per acre will be needed, sown in March or April. As for other legumes inoculation is important, and this factor accounts at least in part for the poor results obtained in many experiments. The growth is slow until the advent of warm weather. About the time the plant begins to bloom it tends to branch out rapidly and cover the ground.

SILAGE-CROPPING: Its History, Processes and Importance. Figs. 804, 805. [See also page 414.]

By *J. W. Sanborn.*

No subject is of more commanding importance in the corn-growing dairy states than that of silage-cropping, or the raising of forage crops for preservation in the silo. So rapid has been the recognition of the value of this method of preserving green feeds, notably corn, that today in the dairy sections one can scarcely find a farm without its silo. Much yet remains to be learned regarding the proper ordering of the ensiling processes, but the silo has demonstrated its indispensableness and has immovably intrenched itself in the economy of the American dairy-farm.

History.

According to the researches of Professor McBryde, silos reach back to Persian and Roman times. Varro speaks of pits in the ground made tight to exclude air and insects, and mentions their use in Thrace, Carthage, Spain and Rome. While the records mention the pitting of the grain crops and forage crops, wheat having been kept in a good state of preservation in the pits for fifty years, yet McBryde, reasoning from historic data, draws the conclusion that green crops were thus preserved.

While it is probable that we may not ascribe with historic accuracy the use of pits for the preservation of green fodders by the ancients, there can be no doubt that in the early decades of the last century pitting of green crops was not unknown to the farmers of several of the European nations. These pits were dug as deep as twelve feet and lined with brick, stone or wood. As now, the ensiled or pitted material was heavily trodden and well pounded around the edges of the pit.

To M. Goffart, of France, belongs the honor of having adapted the preservation of green crops to common modern use by storage above ground in stone structures known as silos. The top of the material was loaded by a following weight. Led either by J. B. Brown's translation of Goffart's work or by an earlier article on the system of Goffort's trials that appeared in the Report of the United States Department of Agriculture, a Mr. Morris, of Maryland, built in 1876 the first silo in this country. Soon after this, Dr. Bailey, of Billerica, Mass., constructed a concrete silo on his farm. By gatherings of the press and of public men at the opening of his silo, and by free writing on the subject of silage, coupled with extravagant praise of the material, he created a sudden and wide interest in the new method of crop storage. In a decade the silo came into wider use and underwent a more radical change than had occurred in the century or centuries of previous use.

Stone loaded on plank, earth, bags of sand, screw pressure, and other methods of weighting, quickly followed each other, until it dawned on observers that the immense weight of the green forage supplied adequate pressure for all but the very top layer. The omission of weighting was followed by covering with straw or poor hay as a method of retaining in part the moisture of the surface of the silage, and by its quick decay of excluding the free access of air. Later this covering was generally omitted, as it involved cost and loss of its own substance, which was found to equal the loss accruing to the uncovered silage. It is now found that this loss may be greatly reduced by spraying the top of the silage with water on conclusion of the filling or by frequent treading of the surface for a period after cutting ceases. The last and best practice is the immediate and daily feeding of the surface material, a method in harmonious keeping with the essential requirements of farm stock at the period following the close of corn harvest when out-of-door feeding material is in deficiency.

The costly stone silo, invariably accompanied by decay of silage around the entire inside surface, soon gave way to the concrete silo, and this to the cheaper and more perfect, though less durable wooden silo. These at first were made in the corners of the barns, double-boarded with matched boards, lined between with suitable paper. The cheapened silo proved more effective than the parent ones, and cheapening still further became a growing custom until many silos were constructed with a single thickness of unmatched boards. As they were made mainly of the porous white pine lumber in the East, it was soon found that this material expanded quickly and closed the cracks, thus keeping the material (except in the upper few feet of the silage, where pressure was light and the expansion of the lining slow) up to the very edge of the boarding, in good, fairly palatable condition. Indeed, during the progress of ensiling it has been found that anything that secures rigidity to the sides of the silage will insure the keeping of the mass if depth enough to give pressure and exclusion of air is secured. So it has occurred that silage has been made after the stack fashion.

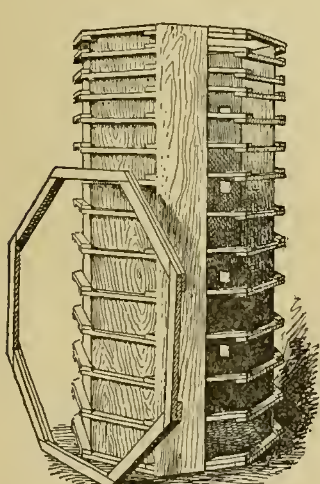

Fig. 804. Small model silo of the octagonal form of silo, showing method of construction.

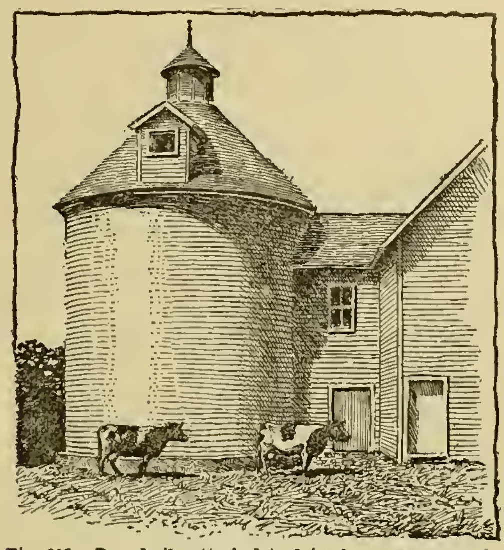

Fig. 805. Round silo attached to dairy barn, as commonly seen in dairying sections.

It is now understood by all that the supreme end to be secured in ensiling is the exclusion of air. The more complete this exclusion, the more perfectly is the material kept. For this reason there has been a constant tendency to increase the height of silos to secure pressure that not only should expel air, but exclude it from entrance. The more recent critical research has shown that the more perfect the silo or the more perfect the exclusion of the air, the less the loss of the organic material of the fodder ensiled.

The demonstrated economy of material in the better class of silos is now producing a counter current in silo construction, moving toward a class of silos that conserve best the material committed to them. The round silo, presenting the least surface per ton capacity, and therefore also requiring the least material for construction, is at present the popular form of structure. (Fig. 805.) It is made of many forms and is covered in many fashions. The stave silos made of 2 x 4 and held by iron hoops was the parent form. It was made of matched two-inch pine, of stuff merely beveled, and again of unbeveled material. This form has the demerit of shrinking when dry, and of occasionally collapsing or blowing over. It requires biennial screwing up of nuts and unscrewing when empty and when being filled. This has turned many to the round silo made by bending half-inch stuff to studding set on a circular foundation. These are single-lined of matched stuff, or double-lined with paper between. A very popular modification of this construction in considerable use in Ohio is made by boarding perpendicularly of half-inch stuff on horizontal hooping, this hooping being made of half-inch stuff. These hoops are several layers deep and of an increasing distance apart from bottom to top. It is loudly proclaimed that the coming age is to be one of concrete, and, true to this propaganda, a few cement silos on the interlocked block plan are being erected, and, it is said, successfully used.

In effectiveness and true economy the Gurler silo, so named from its maker, appears to offer the largest number of advantages per dollar of investment. It is round, made of studding and half-inch stuff laid as above directed, and differing only in being lathed with beveled one-half-inch stuff to hold the cement plastering applied in the interior. This will not decay under the acids of the silage, permits free settling of the silage and excludes the air probably more perfectly than other structures. It is thought that loss of the organic matter of the silage in this silo is reduced to its economic minimum. None is spoiled on the sides, and if feeding begins at filling time little is lost from the surface.

The rapid evolution of the silo and its quick adaptation to the needs of the farm are vivid illustrations of the versatility of the American farmer, and a refutation of the oft-repeated charge that he is slow or slower than other industrialists in perception and execution.

Processes of ensiling.

The old or early method of thick planting of corn and its early harvesting for the silo, has given way to the reverse custom, as, according to investigations, a less ratio of water to handle, a larger ratio of digestible ear corn and a more complete conversion of amid bodies into their final and probably more valuable organic forms resulted from the change. The proper time to harvest is not to be a part of this discussion any further than to note that the proper preservation of silage depends in some measure on the time of harvesting. As is well shown by investigators, crops increase in total weight of dry matter up at least to the dough stage of the seed and to the early hardening period. If we cut corn before this period it is at a loss of total dry weight, and, if after it, at such a loss of water content of leaves and stems that the cells of the plant carry an increased volume of air in replacement of the evaporated water. If in our comparatively air-tight silo we are to have well-preserved silage, we must introduce fodder in a condition approximating closely to its fully grown state. All crops having hollow stems have proved unsatisfactory silage crops, as too much air is introduced into the silo and is not easily excluded.

Remembering that exclusion of air is the *sine qua non* of well-preserved silage, it appears that the not infrequent method of cutting corn by a day or so before it is drawn in order that it may wilt, and its subjection to frost and rapid volatilization of moisture, or to slow filling, are wrong practices. They involve the more ready access of air, to be followed by an increased fermentation in the silo. This process is one of slow combustion and loss of matter. It is not alone an error of carrying air in the cells of plants into the silo, but equally one of retention of air by the lessened pressure of the silage due to loss of water and its added weight. In short, less air is pressed out of the silo or from between the pieces of fodder. Slow filling is increased burning.

The above basic reasons call for fine cutting of the silage. It packs closer and therefore excludes more air. It has the further merit of economizing room. All careful owners of silos advocate heavy tramping around the edges to overcome the friction of the sides in the settling mass. Their action is in line with this reasoning. The proper practice of sprinkling over-dry fodder as it enters the silo, or the top at the conclusion of filling, has the same defense. Such scientific data as bear on this matter, if massed here, would add much to space, and is so obviously well founded as to be dispensable.

The increasing depth of construction of silos is but a popular recognition of the principles stated. Thirty-five feet has become a common depth, while extremes of sixty feet have been reached. Professor King estimates the weight of silage at the first foot at 18.7 pounds, and at thirty-six feet depth at sixty-one pounds per cubic foot. The deeper the better the silage averages, and into this position of little-included air silage, should quickly come. In this connection it should be said that the more air the less acetic acid or sour silage, but the greater the loss of fodder. In open silage acid conditions develop, but the difference, while in favor of loose packing, is only one of small degree and by no means an offset to the extra loss of material.

Silage cutters (By J. W. Gilmore).

The silage cutters have grown up with the use of the silo in dairying regions, and, while they are capable of much improvement, yet they are very efficient and economical in rendering what otherwise would be waste material on the farm into acceptable forage for cattle. Silage cutters may be divided into two classes according to the method of disintegrating the material: Those which cut and those which shred the material. In recent years the tendencies are in favor of the shredders, because the material to be put in the silo is more thoroughly disintegrated. Precaution must be taken, however, in not having the material too moist. In many instances when green corn is shredded, the moisture is so abundant as to be pressed out at the bottom of the silo and lost. On the other hand, with the cutters some tough and large pieces of the stalks may not be eaten by the cattle, and, moreover, the cut fodder does not pack so readily in the silo as that which is shredded. If the material can be put in the silo and enter into the state of silage within two or three days, it is better than that which requires five or six days to become silage.

Both blowers and elevators may be used in connection with either of these classes of machines for elevating the material into the silo. The blowers, while requiring more power, are usually considered the better, because the material is more uniformly distributed in the silo. It is not infrequent that coarse silage put in with a cutter will vary from fifty to eighty pounds in weight, due to the butts of the corn or the ears being thrown in one place in the silo. This, of course, renders feeding less uniform and is not desirable when feeding experiments are being conducted. Silage cutters should be run with sufficient power to carry the heaviest loads, as insufficient power is a source of much loss in time as well as labor.

Silage as a factor in farm practice (Sanborn).

Silage has been derived mainly from corn and has become practically synonymous with the use of this crop. Hollow-stemmed plants are eliminated for reasons given, and other crops are so far inferior to corn as sources of silage as to be little used. Clover has been used successfully and often very unsuccessfully and has not come into general use. Other leguminous crops are grown to cut in with corn to give a balanced ration, so called. The wisdom of the practice has not reached a demonstration, nor is it generally applied.

Corn is the royal forage crop of the country. It is peerless in its many-sided values. As a machinery-grown and tillage crop it is unequaled. In productivity, certainty of a full crop, palatability, digestibility, as a milk- and butter-producer in flavor, color and texture, and in cost per pound of digestible nutrition, it heads the list of forage crops. The silo, especially for the East, utilizes this crop to the fullest advantage. In a measure, it solves the problem of home-grown concentrated feed, as it has been shown by the Vermont and other experiment stations that the ear can be cut into the silo without loss. Husking, driving to the grist-mill, and levy for grinding are all saved, or about one-fourth to one-third of the cost of producing a bushel of corn. As but a little less than two-fifths of the weight of the whole corn plant is in its seed, the importance of this fact is made prominent.

Any reasonably good farm rotation requires a hot weather tillage crop. The silo has done more to hold this indispensable crop in a prominent position in eastern agriculture than any other one factor. It has been an especially noteworthy factor in increasing the stock, especially milch cows, kept in New England. It invited an increase in area of a very productive plant and added the beneficent influence of more tillage of grass-locked areas. This is tantamount to an increased source of plant-food from the soil.

Feeding value.

Early investigations by several state experiment stations give silage about the same digestibility as corn fodder and a loss in the silo exceeding good practice with air-dried fodder. Since the deep silo made tight has supplemented silage fodder cut at the right period into short lengths, the loss in the silo by fermentation has been reduced to 10 per cent or less, and by King and Woll is held to be stored at its best at a loss not to exceed 5 per cent.

Many trials with dry fodder and hay make it certain that 15 per cent is about the minimum loss to be expected by dry storage, while this loss may rise to 20 per cent or more in ordinary practice. Late trials give silage a digestibility slightly exceeding fodder corn, while in milk yield it has become the superior of corn fodder and most dry fodders. In palatability it excels all dry fodders.

Limitations of silage.

Farming requires a well-balanced rotation, and corn should not exceed its mathematical share of arable soil, nor should an undue amount of it be fed. It tends in large amounts to undue looseness of the bowels and to an illy balanced ration in its ratio of carbohydrates to protein. Its heavy percentage of water at times and for some classes of stock, as an exclusive diet in cold weather, for so it has been fed, would give an excess of water to burden the system. Its heavy growth and use concentrates labor in field and barn in too brief periods. Thirty to thirty-five pounds per day appears to balance all the factors of advantage found in silage.

The writer dislikes to dogmatize, and begs to state that before him is a collection of the materials of thirty years of experiment station work and many years of personal work, and that opinions necessarily briefly expressed are based very largely on these data. However, he is fully aware that many problems relating to the silo require much more investigation before full ultimate economic truth is reached.

Literature.

See under *Maize-growing for the silo*, page 414.

SOILING: Its Philosophy and Practice. Figs. 806, 807.

By *F. W. Woll.*

The soiling system consists in feeding farm animals a succession of green fodder crops in the stable during the entire summer period. This system, which has long been practiced by European dairy-farmers, became known in this country mainly through two admirable essays on "Soiling of Cattle," by Josiah Quincy, prepared for the Massachusetts and Norfolk Agricultural Societies, and published in the Transactions of these societies for 1820 and 1852, respectively. The advantages of the soiling system enumerated by this writer are, briefly stated, as follows:

(1) Three times as much feed can be produced per acre of land by this system as when the land is pastured.

(2) The feed is better utilized by cattle, as there is no waste through treading-down, fouling, and the like.

(3) The cattle are more comfortable and in better condition when fed green feeds regularly and liberally in the stable than when left to find their own food on the pasture, with the uncertainties as to the condition of the pasture, weather and the like.

(4) The system is therefore conducive to the production of a large and even flow of milk (or a uniform increase in live weight, in the case of fattening stock).

(5) There is a great increase in the quantity and quality of the manure, since all the manure from the stock is saved, thus placing the farmer in the best position to maintain the fertility of his land.

(6) The necessity for interior fences is largely done away with.

Later experience and the results of carefully conducted feeding experiments have fully established the assertions made for the soiling system by Quincy, especially for feeding dairy cattle. In addition to the advantages stated above, it should be noted that the system does not call for any machinery or devices that are not already found on nearly all dairy-farms.

Against these points in favor of the system, we have the disadvantage that it increases considerably the labor connected with the feeding and the management of the herd, since the green feed must be cut and placed before the stock in the barn several times a day. In rainy weather or when fields are muddy the harvesting of the crops also presents difficulties. But these objections are more than offset by the advantages, which bring about a greater production of crops from the land and a better utilization of the crops, hence greater returns from the animals kept. In regard to the question of the better saving of the manure by the soiling system, Quincy gives as his experience that it alone is "a full equivalent for all the labor and expense of raising, cutting, and bringing in the food, feeding, currying and other care of the cattle."

The production of soiling crops implies intensive methods of farming, since immense quantities of feed are produced by this method, in some cases exceeding twenty to twenty-five tons per acre, and the land may also in the case of some crops be sown to two different crops in the same season, as will be shown presently. To guard against soil exhaustion, heavy applications of manure, supplemented by commercial fertilizers, must therefore be made. It is also well to resort occasionally to green-manuring in order to prevent a reduction of the humus content of the soil; this is preferably done by plowing under the second crop of clover or other legumes so as to take advantage of the high nitrogen-content of these crops.

Soiling is of special value in regions where high land values prevail and only small areas are available for pasture. As the price of farm lands increases it is likely to become of more and more importance. The system has been recommended primarily for dairy cows, but is also valuable in steer- and sheep-feeding. It has been adopted, however, only to a limited extent in the past by American dairy-farmers and others because of the large amount of labor involved in feeding stock in this way, and owing to the fact that our farmers have generally had abundant pasturage. It is less likely than ever to become a general practice in the future, owing to the introduction of the silo during the last few decades and to the use of summer silage (q. v.) as supplementary feed to scant pastures during the latter part of the summer season.

Partial soiling.

A modification of the soiling system—so-called partial soiling—is practiced by many farmers, and is worthy of serious consideration by dairymen who are anxious to secure maximum returns from their cows. In partial soiling, green forage crops are fed supplementary to pasturage or to hay or straw and concentrated feeds, at the time when the pastures no longer furnish sufficient feed for the stock. This modified soiling system is of the greatest importance to American dairy-farmers, and its use is likely to be largely extended in the future with the further developments of our dairy industry.

In case of either complete or partial soiling, a succession of fodder crops is grown that will furnish green forage at its best stage of growth for feeding as the season progresses. This will be, in the case of complete soiling, from spring to late fall, say May 1 to November 1; in the case of partial soiling, during late summer and fall. Soiling crops are especially valuable to the dairy-farmer during the latter period, as pastures are then likely to be poor, and cows are greatly annoyed from the heat and flies, if left out-of-doors all day long. The practice has become very general among progressive dairymen to keep the cows in a darkened stable during the day at this time of the year, where they are fed green crops with some dry roughage and grain, and to let them out on pasture at night. The shrinkage in milk flow that ordinarily occurs at "fly-time" will be largely overcome, or at least reduced so far as possible by a judicious system of soiling and management of the herd, as suggested.

Soiling crops.

Among the large number of crops that have been recommended for soiling and have proved satisfactory for this purpose, mention of a few of the more important ones will suffice here: winter grains (cut before blooming), peas and oats, alfalfa, clover, vetch, soybeans, millet, cowpeas, corn, sorghum and rape. All these crops are valuable when grown on fertile land and in localities suited to their culture. Perhaps no single crop is of more importance and value for soiling than alfalfa, where it can be grown successfully. Peas, corn and rape also rank high as soiling crops, the latter especially for sheep and hogs.

For description of methods of culture and the characteristics of the various crops, reference is made to the special articles dealing with the crops included in the tables.

Rotations of soiling crops.

The details as to growing a succession of soiling crops will necessarily vary, according to the character of the land and the crops adapted to each particular locality. If it is desired to feed green crops through the entire season, the following is one of the simplest rotations that can be adopted:

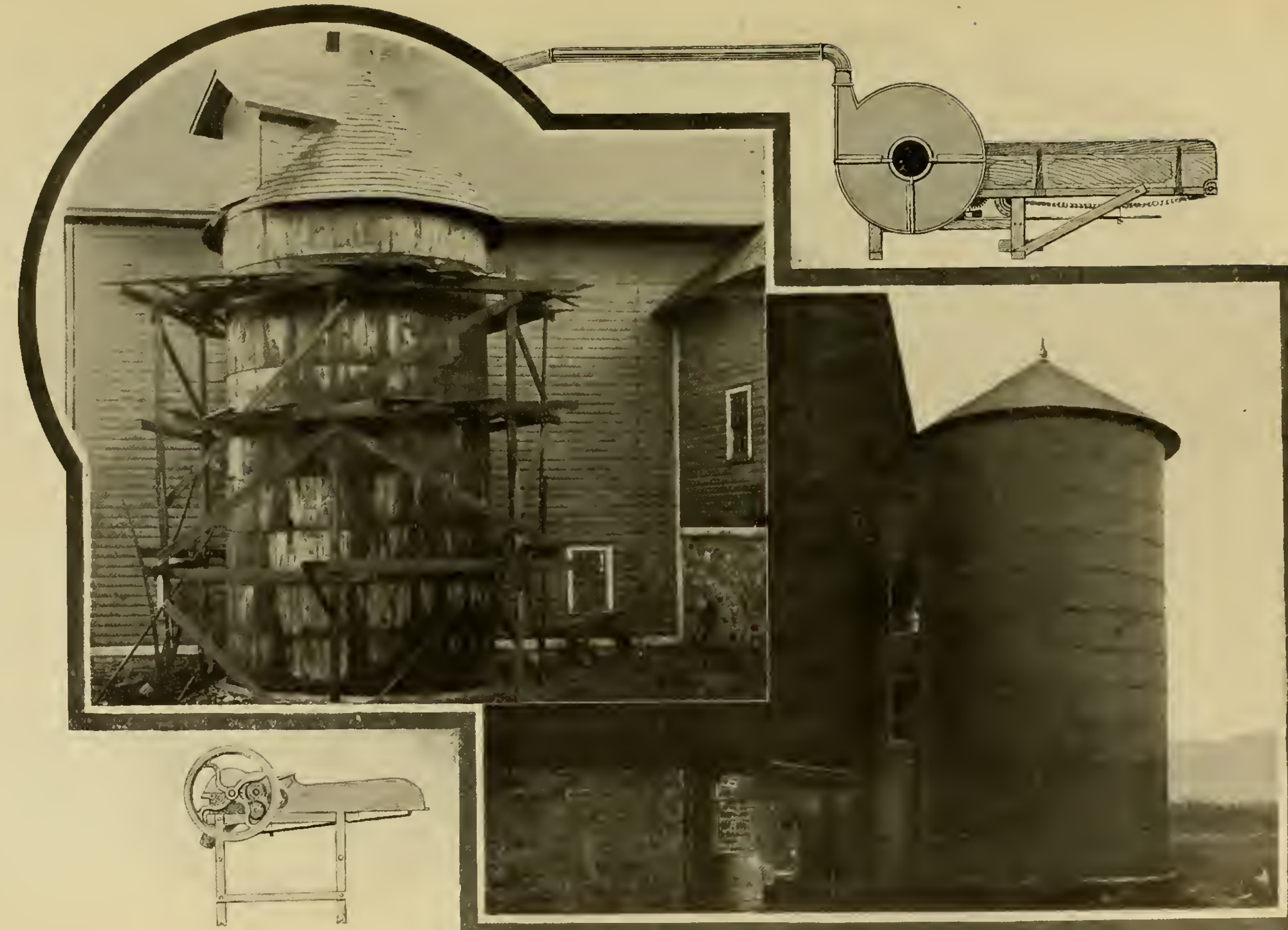

Plate XXII. The silo, in construction and completed

(1) Winter wheat or rye, ready to cut and feed during May;

(2) Green clover, for feeding during the early part of June;

(3) Oats and peas, sown as early as possible in the spring, and later two or three times at weekly intervals; available for feeding during the remainder of June and in July;

(4) Corn or corn and sorghum planted at the usual time, for feeding in August and September;

(5) The land occupied by oats and peas when cleared may be sown to millet or barley, for feeding during the fall months.

The following crops for partial soiling are recommended by Jordan: Three sowings of peas and oats in May and early June and two plantings of corn, one at the usual time, the other two weeks later. These crops will furnish a supply of green feed when this is most likely to be needed. Quincy included four crops in his system, viz., early clover (for feeding during May and June), oats (for July), corn (for August), second growth of clover or grass (September to October 15), tops of carrots and turnips, cabbages (October 15 to November).

Special rotations for soiling crops have been recommended by various authorities, and the farmer has the choice of a variety of crops that may be grown for this purpose. In deciding on a system of rotation to be adopted, he should consider the kinds of crops that will do best under his special conditions of farming, that will furnish green forage at the time when wanted and are especially adapted for feeding the kinds of stock kept. The rotations suitable for soiling included below are given as guides for farmers living in the states mentioned, or under similar agricultural conditions. While they need not and in many cases probably cannot be followed in every detail, they will prove useful (as helpful outline plans) to farmers located in different sections of the country, who intend to adopt the soiling system of feeding cattle and other classes of live-stock.

Examples of rotations of soiling crops.

(1) Soiling Crops Adapted to Northern New England States.—Lindsey. (For 10 cows' entire soiling.)

Kind	Seed per acre	Time of seeding	Area	Time of cutting
Rye	2 bushels	Sept. 10–15	½ acre	May 20–May 30
Wheat	2 bushels	Sept. 10–15	½ acre	June 1–June 15
Red clover	20 pounds	July 15–Aug. 1	½ acre	June 15–June 25
Grass and clover	½ bushel red-top, 1 peck timothy, 10 pounds red clover	September	⅔ acre	June 15–June 30
Vetch and oats	3 bushels oats, 50 pounds vetch	April 20	½ acre	June 25–July 10
Vetch and oats	3 bushels oats, 50 pounds vetch	April 30	½ acre	July 10–July 20
Peas and oats	1½ bushels Canada peas, 1½ bushels oats	April 20	½ acre	June 25–July 10
Peas and oats	1½ bushels Canada peas, 1½ bushels oats	April 30	½ acre	July 10–July 20
Barnyard millet	1 peck	May 10	⅓ acre	July 25–Aug. 10
Barnyard millet	1 peck	May 25	⅓ acre	Aug. 10–Aug. 20
Soybeans (medium green) . . .	18 quarts	May 20	⅓ acre	Aug. 25–Sept. 15
Corn	. . . .	May 20	⅓ acre	Aug. 25–Sept. 10
Corn	. . . .	May 30	⅓ acre	Sept. 10–Sept. 20
Hungarian	1 bushel	July 15	½ acre	Sept. 20–Sept. 30
Barley and peas	1½ bushels peas, 1½ bushels barley	August 5	1 acre	Oct. 1–Oct. 20

(2) Time of Planting and Feeding Soiling Crops.—Phelps.

Kind of fodder	Amount of seed per acre	Approximate time of seeding	Approximate time of feeding
1. Rye fodder	2½ to 3 bushels	September 1	May 10–20
2. Wheat fodder	2½ to 3 bushels	September 5–10	May 20, June 5
3. Clover	20 pounds	July 20–30	June 5–15
4. Grass (from grass-lands)			June 15–25
5. Oats and peas	2 bushels each	April 10	June 25, July 10
6. Oats and peas	2 bushels each	April 20	July 10–20
7. Oats and peas	2 bushels each	April 30	July 20, August 1
8. Hungarian	1½ bushels	June 1	August 1–10
9. Clover rowen (from 3)			August 10–20
10. Soybeans	1 bushel	May 25	August 20, September 5
11. Cowpeas	1 bushel	June 5–10	September 5–20
12. Rowen grass (from grass-lands) . . .			September 20–30
13. Barley and peas	2 bushels each	August 5–10	October 1–30

The dates given in the table apply to Central Connecticut and regions under approximately similar conditions.

(3) Soiling Crops for Pennsylvania.—Watson and Mairs.

Crop	Area for 10 cows	When to be fed
Rye	½ acre	May 15–June 1
Alfalfa	2 acres	June 1–June 12
Clover and timothy	¾ acre	June 12–June 24
Peas and oats	1 acre	June 24–July 15
Alfalfa (second crop)	2 acres	July 15–August 11
Sorghum and cowpeas (after rye)	½ acre	August 11–August 28
Cowpeas (after peas and oats)	1 acre	August 28–September 30

(4) Crops for Partial Soiling for Illinois During Midsummer.—Fraser.

Kinds of fodder	Amount of seed per acre	Approximate time of seeding	Approximate time of feeding
1. Corn, early, sweet, or dent	6 quarts	May 1	July 1–August 1
2. Corn, medium, dent	5 quarts	May 15	August 1–September 30
3. Cowpeas	1 bushel	May 15	August 1–September 15
4. Soybeans	1 bushel	May 15	August 1–September 15
5. Oats and Canada peas	1 bushel each	April 15	July 1–July 15
6. Oats and Canada peas	1 bushel each	May 1	July 15–August 1
7. Rape (Dwarf Essex)	4 pounds	May 1	July 1–August 1
8. Rape, second sowing	4 pounds	June 1	August 1–September 1
9. Rape, third sowing	4 pounds	July 1	September 1–October 1

(5) Succession of Soiling Crops for Dairy Cows for Wisconsin.—Carlyle.

Crop	Pounds of seed per acre	Time for sowing	Approximate: Time of cutting	Approximate: Days from sowing to harvest	Approximate: Daily feed per cow	Approximate: Acreage for ten cows	Degrees of maturity	Palatability
Fall rye	168	Sept. 10	May 15–June 1	248	38	$\frac{1}{3}$	Before blooming	Poor
Alfalfa	20	Mar. 20	June 1–15	72	36	$\frac{1}{3}$	Before blooming	Fair
Red clover	15	. . . .	June 15–25	. .	36	$\frac{1}{3}$	In bloom	Fair
Peas and oats	P 60, O 48	April 16	June 25–July 5	70	32	$\frac{1}{6}$	In milk	Average
Peas and oats	P 60, O 48	April 26	July 5–15	70	32	$\frac{1}{6}$	In milk	Average
Oats	80	May 5	July 15–25	70	32	$\frac{1}{6}$	In milk	Average
Alfalfa (second crop)	. . .	. . . .	July 15–30	. .	36	. .	Before blooming	Average
Rape	2.5	May 26	Aug. 1–15	67	42	$\frac{1}{8}$	Mature	Good
Flint corn	. . .	May 20	Aug. 15–25	86	40	$\frac{1}{8}$	In silk	Very good
Sorghum	50	June 1	Aug. 25–Sep. 10	86	39	$\frac{1}{10}$	When well headed	Very good
Evergreen sweet corn	. . .	May 31	Sept. 10–25	102	39	$\frac{1}{8}$	In silk	Very good
Rape	2.5	July 20	Sept. 25–Oct. 10	67	42	$\frac{1}{8}$	Mature	Good

Remarks.—Feed in stable during day and turn cows on pasture at night, or feed carefully in the pasture, spreading the forage. After cutting rye, use same ground for the rape, flint corn and sorghum, and after cutting peas and oats, use same ground for evergreen sweet corn and rape. After oats, sow peas and barley. In this way a single acre only is required (except alfalfa, which is permanent), and the forage produced is ample succulent feed for ten cows for nearly half the year.

(6) *Mississippi.*—"One of the best, surest and safest crops for soiling is sorghum, planted thick, and with the rows not over two feet apart. The sorghum may follow a crop of oats or some other early crop, and will withstand dry weather better than most other plants. Cowpeas are good, and corn may be used satisfactorily on land that will produce fair to large yields." (Moore.)

(7) *Kansas.*—Dates when soiling crops are available: Alfalfa, May 20 to September 30; wheat, June 1 to June 15; oats, June 15 to June 30; sweet corn, July 15 to July 31; field corn, August 1 to September 15; sorghum, August 1 to September 30; kafir, August 1 to September 30; wheat and rye pasture, until the ground freezes. (Otis.)

The development of dairying in the southern states means more attention to care and feed of the livestock; and the advance of land values and comparative cheapness of labor should bring southern dairymen to consider the many ways in which soiling, or at least partial soiling, may be of advantage under their special conditions. Cost of labor is the greatest item against the soiling system, and even this may be largely overcome by judicious planning.

(6) DATES FOR PLANTING AND USING SOILING CROPS IN WESTERN OREGON AND WESTERN WASHINGTON.—Hunter.

Crops	When planted	When used
Rye and vetch	September 1-15	April 1-May 15
Winter oats and vetch	September and October	May 15-July 1
Winter wheat and vetch	September and October	May 15-July 1
Red clover	. . . .	May 15-July 1
Alfalfa	. . . .	During June
Oats and peas	February	During June
Oats and vetch	February	June 15-July 15
Oats and peas	April	During July
Rape	May 1	During July
Oats and peas	May	During August
Rape	June	During August
Corn	May 10–20	During August, September and October
Turnips	July 1	Late fall and early winter
Thousand-headed kale	March 15 and trans. June 1	October 15-April 1
Mangels, carrots and rutabagas	April	October 15-April 1 (fed from bins, pits or root-houses)

(7) The following rotation has been used successfully by a large number of practical dairymen in the middle latitudes (40° N.).

Crop	Seeding time	Seed per acre	In prime feeding condition
Rye and vetches	September	2 bushels rye, ½ bushel vetch	April 25 to May 10
Wheat and vetches	September	2 bushels rye, ½ bushel vetch	May 10 to June 1
Red and alsike clover	April or August	25 to 30 pounds	June 1 to June 25
Oats and Canada peas	April	2 bushels oats, 2 bushels peas	June 25 to July 10
Very early sweet corn	May	8 quarts	July 10 to July 25
Late sweet corn	May and June	6 quarts	July 25 to August 25
Sorghum and cowpeas	June	10 qts. sorghum, 50 qts. peas	August 25 to frost

Feeding soiling crops.

The cereals are ready for feeding when the kernels are in the milk stage, while the legumes may be cut in full bloom or before. Ordinarily, a soiling crop cannot be fed to advantage for a longer period than ten to fifteen days, so that a change of feed should be provided at this interval. A few crops, such as corn and sorghum, may be cut every second or third day, but most soiling crops must be cut daily for feeding in the stable. This work can be systematized so as to save labor by the use of a mowing-machine, horse-rake, and low-feed truck, so that the feed may be hauled directly into the stable and unloaded in front of the cows in one handling. Soiling crops are usually fed uncut; but green corn and sorghum, if left in the field till nearly mature, are preferably run through a feed cutter before being fed. If the pastures are greatly dried up, so that it is necessary to place the animals on soiling crops only, with some dry roughage, it is well to feed green crops three or four times a day.

Cows will eat fifty to one hundred pounds of green forage, depending on the kind of crop at hand and its stage of maturity. In planting a rotation of crops it is safe to allow about one-half a square rod per day of such crops as oats and peas, clover, alfalfa and millet for each full-grown animal (cows or steers), and a quarter of a square rod of corn or sorghum.

A very important advantage of "soiling" dairy cows lies in the fact that it enables the farmer to keep his cows up to a uniform standard of production during nearly the entire lactation period, as they may be furnished a variety of palatable and nutritious feeds throughout the growing season.

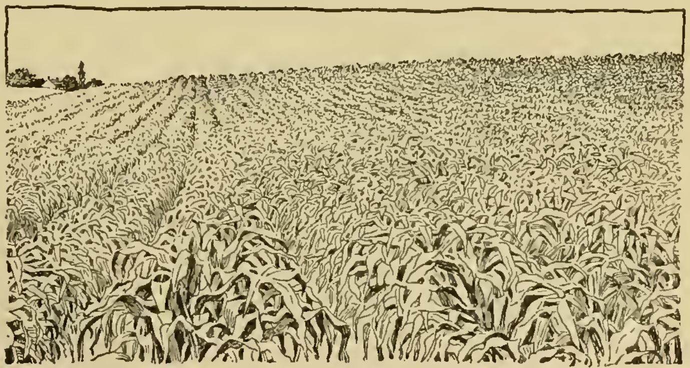

Fig. 806. Field of corn for soiling.

and by feeding silage and roots in winter the conditions of both summer and winter feeding are such as are most conducive to a large and profitable dairy production.

Care of stock under soiling.

Cleanliness in the stable and the grooming of the cattle are important factors in soiling. When in pasture the hair of the stock is kept clean through rain and wind, but when confined the waste thrown off by the skin must be removed by currying in order that the skin secretion of the animals be not interfered with, and that they may thrive under the rather artificial conditions under which they are kept, with the incidental heavy system of feeding and production.

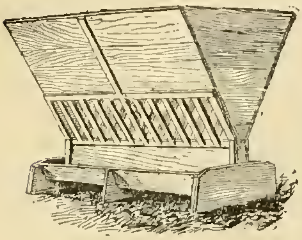

Fig. 807. Rack for sheep-feeding. (See also Figs. 186 and 187, Vol. I.)

Literature.

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SORGHUM. *Andropogon Sorghum*, Brot., or *Sorghum vulgare*, Pers. *Gramineæ.* Figs. 808–814.

By *Carleton R. Ball.*

Agriculturally the term sorghum is commonly restricted to the sweet or saccharine varieties.[1] Botanically the species, *Andropogon Sorghum*, is held to include all groups of cultivated sorghum, such as the broom-corns, sweet sorghums, kafirs and durras. All other specific names which have been applied to cultivated sorghums are regarded as synonyms. *A. Sorghum* is not certainly known in a wild state, and all the cultivated forms referred collectively to this species are thought to have been derived from the wild *A. Halepensis*, Brot. (Figs. 518, 673). This species, well known in the southern states as Johnson-grass, is widely distributed in tropical and subtropical regions. In Africa and Asia it presents a number of striking forms varying from each other in the same directions as do the chief groups of cultivated forms. A few of the cultivated forms of India are said to be directly traceable to the wild *A. Halepensis*. The differences usually cited between the two species are the slender habit, lax open panicle and stout, jointed, perennial rootstocks of *A. Halepensis*. However, in rich soil *A. Halepensis* is often more robust than some forms of *A. Sorghum*, as for example, certain kaoliangs from China or some forms of Amber sorghum in this country. The lax, open panicle is also characteristic of Amber sorghum, of some kaoliangs and of some varieties of African origin, as Collier. The stout rootstocks are not possessed by any cultivated variety of sorghum so far as known, though our annual varieties not infrequently become perennial under favorable climatic conditions. Another separating character, emphasized by Hackel, is the jointed pedicel of the spikelet in the wild species and the continuous pedicel in the cultivated species. However, he states that a cultivated form, referable to *A. Sorghum* in other characters, was found to have the jointed pedicels of *A. Halepensis*, thus breaking down the last distinction separating the two so-called species.

[1] For this reason the methods of culture and handling given by Mr. Warburton, in the succeeding article, are for the sweet sorghums only. For the methods applicable to the other groups, see *Broom-corn* and *Kafir and Durra*, respectively.

Cultivated sorghum is known to have originated in the tropical or subtropical regions of the Old World and to have been many centuries in cultivation for human food. From the abundance and diversity of its forms and their very extensive cultivation and use, tropical Africa is generally considered the birthplace of the species. For the same reasons it may be held to be indigenous to India also. In either case, it was probably cultivated in the Orient long before the beginning of the Christian era.

Botanical description.

Annual grasses, 3–15 feet in height, with stout, erect, jointed stems, $\frac{1}{2}$–$2\frac{1}{2}$ inches in diameter, stooling little or much from the base, simple above or producing a single, simple, fruiting branch from each of 1–5 upper nodes, except the uppermost; nodes 7–20 in the forms cultivated in this country; internodes normally longer than or about equaling the sheaths, or sometimes shorter, the sheaths then overlapping, as in kafirs; leaves in two opposite ranks (distichous), large, 1–5 inches in width, 1–$3\frac{1}{2}$ feet in length, acute at the apex, broadest about the middle, somewhat to considerably narrowed at the base or broad and more or less clasping, depending much on vigor of growth. Peduncles slender or stout, 10–36 inches long, erect or recurved ("goosenecked"). Seed-head a panicle, 5–28 inches in length, of widely different color and shape in different cultivated varieties: a corymb or umbel in form, as in broom-corns, Collier sorghum, and the like; a true panicle in Amber sorghum, in Shallu and others; a close and spike-like panicle in Orange and Sumac sorghums, kafirs, and others; and a dense, ovate or globose, head-like panicle in many durras; the rachis or central axis of the panicle greatly shortened in the corymbose forms, as broom-corns, from one-half as long as to equaling the panicle in sweet sorghums, and nearly equaling it in kafir and durra varieties; spikelets in pairs, one sessile, fertile, prominent, the other stalked, sterile, slender, less conspicuous, and falling off readily at maturity; seeds oval, obovate, subglobose or lenticular in shape; white, pearly, yellowish, reddish yellow, red or reddish brown in color; shorter than the empty glumes (included) or longer (exserted); empty glumes (hulls or outer chaff) usually thick, leathery, much shorter than to longer than the seed, rounded or acute at the apex; normally greenish white while immature, sometimes remaining so in maturity, in other varieties becoming different shades of red, brown and black, more or less silky-hairy, at least while young, some forms almost glabrous at maturity; flowering glume thin, transparent, awned or awnless.

Groups.

The cultivated sorghums of this country may properly be divided into five groups, as follows: broom-corns, shallu, sweet or saccharine sorghums, kafirs, and durras. Popularly they are classed as broom-corns, saccharine sorghums and non-saccharine sorghums, the last class including both kafirs and durras. The term non-saccharine is cumbersome and not distinctive, as some of the kafirs have a fairly sweet juice and could doubtless be developed into saccharine varieties. The term kaoliang, mentioned on page 572, designates Chinese varieties in general, it being the Chinese name for sorghums.

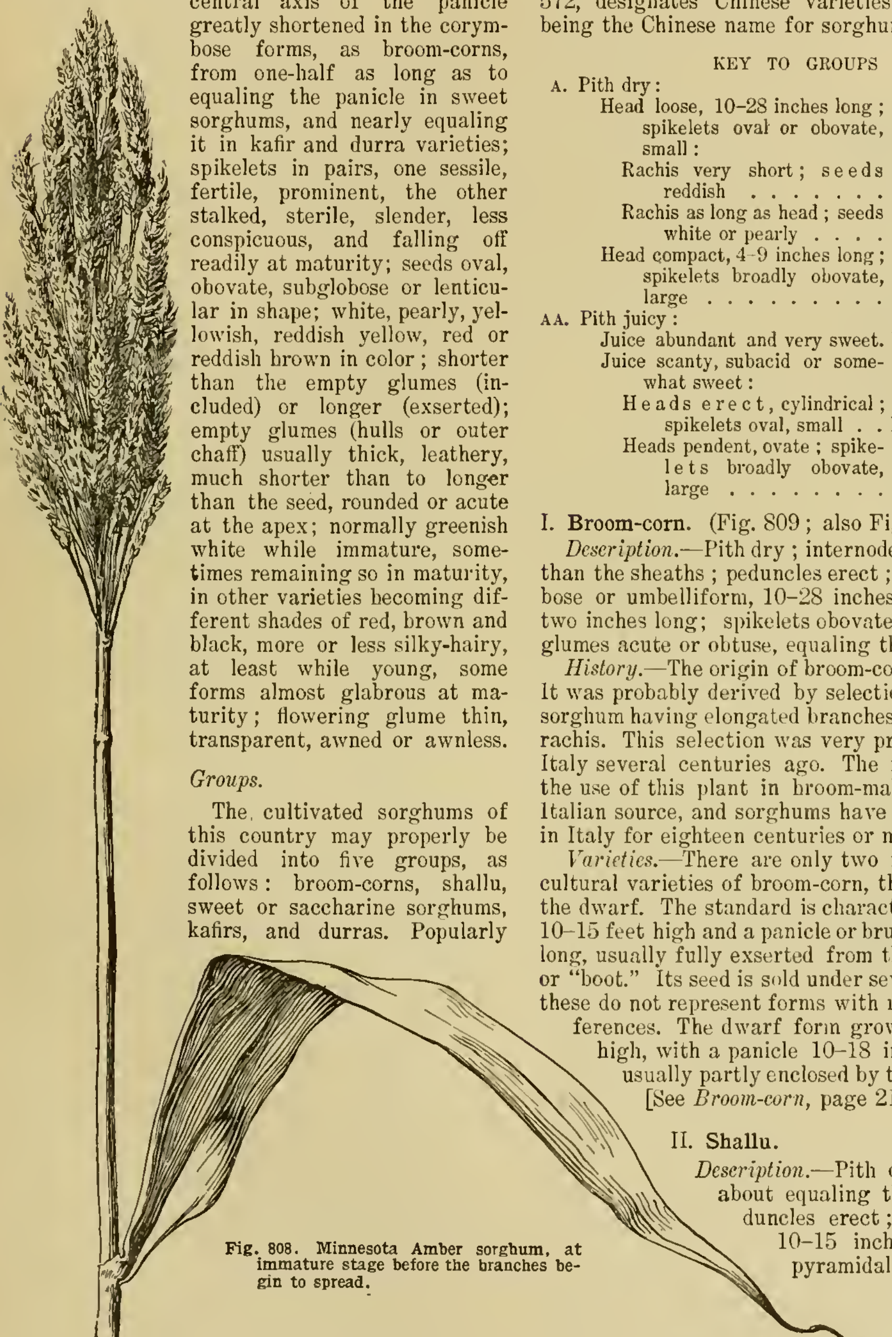

Fig. 808. Minnesota Amber sorghum, at immature stage before the branches begin to spread.

KEY TO GROUPS

A. Pith dry:
- Head loose, 10–28 inches long; spikelets oval or obovate, small:
  - Rachis very short; seeds reddish . . . . I. **Broom-corn**
  - Rachis as long as head; seeds white or pearly . . . . II. **Shallu**
- Head compact, 4–9 inches long; spikelets broadly obovate, large . . . . V. **Durra**

AA. Pith juicy:
- Juice abundant and very sweet. III. **Sorghum**
- Juice scanty, subacid or somewhat sweet:
  - Heads erect, cylindrical; spikelets oval, small . . IV. **Kafir**
  - Heads pendent, ovate; spikelets broadly obovate, large . . . . V. **Durra**

I. **Broom-corn.** (Fig. 809; also Fig. 309.)

Description.—Pith dry; internodes usually longer than the sheaths; peduncles erect; panicles corymbose or umbelliform, 10–28 inches; rachis one to two inches long; spikelets obovate, mostly awned; glumes acute or obtuse, equaling the seeds.

History.—The origin of broom-corn is not known. It was probably derived by selection from a sweet sorghum having elongated branches and a shortened rachis. This selection was very probably made in Italy several centuries ago. The first mention of the use of this plant in broom-making is from an Italian source, and sorghums have been cultivated in Italy for eighteen centuries or more.

Varieties.—There are only two recognized agricultural varieties of broom-corn, the standard and the dwarf. The standard is characterized by stalks 10–15 feet high and a panicle or brush 15–28 inches long, usually fully exserted from the upper sheath or "boot." Its seed is sold under several names, but these do not represent forms with recognizable differences. The dwarf form grows only 3–6 feet high, with a panicle 10–18 inches in length, usually partly enclosed by the upper sheath. [See *Broom-corn*, page 216.]

II. **Shallu.**

Description.—Pith dry; internodes about equaling the sheaths; peduncles erect; panicle large, 10–15 inches long, ovate-pyramidal, loose and open, pale yellow, branches commonly drooping; rachis as long as the panicle; spikelets elliptical-lanceolate, awned; empty glumes straw-colored, hairy, becoming gaping and inrolled at maturity; seeds oval, flattened, white or pearly, hard, fully exposed at maturity by the spreading and inrolling of the glumes; awns long, yellowish and rather persistent.

History.—A peculiar sorghum introduced from India, where it is extensively cultivated in Bombay and the Deccan under the native name, Shallu, usually as a winter crop. It was imported and tested by the Louisiana Agricultural Experiment Station more than fifteen years ago. It is now found growing at scattered points from Kansas to Texas under such names as "California wheat," "Egyptian wheat," and "Mexican wheat." The source of these culture areas is not known, but probably from the Louisiana importation.

Fig. 809. Broom-corn. Seed-head or brush, and seeds in detail at right.

Varieties.— But a single variety is found in this country. The stalks are slender, 5–7 feet tall, with rather small leaves. It requires 100 to 120 days to reach maturity. Its value is not yet known.

III. Sweet sorghums.

Description.— Pith juicy and sweet; internodes about equaling the sheaths; peduncles erect (recurved in Gooseneck); panicle variable, loose and ovate to compact and cylindrical; rachis variable in length; spikelets ovate, oval or obovate, awned or awnless; glumes equaling or shorter than the seeds; seeds pale orange to deep red.

History. — The sweet sorghums of the United States were obtained originally from two widely separated regions,—China and Natal. The Chinese variety reached this country in 1853, by way of France. It was at first called *sorgho.*

From it has since been derived our well-known Amber sorghum. The Natal varieties, fifteen or sixteen in number, collectively called Imphee, were brought from Europe in 1857, and were first grown in South Carolina and Georgia. From them have descended our Orange (Neeazana), Sumac (Koombana) and Gooseneck (native name not certain). These are varieties in common cultivation today. Three other little-grown varieties, Collier, Planter's Friend and Sapling, are probably of the same origin. Many additional forms and so-called varieties have since arisen through sports, selections and natural crossing. The sweet sorghums are not sharply separated from the kafirs.

KEY TO VARIETIES OF SWEET SORGHUM

A. Peduncle and panicle erect:
- I. Panicle loose, open, branches spreading to horizontal or drooping:
  - Rachis two-thirds as long as to equaling the panicle; spikelets usually awned:
    - Stems slender; panicle ovate-pyramidal or one-sided; empty glumes deep red or black:
      - Empty glumes black:
        - Empty glumes rigid, long, more or less hairy, pure black, usually awned . 1. **Amber**
        - Empty glumes longer and thinner, glabrous, usually glaucous when mature, never awned . . 1. **Minn. Amber**
      - Empty glumes deep red . 2. **Red Amber**
    - Stems stout; panicle oblong, elongated; empty glumes light brown . . . . . . 3. **Honey**
  - Rachis less than one-half the length of the panicle:
    - Panicle light weight, red-brown, branches 6–10 inches long, drooping; glumes with pale margins, acute; seeds deep orange to red . . . . 4. **Collier**
    - Panicle heavy, pale orange or darker; glumes pale straw-color or darker, never all dark; seeds pale orange to deep orange . . . . 5. **Planter's Friend**
- II. Panicle close, compact, obovate-oblong or cylindrical; branches appressed or the uppermost spreading:
  - Panicle oblanceolate or oblong, 5–7 inches long; stems 5–7½ feet high:
    - Empty glumes about equaling the large seeds:
      - Color of panicle pale orange or darker; glumes pale straw-color or darker but never all dark, acute; seeds pale orange or darker . . . . 5. **Planter's Friend**
      - Color of panicle reddish brown or deep brown; glumes red to black, all dark; seeds pale orange to red . . . . 6. **Orange**
    - Empty glumes about half as long as the small seeds:
      - Panicle very compact; glumes black, seeds dark red . . . . 7. **Sumac**
  - Panicle cylindrical, elongated, 10–14 inches long; stems 8–10 feet high:
    - Empty glumes narrow, somewhat shorter than the red seeds . . . . 8. **Sapling**

AA. Peduncle strongly declined or recurved (goosenecked), or sometimes erect; hence, panicle horizontal or pendent, or erect:
Panicle black, ovate or triangular, awned; stems tall and stout, reddened below 9. **Gooseneck**

Descriptions of varieties of sweet sorghum.

1. *Amber.* (Fig. 810.) This is the earliest variety, maturing in about 90–100 days; stems slender, 5–7 feet tall, averaging 8–10 nodes, branching freely late in the season; leaves rather slender. Panicles black, loose and very open, 8–12 inches long, oblong or ovate-pyramidal in outline, frequently one-sided (secund) and triangular through the leaning of the stalks, the lower branches usually drooping. Typically awned, but awns deciduous at maturity, and sometimes entirely wanting. Glumes broad, jet black, more or less silky-hairy, exceeding and enclosing the orange or reddish, oval seeds. Exceeding variable. Forms with contracted panicles are common, especially in the Plains region and the extreme North, where lack of moisture and short season prevent luxuriant growth. It is known commercially under many names, as Early Amber, Minnesota Amber, Improved Amber, Wisconsin Amber, Black Dwarf, and others. Is found in cultivation on every continent. Amber is very subject to blight and smut.


Fig. 810. Amber sorghum.

Minnesota Amber was originated through selection more than forty years ago by Mr. Seth H. Kenney, of Waterville, Minn. It is distinguished by more slender panicles with longer branches and larger spikelets, by glabrous and usually glaucous or bluish-white glumes which are less rigid in texture, and by absence of awns.

Folgers Early was developed as a specially productive syrup strain, and when true to name is said to be somewhat later.

2. *Red Amber.* This differs from Amber mainly in the red empty glumes, but is also 5–10 days later. It is now cultivated in this country only sparingly if at all, but was probably in more general use at one time. The seed has recently been received from Australia under the name Orange. The value is the same as for Amber.

3. *Honey.* This is a very distinct variety recently discovered in the Southwest. Stalks 7–10 feet high, averaging 13–18 nodes in different localities, stout, 1–1½ inches in diameter at the base, very sweet. The stems are markedly tender in comparison with other stout varieties. It is, however, the latest variety known, requiring 130–140 days to mature. For the southern states it is likely to prove one of the best syrup varieties.

4. *Collier.* This is a tall slender variety, 7–10 feet high, less than an inch in diameter, averaging 12 or 13 nodes, medium late, requiring 110–130 days to ripen. True Collier may be recognized by the resemblance of its panicle to a small broom-corn panicle, 6–10 inches long, the rachis much shortened or occasionally half or more than half as long as the panicle; branches long and slender, drooping on all sides or, when the slender stalks are leaning, drooping on one side only; seeds deep orange or red, slightly exserted from the dark glumes with pale margins.

5. *Planter's Friend.* This is a fairly tall and stout variety, erect, 7–9 feet high, averaging 13 or 14 nodes, ¾–1¼ inches in diameter at the base, yellowish green in color; leaves large; panicle usually compact but not heavy, 5–8 inches long, lighter in color than that of Orange, the glumes a light straw-color and the seeds very pale orange in dry regions, glumes and seeds both strongly reddened in more humid climates. The top of the panicle is often flaring through the spreading of the longer upper branches; the rachis is normally more than two-thirds as long as the panicle but occasionally much shortened, and the long branches are then more or less drooping.

The origin of this variety has not been ascertained, but it is probably one of the original Natal varieties, grown in Kansas as early as 1889, in India in 1875, and now in common cultivation in Australia. It is found in local cultivation in many of the southern and southwestern states under such names as Improved Orange, McLean, Silver, Silver-drip, Silver-rind, Simmon's Cane, Sourless and "Straightnecked Ribbon Cane." The seed is not obtainable commercially. A variety known as Sugar-drip, locally cultivated in North Carolina and Texas, is a probable hybrid of this variety with Blackhull kafir. Planter's Friend ripens at about the same time as Orange, to which it is most closely related, and is likely to have about the same value as a syrup and forage plant.


Fig. 811. Orange sorghum.

6. *Orange.* (Fig. 811.) The Orange is a rather stout, erect variety, 6–8 feet tall, ¾–1¼ inches in diameter, yellowish green, with an average of 12–14 nodes and rather large leaves. Panicles compact and heavy, oblong or cylindrical, 6–9 inches long, in color a mixture of the red or black glumes and the slightly exserted, orange or reddish seeds. The top is occasionally open or flaring by the spreading of the

elongated upper branches. It is one of the original Natal varieties, introduced and at first grown under the native name, Neeazana. It matures in 105–125 days, about 15 days later than Amber, and, after it, is the most widely grown variety in this country, where it is one of the most valuable for forage, silage and syrup. It is found abroad only in France and Australia.

Colman, as now grown, is apparently identical with Orange. It is said to have been a cross between Amber and Orange, but now shows almost none of the Amber characters. Kavanaugh is also an Orange sorghum.

Fig. 812.
Sumac sorghum.

Fig. 813.
Gooseneck sorghum.

7. *Sumac.* (Fig. 812.) The Sumac is a stout, erect variety, 6–9 feet high, about one inch in diameter, with an average of 14–16 nodes, good foliage and short, very compact, cylindrical, red heads, 4–8 inches long. Glumes very short, black. Seeds deep red, obovate, smaller than in any other variety, but much exserted from the very short glumes. It is also one of the original Natal varieties, introduced under the native name, Koombana, but apparently not long grown under that name. It matures at about the same time as Orange or slightly later, and is an especially valuable variety for forage, silage and syrup. For forty years this has been the most popular variety in the South, especially in the Piedmont districts. It is now largely grown in Texas and Oklahoma also. It has been variously known as Liberian and Red Liberian, Redtop African, Redtop and Sumac. It is the most uniform of our varieties, apparently not being crossed readily by pollen from other varieties.

8. *Sapling.* This is a tall and slender variety, 8–12 feet high, ½ to 1 inch in diameter, with 12–15 nodes and slender, cylindrical panicles, 10–14 inches long, with long and mostly appressed branches. Glumes narrow, elliptical, red to black, about three-fourths as long as the oval, red and well-exserted seeds. It matures in 110–125 or 130 days. Owing to its tall, slender habit of growth, and consequent tendency to lodge, it is, like Collier, not likely to prove a valuable variety.

The origin and history are unknown, but it is probably one of the original Natal introductions. It was first grown at the sorghum-sugar experiment stations in Kansas many years ago, under the name of Red X or Red Cross, and is still grown at Fort Scott, and locally in Missouri and Texas. It has recently been found in the mountains of northern Georgia and in Texas (from North Carolina seed) under the name of Sapling.

9. *Gooseneck.* (Fig. 813.) This is the largest and one of the latest varieties in cultivation. The stalks are 8–12 feet tall, 1–2 inches in diameter at the base, with 12–20 nodes; lower internodes usually red; leaves very large, frequently over three feet long and nearly four inches wide, often red or purple at the base. Peduncles recurved ("goosenecked") or erect; panicles black, contracted, rather dense, ovate or one-sided (secund) and triangular, 10–50 per cent pendent; spikelets broadly obovate, awned; seeds small, reddish, shorter than the black, more or less silky glumes. It requires 120–135 days to reach maturity.

Gooseneck is one of the original Natal varieties, but the native name is not known. It was a favorite in the South many years ago, and is still sparingly cultivated there. Four years ago this variety was brought to public notice in Texas under the name, "Texas Seeded Ribbon Cane," erroneously said to be a seed-producing variety of the true sugar-cane or ribbon cane. Since then it has been widely advertised and grown in the Southwest under that name. It is a very valuable variety because of the large yield of syrup, but it is too late to mature north of Tennessee and southern Missouri.

IV. Kafir.

Description.—Stems stout, 1–2 inches in diameter, 4½–6 or 9 feet tall, with 12–15 nodes; pith semi-juicy but juice subacid or only slightly sweet; internodes much shorter than the sheaths (equaling them in Old kafir), the leaves thus closely crowded; peduncle erect; rachis about as long as the heavy, compact, oblong or cylindrical panicle; glumes about half as long as the seeds, never awned. With the exception of Old kafir, the kafirs form a very uniform and well-defined group of low, stout, stocky, heavily-seeded plants, most closely related to the sweet sorghums.

History.—The kafirs are native to eastern Africa, from Abyssinia to Natal. Old kafir was introduced about 1875, and distributed by the "Rural New-Yorker" in the spring of 1881 as Rural Branching Sorghum. It soon after became known as milo maize or White milo maize, and later as African millet. Two varieties, one the White kafir and the other probably the Red, were exhibited by the Orange Free State at the Centennial Exposition, Philadelphia, in 1876. Seed of the White kafir was secured by the Department of Agriculture of Georgia and transmitted in February, 1877, to Dr. J. H. Watkins, still living at Palmetto, Ga. He grew and selected it for several years and began to distribute it in 1885. It was widely distributed by the Georgia Department of Agriculture and by the United States Department of Agriculture from 1886 to 1889. The seed of the Red variety was apparently not distributed for about ten years, when it was sent to Mr. A. A. Denton, in Kansas.

KEY TO VARIETIES

A. Seeds white:
- Glumes greenish white or some darker . . . . 1. **White kafir**
- Glumes black or nearly so:
  - Stalks 5–6 feet tall; internodes much shorter than the (overlapping) sheaths . . . . . . 2. **Blackhull kafir**
  - Stalks 7–10 feet tall; internodes equaling or longer than the sheaths 3. **Old kafir**

AA. Seeds red; glumes deep red to black . . . . 4. **Red kafir**

Description of varieties.—Old kafir differs from the others in the greater height, 7–9 feet, caused by longer internodes, and hence in having the leaves not crowded. It is also a later variety. It has been on the market for many years under such names as Rural Branching Sorghum, African millet, White milo and others. By some it is thought to be the form from which Blackhull kafir has been derived.

White kafir is distinguished by the pale glumes and the heads usually not fully exserted from the sheaths. Blackhull kafir, now the most promising variety, is marked by the black glumes, and heads almost always fully exserted. Red kafir is very similar to the White and the Blackhull except in the red seeds and the longer, slenderer heads. [See *Kafir and Durra*, pages 384–388.]

V. **Durra.**

Description.—Stems medium to stout, 4–7 feet tall, ½ to 1½ inches in diameter; nodes 8–11, averaging 9; internodes usually shorter than the sheaths, sometimes equaling them; pith dry to semi-juicy, not sweet; leaves broad and short; peduncle stout, recurved or sometimes erect; panicles compact, ovate or broadly elliptical, mostly pendent, sometimes erect or inclined; spikelets very broad, obovate or rhomboid, awned or awnless; seeds large, flattened, lenticular or subglobose.

History.—The durras have been cultivated since historic times as sources of human and animal food. They are found abundantly today in northern Africa, southwestern Asia and India. Some were brought from Mediterranean regions to America in early colonial days, but only sparingly cultivated. The White durra and the Brown durra at present cultivated in this country were introduced from Egypt into California in 1874 and known as White and Brown Egyptian corn, respectively. Yellow milo is of Egyptian origin, but the circumstances of its introduction are not known. The Blackhull durra, only sparingly found in this country, is either an importation from India or, as is certainly true in some cases, a hybrid between Blackhull kafir and White durra.

KEY TO VARIETIES

A. Seeds white:
- Glumes greenish white, silky; seeds much flattened, lenticular; floret awned . . 1. **White durra**
- Glumes black, scarcely hairy; seeds smaller, less flattened, rare . . . . . . 2. **Blackhull durra**

AA. Seeds yellowish, reddish or reddish brown:
- Glumes short, transversely wrinkled, reddish to black, not silky; seeds yellowish brown; florets awned . . 3. **Yellow milo**
- Glumes as long as the seeds, greenish white, silky; seeds reddish brown; not awned . . . . 4. **Brown durra**

Description of varieties. — Except in color of seeds and glumes, these varieties are very similar. White durra and Brown durra are most closely related, differing only in the color of the seed and the presence or the absence of the awn. Yellow milo, now a very important crop, differs in the much shorter, transversely wrinkled glumes and the less flattened seeds. All three of these durras have fewer leaves than the kafir varieties. The stalks are less juicy and the juice less sweet. The pendent, or goosenecked heads of all three and the easily shattered seeds of White durra and Brown durra put them at a disadvantage in comparison with the kafirs. The seed of Yellow milo does not shatter, and this variety has now become a staple crop in western Texas, Oklahoma and adjacent sections. It is there commonly know as Dwarf milo, owing to its small size in that dry and elevated region. [See *Kafir and Durra*, pages 384–388.]

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Sorghum-growing.

By *C. W. Warburton.*

Sorghum is a drought-resistant crop largely grown in the southern and southwestern United States, and to some extent in other sections, for forage and for the production of syrup. The forage is used as fodder, hay, silage, pasture or for soiling. Sorghum out-yields the best varieties of fodder corn in the South, and is generally considered superior to them for forage production. In the corn-belt it is little grown as a forage crop, but formerly was extensively used in the production of syrup. The use of sorghum for this latter purpose has rapidly decreased in the last few years owing to the presence on the market of large quantities of cheap glucose syrups, until now the sorghum-syrup industry is an unimportant one.

Culture.

Soils.— Sorghum is not particular as to soils; it does well on any rich, well-drained land, but gives best returns on sandy loams or clay loams. As the crop is comparatively a surface feeder, it responds readily to manuring. It has an extensive root system, however, and produces fairly good crops on poor land. Sorghum draws heavily on the moisture and plant-food in the surface soil, and so should not be followed by fall-sown crops. The prevalent idea that this crop is "hard on the land" is largely due to the bad physical condition in which it leaves the soil. If the land is plowed in the fall and put in good condition, the following crop should not be materially lessened because of the sorghum which preceded it.

Fertilizers.—For the production of forage, barnyard manure and the use of leguminous fertilizers, such as cowpeas, give best results. In semi-arid sections the manure should be well distributed, as large lumps will cause the soil to dry out very rapidly, with consequent injury to the crop. If a green-manuring crop is used, it should be plowed-in some time before the sorghum is planted, in order that the ground may become well settled and in good condition to retain moisture.

Preparation of the land.—No special preparation is necessary for this crop other than that given for corn. The land should be thoroughly plowed some weeks before planting, preferably in the fall. A few days before planting time it should be disked and harrowed until the surface is fine and mellow. The young plants grow very slowly, so that land reasonably free from weed seed should be used, and harrowing just before the seed is planted is desirable to kill any weeds which may have started.

Varieties.—The best known varieties of the saccharine sorghums are Amber (Fig. 810), Orange (Fig. 811) and Sumac (Fig. 812). Of these, Amber is the earliest, and produces a fair amount of forage. Orange and Sumac are later in maturing and yield more heavily. All make good syrup, Amber being most popular in the North, because of its earliness. Sumac is most largely grown in the Southwest, while Orange is the prevailing sort in many sections in the southern and central states.

Seeding.—When the crop is to be used for hay or pasture the seed is sown either broadcast or with a grain drill, using one-half to two bushels to the acre. The larger quantity is used in the southern states; the smaller one in regions of light

Fig. 814. Field of sorghum in shock.

rainfall. If the seed is sown with a grain drill, all or only a part of the holes may be used. For silage and soiling, and for fodder and syrup as well, it is customary to plant in rows three to four feet apart, using special sorghum plates in a corn- or cotton-planter, and planting six pounds to one-half bushel of seed per acre.

Cultivation.—When planted in rows, sorghum should be cultivated the same as corn. One or two harrowings lengthwise of the rows soon after planting will aid in keeping down the weeds, and this treatment should be continued until the plants are large enough to enable the use of any of the ordinary cultivators. After that time the crop should be handled like corn. If the weeds have been allowed to get a start, hoeing in the rows may be necessary. If the seed is sown in drills, harrowing a few days after seeding is often of benefit in checking the growth of weeds.

Harvesting.—For silage and fodder, and for syrup, the sorghum should be cut when the seed is in the dough stage. The silage will be much improved, if cowpeas are grown and harvested with the sorghum. For soiling, the crop may be cut at any time it is needed, but can be cut most profitably only after the plants begin to head. The fodder is usually cut with the corn-binder, shocked and stacked, or fed from the shocks the same as corn fodder. It is not usually advisable to stack the fodder until early winter, as the stalks are very succulent and are not thoroughly cured until that time. An acre will produce three to six tons of fodder or eight to twenty tons of green forage or silage.

When the seed has been sown broadcast or with a grain drill, and the crop is to be used for hay, it may be cut at any time after the heads have appeared. The best quality of hay can usually be obtained by cutting when the plants are just past the blooming stage, or before the seed hardens. In dry sections a grain-binder may be used and the bundles shocked, cured and stacked like wheat. In humid sections this is inadvisable, as the bundles are likely to mold. Ordinarily, however, the hay is cut with a mower, allowed to cure in the swath a short time, raked into windrows, cocked and the curing completed in the cock. When well cured it is stacked or put in barns. Considerable care is required in curing, as the stems are very succulent. In the South two or more cuttings may be made from a single seeding in favorable seasons. The yield of cured hay ranges from two to eight tons per acre.

Uses.

Sorghum makes excellent pasture for hogs, but in many sections it must be pastured sparingly, if at all, by sheep and cattle. After periods of extreme drought, or when growth is stunted from other causes, the leaves of the sorghums often contain a large amount of prussic acid (p. 388). A small quantity of this poison is fatal to stock, and death frequently results soon after the sorghum is eaten. Normal growth seldom contains prussic acid in appreciable quantities, and it largely disappears in curing, so that cured sorghum may be fed with little danger. There is also some danger from bloating; cattle and sheep should not be turned on sorghum pasture when hungry or when the plants are wet. With the exercise of care, however, the crop can usually be pastured with safety. It should be at least two feet high before stock are turned on it; for cattle, sheep and horses it may be much more mature than for hogs.

The hay and fodder may be fed in the same way as other coarse hays. The fodder compares favorably with corn fodder in feeding value. Sorghum silage is slightly less nutritious than corn silage, as it contains less protein. Kafir and sorghum fodder are usually considered about equal in value; fodder from the other non-saccharine varieties is rather less palatable and usually contains more fiber. The grain of the non-saccharine sorghums is less valuable for feeding purposes than corn, five bushels of kafir being considered about equal to four of corn. Seed of the saccharine sorghums ranks lower in feeding value than that of the non-saccharine varieties, as it contains a larger percentage of hulls and the astringency of the seed-coat causes the grain to be less relished by animals than that of the non-saccharine sorts.

Syrup production.

Extent of the industry.—When sorghum was first introduced into this country and for many years thereafter, it was used almost wholly for the production of syrup or molasses. This industry reached its greatest height between 1880 and 1890, when twenty-five to thirty million gallons were produced annually. About 1885 the production of syrup began to decrease, the Census of 1900 showing only 24,000,000 gallons from the crop of 1889, while ten years later, in 1899, the production had further decreased to 17,000,000 gallons. This decrease was due largely to the great increase in the production of the cheap glucose syrups. The cost of manufacture of sorghum syrup necessarily remains high, owing to the large amount of impurity which must be removed from the juice.

Grinding the cane.— For syrup production sorghum is grown rather thinly in rows three and one-half feet to four feet apart. The stalks are cut for grinding when the seed is in the dough stage or about the time it begins to harden; if cut earlier the syrup has a green taste, while if not cut till fully ripe the juice carries more impurities and is more difficult to make into good syrup. The cane is frequently cut as it stands, hauled to the mill, and ground. When possible, especially when the crop is grown on a small scale, it is better to strip the leaves and remove the heads from the stalks before grinding, as grinding the leaves and seed with the stalks injures the quality of the syrup. The stalks are usually ground with a horse-power mill, though often gasoline or steam engines are used to furnish the power. The mills ordinarily in use do not extract more than 60 per cent of the juice from the cane.

Clarification. — The sorghum juice as it comes from the mill contains about 25 per cent of impurities of various kinds. This material must be removed by clarification in order to secure syrup of high quality. Some of the impurities rise to the surface when the juice is heated and may be removed by skimming; others settle to the bottom of the pan and may be removed by drawing off the juice from above, leaving the sediment undisturbed. Filtering aids in removing foreign material, while the addition of some substance, such as milk, which coagulates on heating and rises to the surface, carrying with it some of the suspended matter, is used to remove others. The substance most used for this purpose, however, is dry medium-grained clay, using about ten pounds of clay to fifty gallons of juice. The particles of clay on settling to the bottom of the pan carry with them much of the impurity suspended in the juice. The clay may be added to the juice either before or after heating. Liming to neutralize the natural acids in the syrup is sometimes practiced. The processes most frequently employed are skimming, settling and claying.

Making the syrup.—The juice is reduced to syrup by heating, the water being driven off by evaporation. Shallow pans are used for this purpose, the juice usually being about three inches deep in the pans. The evaporation should be rapid and the juice should be cooled quickly after evaporation. Six to eight gallons of juice are required to make one gallon of syrup, which weighs about eleven and one-half pounds. The molasses, after being reduced to the proper density, may be stored in barrels or put up in tin cans. Its salability in most markets is greatly increased if the packages containing it are attractively labeled. The average production of syrup to the acre is fifty-eight gallons, though this yield is greatly exceeded under favorable conditions.

Sugar production.—The production of sugar from sorghum has never been practiced commercially, though it has been found possible to make sugar of good quality from this plant. Until a strain of greater sugar content than we now have is developed and improved methods of handling the juice are perfected, little sugar will be made from this crop.

Selecting and storing the seed.

While the great bulk of the seed planted is not selected at all, yet the time required to select seed-heads from stalks having desirable characteristics is comparatively slight, and when only a few acres are grown the yield and quality of the crop can be materially increased with little trouble. When the crop is grown on a large scale it is a good plan to select seed enough to plant a few acres and use the progeny of this selected seed for planting the main crop the ensuing year.

The heads should be removed when fully ripe; after they are well cured they may be threshed, or stored without threshing. In either case the seed should be kept in a dry place where it will not heat or mold. In the South it is often necessary to store in a tight box and treat with carbon bisulfid or some other insecticide to prevent the destruction of the seed by weevils. The seed weighs fifty to sixty pounds per bushel, according to the proportion of hulls.

Enemies.

The sorghums are not often seriously affected by insects or diseases. Chinch-bugs sometimes cause trouble, especially when they migrate from adjoining grain-fields. In some sections of the South the green aphis attacks the growing parts of the plants, but usually little damage is done. Remedial measures are seldom necessary, other than the avoidance of continuous cropping with the sorghums on any given piece of land.

The grain smut of sorghum (*Phacelotheca diplospora*) and the whole-head smut (*Phacelotheca reiliana*) attack the plants, but the resulting damage is usually comparatively slight. Both smuts can be kept in check by rotation and by selecting the seed; the grain smut can be further held in check by treating the seed with hot water, formalin, or any of the other well-known smut remedies.. [See Index.]

SOYBEAN. *Glycine hispida*, Maxim. *Leguminosæ*. Soja bean. Fig. 815.

By *J. F. Duggar.*

The soybean is an annual leguminous plant, valuable as human and stock-food, and as a soil renovator. In botanical relationship and in appearance it is close to the cowpea. It is an erect, hairy plant, two to four and one-half feet high, branching freely, and of bush form. The leaves are trifoliate, the leaflets in size and shape resembling those of ordinary beans and cowpeas. The small flowers, in clusters of two to five, are usually purplish or whitish. The seed-pods are short, one to two inches long, downy, usually cream-colored or whitish, and contain one to three seeds, usually two. The pods are clustered on the main stems and main branches. When mature, they split and drop the seeds. The seeds are generally roundish, in some varieties flattish, and are without any indentation on the surface. The scar is long. In shape and size the soybean seed somewhat resembles that of the Canada pea or Marrowfat pea. The usual colors of the seed

Fig. 815. Soybean (*Glycine hispida*).

are cream or yellowish white, green, black, and shades of brown.

The soybean in the United States is used for the same purposes as the cowpea, and possesses the following advantages over it:

(1) Being erect and without runners, the forage does not tangle.

(2) The seeds are removed by threshing and not by hand-picking, since the seeds usually do not split so easily in threshing.

(3) After falling on the ground, soybeans remain sound longer than cowpeas, thus giving a longer season for hogs to subsist on the field in the fall.

(4) Certain varieties of soybean mature earlier than cowpeas, and are thus better suited to the northern states.

(5) Soybeans give larger yield of grain than do cowpeas.

(6) The grain, or seed, is much more valuable for stock-feeding than that of the cowpea.

In general, in the North and West the soybean is preferable for grain and the cowpea for hay, but in the South both may be regarded as hay plants as well as grain plants. The soybean, however, is not usually considered as valuable as the cowpea as a hay or forage plant or for use as a catch-crop, since sometimes it is less productive of forage and has less adaptability to various conditions such as wet or dry land, or poorly prepared seed-bed. Rabbits are also very fond of feeding on the soybean and it is impracticable to plant this crop in small fields in localities where this pest is common.

Geographical distribution.

The soybean is thought to be native of southeastern Asia. It is thought to be derived from the wild *Glycine Soja* of Japan, being itself not known in a wild form. It is grown extensively in China and Japan. The varieties differ widely in maturity, requiring 70 to 166 days, thus permitting different varieties to be grown throughout the greater part of the United States, from Massachusetts and Michigan to the Gulf of Mexico. The northern limit of cultivation of the soybean coincides nearly with that of corn.

Composition.

The following tables from Farmers' Bulletin No. 58, of the United States Department of Agriculture (compiled from various sources), give the composition and digestibility of the various kinds of forage from the soybean plant:

From these tables it will be seen that all parts of the soybean plant are rich in nitrogen. The hay is similar in composition to cowpea hay. Soybean seeds are much richer in protein and fat than the seeds of the cowpea.

Culture.

Soil.—The soybean is adapted to a wide range of soils, sandy to clay. In high latitudes a well-drained sandy or sandy loam soil is preferred, as hastening maturity. The crop is quite resistant to drought and yet able to grow in a soil that is rather wet.

Ordinarily, the fields should be plowed and harrowed and level or surface planting practiced.

Fertilizers.—In case fertilizer is used in quantity, it is desirable for it to be mixed with the soil without coming in immediate contact with the seed. For drilled soybeans, fertilizer should be applied in the drills. When fertilizers are needed, it will usually be advisable to apply both phosphate and potash, using, in the South, for example, 200 or 300 pounds of high-grade acid phosphate and 50 pounds of muriate or sulphate of potash per acre.

CHEMICAL COMPOSITION OF THE VARIOUS KINDS OF FORAGE MADE FROM THE SOYBEAN.

Soybean forage	No. of analyses	Fresh or air-dry substance						Water-free substance				
		Water	Protein	Fat	Nitrogen-free extract	Fiber	Ash	Protein	Fat	Nitrogen-free extract	Fiber	Ash
Fodder (early bloom to early seed)	13	76.5	3.6	1.0	10.1	6.5	2.3	15.3	4.1	43.0	27.6	10.0
Soybean hay (Japanese)	1	16.0	16.9	2.2	23.1	35.9	5.9	20.1	2.6	27.5	42.7	7.0
Soybean hay (Mass.)	4	12.1	14.2	4.1	41.2	21.1	7.3	16.2	4.7	46.8	24.0	. .
Soybean-straw (Mass.)	3	11.4	4.9	1.9	37.8	37.6	6.4	5.5	2.2	42.7	42.4	. .
Soybean-straw (hulls and vines after threshing)	1	5.7	4.0	0.8	36.0	49.5	3.9	4.25	0.85	38.2	52.6	5.3
Soybean seed	8	10.8	34.0	16.9	28.8	4.8	4.7	38.1	18.9	32.2	5.4	5.3
Soybean meal	2	10.4	36.0	18.9	27.0	2.6	5.1	40.2	21.0	30.2	2.9	5.7
Soybean silage	1	74.2	4.1	2.2	7.0	9.7	2.8	15.7	8.7	27.0	37.6	11.0
Corn and soybean silage	4	76.0	2.5	0.8	11.1	7.2	2.4	10.4	3.3	46.3	30.0	. .
Millet and soybean silage	9	79.0	2.8	1.0	7.2	7.2	2.8	13.3	4.8	34.3	34.3	. .

DIGESTIBILITY OF SOYBEAN FORAGE.

Soybean forage	Kind of animals	Number of trials	Protein	Fat	Nitrogen-free extract	Fiber	Organic matter	Ash
Soybean fodder	Sheep	8	75.1	54.0	73.2	47.0	64.5	18.9
Soybean meal and timothy hay	Sheep	8	77.7	73.6	66.2	61.3	69.1	47.1
Soybean meal alone (calculated from the above mixture)	Sheep	8	85.8	84.9	73.4	. .	78.0	21.3
Soybeans (seed)	Ruminants	2	87.0	94.0	62.0	. .	85.0	. .
Soybean pods	Ruminants	2	44.0	57.0	73.0	51.0	63.0	. .
Soybean-straw	Ruminants	4	50.0	60.0	66.0	38.0	55.0	. .
Soybean hay	Ruminants	6	70.0	30.0	67.0	56.0	. .	. .
Soybean silage	Goats	2	76.0	72.0	52.0	55.0	. .	. .
	Steers	2	55.0	49.0	61.0	43.0	. .	. .
Corn and soybean silage	Sheep	3	65.0	82.0	75.0	65.0	. .	. .
Barnyard millet and soybean silage	Sheep	4	57.0	72.0	59.0	69.0	. .	. .

The soybean seems to profit by the addition of nitrogenous fertilizers, but these should not be needed after the soil becomes thoroughly inoculated. If nitrogen be used it may well be in the form of nitrate of soda and in small quantities, chiefly to stimulate very young plants.

Seeding.—For seed, the rows should be thirty to thirty-six inches apart, and one plant should be left every two or three inches in the North, or every three to eight inches in the South. For forage, the drills may be of the above width on poor land, while on rich land the seed may either be drilled, sown broadcast, or planted with a grain-drill as is wheat. For seed-growing, about one-half bushel of seed per acre will suffice. For forage in drills wide enough for cultivation, three pecks will be required, and for broadcast-sowing more than one bushel. For drilling the seed, one may employ hand-dropping, a one-horse planter, a corn-planter, or a grain-drill with enough of the tubes stopped to leave thirty to thirty-six inches between the rows. Soybeans are sometimes planted in the South between the rows or hills of growing corn.

Time to plant.—Soybeans must not be planted until all danger of frost is past and the soil has become warm. In the northern part of the United States the planting of this crop occurs just after corn-planting. In the Gulf states the best time is from the beginning of May to the middle of June. Planting may continue to the middle of July, but germination and early growth and yield are less satisfactory from this delay. From Kansas southward it is practicable under favorable conditions to mature soybeans grown as a catch-crop after wheat or, in the Gulf states, after oats.

Cultivation should be shallow and level, and similar to that given corn.

Inoculation.—No soybean plant is doing its best work for the farmer unless its roots bear a number of tubercles or root nodules. On this plant, the root tubercles are roundish enlargements that when fully developed are about the size of peas (Fig. 590). On any soil in which root tubercles fail to develop spontaneously, it is advisable to effect artificial inoculation by the introduction into the soil or on the seed of the nitrogen-fixing germs appropriate to soybeans. This may be done by moistening the seed with a dilution of pure cultures of the germ, directions for which accompany each package; or, more certainly, by the use of soil from a field where soybeans have recently produced abundant tubercles.

If this soil be drilled in with the seed, in a dry, finely powdered condition, 600 to 1,000 pounds per acre may suffice, but if applied broadcast, and not in immediate contact with the seed, at least one ton will be required. If only a very small quantity of soil is available, a peck of it may be stirred in about ten gallons of water, and the same day the seed moistened with this liquid. By this process, apparently a smaller number of plants become inoculated than by the use of larger quantities of dry soil. It has been found that it is less easy to cause a sufficient number of germs to adhere to soybeans than to cowpeas, for the reason that soybeans are so smooth and free from indentation or cracking. Hopkins prefers not to attempt thorough inoculation the first year, but to use only about 100 pounds of inoculating soil per acre, reseeding the land to soybeans the second year and relying on the natural spread of the germs from the decaying tubercles produced by this partial inoculation.

In Kansas, Connecticut, Illinois, and apparently in most states, the soybean when first grown developed no tubercles, but when grown for several years in succession in the same land, inoculation gradually increased. On lime soil at Lexington, Kentucky, tubercles were abundant the second year, but not the first; in experiments in Connecticut, there were no tubercles for at least three years. The gradual self-inoculation of soils is probably due to germs carried on the seed in such small numbers as to produce an insignificant number of tubercles the first year, which few would constitute the parent stock of a far larger number the second year, and so on. On medium and poor soils, inoculation may greatly increase the yield of seed or forage and the extent of soil-impovement. On rich land, soybean plants without tubercles are sometimes as thrifty and productive as plants bearing nodules. But even here inoculation is beneficial in decreasing the draft on the soil and in the enrichment of the land for future crops.

Inoculation sometimes greatly improves the composition of soybean forage and seed. At the Michigan Experiment Station there was little difference in the appearance and yield between plants with and those without root tubercles, but the presence of nodules increased the percentage of nitrogen in the dry matter of the leaves and stems from 1.77 to 2.78, and in the seed from 5.41 to 6.20, while the percentage of nitrogen was decreased in the roots from which nodules had been removed. At the Kentucky Experiment Station, the roots contained in the air-dry material 1.81 per cent of nitrogen when not inoculated and 2.7 per cent of nitrogen when covered with tubercles. At the Connecticut (Storrs) Experiment Station, the presence of tubercles raised the nitrogen percentage in the seed from 6.28 to 7.08.

Place in the rotation.—The place of soybeans in the rotation is as a cleaning or fallow crop, putting the land in good condition for an immediately following crop of small grain, alfalfa or other crop. In the South, soybeans may be grown as a catch-crop after wheat or oats. Hopkins suggests (Illinois Experiment Station, Bulletin No. 99) several rotations for the southern part of Illinois, in which the soybean may enter; for example, four-year rotation:

First year, corn, with cowpeas or soybeans as a catch-crop.

Second year, cowpeas or soybeans.

Third year, wheat (with clover to be seeded in spring).

Fourth year, clover.

Varieties.—There are many varieties of soybeans, differing chiefly in the time of maturity, size of plant, and color and shape of seed. In the latitude of Massachusetts only the early varieties mature seed, and even in Kansas an early variety is required. The standard variety in that state is Early Yellow, which matures there in about three months. Among the early varieties are Early Yellow, Ogema, Ito San and Early Brown, maturing in seventy-five to ninety days; among the varieties of medium maturity are Medium Black, Medium Green, Green Samara and Olive Medium, requiring a growing period of 95 to 110 days; among late varieties are Late or Mammoth Yellow, Flat Back, Tamarat Sukun, Nalrade, Asahi and Best Green (United States Department of Agriculture No. 4914). The Late Yellow matures in the Gulf states in about 130 days, while the other varieties of this late group are credited with a growing period of 114 to 166 days, the last mentioned being the latest variety on record. Generally, the varieties of the second or medium-maturing group have afforded the largest yield of forage in the northern states, especially the Medium Green. In the Gulf states, the late varieties are decidedly the most productive both of seed and of forage. The standard variety here is the Late Yellow, also known as Mammoth Yellow. Farther north, either the early or the medium varieties are used for seed production.

Harvesting.—When soybeans are grown for seed, it is necessary to harvest the plant as soon as the earliest beans ripen; otherwise the pods split and shed the beans. Harvesting may be done by the use of a self-binder, self-rake or reaper or by the use of a corn knife. The small, early varieties are too low for the use of binder or reaper, and are best harvested for seed by a bean harvester or an equivalent home-made implement, consisting of two knives bolted to the shanks of a cultivator and sloping backward, thus cutting the plants just below the surface. If this is not available, the small varieties must be pulled by hand.

In cutting soybeans for hay, the mower is commonly used, but it is sometimes desirable to cut the large varieties with a corn knife, in which case the cut plants are placed in loose small bundles, which are turned over just before the upper exposed leaves become crisp. A few days later these loose bundles or hands are piled in cocks, butts inward, thus making a large cock with a rather open center. The open center is then capped by the use of several bundles placed with the leaves near the center of the top of the shock. In cutting soybeans for hay, they should be past full bloom and the seed-pods formed, but not filled. For the silo the date of harvesting may be a little later, but before any seeds have ripened.

When soybeans are cut for hay with the mower, the method of curing is the same as with other legumes,—cowpeas, clover and the like. Soybeans grown for seed should be cured with as little handling as possible, and this handling, if practicable, should be in the early morning and late afternoon to reduce shattering to a minimum. The plants must not be bulked when damp. The threshing is done with an ordinary grain thresher, with blank concave. The seeds after threshing should not be bulked, as they heat easily, but should be kept in thin layers to insure soundness.

Yield.

The yield of seed is usually twelve to twenty bushels. In Massachusetts and Wisconsin and on limestone soil in Kentucky and Alabama, yields of more than thirty-four bushels per acre have been secured. At the Kansas Experiment Station, the average for twelve years was twelve bushels of soybeans as compared with 31.6 bushels of corn and 43.8 bushels of kafir, the soybeans, however, affording the largest amount of protein per acre. On poor soils in the Gulf states, yielding twenty bushels of corn or less per acre, the yield of soybeans will ordinarily equal or exceed that of shelled corn. The usual yield of hay is one and one-half to three tons per acre, and of green forage or silage six to ten tons per acre. In both Connecticut and Massachusetts, the weight of soybean silage has been about two-thirds that of corn silage from the same area.

Uses.

As a feed.—The soybean is valued as a grain or seed crop for domestic animals, as a crop for the silo, for hay, and in Asia as a food for mankind. The seeds constitute the richest natural vegetable food known, being nearly equal to cottonseed meal. They have been fed with entire satisfaction to milch cows, steers, calves, hogs, sheep, horses and poultry. They should not be fed alone, but mixed with four or five times their weight of corn, kafir, or other starchy foods, thus taking the place of cottonseed meal, linseed meal and gluten meal. When fed to milch cows, the production of milk and butter has been entirely satisfactory and the flavor of these products faultless. The butter from soybeans is somewhat softer than that from cottonseed meal. For cattle and horses it is advisable to grind the seed, but this is unnecessary for hogs and poultry. For hogs, threshing is unnecessary, the entire mature plants being fed on tight floors. If the beans begin to shatter in the field before it is practicable to harvest the crop, hogs can be turned in to consume them. The seeds thus shed remain sound on the surface of the ground for several months, or much longer than cowpeas. In a number of experiments at the Kansas Experiment Station, a mixture of a small proportion of soybeans in the food for hogs resulted in a saving of about 30 per cent in the total food required to produce a given amount of growth.

The soybean is a very useful crop for soiling, a succession of plantings affording green food throughout July and August.

As silage.—The use of the soybean as silage generally has been satisfactory, especially when mixed in the silo with twice its weight of corn silage. When placed alone in the silo, there have been instances of a strong objectionable silage which imparted a disagreeable flavor to milk and butter, even though the silage itself was sound. In Michigan, 13,500 pounds of green soybean plants, placed in the silo in September, had shrunk by the latter part of the next April to 11,285 pounds. When one part of soybeans is mixed in the silo with two parts of corn, the average protein content of the resulting silage is increased from 2 per cent with corn silage to about 2.7 per cent for the mixed silage.

As a land renovator.—Like the other legumes bearing tubercles, the soybean plant assimilates the nitrogen of the soil air, and thus may improve the nitrogen content of the land. For this purpose, the large varieties are most satisfactory. When the entire growth is plowed under or pastured, the increase in the succeeding crop of wheat or oats has been very large at the Alabama Experiment Station, while the plowing under of the stubble alone has increased to a moderate extent the yield of the succeeding crop. The analyses on record seem to indicate that soybeans usually contain more nitrogen to the acre than a crop of cowpeas, but that the stubble of an acre of soybeans contains a smaller amount of nitrogen than the stubble of cowpeas. This is doubtless due to the thinner planting of soybeans, to the smaller number of leaves dropped and to the smaller number of branches that escape the harvesting machine.

At Fort Hays, Kansas, the yield of wheat following wheat was 12.33 bushels, while following soybeans removed for grain the yield was 15.78 bushels per acre. At the Michigan Experiment Station, rye yielded 13 per cent more grain where soybeans had just been plowed under than where buckwheat had been plowed under. At the Massachusetts Experiment Station, the stubble of soybean was decidedly inferior to that of red clover for soil improvement. [See page 214.]

As human food.—As human food the soybean has not come into general use in Europe and America, but it is extensively used for this purpose in Japan, where soybean dishes supplement the usual rice diet. Langworthy gives the method of preparation of a number of Japanese dishes made from soybeans, with analyses of each food. Generally, the seeds are boiled for a long period and then subjected to fermentation.

Enemies.

The soybean is relatively free from insect injuries. The seeds are not eaten by weevils or other granary insects. Rabbits are the worst enemy of the young plants, and a sufficient area must be planted for both farmer and rabbits. The crop is not attacked by chinch-bugs, and insect enemies of the foliage are not numerous or serious. Garman (Kentucky Experiment Station, Report 1902) lists the following insects as attacking the foliage in Kentucky, but apparently none of them has done serious harm : Grasshoppers, a reddish brown hairy caterpillar (*Spilosoma Virginica*), and grubs of a small beetle (*Odontota* sp.). He also found on the roots of a few plants the bean root-louse (*Tychea phaseoli*). Nematode root-worms (*Heterodera radicicola*) next to rabbits constitute the principal animal enemy of the soybean on certain old sandy fields in the Gulf states.

Among vegetable parasites, the most serious pest of soybeans at Auburn, Alabama, is a sclerotium disease which forms white threads over the stem just below the ground and whitish to brownish tiny, spherical masses clustered around the stem at the surface of the ground. The plant attacked by this disease is killed at any time between early growth and the period of pod formation.

Literature.

Alabama College Experiment Station, Bulletins Nos. 114 and 123; Alabama Canebrake Experiment Station, Bulletin No. 20; Connecticut (Storrs) Experiment Station, Bulletin No. 22; Delaware Experiment Station, Bulletins Nos. 60 and 61; Georgia Experiment Station, Bulletin No. 17; Indiana Experiment Station, Bulletin No. 108; Kansas Experiment Station, Bulletins Nos. 18, 92, 100 and 123; Report 1889; Kentucky Experiment Station, Bulletins Nos. 98 and 125; Report 1902; Louisiana Experiment Station, Bulletin No. 8; Massachusetts Experiment Station, Bulletins Nos. 7 and 18; Michigan Experiment Station, Bulletins Nos. 224 and 227; North Carolina Experiment Station, Bulletin No. 73; South Carolina Experiment Station, Report 1889; Virginia Experiment Station, Bulletin No. 145; United States Department of Agriculture, Farmers' Bulletins Nos. 58 and 121.

SPICE-PRODUCING PLANTS.

By *R. H. True.*

It is somewhat difficult to separate spices from other aromatic flavoring agents, such as anise seed and bay leaves. As a rule, however, spices have a sharp, pungent taste modified by other flavors characteristic of each sort. Most of them are used in a ground state, owing to the necessity of using them in small quantities because of the intensity of the taste-sensations which they impart. Many aromatic products are much milder and can be used in a whole state without the development of too powerful sensations. These more powerful flavoring agents, by common usage known as spices, are here briefly discussed.

Botanical sources.

The common spices are derived from almost as many botanical families as there are spices, and nearly all products here concerned are of tropical origin. The Banana family (*Scitaminaceæ*) includes a series of perennial, herbaceous, rather succulent plants, having strong flavoring properties distributed more or less widely throughout the plant, as ginger, turmeric (*Curcuma*) and cardamons. The Nutmeg family (*Myristicaceæ*) furnishes nutmegs and mace, products derived from the fruit of the nutmeg tree. The Myrtle family (*Myrtaceæ*) supplies two of our most important spices,—cloves and allspice or pimento. The Laurel family (*Lauraceæ*) yields cinnamon bark and cassia buds, products of a number of species of the genus *Cinnamomum.* Black and white pepper are derived from the same plant, *Piper nigrum,* a member of the Pepper family (*Piperaceæ*). Red pepper is not a member of the Pepper family, belonging, rather, to the Potato family (*Solanaceæ*). [See under *Medicinal,* *Condimental and Aromatic Plants.*] Mustard is furnished by members of the Mustard family (*Cruciferæ*), the black mustard being produced, supposedly, by *Brassica nigra*, and the white mustard by *B. alba*.

Parts used, and method of preparation.

The parts of the plants used in making spices seem to be determined by three points: (1) The part must contain the pungent or aromatic principle in large quantity. (2) It must be accompanied by other tastes giving a pleasant combination, or it must at least lack unpleasant constituents. (3) The texture of the product must not be too hard, tough or woody for proper grinding and use. Consequently, in general, spices consist of the tenderer parts of the plants, such as the inner bark, seeds capable of ready grinding, buds, rhizomes and fruits.

Among the spices above mentioned, ginger and its near relative, turmeric, are made from the younger, tender parts of the rhizome. Cinnamon consists of the carefully cleaned and dried inner bark of the smaller branches of the tree. Cloves consists of the unopened flower-buds picked and carefully dried. Cassia buds represent immature fruits enclosed in the calyx of the flower. Allspice consists of the full-sized but immature fruit picked from the pimento tree while still rich in the pungent principles. These in part disappear on ripening.

Black pepper consists of the small round fruits of the pepper vine, plucked when the color has changed from green to red. These hardly ripe berries are more pungent than when fully ripe. White pepper is prepared from this fruit after it has ripened. The berries are soaked in water and the dark pulpy covering bruised off. The remaining part is less aromatic and pungent than the black pepper. Red pepper is obtained by grinding the dry ripe fruit.

Mustard consists of the ground mature seeds, usually of the white sort. Nutmegs are the hard inner kernel of the fruit of the nutmeg tree. The entire fruit, having the size of a small apple, consists of three parts: an outer, fleshy, pulpy covering, beneath which is found the mace, occurring as a partial covering over the kernel or nutmeg proper. All parts are aromatic, but the mace and kernel are especially so.

Geographical sources.

With the exception of a small part of the red pepper and of the mustard, these spices are all imported products.

Red peppers and mustard grown in the United States are to a small extent articles of commerce as spices, the former being grown especially in South Carolina, Louisiana and California, the latter in California. Black and white pepper together form an important agricultural interest in India, Malay peninsula, Ceylon and other points of tropical eastern Asia. Cloves form a very valuable resource in Zanzibar, also in the Molucca islands, and are widely cultivated in other parts of the tropics. Cinnamon products are secured chiefly from Ceylon and Indo-China and other regions in tropical Eastern Asia. Allspice is derived chiefly from the Antilles, Central America, northern South America and Jamaica, whence the name sometimes used, Jamaica pepper. Ginger is widely cultivated the world over in tropical and subtropical regions, Jamaica, India and parts of Africa, including Sierra Leone and Egypt. Turmeric has a similar range but is secured in commerce chiefly from India.

Nutmegs and mace were for a long time grown chiefly in certain islands of the Indian archipelago, but the culture is said to have reached the Antilles and parts of South America. The chief commercial sources continue to lie in tropical eastern Asia.

Importations.

The extent of the commerce of the United States in spices may be judged from the following table, taken from the Customs reports of the United States, giving the imports during the year ended June 30, 1905:

Article	Quantity	Value
	Pounds	
Mustard seed	6,366,706	$189,894.18
Cassia buds	86,564	11,538.00
Cassia and cinnamon vera	4,626,617	406,152.00
Cinnamon and cinnamon chips	621,948	78,425.11
Cloves	4,998,770	535,901.00
Clove stems	163,184	99,216.00
Ginger root (not powdered nor candied)	6,928,187	269,345.96
Mace	328,646	84,788.00
Nutmegs	2,379,118	339,368.00
Pepper, black and white	19,604,253	1,982,456.00
Pimento (allspice)	10,511,568	418,157.00
Capsicum (red pepper or cayenne)	3,509,444.30	259,630.69
Mustard (ground or prepared)	1,079,523.38	286,246.00
Total	61,204,528.68	$4,961,117.94

Literature.

The products serving as spices are also drugs, and works on the latter subject treat of them. See *Medicinal, Condimental and Aromatic Plants.* See also, H. W. Wiley, Foods and their Adulterations, Philadelphia (1907); A. L. Winton, The Microscopy of Vegetable Foods (with collaboration of Dr. Josef Moeller), New York (1906); Henry G. Greenish, An Anatomical Atlas of Vegetable Powders, designed as an aid to microscopic analysis of powdered foods and drugs, London (1904).

SPURRY. *Spergula arvensis*, Linn. *Caryophyllaceæ.* Fig. 816.

By *C. V. Piper.*

Spurry is used for forage and as a green-manure. In the genus are three to eight species, widely distributed throughout the temperate regions of the Old World. Only two species have been cultivated, one of which is the common or sand spurry (*Spergula arvensis*) and the other the giant spurry (*S. maxima*). The latter differs principally in its larger size and by some botanists is considered a mere variety of the former. Because of its large size it is a more valuable species under cultivation. *S. arvensis* is an annual, growing twelve to fifteen inches tall, and producing a mass of stems bearing numerous whorls of narrow, linear leaves. The spurrys are closely related to chickweed.

Fig. 816. Spurry (*Spergula arvensis*).

Spurry is cultivated considerably by dairy farmers, especially on sandy soils, in Holland and to a less extent in Great Britain and Germany. The common spurry occurs throughout this country and is sometimes troublesome as a weed in grain, especially on sandy lands. About Sitka and other places on the Alaskan coast it is the most troublesome weed yet introduced. The seed yield is eight to twelve bushels or more per acre, and it is largely owing to its enormous seed production that it becomes troublesome.

Spurry has been largely tested in this country in an experimental way and great hopes were entertained that it would become an exceedingly valuable crop on the sandy jack-pine lands of Michigan, which, however, has not proved to be the case. In the light of our present knowledge it can not be recommended as a farm crop in any part of the United States.

The value of spurry depends largely on its rapid growth, the crop maturing in six to ten weeks from seeding. It is mostly fed green and is considered an especially good feed for dairy cattle and sheep. It is not infrequently refused by livestock at first, but animals soon become used to it and eat it readily either as hay or as pasture. It has also been used as a green-manure crop on sandy soils, and in exceptional cases has yielded as much as twenty tons of green substance per acre.

It is hardly worth while to experiment with spurry, except as a catch-crop, on other than loose sandy soils. The seed should be sown at the rate of six to eight quarts per acre and lightly covered with a harrow when grown for hay or pasture or for green-manure. About half this quantity of seed is required when the crop is raised for seed. It is most commonly planted in early spring, but in Germany it is also planted in early fall on grain stubble. It is somewhat drought-resistant. A good seed-bed should be prepared, as for clover. Germination takes place quickly, and in two months the crop will have ripened seed. It may be cut for hay at the end of six weeks from sowing, and may be pastured as early as one month from sowing. If the crop is allowed to stand until the seed is fully ripe, enough seed will shatter to ensure a succeeding crop.

Literature.

Bulletin No. 91, Michigan Agricultural Experiment Station ; Bulletin No. 2, Division of Agrostology, United States Department of Agriculture ; Handbook of Experiment Station Work ; Schmidlen-Schuler, Futter and Wiesen Krauter. (Illustrations are given in the first and last mentioned citations.)

SUGAR-BEET. *Beta vulgaris*, Moq. *Chenopodiaceæ*. Figs. 817–825.

By *C. O. Townsend.*

The sugar-beet is a "root crop," grown chiefly for the manufacture of sugar from the roots, and for stock-feeding. It is one of the small-growing varieties of *Beta vulgaris*, with medium tops. The roots are small to medium, usually fusiform, smooth and nearly always yellowish or whitish. Other forms of beet-root are mangels [see article on *Root Crops*], garden beets, chard and ornamental-leaved beets. All of them, probably, are developed from the wild *Beta maritima* of the coasts in Europe.

History.

Both the red and the white beet were known at least three centuries before the Christian era, but it is only within comparatively recent times that any variety of beet has been recognized as a sugar-producing plant. About the middle of the eighteenth century, Marggraff, a member of the Berlin Academy of Sciences, succeeded in separating sugar from a large number of plants, including beets. He found more sugar in the beet than in any other plant which he investigated, and at once advocated the manufacture of sugar from the beet root on a commercial scale. Nothing was done, however, until a half-century later, when Achard, a former pupil of Marggraff, took up the investigation and modified and cheapened the process of extracting the sugar. As a result of Achard's investigations, much interest in producing sugar from beets was awakened throughout the civilized world, so that, at the beginning of the nineteenth century, we find a large number of investigators endeavoring not only to improve the methods of extraction and purification of sugar from beets but also by selection and cultivation to improve the beet itself both in size and in quality. This interest was further stimulated and encouraged by governmental aid, especially in France, and by prizes offered by numerous scientific and industrial societies in various countries, with the result that as early as 1812 beet-root sugar was offered for sale in commercial quantities, about thirteen tons being placed on the market at that time. From this small beginning the beet-sugar industry has advanced in spite of many difficulties, until the beet-sugar factories now in operation throughout the civilized world number more than 1,300, and the total quantity of sugar produced from beet roots aggregates upward of 7,000,000 tons annually.

Beginnings in the United States.—The first attempt to introduce sugar-beets into the United States for sugar-producing purposes was made in 1830, by some persons living near Philadelphia. This and many subsequent attempts to establish the beet-sugar industry in this country failed. A small quantity of sugar, less than one ton, was made from beets at Northampton, Mass., in 1838, but this venture proved unprofitable and was soon abandoned. During the thirty years that followed, several attempts were made to establish beet-sugar factories in different parts of the United States, but none of them proved successful, owing to unfortunate location or to an imperfect knowledge of the methods of sugar-beet-growing and beet-sugar-making. The first successful beet-sugar factory in this country was established at Alvarado, California, in 1869, having been removed to that point after several unsuccessful attempts to establish it elsewhere. This factory has been in operation every year but one since its erection, and may well be considered the pioneer factory of the country.

In the decade that followed the building of the Alvarado factory, four other factories were established, one in each of the following four states: Maine, Massachusetts, New Jersey and Delaware; but none of them survived the struggle through which they were obliged to pass. As late as 1892 only six factories were in operation, by which it appears that the early growth of the industry in this country was slow. Several states tried to encourage the development of the sugar industry by offering bounties on all sugar produced within the state. While, for a time, this plan seemed to stimulate the industry, the difficulties that arose in regard to paying these bounties made it inexpedient to continue them, in most instances. Nevertheless, in spite of the many difficulties that have attended its early development in this country, the beet-sugar industry has steadily progressed since 1890, until, at the present time, sixty-four factories and three slicing stations are in operation. The combined capacity of these factories is, approximately, 50,000 tons of beets daily. They are distributed among sixteen states, as follows: Arizona, 1; California, 8; Colorado, 15; Idaho, 4; Illinois, 1; Kansas, 1; Michigan, 17; Minnesota, 1; Montana, 1; Nebraska, 2; New York, 1; Ohio, 1; Oregon, 1; Utah, 5 factories and three slicing stations; Washington state, 1; Wisconsin, 4.

The possibilities of beet-sugar-making in this country are practically unlimited. The growth of the industry thus far has not kept pace with the increased rate of consumption of sugar per capita. Assuming that the cane-sugar industry will maintain its present output, the United States will not be able to make all the sugar it requires for home consumption until at least 400 beet-sugar factories are operated at full capacity each year.

Culture.

Land.—A special soil, that is, a soil radically different from that needed by other crops, is not required by sugar-beets. Any good land will produce sugar-beets when the climatic conditions are suitable, if the seed-bed is prepared properly and the plants are thinned and otherwise cared for in a timely and workman-like way.

Experience has shown that virgin lands, even of good quality, are not generally satisfactory for sugar-beets; hence it is advisable to get the land in good tilth by growing other crops for two or more seasons before planting to sugar-beets. Clay loam has been found to be one of the most satisfactory types of soil. A sandy loam will frequently give equally good returns, but if there is too much sand, so that the soil approaches lightness, the beets are likely to be low in sugar content. Furthermore, sandy soil frequently loses its moisture too rapidly, thus allowing the beets to wilt and become retarded in growth, or even to die if the dry conditions continue too long, especially in those sections where the soil moisture is dependent on rainfall. Another serious objection that has been found to sandy soils in localities where strong winds prevail, is the likelihood of the young plants being covered with sand, causing the loss of many, so that the stand is seriously reduced.

In some of the sugar-beet areas of the West and Southwest an adobe soil is common, and when properly handled this gives satisfactory results both in regard to the quality and the quantity of beets. An adobe soil can not be plowed when it is very dry; on the other hand, if plowed when too wet it bakes and becomes almost unmanageable. Another difficulty lies in its readiness to form a hard crust after the surface has been moistened by rain or irrigation. As these conditions for crust-formation frequently prevail in the spring soon after planting, the seedlings that form under the crust are unable to get through to the light without assistance. The crust is easily broken without serious injury to the young plants by the use of a light drag harrow or other suitable implement. Even after the plants are up they are sometimes "bound off" by the formation of a crust that prevents growth at the line of contact with the surface.

Muck soils are usually unsatisfactory. They frequently produce a large tonnage but the quality of the beets is usually poor, although some exceptions to this statement have been recorded.

One of the least satisfactory soils is the gravelly type, probably because of its inability to retain moisture. A soil that is of considerable importance in some of the sugar-beet areas of the West is the alkali land. While this crop is capable of making satisfactory growth in soils too strongly alkaline for many other farm products, there are thousands of acres of otherwise good soil where the percentage of alkali is too strong even for existing strains of beets. Much has been done toward reclaiming this land by washing out large quantities of the alkali. Efforts are also being made to develop a strain of sugar-beets that shall be so resistant to excessive quantities of alkali that they will thrive in many areas that are now useless for agricultural purposes.

Climate.—In regard to climate, two points have been found to be of vital importance to the growth and quality of sugar-beets,—temperature and moisture. In general, high temperatures are detrimental to the best development of the sugar content of the beet. It has been observed that an average temperature of about 70° Fahr. during the growing months has a marked influence in producing satisfactory sugar content of the beet. Abnormally cold weather at any time during the growing season has a tendency to retard the development of the beets. The danger from this source decreases as beets develop, since they become more resistant to cold as the season advances. While a certain amount of moisture is necessary to enable the seeds to germinate, an excess of moisture will often cause the seeds to rot or will aid in bringing about a damping-off of the seedlings. When sugar-beets become well established, they will stand more moisture than most other farm vegetation crops, but, like other crops, they do best in well-drained soil.

Excessive moisture accompanied by growing temperature at or near the close of the growing season when the beets are ripe, or nearly ripe, will often cause a renewed growth of foliage which has a tendency to reduce the sugar content of the beets. This reduction varies from a fraction of one per cent up to two per cent or more. If circumstances are such that the beets can be left undisturbed after normal conditions are restored, the sugar content will be gradually increased again.

The seed-bed.—The seed-bed for sugar-beets, when properly prepared, consists of a deep, well-drained but moist, firmly-packed surface soil covered with a layer of well-pulverized but looser soil, which will admit the air freely around the roots of the plants and which at the same time acts as a blanket to prevent too rapid evaporation of moisture from the lower part of the seed-bed. In order to produce a seed-bed that will fulfil the required conditions, drainage should receive first attention. The ground should therefore be broken to a good depth, eight to eighteen inches, depending on the nature of the soil. As with other crops, not much raw soil should be turned up at one time, but the seed-bed should be brought gradually to the proper depth in order to get the best results. The subsoil plow, though not so commonly used as formerly in preparing ground for sugar-beet seed, would be advantageous in many instances where greater depth is desired. Fall-plowing is generally recommended and frequently practiced by sugar-beet-growers, but the time of plowing must be governed largely by soil and climatic conditions. In many sugar-beet sections the ground is too dry in the fall to be plowed to advantage. Having broken the ground under the best possible conditions, the most important point is to conserve the moisture; to this end the ground should be rolled or harrowed immediately after plowing and no crust allowed to form on the surface. Previous to planting, the ground should be worked thoroughly with such implements as will pack the seed-bed below and leave a loose layer of soil on the surface. In most instances, a float and a harrow properly adjusted as to depth will produce the desired result. A thorough preparation of the seed-bed has the secondary advantage of materially lessening the labor in the subsequent care of the beets, by destroying many weeds that must otherwise be removed by hand.

Fertilizers.—Three kinds of fertilizer are in common use for sugar-beets: green fertilizers, stable manures and chemical or so-called commercial fertilizers. The green fertilizer most commonly used with sugar-beets is alfalfa. It is becoming more and more common to use alfalfa in a system of rotation with sugar-beets, plowing the alfalfa under at the end of three or more seasons. A crop of alfalfa may or may not be plowed under, depending on the requirement of the soil for humus. The roots of the alfalfa necessarily furnish more or less humus and should be broken up long enough before beet-seed-planting to allow them to rot, otherwise they will be very troublesome in the cultivation of the young beets. Usually alfalfa sod plowed in the fall is in proper condition for beet seed the following spring, but with some growers it is customary to use another crop in the rotation between the alfalfa and beets. For this purpose potatoes or one of the small grains are generally used. Other green crops are sometimes used in rotation with beets, of which clover, rye or rape are employed when a supply of humus is desired as quickly as possible.

So far as any exact data have been secured, stable manures give better results with sugar-beets than do commercial fertilizers. While it is true that different kinds of stable manures produce different results with sugar-beets, the same kind of manure will give even more variable results, depending on the time of its application and the conditions under which it was kept previous to using. A good crop has generally been secured by applying well-rotted manure just before plowing, and incorporating it thoroughly with the soil.

In regard to commercial fertilizers, the best results have generally followed the use of a complete fertilizer, although when a certain element is known to be present in the soil in sufficient quantity and in an available form, nothing seems to be gained by applying that particular element in the form of a chemical.

The time of applying the commercial fertilizer must be governed by its solubility. If it is ground bone, or other material that dissolves with difficulty, the best results are secured by applying it long enough before the beets are up to allow the material to begin to break down and become soluble. On the other hand, if the material is easily soluble, as nitrate of soda, the results are more satisfactory if several applications are made at intervals of several weeks. Nitrate of soda has a tendency to prolong the growth of the beets and therefore should not be used very late in the season, as in such case the beets would fail to ripen properly.

The seed.—Beet seeds are produced from flowers that occur, for the most part, in groups of two to seven, giving rise to seed-balls which usually contain as many germs as there were flowers in the cluster. Occasionally a flower stands by itself and develops a single seed ; in other instances, one or more of the flowers, either singly or in groups, fails to produce seed, thus reducing the number of seeds, or the number of germs, in the seed-ball. The flowers are five-parted ; that is, there are five stamens and five parts to the corolla. The petals are wanting and the pistil is three-parted. Fig. 817 shows the construction of the beet flower as seen in longitudinal section. The sepals persist and form a part of the seed-coat, giving to the single-germ seeds the form of a five-pointed star. The individual seeds in the seed-balls are made up in the same way, but the star-shape is not so apparent when the seeds are welded together in the form of balls. Seed plants are shown in Figs. 818, 819.

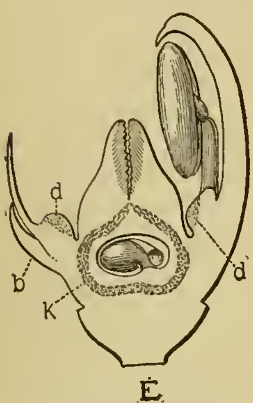

Fig. 817. Longitudinal (diagrammatic) section of beet flower. *d*, glands; *b*, bract; *k*, tissue surrounding undeveloped seed.

Beet plants are biennial, that is, they produce seed the second season. In those countries where the beet is indigenous, the winters are warm enough so that the plants will live over from the first to the second season ; but in most of our commercial sugar-beet sections it is necessary to protect them from frost during the winter. This is usually done by placing them in some form of a silo or pit. One of the common and most satisfactory methods of pitting consists in piling the beets in the form of a cone or a pyramid on the surface of the ground, having selected for the purpose a well-drained spot. The piles are then covered with straw, which, in turn, is covered with earth; as the temperature falls with the advance of winter, more earth is added to keep the frost from reaching the beets. (Fig. 820.) As soon as the danger of killing frosts is over in the spring, the beets are taken from the silo, tested for sugar if they were not tested before pitting, and, if up to the standard or above, are planted for seed production; but if below the standard, they are discarded.

The sugar test is considered necessary in order to keep the descendants of the seed of the parent beets from deteriorating in quality for successful sugar-making. Fifteen per cent of sugar is usually taken as the standard, although many of the beets planted for seed test much higher. Many other factors enter in to influence the quality, so that from roots possessing a given sugar content there are often secured beets much richer as well as much poorer than the original seed. Beets possessing a minimum amount of certain salts are also desired for seed, since such salts taken up by the beets are dissolved with the sugar and prevent a part of the sugar from crystallizing in the process of sugar-making. This quality, like the sugar content, is influenced by other factors than the quality of the parent.

Having selected the beets that are up to the standard in quality, they are planted in the early spring in rows three feet apart, the beets standing two to three feet apart in the row. Each acre thus contains approximately 5,000 to 7,000 beets.

The seed-stalks vary within wide limits both in regard to number and size. Some beets produce but a single stalk, others will send up several dozen. Sometimes the stalks are large and upright, while others are small and spreading. (Figs. 818, 819.) The flowers usually open in June and the seed is ripe in August, when the stalks are cut off near the ground and left to cure. As soon as it is thoroughly dry, the seed is removed by some convenient method ; frequently, an ordinary threshing machine is used. It is then put through the cleaner, which removes all leaves, stems and other foreign matter, and is then sacked for shipment. The average seed yield per acre varies from season to season, but is usually 1,200 to 1,500 pounds.

The sixty-four factories now in operation in the United States require for the use of their growers more than 5,000,000 pounds of sugar-beet seed annually. Less than 2 per cent of this amount is produced in this country at present. However, the possibility of growing and maturing sugar-beet seed in several of the western states has been


Fig. 818. Beet seed-stalk, with flowers growing singly and in clusters.

demonstrated beyond question, and it is undoubtedly only a matter of time when all beet seed required by American growers will be produced on American soil.

Planting.—After the seed-bed has been thoroughly prepared in the way already indicated, the

Fig. 819. Small, spreading beet seed-stalks (about five feet across).

seed is planted, usually in solid rows, by means of a four-row planter. Occasionally a hill dropper is used, but this has not yet come into general use, since the growers are afraid that this method of planting will injure the chances for a good stand. For the solid-row method a drill planting four rows at a time is commonly used. The space between the rows varies from fourteen to twenty-eight inches, eighteen or twenty inches being the most common. The distance between the rows is determined largely by the quality and condition of the soil, especially as regards moisture; and by the method of cultivation that is to be employed.

Fifteen to twenty pounds of seed per acre is recommended in order to insure a good stand,—a condition on which the tonnage and the sugar per acre depend in a large measure. A much smaller quantity of seed is required with the hill dropper. The seed is planted just deep enough so that it comes into contact with the moist earth and is covered with a thin layer of fine soil one-half to one and one-half inches deep. Under favorable conditions of moisture and temperature, the plants are up in four to ten days. Inexperienced growers should be cautioned against planting the seed too deep, since the inability of the seedlings to push their way through a too thick layer of soil may result in a very unfavorable stand. In the irrigated sections it is not uncommon to irrigate the plants up, but in those areas where moisture depends on rainfall it is necessary to wait until the soil is sufficiently moist before planting.

Blocking and thinning.—As soon as the plants are large enough so they can be handled, i. e., when they have about four leaves, they are blocked and thinned. Blocking consists in cutting the seedling beets out of the solid row, leaving small tufts or bunches of beets at intervals of eight or ten inches. This operation is usually performed by means of a hand hoe, although blocking machines operated by horse-power are coming into use in some localities.

Having blocked the beets, the next process, called thinning, consists in pulling from these remaining clumps or tufts all the beets but one, thus giving the remaining beet every possible chance to develop. Thinning is one of the most laborious and at the same time one of the most important operations in growing sugar-beets. If the thinning is not done properly, or if it is delayed too long, the yield per acre is greatly reduced. The closeness of the seedling beets in the clumps that are left after blocking makes it necessary to do the thinning by hand. The structure of the seed-balls renders it impossible to plant the seeds far enough apart in the row to get one plant in a place. As already pointed out, only a few of the seeds are separate, most of them being produced in balls of two to seven. The Department of Agriculture has undertaken to produce a plant that will yield only single-germ beet seed. If such seed can be produced in quantity sufficient for commercial use, hand-thinning may be abandoned, since the seeds can then be planted close enough together to insure a good stand and at the same time far enough apart in the row so that the resulting plants can be cut out with a hoe or other implement.

Hoeing and cultivation.—Sugar-beets receive two to four hoeings in the season. The first hoeing is frequently given at the time of thinning; but often the beets, more or less disturbed by the thinning, are allowed to reëstablish themselves first. Hoeing serves the twofold purpose of destroying the weeds and of keeping the soil and the plants in condition to conserve moisture, hence indirectly inducing the plants to feed or grow. It is a common saying among the German beet-growers that the sugar is hoed into the beet.

Fig. 820. Pile of seed beets, as seen when opened in the spring.

Cultivating is begun as soon as the beets are large enough so that the rows can be followed, and is repeated at longer or shorter intervals until the tops cover the ground. Owing to the narrowness of the rows as compared with most field crops, specially constructed cultivators are required. Some are made so that they will cultivate a single row at a time, but those most commonly in use will work two rows at a time. They are usually provided with two sets of teeth, namely, "weeders" and "duck feet." The weeders are thin blades of metal so adjusted that they move along just below the surface of the ground and destroy the weeds over the entire space between the rows. The duck feet are more or less triangular in shape and can be set so that they will work to any desired depth. Some growers hold that deep cultivation is necessary for the production of long, well-shaped beets, but shallow cultivation is generally practiced. The cultivation of beets, like hoeing, is twofold in its purpose—to accomplish the destruction of weeds and the conservation of moisture. When the tops become too large or for other reasons the hoeing and cultivating ceases, the crop is said to be "laid by.

Irrigation.—Very few field crops are able to adjust themselves to the extremes of moisture supply in the soil more readily than sugar-beets after they have become well established. However, a certain amount of moisture is necessary, not only for the germination of the seed, but also for the subsequent development of the beets. There is, therefore, no question of greater importance to the beet-growers of the semi-arid sections than that of water rights and the proper use of irrigating waters. Irrigation by flooding, that is, allowing the water to flow over the entire surface of the field, is not usually practiced in sugar-beet-growing. The furrow method of irrigation is employed almost entirely, in which case small ditches or furrows are made between each two rows, or between alternate rows, extending across the field from the higher to the lower side. The water is then turned on and allowed to flow until the ground around the beets is well supplied with moisture. In case only alternate rows are furrowed at the first irrigation, furrows are made at the next irrigation between the rows not previously furrowed, so that the rows are watered first on one side and then on the other.

The number of irrigations necessary to bring a crop through successfully depends on soil and climatic conditions and on methods of cultivation. Usually, two to five irrigations are necessary, but some areas are so situated with respect to the surrounding country that the crops are watered naturally from below, and no water in any form need be applied to the surface. This may be called natural subirrigation. Such sections are very limited, however, as compared with the vast areas of land to the surface of which water must be applied, either in the form of rain or of surface irrigation, in order to produce satisfactory crops.

Harvesting (Fig. 821).—The harvesting of beets consists of four distinct operations,—lifting, pulling, topping and hauling. In the first operation the beets are simply loosened in the ground. In performing this work, two distinct types of implements are in common use. One of these is a side plow, which is usually operated with three horses, and is so held that it runs along one side of the row to be loosened and close enough to the roots so that each beet is disturbed as it progresses. The most serious objection to this lifter is that it frequently breaks the beets, which are very brittle at harvest time, and leaves the lower part in the ground, thus causing considerable loss in tonnage.

The other form of lifter is a double-pointed plow with the points so adjusted that one passes on either side of the row. Each point extends backward in the form of a shoe. These shoes approach each other by degrees without meeting, and are gradually elevated from the toe toward the heel. The construction and arrangement of the parts of this implement are such that, as it progresses, each beet in turn is caught between the shoes and lifted several inches from its original position. In either case the beets are loosened so that they are easily pulled. The pulling is usually done by hand, in which case the beets are picked up and thrown in piles, or in rows, depending on the method later to be employed in topping. The most common method is to throw the beets in piles at convenient intervals. With some growers it is the practice to throw them so that all the tops lie in the same direction ; this practice takes no more time in pulling and greatly facilitates the work of topping.

Topping is also a hand operation and is usually performed by means of a straight, heavy knife, which should be kept sharp. It consists in removing the leaves and crown at the line of the lowest leaf scar. The proportion of the beet thus to be dis-

Fig. 821. Sugar-beets topped and ready for the factory.

carded depends on the habit of growth of the plant. Beets with long crowns should not be selected for seed, since this is an undesirable quality to propagate. The reason for removing the crown is that this part contains so much mineral matter in comparison with the sugar, that it has been found advisable not to use it in sugar-making. The mineral matter prevents the sugar crystallizing and often more sugar would be lost than gained by using the crown. When the beets are topped, they are thrown into piles where the ground has been previously freed from tops and other refuse matter, so that they can be forked into wagons ready for the factory. Numerous attempts have been made to construct a machine to be operated by horse-power, which shall lift, pull and top the beets, but, while success has been achieved in some instances, such machines have not come into general use.

Hauling the beets to the factory is usually done by wagon if the fields are within a few miles of the factory. If the distance is too great, they are loaded on the cars at the nearest station and transported by rail. In either case they are first forked on the wagon, and then unloaded in the beet sheds or into cars. Most shipping stations are provided with dumps, so that the wagons are unloaded by machinery directly into the cars. (Fig 822.) This method avoids the necessity of forking the beets by hand from the wagon into the cars, but is open to the objection that all the dirt, more or less of which clings to the beets when pulled, goes into the cars

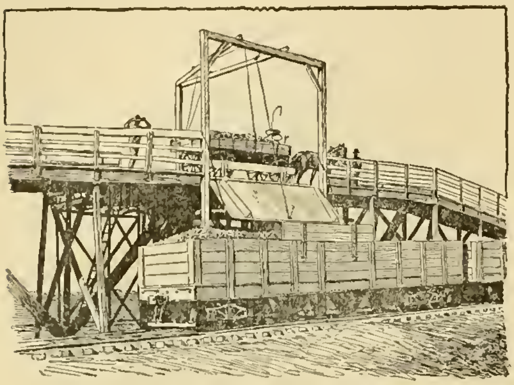

Fig. 822. Use of wagon-dump in unloading sugar-beets.

and is hauled into the beet sheds. If the cars are dumped at the sheds, as is frequently the case, the dirt goes with the beets into the bins.

If the harvest progresses more rapidly than the factory is able to handle the beets, it frequently becomes necessary to pit them temporarily in the field. These pits differ somewhat from those used for seed beets. In these field pits, the beets are dumped in long piles about three feet high and provided with some light covering to keep out the frost. As soon as the beets are needed, they are reloaded and taken to the factory.

Causes of injury to the crop.

Hail.—Factory beets and seed beets are frequently damaged by severe hail-storms. Fortunately these storms are usually local, so that comparatively few fields are seriously injured in a single season. The storms occur most frequently in the early part of the season, when the beets are small and tender. It sometimes happens that a field of beets will have its foliage entirely destroyed. Since nothing can be done to prevent the storms, every effort is made to enable the beets to produce new foliage, and it seldom happens that the beets themselves are destroyed, although their growth is retarded to the detriment of the harvest.

With seed beets the damage is considerable if the hail-storm occurs after the seed-stalks have begun to form, since it may either break down the seed-stalks or cut off the flowers or seeds, depending on the time the storm occurs and on its severity.

Wind.—In some sugar-beet sections, strong winds prevail. These are not injurious except in certain localities where the soil is light. In such instances, the young beets are sometimes covered with sand and smothered, or their growth greatly retarded. The real losses from this source have been slight but sufficient to emphasize the importance of avoiding light soils for sugar-beet production, especially in those sections where high winds usually prevail in the early part of the growing season when the beets are small and easily covered with shifting sand.

Rain.—Few crops can withstand excessive rains with less injury than sugar-beets, especially if heavy rains do not occur until after the beets are well established. The greatest damage is done when such rains occur soon after planting, and either the seed or the seedling beets are actually washed out of the ground. Excessive rains falling on improperly drained fields must necessarily be injurious, since under such conditions the roots cannot receive the proper amount of air. The only remedy for this evil is proper drainage. Warm rains sometimes occur when the beets are ripe. This condition frequently causes a new growth of foliage and a consequent reduction of the sugar content. If it is impossible to harvest the beets before such rains occur, it is often advisable to let the beets remain in the ground until the sugar content is again restored to its maximum. The effect of rainfall on adobe soil, with the remedy therefor, has already been mentioned.

Insects.—According to Bulletin No. 43, Division of Entomology, United States Department of Agriculture (entitled A Brief Account of the Principal Insect Enemies of the Sugar-beet, by F. H. Chittenden), about one hundred and fifty insects feed more or less exclusively on sugar-beets, of which perhaps one-third are noticeably destructive. A more or less complete account of these pests, together with the means of combating them, will be found in Bulletins Nos. 19, 23, 29, 33, 40 and 43 of the Bureau of Entomology, United States Department of Agriculture.

Diseases.—There are very many specific diseases of the sugar-beet; some of them are due to bacteria, some to fungi, some to physiological or other causes. Only two of the diseases have proved especially serious in this country up to this time, namely, the leaf-spot, due to the fungus *Cercospora beticola*, and the western blight or curly top, the cause of which is not known. The leaf-spot may be controlled by thorough spraying with Bordeaux mixture. Rotation is to be advised. The most significant fact in regard to the curly top is that it seldom occurs in two successive seasons in the same locality or in the same field.

Literature.

Some of the important treatises on sugar-beets follow: Hermann Briem, Die Entwicklungsgeschichte der Rübensamenzucht (1889); same, Der praktische Rübenbau (1895); C. J. Eisbein, Der Zuckerrübenbau (1894); J. Fühling, Der praktische Rübenbauer (1877); Herzog, Monographie der Zuckerrübe (1899); Fr. Knauer, Ueber Rübensamenzucht (1857); W. Krüger, Die Entwicklungsgeschichte, Werthbestimmung, und Zucht des Rübensamens (1884); E. O. von Lippman, Die Entwicklung Der Deutschen Zuckerindustrie von 1850 bis 1900 (1900); G. Marek, Die Ergebnisse der

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The Manufacture of Beet-Sugar. Figs. 823–825.

By *G. M. Chamberlin, Jr.*

A century has now passed since the first sugar was made from the sugar-beet, and the development of the industry has been of such great magnitude in the past twenty-five years that, with the steady perfection of the various parts of the machinery necessary in an up-to-date sugar mill, it has become possible to produce a high grade of sugar at a very reasonable price.

Details of beet-sugar-making.

The crop.—The seeds of the sugar-beets are planted in the spring in order that the beets will mature before the frost gets into the ground. The date of the campaign does not always depend on the maturity of the beet, but rather on the capacity of the factory and the saccharine quality of the beet, which is determined by chemical tests.

Storage sheds. — Having reached the proper period in their growth, the beets are brought to the storage sheds of the factory either in cars or wagons, and unloaded by hand or with the aid of automatic dumps into the various bins especially constructed for them until they can be brought into the factory to be worked into sugar. These sheds are built like a "V," with a flume extending the entire length of each, in order that the beets may be carried into the factory with the aid of water. This prevents the beets being bruised and at the same time assists in cleaning them of adhering dirt. The water for this purpose comes from the condensers of the evaporators and vacuum pans, as well as from the overflow of the main water-supply tank.

Stone-catchers.—As the beets enter the factory they pass over the large stone-catchers, so built as to remove the stones and dirt that come from the sheds with the beets, and which, if allowed to pass on, would cause much trouble as well as material loss to the knives in the slicing machine. Not only would the knives be injured, but the beets would be torn instead of being cut into good, clean strips, which are necessary for the perfect working of the battery in the process of the extraction of the sugar, as well as in the treatment of the juices at the various stations in the mill.

The washer. — Passing over the stone-catcher, the beets are carried by the aid of an Archimedean screw, or a beet wheel, up into the mechanical washer, where they are entirely freed of all remaining dirt. This washer consists of a large tank in which arm-agitators revolve. As the beets have had most of their impurities removed in the hydraulic transportation from the sheds, the agitation in the washer renders excellent service in removing the particles that still adhere.

Slicing.—During the entire operation of washing, fresh water is being run in at one end and the dirty water out at the other. The beets enter the washer at one end and are thrown on an endless carrier at the other end and carried to the bucket elevator, which elevates them to the slicer several floors above. Here they are cut into strips, or slices as they are called, and emptied into the various cells of the diffusion battery for the extraction of the sugar which they contain.

The slicer.—In order that the greatest amount of surface may be exposed to the action of the water in the extraction of the sugar, it is necessary to cut the beets into long, slender strips, or cossettes, by the aid of knives made especially for this purpose. These knives vary in shape as regards their cutting surfaces, but all types tend to secure one result, that of producing a long slender strip, cut lengthwise of the beet, and having a smooth, uniform surface. To secure this, a special apparatus is used which generally consists of a cylinder, or hopper, at the bottom of which is a circular disk with openings for knife attachments, and having a rotary motion. This is the slicer. The beets are fed into the hopper from the automatic scales, if these are used, otherwise directly from the beet-elevator, and, falling on the knives, are cut into cossettes. These drop either from a spout into the cells of the battery direct or else on a moving belt conveyor, as in the case of a longitudinal battery, and from this are fed into the various cells as is necessary.

Diffusion battery.—The diffusion battery consists of a series of ten to fourteen iron tanks, or cells, known as diffusors, which are arranged in a circle or in a straight line. Each diffusor is connected at the bottom by means of a pipe with the top of the next in the series, so that a continual flow of water passes through the mass of sliced beets as long as they remain in the cell of the battery. Their shape is that of a round tank set on end, which permits of the extraction of the sugar from the cossettes regardless of how they lie in the diffusors, and at the same time does not retard the circulation of the juice. There are openings at the top for filling the cells and at the bottom for emptying after the sugar has been extracted, tight-fitting doors being used in all cases to close these openings. Near the bottom of each cell and above the opening of the pipe there is a screen of heavy sheet iron for the purpose of preventing the cossettes entering the juice as it leaves the diffusor, thus resulting in a stoppage of the pipe.

The principle of diffusion is based on the theory of osmosis, and, as sugar belongs to the category of crystaloids, the advantage of the diffusion process over all others for the extraction of the sugar from the sugar-beet will be easily understood. Owing to the fact that a certain number of the cells in the beet become either broken or cut in the course of their passage through the slicer, thus allowing the contents of the cells other than sugar to pass into the juice, which would otherwise be absent, it will be seen why it is necessary to watch the knives and to take such precautions as will tend to keep them in the finest possible condition. Keyr estimates that about 6.41 per cent of all the cells of the beets are either crushed or torn in the slicing.

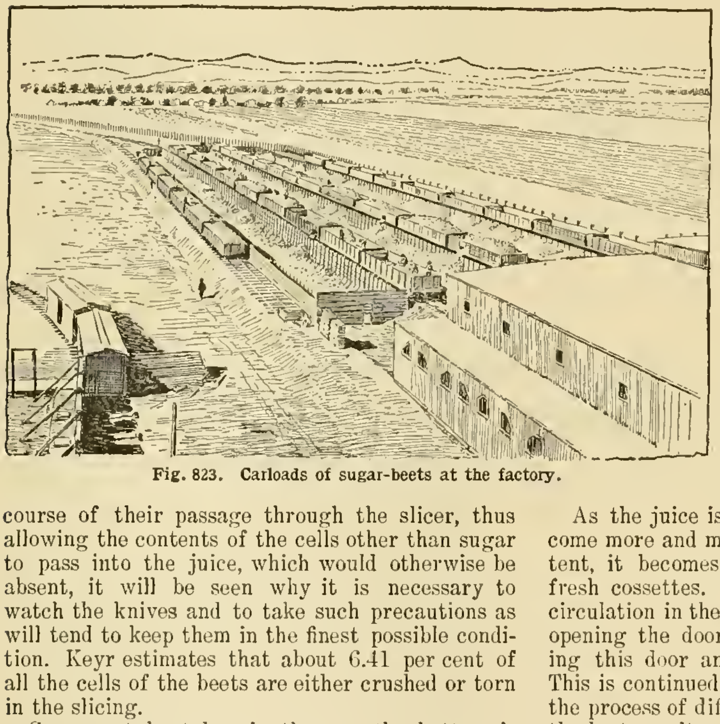

Fig. 823. Carloads of sugar-beets at the factory.

Care must be taken in the way the battery is worked, for, should the water remain too long in contact with the tissue of the beet, or reach too high a temperature, other impurities than those which pass into the juice from the broken cells would be absorbed by the water and produce trouble in the further treatment of the juice. The cell walls of the cossettes contain organic salts of lime and potash, and pectic compounds which become dissolved under the influence of too high temperature. As an example: Asparagine and glutamin, by heating in the presence of an alkali, are converted into apparetic and glutaminic acids, which, in the combination with alkalis, remain as salts in the juice; by the above heating, ammonia is constantly given off, which tends to show a higher percentage of alkalinity than is really present. This interferes with the work at the carbonatation stations. The best working temperature of the battery is between 75° and 80° Centigrade, as above 80° there is a tendency for the pectine and the pectates to be absorbed from the cellulose of the beet, and this, as well as the high alkalinity at the carbonatation stations, tends to make the presses slimy and hard to wash. Frozen beets take an entirely different temperature from those that are fresh from the field. The size of the slices as well as their thickness has an influence on the circulation of the water through the cells if the temperature is not right.

One of the most important stations in the sugar-house is the diffusion battery, and when that is in good working order, with everything moving smoothly, it can safely be said that the entire house is working all right.

Starting the operations. — In starting the factory at the beginning of the season, it is necessary to fill eight or nine cells of the battery before making the first draw of juice that is to be sent to the first carbonatation station for treatment. When the proper number of diffusors have been filled, a certain number of hectoliters of the juice, containing sugar extracted from the beets, are measured off and sent to the first carbonatation station, for the purpose of clarifying and thus rendering the juice in a condition more easily to be treated for the process of boiling, when the sugar is secured by crystallization from a highly concentrated syrup.

As the juice is drawn off and the cossettes become more and more exhausted of their sugar content, it becomes necessary to replace them with fresh cossettes. This is done by shutting off the circulation in the cell to be refilled, emptying it by opening the door at the bottom of the cell, closing this door and refilling as at the beginning. This is continued at regular intervals in order that the process of diffusion may be continuous and that the best results may be secured. The beets remain in contact with the water at the temperature of 70° to 80° for one hour, when nearly the entire amount of the sugar has been extracted. The extracted cossettes are carried to the pulp pile and can be used to good advantage in the feeding of stock.

First carbonatation.—The first carbonatation station consists of several tanks into which the juice is pumped and milk of lime added, having the density of 18° to 22° Baumé, the amount being figured at the rate of 3 per cent of dry lime to each ton of beets, and in terms of liters of juice. The addition of the lime to the diffusion juice is the most important operation in the sugar mill, and experience has shown that unless it is added and the juice then treated according to established rules, the final yield of sugar is affected, both as to color and amount.

The effect of the lime on the raw juice is both mechanical and chemical. Mechanically, it clears the juice by causing those particles held in suspension to settle with the precipitate. In the chemical action, the lime has the power to decompose the non-sugars, neutralizing the free acids and acid salts, forming insoluble salts with the oxalic and phosphoric acids present, as well as many other compounds with the organic substances present. By the carrying down of the impurities with the lime a large number of bacteria and ferments are separated and sink to the bottom of the tank on standing, leaving the juice clear, of a light amber color and perfectly sterilized, thus reducing the tendency of sugar inversion.

The lime.—The lime required for the purification of the juice is secured from the purest grade of limestone. This stone is burned in specially constructed kilns in the presence of coke. The limestone is composed of a lime-carbonate which is broken up into lime and the carbonic acid gas which is used in the treatment of the juice in the first and second carbonatation. Impure limestone often causes much trouble.

While the operation of running a lime kiln is simple in itself, there are few persons who know how to do it to produce the best results, and it is important to dwell a little on that point. In loading the kiln, start at the bottom, using considerable oily waste, some shavings, small sticks, and the like,—enough in one's judgment to start a good fire. Then work up for some distance with gradually larger pieces of wood, until just below the damper holes proper. Beginning at that point, start loading again with fine material, as below, arching over the space in front of the holes, filling with more oily waste directly in front of the holes. Then continue, as below, gradually putting in heavier stuff and working in wood to a distance of six or seven feet above the damper holes. Then loading about one foot of pure coke on top. Above that, for a distance of five to seven feet, loading with coke and rock, using 20 per cent coke to rock. Now fill the kiln about three-fourths full with 105 per cent coke to rock.

In touching off the kiln, always light the fires at the damper holes, thus beginning at once to burn the coke and the rock, and continue burning as the wood burns downward. This has a twofold advantage, as, should the fire go out for any reason, the kiln can be lit again at the bottom. Never use the gas-pump in starting the kiln, if it is possible to avoid it, as the tar coming over causes a great deal of trouble in the pump; but use the draft pipe in the top of the kiln for giving the draft until most of the wood has been burned, when the pump can be put on to produce a forced draft.

Always draw enough and only enough lime to last the factory until about the time of the next draw. In this way the lime will be drawn cold, which is much to be preferred to the drawing of the hot lime, as it will then be in the form of cold ashes and be burned thoroughly. It is only in extraordinary cases that more than 10 per cent coke to rock is necessary, and more than that amount is dangerous, as it often culminates in fuzing the rock too much, and a consequent bridging of the kiln.

About half an hour before charging the kiln, the kiln-boss should look in at the peek holes above the top of the rock, and see whether the fire is coming through. If so, half an hour afterward would be the time for charging the kiln; but, should the fire not have broken through, the time for charging should be delayed until the fire shows. On the contrary, should the top of the rock be red hot, the kiln should be charged at once. If, in looking into the kiln, one side be found hot and the other dark, the lower charging doors on the dark side should be opened, while the others should be closed, thus forcing the draft up through the dark side and producing an even fire.

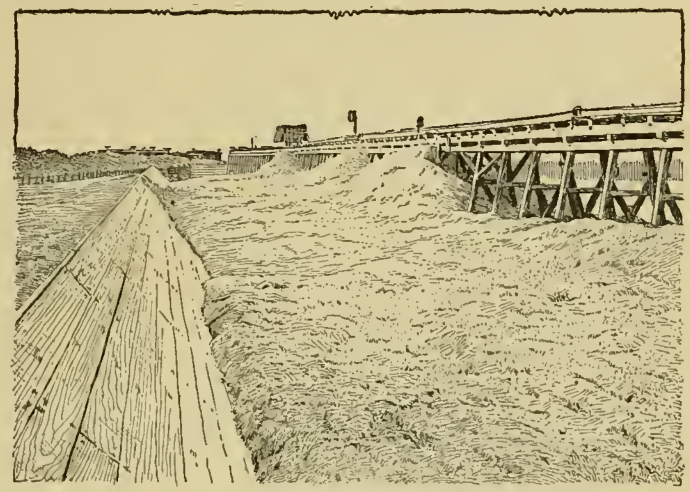
Fig. 824. Sugar-beet pulp at sugar factory.

The kiln should always be charged and run in conjunction with the gas analysis. Should the gas by analysis show a large percentage of oxygen, the pumps should be allowed to slow down; should the analysis show a large quantity of carbonic oxid, the pumps should be speeded up. In drawing in this way,—that is, drawing simply enough lime to keep the house running,—one will find that the amount of gas will always take care of itself.

A rock having over one per cent of magnesium should be carefully watched, as it causes great trouble in the juices; and a rock containing a large percentage of silica should be avoided, as it fluxes and helps to bridge in the kiln. A rock of 96 per cent carbonates, as a rule, is considered excellent.

At all times it is very desirable to load the kiln with nothing but uniform sizes of rock. No rock smaller than one-half the size of a man's fist should be put into the kiln, as the small pieces will tend to stop the draft; and no pieces much larger than the size of the two fists should be used, as the very large rocks will not be burned through entirely. The top of the rock should always be four to six

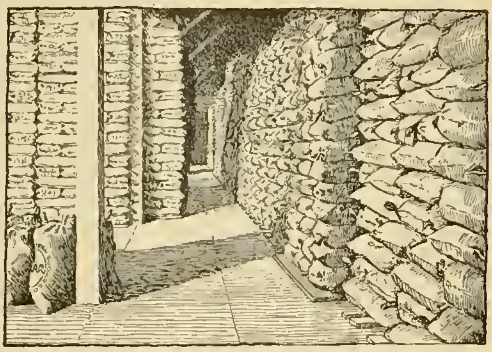
Fig. 825. Sacks of beet-sugar ready for shipment.

feet below the gas pipe in the kiln. The coke should be of open grain, and at the same time be fairly compact, for then it will hold its heat during the required time to give the best results. The coke should be free from sulfur, as there is a possibillty of sulfuretted hydrogen being generated, which, when carried into the carbonatation tanks, might do considerable harm.

The importance of care in addition of lime to the juices cannot be overestimated, and, if the liming is not done according to the various rules that have been applied only after years of experience, the succeeding operations will prove failures and the final product will be of little value as a marketable commodity. The changes which take place during the carbonatation are both mechanical and chemical. In the chemical nature, the lime forms compounds with the sugar and the impurities present in the juice. Some of these compounds are of complex combination, while others are very simple in their composition.

The gas.—The gas which is produced in the kiln and pumped into the tanks of this first carbonatation station has a great affinity for the lime, breaking up the compound it forms with the sugar and forming an insoluble lime carbonate, thus setting the sugar free and leaving it in solution in the juice. The gas is pumped into the tanks through pipes which extend to the bottom of the tanks and are there divided into three sections. From each of these sections it passes through the perforations in the pipes and bubbles upward through the juice. The moment the gas comes in contact with the juice it causes a change to take place; there is a thickening of the juice in proportion to the degree of concentration and the amount of sugar present. During this period there is no precipitation, but rather a gelatinous consistency, which decreases with the length of time that the juice is acted on by the gas. At the beginning of the carbonatation there is extreme frothing, which gradually diminishes and finally ceases altogether. At this point the precipitate forms, settling rapidly and easily, and is readily filtered. The juice is then ready for filtration, and is pumped through the filter presses, leaving behind the heavy deposit, while the translucent yellowish liquid passes on into the second carbonatation tanks.

The filter.—The filter presses consist of a series of iron frames, every alternate one of which is hollow. The solid frames are covered with heavy duck cloth, which allows the juice to pass through but prevents the passage of the heavy deposit formed in the tanks. This deposit is called lime-cake and is an excellent material for fertilizing the farm lands. After the presses have been filled with lime-cake, they are washed, emptied of the cake and made ready for filtering more juice. The presses are screwed together under great pressure in order to prevent the possibility of any loss due to leaky joints in the press.

Second carbonatation.—From the presses of the first carbonatation the juice passes to the second carbonatation station to be treated as before, with the exception that only a small quantity of lime is added and the time of carbonatation is not so long. The action of the lime and the introduction of the gas at this station produce a clear liquid of bright amber color which filters with more ease than at the first station, and is then ready for the treatment with sulfur gas. As the juice leaves the first presses it has a high alkalinity, which must be reduced before it is ready for boiling. The greatest epurating action has been found to be after the lime has been added twice to the juice and the juice carbonated after each addition. Usually .25 per cent to .50 per cent of lime is used in the second carbonatation.

In all operations in the process of making the sugar the juices must be kept hot and at specified temperatures. The cake formed at the second presses is softer, whiter and more chalky than that of the first presses, but at the same time it is inferior for agricultural purposes.

Sulfuring.—Leaving the second presses, the juices are pumped to the sulfur station to be further treated before the first evaporation. Here the juices are brought into contact with the gas secured by passing air over burning sulfur. This gas is carried into the tanks in the same way as in the tanks of the first and second stations. The action of this gas on the coloring substances that are in the beet juices varies, destroying only in part the coloring matter present. While sulfuring has hardly any effect on the purity of the juices, it gives a sparkle and has a brightening influence, and causes the juices to crystallize better. It is also important to note that the sulfurous acid decomposes the organic lime salts, while the carbonic acid does not.

Evaporating.—After sulfuring, the juices are filtered through special filter presses, or mechanical filters, and are then ready for the evaporators, in which they are boiled under a vacuum in order to concentrate them without the danger of destroying the sugar. About 80 per cent of the water in the original juice is taken out in the evaporators. The "effects," as they are called, are built in a series, usually four in number, and so connected with a vacuum pump that the heat of the first effect, where the juice boils at the ordinary temperature, causes the juice in the second to boil, but under a vacuum; the second heats the third, the third heats the fourth. The following table will illustrate this:

No. effect	Steam	Vacuum	Temperature °C.
	Pounds	Inches	
1	4–6	. . .	110°C.
2	000	8–14	90°C.
3	000	16–18	80°C.
4	000	24	62–65°C.

Having reached the density of about 32° Baumé, the juice in the fourth effect is pumped to the sulfur station for further treatment. The sulfuring of the "thick juice" takes place as with the thin juice. Having been reduced to the required alkalinity, the thick juice is then ready for filtration and boiling in the pan.

Securing the massecuite.—The pan is a large tank built of cast iron, fourteen feet in diameter and fifteen feet high on the average. It is connected with a vacuum pump in order that the boiling of the juices may take place at low temperatures without the danger of destroying the sugar. As long as the juices have been treated properly in the first part of the process, there will be no trouble in producing a good grade of sugar in the pan. In order to get a high-purity massecuite from the first pan, it is necessary to have juices of high purity to start with. The massecuite is a mixture of sugar crystals, which are formed in the process of boiling, and sirup from which all of the sugar has not been crystallized. This mixture of sugar crystals and sirup secured from the first pan is run through the centrifugal machines, revolving at the rate of 1,200 revolutions per minute. The sirup is thrown out through the fine perforations in the walls of the machine and carried into tanks used only for collecting this product. In the bottom of the centrifugal machine is a covered opening through which the sugar is dropped into a scroll that carries it up to the sugar box, from whence it is passed through the drier before it is put in the sacks for the market.

The sirup is then sent to the pan floor to be boiled in the second pan, in order that it may be further concentrated and more sugar secured. When of the necessary density, it is run into large tanks and allowed to remain until all the sugar possible has been crystallized. This is the second massecuite, and the sugar from it is used to get a higher grade of sirup from which to produce a high grade of white sugar.

Treating the molasses.—The molasses from this is treated in various ways to get all the sugar possible, either by the "osomose process" or by the "Steffens process." The osmose consists of a series of frames separated by parchment paper; the hot molasses passes through the press on one side of the paper and the hot water on the other side. The principle employed is the same as that of the diffusion battery, with this exception, that in this case the impurities, or salts as they are called, are dissolved instead of the sugar. In the Steffens process, the molasses is treated with powdered lime, and the sugar forming a combination with the lime in the cold is separated from the mother liquor by means of presses, and is then diluted to a certain density; it is run into the juice of the first carbonatation and the combination of lime and sugar is broken up, setting the sugar free while the insoluble lime carbonate is formed as the lime-cake.

This, in general, is the process by which the sugar in the sugar-beet is converted into the granulated sugar used on our tables.

SUGAR-CANE. *Saccharum officinarum*, Linn. *Gramineæ.* Figs. 826–836; also Fig. 517, page 367. [See, also, the articles on Porto Rico, Hawaii, and Philippines in Vol. 1.]

By *N. A. Cobb.*

Sugar-cane is a gigantic perennial grass grown for its stems, the juice of which is extracted for the making of sugar and molasses. The plant grows 8 to 15 feet tall, producing solid heavy maize-like jointed stalks. The flowers are perfect, very numerous in large silky terminal panicles; stigmas 2, spreading; stamens 3. The genus to which the plant belongs contains several species, and it is even a moot question whether the various varieties of sugar-cane do not include representatives of more than one of these. In an article of this nature it is impossible to consider the biology of the sugar-cane further than is necessary graphically to portray the main industrial features of the subject. We must be content, therefore, with the statement that all of the dozen species belonging to the sugar-cane genus are Old World plants. It is doubtful whether wild sugar-cane has been seen by any scientist. It is thought that its natural habitat was southeastern Asia or the adjacent large tropical islands. Several varieties of the species are enumerated by agrostologists.

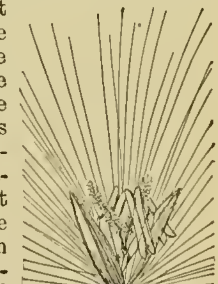

Fig. 826. Spikelet of sugar-cane (*Saccharum officinarum*), opened to show floret.

Sugar-cane has been cultivated so long that its origin is lost in antiquity. Its parts are so perishable that it is extremely improbable that any fossil evidence will be discovered showing its connection with man in prehistoric times. The probabilities are that it was used by man ages before there is any record of such a fact, and that its culture was among the first undertaken by tropical peoples. In these early times, however, its use was confined almost exclusively to such varieties as could be eaten raw. Only with the art of extracting the juice and converting it into sugar and molasses, did the plant take on its modern high rank in agriculture. As a source of sugar it stood practically alone until the beginning of the last century, and, notwithstanding the immense increase in the culture of other sugar-yielding plants, it still maintains in most countries its preëminence in this respect.

The plant is grown under so many various conditions, is handled by such a great variety of machines, and converted into sugar by such intricate methods, that it is doubtful whether there is another crop plant whose various features are the subject of so much discussion from a practical point of view. The crop is grown where labor is cheap, and by hand methods, or, at least, with simple machinery adapted to cheap ignorant labor. It is also grown where labor is much more expensive, and where intricate and costly machinery has to take the place of the ordinary simple agricultural implements. Furthermore, the plant is usually converted into sugar,—even refined sugar, in some cases,—on the plantation where it is grown, and usually under the same management, by means of machinery of the very largest and most costly description, and by exceedingly intricate methods requiring expert knowledge of a high and varied order. The adaptation of the crop to these various methods involves the consideration of hundreds of features that are never, or at least rarely, considered in connection with any other plant. Most important among these features are the structure and physiology of the plant. It is only by a clear understanding of these matters that the rationale of the culture of cane and its conversion into sugar can be properly understood. From an industrial point of view, we need to consider the structure of the root, stalk, leaf and blossom. [For other botanical characters, see page 367.]

Physiological considerations.

Root.—Among the numerous roots of the cane plant, there is no single prominent taproot. The distribution of the system under ground is for a short distance, at least, somewhat uniform in the space available, various individual roots, however, penetrating to a distance of several feet. The nodes of the stalk are supplied with incipient roots; and the lower nodes are particularly active in rooting, so that it is very common for them to produce roots successively from the base up, that enter the ground and actively function in promoting the growth of the top. It is common for the older roots to perish, and be replaced by new roots derived in part, at least, in this way. As a rule, the roots of the cane branch but little. The root-cap presents no novel features, except that it is now known to be a vulnerable point in some varieties for the entrance of various fungous parasites. When the end of the root is thus infested and killed, it is not uncommon for buds to be produced higher up on the same root, the new root thus originated taking up the functions of the destroyed part. The structure of the roots of some varieties is such that they are in other ways susceptible to various pests inhabiting the soil. Though destruction of the roots is accomplished for the most part by fungous pests, in many cases an entrance is made for these pests by wounds caused by soil-inhabiting nematodes and insects. These facts have been brought to light by the most modern researches and emphasize the necessity of giving greater attention to methods of culture that will diminish losses of this nature.

Stalk.—The industrial value of the cane-stalk depends on a great variety of features, all related to the amount and nature of the saccharine matter that can be extracted at a given cost, and the ability of the stalk to reproduce itself with its properties unimpaired. This subject is very complicated, and only a brief outline can be undertaken. Two main features will be discussed: (1) The amount and nature of the saccharine matter; (2) The structure of the stalk. These two are closely related.

(1) *Amount and nature of the saccharine matter.*—The saccharine matter is distributed in the stalk according to a definite law which may be roughly expressed by saying that it reaches its maximum near the middle of the stalk and is at a minimum near the ends, the decrease being least toward the ground and greatest near the top. At a certain period of growth, varying widely with climate, the total saccharine matter reaches a maximum. This is the ripening period, and, of course, the period at whose termination the cane should be crushed. Judging this stage is a crucial test of the grower's skill. Not only does it vary with the general climate, but also with the particular season and with the soil and the variety. In general it may be said that the ripening is governed by the temperature and the sunlight. Two plantations having the same conditions otherwise, but the one subject to more cloud shadow than the other, will vary in the richness of the juices extracted from the cane. In a similar way any change in the temperature will work a like change in the yield of sugar. One plantation, irrigated with cold spring-water derived from high mountains, will vary materially from another irrigated with rain-water brought from a distance in open ditches, and therefore applied at a higher temperature.

After reaching their maximum, the extractable saccharine matters decrease as the cane grows older and begins to form its inflorescence. In fact, it is for the work of flowering that the cane plant stores up saccharine matter. In the effort to harvest the cane at its maximum saccharine content, the planter is aided by the chemist who makes analyses of sample stalks of the crop. This test, however, is not always resorted to, as the planter learns by experience to judge the ripeness of the cane by its outward appearance, i. e., its color, the stage of its inflorescence, and the like.

Because of the expensiveness of the modern mill, it is necessary for economic reasons to prolong the crushing season as much as possible, and for this reason the planter resorts to various methods to prolong the ripening of his fields in such a way that they reach their maximum sugar yield in succession during the crushing season, which may thus last for several months. By using several varieties

Plate XXIII. A sugar-planter's home. Burnside Plantation, estate of Gen. Wm. P. Miles, Burnside, Louisiana

of differing degrees of earliness, by varying the planting season, by taking advantage of low land and high land and other natural conditions, it is possible to extend the crushing season so as to get a maximum result from the capital invested in the mill and from the laboring force of the plantation. As we shall see later (page 602), the time of ripening, i. e., the distribution of the sugar in time, as well as the distribution of the sugar in the stalk, have much to do with the selection and preparation of seed-cane.

The kind of sugar present in the cane, as well as the amount of it, determines its industrial value. The property that makes the saccharine substance of the greatest industrial value at the present time, is that of its being extractable by the known processes of crushing, concentration and crystallization. Preëminent among the extractable saccharine substances of this nature is sucrose. This crystallises out as "cane-sugar," and is the same substance as that obtained from sugar-beets and a variety of other plants. In fact, from a practical point of view, at the present time, we may say that the amount of extractable sucrose determines the value of the cane more than any other factor except that of ability of the cane economically to reproduce itself with this sugar-content unimpaired. We must not forget in this connection, however, that the ease with which the sugar can be extracted is also an important factor. The presence of saccharine matters other than sucrose is deprecated by planters because their presence generally indicates a lowering of the sucrose, the energy of the plant having been consumed in producing sugar or saccharine matter that is not extractable, in place of a certain amount of sucrose that might have been produced. The extractability of the sucrose depends to a certain extent on the absence of certain organic substances which tend to cause the sucrose so to change its molecular form as to become unextractable or of less value. To a large extent, these difficulties are surmounted by the application of hydrate of lime to the juice as soon as possible after it is removed from the cane.

For practical purposes it is often convenient to consider the cane as composed of juice and fiber, leaving out of mind the composition of these two component parts. Proceeding on these lines, we may say that the amount of juice in a given volume of cane will be the greater, the less the amount of fiber. The fiber of the cane-stalk exists in the form of strands or fibrovascular bundles distributed in the stalks as follows: (1) A part in the form of fine parallel fibers in the internodes, and (2) a part woven together at the nodes. From this it follows that a cane having numerous nodes close together, so that the internodes are short, contains the greatest amount of fiber, because it is at the nodes or joints that the fiber is most compact, and the sugar-bearing tissue is at its minimum. Cane with long joints is therefore generally looked on with favor by planters as being likely, other things equal, to contain the greatest amount of sucrose. It frequently happens when the growth of the cane is hindered by cold weather or by drought, that the slower growth is marked by an abundance of joints or nodes near together. Such cane is usually characterized by a lower percentage of sugar. The practical application of this fact is illustrated by all those methods of culture that tend to keep the cane growing uniformly, as, for example, in the application of irrigation water to piece out the irregularity of the natural rainfall, and the application of artificial manures to stimulate the growth during periods when the growth would naturally be slow.

In general it may be said that the varieties that are lowest in fiber are such as give the highest yield of sucrose and are the varieties preferred where the conditions are suitable for them. They are, however, what may be termed

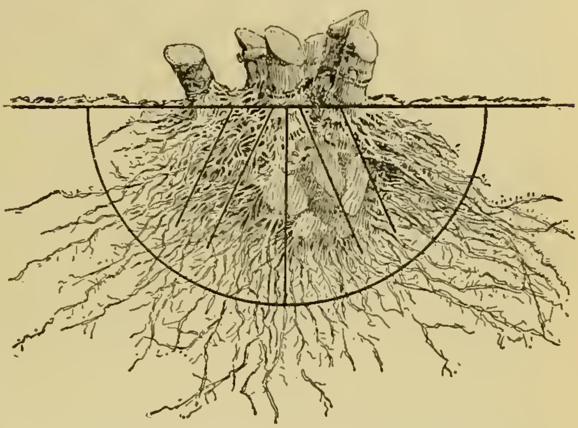

Fig. 827. To show action of a plow employed to burst up the big ratoon stools of sugar-cane. Location of root disease is indicated by the curved line. This plow cuts the stool into six pieces, as shown by the lines. The more obliquely the disks are set the more squarely the stubble is cut across. The more squarely it is cut the quicker it dries, thus creating conditions unfavorable to root disease. (Redrawn from Bulletin No. 5, Division of Pathology, Hawaiian Sugar Planters' Association.)

delicate canes, and it frequently happens that through the attacks of diseases they are made unproductive, so that in time they have often been replaced by other varieties with more fiber, but more resistant to disease. Examples of this are the Bourbon cane of the West Indies, the Lahaina cane of Hawaii, and the Rappoe cane of Australia. When, however, these canes meet with the right conditions, they are still preferred to any others. With strong sunlight, fertile soils, high temperature and uniform conditions, all of which favor the growth of the cane and are not particularly favorable to fungous pests, these canes are the most profitable. Good cane, as it comes to the mill in most tropical countries, contains up to and sometimes even beyond 20 per cent of sucrose, averaging 15 to 18 per cent. The extracted juice contains, under favorable conditions, 17 to 18 per cent of sugar.

It will have been noted that the amount of extractable sugar depends on its own nature and that of the collateral products, and not altogether on the structure of the stalk. Modern mills are so powerful and modern methods so efficient that the sugar extracted has reached as high as 97 per cent of the total sugar content, so that the absolute limit has been very nearly reached. The economic limit has even been much more nearly reached, since the extraction of the last traces of sugar would be too costly to render it practicable. The average of good mills is not far below 95 per cent.

The importance to the planter of understanding the distribution of the sucrose in the stalk is also shown by the bearing this distribution has on the matter of harvesting. Cutting close to the ground results in saving more sugar, and it frequently happens that attention to this matter results in a material increase in the profits at a cost small in proportion to the gain. So, too, it sometimes happens that in certain soils and under certain conditions, when the land afterward is to be plowed and replanted, it is profitable to pull the stalks, in spite of the fact that the operation is more expensive than cutting. These details of the management are dependent on the fact that the lower part of the stalk contains considerable amounts of sucrose. Again, it sometimes happens that the planting and the harvesting can go on simultaneously for months at a time. Under such conditions it is possible to secure seed-cane for the new planting from the tops of the cane that is being harvested. Now the tops, above a certain point that has accurately to be determined, contain comparatively little extractable sucrose. The point at which to cut off the top for seed purposes therefore becomes an important matter, especially as it is precisely the parts that contain the less amount of sugar that are particularly good for seed. By cutting the tops too low, tons of sugar may be lost without any corresponding gain to the seed.

(2) *Structure of the stalk.*—The nature and distribution of the fiber in the stalk determine the resistance of the cane to various adverse influences, so that these qualities become of great importance. If, owing to the nature of the fiber, the stalk is brittle, this fact will cause the cane to break more easily during wind-storms, so that for windy locations canes of this character are unsuitable. The toughness of the stalk is also related to the access of certain pests. Strong fibrous varieties are more resistant to certain insect borers than are the varieties with less fiber, so that, although the latter may be higher in sucrose, it is sometimes more profitable to grow the former. Where the attacks of these pests are severe, the actual yield and the profits may be greater with the poorer variety, owing to the fact that the ravages of the pests are less.

In a somewhat similar way, it appears that the infestation by certain fungous pests is determined, to a certain extent, by the nature of the rind of the stalk where the fibrous matter is in excess, and, the presence of epidermal cells assisting, the resistance of the cane to the fungous pests is in a degree proportional to the amount of the fibrous matter so located.

Another matter connected with the structure of the stalk, and one of great practical importance, is its size. By a mathematical law, the larger the stalk the greater strength will be imparted to it by the distribution in its outer layers of a given amount of fibrous matter. Further, the larger it is, in view of the foregoing fact, the more space is available for the storage of sucrose in the interior tissues. Hence, varieties with large stalks are generally viewed with more favor than those with

Fig. 828. Planting cane in Louisiana.

small stalks. Certain varieties of cane produce a comparatively small number of long stalks, while other varieties tend to produce a larger number of shorter stalks. It is evident that these characters adapt the various varieties to various conditions. Short-stalked varieties are better adapted to certain windy locations.

Not only is the location and distribution of the joints important in determining the value of a variety, as above mentioned, but the size, location and germinating power of buds and roots situated at the joints are also important factors. This is so for two reasons: First, the growth of the roots is at the expense of the sucrose near by, so that, if a variety has a tendency to root unnecessarily at the base, then the sugar-yield is lessened. Second, it is the nature of the bud that determines the value of the cane for seed purposes. This factor is important in proportion to the frequency of planting. In some localities ratooning is dispensed with, so that after each crop is harvested the land is at once replanted. In many localities the cane is allowed to ratoon only once or twice and then replanted. Of course, in such localities the question of seed is one of greater importance than in those localities where the cane ratoons for a long series of years, and is not often replanted.

Varieties of cane differ to a remarkable extent in respect to the germinating power of their eyes. In some varieties eyes in any part of the stalk germinate readily ; in others, only those eyes near the top can be relied on to germinate promptly and vigorously, and these latter are by far the more numerous among the best-yielding varieties. Then, some varieties germinate much better as plant-cane than as ratoon, while other varieties show much less difference in this respect. The germinating power of a variety depends on the vigor of the buds and on the vigor of the root-tissues developed at each node, but this is not the whole of the matter. It happens that there are insects whose special habitat is the buds of the cane-stalk, and resistance to the attacks of these pests constitutes an important part of the value of cane for seed purposes. Buds, otherwise good, are rendered worthless by the attacks of these pests, so that resistance to them may determine the value of the cane for seed purposes almost as much as the production of vigorous buds.

The handling of cane is necessarily rough, and prominent buds are often bruised or broken during the handling. From this it follows that canes with low flat buds are to be preferred to those with round and prominent buds. This is especially the case where the cane has to be flumed for long distances, as the effect of the water is to soften the buds and they are then more easily rubbed off as they pass along the flume.

To prepare cane for seed purposes, it is cut into sections, each having one or more buds which it is intended shall germinate and start a new stool. While the new plant is establishing itself, it grows at the expense of the sucrose and other matters stored up in the cutting. It is important, therefore, that this store of food shall be preserved for the use of the plantlet. If the cane is brittle, it is likely to shatter when cut for seed; that is to say, the stroke of the knife causes each piece to split at the end in the manner familiar to everybody in chips of wood produced by the axe. These cracks afford an opportunity for various organisms to enter the cutting after it is planted, and cause it to decay much more rapidly than it otherwise would. For this reason a cane that is brittle is one that is of less value as seed than one that is not. For this reason, also, the tops of stalks are more valuable than other parts because they are more succulent, and therefore less liable to shatter. To avoid shattering, or even cutting, it is the custom of some planters to use whole cane for seed.

Leaf.—The microscopic structure and the chemical composition of the leaves determine the amount of resistance they will offer to the attacks of the various fungi that are peculiar to this part of the plant. This subject is one that has not yet been sufficiently studied to determine the precise nature of the various factors, but it is known to growers that certain varieties are more susceptible to leaf diseases than others. For example, the yellow varieties are more susceptible to many leaf diseases than the red and green varieties. It is now known that the various structures indicated vary to a considerable extent in the different varieties, and it is reasonable to suppose that some of these variations are correlated to resistance to disease. The thickness and the chemical composition of the cell walls will determine the resistance of the internal cells to the dissolving effect of parasitic fungi. So, too, the thickness of the cuticle and its chemical composition will determine the resistance to such fungi as dissolve their way through the cuticle. No doubt many of the fungi that enter the cane-leaf do so by way of the stomata. It is known that these vary in number and structure in the various varieties and thus offer various degrees of ease with which the parasites may enter. Again, it is through the stomata that a number of these parasites make their exit for fructification. Here, again, the number and size of the openings determine the degree of resistance to the formation of fructifications.

Resistance to drought is largely a function of the leaves, for it is through the opening and closing of the stomatic openings that transpiration is controlled. A variety that promptly and effectually closes its stomata under dry conditions is one that, other things being equal, resists drought best.

At certain periods of its growth, it is customary in some localities to strip the stalk of its lower leaves in order to facilitate the ripening processes. The attachment of the leaf is a factor of importance in this connection. In some varieties the leaf comes away with ease, and leaves a beneficent scar, while in other varieties when the leaf is removed the connection is such that there is a tendency to tear away some of the tissue of the stalk, and thus leave wounds which may be entered by wound-parasites that work injury to the cane in reducing the sucrose. The attachment of the leaves is also related to disease in another way. In some varieties the sheath of the leaf is so related to the stalk as to resist the entrance of both insect and fungous parasites, while other varieties admit of the early entrance of moisture and injurious parasites.

It is the large-leaved varieties that, as a rule, are the most prolific, although, unfortunately, also generally the most subject to disease. It appears that the rapid growth resulting in the production of large leaves is more or less incompatible with the production of disease-resistant tissues.


Fig. 829. Sugar-cane. Stripping and cutting.

Flower.—Of recent years, the structure of the flower of the cane plant has assumed great importance because of the attempts to produce new canes by crossing known varieties. These attempts and the resulting studies have disclosed a number of very interesting facts with regard to the anatomy and physiology of the blossom. Until recent years it was thought that the blossoms of the cane plant were infertile and that such a thing as a cane seedling was an impossibility. In the latter eighties, however, seedling canes were reared, and from that time much progress has been made in the art of producing new varieties. In the following countries and in the following order, approximately, the subject has received attention: Java, Australia, West Indies, Hawaii. The making of definite crosses was first successful, it is thought, in the West Indies. The greatest amount of this work has thus far been accomplished in the West Indies, although it has now begun in Hawaii and elsewhere. The following facts have been slowly developed :

Fig. 830. Harvesting the cane crop. Hawaii.

The number of fertile seeds produced in a panicle of cane is relatively small, as is the case with many other grasses. The germinating power is very transient, being at a maximum a few days after ripening and rapidly decreasing thereafter so that at the end of a few weeks it is often wholly lost. An examination of the seeds of cane discloses the fact that a large proportion of them are shrunken, and this seems to indicate that a large proportion of them are not fertilized. Nearly all the plump seeds germinate when they are a few days old if they are soaked in water for 12 hours and placed in a saturated air of 100° Fahr. These are probably the properly fertilized seeds. It is rare for certain varieties to produce fertile seed ; in fact, a large number of varieties are not yet known to produce them, though this may be due to insufficient observation. On the other hand, it has been established by observation that the pollen of certain varieties is incapable of germination and therefore of properly fertilizing the ovaries. This fact is determined by the structure of the pollen, and by the fact that it will fail to develop when given the proper conditions. In some instances the anthers appear never to ripen properly, as they are thin, off color, and never open at all. On other occasions they appear to contain pollen mother-cells only, the growth appearing to be arrested at that stage. Attempts to secure fertile seed with such anthers end in failure. It is possible that the method of propagating cane solely by means of cuttings has ended in a deterioration of the seed-producing powers, and that perseverance in the effort to secure successive generations of seedlings may resuscitate this power. It is to be hoped that this is the case, as it is some of the very best varieties that have apparently failed hitherto to produce good seed.

Thus far three methods have been used in the production of seedlings: First, seed has been harvested in a haphazard way from varieties that it was desired to propagate This method has produced a large number of seedlings whose parentage pollen is unknown. Second, an attempt has been made artifically to fertilize certain panicles by giving them an excess of pollen of a given kind, such as by placing near them, at the proper time, panicles of other plants, either by removing these latter from distant canes or by previously having planted the canes near by. This has resulted in the production of a considerable number of seedlings, whose parentage pollen is uncertain, but less so than by the first method. Third, by emasculating definite blossoms before the ripening of their pollen, and by supplying fertile pollen of another sort at the proper time. Owing to the difficulty of accomplishing this the number of such seedlings has thus far been limited to a few hundred. By far the greater proportion of these have been produced in the West Indies, notably at the experiment station of Harvard University, where it is said that several hundred such crosses have been made.

The third method is the only scientific one, and it is probable that the difficulties will be so much lessened by experience that it will soon be possible to produce crosses of definite parentage with ease. As such can then be repeated at will, a definite knowledge of cane pedigrees can be established. This will lead to accuracy in the breeding of new varieties. It is probable that the rapidity of our progress in this direction will be in proportion to the accuracy of our knowledge of pedigree, as is the case with other species.

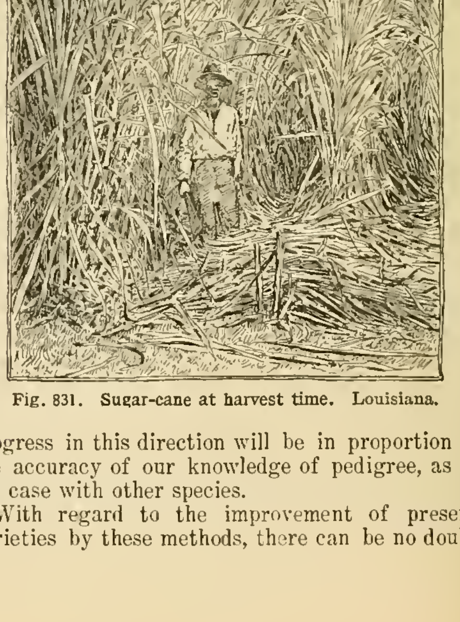

Fig. 831. Sugar-cane at harvest time. Louisiana.

With regard to the improvement of present varieties by these methods, there can be no doubt about the great value of the improvements already effected. Reports show that disease-resistant varieties have been produced, and the analysis of certain seedlings in their first, second and succeeding years, indicate that the sucrose content of sugar-cane can be increased in much the same way as illustrated in the recent history of the sugar-beet.

Varieties.

There has been no satisfactory study of the varieties of cane, and, in consequence, there is no satisfactory system of classification of the varieties. The division most usually spoken of by planters, and that which may therefore be inferred to be the one they find most useful, is based on the color of the stalk. Three color-groups are recognized: (1) the green and yellow group, in which the stalk is more or less uniformly green or yellow; (2) the red group, in which the stalk is more or less uniformly reddish in color; and (3) the striped group, in which the stalk is more or less distinctly striped. This grouping is wholly, or almost wholly arbitrary, and presents little to recommend it from a scientific standpoint. With the multiplication of varieties following on the production of new crosses, it is to be hoped that increased knowledge will result in improvements in nomenclature. It is manifest that the color scheme mentioned above includes in its striped division canes so closely related to each of the other divisions as to require its division into two coördinate parts, each on a par with the uniformly colored divisions. Many other objections to the above classification might be pointed out. The great objection to the system is that it leads to the assumption that striped canes, for example, have some important property in common, which is far from being necessarily the case.

Culture.

Soil.—Soil that is good for average agricultural purposes is good for cane. It should be naturally well drained, or if not, drainage should be provided. It is usual to provide drainage by means of open ditches, comparatively little cane land being drained by means of tiles. Soils naturally acid are frequently corrected by the application of lime, and often with very profitable results. Exceedingly stony lands are sometimes profitably used.

The plowing should be deep, the deeper the better, so that the depth is limited only by the kind of plow and the nature of the land. The deepest and best plowing is accomplished with steam plows, the depth reached within economic limits being eighteen inches to two feet. Sometimes subsoil tools are alleged to go below two feet, but that is rare. The limitations are often determined by the nature of the subsoil, which in some localities is such that it is inadvisable to turn it up to the surface except in small quantities. In some volcanic soils, for example, the iron compounds in the subsoil are injurious to the growth of cane.

Good surface tillage after plowing pays as well with cane as with any other crop. All the labor-saving implements connected with big-scale agriculture are in use in some regions.

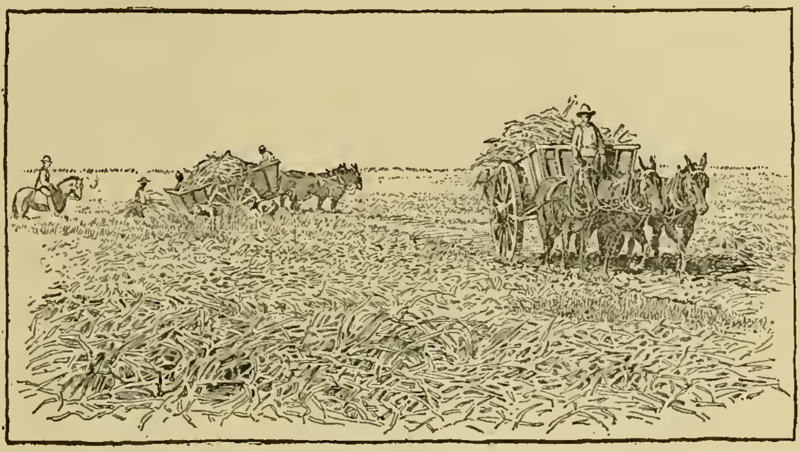

Fig. 832. Hauling sugar-cane from field in wagons. In the old days all cane was handled in this way.

Fertilizers.—Stable manure is one of the best fertilizers, but it is seldom to be had in sufficient quantity, and artificial manures are widely used. Where animal traction is in use there is much stable manure plowed or harrowed in. When combined with irrigation, the application of commercial manures may be reduced almost to an exact art. Cane-planters establish their own standards of manure value, and make contracts on the basis of their own analyses, less often making use of state fertilizer control. The proportion of the different elements used in the fertilizers is influenced to a large extent by the peculiar nature of the industry, which consists of extracting from the crop and sending away from the plantation only the sugar, a carbohydrate containing none of the three most valuable elements in manure, namely, nitrogen, phosphorus and potash. The burning of the trash destroys much nitrogenous fertilizer, but the potash and phosphorous compounds remain on the plantation for future use, and if they are not lost through leaching may be utilized over and over in successive crops. It follows that the most commonly purchased ingredient for cane-fertilizer is nitrogen. The soluble artificial fertilizers are applied in small quantities to the surface and with more or less frequency, according to the requirements of the crop. The less soluble artificial manures, such as dried blood and fish refuse, are applied slightly below the surface of the soil, where the conditions are favorable for their decomposition.

Lime is used extensively as a manure in nearly all cane-growing regions. It is used in large quantities in the mill and appears in the by-products, which are applied to the soil, mixed with other ingredients to form fertilizers. Natural lime in the form of limestone is also applied, as is also quicklime. Many tropical soils are sufficiently rich in humus to permit the free use of lime, and its use is beneficial in connection with potash compounds. Recently, a modification of the application of lime has been recommended to counteract the accumulation of those fungous pests of the cane that inhabit the soil,—the pests that have been called "root-disease." In these cases the lime is applied unslaked, or partially slaked, and is applied only to the bases of the ratoon stubble a few days or weeks before plowing out the latter. The after-culture is calculated to spread the lime through the soil, and it then exercises its customary manurial effects in proportion to the perfection of the distribution.

Seed and planting.—The rows of cane-stools are usually four to six feet apart, five feet being a common distance. The aim in planting is to produce a stool of cane at about every two feet in the row. In the hill-planting system the distances are greater. The planting varies widely in various regions, according to the way the seed is prepared. In some localities great carelessness prevails in the preparation of the seed, so that it is necessary to allow for the failure of a large proportion of the eyes. In such cases the planting is nearer together than when the seed is more carefully prepared and gives a better percentage of germination. In any case, it is the general practice to replant all the failures so as to secure as even a stand as possible.

The practice in reference to seed varies from planting whole cane to the planting of a single eye every eighteen inches to two feet. It is most common to lay the seed-cane horizontally in a row, with the eyes facing laterally so that in sprouting the shoot from each eye grows at first horizontally and then turns upward. As it is usual to have more than one eye on each cutting or set, this position gives all the eyes the same opportunity. The method gives to the roots on the upper side of the cutting small opportunity to succeed, those on the under side only having a fair opportunity. Another method is to place the cuttings on a slant of about 40°, with the end protruding from the soil. Still another method is to set the cuttings vertically in the soil, with the end protruding, the protruding end, of course, being always the upper end of the cutting. These latter methods are used when the cuttings are grouped in "hills," or when it is desired to secure a specially good or quick germination.

In regions where the cold season is so severe that all the cane has to be cut before winter, the planting is sometimes done in the spring. This necessitates preserving the cane-stalks over winter. This is done by a process that may be compared to the first stages of ensiling. The stalks with the leaves left on, are cut and covered in some way so as to keep them cool and moist, but not wet. The stalks are sometimes laid in piles and the trash of the cane used as a cover to keep out the excess of cold and to prevent too rapid evaporation. Another method is to windrow the cane. The stalks, with the leaves on, are laid on the ground between the rows and so arranged that the leaves completely cover the stalks. The rows of stalks thus arranged are covered over by plowing furrows on either side and turning the soil onto the cut cane. The covering is completed by hand. Where the plowing cannot well be done because of dryness, it is customary to complete the operation with rollers so as to pulverize the lumps and compact the soil above the cane-stalks. When this operation is favored by the season, it results in well-preserved seed-cane for the spring-planting. Often, however, owing to the nature of the season, there is a severe loss of seed-cane so treated. These methods all have their advantages and their disadvantages, although the most widely prevailing practice is that first described.

The seed is very lightly covered where irrigation is practiced, the covering being half an inch to one inch. The covering is greater where cane is grown with the natural rainfall, although even here the covering is light. The germination and growth of the seed requires for its best result strong heat, and moisture represented by at least two inches of rainfall per week. In regions where diseases of cane are common, it is best to preserve the cuttings from contact with any trash from the previous crop since trash is liable to contaminate the new crop. As the seed is usually covered by hand, it is possible to do this at a comparatively small cost.

Of late years a practice of treating the cuttings previous to planting is springing up. This is owing to the attacks of a disease that rots the cuttings before they have opportunity to grow, or at least injures them sufficiently seriously to diminish the stand. This treatment consists in covering either the end alone, or the whole surface of the cutting, with some fungicide. Tar is applied to the ends of the cuttings, or Bordeaux mixture of double strength is used to soak the cuttings for a few minutes or a few hours. Such treatments are useless unless the seed itself is carefully selected, for, if the cutting is already diseased, such treatment will not save it from further ravages of the disease already established. The treatment simply prevents the rots present in the soil attacking the cuttings as soon as they otherwise would.

The selection of the seed should begin in the field (i. e., the best cane should be cut for seed) and continue through the process of preparing the seed. All defective seed should be discarded if the best and most profitable results are to be secured. It is best in some localities to grow cane especially for seed, so that at sowing time there will be at hand plant-cane of the right degree of maturity. The question of seed is one whose importance is directly proportional to the frequency of planting. When the cane can be ratooned for a long series of years, the securing of sufficient first-class seed is an easy matter. On the other hand, when cane is not ratooned, the seed question is of the greatest importance.

Subsequent care.—For the first few months after planting, the cane is actively cultivated. The com-

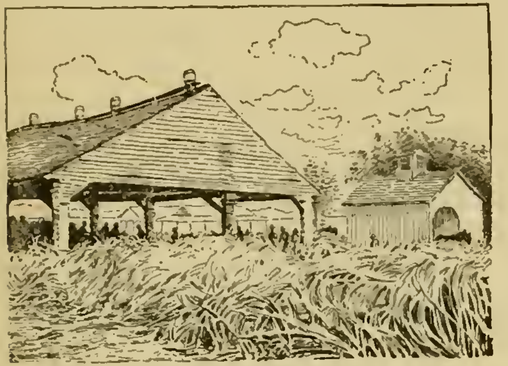

Fig. 833. An old cane shed; placing cane on a carrier by hand in the old method. Louisiana.

monest tool is a one-horse cultivator. This is followed by boys with hand-hoes. Cross-cultivating with machines is not much practiced, and, in consequence, the work of the horse-machines is completed by hand. The horse cultivators are mostly of the tooth pattern, but recently disk-cultivators have come into vogue and promise to prove very useful in certain cases. In one machine these consist of two disks run on either side of a light beam, like that of a single-furrow plow.

In regions where the original timber was heavy it often happens that for some years the crop has to be cultivated by hand throughout. This is also the case on certain rocky lands that nevertheless yield good crops of cane. The object of the culture is to keep out weeds and to encourage the growth of the cane. The methods vary according as the crop is grown without or with irrigation. In the latter case it is necessary to keep the rows of cane at the bottom of a furrow so as to accommodate the irrigation water. The land usually becomes "covered in" by the cane at the end of four to six months, and machine cultivation then ceases.

Harvesting and handling.

Cane is harvested by hand. Machine cutters have been invented and tried, but so far no machine has been a great success. It is hardly unsafe to predict that a cane-harvester will yet be invented. The cane-knife and the machete are the tools with which cane is cut. Where ratooning is frequent, the ratoon-cane is sometimes pulled in order to secure as much stalk as possible. The gain, however, is not great, as good cutters leave very little of the stalk in the ground. Immediately after the cane is cut it is started for the mill and, as a rule, is ground within twenty-four hours, as, owing to fermentation, the sucrose content diminishes at the rate of about one per cent per day.

Hand labor is necessary in loading the cane on to the carriers that take it to the mill. The cutters lay the stalks in rows after topping them. The roughness of the fields is such that a large load cannot economically be transported over them, and hence small loads are taken short distances to the carriers which are arranged on definite transportation lines that radiate from the mill as perfectly as the conformation of the plantation admits. These intermediate carriers vary all the way from laborers' shoulders, through small two-mule sleds to carts and wagons of small capacity. The permanent ways are roads, canals, wire cables or flumes. The roads may be for teams of horses, mules, oxen, or steam traction-engines, or they may be railroads for locomotive engines hauling lines of trucks, varying in capacity up to twenty tons. The commonest arrangement is the latter, and much ingenuity has been exercised in the invention of engines, trucks and portable rails adapted to this purpose. When the cane lands are along river-banks the various creeks emptying into the river are utilized to carry punts, and artificial canals for the punts are sometimes provided. The latter are as a rule adapted also to furnish additional drainage. The punts and tugs present no peculiar features. The mill carriers come to the waterside and the cane is dumped on to the carriers with the aid of machinery, or more often without. On certain plantations having steep grades, gravity cable-cars are in operation, the loaded cars at the top of the incline drawing up the empties, thus affording an economical power. Plantations of this character are sometimes supplied with overhead cable-systems for carrying light, single-wheel trolleys capable of taking several hundredweight of cane. The cane is hauled to the

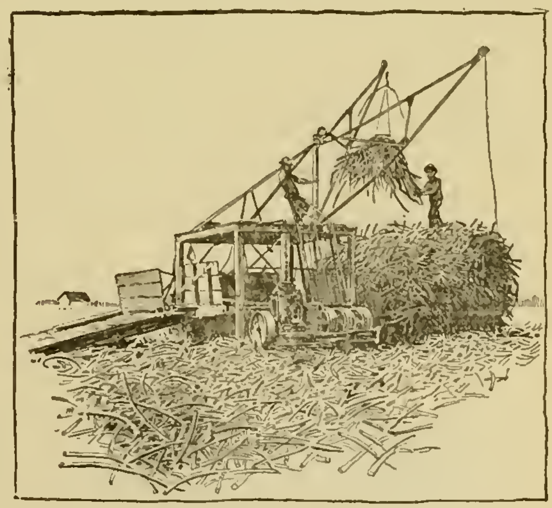

Fig. 834. Wilson-Webster cane loader. A recent method.

upper trolley-station, attached to the trolley in bundles of requisite size, and sent by gravity to the mill with great speed. The trolley wheels are packed back up the hills on the backs of mules. Where water is abundant, the cane is sent down to the mill in wooden flumes carrying a stream several inches deep, the distant flumes being V-shaped and of two boards, the mill flumes larger and of three boards.

Machine loaders are coming into use for transferring the bundles of cane from the primary carriers to those on the permanent ways. Chains or wire cords of the requisite length are provided, and these are fastened about the bundles of cane as they are assembled on the primary carriers. When these latter reach the permanent-way carriers, mechanical loaders attach their tackle to the bundles and lift them to the trucks, trolleys, or punts, as the case may be. These loaders are usually portable derricks. Where plantation railways are in use, they often have portable derricks attached to trucks. These are run on to sidings and from thence the trucks of the main train are loaded in succession. Naturally, all the mechanical contrivances are in use just in proportion to the price of efficient labor. Where labor is high they are in more common use than where it is cheap. In some countries that produce much sugar the modern labor-saving machines and implements are almost unknown. That they will be further perfected and come into wider use is certain.

There are more patterns of unloaders than of loaders, as might be expected from the fact that the problem is simpler. One of the commonest unloaders is a series of sprocket chains arranged on a frame and carrying at intervals perpendicular steel fingers a foot in length. The moving chains are lowered over the truck of cane and the motion of the steel fingers slides the cane off on to the mill carriers. As these fingers can be raised or lowered at will, the cane can be unloaded to accommodate the speed of the crushers. Another unloader consists of a fifteen-foot mechanical finger with a universal movement. The end is forked and hooked downward, so that the cane can be raked off the truck on to the mill carrier.

Manufacture of cane-sugar.

To produce sugar from sugar-cane it is necessary to extract the juice, purify it, and then evaporate

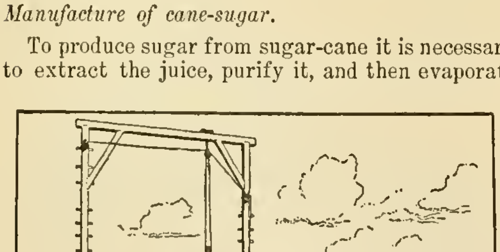

Fig. 835. Sugar-cane loading-derrick in action.

it until the sugar will crystallize. Formerly these operations were conducted with very simple apparatus, and even now such crude methods are in use in the less progressive countries. The most primitive wooden or stone rollers driven by direct animal power, will express much of the juice from good ripe cane, and it may be concentrated without purification in simple open pans. The result is a poor sugar, much molasses, and the extraction of only a part of the sugar, much of it remaining in the bagasse and going to waste. The most perfect

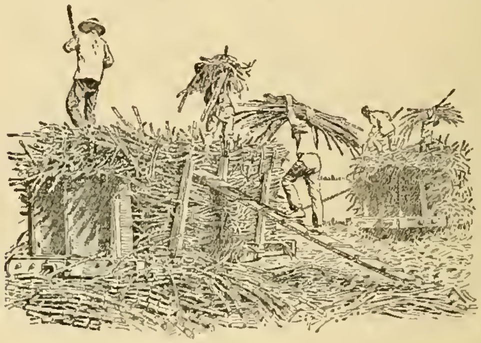

Fig. 836. Loading cane into cars. Hawaii.

mills are only improvements of this simple process. The use of more powerful rollers was the first improvement; then came the multiplication of the rollers, not only because the repeated pressings would remove more juice from the already pressed fiber, but because between the crushings the fiber could be treated with hot liquids, that on being removed by the next set of rollers left the sucrose in a more dilute solution in the bagasse. The amount of moisture that is left in the bagasse is determined by the pressure; the amount of sugar is determined, however, by the concentration of the solution of sucrose in that moisture.

Shredding and crushing. — Endless carriers, several feet wide, receive the stalks and elevate them twelve to fifteen feet and dump them into a shredding machine or its equivalent. Here the cane-stalks are torn into fragments by revolving cylinders that somewhat resemble a peg-drum threshing machine in their action. The cane fragments pass without further alteration to the first set of rollers. These three corrugated steel rollers are set to press out about three-fourths of the sucrose, an operation easily possible with the best mills. The fiber or bagasse from these rollers is macerated during about two minutes, as it passes on carriers to the second rollers, the macerating liquid being the heated juice from the final set of rollers used at about 150° Fahr., and sprayed at the rate of about six cubic feet per minute. About 10 per cent more of the sucrose is pressed from the macerated bagasse as it passes through the second set of rollers, which are like the first in action. These operations are repeated between the second and third sets of rollers, except that the macerating liquid is hot water in this case. The third rollers extract another 3 to 4 per cent of sucrose.

The bagasse from the third rollers is carried to the furnaces and is mechanically dumped into them at a rate that can be regulated, so that the possible excess may be saved to supply any deficiency that may occur when richer cane is being crushed. The average amount of bagasse produced furnishes sufficient fuel to keep up steam for the mill. With rich cane there may be a deficiency of bagasse, which compels the use of some other kind of fuel.

Purifying the juice. — The mixed juices are strained and then heated by being passed at once through a super-heated steam heater, with the result that some of the coagulable matter is thus coagulated and the remainder rendered more susceptible to purification by the addition of freshly slaked lime, which constitutes the next operation. The lime-water is added in measured quantities, according to the composition of the juice, and at a temperature of nearly 212°, this being the temperature at which the maximum purification is secured. The impurities settle rapidly, or rise as a scum or "blanket," and the juice, often further purified by boiling or skimming, is drawn off into the evaporating pans. The blanket and precipitate go to the filter presses, where the remaining juice is pressed out through a long series of cloth filters. Each element of the filter press is a metal frame with its accompanying cloth filter. The pressure is applied to the whole series at once, usually by means of screws. The filtered juice goes to the evaporators. The resulting filtrate, known as press-cake, is used to form fertilizer for the cane-fields. It is rich in lime and nitrogen.

If the evaporating plant breaks down, there is danger of losing juice through fermentation. This is prevented by the use of antiseptics, such as formaldehyde.

Concentration.—The juice is concentrated in a series of evaporating pans enclosed separately in vacuums of varying degrees, that of the first pan (6-inch vacuum) being less than that of the second (15-inch vacuum), and that of the third being nearly the highest that can be practically maintained by large pumping machinery (26- to 28-inch vacuum). These pans are raised on a high platform so that the later operations may take advantage of the force of gravity. The product of the evaporating process, known as massecuite, is a thick, grainy mass composed of crystallized sugar and molasses.

Crystallization. — The operation of converting the sucrose into the crystalline form in which it is sold, under the name of sugar, is carried out in what is known as the vacuum pan, a cast-iron cylinder with a conical bottom and domed top, the bottom containing the pan and its coils of steam-pipe for heating the syrup and apparatus for keeping the boiling mass in motion, and the top being supplied with large delivery pipes for the vapors which must move off slowly so as to prevent syrup entrainment. The highest possible vacuum must be available in the pan, and it must be under complete control, so that the temperature of the boiling can be promptly altered as required during the crystallization of the sugar. This latter operation follows the known laws of crystallization, in that the presence of crystals in a crystallizable syrup has much to do with the formation of new ones, and in that the presence in a syrup of a multitude of minute crystals determines the accretion of further sugar on these crystals as a base. As the syrup approaches the necessary consistency, small samples are drawn off and tested for physical properties,—grain, consistency and the like. The approach of the boiling mass to this point is controlled by varying the vacuum and temperature, and by adding more syrup, this latter being derived from the molasses. At the proper moment the "boiling" is "struck"; that is, the massecuite is delivered from the bottom of the pan through a valve at as low a temperature as possible, part, however, being left in the pan as a basis for the next boiling. Throughout all the apparatus for concentrating and crystallizing the syrup, are placed vacuum gages and temperature gages, and strongly glazed peek-holes are provided for viewing the different processes.

The proper manipulation of the vacuum pan determines not only how much sugar is secured by the centrifugals from the massecuite, but the ease with which it may be done. Improperly grained sugar may be difficult or even impossible of separation in the centrifugals. The amount of sugar that crystallizes out, and the rapidity of the crystallization, depend also on temperature and the perfection of the purification of the juice. Gummy matters not removed from the juice, for example, may delay or prevent crystallization of part of the sucrose. The massecuite may contain as low as 5 per cent of water. The cooled massecuite is dried in centrifugal machines about thirty inches in diameter, run at the rate of 800 to 1,300 revolutions per minute, 1,000 being standard for thirty-inch machines. The sugar passes down from the centrifugals as "first" sugar and, after weighing, is at once bagged.

Bagging.—For this operation the sugar is sometimes elevated again and spouted on to more or less automatic weighing machines. The bags into which it is spouted are sewed by machinery, being carried in succession on a horizontal carrier so that the free upper ends pass a horizontally-acting sewing-machine needle.

Molasses.—The molasses extracted by the centrifugals is cooled and allowed to stand days, weeks or even months, the result being that a further amount of sugar crystallizes out, yielding "second" and even "third" sugars. According to the completeness of the crystallizing, the molasses is rich or poor in saccharine substance. With the best work so little utilizable saccharine matter remains that the molasses is thrown away, or at best is used for fertilizer because of the mineral matter it contains in solution. Where the crystallization is imperfect, molasses of commercial value is a secondary product and may be marketed as such, or be converted into rum or alcohol. With the reduction of the duty on denatured alcohol, recently enacted by Congress, more attention is being given to the manufacture of such alcohol from the poorer grades of molasses.

YIELD—TONS OF SUGAR PRODUCED IN THE WORLD, 1900 TO 1906. Estimated by Willett and Gray, New York.

	1901	1902	1903	1904	1905	1906
Louisiana	275,000	321,676	329,226	215,000	335,000	300,000
Porto Rico	80,000	85,000	85,000	130,000	145,000	210,000
Hawaii	321,461	317,509	391,062	328,103	380,576	370,000
	676,461	724,185	805,288	673,103	860,576	880,000
Philippines (Export)	52,000	78,637	90,000	84,000	106,875	135,625
Cuba	635,856	850,181	998,878	1,040,228	1,163,258	1,300,000
North and South America	2,235,569	2,742,191	2,777,530	2,746,611	3,007,248	3,258,000
Asia	784,120	860,767	947,812	984,561	1,145,775	1,144,525
Australasia and Polynesia	144,554	169,858	133,126	163,328	223,688	232,000
Africa	305,147	278,926	277,473	321,706	232,101	295,000
Europe (Spain)	33,000	28,000	28,000	29,000	29,000	28,000
World	3,502,390	4,079,742	4,163,941	4,244,206	4,636,812	4,957,525
World, with beet-sugar added	9,648,243	10,993,346	9,920,661	10,333,674	9,559,510	12,172,525
United States (beet-sugar)	76,859	163,126	195,463	208,135	209,722	285,000

Enemies.

The sugar-cane crop is subject to the depredations of animals, insects and fungous parasites. Of the animal pests the rat is the most important. It is combated by the usual means, and, besides, is fought by fire and the mongoose. When burning off trash it is possible to entrap the rats of infested fields in a circle of fire. This is sometimes done most successfully. Opinion is divided as to the mongoose. The drawback to its introduction is the fact that it attacks poultry and native birds and useful small animals. By some these depredations are reckoned more than to offset any good it may do in destroying rats. There is no way of exterminating the mongoose, once it is introduced.

Insects.—The list of insect enemies of the cane is a rather formidable one. The worst are the borers, for the most part the larvæ of beetles. These are fought by hand-picking and by agricultural methods, such as the rotation of crops, or the resting of the land, or the use of fire in destroying the "rotten" cane-stalks, which at considerable expense are sometimes gathered together and burned in heaps. Borers are sometimes hand-picked at a cost of hundreds of dollars per annum. Occasionally trap-crops are used, i. e., crops are planted at times calculated to attract the borers and are then cut green and destroyed by fire. In some regions one of the principal items of expenditure in connection with harvesting is that connected with the control of borers.

More than twenty beetles, several ants, several flies, about thirty butterflies and moths, numerous bugs, hoppers, aphides and scales, and several grasshoppers and crickets attack cane. Mites of various kinds are troublesome.

In fighting the insect pests various methods are employed. Where hand methods are applicable they are used. The use of insecticides is for the most part out of the question, the crop being so extensive and bulky, and impenetrable. The introduction of insect and other parasites has been attended with marked success in some instances, and work in this line continues to promise well.

Stripping is closely related to certain insect pests, as it favors some and hinders others. This is one of the reasons for the great diversity of opinion and practice in connection with stripping. The leaf-hoppers are being fought successfully in Hawaii by the introduction of insect parasites and predaceous insects.

The underground parts of the cane plant are attacked by a great variety of free-living and parasitic nematodes, and it has been recently shown that their attacks are a potent factor in various root diseases. The attacks of the parasites cause galls. These worms can be combated only by agricultural methods, one of the chief of which is a method of culture that exposes the soil as much as possible to the action of air and sunlight.

Diseases.—Twenty-five to thirty fungous pests of the cane are known, some of these being the most wide-spread and destructive of all the pests of the crop. Of these, two of the most serious, namely sereh and gumming, are not known to do serious damage in the United States or its possessions. Most of the others are probably as prevalent on American plantations as elsewhere, due regard being had to climate and other local conditions. The following is a list of the fungous diseases of cane somewhat in the order of their seriousness: Root diseases, rind disease, sereh, pineapple disease, red-rot, top-rot, smut, rust and various leaf and leaf-sheath diseases.

The nature of the cane crop precludes the use of fungicides except in connection with the rots that attack the cuttings after planting. Here fungicides come into play as explained on page 606. The remainder of the pests are fought by modifications of agricultural practices. Where the pests are abundant it is generally advisable to burn over the fields after each crop is removed. This results in the destruction of a vast amount of diseased material that would otherwise remain to infest the succeeding crop. Where the pests are not prevalent, the plowing in of such refuse is permissible. The destruction of infested cane of all kinds is sometimes accomplished by passing it through the mill at convenient times, as at the end of the week where the run is a weekly one. The crushing and heat kill everything thus treated and it seems probable that this method will come into wider use. It is possible that in a large mill, it would pay to maintain a small set of rollers for this purpose.

Careful attention to the seed, its selection in the field and its careful preparation and planting, constitutes a strong defense against these pests. Special plows and other tools have been devised for use in fighting these enemies. Quicklime is used as a soil fungicide.

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SUNFLOWER. *Helianthus annuus*, Linn. *Compositæ.* Fig. 837.

By *A. M. TenEyck.*

The sunflower is a native annual plant, the seeds of which are used for bird and poultry food, and to some extent for stock-food and for the manufacture of oil. The entire plant is also used for feeding dry and for ensiling. The seeds of the large-seeded variety are sold in Russia as peanuts are sold in this country, except that they are to be eaten raw. The stems are 3–20 feet high, rough-hairy, often mottled; leaves 4–12 inches long, broadly ovate, acute, and the lower cordate, coarsely serrate, rough on both sides; flower-heads 3–6 inches wide in wild specimens, often 14–22 inches in cultivated specimens.


Fig. 837. Sunflower (*Helianthus annuus*).

Although the sunflower is native in Kansas and the Great Plains region from Nebraska to Mexico, it has received little development by culture as a farm crop in this country. The American Indians cultivated and developed it, using the seed for food and to make oil which they used on their hair. These cultivated varieties were first introduced into Europe about the middle of the sixteenth century. In western Europe and America the plant has been grown chiefly for ornamental purposes, or occasionally for poultry food, and, except in recent years, has hardly risen to the dignity of a farm crop; but in Russia, sunflower seed has come into general use as a staple article of human food and for the production of oil, which resembles olive oil and which is used in cooking and for other domestic purposes in that country. In recent years some exportation of this oil is being made from Russia to other countries. In Russia the plant has come to be extensively cultivated; improved varieties have been developed, and the best varieties now grown in the United States are those introduced from that country. The crop is also grown extensively in India and Egypt.

Sunflowers have a wide adaptability, and could be grown successfully throughout a large part of the country. For growing on a commercial scale, however, the Ohio valley and Kansas and Missouri seem to be best adapted. Sunflower seed is very rich in fat and protein, containing four to five times as much fat as corn and more protein than any of the cereal grains. In protein, it compares well with peas, cowpeas and soybeans.

Varieties.

Aside from the common sunflower, two other varieties are grown in this country. The largest flowered of the three is the Black Giant, in which the heads may reach a diameter of twenty-two inches. In the Mammoth Russian the heads may reach a width of twenty inches. The seeds of the former are about three-eighths of an inch long, and black; the seeds of the latter are slightly longer, and bear dark stripes.

Culture.

Soil.—Sunflowers may be grown successfully on any good corn land in those states which are best adapted for growing corn. For the largest crops the land should be fertile, and especially rich in humus and nitrogen. The crop exhausts the nitrogen of the soil in producing the large amount of protein stored in the seed, though the most valuable constituent of the plant, the oil, is formed during growth from the elements carbon, hydrogen and oxygen, which are secured by the plant from the water and the air without diminishing the fertility of the soil. The crop has succeeded on alkali soil in California.

Planting.—Sunflowers should be planted at about the same time as corn, though somewhat earlier planting is safe, as slight frosts are not injurious to the young plants. The seed may be planted with a grain drill or drill planter in rows three to three and one-half feet apart. Usually to insure a good stand the seeds are dropped three to four inches apart in the drills, and later the plants are thinned to twelve to eighteen inches apart in the row. The seed is planted in a well-prepared seed-bed, a little shallower than corn would be planted under similar conditions. Six to twelve pounds of seed per acre are used. Shallow cultivation is given, and the subsequent care is much the same as for corn. It is advised to remove all but three or four heads per plant when the plants are in bloom, in order that the best development may be secured.

Harvesting, threshing and storing.

The sunflower heads should be harvested before the seeds are fully ripe. As soon as the seeds are ripe they begin to shatter, and before the crop is mature it is likely to be damaged by birds which gather in flocks to feast on the rich seeds. As ordinarily gathered the seeds will not be dry enough to shell and store, but the heads should be cured for a week or so before threshing or shelling. If only a small quantity is grown the heads may be spread out on the barn floor or in a loft or shed. At the Kansas Experiment Station has been followed the plan of cutting off the heads with a sickle or corn knife and putting them in shallow windrows in the field for several days, when they are hauled in and threshed or stored in large piles. More or less loss attends the handling of the crop in this way.

There seems to be no satisfactory or economical method of threshing out the seed. Often the seeds are shelled out by hand, or they may be pounded out with a flail. Some farmers construct a wooden disk or wheel arrangement, hung and operated in the same way as the ordinary grindstone. The sides of the disk are driven very full of nails, against which the sunflower heads are held as the disk revolves, thus removing the seeds quickly. These methods are slow and cumbersome. Although the writer has not seen it tried, it seems probable that when the heads are fully dried the seeds may be threshed out by the ordinary grain separator. At least some cheap and more rapid method must be found for harvesting and handling the crop before it can be grown successfully in a large way.

If the seed is fully dry when it is threshed it may be stored safely in large bins, but if the heads are yet green and the seeds not fully dry when threshed, the seed must be spread out and dried before storing in large quantities. Often the seed may be stored safely in sacks, barrels or small bins before fully dry. Fermentation must be avoided, otherwise the quality of the oil will be lowered.

Yield.

By the reports of farmers who have grown the crop, an average yield appears to be 1,000 to 1,500 pounds of seed per acre. W. S. Dean reports a yield on his farm of 2,250 pounds of seed per acre in 1894, while other growers report yields as low as 600 pounds per acre. The yields of green matter per acre is four to five tons. The average weight of a bushel of seed is about thirty pounds.

Uses.

Feeding.—No experiments in feeding sunflower seed to stock have been published by any of our experiment stations. Some experiments were made several years ago in Maine, Vermont, and at some of the Canadian experiment farms. in ensiling sunflower heads in combination with other crops, and feeding the silage, but, on the whole, the results of these experiments seem to have been unsatisfactory. By the reports received, so far as sunflower seed has been fed by farmers in this country the results have been satisfactory. The whole seed ground and fed with other grains makes a rich and palatable food for growing and fattening stock. If sunflower seed can be produced in sufficient quantity and cheaply enough, it should become a valuable feed for stock in this country. In Russia, the stalks of the plant are ground up and fed as roughage to horses, cattle and sheep.

In the manufacture of sunflower oil, "oil-cake" is left as a by-product, and meal made from the oil-cake makes an excellent food for stock. The cake is rich in protein and oil and is well relished by stock.

Robertson mixture.—The Robertson mixture is a combination of corn, sunflower heads and broad beans in the form of silage, in the proportion of one-half acre of sunflower heads to two acres of broad beans and corn. The corn and beans are harvested when the corn in the ear is beginning to glaze. Fifty pounds of this mixture may take the place of the corn silage in the ration, using about four pounds less grain than ordinarily goes with the corn silage. [See *Bean, Broad*, p. 212.]

Oil.—The small-seeded variety is preferred for the manufacture of oil. When cold-pressed, a yellow, sweet oil is secured that is considered equal to olive or almond oil for table use. If this residue or "oil-cake" is warm-pressed it yields an oil that is useful for lighting purposes, and for woollen-dressing, candle- and soap-making. The percentage of oil ranges from 15 to 28.

Medicine.—Sunflower seed also has some medicinal use. When ground and mixed with other food products and fed to animals it improves their digestion and keeps them in good physical condition. The ground seed is said to be used extensively as an important constituent of condition powders and stock-foods.

Paper and fiber.—Sunflower stems are used for fuel, though they would make excellent paper stuff and yield a fine fiber if industries were developed thus to utilize them.

Commercial status of the crop.

Up to this time sunflower seed has been used mainly for poultry food and in the manufacture of stock-food. For these purposes the limited amount grown has usually found a ready sale at an average price of about two cents per pound. Sunflowers may be grown at about the same cost per acre as corn, but by the methods now employed the harvesting and threshing of sunflower seed is a rather slow and expensive process, and until better methods and improved machinery for handling the crop are secured, it is not practicable to grow sunflowers on a large scale.

Literature.

The best publication on the sunflower which the writer has seen is Bulletin No. 60 of the Division of Chemistry, United States Department of Agriculture. This bulletin has been used in the preparation of this article.

SWEET-POTATO. *Ipomœa Batatas*, Poir. (*Convolvus, Batatas*, Linn. *Batatas edulis*, Choisy.) *Convolvulaceæ.* Figs. 838–847.

By *M. B. Waite.*

The sweet-potato is an edible tuberous root, much valued in this country, especially in the southern states, where it is a staple. It is used chiefly for human food as a table vegetable, for canning and for pies. It is more valuable for stock-food than the Irish potato because of its high content of fat, sugar (4–6 per cent) and starch (16–18 per cent). Hogs can be turned in the patch and will root out the sweet-potatoes for themselves. The sweet-potato is sometimes fed to cattle and horses, for which purpose it is sliced.

This plant belongs to the morning-glory family. The trailing vine closely resembles some of the wild species, especially *Ipomœa pandurata*, and it is difficult to distinguish the latter when it grows as a weed in the sweet-potato patches. The flowers, which are rarely produced in the North, resemble very closely those of the common varieties of morning-glory, but are smaller. The leaves are ovate-cordate, usually angular or lobed, petioled and exceedingly variable; the peduncles equal or exceed the petioles, several-flowered, the corollas one to two inches wide. The flowers are purplish, 3 or 4 on each peduncle or branches of the peduncle; stamens 5; pistil 1, ripening into a pod with four 1-seeded cells.

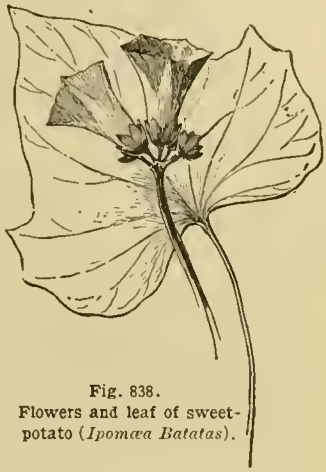

Fig. 838. Flowers and leaf of sweet-potato (*Ipomœa Batatas*).

The nativity of the sweet-potato is unknown, but it is probably tropical America. It was cultivated in the tropics of both hemispheres when authentic records began. DeCandolle inclines to an American origin. The species *Ipomœa Batatas* is nowhere known in a wild aboriginal state; it has been suggested that it may be a derivative of some other species, as *I. fastigiata.* Safford saw models of the sweet-potato in the pre-historic Yunta graves of Ancon, Peru, which exhibited the pentagonal form often seen in certain varieties.

Distribution.

The sweet-potato is essentially an American crop, but it is now in cultivation in many of the islands of the Pacific. Some of the varieties in cultivation in the United States have come back from China. Commercially, the northern limit of sweet-potato-culture on the Atlantic coast of America is about the middle of New Jersey. This line, extended westward, barely takes in southern Ohio and Kansas. At Muscatine island in the Mississippi river and in certain other warm, sandy soils from there southward, a few districts compete with the southern growers. Sweet-potato-culture practically disappears on the Rocky mountain plateau and the arid regions of the West, except in irrigated sandy soils far to the southward, as in southern New Mexico, Arizona and in California. The crop is grown extensively in southern California under irrigation, both in the Imperial valley and in the Los Angeles district. It is also grown under irrigation on some sandy soils of the lower San Joaquin, especially near Merced and Atwater, and to a limited extent at other points in the great interior valley of California. The crop does not appear to be adapted to the cool nights and dry atmosphere of the Rocky mountain plateau, or the great basin, or even in the higher parts of

Arizona and California, in spite of the fact that the total heat is more than ample and the warm sandy soils supply ideal conditions, with irrigation water to maintain the soil moisture. Sweet-potato-culture, therefore, even in the warm parts of arid America is pursued commercially only at a few points. Sweet-potatoes may be grown in the northern states by careful attention, but neither the quality nor the quantity of the crop is satisfactory when compared with that of the South.

According to the Twelfth Census, the sweet-potato is the most extensively grown vegetable in the United States, next to the Irish potato. In 1899 it was reported by 1,001,877 farmers, or more than one-third of the number reporting Irish potatoes. The acreage, including that of yams, was 537,447, and the value of the crop in 1899 was $19,876,200. The five leading states in production were North Carolina, Georgia, Virginia, Alabama and South Carolina. They produced 52.1 per cent of the aggregate crop. Georgia, North Carolina, Alabama, South Carolina and Texas cultivated, in the order named, 70,620, 68,730, 50,865, 48,831, 43,561 acres, which constituted 52.6 per cent of the acreage of the crop of 1899. The acreage of the south Atlantic division was 49.1 per cent of the total; the south central, 39.9; the north central, 6.2; the north Atlantic, 4.5, and the western division only 0.3.

Culture.

Climate.—The sweet-potato demands, for best results, a rather warm, moist climate in the growing season. An ideal season is one which has frequent showers from April and May, when the crop is planted, into July or early in August; then when the crop is maturing in August and September, rather dry weather should follow. This is particularly true of the much-grown Yellow Jersey type of sweet-potato, which is retarded by drought before the plants are established and requires considerable moisture for proper growth. On the other hand, cold rains on the young plants are objectionable. North of the cotton-growing districts heat seems to be the important and frequently lacking requirement. In the cotton-belt, however, the temperature conditions are more favorable.

Soil.—The sweet-potato likes a warm, sandy soil that is well drained and well aërated. Light sandy soils may sometimes be benefited by artificial drainage if the subsoil is slowly pervious. The highest yields are often secured on sandy knolls on which corn would fire or burn, and other crops suffer from lack of water. New, cleared land on which a crop of corn has been grown raises fine crops of sweet-potatoes. Successful crops are often grown on soils that are not ideal, provided they lie on hill slopes and are otherwise exceptionally well drained. The red clay hills in the Piedmont region of the Atlantic and Gulf states grow good crops, although, as a rule, commercial cultivation is not attempted on these soils. Some clays are crumbly and grainy so that they allow the necessary aëration, and the droughty character of the soil may prove favorable.

Fertilizers.—The sweet-potato is especially susceptible to artificial fertilizers and manures, and on droughty soils where weak vine-growth is likely they should be employed. Humus is essential. For old land, growers sometimes haul pine leaves or "woods trash" to the fields in the winter and plow it under to supply humus. Light straw manure is very favorable. Crimson clover sod is especially valuable for this purpose when old land is to be used. If used as a cover-crop, crimson clover should be plowed under when it has made half its growth. Cowpeas are excellent, but they disintegrate rather too rapidly; and while the cowpea land works up well in the spring, it does not retain its humus through the season so well as the clover. As a rule, the cowpeas should be left on the ground, or perhaps, pastured by hogs, and plowed under in the spring two or three weeks before planting. Rye plowed under when it is just shooting into head is also excellent, though by no means as good as the clover. [See below, under Preparation of the land.]

Place in the rotation.—Sweet-potatoes do very well after corn, cantaloupes, tomatoes and most other field and garden crops, with the exception, perhaps, of root crops. In general, planting after fall-dug root crops is not to be recommended. Corn, melons, tomatoes and certain other crops give an opportunity for sowing crimson clover at their last cultivation, and there is nothing better for the sweet-potato crop than to plow under crimson clover when it is about six or eight inches high. Early dug potatoes and early harvested vegetable crops can be cleared from the land and crimson clover sown. Cowpeas may be sown in the same way, but for the later crops this is not so desirable.

With heavy manuring and fertilizing sweet-potatoes can be grown on the same land for several years with good results, but this practice is not to be recommended. The writer has had excellent crops for three years in succession, but generally the second crop has been the best. This is doubtless the result of the accumulation of manure and fertilizer from the previous crop. The third crop begins to feel slightly the injurious effect of continuous cropping. One evil of successive crops of sweet-potatoes on the same land is that too little opportunity is afforded for cover-crops and for the addition of humus. Sweet-potato vines decay so completely that they add little humus to the soil. With early dug sweet-potatoes, however, especially toward the South, crimson clover or rye, or even winter oats, can be sown to supply organic matter.

Preparation of the land.—As a rule, very deep plowing is not best for sweet-potatoes. The commercial demands are for a short, thick root as nearly round as possible, and deep preparation, though increasing the total yield, tends to make long roots. On the average, five or six inches may be regarded as the proper depth, although seven inches would answer very well; some growers prefer to plow only three or four inches. The plowing should be done shortly after the land comes into condition in the spring; as the sweet-potato is an intensive money crop, it is often possible to select the most favorable time for plowing for this crop. When the soil reaches a certain condition, neither too wet nor too dry, it crumbles nicely before the plow and harrows down into a fine garden condition. Since the sweet-potato plants have to be transplanted into the soil, specially fine preparation is required. It is seldom safe to postpone the harrowing of sweet-potato land. A spike-tooth harrow should be run over the land the same day that it is plowed, thoroughly pulverizing the surface. In certain very light sandy soil best adapted to sweet-potatoes, the preparation is so simple and easy that no special care is required. But many sandy soils have enough clay in them to bake and form clods, and hence need careful attention.

After the field is plowed and harrowed, the fertilizer can be drilled in, or sown broadcast if it is desired to make a large application. The writer uses 1,200 pounds per acre, 800 pounds of which is drilled in after the harrowing. This is done preferably at least two weeks before planting, so that, if possible, one or two rains will intervene, thoroughly dissolving and diffusing the caustic parts of the fertilizer. If there is a rain sufficient to wet down the plowed land, and this is particularly desirable at this time, as soon as the soil comes into condition it is thoroughly and deeply harrowed with a disk-harrow or one of the cutaway or spading harrows. The disk is then followed either at once or in a short time by the acme, spike-tooth or some surface pulverizing harrow. Land in this condition, finely pulverized and full of moisture, is ready to resist any reasonable drought, and the plants can be set out in all but the most intensely dry weather. A week or two before planting time, furrows three to five inches deep should be run with a one-horse plow. The distance may be three feet six inches to four feet, or even slightly more. In these furrows, 400 pounds per acre of commercial fertilizer is applied. This can be put in most economically with one of the little distributers of the wheelbarrow type. The manure can then be distributed in the bottom of the furrow. The quantity of manure naturally varies; the average would be a strip four inches wide and one inch deep. If the manure is light and strawy, of course the depth would be greater.

In applying such a quantity of manure an average forkful reaches three or four feet in the drill, and the amount used per acre is about eight tons. The manure can be applied previous to plowing. It may be spread on crimson clover sod in the fall, with excellent results, or it may be distributed on the ground in the winter. Care should be taken, however, not to haul heavy loads over the land when it is very wet. Most sweet-potato-growers prefer to put the manure in the furrow under the crop. The greater economy of fall and winter distribution in labor and teams is an argument for the latter method. If possible, the drills should be opened, the fertilizer and manure applied and then a ridge bedded over the fertilizers by a one-horse plow the same day, unless the soil is very moist. In dry weather it is also necessary to bed up the ridges several days before planting, while in a tolerably moist time planting can proceed at once after bedding.

Starting the plants (Figs. 839–841).—While the preparation of the soil is in progress, the propagation of the plants should be proceeding. Sweet-potato plants can be purchased in quantity, and some growers prefer to buy them from men who make a business of growing the plants. Formerly, in the southern states parts of the sweet-potato roots were sometimes cut and planted after the method commonly used for Irish potatoes. As a rule, however, plants are grown in the hotbed, pulled from the potatoes when they are the proper size and transplanted into the field. The propagation of these plants in the hotbed becomes one of the important features of the growing of this crop.

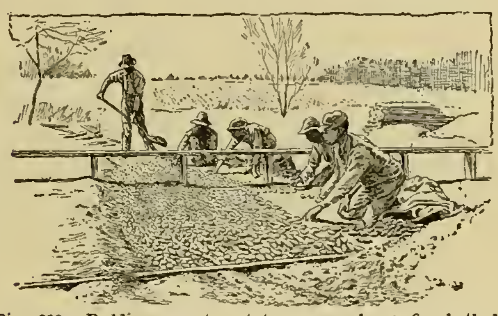

Fig. 839. **Bedding sweet-potatoes on a large fire hotbed, twenty feet in width.** Sweet-potatoes rest on four inches of soil and are covered two inches deep.

Ordinarily, the small potatoes, three-fourths inch to about one and three-fourths inches in diameter, are stored separately and are used as seed-roots. Generally the seed-roots are saved from the ordinary crop and more or less selection is practiced by choosing the short, smooth shapely roots, or, at any rate, by rejecting the misshapen, ribbed or crooked potatoes. "Slip-seed" is generally preferred to "seed-roots" saved from the crop. This is produced by taking cuttings from young vines, varying in length from eight to ten inches up to twenty inches, and thus avoiding fungous diseases which are carried over on the roots. "Slip-seed" is also supposed to be more vigorous and productive. Usually "slip-seed" may bring nearly double the price of ordinary "seed-roots." This is particularly true in New Jersey, Maryland and elsewhere, where propagation from cuttings is not so easy as it is further south where there is a longer season. In the South, it is not unusual for a man who is to plant ten acres of sweet-potatoes to bed a barrel or two of roots, plant a couple of acres and then make cuttings for the remainder of the crop. These cuttings may consist of two or three joints of the vine with a single leaf on the upper joint, or, possibly, of a longer piece. When short cuttings are used they are set out just like plants, leaving the single leaf and bud above ground. When longer cuttings, a foot or two in length, are used, the cutting is usually planted about half its length in the ground. Some growers use a long cutting and loop it, putting both ends in the ground. These cuttings can be planted out in moist weather the same way as plants, and in a favorable "season" appear to leaf and root almost as well as rooted slips.

The roots should be bedded in the hotbed a month or six weeks previous to planting time. In the latitude of Washington, where planting begins May 10, the roots should be planted in the hotbed about April 1 to 10. Usually in the first two weeks in April there is a warm-wave which hurries out the peach blossoms, and these are followed a week later by the pears. The bedding season, therefore, may be considered as the time when peaches and pears are in blossom. In the northern states it is necessary to bed the potatoes in hotbeds a month or more earlier than the climate will permit them to live in the field.

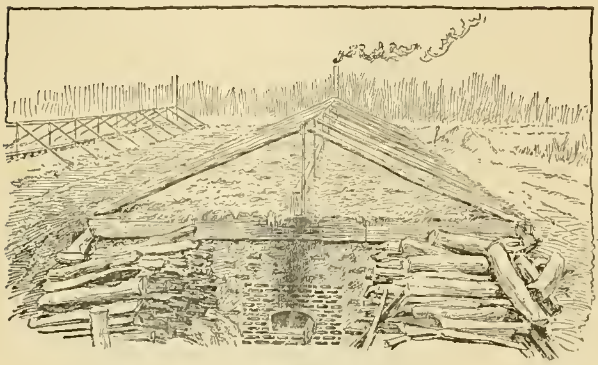

Fig. 840. Fire hotbed in operation, with four inches of straw-covering and without the tent. Tent should replace the straw after the plants are up.

Various types of hotbeds are in use. The simplest arrangement for the southern states is a little pit or frame sunk in the ground ; about six inches or more of manure is carefully filled in; and a four-to-five-inch layer of good sandy loam is placed on the manure. This should be moistened, after lying about forty-eight hours for the first heat to pass off, especially if the manure is new; the potatoes can then be bedded. Bedding or planting sweet-potato "seed-roots" consists simply in laying them on the soft sandy soil, preferably with their ends all in one direction, and cross-ways of the bed ; when the potatoes are curved, the convex side should be upward, thrusting the points in the sand. They are then covered with the same sandy loam to a depth of about one and one-half inches above the upper surface of the roots. Some growers prefer to cover them lightly, say one-half inch ; then, after the tips appear, to add the additional inch of soil. The simplest protection consists of a layer of pine leaves six inches thick. This has to be carefully watched, however, and removed as soon as the sprouts begin to appear, otherwise slender white "drawn" sprouts will result. A better covering is a cheap grade of white cotton cloth, and a still better one is the ordinary hotbed sash. Extensive beds, utilizing several dozen sashes, are in use by some growers.

Wherever glass sash is used, careful attention has to be given on the first warm days, especially after the sprouts appear, to ventilate the beds by placing a block under the end of one sash and under the opposite end of the next sash, and so on.

Before the plants are up a warm spell may be had, or, through some unusual activity of the fermenting manure, sufficient heat may be generated to cause the roots to decay. Old-time gardeners trust to their sense of feeling in changing the heat. A better method is to use a thermometer and to keep the temperature as low as 90° Fahr., preferably between 80° and 90°.

The best method of propagating the sweet-potato in the North is through the fire hotbed (Fig. 840). The intense bottom heat, with the exposure of the plants to the open air during a large part of their growth, not only makes this an effective method of getting large quantities of plants, but with proper attention to the covering and watering the plants will be of the most desirable quality. Briefly, the fire hotbed consists of a floor or bed on floor beams or joists with a two-foot air space underneath and with a brick furnace at one end, from which tile flues carry the heat part way across the bed. At the opposite end a wooden flue, some ten feet in length, carries off the smoke and furnishes a draft. The bed should be sunk in the ground nearly to the level of the soil and should have a tilt or incline of about one foot to every twenty or thirty feet of length. Since the upper half of the bed, or rather the air space beneath it, serves as a chimney, this inclination is required to carry the smoke and hot air from the furnace to the far end of the bed. With this inclination the bed will be but little warmer over the furnace than it is at the opposite end. The brick arch or furnace should be depressed so that its top is three feet below the floor beams. It is then covered with a foot of soil, making the two-foot air space continuous. In an average-sized bed, say sixty to eighty feet long and twelve to fourteen feet in width, the furnace should be six feet by two feet six inches inside, so as to burn cord-wood. The flues should be of six-inch tile and should extend for about thirty feet, gradually rising to the surface of the ground until at the outlet it is raised one inch above the ground. At thirty feet from the furnace the smoke and the fumes will be sufficiently cooled to permit discharging into the air space without danger. An inch or two more of soil, however, should be placed under the plants in that part of the bed directly over the furnace and over the discharge of the tile flues. No wood construction can be used in touch with the furnace. The end wall has to be built of brick or stone. To avoid digging a pit in which rain may collect, it is best to place the bed just at the crest of the hill, allowing the furnace end to extend over the crest.

The remainder of the walls of the hotbed may be built of wood, cement, brick or stone. The floor beams should be of some rot-resistant wood, such as chestnut, cypress, or whatever it is customary to use as posts in the vicinity. The walls may be built of wood by setting posts two or three feet apart and spiking slabs or planks on the outside. A rough floor is laid over the floor beams, four or five inches of soil is put on, and then the roots and the covering are applied in exactly the same way as with the manure hotbed. A cover may be conveniently constructed by placing rafters eight or ten feet apart and connecting them with the ridge-pole, forming a skeleton roof; over this is stretched ordinary unbleached cotton. (Fig. 841.) There is no great necessity for heavy cloth such as tents are made of, except that it will last longer. The cotton cloth should be sewed into a single sheet and a roller made by tacking together strips three-fourths-inch by one-and-three-fourths-inch, fastening the edges of the cloth between them. The gable end may be of boards or of cloth.

After the potatoes are bedded the cloth tent is put in place and kept there until the plants begin to push through, which should be in about ten days to two weeks. Sometimes a few precocious sprouts will be through in less than a week. After the plants begin to break the soil, attention should be given to ventilating the bed on very hot days. A thermometer should be placed at some average point in the bed, and when the outside temperature is in the eighties, as often happens in the latter part of April or May, the cover should be rolled up, and unless the night is unusually warm it should be lowered at sunset. As warm weather and planting time comes on, the cover may be rolled up and the bed kept open to the air the greater part of the time.

After the roots are bedded the bed should be moistened by watering. It is a great mistake to bed the roots in rather dry sand or sandy soil and leave them several days without watering. Moistening the soil and the roots starts them into activity and prevents rotting. It is not desirable, however, to keep the hotbed very moist until the plants are up. When the plants are breaking the crust a good watering should be given, or, better yet, the cover

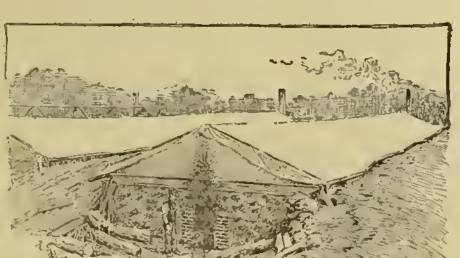

Fig. 841. Fire hotbeds in operation, showing furnace end. The cloth covers are here shown in place.

should be raised while a spring shower is passing. All experienced sweet-potato-growers agree that no watering is so beneficial to the growing plants as a warm rain. If too much rain is falling, especially if followed by a cold wind, the covers may be rolled down as soon as the bed is moistened. As the plants begin to form leaves and draw heavily on the soil moisture, they will stand a great deal of watering. In fact, up to a certain limit the output of the bed is largely determined by the amount of water given. Too much water makes rank, sappy and tender plants. It is a good plan to keep the bed somewhat dry for two or three days before using the plants for setting out, but serious losses in the next pulling will result if this is carried too far.

When the planting season arrives and the plants are four inches above the ground, making their total length with roots about six to seven inches, the bed may be gone over and all plants of sufficient size carefully pulled. Usually, when the fingers are thrust below the soil-line and the plant skilfully pulled sidewise it will come out without dislodging the root. In pulling those plants which are up to size, it is important to disturb as little as possible the root and the other growing plants. As soon as a given area is pulled over, it should be immediately watered to wet down the disturbed roots and prevent injury to the remaining plants.

An average barrel of seed-roots will cover fifty to sixty square feet of space on the hotbeds. The larger the roots the smaller the space covered, and vice versa. At the first pulling the product of a barrel of roots under favorable conditions will be 3,000 to 5,000 plants, or sufficient for a half-acre or more of ground. As soon as the bed is pulled over, by watering and perhaps adding a little soil and giving the necessary attention, the remaining plants continue to grow and new sprouts are pushed out from the same roots. In this way the bed is ready to pull over again in ten days to two weeks, or perhaps even less time, depending on how closely it was pulled at first. Three pullings are commonly taken from the hotbed during the planting season, but sometimes more. The first pulling is usually regarded as slightly superior to the others.

When plants are grown for sale they are commonly tied in bundles of one hundred, when they may be packed and shipped about the country by express. If they are to be used on the farm, it is a good plan to have a tub of mud batter made by mixing some good clay soil or river mud with water, preferably with the addition of fresh cow dung. The plants are then dipped in bunches of about twenty into this batter and kept in the shade in baskets or trays until they are used. It is necessary always to set them in a vertical position, or they will curve to the light.

Transplanting.—It is a problem to get the plants set out in a proper and timely way. The old method was to depend on a "season," or a rainy time, and with a mild spring shower and a set of active men results can be secured in this way equal to the very best. For hand-planting it is usually best to throw up a ridge four to six inches higher than necessary, and then a boy with a garden rake can flatten the top of the ridge to six or eight inches in width nearly as fast as he can walk. A better way is to fasten a board, five or six feet long, on an old cultivator frame ; by this means a boy and a horse can knock off the tops of two ridges at once.

In dry weather, if the ground has been properly prepared so as to maintain its moisture, and the ridges have been thrown up several days before so as to allow the subsoil moisture to rise, plants can be set with perfect success without a "season." The tops of the ridges are knocked off just ahead of the planting, exposing the moist soil, and the plants, having been lightly dipped at the hot-bed, are dipped in a rather thick batter, so that a considerable mass of mud clings to each plant. They are then dropped and planted at once. Some growers prefer in dry weather to have an extra boy drop a small dipper of water with every plant, and this is undoubtedly a good practice. The object in transplanting is not only to have the plants live, but to have them prosper, and attention to the care of the plants, especially the prompt dipping and the proper watering, will result in the prompt response of the plant.

The customary distance apart in the row for sweet-potatoes is eighteen inches. With the big-stem Jersey variety the writer prefers to plant sixteen inches apart to keep down the size. Some men are able to guess this distance accurately, but as a rule a marker should be made. A common and convenient form is that shown in Fig. 842, which consists of a strip of wood six feet long, on which five cleats, $1\frac{1}{2} \times \frac{3}{4}$ inch, are screwed. A handle and brace complete the structure. The whole should be light so as readily to be carried by a boy in one hand. One boy goes ahead and marks the places, and another follows with a bundle of plants, dropping the plants at each mark, while a man either with a trowel or dibble, or on very soft ground with the hand, sets out the plants. The handiest tool to use in this way is a rather small mason's trowel. The trowel is thrust into the soft ground with the right hand, the plant slipped in position with the left hand, and while the top is still held the trowel is withdrawn and with a single punch of the fist, the earth is driven compactly about it. An average worker, with boys to drop and mark, should set an acre of 7,000 to 8,000 plants a day. This is such tiresome work that few men are able to keep it up for many days in succession. The writer has had men set 15,000 plants, or two acres in a day.

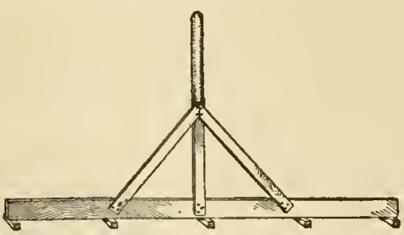

Fig. 842. Hand-marker for the proper spacing of sweet-potato plants.

For setting out large areas, say twenty acres or more, it will usually pay to get a transplanting machine. Several of these transplanters are on the market, and work with a fair degree of success when operated by a well-trained crew. One great advantage of the transplanting machine is that it carries its water, enabling the planting to proceed in dry weather; in fact, it can be used only when the ground is dry enough to cultivate. As a rule, the ridges need to be a little higher and wider with the machine than with hand-planting. A slow, steady team and a skilful driver are necessary to make straight rows. Two boys quick with their hands are required. When the outfit is working properly, twenty-five to thirty thousand plants a day can be transplanted.

Fig. 843. Transplanting machine setting sweet-potatoes. See Figs. 230, 871.

There are several other methods used in setting out plants, particularly by the New Jersey growers in their soft, sandy soils. One of the simplest planting machines is a lath or stick about the length of a cane, one end of which is two inches wide and distinctly concave; over this concave end a piece of soft leather is tacked. As the boy drops the plant as nearly as possible in its proper place, the man following simply pushes it into the ground by dropping the leather-covered staff over the root-end of the plant. A second thrust is made to force the soil around the plant. More elaborate tongs and planters are used in some places.

Cultivation.—The first operation in the cultivation of the sweet-potato is ordinarily the splitting out of the middles. A round trip is made with a one-horse plow, throwing against the sides of the ridges the additional soil left undisturbed in making the ridge. This is done within a week from planting time, or as soon as convenient, and before weeds have started. It is followed before weed-growth begins, and usually within two weeks of planting, by the first cultivation. The cultivator used by the writer is an ordinary five-tooth garden cultivator of the Planet Jr. type, having a narrow (one and one-fourth-inch) tooth to go next to the plants. The rear tooth can be a broad one, so as to throw the dirt to some extent toward the ridge. Straight rows are very necessary for good cultivation. With care, the ground can be disturbed the first time within two inches of the plants.

The next operation ordinarily is hoeing. Hand-hoeing is one of the most expensive operations and may exceed the cost of planting. To keep down the expense, the writer has used a weeder extensively. It is rather difficult to use the weeder to accomplish the purpose without destroying many plants. It is important to have the ridges broad, so that the cultivator tooth will not tear down too much of the soil. Furthermore, the weeder must be used before the earth becomes too firmly compacted by the rain, or before the weed seedlings have come up. In other words, the weeds must be killed while the seeds are germinating in the soil. Hand-hoeing is much cheaper when it is done promptly than when deferred until the weeds and crab-grass form a thick mat on the uncultivated strip. As a rule, two hoeings may be made cheaper than one. If the first hoeing is timely, just as the weeds are beginning to come up, the second one will be extremely light.

Three or four cultivations are commonly practiced, although in the South sometimes two are sufficient. In the second cultivation the ordinary cultivator tooth is used and kept at a distance of four or five inches from the plant. On the third or fourth cultivation the vines should be beginning to run. A vine-turning attachment, a special tooth and rod, enables the cultivator to pass through, lifting the vines from its path. Cultivation in Maryland ordinarily ceases early in July. The method usually pursued is to keep the crop clean until the vines begin to cross the rows, then lay by, when the ground will be quickly covered and weeds will stand a poor chance. If occasional bunches of crab-grass or weeds still escape, it is necessary to go over the patch and hand-pick them, as these, especially crab-grass, draw heavily on the yield and are a nuisance in digging.

The vines root at the joints very commonly, especially the Nansemond or the Yellow Jersey, and form numerous potatoes, usually of the size of one's finger or smaller. Little attention need be paid to this by the commercial grower. The Big-stem Jersey and many other varieties, while rooting freely, deposit nutriment wholly in the hill.

Digging, storing and marketing.

Digging, storing and marketing the sweet-potato may be considered as two types of operation — digging and marketing from the field in the summer and fall, and storing the crop and marketing in the winter.

(1) *Marketing from the field.*—Harvesting the crop to ship direct from the field is a comparatively simple operation. It is best, even with a small patch, either to plow out the crop or to dig it with a machine-digger, which is essentially a modified plow. If the vines are very heavy it may be necessary, when using the common plow, to make a trip on one side to cut the vines, and then follow with a furrow, throwing out the potatoes. As soon as the potatoes are plowed out they are lifted and broken from the vines or left on the ridge to dry. After they are surface-dry the pickers gather them in baskets. It is customary to sort the potatoes as they are picked. The picker carries two baskets, —one for primes and the other for seconds. The latter are the small, inferior or misshapen roots. Some growers put all grades together, but this usually is not considered good marketing. The potatoes are barreled in the field, usually in open-head truck barrels, which may be regarded as the commonest package for sweet-potatoes. Where fancy stock is being sold to discriminating markets, the potatoes may be put in double-head or special barrels, such as flour barrels, and the heads pressed in, as is customary in barreling apples. The greater part of the crop, however, goes in truck barrels covered with burlap.

Great care should be taken not to keep the potatoes exposed too long to a very hot sun; when digging in hot weather it is a good plan to keep the potatoes covered up closely, and haul the baskets either to the shade of the packing house or to a grove of trees and pack under cover. It is necessary in hot weather to use ventilated barrels, both in case of the open-head truck barrels and the double-head barrels. Sometimes the potatoes are hauled directly to the city markets in peach baskets or crates.


Fig. 844. Field of sweet-potatoes. Delaware.

(2) *Sweet-potato storage and winter marketing.*—In digging sweet-potatoes for storage, much care is required not to bruise or injure them. The potatoes are dug preferably just before the first frost, when the crop is as nearly ripe as possible and has nothing further to gain by remaining in the field. This stage at Washington, D. C., is reached about the 5th to the 10th of October. Warm weather is necessary in digging. The potatoes are plowed or thrown out by the digger and are allowed to surface-dry in the sun. Usually, this requires one to two hours, but if the soil is very dry the potatoes may be picked up into baskets at once and will be surface-dried before they reach the bins.

Two methods are employed in sorting the potatoes. It is usually necessary for those who sort for seed to separate the seed or small potatoes from the shipping potatoes, and also to cull out strings and other defective roots, fit neither for seed nor

Fig. 845. Sample hill of sweet-potatoes, showing six or more merchantable potatoes and two seed-roots or "seconds."

market. This may be done in the field, when those gathering the potatoes sort them in separate baskets. When first-class help is used in gathering this is the most satisfactory way, as the potato is handled only once and is then placed in its proper class. On the other hand, with careless and indifferent labor, such as is often necessary, the sorting can best be done by a few picked hands working on benches at the storage house. The crop is then gathered promiscuously by the field hands, and, when dry, is hauled to the storage house, dumped on the tables and there sorted. By this means the best results in grading can be secured and the additional expense is not very great. The field pickers, having no discrimination to make, can gather the crop more quickly than when they are required to decide on the class of each potato. Five or six good sorters at the house will handle a couple of hundred barrels per day and often save, by careful and accurate grading, many times their hire.

The main requisite for the storage of sweet-potatoes in the middle states is a warm, tight building in which the crop can be placed when dug in the fall. This building may be a single small room or may be of large size sufficient to hold several thousand barrels, provided it can be heated and ventilated throughout. A single room in the cellar or in a building of any kind in which a stove can be placed and ventilation can be provided will suffice. For ordinary farm purposes, however, where sweet-potatoes are a main crop, a building of a size sufficient to meet the demands should be constructed especially for this purpose. One of the most desirable types of building is built on the plan of a bank barn. The lower or basement story is of stone or brick and sits mostly in the ground, except the one exposed side or front in which are the windows and door. The stove may be placed in the center and bins arranged so that the nearest are some three feet from the stove. It is advisable to have the bins raised at least six inches from the floor, and it is best to have an air-space of a few inches between the bin-boards and the walls of the building. Ventilation can be arranged through the doors and windows, or ample top ventilation in the form of one or more trap-doors through the ceiling should be provided. If a second story is to be used, and this is very convenient, the top floor can be level with the ground above, and the upper room can be heated by an extra stove or by means of registers in the floor from the stove in the lower room. The bins may be large, even large enough to hold five or six hundred barrels, but as a rule it is better to divide the bins so that more or less air can get around and through the potatoes or underneath them. The building should be warm and tight, should have but few windows, which, if possible, should be on the south and east rather than on the north and west sides. Other conveniences in the way of passageways, platforms for handling the potatoes and sheds under which the wagons may be loaded and unloaded, add to the utility and success of the sweet-potato storage house just as may be the case with any warehouse.

For heating, a common wood stove answers fairly well, but some of the air-tight sheet-iron heaters have proved very successful. A good hard-coal stove with a self-feeding arrangement is a satisfactory type of heater. Hot-water heating is almost ideal, inasmuch as the hot-water pipes can be run around the floor, warming the cold exposed corners of the room.

When hauled from the field or taken from the sorting benches the potatoes are dumped into the

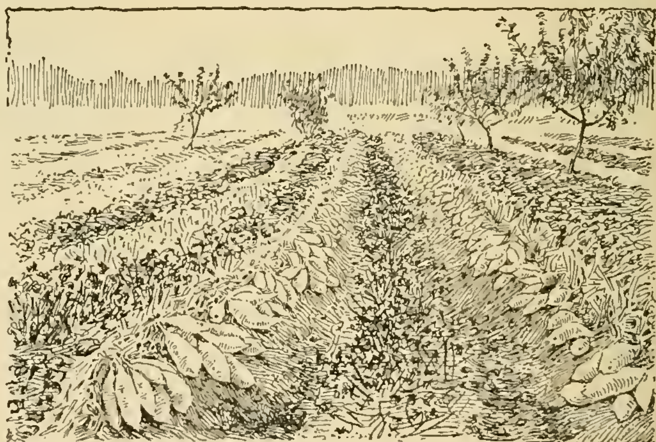

Fig. 846. Sweet-potato field as the hills have been lifted from the soil after the digger. The field will run at least 400 bushels per acre.

bins. All handling should be done as carefully as possible. The two prime requisites of success in getting the crop into the house are to have the potatoes well dried, clean and free from dirt and to handle them without bruising. It is a good plan to place a bed of pine leaves six inches deep on the bottom of the bins and around the sides, and by proper management with a plank, a carpenter's saw-horse and a sack or two filled with straw, the potatoes can be piled in the bins to a height of eight or nine feet with very little bruising.

The storage house should be thoroughly heated and dried out for two or three days before the first potatoes are put in it. The weather is usually warm at that time, so that the temperature may easily be run up to 80° or 90°, or even 100°. While the potatoes are being put into the house, it should be heated to about 90°; any temperature from 80 to 100° will do. Considerable ventilation should be allowed. Under no conditions should the house be heated above 90° for long periods without rather free ventilation. With temperatures above 80° the newly dug potatoes undergo a sweating process and give off much moisture, which often condenses on their own surfaces. The air of the room becomes extremely damp, and if not removed the house soon reeks with moisture. The purpose is to warm the house by passing currents of warm air over the potatoes and out through the ventilators. A temperature of about 90° should be maintained day and night while the potatoes are being put into the house, and for ten days to two or three weeks after the last potatoes are in. When the house is thoroughly dried the air feels dusty and dry and the potatoes feel soft and velvety, when they are said to be kiln-dried. Whatever bruises may have been given them and the broken ends where they were snapped from the vines are thoroughly dried and healed over, and they are then in a condition to keep through the winter. As a result of this drying they have shriveled slightly and undergone some physiological change not fully understood. The young or immatured roots sometimes shrivel seriously, but well-matured potatoes remain plump. Frequently there is considerable sprouting in the bins, which may be regarded as a sign of too much moisture or too-long delayed movement of the moisture out of the bins. But the sprouting is not a bad sign, since sprouting potatoes do not decay.

When the house is found to be thoroughly dry, the temperature may be reduced. About this time of the year cool weather naturally comes on and this, in connection with lighter firing, should allow the house gradually to cool down. The drop should be made slowly ; the first week it may be down to 75°, the next week to 70°, until finally a stationary temperature between 55° and 60° is reached. This is maintained throughout the winter. Temperatures above 60° cause slightly more shriveling than may be necessary and are conducive to more sprouting than is desirable. Temperatures below 55° may not prove injurious, especially if they are only of short duration, but they are not advisable. Some growers keep their houses for weeks at a temperature of only 45° ; but the margin between freezing and chilling temperatures is dangerously small when a house is kept so cool. No matter how mild the winter day, it is necessary to keep some fire in the house in order to keep the movement of moisture toward the outside. If the house becomes cooler than the outside air the moisture condenses in the house. On the other hand, some growers prefer to keep their sweet-potatoes at 70° or 75°, or about the temperature of the ordinary living-room. It may be said in a general way that the conditions of the ordinary living-room are ideal for sweet-potato storage except that the temperature is 10° to 15° too warm.

Light is supposed to be objectionable, but seems not to be seriously so. As a rule, the windows of the storage house should be covered with shutters to keep out the light. After the potatoes are thoroughly dried out, and while the house is being gradually cooled, the amount of ventilation should be reduced correspondingly, and finally, when the temperature is settled for the winter, the ventilators may be closed or nearly so. If under these conditions on a cool night there is pronounced sweating on the windows, it is better to continue slight ventilation for a few days longer, especially when it is sunny and dry outside. When a rainy or damp spell occurs during the process of drying, it is better not to let in much of the outside damp air, and this will necessitate corresponding reduction in the firing. On the other hand, on a dry day a very hot fire can be built and plenty of ventilation given. The process of curing under these conditions proceeds rapidly.

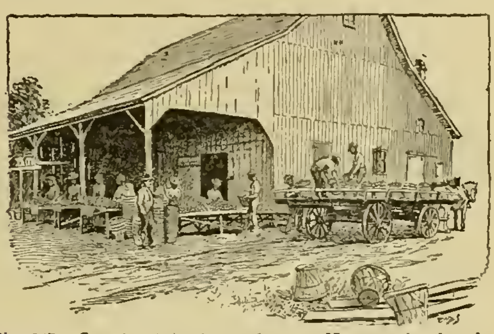

Fig. 847. Sweet-potato storage house. Note sorting benches and the sorters grading as crop is received.

When the house is once thoroughly cured, shipping can begin at any time, when the price or market demand justifies. As a rule, stored potatoes are not shipped until about Thanksgiving time, when the ordinary unstored stock is either used up or is of such poor quality as to offer no competition. Some growers prefer to hold their entire supply of potatoes until late winter or early spring, but ordinarily shipping begins as soon as cool weather comes on. The bin should never be disturbed until shipment is to begin. The potatoes in storage will not stand moving. Unfortunately their life is limited after being taken from the storage bin. While a stored sweet-potato may keep until May, if left in the place where cured, when taken out and barreled it will probably rot in about a month. Even at the end of a week a barrel of stored potatoes may begin to show some rot, and at the end of two or three weeks a good many rotten ones may be found. On the other hand, a single potato may often be taken from the top of the bin, carried into the house and kept for weeks. Even the movement or disturbing of the potatoes in the bin results in their destruction. It is necessary, therefore, when a bin is once opened to keep shipping continuously, say two or three times a week, otherwise the exposed potatoes may begin to decay.

A large part of the sweet-potato crop is shipped in three-bushel barrels, the same size as the apple or flour barrel. Occasionally "snide" or irregular-sized barrels are used, but these do not ordinarily pay the shipper. On the other hand, potatoes may be shipped in sugar barrels and large packages of any kind when they are sold by weight. In New Jersey, Delaware and Maryland a one and one-half-bushel basket made or fashioned after the Delaware peach basket has come into use. Some of these hold a bushel and some one and one-fourth bushels.

In shipping in winter it is necessary to use considerable care to avoid having the stock frozen, though it will stand considerable cold if not too long exposed. On the other hand, sweet-potatoes frequently suffer from the heat. The disturbance of sorting and barreling causes them to sweat. If they are shipped in open-head truck barrels under a burlap cover, the cover should be removed on their arrival on the market. In warm weather it is often better to bore several ventilating holes an inch in diameter or with a hatchet to remove a chip from several parts of the barrel.

The Yellow Jersey type of potato is usually preferred by northern markets. On the approach of warm weather, however, in March and April, this sweet-potato ordinarily loses quality and becomes slightly out of season. Of late years the trade in the so-called yam or sticky sweet type of potato has increased, especially for the spring and early summer trade. Southern people usually prefer the yam type of sweet-potato at all seasons. Some of the yams keep better, or actually improve in quality in the spring of the year, and these yams may be kept through to June or July, when sweet-potatoes from Florida and the Gulf coast begin to arrive. The result is that the market is continually supplied with this vegetable throughout the year. As a rule, growers of the Yellow Jersey close out their stock in March. April is the season for bedding, so that attention is then given to the seed bins.

Enemies.

The crop of sweet-potatoes grown in the field is generally remarkably healthy and free from both fungous diseases and insect enemies. However, there are some pests on the foliage and some very serious diseases on the roots.

Black-rot (*Ceratocystis fimbriata*).—This disease is more troublesome in the storage house and hotbed than it is on the crop in the field. It is a pronounced fungous disease and usually appears as large, irregular black spots, slightly sunken in the skin of the potato. On cutting or breaking them open, these spots are found to be deep, usually extending through the skin and sometimes into the central part of the potato. They are of a peculiar blue-black tint, ordinarily distinguishable from ordinary rots or other fungous diseases. Even though sweet-potatoes may be apparently free from disease when placed in the storage house in the fall, this rot often develops badly. The infected potatoes are rendered bitter and worthless, and are unsalable when the spots are bad. Black-rot is particularly objectionable in the seed-roots, as when these are bedded the disease is started in the hotbed producing the so-called "black shank" or black-rot of the plants. The failure of black-rot-infected plants is more pronounced during the cool, moist weather than during a hot spell. In fact, on a vigorous variety the disease is largely outgrown during favorable hot weather.

The best remedy for black-rot is the use of slip-seed. It is advisable to grow the crop of vine cuttings on new land which is not infested, or on land which has never grown sweet-potatoes or has not been in sweet-potatoes for several years, thus making an absolutely clean start, even though the vine cuttings are taken from an infected crop. Another remedy is to clean and sweep the storage house both overhead and underneath before putting in the potatoes, and whitewash the entire interior of the house with a spray pump. The addition of boiled lime and sulfur to the whitewash would undoubtedly be an improvement. The whitewash would then consist of the ordinary lime-sulfur wash thickened with lime. The hotbed should have all the old soil removed, and the boards and (in the case of a fire hotbed) the floor thoroughly whitewashed with freshly slaked lime before new earth is put in. The new soil should be from ground that has never been in sweet-potatoes. Early bedding and early planting out in the field are objectionable, as they put the crop at a disadvantage. In the same way, digging late in the fall encourages black-rot, while early digging just before the first frost, when the weather is still warm, seems to be particularly desirable. The black-rot is the worst of the diseases of the sweet-potatoes.

Soil rot (*Acrocystis Batatas*) is injurious to young roots in dry seasons. The diseased part ceases to grow. Crop rotation and the application of kainit or sulfur at the rate of 300 pounds per acre are suggested remedies. Soft rot (*Rhizopus nigricans*) occurs in the storage house during the curing process. If the potatoes are dry before storing it is not likely to be troublesome. Affected potatoes should be destroyed. Other diseases of little importance are white rust, white rot, stem rot, dry rot, scab and leaf spot.

Among insects, sweet-potatoes are attacked by the weevil, plume moth, tortoise beetles, sawflies, cutworms, flea-beetles, crickets and tobacco worms [See Index]. The weevil (*Cylas formicarius*) is a small bluish black insect that deposits its eggs in recesses at the base of the vine or at the upper end of the root. The white grubs burrow in the vine and down into the roots, which they destroy. The remedy is to feed or completely destroy all infested vines and roots. The plume moth (*Pterophorus monodactylus*) is a silver-brown insect bearing black lines on the forewings. It is the larva of this that is destructive to sweet-potatoes by feeding on the leaves. The use of arsenical sprays (one pound to twenty-five gallons of water) will control this pest. The larva is of a green color and bears a dark stripe along the middle of the back. Several kinds of tortoise beetles feed on the leaves soon after the plants are set. As a protection the plants may be dipped before setting in a solution of arsenate of lead, one pound to twenty-five gallons of water. Paris green of a strength of one-fourth pound to forty gallons of water, to which is added one-fourth pound of lime, is also effective. Flea-beetles may be controlled by the arsenical treatment, and sawflies by either the Paris green or the arsenical treatment.

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TANNING MATERIALS. Figs. 848–851.

By *F. P. Veitch.*

Nearly all plants contain an astringent principle known as tannin, which is distinguished by its property of forming with proteid matter, such as animal skins, an insoluble compound called leather, which is strong, flexible, and resistant to wear. Because of the many uses of leather, there is great demand for large quantities of tannin with which to make it. While many plants contain tannin in considerable quantities, practically all the tannin is secured from a few, and these few are as a rule those from which the tannin can be secured in commercial quantities most economically. In this country, bark of hemlock, chestnut or rock oak has been and still is the chief source of tannin, but as the supplies of these barks are exhausted and are farther removed from the tannery, other materials are used in constantly greater quantities, particularly in eastern tanneries where supplies of bark are most difficult to secure. This condition has encouraged the importation of foreign materials and the use of extracts which can be made where the tanning materials grow, and transported to the tannery much cheaper than the raw materials. In addition to hemlock and oak bark, the use of chestnut wood, quebracho, palmetto, mangrove and sumac extracts, as well as of other materials, is rapidly increasing, so that products at present but little known or used are mentioned in the following list, as the time is fast approaching when many of them will be used in considerable quantities. Very few plants are cultivated for their tannin and, with the possible exception of canaigre, none are cultivated in the United States.

Tanning extracts.

Until within recent years all tanneries prepared their own tanning liquors directly from the raw materials, each having its own leach house and maintaining immense ricks of bark. With rapidly decreasing supplies of bark and other native tanning materials, this is no longer possible in some of the older settled parts of the country, and many tanneries rely in part or entirely on extracts which are simply tanning liquors made where the raw material is still accessible and cheap, and concentrated to a small bulk for the sake of economy in handling and transportation. The most commonly used extracts produced in this country are made of chestnut oak and hemlock barks, chestnut and quebracho woods, sumac, palmetto and mangrove.

In preparing liquors or extracts, the material must first be ground; how fine is largely determined by experience, the aim being to secure the maximum quantity of tannin at the lowest cost. If the material is too finely ground it will pack in the leaches and extraction will be too slow to be economical. The ground material is carried by conveyors to the leaches, which are large round wooden vats about fourteen feet high and fourteen feet in diameter, each holding about ten tons of bark. These leaches are provided with a false perforated bottom through which the tanning liquor can pass, an opening in the bottom through which the exhausted material passes in emptying the leach, and which, when the leach is working, is closed with a long plug reaching to the top of the leach. Each leach also has a vertical spout rising from under the false bottom to near the top and connected with the next adjoining leach, so that the liquor from the bottom of one leach may pass to the top of the next succeeding one. The leaches are arranged in the form of a battery, and six to fourteen leaches are used. In extracting the tanning material, very hot water is run on the top of the material in a leach which has previously been nearly exhausted of its tannin. This is known as the "tail leach." From the bottom of the tail leach the liquor passes to the top of the next leach, the material in which has not been so completely exhausted as that in the tail leach. The liquor passes successively from the bottom of one to the top of the next leach, each containing material less exhausted than that in the previous leach, until it passes on to the "head leach," containing material from which no tannin has been removed.

From the head leach the strong tanning liquors run to the settling cooler where much suspended matter as well as that which is insoluble in cold water settles out, or the liquors are carried immediately to the evaporating pans to be concentrated. In a long battery of leaches it is customary to pump the liquors from one leach to another and often to reheat them at least once. To avoid repeatedly reheating the liquors between the leaches, a copper coil is often placed in the bottom of each, and the contents heated by steam.

It is customary partly to decolorize extracts. For this purpose dried blood is chiefly used, though blood albumen, casein, and other albuminous materials, as well as lead acetate and salts of alumina, are used to a certain extent. In decolorizing, the dilute liquor from which the suspended matter has settled out is run into a vat provided with a stirring gear and steam coil, and to the liquor the decolorizing material dissolved in a little water is added and the whole well stirred. The temperature is raised to 70° C., when the albumen coagulates and carries down part of the coloring matter with it. The solution is allowed to settle in another tank, the clear liquor drawn off and sent to the vacuum pans, and the sediment filter pressed to recover the remainder of the liquor as well as the tannin-blood compound which it contains and which is used as a fertilizer. Tanning liquors may also be decolorized, or rather bleached, by passing sulfur dioxid through them before concentrating. The color thus temporarily removed is likely to return.

The material that goes out of solution when the dilute liquor is cooled in the settling tanks consists largely of tannin which is difficultly soluble, but is capable of tanning leather. After being decolorized, or directly from the leaches, the liquor passes to the vacuum pans where it is concentrated

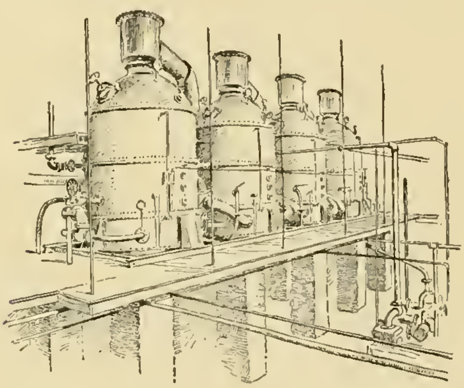

Fig. 848. Vacuum pans used in making tannin extracts.

to about 45° Twaddle, for liquid, or until the extract will solidify on cooling, for solid extracts. To avoid excess of color and the destruction of tannin the concentration is done at low temperature and without access of air. Liquid extract is sold in barrels or in tank-cars, the solid extract in bags or bales.

Future tanning materials.

The native tan-barks of the eastern and northern part of the United States are rapidly decreasing under a heavy demand, which amounted to 1,425,000 cords in 1905, and it is only a question of comparatively few years when a large part of the supply must come from other sources. There are three ways in which the material may be supplied, and doubtless all of them will contribute a part. They are: (1) larger use of foreign and little-used materials; (2) more careful handling of tan-bark trees; and (3) cultivation of tannin-containing plants as regular farm crops.

The growing of plants primarily for the tannin they contain will probably develop slowly, because other crops pay better. For this reason canaigre has failed in the South and West. So, too, the growing of woods or of barks rich in tannin, except on land that cannot be otherwise regularly cropped, does not promise at present to be a profitable undertaking. At present the most promising plant for cultivation is sumac, which may be planted, cultivated and harvested by machinery and handled in much the same way as other farm crops. Its cultivation is conducted successfully in Italy, where labor is much cheaper than it is here, but it remains to be demonstrated that sumac can compete with other farm crops under conditions in this country. On lands not suitable for general agriculture chestnut wood and chestnut oak bark may be grown or allowed to reproduce profitably within a period of twenty to thirty years. It is probable, however, that the price of raw tanning materials must rise considerably before their cultivation will develop to any extent.

Wild-grown materials will undoubtedly continue to be the almost exclusive source of tannin, but to meet the demand many materials but little used will be developed, and more care be exercised in gathering and marketing all kinds of tanning materials now used.

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Sources of Tanning Materials

Conifers.

Hemlock (*Tsuga Canadensis*). Hemlock bark is still the chief American tanning material. It contains 8 to 14 per cent of catechol tannin. The tree is native from Nova Scotia to Minnesota and Wisconsin, and southward in the Alleghany mountains to Northern Alabama and Georgia. Michigan and Pennsylvania furnish about 60 per cent of all the hemlock bark now secured. The bark is used extensively alone or in combination with oak bark in the production of sole leather. Hemlock leather is harder and less pliable but more permeable to water than oak leather. The total quantity of hemlock bark used in 1905 was 1,000,000 cords, worth $8,470,000. An extract is also made of which about 52,000 barrels were used in 1905.

Western hemlock (*Tsuga heterophylla*) is found from Alaska to Idaho and Montana, and southward in the Cascade and Coast ranges of Washington, Oregon and California, where it may constitute 13 per cent of the forest growth. The bark contains 8 to 20 per cent of tannin and is somewhat thinner than that of eastern hemlock. The wood contains less than one per cent of tannin.

California swamp pine (*Pinus muricata*) is native along the coast of upper and lower California. The bark contains about 13 per cent of tannin.

Monterey pine (*Pinus radiata*) is native on the coast of California. The bark contains about 14 per cent of tannin.

Pine bark is used largely in Austria, Bavaria and southern Germany. Aleppo pine (*Pinus Halepensis*) contains about 15 per cent of tannin very similar to hemlock. The inner part of the bark is called Snoubar and contains as much as 25 per cent of tannin of lighter color than the outer bark. Other pine barks contain 2 to 7 per cent of tannin.

Sitka spruce (*Picea Sitchensis*) is native along the coast from Alaska to northern California. The bark contains about 17 per cent of tannin.

Norway spruce (*Picea excelsa*). The bark contains 7 to 13 per cent of catechol tannin and much fermentable sugar. It is used largely in Austria and is the source of the so-called larch bark extract. White spruce (*P. alba*), native in northern United States and Canada, is very similar.

Silver fir (*Abies pectinata*) is used to a limited extent. The bark contains 6 to 15 per cent of iron-bluing tannin.

Lowland fir (*Abies grandis*) is native along the coast from Vancouver island to northern California, and inland to Idaho and Montana. The bark contains about 9 per cent of tannin.

Larch (*Larix Europœa*) contains 9 to 10 per cent of a pale catechol tannin and is suitable for light leathers.

Dwarf juniper (*Juniperus communis*) bark is used in Russia. Several members of the *Taxaceae* or yews are used in Australasia for tanning and contain 20 to 30 per cent of tannin.

Redwood (*Sequoia sempervirens*) is native along the coast and thirty miles inland from southern Oregon to south of Punta Gorda, California. The wood contains about 2 per cent of tannin and the bark probably somewhat more.

Big tree (*Sequoia gigantea*) produces a gum which exudes from the tree and which may contain as high as 70 per cent of tannin.

The oak tannins.

Chesnut oak (*Quercus Prinus*) is found from southern Maine to Maryland and in the mountains southward to northern Alabama and Georgia, and westward to Lake Erie and central Kentucky and Tennessee. Chestnut oak bark is next in importance to hemlock bark in this country, and contains 8 to 14 per cent of tannin, probably both catechol and pyrogallol. The wood contains 2 to 5 per cent of tannin. An extract is also made from the bark. It is customary to cut all trees when the sap is rising if the bark is to be used, as it can be most easily peeled at this time. All barks should be carefully piled in the woods as peeled, as otherwise there is considerable loss of tannin from exposure to the weather. The quantity of oak bark used in 1905 was 422,000 cords, valued at $3,765,000; in addition, 214,000 barrels of extract, valued at $2,300,000, was also used.

Tanbark oak (*Quercus densiflora*) is found in southern Oregon and southward to Mariposa county, California. The tree is also known locally as chestnut oak. The bark contains 9 to 22 per cent of tannin and averages about 18 per cent. The foliage and twigs contain about 5 per cent of tannin.

The barks of other American oaks contain considerable tannin. White oak (*Quercus alba*) contains 3 to 9 per cent; red oak (*Q. rubra*), 3 to 5 per cent; black oak (*Q. nigra*), largely used as a source of quercitron, a dyestuff, but of little value for tanning; California black oak (*Q. Californica*), about 10 per cent of tannin; Highland oak (*Q. Wislizeni*), about 7 per cent; California white oak (*Q. lobata*), about 12 per cent; Canyon live-oak (*Q. chrysolepis*), about 10 per cent; Pacific post oak (*Q. Garryana*), about 8 per cent.

Other oak barks used largely abroad are the following: English oak (*Quercus pedunculata*), common in England, Ireland, Scotland and Slavonia. It is used for making oakwood extract. The bark contains 8–15 per cent of tannin. *Q. sessiliflora*, the bark of which contains 10–14 per cent of tanning matter, possibly both catechol and pyrogallol groups. The yield of tannin is less from trees over twenty-five years of age, and coppice barks, from absence of ross, are often strong, and also contain less coloring matter and more fermentable sugar. Oakwood contains only a very small percentage (2–4 per cent) of tannin, practically identical with that of chestnut. Turkey oak (*Q. Cerris*), of southern Europe; *Q. pubescens*, in mountain districts and scattered in southern Europe, 8–15 per cent of tannin; Evergreen oak (*Q. Ilex*), south Europe and Algeria, 5–11 per cent of dark colored tannin, well adapted to sole leather; cork oak (*Q. Suber*), the outer bark of which is cork; the interior bark contains 12–15 per cent of tannin, which is redder than that of ordinary oak; African oak (*Q. pseudosuber*), of Algeria, 10–14 per cent of tannin; *Q. Mirbecki*, of Algeria, 8 per cent of tannin in the bark; *Q. Toza*, of the Pyrenees and south France, 14 per cent of tannin in the bark; Kermes oak (*Q. coccifera*), of south Europe and Algeria, has an average of 10–18 per cent of tannin, giving a firm, dark, sole leather.

Valonia (from *Quercus Ægilops* and probably other species, *Q. macrolepis, Grœca, Ungeri, coccifera*), is the commercial name of the acorn cups of these several kinds of oaks. Best Smyrna valonia contains up to 40 per cent, Greek 19–30 per cent, Candia valonias up to 41 per cent, and Caramanian 17–22 per cent of pyrogallol tannins or pyrogallol derivatives, and deposit a great deal of bloom consisting of ellagic acid. The acorn contains a considerable amount of fermentable sugar and but little tannin. Valonia is hand-picked in three grades. The beard sometimes contains over 40 per cent of tannin. Valonia is especially suitable for the manufacture of sole-leather. It deposits much bloom, and is used as a dusting material. It makes the leather solid and compact, but leaves the grain somewhat rough and hard to work. In mixture with gambier and other materials, as it is generally used, it is an excellent tannin for dressing leather, and with proper management deposits little or no bloom.

"Nut galls" is the term applied to the excrescences on plants produced by insects for the purpose of depositing their eggs. "Turkish" or Aleppo galls, from *Q. infectoria*, are developed from the young shoot of the oak, and are best before the insect has escaped, as they contain in this stage up to 50 or 60 per cent of gallotannic acid. These galls and those of *Rhus semialata* are the principal sources of the pure tannin of commerce. *Q. infectoria* also bears a large gall like an apple, called "Apples of Sodom," or "rove," caused by a different insect, which contains 24–34 per cent of gallotannic acid.

Knoppern are galls produced on the immature acorns of various species of oaks, principally *Quercus Cerris* in Hungary, and contain up to 35 per cent of gallotannic acid. Like all purely gallotannic materials, they naturally give a soft and porous tannin, ill-adapted for sole leather.

Fig. 849. Chestnut bark and foliage.

The bark of a number of Indian oaks yields tannin, *Q. incana* containing about 22 per cent.

The chestnuts.

Chestnut (*Castanea Americana*, Fig. 849) is native from southern Maine and Ontario to Delaware, Maryland, Ohio and Indiana, and in the mountains to Alabama and west to Michigan. The wood contains 3 to 10 per cent of tannin, giving blue-black with iron salts. The older trees contain the highest percentage of tannin. The bark contains about 8 per cent. The wood is used for making extracts which give a firm leather, with a good deal of bloom if used strong, and a more reddish tint than valonia. The extract often contains dark coloring matters, and the color of leather tanned with it is readily darkened by traces of lime. Like all wood extracts it tans rapidly, the color penetrating first and the tan following. Decolorized chestnut extracts, sometimes mixed with quebracho and other materials, are often sold as "oakwood" extracts. There were 187,000 barrels of chestnut extract made in 1905, and the use of this material is steadily increasing.

Spanish chestnut (*Castanea vesca*) bark contains up to 17 per cent of tannin. The wood contains 3 to 6 per cent of tannin and is used abroad for making extract.

Sumac and related plants.

Sicilian sumac (*Rhus Coriaria*) leaf contains 20 to 35 per cent of tannin which is principally gallotannic, with some ellagitannic acid, and is the best tanning material known for pale color and soft tanning, and hence is used for moroccos, roans, skivers and the like. Sumac is frequently adulterated with ground leaves and twigs of *Pistacia Lentiscus*, *Ailanthus glandulosa*, *Vitis vinifera*, and some other species of the Rhus family, but *Pistacia Lentiscus* is used to a much larger extent than any of the others. The stem contains but little tannin. Between 300,000 and 400,000 tons of sumac leaf are imported annually. The Sicilian sumac is cultivated in Italy and Sicily. The best leaf grows on stony calcareous mountain soils near the sea and is known as "Masculino," while the leaf which contains much less tannin is called feminella.

Fig. 850.
Smooth sumac (*Rhus glabra*).

Smooth sumac (*Rhus glabra*, Fig. 850), *Dwarf sumac* (*R. copallina*) and *Staghorn sumac* (*R. hirta* or *R. typhina*) are native from the St. Lawrence river to the Gulf of Mexico and west to the Mississippi river, in poor soils, waste places, and on the hills and mountain sides. The leaf contains 15 to 30 per cent of tannin and makes leather of a rather darker color than Sicilian sumac because it contains more coloring matter. The leaf is extensively gathered in the mountains of Pennsylvania, Maryland and Virginia and sells to the tanners at $35 to $45 per ton. The leaf should be gathered in July before it begins to turn red, as the percentage of tannin is higher and it produces a lighter colored leather than the leaf gathered in August and September. Better prices would be realized if the leaf were gathered earlier than it now is. After drying, the leaf is ground under mill-stones, sifted to get out stems, and the leaf bagged or baled for market. Sumac is not cultivated in this country. It is possible, however, that the American sumac could be cultivated as a profitable farm crop.

Other tannin-bearing species of Sumac or Rhus are: *R. aromatica*, 13 per cent tannin; *R. Metopium*, 8 per cent; *R. pumila*; *R. Canadensis*; *R. Toxicodendron*. Venetian or Turkish sumac (*R. Cotinus*) is more important as a dyeing than as a tanning material. The leaves contain about 17 per cent of tannin. Kliphout (*R. Thunbergii*), from the Cape of Good Hope, contains 28 per cent of catechol tanning matter of reddish color. *R. semialata*, containing 5 per cent of tannin, yields Chinese and Japanese galls, containing up to 70 per cent of gallotannic acid. They are caused, not by a fly, but by the attack of an aphis, as are those of the allied *Pistacia*.

Japanese or Chinese galls, made on leaves of *Rhus semialata* by the sting of a plant-louse, contain 70 per cent of tannin.

French sumac (*Coriaria myrtifolia*) is a poisonous shrub of the south of France; the leaves contain about 15 per cent of tannin and are used for tanning and as a sumac adulterant under the name of "stinco." Tutu (*Coriaria ruscifolia*) bark, of New Zealand, contains 16 to 17 per cent of tannin.

Quebracho (*Loxopleryngium Lorentzii*). The wood contains about 20 to 28 per cent of a red, difficultly soluble tannin, yielding "reds," and containing catechol and phloroglucol. It gives a firm, reddish leather. Quebracho is obtained from Argentina, whence large quantities of logs, or extracts made therefrom, are exported to Europe and the United States.

Pistacia Lentiscus, grown in Sicily, Cyprus and Algeria. The leaves contain 12 to 19 per cent of a catechol tannin, and are used chiefly in the adulteration of sumac. Leather tanned with sumac adulterated with lentiscus darkens and reddens on exposure to light and air, and for this reason its use in cases where a good color is desired is objectionable. *P. orientalis*, *Terebinthus*, *vera*, and others of India and the Mediterranean region, bear various aphis galls yielding 30 to 40 per cent of tannin.

Pepper Tree or *Molle* (*Schinus Molle*), of Buenos Ayres. The leaves only are used, and are said to contain 19 per cent of tannin. The wood contains less than 3 per cent, and the bark 5 to 10 per cent of tannin. *S. Aroeira*, of Brazil, is said to contain 14 per cent of tannin.

Palm tannins.

Saw palmetto, Dwarf palmetto (*Sabal Adansoni*, *S. serrulate*), grows freely in the southern states and is especially abundant on the east coast of Florida. The plant is an evergreen, the stem of which grows flat along the ground and is held in place by numerous small roots. The leaves are fan-shaped and ribbed. The plant is very hardy and the leaves may be cut without damaging the plant. The average yield is stated to be about one-half ton of stems to the acre, but in good seasons and with rich land over a ton per acre has been secured. The air-dried stems contain 5 to 20 per cent and average about 13 per cent of tannin, and are used in making an extract which produces a very soft and mellow leather of good color. The extract contains noticeable quantities of common salt and organic salts of soda. The leaf also contains tannin. There were 3,500 barrels of extract made in 1905.

Coconut palm (*Cocos nucifera*) contains tannin in the roots.

Gambier extract.

Gambier or "*Terra Japonica*," also called Pale "Catechu," is a solid extract made from *Uncaria* (or *Nauclea*), *Gambier*, an East Indian climbing shrub. The plant is crudely cultivated but yields rapid returns. As the plants do not receive proper attention, a plantation is exhausted in ten to fifteen years. Cropping begins three years after planting, and is continued two to four times annually. In preparing the extract, the leaves and twigs are put in a boiler, heated, with water, till the liquid, which is constantly stirred, becomes sirupy. The leaves are removed, drained, and the liquor returned to the boiler. The liquor is strained into small shallow tubs, where it is allowed to cool, with constant stirring, until the catechin crystallizes. When cool, the pasty mass is turned out of the tub, cut into one-inch cubes and dried. A commoner quality, called "block-gambier," is marketed in large, oblong blocks of about 250 pounds weight, which are wrapped in matting and exported in a pasty condition. These contain 35 to 40 per cent of tannin, while the best cubes reach 50 to 65 per cent. The tannin is a catechol-phlorglucol derivative and is used with other materials in tanning light and heavy leathers.

The myrobalans.

Myrobalan (*Terminalia Chebula*), the fruit of a tree forty to fifty feet high, which is found in India, Ceylon, Burmah and elsewhere, is the source of all the ordinary varieties, which differ only in the district from which they are secured and the state of maturity of the fruit. The nuts contain 30 to 40 per cent of tannin. Those known as Bombays are the ripest, while "lean greens" are least ripe. The unripe fruit is the richest in tannin. Neither the stones nor kernels contain tannin, but the latter have an oil which gives a peculiar odor to leather. The tannin exists in the pulp which surrounds the kernel, and is not very easily extracted. The bark is almost as rich as the fruit, and the tree also yields galls. Myrobalans are used in combination with other materials. By itself it produces a soft and porous leather. *T. Bellerica* yields Beleric or "Bedda nuts," which contains about 12 per cent of tannin. It is used as an adulterant of ground myrobalans. The nuts of *T. tomentosa* contain about 10 per cent of tannin and the bark 10 to 36 per cent of tannin. "Badamier bark" (*T. Catappa*), of Mauritius, contains 12 per cent of tannin. "Jamrosa bark" (*T. Mauritiana*) contains about 30 per cent of tannin. "Thann leaves" (*T. Oliveri*), of Malay Archipelago, yield an extract used as a cutch substitute; the tannin is a catechol derivative. The bark contains about 31 per cent of tannin, the leaves about 14 per cent.

Mangrove tannins.

Mangrove, or Mangle (*Rhizophora Mangle*), grows on tropical coasts all round the world. In the United States it is grown on the southern coast of Florida, the Mississippi delta, Texas coast, on the east and west coasts of Mexico and Central America, and in the West Indies. It is now being used in Florida for making extract. The barks vary much in strength, from 15 per cent up to 40 per cent in different species. The leaves, used in Havana, are said to contain 22 per cent of tannin. Young plants contain the highest proportion of tannin. *R. Mangle* seems to yield a bark inferior to several other species. The catechol tannin, which is easily extracted, is of deep red color, and allied to that of the mimosas. In admixture with other materials the red color has a much smaller effect, and mangrove bark is now largely used in combination with pine, oak and mimosa. *Rhizophora mucronata*, of India and Burmah, has bark that contains 4 to 50 per cent of tannin.

Bakau or *Tengah bark* of the East Indies, "Goran" of Bengal. It contains up to 27 per cent of tannin and yields an extract which promises well as a substitute equal to cutch, for dying purposes. The solid extract contains up to 65 per cent of tannin, making a good but dark red leather. *Ceriops Roxburghiana* bark is very similar in strength and character to the above.

Eucalyptus barks.

Blue gum (*Eucalyptus Globulus*) and other species of Eucalyptus are common in Australia. Blue gum has been introduced into the United States, in southern California and Arizona, and is found in Algeria and southern Europe. The Eucalyptus is more or less rich in catechol tannins, the sap being the source of Botany Bay or Australian kinos, which contain up to 79 per cent of tannin. Several species of Eucalyptus afford astringent extracts; those from the "red," "white," or "flooded" gum (*E. rostrata*), the "blood-wood" (*E. corymbosa*), and *E. citriodora*, being quite suitable for replacing the official kind. The bark of *E. occidentalis* contains 35–50 per cent of tannin and is now being used under the name Mallet bark, from which the tannin is readily soluble. It makes a light brown leather. The bark of *E. longifolia*, the "woolly-butt" of Australia, contains 8.3 per cent of tannic acid, and 2.8 of gallic acid. The bark of the "peppermint" tree contains 20 per cent of tannic acid. The "stringy-bark" (*E. obliqua*) gives 13½ per cent of kinotannic acid. The Victorian "iron-bark" (*E. leucoxylon*) contains 22 per cent of kinotannic acid, but is available only for inferior leather.

Cæsalpinia.

Divi-divi (*Cæsalpinia Coriaria*). This is a tree of 20–30 feet high, native in central America and introduced successfully into India. The dried pods contain 40–45 per cent of a pyrogallol tannin, mainly ellagitannic acid, and would be a most valuable tanning material but for a liability to fermentation and sudden development of a deep red coloring matter. If used in strong liquors it gives a heavy and firm leather, but is principally employed as a partial substitute for gambier on dressing leather. The seeds do not contain tannin. Tari or teri pod (*C. digyna*) occurs in parts of India and Burmah, where it is used as a drug. The pod-case is said to yield over 50 per cent of tanning material. *C. digyna* promises to become a valuable tanning material if it proves free from the tendency to ferment. It yields a leather quite as white as sumac. Cascalote (*C. Cacalaco*) is found in Mexico. The pods are rich in tannin, in some instances containing 55 per cent. The tannin is similar to that of divi-divi.

Algarobilla (*C.* [or *Balsamocarpon*] *brevifolia*) is found in Chile. This is one of the strongest tanning materials known, containing an average of 45 per cent of a tannin very like that of divi, but less prone to discoloration. The tannin lies loose in a very open skeleton of fiber, and is easily soluble in cold water; the seeds contain no tannin.

Logwood (*C.* [or *Hæmatoxylon*,] *Campechianum*) is found in Central America. It contains about 3 per cent of tannin. Its principal use is in dyeing blacks with iron or chorme mordants.

Cassias.

Turwar or *Tanghadi bark* (*Cassia auriculala*) is found in southern India. It is used for tanning so-called "Persian" sheep and goat-skins, and contains about 17 per cent of a catechol tannin. Leather tanned with it is of a pale yellow color, but rapidly reddens in sunlight. *C. Fistula* is found in India. The husk of the pod contains 17 per cent tannin.

Mimosas.

"*Babool*," or "*Babul*" (*Acacia Arabica*), is found in India and Egypt. The bark contains about 12 to 20 per cent of catechol tannin and considerable red coloring matter. It is extensively used in India for tanning kips and heavier leathers. The pods contain about the same amount of tannin as the bark but of a different kind.

Cutch is derived from the wood of *A. Catechu* of India. A lighter colored variety called kath is made in northern India, and used principally for chewing with betel. The extract or cutch is made by boiling the chips with water in earthen jars over a mud fireplace. As the liquor becomes thick and strong, it is decanted into another vessel and the evaporation continued until the extract will set on cooling, when it is poured into moulds made of leaves or clay, the drying being completed by exposure to the sun and air. Kath, or pale cutch, is made by stopping the evaporation at an earlier point and allowing the liquor to cool and crystalize over twigs and leaves thrown into pots for the purpose. Good cutch contains about 60 per cent of tanning matter, and is principally used for dyeing browns and blacks with chrome and iron mordants. It contains quercetin, a yellow coloring matter. "Pilang" (*A. leucophlœa*) is found in India and Java. The pods and bark contain about as much tannin as *A. Arabica.* "Golden wattle," or "Broad-leaved wattle" (*A. pycnantha*), is found in South Australia. It has one of the strongest tanning barks known, containing 30 to 50 per cent of tannin. It has been cultivated successfully in California and Hawaii. The Golden wattle (*A. longifolia*), of New South Wales, contains only half as much tannin as *A. pycnantha.* Black wattle (*A. mollissima*), with its two varieties, *A. decurrens* and *A. dealbata,* is among the most important of the Wattle family commercially. The bark contains 30 to 50 per cent of tannin and is grown successfully in Natal and in California. Hickory bark (*A. penninervis*) contains about 30 to 40 per cent of tannin. *A. binervata,* another Black wattle, contains up to 30 per cent of tanning matter, as does also the Weeping willow (*A. saligna*). The bark of *A. prominens* contains 14 per cent of tannin.

In Natal the Australian wattles (especially *A. mollissima*) have been cultivated with success. The barks contain about 30 per cent of tannin. The bark of *A. mollissima* from trees growing on limestone soils contains 10 to 25 per cent less tannin than that from other soil formations. An acre of ten-year-old trees will yield five or six tons of bark, so that the tree promises to be valuable for growing in California and other western and southern states as a future source of tan bark.

Acacia Cavenia, Espinillo. Native in South America. The bark contains 6 per cent and the pods 18 to 21 per cent, or more, of tannin. *A. Cebil,* the Red Cebil, has 10–15 per cent of tannin in the bark and 6 to 7 per cent in the leaves. It is found in Argentine Republic. *A. Guarensis,* the Algarobilla of Argentine Republic, is said to contain tannin in the bark, pods and flowers. *A. Timbo* is found in Buenos Ayres. *A. Angico,* or *Piptadenia macrocarpa,* of Brazil, yields "angica bark," containing 20 per cent of tanning matter. *Acacia horrida,* "Doornbosch," of the Cape of Good Hope, contains 8 per cent of tannin. *Inga Feuillei,* "Pay-pay," of Peru, is said to have 12–15 per cent of tannin in the pods. *Elephantorrhiza Burchellii,* Elandshochjes, Tugwar or Tulwah, of South Africa, is a papilionaceous plant, the air-dry root of which contains 12 per cent of tannin and a great deal of red coloring matter.

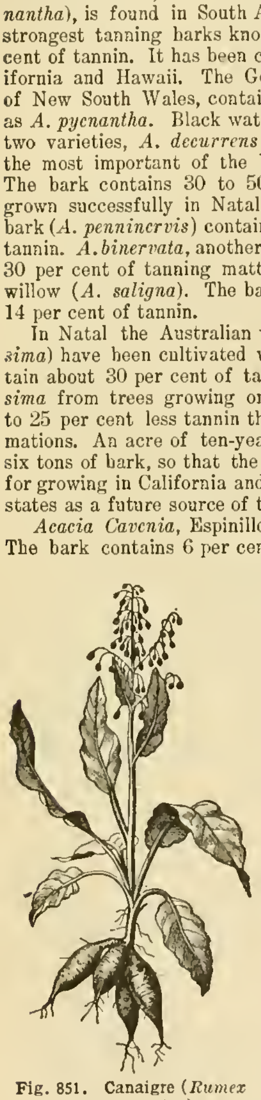

Fig. 851. Canaigre (*Rumex hymenosepalus*).

Canaigre. (Fig. 851.)

Canaigre (*Rumex hymenosepalus*), also called Gonagra, Red Dock and wild pie-plant, is common in the sandy, semi-arid plains of Mexico, Arizona and Texas, as far north as Indian Territory and Utah, and westward to southern California. It considerably resembles rhubarb. The roots, when air-dried, contain 20–35 per cent of a catechol tannin, probably allied to that of mimosa. The fresh roots contain about 68 per cent of water and 8 per cent of tannin. The tannin produces leather of bright orange color, having considerable weight and firmness. Sandy soils, subject to inundation or irrigation, seem best suited to its culture. In California and Arizona, the growth begins in October or November with the winter rains. The plant blooms about the end of January, while the leaves die down in May and no growth takes place during the dry hot summer. Planting is done in autumn, in rows 30 inches apart, with ten inches between each two roots. Roots for "seed" should be kept in the ground or stored in dry sand. The yield in an average season is 10–20 tons of green roots per acre. The plant has been grown successfully in Texas, New Mexico, Arizona and California, but as a rule larger profits can be made from the land by growing other crops, so that its cultivation has not been a commercial success. The roots should be harvested when two years old, as they contain the most tannin at this age. If allowed to remain longer they become darker and deteriorate. The roots should be sliced and extracted at once, or dried at a low temperature if this is not possible.

Other rumexes and polygonums containing considerable tannin.

Rumex maritimus is found in Central Europe, England and Ireland. After drying, it contains 22 per cent of tannin.

Polygonum amphibium is very abundant in the United States, growing vigorously in wet soils. It is particularly abundant in the upper Mississippi valley. The roots contain 22 per cent and the branches 17 per cent of tannin. *Polygonum Bistorta* is common in damp places in England. The roots contain 16–21 per cent of tannin. Smartweed (*P. Hydropiper*) is common in damp ground in northern and central United States, and contains about 5 per cent of tannin.

Coccoloba uvifera, the Seaside Grape of the West Indies, is the source of West Indian kino. The entire plant is rich in tannin.

Less important tannin plants.

Bearberry (*Arctostaphylos Uva-Ursi*) is used in Russia and Finland. The twigs and leaves contain about 14 per cent of tannin.

Manzanita (*Arctostaphylos Manzanila*) is found in the coast region from British Columbia to California. The wood containing about 5 per cent, twigs about 8 per cent and leaves about 12 per cent of tannin.

"Curtidor" bark (*Weinmannia glabra,* Linn.) of Venezuela, (*Weinmannia macrostachya,* D. C.), of Reunion and New Zealand Towai or Tawheri bark (*Weinmannia racemosa*) contain 10 to 13 per cent of iron-bluing tannin, and have been practically used, but are not of much importance.

Tamarix (*Tamarix Africana*) is secured from Egypt and Algeria. The galls contain 26 to 56 per cent of tannin. The small twigs, which contain about 9 per cent of tannin, are collected in Tunis, and dried, ground and imported into Sicily where they are used for the adulteration of sumac under the name of "Brusca." *T. articulata* from Morocco yields galls produced by aphides, stated by Vogel to contain 43 per cent of tannin.

Churco (*Oxalis gigantea*) is secured from Chile. Its thin, brittle, dark red bark contains about 25 per cent of an easily extracted dark red tannin, giving green-blacks with iron.

Cleistanthus collinus, "Kodarsi," is found in the Deccan. The bark is said to contain 33 per cent of tannin.

Phyllanthus Emblica, of India, yields emblic myrobalans, which in an immature condition contain considerable tannin. The leaves and bark are used for tanning. The leaves contain 18 per cent of tannin.

Willow bark (*Salix* species). The bark of willow shoots grown for basket-making contain 7 to 12 per cent of tannin, but the quantity of bark thus available is small. *Salix arenaria* and *S. Russelliana*. The bark of these is used for tanning in Russia, and for Danish grove leather. Some barks contain up to 12 to 14 per cent of iron-bluing tannin. They impart a strong odor to leather.

Poplar barks have been used for tanning, but contain only 2 to 3 per cent of tannin.

Persea, or *Laurus Lingue*. The bark is used in Chile for tanning Valdivia leather. It contains 17 to 19 per cent of a catechol-phloroglucol tannin.

Cape Sumac or *Pruim Bast* (*Osyris compressa, Fusanus compressus, Colpoon compressum, Thesium Colpoon*) is found on the Cape of Good Hope. The leaves contain about 23 per cent of tannin and are used as a substitute or adulterant for sumac.

Quandong (*Fusanus acuminatus, Santalum acuminatus*), of Australia, contains 18 to 19 per cent of dark colored tannin. The bark of *Exocarpus cupressiformis*, of Australia, contains 15 per cent of tannin.

Heath honeysuckle (*Banksia serrata*), of Australia, contains 11 to 23 per cent of tannin. *Banksia integrifolia*, of Queensland, has 11 per cent of tannin in the bark. *Grevillea striata*, of Australia, has 18 per cent of tannin in the bark. Kruppelboom, or Knotted tree (*Leucospermum conocarpum*), of the Cape of Good Hope, contains 10 to 22 per cent of tannin. Sugarbush (*Protea mellifera*), of Cape of Good Hope, yields 18.8 to 25 per cent of tannin. Waagenboom (*Protea grandiflora*) yields 15 to 25 per cent of tannin. *Silver tree* (*Leucadendron argenteum*), of the Cape of Good Hope, has 9 to 16 per cent of tannin in the bark.

Marsh Rosemary (*Statice Limonium*), of the south of Russia, contains 22 per cent of tannin. Sea Lavender (*Statice Limonium*), of the coasts and salt marshes of Europe and America, yields about 20 to 25 per cent of tannin. It is used in France, Spain and Portugal.

Nancite or *Mangrutta* (*Malpighia punicifolia*), grown in Nicaragua. The bark contains 20 to 30 per cent of light colored tannin.

Casuarina equisetifolia, Linn. (*C. leterifolia*, Lam.) The bark is known as Filao bark in Reunion. It is the Tjamara laut of Java and the Casagha or Tinian pine of Ceylon. It gives blue-blacks with iron and contains 11 to 18 per cent of tannin. It is one of the beefwoods.

Sweet fern (*Myrica* [*Comptonia*] *asplenifolia*) grows wild on many thousands of acres in Michigan. It yields 40 per cent of "extract." The leaves contain 4 to 5 per cent and the roots 4 to 6 per cent of tannin. *Myrica Nogi* (*Hind. Kaiphal*), of India, contains 13 to 27 per cent of tannin in the bark.

The common alder (*Alnus glutinosa*) contains 16 to 20 per cent of iron-green tannin, with much red coloring matter. Old barks may be as low as 10 per cent in tannin. When used alone it gives a red, hard and brittle leather, but, with galls and valonia, it produces a satisfactory tannin.

Hannoki (*Alnus maritima*) and *Minibari* (*A. firma*), of Japan. The fruits (yashi) contain 25 per cent of iron-bluing tanning matter and little coloring matter. *A. Nepalensis* and *A. nitida* are used in India for tanning purposes.

White or *common birch* (*Betula alba*). The inner bark is used in Scotland (in conjunction with larch for tanning sheep-skins), Norway, Russia and elsewhere. It contains only 2 to 5 per cent of iron-greening tannin, and much fermentable sugar. It is used to produce the birch-bark tar used to give scent and insect-resisting power to "Russia-leather."

Pomegranate (*Punica Granatum*). The peel of the fruit is employed in Spain and the East as a substitute for sumac, and contains up to 25 per cent of tannin. The bark is said to contain 25 per cent of tannin. Balaustines, or wild pomegranates, are found in the East Indies The fruit is said to contain 46 per cent of tannin.

Bloodroot or *Shepherd's Knot* (*Tormentilla erecta, Potentilla Tormentilla*). The root is variously stated to contain 20 to 46 per cent of tannin. It produces a red colored leather.

Mountain Ash (*Sorbus* or *Pyrus Aucuparia*). The bark is said to be stronger than oak.

Butea frondosa, with *Pterocarpus Marsupium*, furnishes East Indian kino. The flowers are used in India as a dye, under the name of Tesu. The bark is fairly rich in tannin.

Pterocarpus, or *Drepanocarpus Senegalensis*, is the source of African kino, which contains up to 75 per cent of tannin.

Mango (*Mangifera Indica*) is widely distributed in the tropics. The bark and leaves are rich in tannin which gives green-blacks with iron.

TARO. *Colocasia antiquorum*, var. *esculenta*. (*Caladium Colocasia*.) *Aroideæ*. Figs. 852, 853; also Figs. 131, 132, 135, in Vol. I.

By *J. E. Higgins.*

The taro plant is cultivated for the thickened starchy underground parts. The plant is a perennial herb, with large cordate-peltate leaves. The spadix terminates in a club-shaped appendage destitute of stamens, half as long as the staminate inflorescence. The species, in some forms, is in common cultivation for ornament. Taro is the chief food plant of the natives of Hawaii and other of the Polynesian races. It is supposed to be a native of India, whence it has been distributed to Malay, Sumatra and the Polynesian archipelago. It reached Hawaii, no doubt, with the early migrations from the south.

Varieties.

Although propagated by asexual parts, the taro has run into many varieties. In the ancient Hawaiian cultivation there were thirty to fifty named varieties, more or less distinct. They varied in size, form, color of flesh, color of leaf and leaf-stalk, in texture and flavor, and in the period required for maturity. There was a variety known as the Royal taro, which was used by the kings and high chiefs. Most of these varieties are not extensively cultivated to-day, but a large number could doubtless be collected among the native Hawaiians.

There are two general types of taro, the one growing partly submerged, and known as water taro, and the other growing on uplands which are abundantly supplied with moisture, but not submerged. The latter is spoken of as dryland taro.

Culture of water taro.

Soil.—The soil for water taro should be heavy and retentive of moisture. Muck soils of the valley bottoms are usually selected. The whole valley bottoms in Hawaii are frequently laid out in taro patches. These vary in size and shape, no two of them being alike, and are so arranged that the water may pass over the higher patches, through those adjoining, to the lower fields.

To prepare a new taro patch, dikes must first be thrown up around it and the bottom prepared so that it will hold water. To do this the land is plowed, water is turned on, and the subsoil packed to make it tight. This puddling, of course, is not necessary for an old taro patch. When the land has been thoroughly prepared, and the water has been partly drawn off, the taro patch being a mass of mud, it is ready for planting.

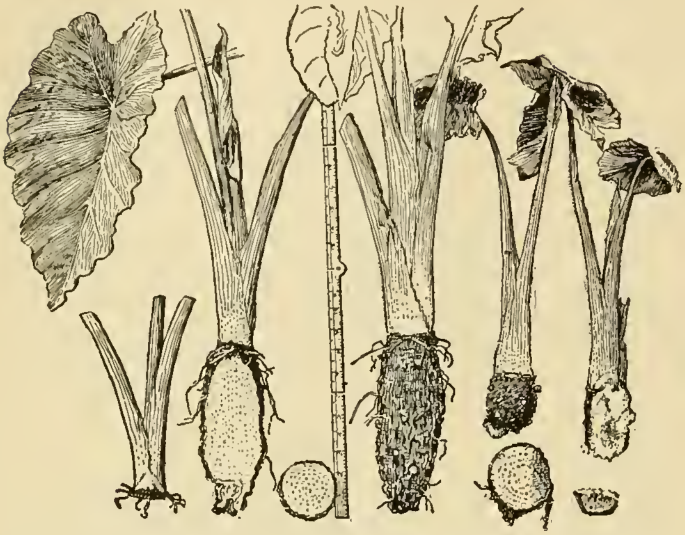

Fig. 852. Taro. To the left is a "huli"; two last on right show disease known as "root-rot" of taro; the others are normal roots.

Planting.—Taro is propagated by planting the crown of the former plant. An inch or two of the crown, together with about six inches of the leaf-stalks, is planted in the mud. This cutting or plant is known as a "huli." The hulis are set about one foot apart in a row, and the rows one to two or three feet apart, according to variety and method of cultivation. Some growers plant in hills, four or five hulis being placed in a little circle slightly elevated.

The lower part of the huli beneath the soil sends out roots and enlarges, forming the central taro plant around which are arranged the younger plants, which arise from buds on the corm of the parent.

Subsequent care.—The after cultivation consists in pulling the weeds, which is usually done by hand or with a hoe, in removing the outer and dead leaves, and in keeping the patch supplied with water. In hoeing, the weeds which are not likely to grow again, and the outer and dead leaves of the taro plant, are buried in the soil under the water, and thus used as fertilizer. No horse tillage is used in cultivating the water taro. The water must be kept running continuously, or must be changed frequently.

Harvesting.—The crop matures in thirteen to fifteen months, according to variety. It frequently is gathered before it is mature because of the desire to reap rapid returns. This fact may be responsible, in part, for the deterioration of taro. The laborers pull the plant by hand, throwing it out on the banks, where the tops are removed and the corms are bagged for marketing for the manufacture of poi. If it is to be marketed as a vegetable, it is tied in bunches by the tops, there being three to five corms in a bunch.

Culture of upland taro.

The so-called dry-land taro might better be known as upland taro, since a dry soil is in no way suitable for its cultivation. It requires abundant moisture and is cultivated only where there is a liberal rainfall. The land is prepared as for any root crop. It should be plowed, harrowed and furrowed, making the rows about three feet apart, to allow for tillage by horsepower. The method of propagation is the same as that employed in the growing of water taro.

Uses and manufacture.

Poi.—The chief use of taro in Hawaii has always been in the manufacture of poi. For this purpose the corm, or rootstock, is cooked by steam. The skin is then removed and the taro beaten on a long boat-shaped taro-board, with stone pounders. This is the ancient method and is still in vogue, but has been replaced to some degree by machinery. In this method, sufficient water is added to the taro by moistening the stone pounder.

In the modern method, essentially the same results are obtained by machinery. The taro is steamed and run through a machine similar in construction to a meat chopper, a small quantity of water being added as necessary. The consistency

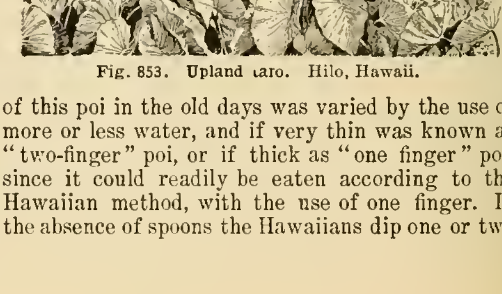

Fig. 853. Upland taro. Hilo, Hawaii.

of this poi in the old days was varied by the use of more or less water, and if very thin was known as "two-finger" poi, or if thick as "one finger" poi, since it could readily be eaten according to the Hawaiian method, with the use of one finger. In the absence of spoons the Hawaiians dip one or two fingers in the poi, giving it a twirling motion, and dexterously convey it to the mouth. Poi is not considered ready for use by the Hawaiians until it has fermented for one or two days.

As a vegetable.—The taro corm is also much used as a vegetable, being a good substitute for potatoes. As such it is steamed, boiled or baked.

The young and tender leaves from the center of the growing taro plant are also used for food. When boiled they make an excellent pot-herb, not unlike spinach. The unopened floral spathes are also cooked.

Flour.—The manufacture of poi flour from the corm is an industry which has received some attention. Taro in all forms being a most wholesome and nourishing food, and particularly easy of digestion, has commended itself as a health food. Practically the only way to put it on the market as such is in the form of flour, since the taro itself does not keep well. Taro flour, if pure, is simply the "root" cooked, dried, and ground to a powder. It is sold under various proprietary names.

Enemies.

There are no serious insect enemies of taro. A fungous disease known as "root-rot" is a somewhat serious hindrance to successful taro-growing, but may be controlled by judicious methods of cultivation, including proper selection of hulis, rotation of crops, fallowing and fertilization. [For further notes on taro, see Index, Vol. I.]

TEA. *Camellia Thea*, vars. Link. (*Thea Sinensis*, *T. Bohea*, and *T. viridis*, Linn.). *Ternstrœmiaceæ*. Figs. 854–857; also Figs. 173, 174.

By *Charles U. Shepard.*

Tea is a shrub grown for its leaves, which are used in the preparation of the well-known beverage by the same name. It sometimes becomes a tree, reaching a height of thirty feet; leaves elliptic-lanceolate or obovate-lanceolate, acuminate, serrate and glabrous, sometimes pubescent beneath; flowers white and fragrant, one to one and one-half inches broad; petals five; stamens many. It is largely grown in China and India.

Tea-culture in America.

One hundred years ago the French botanist, Michaux, set out the first tea plant in America at the beautiful gardens of Middleton Barony on the Ashley river, near Charleston, S. C.; its subsequent thrifty growth to nearly twenty feet in height attested the congeniality of the climate. Some forty years thereafter a South Carolina woman observed the striking similarity of the climate and flora in the tea-producing region of British India with those of her home, and thus led her father, Mr. Junius Smith, of Greenville, S. C., to undertake on his plantation his most interesting experiments in the cultivation of tea. Unfortunately, these efforts were brought to an early close by the sudden death of that pioneer. Just previous to the civil war, and probably as a result of the "boom" in East Indian tea, the United States government introduced considerable quantities of tea seed into the southern coast states. This gave rise to many small domestic gardens, and clearly demonstrated the feasibility of profitably producing tea of excellent quality and amply sufficient for household wants. But the ravages of war destroyed most of these little gardens. A few, however, survived hardships and neglect; and as the plants had escaped pruning, they grew into "seed-groves" as distinguished from "tea gardens," where the bushes are systematically restricted in size. About twenty years later, Hon. Wm. G. LeDuc, United States Commissioner of Agriculture, started a tea experiment station on a part of the same "Newington" plantation from which ten years afterwards "Pinehurst," near Summerville, South Carolina, was cut off. After a few years of existence and the further confirmation of the suitability of the tea plant to this region, the station was abandoned by Dr. Loring, the next commissioner.


Fig. 854. Tea flower (*Thea viridis*). Adapted from Botanical Magazine, Vol. VI, Plate 3148.

Thus far, then, by adequately supplying the family wants from domestic gardens and furnishing small samples of approved tea for tasting by experts, the first step in the establishment of a tea industry had been taken successfully. But the question remained unanswered whether tea as a commercial commodity might be raised profitably in this section, and to its solution have been devoted the activities and means of "Pinehurst," greatly assisted and encouraged by the United States Department of Agriculture and the Secretary of Agriculture. Indeed, it may be very properly added that the local work has received the greatest attention and coöperation from the public. The effort will not be relinquished, whether Pinehurst be acknowledged a success or not. Today, as the sole representative of American-grown teas in our markets, it must stand for the new industry; consequently, what follows as relating to Pinehurst should be regarded as of possibly wider application in the future.

The promise of the new industry.

There were many reasons for undertaking the investigation. It was questionable whether sufficient data supported the official dictum that the commercial cultivation of tea in the United states was impossible. The climate certainly should suit. In Pinehurst and the vicinity are found clumps of *Berberis Japonica*, *Cleyera Japonica*, *Camellia Japonica*, *Pyrus Japonica* and many other plants (persimmons, plums, walnuts, evergreens,) from

Japan. If, therefore, the same flora prospers in Japan and here, there can be no natural difficulty in substituting in our markets American tea for the 40,000,000 pounds annually imported from that insular empire.

It is very evident that great good must follow the introduction into the southern states of a new industry, whereby an easy, outdoor employment may be afforded to women and children unable to bear harder labor and yet needing remunerative occupation, especially as tea-leaf-plucking but slightly infringes on the gathering of the great southern staple, cotton. And there are great tracts of fertile land in the vicinity of Pinehurst, now idle or worse from the lack of drainage, and therefore impregnated with malarial fevers, which tea cultivation might render safe and profitable. The people of the United States are paying the Orient for tea upwards of $15,000,000 annually, which sum might better be kept at home by local production. Indeed, the present small consumption of tea in this country, as compared with other English-speaking peoples, amounting to one and one-third pounds per capita per annum, and of late years diminishing rather than increasing in quantity, might be greatly enlarged by more confidence in the purity of the home product than now exists in the imported article, and the quality of the beverage improved by avoiding the deleterious effect of the long ocean voyage.

Varieties of the tea plant.

Whatever may be the opinions as to their origin, i. e., whether, as stoutly maintained by many British writers, all are derived from the indigenous Assamese stock, and owe their special characteristic to changes of climate and cultivation, as the result of their removal to other countries, there are great and practical differences between the several types

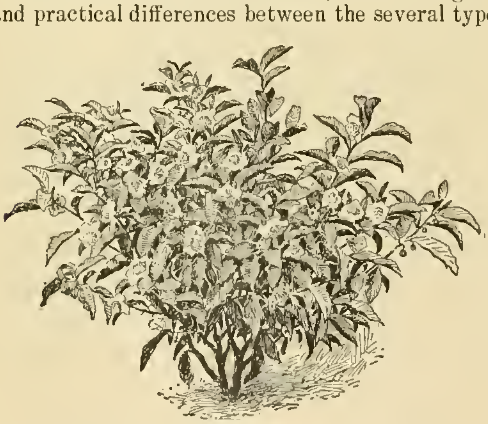

Fig. 855. Tea bush in flower.

of the tea plant. As extremes may be mentioned the tea tree of the Brahmaputra jungles, attaining a height of thirty to forty feet, with light green, silky leaves, frequently nine inches in length by four inches in width, and the stunted bushes of far northern climates, hardly exceeding two feet in height, with narrow, dark green, leathery leaves, two or three inches by one-half inch in size. Between them are innumerable variations of size and appearance.

Experience has demonstrated that all the varieties of the tea plant except those from tropical climates which succumb to the cold of our winters, will flourish in the southern sea-board states. Those that have done best at Pinehurst are:

(1) That stock which was introduced into this country fifty years ago, and has thus become thoroughly acclimated, although liable to be cut to the ground by a recurrence of the phenomenal cold of 1899, when the local thermometer fell below zero of Fahrenheit. Nevertheless, very few plants were killed thereby, and today the same gardens are as thrifty as ever. This type, which, from lack of more specific information, we call "Assam-hybrid," as being of an intermediate character, is capable of producing, under favorable conditions, 2,000 pounds of suitable leaf or 500 pounds of dry tea to the acre per annum. The leaf is well adapted to the making of black tea, and possesses most excellent cup qualities.

(2) "Darjeeling," from the slopes of the Himalayan mountains, the source of the best Indian teas, less productive and less hardy than the Assam-hybrid, but yielding a delightfully fragrant and delicate tea, either green or black according to the method of curing.

(3) "Dragon's Pool," secured through the kindly offices of the United States Department of State and the Chinese government from a celebrated garden in China, the product of which commands a price prohibitive of exportation, except perhaps to Russia. The plants are dwarfish and the leaf small. It is made into green tea both here and in China, yielding a most delicate beverage both to the smell and to the taste, and requiring for the most fastidious neither cream nor sugar.

(4) Among the varieties exciting the most interest is the "Shelter" tea, so called because it is grown under matting which excludes the direct sunlight. It is produced elsewhere only in Japan, where it is called "sugar" tea, because of its slightly sweet taste. This saccharine character is due to the storing up in the leaves of large quantities of starch, which in the process of manufacture is converted into sugar. The sheltered foliage is blue and large. The leaves are very soft and silky. This tea commands a very high price in Japan, if sold at all. The best of it is reserved for the imperial court.

(5) The gardens of Japanese and Kangra (British India) sorts afford most excellent green teas. Those made at Pinehurst from the former have been pronounced by the ablest tea-tasters of this country as not surpassed in their cup qualities by any imported from Japan; and a very prominent tea-planter from Kangra valley has recently tasted tea grown at Pinehurst from seed supplied by him, and has stated that it was fully the equal of the best in its original home.

The gardens raised from seed secured from the highest altitudes of Ceylon have not developed sufficiently to warrant an opinion as to their adaptability to this climate, but they have yielded a strong, flavory tea without astringent effect. The climates of Assam and the lower levels of Ceylon are too tropical for the production of tea seed suitable for this section.

Great difficulty has been experienced in the attempt to establish gardens from Formosa seed. The very limited number of plants raised must defer any definite opinion as to their utility here. It is now asserted that the best Formosan tea is derived from plants propagated by layers.

If it be remembered that green tea is non-oxidized, and black tea is oxidized, it will readily be seen that those leaves which are less susceptible to oxidation are better adapted for the production of the former sort; and as the ordinary curing of tea involves the exposure of the leaf for a greater or less time to the atmosphere, whereby some oxidation is liable to occur, an inherent proneness to this chemical change renders the making of green tea difficult. The black teas come chiefly from warmer climates, the greens from cooler climates. Either sort may be made from all tea-leaf, but each variety is better adapted for the production of the one or the other, or one of the numerous intermediate kinds of commercial tea.

Relative values of different parts of the tea plant.

The names and average weight of the leaves and stem on a young tea shoot, freshly plucked, are given below, beginning at its apex. ("Pekoe" in Chinese means "white hairs," referring to the appearance of the folded tip when dry.):

	Grains
Flowery pekoe or tip	½
Orange pekoe leaf	1
Pekoe leaf	2½
First souchong leaf	5
Second souchong leaf	8
First congon leaf	9
Second congon leaf	8
Stem	16
	50

It appears that the orange pekoe weighs twice as much as the tip; the pekoe leaf almost twice as much as the tip and orange pekoe; the first souchong (corruption of Chinese for small or scarce sort) more than all the pekoes together; the second souchong almost as much as every leaf above it, and the congons (corruption of Chinese for labor in rolling) are each as heavy as the second souchong. It takes 50,000 pekoe tips to make a pound of dry tea, but less than 4,000 of second souchong or congon leaves. Therefore the estimates of the yield of an acre of tea depend to a considerable degree on the method of plucking, whether fine or coarse. Those before given, as the productiveness of the Pinehurst gardens, are the result of fine plucking, whereby only the pekoe tip and leaves, and very rarely the first souchong, are gathered. A leaf or two more from each stem should greatly enhance the size of the crop, but would materially reduce the quality.

The constituent principles which give intrinsic value to tea are contained in cells which have to be broken that they may be taken into solution by the hot water poured on the dried leaf. These cells yield to slight pressure in the young and tender leaf, but are so securely enveloped in the older leaf that they require severe rolling. Again, by the economy of nature the most valuable substances

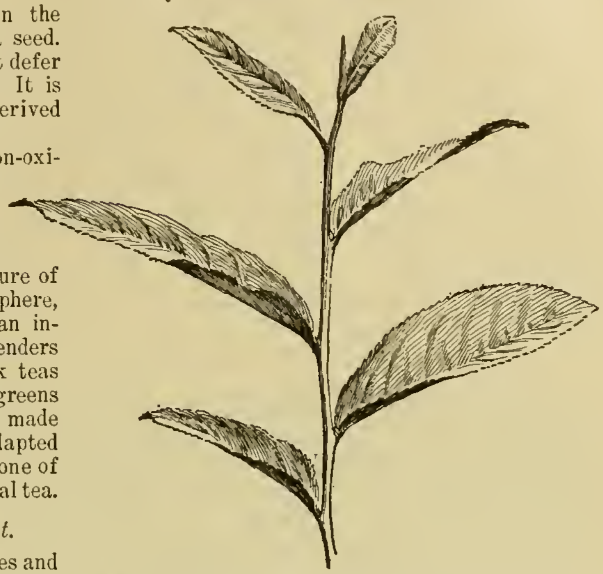

Fig. 856. Pinehurst tea-shoot from the vigorous and productive type known as "Assam-hybrid." Shows difference in size of leaves on same stem. One-half natural size.

are being constantly withdrawn from the older tissue, to be deposited in parts that are younger and in more rapid growth and replaced by more common and abundant material. The newer, smaller leaf consequently contains more that is valuable and in a much more accessible form. Thus the teas made from the pekoe leaf are more valuable than those from souchong, and the latter than from congon.

Culture.

Soil.—Tea requires for its successful cultivation a deep, fertile soil, easily permeable to air and water, as also to its roots, and entirely free from stagnant water whether on the surface or within its reach. Quite the contrary to the pictures on our grandmothers' blue china, flat lands with a slight slope for drainage are best, as thereby denudation of the soil by severe rains is avoided. The land must be diligently tilled, and consequently should be free from old roots and stumps. With virgin land it is better to raise two or three crops requiring deep cultivation before setting out the tea seedlings.

Climate.—A copious and even rainfall throughout the cropping season is almost essential, but a milder climate does not require so much precipitation as a hotter one. At Pinehurst the total rainfall for the six to seven months which cover the plucking season has slightly exceeded thirty inches during the past (rather dry) five years. In the great tea-producing regions of the Orient the rainfall is double or triple that amount. The Pinehurst observations do not exhibit any marked dependence of the size of the crop on excessive rainfall, but prolonged droughts seriously curtail the production. Downpours are certainly to be dreaded as of little utility and frequently very destructive.

The mean temperature for the cropping season is about 71½° Fahr. When it falls below 70° Fahr. the yield is scant, especially if accompanied by a dearth of water, and the quality is higher. Unquestionably, an equable amount of heat and rain is safest, but the largest yield has been obtained where both were at their highest. The occurrence of zero temperatures is destructive to all of the plant above ground unless it has entered into full hibernation and its stem is well protected by foliage or snow. Bushes raised from tropical seed very largely succumb if the thermometer falls into the twenties. Late frosts in spring and cool nights in summer have a prejudicial effect on the crop.

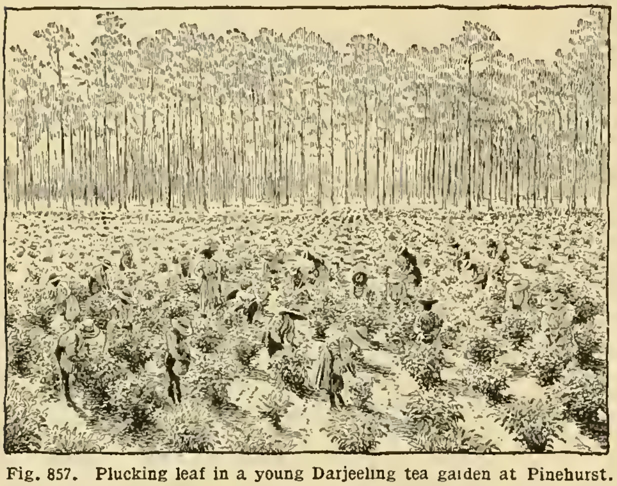
Fig. 857. Plucking leaf in a young Darjeeling tea garden at Pinehurst.

The importation of tea seed from the Orient is attended with very considerable risk. Unless the seed be carefully gathered, packed and expeditiously forwarded, and unless it be zealously protected from cold and excessive heat on arrival, and during its further transportation through this country, the chances of securing successful germination are exceedingly small.

Seeding.— The seed should be planted in the late winter or early spring in nurseries, in well-drained, ordinarily fertile garden soil, at distances of 3 x 4 inches, at about two inches depth, and well covered with pine or other straw as protection from the cold. Where droughts may be expected, it is desirable to command a handy water-supply for keeping the soil fairly moist. Later, when the shoots begin to appear, a moderate shelter from the sun should be raised above the beds and most of the straw removed; with the advent of autumn the shelter should be gradually dispensed with. The beds must be kept clean of weeds and grass.

Transplanting.— The seedlings may be allowed to grow until a foot or more in height, when they may be transplanted to the future tea garden, which here is best done in the late autumn.

There are two ways of planting: (1) by checks, in single hills at distances conformable to the habit of the bush and the fertility of the soil, at 4 x 4 feet to 6 x 6 feet, either rectangularly or alternately ("quincunx"), the latter being preferable as affording more plow-ways. Such planting requires 1,200 to 2,700 seedlings to the acre. Or (2) the plants are set out for hedges, say five feet by fifteen inches apart. The latter method requires much more hoeing, but is better adapted for sloping land, where, by running the rows at right angles to the declivity, the washing of the top soil is largely obviated.

Subsequent care.— The cultivation of tea in this country demands the substitution of plows and cultivators, drawn by horses or mules, for the handwork with spades, forks and hoes in vogue in the Orient. It requires that the soil should be kept free from weeds and grass and as permeable to rainfall as possible, without injuring the surface roots of the plants. Where rainfall is excessive or the site too sloping, suitable measures must be taken to prevent the washing away of the top soil; where danger of drought prevails, steps for the conservation of moisture are in place. Experimental artificial irrigation has not proved successful at Pinehurst, although theoretically suggested. Here it has been found much more urgent to get rid of water in the subsoil than to supply it superficially.

Pruning.—Aside perhaps from differences of individual opinion in the processes of manufacture, there is no subject on which tea-growers present greater divergence of views (and few can resist the temptation to rush into print thereon) than on pruning. The necessity of pruning lies in the evergreen character of the tea plant and its arborescent tendency under favorable conditions of growth. Ordinarily, after the bush has attained a medium size the production of young leaf is small, but withal the growth upward would soon extend beyond the reach of the pluckers. Hence, both to facilitate the gathering of leaf and to stimulate the production of young growth by forcing nature to its utmost effort to restore the natural equilibrium between the roots, stems and leaves, the tea-planter deprives the bush of a greater or less quantity of the leaves, which constitute not only its lungs but also the physiological laboratory wherein the material for future growth is perfected. Usually it is not necessary during the first few years more than to trim the plant into proper shape, and afterward to cut back (in this climate, after the severest cold of the winter) the growth of the past season to within a few inches of the older wood. But this limitation does not suffice for the purposes already stated, and it becomes necessary every five or ten years to subject the bushes to a more vigorous pruning, perhaps to the very ground. Finally, where the winter temperature is liable to drop below 20° Fahr., it is advisable to substitute a clump or sucker-growth for the single-stem bushes of tropical climates, if necessary by the removal of the main trunk, thus providing protection from the cold to the tenderer stems.

As a result of pruning, at the axis of every remaining leaf there appears a tiny shoot which speedily develops into a new stem equipped with several leaves. From the axis of each of these latter springs yet another shoot which under favorable conditions gives rise to another crop of leaf. These successive productions of young foliage are called "flushes," whose rapidity of recurrence depends on climate, soil and systems of cultivation and plucking. They afford the tea-planter the opportunity of gathering the young and tender leaf at frequent intervals throughout the growing season. The fact that upwards of twenty pluckings have been made at Pinehurst during the six months of cropping is due to the picking of only a small modicum of leaf from each new shoot, and the consequent readiness with which young foliage is produced. A large part of the world's tea is the result of a practical stripping of all the leaves and a good part of the stem; but as such depletion removes the embryonic shoots in the axes of the leaves, the power of reproduction is greatly diminished.

Plucking and production.—The plucking of leaf begins with a small topping during the first year after transplanting, and under favorable conditions should exhibit a progressive increment for a number of years. The following table shows the early croppings, expressed in pounds of dry tea per acre, of several sorts of tea on naturally fertile lands:

	Assam-hybrid	Darjeeling	Chinese	Kangra
1902 . . .	1	. .	. .	. .
1903 . . .	34	. .	. .	. .
1904 . . .	103	2	33	110
1905 . . .	195	55	157	203
1906 . . .	284	92	206	209

A comparison of the production of some older gardens, also expressed in pounds of dry tea per acre, since the phenomenal freeze of the spring of 1899, affords the following:

	Assam-hybrid		Chinese		Darjeeling	
	1	2	1	2	1	2
1900 . . .	63 .	. 272	135 .	. 41	147 .	. 48
1901 . . .	60 .	. 347	93 .	. 47	183 .	. 96
1902 . . .	159 .	. 440	252 .	. 111	292 .	. 148
1903 . . .	145 .	. 421	205 .	. 142	264 .	. 149
1904 . . .	89 .	. 363	140 .	. 109	264 .	. 144
1905 . . .	135 .	. 480	170 .	. 119	326 .	. 198
1906 . . .	176 .	. 382	345 .	. 193	347 .	. 225

The plucking of the leaf generally extends in this climate from the beginning of May until into October, and is confined to the pekoe tip and leaves. The colored children who gather the young leaves as they are successively produced have occasion to revisit each garden every ten days to two weeks during the season. By careful training they become expert in their task, and easily equal, if not surpass, the average tea-pluckers of the Orient. But constant supervision as to their thoroughness is requisite not only in the gardens but also at the delivery of the leaf at the factory.

The vitality of the tea plant, under favorable conditions, successfully overcomes the strenuous incursions of the pruner and plucker. Abundant proof has demonstrated that the same plant can be thus depleted for twenty-five to fifty years, without serious impairment; indeed, it is asserted that in one Japanese garden the same bushes have yielded high-grade leaf for two hundred years. The irregularities in the productiveness of the older gardens, as shown in the above table, are preëminently due to meteorological variations. The greater yield of 1902 was probably due to unusually high temperatures, the thermometrical readings having exceeded 100° Fahr. on several days.

Curing and handling.

If it is remembered that all tea-leaf must be subjected to two processes, viz., rolling, to break the oily cells which contain the principles valuable for brewing the beverage and to spread them on the surface of the leaves, and drying, to prevent fermentation and decay; that leaf thus prepared constitutes green tea, the nearest approach to the natural condition; and that the introduction of two additional processes,—withering of the green leaf, and oxidation, by exposure, after rolling, of the damp leaf to the atmospheric air, produces black tea, it will be readily seen how large an opportunity has been given for substituting mechanical for the old-time hand (and naked foot) processes of the far Orient. Indeed, at the present up-to-date tea factory, manual labor has been restricted to that final culling which removes objectionable leaf and adventitious matter.

Intelligently to describe the many machines now in use, should necessarily consume too much time and space, but it may be permitted to refer to two useful ones invented at Pinehurst:

The green-tea sterilizer consists of a rotary cylinder which satisfactorily sterilizes the "enzymes" or soluble oxidizing ferments in the freshly plucked leaf, by directing a current of hot air (550° to 600° Fahr.) against it as it falls for several hundred times through the diameter of the tube on its passage through the length of the latter, until it is discharged in a flaccid condition, suitable for rolling and no longer liable to oxidize.

The attritionizer imparts to the dried unoxidized leaf a gray color due to the friction of the particles of tea on each other in a current of warm air, which otherwise can be secured only by adulteration with foreign and generally deleterious coloring matters.

The final mechanical process is the differentiation of the several sizes of the dry tea particles by means of sieves, and to them are given the names of the leaves of the tea shoot, as if separately plucked and prepared,—which is practically nowhere done. If not previously chopped or cut, the smaller the dry leaf particles the better is the brew.

Enemies.

Thus far the only enemies developed by the American tea experimentation have been the red-spider, during exceptionally dry weather and on weak plants, and the mealy-bug on bushes in the dim light under the covering of the shelter-tea frames. Pruning and burning are the most effective remedies for these pests. Cattle, goats and the general farm-thief do not molest tea gardens; and the depredations of the army-worm must be regarded as an advantage, as the worm spares the tea while destroying the grass.

Quantity versus quality in the product.

The production of large yields is generally at the expense of quality, as frequent flushes appear to interfere with the formation of those chemical combinations which impart value to the leaf. Nevertheless, the problem of quantity or quality steadily presents itself to the average tea-planter of the Orient, and the profit of production vacillates between the two. Of late there would seem to have been more money in poorer and cheaper teas. The price of tea has fallen to about half the price it held one generation ago. If the quality had been maintained, which under the circumstances was impossible, the only sufferers might have been the producers; but as matters now stand, the poorer classes in losing their health from the consumption of inferior teas are most to be pitied. First came the terrible struggle of the Indian and Ceylon planters with China for the supremacy of the world's tea markets; and once accustomed to a steady decline in price, the dealers, both wholesale and retail, have never ceased to demand yet greater cheapness of the commodity, even though incompatible with the real enjoyment or healthfulness of the beverage. Good tea is imported into this country and commands its proper price, but it plays a subordinate part to the great bulk of cheap, often harmfully astringent or worthless stuff made from inferior leaf.

At the very commencement of the Pinehurst experimentation, the impossibility as well as the undesirability of attempting to compete with the cheaper oriental teas was acknowledged because of the great difference in the price of common, unskilled labor. It was foretold that success could be attained only by the production of high-class teas, the product of intelligent labor and suitable machinery. It was felt that the distinctly characteristic cup qualities of American teas, while operating against their introduction, must prove their main reliance because they precluded the substitution of foreign articles for them when once their use had become habitual. For this reason and because the Pinehurst teas possess purity, strength and, withal, freedom from astringency, they have found favor in large sections of the country. The large variety of foreign tea plants, carefully selected from the best sources and intelligently cultivated, has enabled Pinehurst to place on the market a number of different teas, thus appealing to the tastes of all and solving the question as to the disposition of the output.

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TEASEL. *Dipsacus Fullonum*, Linn. *Dipsaceæ*. Figs. 858–860.

By *C. W. Clark.*

The teasel is a biennial plant, the heads of which are used in tearing or raising a nap on cloth. It is a stout herbaceous plant with opposite leaves and with flowers in heads or whorls. During the second season the plant grows into a bush about six feet high, with numerous branches (Fig. 858), at the extremity of each of which a teasel forms. The main stalk produces the largest and strongest teasel, known as the "king." This is called a "male" teasel and is the only one of the kind on the plant, although there are usually a large number of "queens" or "mediums," as they are generally known, at the extremities of the lateral branches. From the subdivisions of these laterals, smaller branches produce the "buttons," as the smallest teasels are termed. The male teasel sheds pollen over the others, without which fertile seed will not be formed. If the "king" be removed, the

Fig. 858. Fuller's teasel, mature plant. Larger heads ready for cutting, smaller ones still in bloom.

other teasels will be larger and for manufacturing purposes fully as good, but the seed will not germinate. Where the branches diverge from the main stalk the leaves grow together and form a cup holding a pint or more of water. It is interesting to note that without water in these cups perfect teasels will not be formed.

History.

The fuller's teasel is a native of the south of Europe, whence it was taken to other sections and is now cultivated to a large extent. In 1840, William Snook, a resident of Onondaga county, New York, visited his former home in England and on his return brought with him teasel seed, and with the help of workmen from the teasel-growing sections of England he began the culture of teasel in America. From this small beginning has sprung a business which, although it has not spread to any great extent beyond a radius of ten miles from the place where it originated, ranks as one of the important industries of that section. In more recent years the teasel has been grown in a small way in Oregon. The Oregon teasels, although of good quality, are not considered by manufacturers to be up to the standard of excellence of the New York product.

Varieties.

A number of species are known, all native of the temperate regions of the Old World. But two varieties are known in America, the *Dipsacus Fullonum* or fuller's teasel, which is the only kind having a commercial value, and the wild teasel, *D. sylvestris*, which is a common wayside weed in many sections, and is said to have some value as a bee plant.

Although there is but the one variety of teasel that has a commercial value, the market teasels vary considerably in quality according to the soil and climate in which they are grown. The dry climate and soil of France produce the most wiry hooks known. These are needed for blankets and deep-napped woolens. The moist soil of England produces the opposite extreme, but it is such a teasel as much of the English cloth requires. The German product, which is very similar to the American, has a medium strength and is adapted to ordinary woolens. This variation causes a considerable interchange between the different countries. Broadcloth, which is almost entirely a foreign product, requires a small, fine teasel. This creates a demand for the "buttons" from this country. Blankets, on the other hand, are exclusively a domestic product and call for the "kings" both home-grown and foreign.

Culture.

The teasel seems to do its best on a limestone soil, which should be made clean by previous cultivation. In the early spring the ground should be thoroughly fitted and the seed sown in drills about three to three and a half feet apart. One to two pecks of seed per acre are used, commonly the smaller quantity. When the young plants appear they should be given clean cultivation, and should be thinned to stand eight or ten inches apart. It is customary to plant a half crop of corn with the teasels. This does not seem to injure the growth of the young plants and it gives some return from the land the first season. The stalks are usually left standing to hold the snow on the teasel plants during the winter. The second spring the field is usually given an early cultivation, after which nothing is done till the time of harvest.

Fig. 859. Teasel, near the end of the second year.

Harvesting and handling.—About August 1 the crop is ready to be harvested, when the plants have acquired their full size. The heads have blossomed and between the blossoms have formed the stiff, recurved hooks that give the plant its value. The heads should be cut as soon as possible after the blossoms have fallen. About three or four inches of stem is cut with the head. The implements for harvesting are a short knife, a pair of gloves to protect the hands and a large basket to hold the cut heads. As the heads do not ripen uniformly, it is necessary to go over the field two or three times to secure the entire crop in its best condition. As soon as cut, the heads are drawn to a building provided with ample ventilation and spread on scaffolds to dry.

Yield.

The average yield in America is about 100,000 heads per acre; in the countries of Europe two or even three times this yield is not uncommon. The reason for this is to be found in the high-priced land and the cheap labor of those countries. The opposite conditions here render intensive cultivation unprofitable.

Marketing.

From the grower the crop goes to the dealer or middleman. The price has varied from fifty cents per thousand (an unprofitable rate) to two dollars and even more, although the latter price has not been reached in many years. For the past few years the price has been ninety cents to one dollar per thousand. Considering that it requires two years to grow the crop and that much hand labor is required, any price under seventy-five cents will not return a fair margin of profit.

Fig. 860. Teasel, first year.

Although nominally sold by the thousand, the teasels are really sold by weight. A thousand of the dried teasels are estimated to weigh ten pounds. The dealers trim off the projecting spurs about the base, shorten the stem, assort them into several grades according to size and the quality of the hook, and pack them for shipment to the manufacturer.

Use.

The teasel has been used from ancient times in raising a nap on cloth. At first the work was done in a rude way by hand. At present the teasels are arranged on a cylinder in such a way that the cloth passes slowly over them while the cylinder or "gig," as it is called, revolves in the opposite direction. Thus the recurved hooks catch the fibers of the wool, causing them to stand up from the surface of the cloth and form a nap, which in fine cloth is sheared to bring it to a uniform length. After a time the spaces between the hooks become filled with the fibers. They are then cleaned by machinery. By this means the teasel may be used several times before it becomes worthless. Although a number of machines have been invented to take the place of the teasel, nothing has been practical enough to come into general use. The teasel hook is strong enough for the work and yet elastic enough to "give" before breaking the cloth, characteristics difficult to secure in a machine.

TEOSINTE. *Euchlæna Mexicana*, Schrad. Also given as *E. luxurians* and *Reana luxurians*, Dur. *Gramineæ.* Guatemala Grass. (Pronounced teosin'te.) Fig. 861.

By *W. J. Spillman.*

An annual forage plant closely related botanically to corn. The appearance and inflorescence are much like corn, but no true ear is formed; the seed is produced on slender spikes in four or five leaf-axils near the center of the plant. A tassel is borne similar to that of corn. Some botanists hold it to be the original form of corn, with which it readily crosses. It is a rank grower, reaching a height of nine to fifteen feet, and bearing an abundance of leaves and tender stems. Thirty to sixty stalks are sometimes sent up from a single root. Some of the suckers attain nearly the same size as the main stem and mature at about the same time. Under favorable conditions, growth continues until checked by frost.

Distribution.

The successful growing of teosinte is restricted by soil and climatic conditions. It demands a rich soil with an abundance of moisture and a long, hot growing season. Where these conditions do not prevail, it is easily superseded by sorghum, corn and other forage crops. The plant is a native of the warm parts of Mexico and Central and South America, though it was first cultivated in Australia. In the United States its best growth is made along the Gulf coast, in Florida and Louisiana, and in Georgia and Mississippi. It may be grown as far north as New Jersey and Kansas, though in the northern states it can scarcely be considered an economic forage plant. It has been grown with some success in Michigan and southern Oregon. In New York and Vermont it has not given satisfaction. In Texas it has given satisfaction, both as a green and as a dry feed. It here grows to a height of nine feet, and produces three crops a year, but it does not mature seed.

It seldom matures seed north of latitude 30°. The seed raised in the United States is grown almost exclusively in the southernmost part of Florida, though seed has been matured at the Louisiana Experiment Station.

Culture.

The planting season is May or June, and it should not be delayed beyond this because of the long growing season required. Rich bottom land or any soil that will produce good crops of corn is most desirable. The drills are three to four feet apart, the plants one foot apart in the row. It is sometimes advised to make the drills five feet apart and the hills three feet apart in the row, three or four seeds being planted in each hill. The richer the land the farther apart should the seeds be planted. One to three pounds of seed per acre is used, depending on the method of planting; usually one pound per acre is sufficient. The seed is rather expensive, and must be purchased each year.

Fig. 861. Teosinte (*Euchlæna Mexicana*).

The crop is given much the same cultivation as corn, and is fertilized as for corn or sorghum. Fig. 861 illustrates the luxuriant growth.

Harvesting and yield.

Teosinte is seldom used in any way except as a soiling crop. Its great succulence and the fact that it is usually grown where there is much rain renders it nearly impossible to cure it for fodder. It has occasionally been ensiled and is said to make a fair quality of silage. When used as a soiling crop, it furnishes several cuttings during the season. It is best cut when four or five feet high, as it becomes less palatable if allowed to mature much beyond this. When grown for fodder it may be cut late in the season, and the amount of feed secured will be practically as great as that secured by cutting it several times during the season.

When grown for seed in Florida, the plants are sometimes cut once or twice before they are allowed to run to seed. The seed is ready to harvest in December. It is run through an ordinary grain thresher and sold by sample.

The yields of forage are enormous, placing teosinte at the head of the grasses in the yields per acre. Harvests of eighteen to thirty tons per acre are not uncommon. When to this great yielding property is added the fact that the entire plant is relished by stock, its importance as a forage crop is readily understood. The stalks are tender and nutritious, and none of the plant is wasted.

Although teosinte has been known for a long time, it has almost no standing as a farm crop in this country. It is utterly useless to plant it on any except moist, rich soil, and such soil is not common in the section where it is grown. The fact that practically its sole use is for soiling purposes greatly limits its usefulness as a farm crop.

Literature.

Farmers' Bulletin No. 102, United States Department of Agriculture; Kansas Experiment Station, Bulletin No. 123; Florida Experiment Station, Bulletin No. 78.

TOBACCO. *Nicotiana Tabacum*, Linn. *Solanaceæ.* Figs. 862–880; also Figs. 178, and 108 in Vol. I.

By *A. D. Shamel.*

Tobacco is a plant of American origin, the leaves of which are used for smoking, chewing, snuff and also medicinal purposes. The genus *Nicotiana* embraces about fifty species, but *N. Tabacum* (from South America) supplies about all of the cultivated varieties of tobacco. Another species, *Nicotiana rustica*, is occasionally found wild in Connecticut, New York, Colorado, and other states. It is commonly grown in Mexico for smoking purposes, being there perennial.

Botanical characters. (Figs. 862, 863.)

The tobacco flowers are arranged on a branching, determinate flower-head, which appears when the middle leaves are about half-grown, and continues to develop and produce new flowers during the remainder of the life of the plant. The calyx is green and five-parted. The corolla is tubular or funnel-shaped and delicately colored. It is comparatively small from the basal end to a point about two-thirds the distance to the terminal end of the flower. At this point it enlarges suddenly to more than twice the size of the basal part. Its five petals coalesce to form the corolla tube, and separate only at the extreme end. The stamens are five in number. The ovary is two-celled. The early capsules always mature before flowering ceases.

The tobacco flower is symmetrical. The number of sepals and stamens is always the same as the

Fig. 862. Flowers of tobacco.

number of petals, but these floral circles do not remain constant, varying rather indefinitely in different strains and even among individuals of the same strain. Trimerous flowers, or flowers with three parts in each flower circle, have been found growing on the same plant with pentamerous flowers, or those having five floral parts. This is the exception, however.

History and distribution.

The extreme antiquity of the use of the leaves of this plant for smoking purposes is indicated by the discovery of pipes and other means for smoking tobacco in the prehistoric mounds of the United States, Mexico and Peru. Columbus, on his voyages, discovered the natives using tobacco for smoking, chewing and as a snuff. In 1558, Jean Nicot, the French Ambassador to Portugal, sent a supply of tobacco seed to Queen Catherine de Medici, and to commemorate this service the generic name Nicotiana was given the plant. Killebrew states that early American explorers heard the plant called tobacco in Mexico, where it was cultivated extensively. The name "tobacco" also may have come from the name of the kind of pipe used by the Carribees, the "tobaco."

Fig. 863. Flowers and seed-pod of tobacco.

The systematic cultivation of tobacco was begun in Virginia about 1612, by John Rolfe. Among the early settlers in Virginia, at Jamestown and other places, tobacco was the common currency and the principal article of export. It is asserted by competent authorities that without this crop the first settlement in Virginia would have been a failure, and that tobacco was the foundation of the prosperity of the state. The cultivation of the crop rapidly developed, so that in 1731 the export of tobacco from Virginia and Maryland reached 60,000 hogsheads of 600 pounds each, yielding $1,875,000.

The culture of tobacco in New England began at the time of the settlement of the country. Its culture was opposed by many of the Puritan settlers, so that it did not develop to any great extent until about 1795. At this time, some of the settlers in the Connecticut valley, finding that the soil and climatic conditions were favorable for the development of a fine smoking tobacco, began to grow considerable areas. It was found that this tobacco, when manufactured into a roll, gave a delightful aroma and had a pleasant taste. In this way the first commercial cigars were made in the homes of the settlers, some of which were shipped for sale to New York and other thriving centers of population. About 1811 or 1812, the first cigar-manufacturing establishments were built at Windsor and Suffield. This section has remained the leading cigar-tobacco producing section until the present time. The industry in New England has had many changes during this period, but, as a whole, it remains one of the most profitable in the Connecticut valley. As a result of the importation of Cuban tobacco, and of the development of the Ohio and Pennsylvania tobacco-producing sections, where the tobacco has a superior aroma and flavor, the Connecticut valley tobacco has come to be largely used for cigar wrapper and binder purposes, the Ohio, Pennsylvania and imported Cuban tobaccos being used for cigar fillers. The New England tobaccos have a peculiar gloss, stretch and burn, which particularly fits them for cigar-wrapper purposes, in addition to the fact that when wrapped on cigars they blend nicely with the best fillers.

Fig. 864. Showing variations in shape and type of tobacco seedlings. Pointed type of leaves.

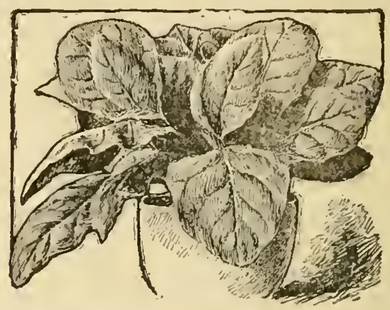

Fig. 865. Variation in tobacco seedlings. Round type of leaves.

Extent of the industry.

The widely varying types of soil in the tobacco districts, and the different varieties of tobacco, have made it possible to produce products suitable for the manufacture of the varied products demanded by the consumers. Some idea of the value of the crop may be gained from the estimate of the value of the crop in 1906, in the United States. About 796,099 acres of tobacco were grown, producing an average yield of 857.2 pounds to the acre, or a total of 682,428,530 pounds. The average value of the crop was about ten cents per pound, or a total of about $68,232,647. The value of the manufactured products of tobacco in 1900 was $283,-076,546. The products may be divided into three general classes, of which the values were as follows: Cigars and cigarettes, $160, 223,152; chewing, smoking and snuff products, $103,754,362; stem-used and rehandled tobacco, $19,099,032. In the manufacture of these products, 142,277 persons were employed, who earned a total wage of $49,852,484. In addition to the tobacco grown in the United States, there was imported into the United States during the year ended June 30, 1906, $4,143,192 worth of tobacco in a manufactured condition, and $22,447,514 worth of unmanufactured products, making a total value of imported tobacco of $26,590,706. In 1891, the tobacco industry furnished almost $50,000,000 revenue to federal government, and this revenue now amounts to one-eighth of the total net receipts. Tobacco has now become one of the great staple crops of the United States, and is being looked on as a necessity rather than a luxury by the people. Its culture is rapidly extending to all quarters of the globe, and its use for smoking, chewing, snuff and medicinal purposes is increasing at a tremendous rate.

Varieties.

The character of the tobacco plant is profoundly affected by the conditions of soil and climate. The flavor, aroma, "burn" and texture of the leaf are particularly affected by these conditions, so that certain sections come to be recognized as specially adapted for growing a special type of tobacco. It has been asserted that the aroma of the leaf is specially influenced by climatic conditions, while texture is affected most seriously by soil conditions. For example, the light, thin, elastic, cigar-wrapper leaf varieties of New England when grown in the heavy clay soil of Tennessee assume the heavy non-elastic character of the Tennessee tobaccos. The fact that a change of seed from one section to others induces variability has been taken advantage of in the production of new varieties. An illustration is found in the origin of the White Burley variety. George Webb, of Brown county, Ohio, found a few striking light-colored plants in a field of tobacco grown from Red Burley seed. The Red Burley seed came from Kentucky, and when grown under different conditions in Ohio threw these sports. Mr. Webb saved the seed of these plants and set out a small field from them the following season. This tobacco proved so desirable that the culture gradually extended until White Burley has become the most extensively cultivated variety in the United States. Another typical illustration is the Uncle Sam Sumatra variety, produced by the writer. In 1903, in the Connecticut valley considerable areas were cultivated to a variety the seed of which was secured from Florida. The marked change of conditions induced tremendous variability. One of the types found in these fields was ideal from the cigar-wrapper standpoint. The leaves were beautifully rounded, of fine venation and color. It was distinct from every other type produced. Seed was saved under bag from these plants, and was found to produce uniform strains of tobacco. The best of these strains has been developed into an established variety which is now grown extensively, producing a better grade of tobacco for wrapper purposes than any heretofore grown.

The tobacco flower is naturally self-fertile, and plants grown from self-fertilized seed are always stronger and more vigorous than those from cross-pollinated seed when the crossing is within the variety. The vitality of tobacco seed is retained with little loss for several years, providing the seed is kept in a warm, dry place and in a glass or other safe receptacle. The writer has often secured plants from seed known to be more than twenty years old. However, it is not safe to depend on such seed for planting on an extensive scale. The loss of vitality in old seed is shown by slow germination and other weak characters of the plants.

Fig. 856. Tobacco plants left for seed. Near Hartford, Conn.

The transmitting power of the tobacco plant is very marked. From seed saved under bag, plants are produced resembling very closely and uniformly the character of the parent plants. For this reason it is possible to improve the varieties of tobacco by careful selection of seed plants of the type desired. If the crop does not vary enough as regards the individual plants to enable the grower or breeder to make the selection desired, this variation can be induced through a change of seed, hybridization or, to a slight extent, by the method of fertilization of the soil. In saving seed from the selected plants, the flower-heads should be enclosed by a strong but light paper bag to prevent cross-pollination. The bag should be applied just before the flowers open, and can remain until the seed-heads are cut off and hung up to dry.

Cross-fertilization is easily effected among the different varieties. By careful selection and propagation of the desirable forms that result, and continued seed selection from these, new varieties are established. Indiscriminate crossing has been of very little use except in rare cases. The writer is of the opinion that variation secured by means other than crossing is much more likely to be effective and valuable from a practical standpoint.

The principal varieties now grown in the United States are described in the following paragraphs, together with directions for their culture. The culture of the different varieties varies widely, according to the variety and the purpose for which it is grown. For this reason, a somewhat detailed description of the leading and most important kinds is essential.

In a general way the varieties may be divided into the following classes: (1) Cigar wrapper and binder; (2) cigar filler; (3) chewing or plug; (4) smoking; (5) export tobaccos. In the following descriptive notes the last group is not discussed separately.

DESCRIPTIONS OF VARIETIES

Cigar-wrapper tobaccos.

Sumatra (Fig. 867, 868).—This variety is used wholly for the production of high-grade cigar wrappers and is not considered of value for fillers. In the United States it is grown under slat or cloth shade. It is adapted to sandy loam soil. In western Florida, where it is grown extensively, the surface soil is underlaid by a red clay subsoil. The leaves are very thin, of fine texture, with small veins, and vary from twelve to twenty inches in length and eight to sixteen inches in width. The plants bear sixteen to thirty erect leaves, with comparatively long internodes. Under favorable conditions the plants reach a height of seven to nine feet. This variety produces the best grade of domestic cigar wrappers. It is grown in western Florida, southern Georgia, and in the Connecticut valley.

Fig. 867. Sumatra tobacco (Uncle Sam variety) grown under shelter. Connecticut valley.

Connecticut Havana (Fig. 869).—This variety is used for cigar wrappers and binders, and the top leaves are frequently used for fillers in the inferior grades of domestic cigars. It is adapted to light alluvial, sandy soils, containing a small percentage of clay; as a rule, the less the clay, the higher the yield of fine cigar wrappers. Where this variety is grown for fillers a rich clay yielding a heavy crop of leaf is probably the most desirable type of soil. The leaves are thin, of fine texture and delicate flavor, set very close together on the stalk, with very short internodes, and have a very erect habit of growth. The plants bear ten to fifteen leaves, varying in average length from twenty to thirty-two inches and in average width from ten to fifteen inches. This variety was secured by continued seed selection from crops grown from seed imported from Cuba, and is probably a cross between these

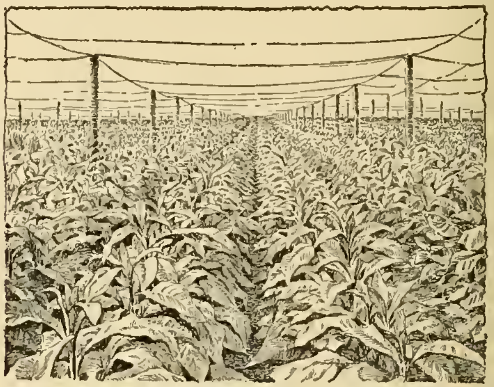

Fig. 868. Uniformity of Belgian type of Sumatra tobacco (from seed saved under bag), grown in Connecticut valley under cover.

Cuban plants and the native Broadleaf of the Connecticut valley. It is grown in the Connecticut valley, Wisconsin (mainly for binders), Ohio, Pennsylvania and New York. It is one of the best general-purpose tobaccos.

Connecticut Broadleaf.—This variety was formerly known and generally recognized in the trade as Seedleaf. It is used for cigar wrappers and binders, and the lower grades, to a limited extent, for blending with other tobaccos for cigar fillers. It is adapted to sandy loam soil. It makes an exceedingly rapid growth. The leaves are very broad, sweet tasting, thin, elastic, silky, and with small veins. They are set very close together on the plant, and have a very characteristic drooping habit of growth. They vary in length from twenty-four to thirty-six inches and in width from twelve to twenty-two inches. The size of leaf varies greatly in different sections and with the different strains. The seed of this variety has been sent to many parts of the United States and a large number of important varieties have been secured, as in the case of the Ohio Seedleaf, which can be traced directly to Connecticut Broadleaf seed. It is grown in the Connecticut valley, New Hampshire, Vermont, New York, Pennsylvania, Ohio, Wisconsin, Minnesota, and, to a small extent, in Indiana and Illinois.

Cigar-filler tobaccos.

Cuban.—The Cuban variety is used for high-grade cigar wrappers which are grown under shade, but is generally grown outside for fillers. It is adapted to alluvial or sandy soil resting on red clay subsoil. This variety has a small leaf of fine texture. The leaves are short and round, with small veins, medium to heavy body, varying from ten to eighteen inches in length, and six to fourteen inches in width. When this variety is taken north the influence of the climate and soil conditions tends to promote the development of a large leaf at the expense of fineness of texture and quality. When grown from freshly imported seed in southern tobacco districts, the tobacco seems to retain the valuable qualities of flavor, aroma, smooth taste, and other characters of the imported Cuban tobacco. Whether these qualities can be retained by continued selection of seed from desirable plants is a subject for experimentation, but the evidence secured up to this time indicates that it is probable that in certain districts in the United States uniform crops of Cuban tobacco having a highly desirable flavor and aroma can be produced by the aid of systematic seed selection.

In the Connecticut valley this variety is grown under shade for cigar wrappers, the top leaves being used to a limited extent for cigar fillers, and it is grown for cigar fillers in Florida, Texas, Ohio and Georgia. In Florida and Texas it produces one of the best grades of domestic fillers.

Zimmer Spanish.—This is largely used for cigar fillers, and is the most popular and extensively grown domestic filler. It is frequently used for blending with other tobaccos in cigar fillers. It is commonly thought to be a hybrid of the native Seedleaf and the Cuban variety. It is adapted to a light loam soil, and in the Miami valley, Ohio, where it is most extensively grown, the surface soil is underlaid by a red-brown clay loam. The leaves are medium in size, have good body and elasticity, with small veins, and resemble the Cuban variety. They are set close together on the stalk, fourteen to twenty leaves to the plant. The plants reach an average height of about four feet. This variety produces an average yield of about six hundred pounds to the acre and brings an average price of about seven cents a pound. It is grown in Ohio and Wisconsin.

Fig. 869. Havana seed plant.

Little Dutch.—This variety is used for cigar fillers, making a cigar with an aroma resembling the Yara tobacco of eastern Cuba. It is adapted to clay loam soils. The seed was introduced into this country from Germany. The leaves are small and narrow and the plants have a short habit of growth, producing a light yield. This tobacco requires careful curing and fermentation. It is grown in Ohio and to a limited extent in Pennsylvania.

Plug tobaccos.

White Burley.—White Burley is used for plug fillers and wrappers for smoking and for the manufacture of cigarettes. It is adapted to well-drained, deep red clay loam soil. In Kentucky such soils are fairly rich in lime and produce good crops of corn, wheat, hemp and grass, but they deteriorate rapidly unless the fertility is maintained by the use of fertilizers and proper methods of cultivation. The leaves are long and broad and have a white appearance in the field. They have a horizontal habit, the tips hanging down and often touching the ground. They vary in length from twenty-eight to thirty-six inches and in width from sixteen to twenty-four inches. The plants bear ten to eighteen leaves and reach an average height of about four feet in the field. This variety is a selection from the original Burley, the peculiar white, translucent appearance of the original plant having attracted the attention of the growers.

The Red Burley and dark tobaccos of southern and western Kentucky and Tennessee are heavy tobaccos, nearly related to the White Burley. Because of their peculiar characteristics they are largely exported. Burley is grown in Kentucky, southern Ohio, Tennessee, and, to a limited extent, in North Carolina and Virginia.

Orinoco and Yellow Mammoth.—These varieties are used for plug wrappers and fillers and are stemmed for export trade. They are adapted to rich, well-drained soils, doing especially well on alluvial soils underlaid with red clay subsoil. The Orinoco variety has short, broad leaves, while the Yellow Mammoth has large leaves, both varieties having a rapid rate of growth. The Little Orinoco type has a long, narrow, tapering leaf, and is the sweetest variety grown. The Yellow Mammoth is largely exported for Swiss trade, and its culture is mainly confined to Tennessee. The Orinoco type is grown in Virginia, North Carolina, Tennessee, West Virginia and Missouri.

Virginia types (Blue Pryor, Sun-Cured and White Stem).—These are adapted to sandy soil, underlaid with red or yellow clay subsoils. They have very broad, large leaves of fine, silky texture, with rather tough fibers and usually have bright, fine colors. Some of the best grades are used for cigar wrappers and others for smoking purposes. They are grown in Virginia, North Carolina, Kentucky, Tennessee, Missouri and Indiana.

Pipe tobaccos.

North Carolina Bright Yellow.—This variety is used for manufacturing plug and smoking tobaccos, cigarettes and for export purposes. It is adapted to sandy soils, underlaid by a red or yellow clay subsoil. The deeper the sand the brighter the tobacco produced, and the nearer the surface the subsoil comes the darker in color is the tobacco. The leaves are light and spongy, of rather thick texture, set close together on the stem, with an erect habit of growth, but drooping at the ends, the tops often touching the ground. It is a modified type of the native Maryland and Virginia tobaccos. It is grown in North Carolina, Maryland, Virginia and South Carolina.

Maryland smoking.—The Maryland smoking variety is used for manufacturing and export purposes. It is adapted to clay loam and sandy soil. The leaves are thick and coarse in texture, but are light and chaffy when cured. They have a semi-erect habit of growth, drooping at the tips, and vary in length from twenty to thirty-six inches and in width from ten to twenty-six inches. The plants bear ten to eighteen leaves and reach an average height of about four feet. This variety was discovered in Maryland when the first settlers explored that region. It is mostly exported to France, Germany and Holland. It is grown in Maryland, Virginia and Pennsylvania. From the Maryland tobacco many of the important native varieties have been developed by growing in different sections of the country and by continued selection of seed for a particular type.

DIRECTIONS FOR CULTURE

Sumatra tobacco.

The seed-beds.—The place selected for the seed-bed for Sumatra tobacco should have a slightly southern exposure in order to get the full benefit of the warm rays of the sun in the early spring and should be permanent. The slope should be sufficient to insure perfect drainage at all times. It is desirable that the seed-bed be surrounded by board walls and covered with regular tobacco tenting cloth or glass sash. The cover will protect the tender plants from the cold north winds and produce more uniform and favorable conditions, insuring early, rapid growth.

The soil should be abundantly fertilized every spring and kept free from weeds and grass, as, under these conditions, it becomes better adapted to plant-bed purposes each succeeding year. The most desirable soil seems to be a rich, friable, sandy loam. Deep plowing or spading should be avoided, the usual depth being four or five inches. The ground should be harrowed and stirred with hand-rakes until thoroughly pulverized, and all roots, tufts and clods of earth should be carefully removed. After this preparation, a liberal application of fertilizer rich in nitrogen and potash should be evenly distributed over the bed. A fertilizer containing 10 per cent of ammonia, 8 per cent of available phosphoric acid and 12 per cent of soluble potash is highly recommended. Chlorin in any form must be avoided.

There is such a limited amount of plant-food in tobacco seed because of its small size, that the reserve material for the nourishment of the young plants is soon exhausted; consequently the tobacco seedlings are forced to prepare their own food much sooner than is the case with most other crops. For this reason it is absolutely necessary for tobacco-growers to have the soil and plant-food in the seed-beds in the best possible condition for use by the young plants, in order to aid the slow-growing young plants during the critical period of the first stages of growth. After applying the fertilizer the bed should be thoroughly stirred again and left very smooth, in which condition it is ready for the seed.

It is customary to sow the seed at the rate of about one tablespoonful to 100 square yards of seed-bed. It is impracticable to sow the seed alone and it should be thoroughly mixed with wood-ashes, corn meal, land-plaster or commercial fertilizer. In order to secure a uniform stand of plants, it is advisable to sow half of the seed lengthwise of the bed and the remainder crosswise. The proper time for sowing is from February 1 to March 1. Whenever practicable it is best to prepare the land and apply the fertilizer one to two weeks before the sowing of the seed. After sowing, a light roller should be run over the bed, or some other means used to put the soil in a firm, compact condition, in which state it will retain its moisture, thus giving more favorable conditions for the germination of seed and the growth of the young plants.

The necessity of properly caring for the seed-bed can not be too strongly emphasized, since nothing is of more importance in securing a vigorous growth in the field than strong, healthy seedlings. They should be made to grow steadily and vigorously, without being checked until ready for transplanting. In order to secure this condition, strict and constant attention must be given to watering, keeping down all weeds and grass and preventing the ravages of insect pests. In some cases it is necessary to use an additional application of fertilizer in the way of a top-dressing. The necessity for this is often indicated by the plants turning yellow. The fertilizer should be essentially of the same composition as that previously used, and often gives best results when applied in a liquid form. This method of application makes it necessary to wash the fertilizer thoroughly into the soil by means of an abundant spray, and thus avoid injury to the tender plants.

Whenever it is found that the plants are too thick in the bed, it is advisable to thin them out by drawing an ordinary rake across the bed, allowing it to sink to a depth of one-half to three-fourths of an inch. This can be done without seriously injuring the remaining plants and is, in fact, of positive benefit to them.

Some system should be provided for watering the plant-beds during spells of dry weather. Water should be applied in the form of a light spray. During the first two weeks of plant growth it is essential that the surface soil be kept comparatively moist at all times, for at this stage a few hours of hot sun, after the soil has become dry, will be sufficient to kill most of the plants. When irrigation is used in growing the general crop, a system of overhead spray nozzles has been found to give excellent results. In every case, before undertaking the process of weeding the bed, it is most important to water thoroughly. This will prevent any serious injury to the roots of the tobacco plants.

The field crop.—The preparation of the field soil for Sumatra tobacco must be thorough and complete. The soil should be pulverized by successive plowing and harrowing, and reduced to a fine condition before transplanting. Deep plowing and subsoiling cause a retention of moisture in the soil if the season is too dry, and at the same time afford the best opportunity for proper drainage if there is an excess of rainfall during the growing season. The disk-plow and disk-harrow have been used very successfully in the preparation of tobacco soils, particularly where the content of clay is comparatively small.

A very satisfactory fertilizer consists of 1,000 pounds of cotton seed, 1,000 pounds of cottonseed meal, 300 pounds of carbonate of potash, 700 pounds of fine-ground bone and 800 pounds of lime to the acre. The cotton seed should be put on the field after it has been plowed and three weeks or one month before it is finally prepared for transplanting. Wherever it can be had, cow manure should be used broadcast at the rate of twenty to twenty-five loads per acre. This promotes very rapid growth and often becomes the means of securing a good crop on land badly infested with nematodes. This plant-food enables the plant to throw out new roots faster than the nematodes can destroy the old ones. When no cover-crop is grown during the winter the land should be plowed frequently and kept thoroughly stirred. This destroys many of the nematodes. This constant cultivation also prevents, to some extent, the depredations of the thrips; it prevents the growth of grass and weeds, which serve as host plants for this insect.

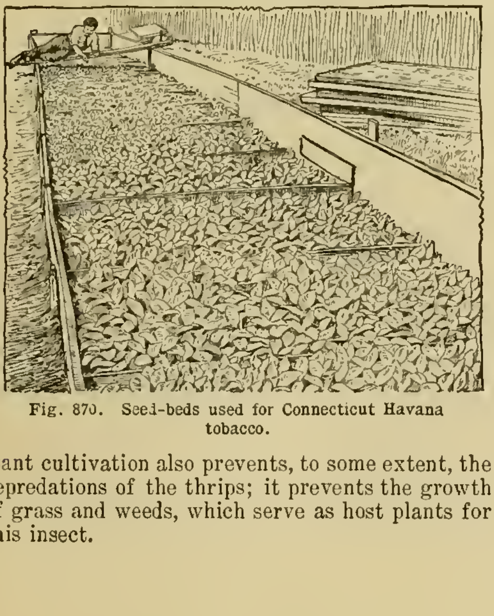
Fig. 870. Seed-beds used for Connecticut Havana tobacco.

When produced for wrapper purposes, the Sumatra variety of tobacco is usually grown under shade. (Fig. 868.) The purpose of the shade is to protect the crop from insects and other dangers and by reason of reducing the light to secure a thin leaf. The effect of the shade is also shown in influencing the humidity of the atmosphere and the temperature. The plants under shade show a much more rapid growth than the outside tobacco, and the leaves are finer, very thin and elastic, and with very small veins. Such characteristics in wrapper tobacco are desired by manufacturers.

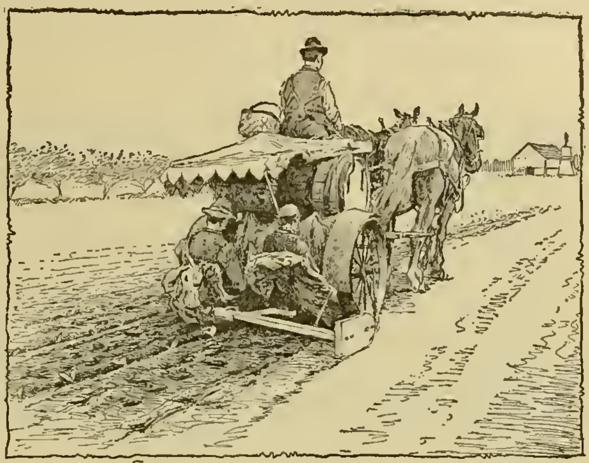
Fig. 871. Tobacco transplanting machine. See also Figs. 230, 843.

When transplanting the young plants to the field, it is desirable to make a selection of the best and most vigorous plants in the seed-bed. At this early stage of growth the most vigorous plants having, the largest and best-shaped leaves, can be very easily distinguished by the grower and selected for the field.

The ordinary distance for Sumatra under cloth is three feet three inches apart for rows, and twelve inches apart in the row. Under slat shades the distance between the plants in the row is usually increased to about fourteen inches.

Before removing the young plants from the seed-bed, the bed should be thoroughly watered and the plants taken out with all possible care. In setting the plants in the field care should be taken to avoid binding and doubling the roots, and the necessary application of water should not be overlooked. It is often found beneficial, just before transplanting, to water the soil where the plant is to be set, and to water again shortly after transplanting.

The cultivation of the crop should include the removal of all weeds from the field, particularly during the early stages of growth, and the keeping of a loose mulch on the surface of the soil. It is the custom to hoe the young plants twice and to use some form of cultivator at least once a week during the remainder of the season until the plants have become too large for inter-tillage. In many instances it has been found desirable and practicable to inter-till the tobacco until shortly before the top leaves are taken off. In dry seasons this serves to retain the soil moisture by preventing excess evaporation due to soil capillarity.

When the plants begin to bud, all except the individual plants saved for seed purposes should be topped. No very definite rule can be given for this process, but it is the custom to break off the top of the plant just below the first seed sucker. The height of topping must be governed largely by the local soil and climatic conditions. It is necessary to remove the suckers before they reach sufficient size seriously to injure or dwarf the plant or interfere in the development of the leaves. In most cases it will be found necessary to remove the suckers two or three times, and more frequently if the season is one which promotes rapid growth. If seed is to be saved on any of the plants, the flower-cluster should be covered with a light and strong paper bag before any of the flowers blossom, in order to prevent cross-fertilization. The bags should be kept in good condition and not allowed to injure the top of the plant in any way. They should remain over the flowers until a sufficient number have been fertilized to produce a good supply of seed.

Fig. 872. Tobacco-field in Louisiana.

The time for harvesting will depend to a considerable extent on the season. The ripeness of the leaves can be distinguished by the development of irregular, light yellowish colored patches over the surface, and a thickening and crumpling of the body of the leaves. The leaves should be harvested before they become overripe, and it is the usual practice to pick them at three or four different periods, the lower leaves maturing first, the middle leaves next, and the top leaves last, generally allowing six to eight days between each two pickings. After picking, the leaves are carried to the curing shed in baskets made for this purpose, and are strung on four-foot laths specially arranged for them, at the rate of thirty to forty leaves to the lath. The leaves are arranged back to back and face to face, and are regularly strung on the cord attached to the lath. The laths are then hung in the curing shed, where the leaves are allowed thoroughly to cure. When the tobacco is primed from the stalk, it should not take more than three weeks to cure; when it is hung on the stalks, four to six weeks are necessary.

The manipulation of the curing barn is governed entirely by the condition of the weather and the nature of the tobacco, so no fixed rules can be given. However, in a general way, it can be said that the barn should be opened during the day and kept closed at night. If there are frequent showers and but little sunshine, the barn should be kept closed and small fires started at points distributed throughout the building. [See under *Connecticut Havana tobacco*, following.]

When the midribs are thoroughly cured the leaves are ready to be taken to the packing-house. To get the tobacco in condition to handle, all the ventilators should be left open for one night, being opened about six o'clock in the evening. Unless the night is a dry one, the tobacco will soften before morning and be in condition or "good order"; that is, it will have taken up sufficient moisture to make it soft and pliable. The barn should then be tightly closed, in order to retain the moisture, and the leaves taken from the laths and tied into hands of convenient size. The bottom, middle and top leaves should be kept separate in the barn. After the tobacco has been taken down and packed, it should be sent at once to the warehouse for fermentation.

The fermentation of the tobacco is to be done in bulk, and this sweating process must be watched with unusual care, in order to prevent disaster to the crop. It is necessary to turn the bulk several times during the process of fermentation, in order to keep the temperature at the desired point. The object of turning the bulk is to reverse its construction, thereby bringing the top, bottom and outside layers into the middle of the new bulk. This plan will permit a uniform fermentation of all the tobacco in the bulk. A convenient and practical size of bulk contains 2,000 to 3,000 pounds. The temperature of the center of the bulk should in no case be allowed to rise above 120° Fahr., and after the temperature falls 8° to 10° the bulk should be turned. The desirable maximum temperature is 115° Fahr. It usually takes six to eight weeks to complete the process of fermentation. After fermentation, the tobacco must be sized, sorted according to the different market grades, tied up in hands, and packed.

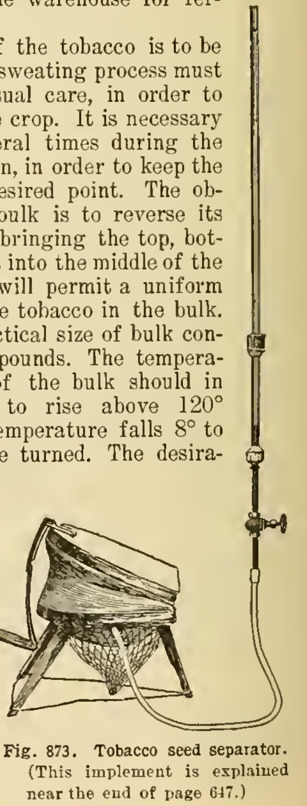

Fig. 873. Tobacco seed separator. (This implement is explained near the end of page 647.)

Connecticut Havana tobacco.

The seed-bed.—For this variety the seed-bed should be located about as for the Sumatra variety. A southern slope where good drainage can be secured is preferable, and a good, rich and friable soil is desirable. As a rule, 200 square feet of seed-bed space should be provided to furnish sufficient seedlings for an acre, although, if the tobacco is to be transferred at different periods a less area will be found to be sufficient. The seed-beds are generally eight feet wide and as long as is necessary to furnish sufficient seedlings for the field. They are usually laid out from east to west.

The framework of the seed-bed is made of 2 x 12-inch boards, set in the ground three to four inches, one side being sunk two inches lower than the other in order that the sash may lie in a slanting position, so that the plants will receive all of the sunlight possible. The best method of covering the bed is by means of glass in sash about three feet wide by eight feet long. These sash are laid over the top of the framework, and can be removed at any time when it is necessary. In some cases, heavy cheese-cloth or tobacco-cloth is substituted for the glass covering, but the temperature of the beds can not be regulated so well as with the glass cover, and the cloth should not be used when very early plants are desired. It is asserted by old tobacco-growers, however, that the plants raised under cloth are more hardy than those raised under glass, and it is a frequent practice to grow the early plants under glass and the later seedlings under cloth.

A successful method of heating seed-beds is by the use of fresh horse manure. In this case the beds should be dug out two feet deep about a week before the time for sowing the seed. The fresh manure should be packed in this space to a depth of one and one-half feet and covered with six inches of sterilized soil. Another successful method of heating is by the use of hot-water or steam pipes, laid around the sides of the bed or under the surface of the soil. General experience has proved, however, that the manure beds are equal in value, if not superior, to the artificially heated ones, mainly from the fact that the heat is distributed evenly through the soil, while, in the case of hot water or steam pipes, the surface of the bed or the air space is likely to be hot while the soil may remain cold and in poor condition for the growth of young plants.

It is the usual practice in the North to sprout half of the quantity of seed used for sowing in moist, but not too wet, apple-tree punk or rotted coconut fiber about one week before the time for sowing the bed. For this purpose the seed is thoroughly mixed with the punk and placed in a glass jar, which should be kept in a warm room. The seed will sprout quickly in this medium, and it is probable that earlier plants can be secured from such sprouted seed than from sowing the dry seed alone. The sprouted seed should be sown about the time the sprouts are one-eighth to one-fourth inch in length. Many growers sow the sprouted seed as soon as the seed-coats burst and the sprouts appear. If the sprouts become too large, they will be injured during the process of sowing. An equal quantity of dry seed should be mixed with the sprouted seed when the beds are ready for sowing. It has been found by comparative tests made by the Bureau of Plant Industry of the United States Department of Agriculture that in most cases the dry seed produces plants about as early as the sprouted seed, and the plants from the dry seed are more uniform in size and apparently more hardy than those raised from the sprouted and dry seed combined. In order to get an even distribution of seed over the seed-bed in sowing, it is a good plan to mix the dry seed and the sprouted seed with several times their bulk of land plaster or gypsum, or, if this is not obtainable, with corn meal or ashes. One to two table-

Fig. 874. Cutting tobacco plants. Near Hartford, Conn.

spoonfuls of seed should be used for every 100 square yards of seed-bed surface.

It has been found in the experiments of the Bureau of Plant Industry that the light seed is undesirable and in every case should be separated from the heavy seed and discarded. In order to make a thorough and complete separation, it is necessary to use some form of a wind-blast machine which will blow out the light seed without throwing out the heavy seed at the same time. In Fig. 873 is shown a satisfactory seed separator, by the use of which the light seed can be separated from the heavy seed and discarded, and the heavy seed used for sowing the seed-beds. The heavy seed produces the most vigorous and uniform young plants in the seed-beds.

The Havana seed variety of tobacco is usually sown in the seed-bed from the middle of March to the middle of April, and the plants are ready for setting out from these beds May 10 to June 10. After sowing the seed, it is desirable to pack the surface of the bed carefully with a roller or heavy plank, in order to press the soil closely about the seed. A good method is to cover the seed by lightly raking the surface with an ordinary garden rake, a method preferred by many experienced growers.

One of the most important points in the raising of a successful crop of Havana tobacco is the care of

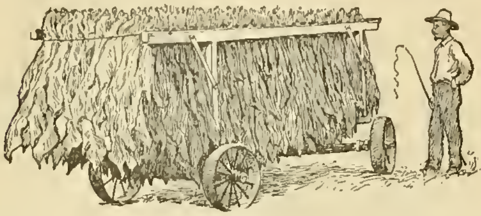

Fig. 875. Load of tobacco in harvest field. Connecticut valley.

the seed-bed. It is necessary to water the seed-bed frequently, usually once or twice every day during the early stages of growth. If the beds are artificially heated, warm water should be used for this watering process, as cold water cools the beds and checks the growth of the young plants. The surface of the seed-bed should not be allowed to become dry, as a few hours of dry surface will kill all of the young plants. The water should be supplied in the form of a light spray, in order not to disturb the seed or the young plants in the bed or to pack the soil so that in drying it will cake and injure the plants.

The temperature of the hotbeds should be carefully regulated, and in no case allowed to rise above 100° Fahr. during the day, or fall below 70° Fahr. during the night. If it is possible to maintain an even temperature, the plants will make the most rapid growth, but it is a question whether they will be as hardy as when subjected to the fluctuating temperatures corresponding to the natural changes between night and day. The beds can be cooled when necessary by raising the sash if the temperature rises, or the temperature can be raised at night by using lanterns set five or six feet apart in the seed-bed, and by covering the sash with heavy cloth, as ordinary blankets, in order to retain the heat. After the young plants reach the proper size for setting out, usually five to six weeks after sowing in the seed-bed, the sash can be taken off most of the time during the day and the beds watered only when the plants begin to wilt. If the plants come up too quickly in any part of the seed-bed, they should be thinned out by using an ordinary garden rake, as for the Sumatra variety. It is necessary to keep out all weeds. Before pulling the weeds, the beds should be thoroughly watered. If flea-beetles or other biting insects attack the young plants in the seed-beds, apply the same treatment as with the Sumatra tobacco. If fungous diseases begin to grow in any part of the seed-bed, it should be thoroughly aired by raising the sash during the day. If this method does not check the growth of the fungus, the beds should be sprayed with a solution of formalin (one part of formalin to 2,000 parts of water). An application of lime dusted over the beds will assist in preventing the spread of fungous diseases.

The field crop.— The preparation of the field for the plants should be begun in the autumn, if possible, by plowing the land two or three inches deep and sowing a leguminous cover-crop. These leguminous cover-crops not only prevent washing and loss of fertility during the heavy rains of the fall and winter, but increase the fertility of the soil through the addition of the nitrogen in the tubercles of these plants and by reason of their extensive root development, which tends to break up and put the soil in the best possible tilth for the young plants. In the spring the land should be replowed, care being used to see that the cover-crop is thoroughly plowed under, with an application of well-rotted stable manure at the rate of twelve to fifteen tons to the acre. In addition to the use of stable manure, it has been found that the following or a similar fertilizer should be used in order to secure the best results: One ton of cottonseed meal, 200 pounds of carbonate of potash, 500 pounds of starter and one barrel of lime to the acre. This should be sowed on the land after plowing and thoroughly worked into the soil with a disk-harrow or by some other means before the young plants are transplanted into the field.

When the plants begin to bud, all except the individual plants saved for seed purposes should be topped. It is the custom to break the tops off just below the first seed sucker. As a rule, the height of topping must be governed by local conditions, such as the soil fertility and the season. In most cases two or three of the top leaves are removed in topping. It is necessary to remove the suckers before they become injurious to the plant. It will usually be necessary to remove them two or three times during the season. It has been found in the tobacco-breeding investigations that by selecting seed from plants having few suckers, sucker-resistant types of tobacco can be secured, and it is recommended that in the case of all of the wrapper varieties of tobacco, particularly the Havana Seed tobacco, such a method of seed selection be followed.

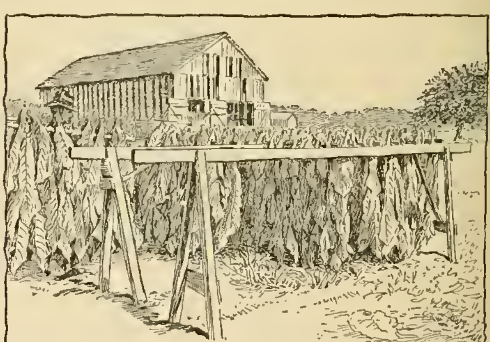

Fig. 876. Tobacco—"Loading a horse." Near Hartford, Conn.

The time for harvesting this variety of tobacco varies with the season, but the ripeness of the leaves can be distinguished as for the Sumatra variety. By crumpling the leaf, if the surface breaks in straight lines, or "cracks," the leaf is said to be ready for cutting.

The plants are usually cut with a regular tobacco hatchet (Fig. 874) or knife, and are strung on laths. Five or six plants are usually strung on each lath, after which they are hauled to the sheds in wagons specially prepared for this purpose. A wagon with special rack arranged for transporting the plants from the field to the curing shed is shown in Fig. 875. These laths are usually four feet in length, and are so hung in the curing shed that a space is left between each two plants in order to get a circulation of air. Common types of curing sheds are shown in Figs. 878–880.

Fig. 877. Tobacco ricks. Filled carriers on way to curing barn. The old method was a wheelbarrow which had to be run by each worker. Every time it was filled it had to be carried to end of row and emptied,—a slow and unprofitable procedure. This saves much time and does with six workers about the work of twelve or more by the old method.

The curing process requires, as a rule, four to six weeks. The manipulation of the barn or curing shed during this period is governed entirely by the conditions of weather and the nature of the tobacco, so that no fixed rules can be given. However, in a general way it can be said that if the barn is filled with green tobacco and the weather is hot and dry, the ventilators should be open most of the time for about three days, by which time the tobacco should begin to yellow. The ventilators should be closed only to prevent too rapid curing during this period. The barn should then be opened at night and kept closed during the day. This is to prevent too rapid curing, which destroys the life of the leaf and produces uneven colors in the tobacco. If there are frequent showers and but little sunshine, the barn should be kept closed, and if there are indications of pole-burn or pole-sweat, small fires, at least two in every bent in the shed, should be started. In order to dry out the tobacco in as short a time as possible, these fires should be distributed throughout the shed and the tobacco above the fires protected by hoods. The best material for making these fires is probably charcoal or coke, but if these two materials can not be used, soft pine wood may be found to be satisfactory. In no case should hard wood be used, as certain odors are given off which it is impossible to get out of the tobacco, and these injure the quality and the sale of the crop. To get the best results, the tobacco during the curing process should be kept fairly moist and fairly dried out once in every twenty-four hours.

After the curing process has been finished, the tobacco is usually sorted according to grade and color as laid down by the tobacco trade. The tobacco is then arranged in hands and packed in cases, where it is allowed to go through natural fermentation, or it is placed in a room which can be heated and is there put through a forced sweat. If the natural fermentation takes place it usually does not begin until the warm weather of the succeeding summer. Great care must be used in the fermenting processes that the tobacco is not damaged by the spread of fungous diseases, mold or other causes of injury to tobacco in cases. The cases are usually arranged to hold about 350 pounds of tobacco.

Connecticut Broadleaf.

The seed-bed.—The method of sowing the seed, preparation of the seed-beds and treatment of the beds are practically the same for the Connecticut Broadleaf as for the Connecticut Havana variety. Many of the growers in the Connecticut valley prefer the tent cover for the seed-beds for this variety. The advantage in the cheese-cloth or light muslin cover for the seed-beds is that plants grown under such conditions are as a rule more hardy than plants raised under glass. As the Broadleaf plants make a very rapid growth in the seed-bed and field, hotbeds for the production of early seedlings are not so essential as with other slower-growing varieties. To get an even sowing, mix one tablespoonful of seed with two quarts of ashes or meal for every 100 square yards of seed-bed, and lightly rake the surface of the bed so as barely to cover the the seed. If the seed is covered too deep, it will not germinate.

The field crop.—The preparation of the land for field planting should be thorough and the soil should be in as good tilth as possible. Cover-crops, such as vetch, are desirable for plowing under. A disk-cultivator is a good implement to fine the surface soil, after which the land should be fitted with drag and harrow, in order to get the surface as level and fine as possible. The land is usually fertilized with well-rotted barnyard manure, at the rate of eight to twelve tons per acre, plowed under in the spring. Frequently, tobacco stems, at the rate of 500 to 600 pounds per acre, are used as a fertilizer in the Broadleaf sections. Most crops of Broadleaf tobacco are grown on these fertilizers alone, but in recent years the growers have begun to apply about one ton of cottonseed meal, 200 pounds of carbonate of potash, and one to two barrels of lime per acre in addition to the usual tobacco starter.

The seedlings of the Broadleaf variety are usually set in rows four feet apart and the plants twenty-two to twenty-four inches apart in the rows. In all cases water should be used in transplanting, even if the ground be moist. If the plants are set by hand, one person distributes the plants at the proper distance along the rows, followed by a man or boy who, with a round stick, makes a hole for the plants. A third person sets the plants in the holes and presses the soil firmly about the roots, leaving the surface of the soil as loose as possible. As the plants are set, a cupful of water should be poured into the holes, and some growers prefer to add water to the plants directly after they are set, although this practice leaves the soil about the plants in such condition as to bake.

The Broadleaf plants are usually topped below the first large sucker. If it is found desirable to hasten the ripening process, the plants are topped low, although, if necessary to prevent the development of too thick leaves, the plants should be topped high. Usually the topping process is delayed until most of the flower-buds appear, so that the topping can all be done in one operation; but many growers prefer to remove the buds as soon as they appear, going over the field later and topping to the desired height. As soon as the suckers appear, they should be broken off, and, in order to do this effectively, it is necessary to go over the field once a week after the plants have been topped.

The time to harvest the crop can be determined only by experience with the strain which is grown. As a rule, a ripe leaf has a rough feeling to the touch, and there is a change in the color of the leaf from a dark to a lighter green; also, by folding the leaf between the fingers a ripe leaf will break easily. In the Broadleaf variety the plants are usually cut, and, as all the leaves on a plant are not ripe at one time, it is necessary to harvest the crop when the majority of the leaves are in the proper condition or about the time that the middle leaves are ripe. Overripe leaves lose their elasticity and strength, and are not suitable for cigar wrappers. The plants are speared on four-foot laths, using a detachable iron spearhead fitted in the end of the lath, placing four to six plants on each lath.

The Broadleaf tobacco is air-cured, the process taking about six weeks. After harvesting, the plants are immediately hung in the barn, and the temperature and humidity of these sheds must be closely watched and controlled by means of the ventilators. If the leaf cures too rapidly, the ventilators should be opened on moist days and nights and closed on dry days. If the curing process proceeds too slowly or the tobacco is liable to injury from pole-burn or other fungous diseases, the ventilators should be opened on dry days and closed on moist days and at night. In long-continued damp spells of weather, when the tobacco cannot be dried out by opening the ventilators during the day, small fires of soft

Fig. 878. Curing shed for tobacco in Connecticut Valley.

pine or charcoal should be used to drive off the excess of moisture and to raise the temperature in the barns.

The Broadleaf tobacco is usually fermented in cases holding about 300 pounds, the hands of tobacco being laid in these cases with the butts of the hands on the outside and the tips in the center. The tobacco is then pressed down under moderate pressure, the tops of the boxes screwed on, and the cases kept in a room having an even temperature.

Cuban tobacco.

Cuban tobacco is grown under shade for wrapper purposes, and without shade when used as a filler for domestic cigars. The percentage of wrappers in this outdoor crop is not large, but when the leaves are primed the percentage is considerably increased. The preparation and care of the seed-

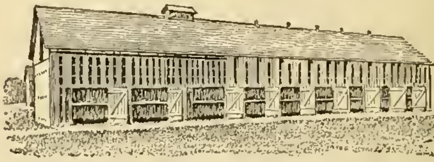

Fig. 879. Tobacco-curing shed, showing provision for ventilation. Connecticut valley.

beds and methods of cultivation are about the same as in the case of the Sumatra variety. The rows in the field are arranged about three feet four inches apart and the plants set about fourteen inches apart in the row. A greater distance results in thick, heavy leaves. If the plants are set too close, the leaves are too thin and lacking in body for filler purposes.

No definite rule can be laid down as to the proper number of leaves to be left on the stalk when the plants are topped. This number varies with the height of the plant and the climatic conditions during the season. Fourteen to sixteen leaves, however, are considered desirable during the ordinary season. The suckers begin to appear very soon after topping and should be removed every eight or ten days, or once a week when rains are frequent.

The method of harvesting the southern Cuban tobacco is essentially the same as that practiced with the Connecticut Havana Seed tobacco. The number of plants to the lath, however, may be increased to eight or ten, when the growth is comparatively small.

Some growers prefer to prime the Cuban tobacco. This process is more expensive, but a thinner leaf is obtained, which makes it possible to use a certain percentage of leaves for wrapper purposes. There are no advantages in this system over the present method of cutting the plants, so far as the production of a filler leaf is concerned.

Where the soil has been abundantly fertilized and the season is favorable, a profitable second crop of filler can be grown, which is commonly called a "sucker crop." A week after cutting, all the suckers should be broken from the old stump with the exception of one, which is to be allowed to remain and mature. It should be handled in exactly the same way as the original crop. The sucker crop ordinarily produces about one-half the yield of the main crop. Insects are always very much worse late in the season and become very troublesome in the sucker crop.

Worms are usually very troublesome on this variety of tobacco and must be picked off and destroyed as soon as they appear, or they can be poisoned with a very light spray of Paris green mixture. The "powder gun" has come into general use and is rapidly replacing the spray pump for poisoning the hornworm and budworm. The growers who still employ the spray pump use one pound of Paris green and an equal quantity of quicklime to 100 gallons of water, this being sufficiently strong to kill the hornworms without injuring the leaves. If a stronger solution is used there is danger of burning the leaves, so that patches of green will appear after curing. A mixture of one pound of Paris green to thirty pounds of lime or land-plaster (gypsum) is recommended for use in the powder gun.

Zimmer Spanish and Little Dutch tobaccos.

The preparation and care of the seed-bed for Zimmer Spanish and Little Dutch varieties, and the preparation of the soil, methods of transplanting and cultivating, harvesting, curing and fermenting are essentially the same as for Connecticut Havana. The plants should be set in rows three feet apart and the seedlings set fifteen to twenty inches apart in the rows. The plants should be topped so as to leave about sixteen leaves for each plant. The average yield of the Zimmer Spanish variety is about 600 pounds to the acre, while the yield of the Little Dutch variety is considerably less.

Maryland smoking tobacco.

The seed-bed should be located on a dark, friable, loamy soil with a southern exposure. The old method of burning the seed-bed has been largely abandoned, but, if used, care should be taken to burn only small timber and brush. A large quantity of ashes is detrimental to the growth of the young plants. All trees within thirty or thirty-five feet should be cut down and piled on the north and west sides of the bed for a partial protection against the cold winds.

The sides of the bed should be eight to ten inches high, and wires three feet apart should be stretched across it. The beds can be covered with light cheese-cloth or tobacco-bed cloth, after the seed has been sown. The covering serves as a protection against the ravages of flea-beetles and other insects, provided there are no open spaces around the bed. When cloth is not used for a covering, the beds must be closely guarded against the attacks of the flea-beetle. When this insect first makes its appearance, the plants should be treated with Paris green at the rate of one pound to thirty pounds of land-plaster. The cloth covering should be removed from the beds at least a week before transplanting, to prevent the injurious effects of the radical change from the seed-bed to the open field.

The bed should be spaded to a depth of four or five inches, and all roots and tufts carefully removed. The soil must be thoroughly pulverized with garden hoes, hand-rakes or other suitable implements. Before the last stirring, an application of a highly nitrogenous fertilizer should be evenly distributed over the bed and thoroughly incorporated in the soil. A mixture of fifty pounds of nitrate of soda, forty pounds of fine-ground bone, and ten pounds of carbonate of potash, applied at the rate of thirty pounds per square rod, is highly recommended. In most cases it is advisable to replenish the plant-food with a top-dressing or fertilizer of the same composition as that of the first application. This should be applied in liquid form wherever it is possible to wash it in thoroughly: otherwise it is important to top-dress the beds only on hot, dry days. The top-dressing should be used when the plants are two to three inches high.

Sow the seed at the rate of two tablespoonfuls to the square rod. It can best be uniformly distributed over the bed by mixing with wood-ashes or land-plaster, dividing it into two equal parts, and sowing half of it over the bed crosswise and the other half lengthwise. All weeds and grass should be removed. It is seldom necessary to water the plant-beds, except in the case of unusually dry weather. Water at this time is very essential. It should be applied as in the northern seed-beds, but less frequently, it being seldom necessary to water the beds more than twice a week.

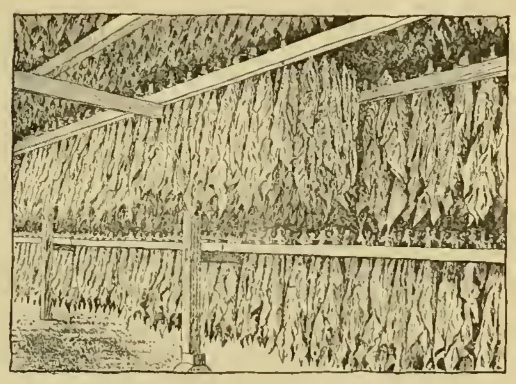

Fig. 880. Tobacco in curing shed.

Care must be used to wet the seed-bed thoroughly before drawing the plants, thus protecting the roots from injury. The mottled or mosaic tobacco, so common in Maryland tobacco-fields, is frequently due to the practice of drawing the plants when the soil is not thoroughly moistened. The plants should be set in the field in rows three and one-half feet apart and the plants twenty to thirty-five inches apart in the row.

Tobacco should be preceded by a leguminous crop of some kind, hairy vetch being highly recommended for this purpose. In addition to the nitrogen from the leguminous crop, a fertilizer rich in potash and containing a moderate amount of phosphoric acid should be added before transplanting. The best stand is secured in the field when the land has been plowed deeply and harrowed several times, thus leaving a thoroughly pulverized soil for the reception of the plants. The method of cultivation, topping, suckering, and harvesting are essentially the same as in the case of the Connecticut Havana variety.

North Carolina, Tennessee and Virginia tobaccos.

The methods of sowing the seed and of preparing and caring for the seed-bed are the same in the case of the North Carolina, Tennessee and Virginia tobaccos as those used by the Maryland growers. The seed, however, may be sown at least a month earlier than in Maryland.

Two systems of harvesting are in general use, both of which have certain advantages. One of these systems is to prime the leaves as fast as they ripen and string them on laths, allowing thirty to thirty-two leaves to the lath. The other and more common system is to cut the entire stalk and cure the leaves on it, as is done with the Connecticut Havana variety.

The North Carolina, Tennessee and Virginia tobaccos are usually flue-cured or fire-cured, for which purpose a special type of barn is used. The essential points of this barn are that it be practically air-tight and provided with one or two furnaces having flues leading up through the center of the barn, giving a large heating surface. There should be at least two small ventilators on or near the top of the barn.

As soon as the barn is filled with tobacco, fires should be started and the temperature raised to 90° Fahr., where it should remain for twenty-four to thirty hours, during which time the tobacco becomes a uniformly bright yellow. Then the temperature is raised from 90° to 120° Fahr., for fifteen to twenty hours. This process is commonly known as "fixing the color." The temperature may then be increased gradually to 125° Fahr., at which point it should be maintained for about forty-eight hours. By this time the leaves should be almost, if not entirely yellow, but the stalk will still be green. In order to cure the stalk, the temperature can be raised to 175° Fahr., at the rate of five degrees an hour, where it should remain until the stalks are thoroughly dried. Great care should be taken during the entire process of curing not to allow the temperature to fall, for a lowering of the temperature during the process of curing invariably produces discoloration in some parts of the leaf.

White Burley tobacco.

The seed-bed should have a slightly southern exposure, in order to get the benefit of the warm rays of the sun in the early spring, and the beds should be protected from cold winds. The best soil for the White Burley tobacco is a rich, friable, virgin loam or sandy soil. The best method is to burn and prepare the seed-bed on old sod-lands. Many farmers select a spot in a vegetable-garden and cover it with virgin mold taken from the woods, and sow it, after thoroughly burning the land until it has a reddish or brick-like appearance, when it should be spaded up and thoroughly chopped over with hoes until it is fine and even. The ashes should not be raked off, but should be thoroughly mixed in with the soil. As soon as the ground can be worked in the spring, it should be lightly spaded and thoroughly loosened to a depth of two or three inches with harrows or hand-rakes. When in good condition, it should be marked off in beds about four or five feet wide and seeded. It is the usual custom with this variety to use a heaping tablespoonful of seed for every 100 square yards of seed-bed. After sowing, the best practice is to run a heavy hand-roller over the bed or press it with a board or with the feet. As a rule, the bed is tramped over with the feet until the surface is packed. The seed-bed is usually protected by a canvas covering to prevent the ravages of flea-beetles and to keep it moist and warm.

The preparation of the land for the field crop is generally begun in the month of March, the usual practice being to turn under the soil with a two-horse plow to a depth of about eight inches. About the middle of April, a revolving disk or harrow is run over the land in order to cut the sod to pieces, after which the field is smoothed over with a slab drag. It is very rare for fertilizers or manure of any kind to be used in the White Burley districts. Tobacco stalks and trash from the barnyard are preferred to any other fertilizer for this tobacco. Owing to the fact that the crop is grown for two years and the field is then put in rotation with other crops, the fertility of the soil is maintained.

The tobacco plants are usually set after a shower, or, when there is no rain, they are set in the afternoon. The land is cultivated with a bull-tongue cultivator during the first week or so, and then cultivated every week with a double-shovel cultivator as long as it is possible to do so without injury to the plants. As soon as the cultivation is finished the plants are topped, leaving sixteen to twenty leaves on each plant. Four to five weeks after topping, the tobacco is usually fully ripe and the plants are cut with a tobacco cutter or butcher-knife. The stalks are split down the middle and strung on sticks four and one-third feet in length, after which they are taken to the tobacco barn and hung twelve inches apart on the tier poles. When fully cured, the tobacco is sorted, usually into six grades, and the different grades are tied into bundles of ten to twenty leaves and packed for the market.

Enemies.

Flea-beetle.—This insect is troublesome in the seed-bed. It is combated by a light spray of Paris green (1 pound of Paris green, 1 pound of quick-lime, 100 gallons of water, constantly stirred while in use). The same remedy can be applied to the hornworm when the seed-bed is open.

Tobacco worm.—Two species of these worms attack the tobacco crop,—*Phlegethontius celeus* (northern), and *Phlegethontius Carolina* (southern). The eggs are deposited on both surfaces of the leaves and the young worms eat the leaves. Hand-picking, dusting with Paris green or spraying with Paris green (one pound to 160 gallons of water) are effective.

Cutworms.—Several cutworms are troublesome, among them being *Feltia jaculifera*, *F. gladiaria*, and *F. subgothica*. They cut off or eat up the young plants immediately after transplanting. Combating is done by sowing along the rows a mixture of bran and Paris green (1 pound of Paris green to 50 pounds of bran). A small quantity of molasses may be added to the mixture.

Budworm (*Heliothis armiger*)—This insect attacks the bud and tender leaves at the top of the plant during the growing period. Hand-picking and dusting or spraying with Paris green are effective.

Pole-burn appears as dark spots near the middle rib or veins of the leaves, and may spread very rapidly. Careful application of heat and ventilation of the sheds to reduce humidity are the remedies.

Root-rot (*Thielavia basicola*).—This fungus occurs most in seed-beds where it may be destroyed by sterilizing the soil with heat or formalin before the seed is sown. In the field, proper rotation of crops, drainage, the application of lime and fertilizers are suggested.

Calico disease is not fully understood. Good cultivation, fertilization and favorable growing conditions are remedies.

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TRUCK-GROWING. Figs. 881–886.

By *John W. Lloyd.*

Truck-growing has been distinguished from market-gardening proper as the growing of vegetables at such a distance from market that railroad or water transportation is required for reaching the market. It is usually practiced where land is low-priced as compared with that on which vegetables are grown within driving distance of the large city markets. Less intensive methods of culture are practiced and a smaller assortment of vegetables is grown, but the acreage devoted to a single crop by an individual grower is usually larger in truck-growing than in market-gardening. Often only one or two truck crops are grown in a given locality, and these may constitute the "money crops" in a system of mixed farming, or in exceptional cases large areas may be devoted to a single crop by a person who gives his whole attention to that one crop. The latter condition obtains only in regions especially adapted to the particular crop in question.

Fig. 881. Truck crops demand heavy manuring. Manuring land for fall spinach after harvesting a crop of dill.

The extension of vegetable-growing to a distance from market has been brought about by the enormous increase in land values near cities, the demand for products earlier in the season, and the great extension of transportation facilities. The latter cause has resulted in the development of early vegetable-growing at the South for shipment to northern markets, while the former has resulted in the removal of the growing of staple, cool-season, late crops to locations more or less remote from the northern markets though perhaps in the same latitude.

It is the purpose of the present article to discuss some of the administration features of the general farm type of truck-growing, rather than intensive and specialized market-gardening [for the latter, see Cyclopedia of American Horticulture, and special books]. Statistical data do not follow this more or less arbitrary division, however, and the census figures do not greatly elucidate such a discussion as this.

Fig. 882. Loading from field wagons to truck wagon, near Creedmoor, N. Y.

Factors determining trucking regions.

Considerations of soil and climate largely determine the general location of truck-growing areas for given crops. Of these, the climate is the more important except in the case of a few crops requiring special soil conditions for their proper development.

In nearly every state in the Union there are regions well adapted in soil and climate to the production of some vegetable crop or crops. However, by no means all localities adapted to the production of certain crops have become commercial centers for those crops. The exact location of truck-growing areas within a region adapted to the production of the crops is determined by transportation facilities and the inclinations of the inhabitants. New shipping points are continually being developed by reason of the extension of railroad lines to new regions, and the enterprise of a few progressive men in each locality.

It is only at points where a sufficient number of men are growing the same crop or crops that are marketed at the same season to enable shipments to be made in car-lots, that good shipping facilities and desirable freight rates can be secured. In the case of some crops, such as watermelons or late cabbage, the individual grower can ship in car-lots; but with many crops, such as asparagus, green peas, muskmelons or tomatoes, an individual grower would usually be able to furnish only a small fraction of a car in any single shipment. In order, therefore, to develop a new shipping point, it is necessary that the men who wish to enter the trucking business induce a sufficient number of other men to grow the same crops to secure adequate shipping facilities.

Marketing the product.

Usually, the growers at a given shipping point are organized into a local association whose manager attends to the icing and loading of cars and other matters of business connected with the association. The methods employed by some of the most successful associations enable the individual grower to consign his products to any firm he may choose in the city to which the car is consigned,

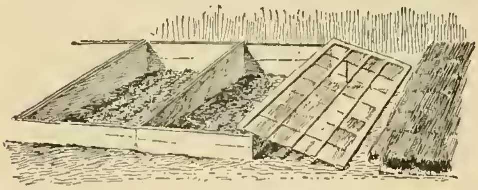

Fig. 883. Hotbeds for starting truck crops.

the directors of the association usually determining at the beginning of the season what markets will be employed, though at any time during the season cars may be loaded for other markets, if a sufficient number of growers wish to patronize those markets. The products of the individual grower are sold on their own merits by the party he chooses.

Truck crops grown at a distance from market are almost invariably handled by commission men located in the large cities, and the bulk of the products will necessarily continue to be handled through the large cities as distributing points, rather than consigned to small towns at a distance from the point of production.

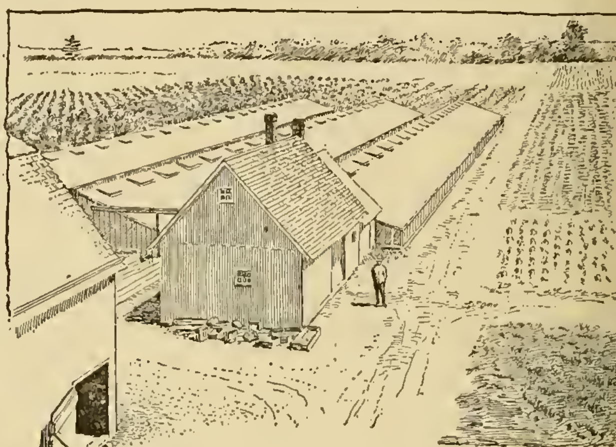

Fig. 884. View on market-garden farm at Irondequoit, N. Y.

Trucking in relation to farm management.

As an adjunct to general farming, truck-growing is becoming an important factor in the agriculture of many localities; and it is on that basis that it is destined to hold a permanent place among the activities of rural people rather than as a system of single cropping partaking of the nature of bonanza farming, except possibly in the case of a few special crops demanding peculiarities of soil not favorable to the production of general farm crops. Specialization in its closest sense is a frequent outgrowth of good trucking soil and climate coupled with good transportation facilities.

In general, truck crops demand heavy manuring and very thorough tillage. If a paying truck crop is to be grown, it is usually necessary so to enrich and work the soil that it will be richer in plant-food and in better condition for the production of subsequent crops after the truck crop has been grown, than it was before preparations were made for growing the truck crop. So well recognized is this fact by land owners in certain regions that they will allow a tenant the use of a piece of land for a full season without the payment of rent, provided the area is to be planted to certain truck crops.

A system of rotation which includes a truck crop every three or four years will usually result in increasing rather than diminishing the productive capacity of the soil. In a sandy region where watermelons thrive and winter wheat is the staple grain crop, a rotation of wheat, clover and melons is highly satisfactory; or, if corn also is grown, the rotation may be extended one year, and the corn planted on the clover sod. In case clover

Fig. 885. Muskmelons for local market.

does not thrive in the region, cowpeas are sown immediately after the wheat is harvested, and they leave the land in ideal condition for melons. On a clay soil in regions where clover does not thrive and wheat is not grown, but where muskmelons constitute an important money crop, the following rotation has given exceptionally good results: corn, cowpeas, melons, timothy. The melons are heavily manured, and the thorough tillage required by this crop leaves the land in ideal condition for seeding to timothy immediately after the melon harvest. Early tomatoes might be substituted for melons in the same rotation with almost as good results.

In regions where manure is not obtainable, and the distance from large cities is too great to warrant its shipment by rail, truck crops are sometimes grown with commercial fertilizer as the source of plant-food. In such cases, the supply of humus in the soil must be kept up by the plowing under of green crops. It may be necessary to plow under a crop of cowpeas instead of harvesting it preparatory to growing a crop of melons or tomatoes, or to sow the land to rye after removing the cowpeas, and plow this under the following spring.

For growing between the trees in young orchards, truck crops are highly desirable, since they demand thorough tillage early in the season, do not shade the trees as would a crop of corn, and can be removed from the land in plenty of time to sow a cover-crop.

The largest item of labor connected with the growing and handling of many truck crops is the harvesting and preparing for market. In the case of many crops, however, the harvest comes at a time when it does not interfere with the handling of the regular farm crops. For example, melons and tomatoes normally ripen after the corn is laid by, the wheat and oats harvested and the hay made, and usually may be disposed of before fall-plowing and the corn harvest begin. Winter onions constitute a crop which is planted in the dull season of early fall, and is harvested before regular farm work opens in the spring. Rhubarb also demands little attention at a time when general farm crops need special care. The growing of a reasonable acreage of carefully selected truck crops in connection with general farming, therefore, may afford a means of giving regular employment to the same working force for the entire season.

Although truck-growing and live-stock-farming may not appeal to the same type of men, nevertheless there are some features about the two industries which would make the combination a desirable one. Truck crops demand large quantities of manure. This could be secured more readily by keeping an abundance of live-stock than by any other method. Live-stock demands more care and attention in the winter, while truck crops demand more attention in the summer, so that if the two lines of effort were combined, the farm labor could be distributed more uniformly through the year. The live-stock also furnishes a ready outlet for the refuse and unsalable vegetables, and the presence of this outlet would tend to improve the grading and leave less excuse for the shipment of culls. Hogs are especially valuable in disposing of refuse vegetables, though nearly all classes of stock feed greedily on cull melons, tomatoes and cucumbers.

Truck-growing demands greater special skill and closer attention to details, than does general farming. The difference between an ordinary and a superior product, and consequently the difference between the prices of the two, is much greater in truck crops than in staple farm products. The niceties of grading and packing and their influence on prices are not fully appreciated by many who attempt to grow truck crops. It is only those who give attention to every detail of growing and marketing their crops with a view to putting a high-class product on the market in perfect condition, that meet the highest success in the production of truck crops.

Literature.

The following are references to literature on general truck-growing: A. Oemler, Truck-Farming

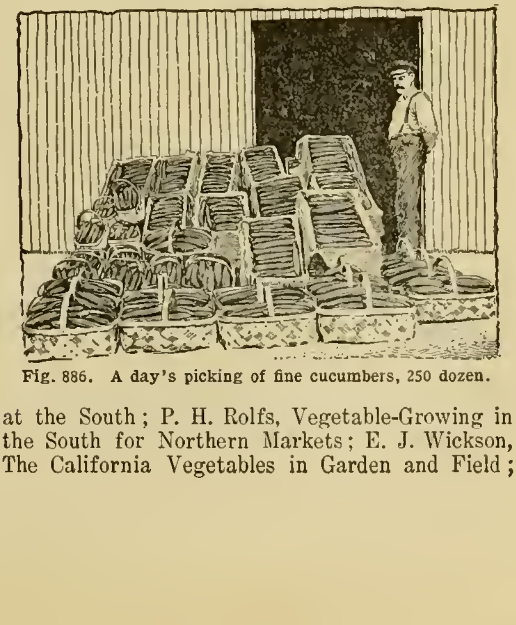

Fig. 886. A day's picking of fine cucumbers, 250 dozen.

at the South; P. H. Rolfs, Vegetable-Growing in the South for Northern Markets; E. J. Wickson, The California Vegetables in Garden and Field;

Thos. F. McCabe, Vegetable-Growing in Southern Illinois. Special truck crops are more fully treated in the following: F. M. Hexamer, Asparagus; J. M. Lupton, Cabbage and Cauliflower for Profit; C. L. Allen, Cabbage, Cauliflower and Allied Vegetables; A. A. Crozier, The Cauliflower; T. Greiner, Celery

Fig. 887. Leaf and part of raceme of velvet bean.

for Profit; E. J. Hollister, Livingston's Celery Book; W. Atlee Burpee, How to Grow Melons for Market; T. Greiner, Onions for Profit; F. S. Thompson, Rhubarb or Pie-Plant Culture; J. J. H. Gregory, Squashes; R. H. Price, Sweet-potato Culture for Profit; J. W. Day, D. Cummins and A. I. Root, Tomato-Culture; A. W. Livingston, Livingston and the Tomato. There are many other available books on the subject. An article on the transportation of truck crops will be found in Vol. IV.

VELVET BEAN. *Mucuna utilis*, Wall., or *M. pruriens*, DC., var. *utilis*, Bailey. *Leguminosæ*. Figs. 887-890.

By *H. Harold Hume*.

The velvet bean is a twining plant grown for its vegetative parts and for its seeds, both of which are used for feeding. The plant is also important as a cover-crop and for green-manuring. The casual observer would probably mistake the plant in its younger stages for one of the pole lima beans (*Phaseolus lunatus*), but a close examination would show many well-marked differences. It has become, in recent years, an important addition to the list of field crops in the Gulf coast sections of the United States, and along the Atlantic coast as far north as the coastal plain of North Carolina. It is likewise well adapted to the climatic conditions of Porto Rico, Cuba, coastal Mexico, Hawaii and other tropical regions. It is in climates where it has a very long growing season that it reaches its maximum growth. It is a native of India and appears to have been introduced into America about 1872 or 1877.

The vine frequently reaches seventy-five feet or more in length, branching, smooth and rather slender. The leaves are large, four inches by three inches, and trifoliolate. The flowers are large and produced in racemes from the axils of the leaves. In general color they are purple. The pods are about three inches long, blunt pointed, slightly constricted between the seeds when mature, and covered with a thick coating of dark velvety hairs. From the latter character of the pods the plant takes its name. Each pod contains three to six almost globular seeds, three-eighths or one-half inch in diameter. The beans are marked or splashed with dirty white color and are somewhat similar to castor-beans. Occasionally beans are found of a solid dull white or a solid brownish black color.

Culture.

Soil.—The velvet bean is not particular in its soil requirements. It may be grown successfully on any fairly well-drained soil, and is well adapted to the agricultural soils of the Gulf states. On lands containing a goodly amount of moisture it produces enormous yields.

Fertilizers.—It is always best to use some fertilizer for the velvet bean. While capable of securing its own nitrogen, it is greatly benefited on most soils by applications of potash and phosphoric acid, and sometimes also by nitrogen. A mixture of seventy-five pounds of high-grade sulfate of potash and 200 pounds of acid phosphate per acre, applied in the drill at the time of planting, is excellent.

Fig. 888. Velvet bean pods. Nearly one-half natural size.

Planting.—It is best to plant the crop in rows four feet apart and allow the plants to stand two or three feet apart in the row. A half-peck of good seed is sufficient for an acre if planted in hills, although as much as a peck is sometimes used. Toward the northern limits of its growth, seed is not produced, as the crop is very tender and easily frosted, and sections so situated must depend on localities farther south for their seed supply.

Place in the rotation.—When grown and fed on the land or plowed back into the soil, the velvet bean makes an excellent preparation for corn, cotton and sugar-cane. The nitrogen and humus supplied are of great value and the mechanical condition of the soil is vastly improved.

The only crop in conjunction with which the velvet bean may be planted to advantage is corn. Planted at the same time or after the corn, it usually does not begin to run until the latter is well grown. In the rotation, the velvet beans must generally be given the ground for one whole season.

Two- or four-year rotations with corn and cotton may be arranged as follows: Two-year.—(1) corn and velvet beans; (2) cotton. Four-year.—(1) corn; (2) velvet beans; (3) cotton; (4) velvet beans.

Subsequent care.—After the beans are up, the ground should be cultivated two or three times to conserve moisture and keep down the weeds until the plants are well started. Then the vines grow rapidly, soon shade the ground and smother out all weeds and other vegetation that may attempt to grow. In a well-conducted rotation, the crop may be made to play no mean part in weed eradication. In fact, the vines take possession of and clamber over almost anything that may be growing on the land, and shrubs and small trees are often destroyed. The introduction of a bush variety would be a decided improvement in many ways.

For seed production.—To secure a good crop of seed in the extreme South, the crop should be planted not later than the third week in April. Larger quantities of seed will be secured if the vines are given something to run on. An excellent method is to plant them with corn and cut the corn just below the bottom ear as soon as it is matured, leaving the lower part of the stalks as a support. It is not best to leave the whole length of the corn-stalks, as the vines climb over them and the weight of the growing pods will at last break them down. Another method which may be used in a limited way is to set small poles along the rows, ten or twelve feet high. The vines may be cut around the poles and these lifted with the vines attached in harvesting.

Fig. 889. Velvet beans. Natural size.

Harvesting.—From the nature of the growth, it can readily be understood that the velvet bean crop is one which cannot easily be converted into hay. It is best cut by means of a front-cut mowing machine. Each swath should be turned back with forks before the next one is cut. The best time to cut is when the pods are well formed, but before the beans begin to swell. The hay may be cured by the methods ordinarily used for cowpea hay.

Because of the difficulties of harvesting, many persons prefer to turn the cattle and hogs into the field and allow them to graze. In the mild fall and winter climate of the South this is a splendid way

Fig. 890. Velvet beans in Florida, with corn for support of vines.

to handle the crop, and meat may be produced at a very low cost by this method.

Yield.

At the end of the growing season the ground is covered with a tangled mass of vines two or three feet deep. At a conservative estimate, the weight of green material will reach ten tons and the weight of dry hay three to four tons per acre. Under favorable conditions, a good yield of pods is eighty bushels, giving about forty bushels, or thereabouts, of shelled beans.

Uses.

As a stock-feed.—The velvet bean is rich in protein, and good hay contains about 8 per cent of protein with a nutritive ration of 1 to 6. Meal may be made from the beans and pods ground together. This meal contains 17 per cent of protein and 4½ to 6 per cent of fat, while meal made from the beans alone contains 22.6 per cent of protein and 6.6 per cent of fat. Both of these have been placed on the market in a limited way. As will be noted from the above, the hay in itself is a fairly well-balanced ration. The meal from either beans or beans and pods together must be classed with the concentrated foods, and should not be fed without other more bulky substances having a wider nutritive ratio.

As a cover-crop.—Velvet beans have been used extensively as a cover-crop in orange, peach and pecan orchards. On poor lands they are admirably adapted for this purpose, as they collect large amounts of nitrogen and provide a great quantity of vegetable matter. Only a narrow space between the tree rows should be planted and the plants must be watched to prevent their climbing into and injuring the trees. Trees are frequently badly broken if this precaution is neglected.

As a soil renovator.—As a soil renovator, the velvet bean, for the regions in which it may be grown, has few equals and no superiors. It is not attacked by the root-knot producing nematodes, nor is it subject to other diseases. It makes a very large growth of vegetable matter to be resolved into humus. On the basis of ten tons of green vines per acre, the crop contains 150 to 200 pounds of nitrogen with ten or twelve pounds in the roots alone. The nodules produced on the roots by the nitrogen-collecting bacteria are much larger than those found on the roots of our common legumes. They are brownish black in color, warty, broad, flat, and frequently measure an inch and a quarter across. The interior is greenish white or greenish pink in color.

As an ornamental.—The rapid growth and the large clean foliage of the velvet bean gives it distinct value as an annual ornamental covering for trellises and for porch screens. In fact, it was as an ornamental that the velvet bean was first used in this country.

Literature.

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VETCH. *Vicia* spp. *Leguminosæ.* Fig. 891, 892.

By *J. F. Duggar.*

The vetches are of importance as cover-crops and as stock-feed. They have never become very popular, partly because of the low trailing habit, and partly because of the high price of the seed. Most of the seed is procured in Europe. When over two years old it sometimes germinates poorly.

Botanical characters.

The vetches, with few exceptions, are slender, climbing plants, bearing tendrils at or near the extremity of each pinnate leaf. They are herbaceous plants with weak stems, requiring the support of other plants, such as the small grains, when grown for hay. The numerous branches springing from a crown near the surface of the ground are usually two to five feet or more in length. Exceptions are found in the broad bean (*Vicia Faba*, which see) and Narbonne vetch (*V. Narbonensis*), which are erect, without tendrils, and with leaflets much larger than the typical vetches. The stipules are entire or half sagittate, or variously notched or cleft, and in many species marked with a dark reddish spot. The flowers are axillary, few or in racemes, chiefly shades of pink, violet, purple and white. The style is slender and its summit is capped with a bunch of hairs. The calyx tube is somewhat oblique, obtuse at base, with teeth about equal. The flattish or roundish pod, containing numerous roundish seeds, bursts open when dry, splitting into two parts and spreading the seed widely. Britton gives the number of species as about 120, describes eleven as occurring in the northeastern part of North America, and notes that about twelve others occur in southern and western North America.

Species of vetches.

The three species of vetch most extensively employed in agriculture are hairy or sand vetch (*Vicia villosa*), common or smooth vetch, or spring tare (*V. sativa*), and narrow-leaved vetch (*V. angustifolia*). They are all annuals in the southern states, making their growth between September and May, and are treated either as winter or as summer crops as we go northward.

Hairy or sand vetch (*V. villosa*, Fig. 891) is distinguished by its dense coat of gray hairs covering

Fig. 891. Hairy or winter vetch (*Vicia villosa*). Enlarged flower, side view, on left.

every part of the plant and by its racemes crowded with numerous slender, deep purple flowers. The seeds are small and black. It has usually afforded larger amounts of forage than other well-known vetches.

Vicia sativa (Fig. 892) and *V. angustifolia* have larger, more spreading flowers, borne singly or in pairs; on the stipules are dark, glandular spots. They differ in that the former has obovate or oblong leaflets, while the latter has longer and narrower leaflets. *V. angustifolia* has black seeds and pods. *V. angustifolia* is specially valuable by reason of its greater earliness.

Vicia sativa, the spring vetch, is native in Europe and western Asia, and was cultivated by the Romans. It was introduced into America a hundred years ago, and was formerly cultivated in the northeastern part of the United States, where in certain sections it has proved successful. It is used as a soiling crop in northern Europe and Great Britian. It may be sown at the rate of five to eight pecks of seed per acre in April or May, with a bushel of oats or rye as a nurse crop. An acre of vetch and oats yields ordinarily six to eight tons of green forage. At present it is little grown in this country except as a winter crop in some parts of the South, and in the states of Washington, Oregon and northern California. The Alabama Station found that a successful crop of spring vetch stocked the soil with the proper root tubercles for hairy vetch.

Stolley's vetch (*Vicia Leavenworthii*) is a promising annual legume that grows wild in central and western Texas. It is useful for early grazing in the spring, and stock are fond of it. It is also valuable as a soil mulch and green-manure. It is said to withstand drought. The leaves are small and the stems trailing.

Three other plants known as vetches are sometimes met with, and may here be mentioned. A winter vetch (*Lathyrus hirsutus*) resembles spring vetch in habit. It is grown in the South for late fall and early spring pasturage. It is not hardy north of Maryland. Its culture is much the same as that of spring vetch. It is cut for hay when in full bloom and cured as are cowpeas. Dakota vetch (*Lotus Americanus* or *Hosackia*) is used as native pasturage and hay in the Northwest. It is a bushy annual. Kidney vetch (*Anthyllis Vulneraria*) is a perennial legume grown in Europe on thin limestone soils. It gives little promise in this country. [See page 308.]

Culture.

Seeding.—The three principal vetches all seed fully, and if permitted to mature no reseeding of the land is necessary. Maturing and reseeding of hairy vetch is secured either by mowing the mixed crop of vetch and small grain while the vetch is still in the stage of early bloom, a slight second growth then usually affording sufficient seed, or by delaying the harvest until enough vetch seed has matured, these seeds either shattering during the mowing or being borne on parts of plants that escape the mower.

In the Gulf states, hairy vetch seeds and dies in May, and the other agricultural species several weeks earlier. Immediately, the land is planted in other crops, as cowpeas, sorghum, sweet-potatoes, and the vetch seeds remaining in the ground do not sprout until August or September. Here the seed of any of the agricultural species is sown broadcast about September on land previously plowed, using two to four pecks of vetch seed and one bushel of beardless wheat or two bushels of oats per acre. When intended exclusively for grazing, one may use the above grains or rye. For hay, the earliest varieties of beardless wheat or Red Rust-proof oats are ready for mowing at the same time as the vetch. Rye and beardless barley mature before hairy vetch. Turf or grazing oats are too late for making vetch-and-oat hay on poor upland, but are suitable for this purpose when sown early on good land with hairy vetch.

When used for pasturage, vetch must not be so closely grazed in May as to prohibit seed formation. It seeds freely, more than one thousand seeds having been formed on a single thrifty plant. For pasturage, vetch is also sown on land not specially prepared, for example among growing cotton plants or where some cultivated crop has just been removed. In this case it is sown alone or with small grain and the seed covered by the use of a one-horse cultivator.

Inoculation.—In most of the southern states, the vetches when first grown require inoculation for best growth. This may be effected by means of pure cultures from the laboratory or by the use of one peck to one ton of soil from a field or garden where the garden pea (Pisum) or any species of vetch has recently grown thriftily and borne tubercles. The seeds are dipped into water, into which a small amount of this soil has been stirred, thus depositing the nitrogen-fixing germs on at least a part of them. Usually a more thorough inoculation occurs when, in addition to this treatment of the seed, one-fourth to one ton per acre of pulverized inoculated soil is sown and promptly harrowed in. By means of inoculation on poor land where no vetch had previously been grown, the yield of vetch in the South has often been quadrupled. [Inoculation is discussed at length in Chapter XIII, Vol. I, and under *Legumes* in the present volume. Root nodules on the hairy vetch are pictured in Fig. 592.]

Fig. 892. Spring vetch (*Vicia sativa*).

Harvesting.—Hairy, common, narrow-leaved vetch and other species make fair yields of palatable and nutritious hay. The hay is cured in the same way as alfalfa or clover. In the Gulf states narrow-leaved vetch is ready to cut in April, and hairy vetch early in May. Cutting should be done three or four days before the vetch is in full bloom.

Uses.

As stock-feed.—The vetches are very useful as pasture plants, cattle, horses sheep and swine usually eating them green or cured with avidity. There are, however, a few records of animals at first having refused to eat vetch. Sown in August or early September on rich land, hairy vetch may afford a little grazing in December and January, but ordinarily little grazing can be expected before February.

Vetch seeds have been fed experimentally to cattle with satisfactory results, but they are too valuable for this use. Hairy vetch is also useful as a food for bees, and in the South as a means of subduing annual weeds that make their growth in spring.

As a soil renovator and cover-crop. [See *Cover-Crops*, p. 258.]—All species and varieties of vetch are useful for improving the soil by means of the nitrogen which the plants take from the air through their tubercles and store up in the vegetation or in the soil. For this reason, also, they find use as cover-crops in orchards. In New York, hairy vetch remains green all winter and grows in the spring.

Weedy character of vetches.

Some species of vetch are likely to become weeds in wheat-fields, the seed ripening at the same time as wheat and being difficult to separate from wheat. At the Michigan station this habit of vetches was pronounced, but farther north, where the season is too short to permit complete maturity of vetch sown in the spring, and in those parts of the southern states where little wheat is grown, this danger may be disregarded. A part of the vetch seed may remain in the ground for several years and then germinate.

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Alabama (College) Experiment Station, Bulletins Nos. 87, 96, 105; Arkansas Experiment Station, Bulletin No. 68; Delaware Experiment Station, Bulletins Nos. 60, 61; Massachusetts (Hatch) Experiment Station, Bulletin No. 18; Louisiana Experiment Station, Bulletin No. 72; Michigan Experiment Station, Bulletin No. 227; Mississippi Experiment Station, Bulletins Nos. 20, 44; New York (Cornell) Station, Bulletin No. 198; United States Department of Agriculture, Farmers' Bulletins Nos. 18, 102, 147, and Circular No. 6, Division of Agrostology.

WHEAT. *Triticum sativum*, Lam. *Gramineæ.* Figs. 893–908; also Fig. 563.

By *E. E. Elliott* and *T. L. Lyon.*

Wheat is a plant of vast economic importance, widely distributed over the civilized world and having a history coincident with that of the human race. The grain is used largely for human food, chiefly as food-stuffs made from its flour, and in the form of breakfast foods. The by-products of its manufacture are used as stock-food. The grain, whole or ground, is also valuable for stock-feeding.

By nature it is an annual, although cultivation and improvement have modified its habits to a large extent. The tribe Hordeæ, in which wheat is included, is distinguished by its many-flowered spikelets which are arranged alternately on a stem or rachis, thus forming a spike. The close relationship of wheat with barley, rye, rice and other cereals having the familiar spike head is readily observable.

The genus Triticum embraces wheat proper, but includes in its species and varieties several plants differing slightly in structure or habits of growth. These species and varieties are further broken up into types. Extensive studies of these with the object of classifying them on a rational basis have been made by scientists in recent years, but as yet a generally accepted arrangement has not been fully worked out. The classifications adopted are further confused with the distinctions made in the various markets of the world and the uses to which the grain is put.

Botanical characters.

The wheat grain.—The wheat seed or berry is the part of the plant of greatest economic value. It is also the one means of reproducing the plant. The seed, or grain, as it is generally called, is a hard, dry, oblong fruit with a longitudinal furrow on one side. The seed varies greatly in size, shape, color, hardness and composition, but retains under all conditions, distinct and common characteristics. In size and weight it varies so that the number of grains in a pound ranges from 8,000 to 24,000, with a probable average of about 12,000. It is obvious that the number of seeds in a given quantity, either of weight or measure, will vary accordingly. Variations in the specific gravity range from 1.146 to 1.518.

In general, the shape is oblong with one end slightly pointed, but in some types the ends of the grain are much elongated, the berry itself being flattened, while in others it more nearly approaches a sphere. In color there is a wide range, from the paler shades of yellow through what is called amber, to deep red. Color is considered to have a close relationship to hardness of the grain and its composition.

The composition of wheat as reported by the United States Department of Agriculture is as follows:

	Grain			Straw		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Water	7.1	14.0	10.5	6.5	17.9	9.6
Ash	0.8	3.6	1.8	3.0	7.0	4.2
Protein	8.1	17.2	11.9	2.9	5.0	3.4
Crude fiber	.4	3.1	1.8	34.3	42.7	38.1
Nitrogen-free extract	64.8	78.6	71.9	31.0	50.6	43.4
Fat	1.3	3.9	2.1	0.8	1.8	1.3

Plate XXIV. The header at work in a wheat-field in the far West

As will be noted, the grain contains 10 to 11 per cent of water. As a matter of fact, as grain is usually handled and shipped, the percentage of water would average much higher. It is well known that wheat transported from a dry climate to one more humid will absorb five to twenty-five per cent of additional weight in moisture. This is particularly true when shipments are made by water. As wheat is handled in milling it is customary to add to it a considerable amount of water before being processed, as in its normal condition it is too dry. It will be seen that the grain has large absorptive powers; and the same facts have been observed in the different manufactures produced from it.

Of the mineral elements in wheat, fully one-half is phosphoric acid, while the greater part of the remainder, consisting of one-third of the whole, is potash.

The wheat grain is characterized by a small embryo or germ, while the percentage of endosperm constitutes a very large proportion of the entire contents, the ratio being as one to thirteen. The embryo, while having a high nutritive value, is not a desired element in the manufacture of flour, although it is utilized to a considerable extent in the production of certain cereal foods and always constitutes a most valuable by-product.

The endosperm is composed largely of pure starch cells which form the chief constituent of wheat-flour as usually made. However, it contains proteids, which by their presence add largely to the value of flour as usually prepared in the form of baker's bread. These proteids have been classified as follows: (1) globulin, (2) albumin, (3) proteose, (4) gliadin and (5) glutenin. For all practical purposes only the last two named are considered in the manufacture of flour. These two proteids combined compose what is known as gluten. It is the gluten contained in the starchy parts of the wheat grain which distinguishes it from flour made from certain other cereals, notably corn. Corn flour or meal is heavy and sodden when baked into bread as compared with flour made from wheat or rye. The difference is due to the presence of gluten. In the process of bread-making the flour is made into a dough by the use of water and the addition of leavening. When fermentation sets in, or, to use the common phrase, the bread begins to rise, carbonic acid gas is formed; this is imprisoned in the dough, which expands with the internal pressure and thus forms an open, porous loaf. The dough owes this elastic quality to the presence of the gluten. Gluten can be obtained from flour by washing the dough with water until all the starchy parts have been removed. The lump of gluten thus obtained will prove to be of a light, yellow color, tenacious and elastic. When dried, it will be semi-transparent, and closely resembles glue. The quantity of gluten in flour is important, but more depends on the quality. As it is not easy to determine the quality except by actual bread-making tests, millers usually select the wheats preferred on the basis of the percentage of total gluten contained.

In the manufacture of flour, the percentage of the grain recovered in the form of flour varies around 70 per cent. The lowest limit of the grades secured will depend on the markets open to the miller. The amount of merchantable flour recovered is also governed somewhat by the processes of milling. There remain always the by-products, known in commerce under the various names of bran, shorts, or middlings.

If a grain of wheat be cut into transverse sections, the various parts of which it is composed will be clearly seen. The embryo, which is rejected in milling, will be shown lying along the side opposite that on which is the furrow. Covering the starchy parts of the grain are several layers of fiber or husk, also rejected in the milling process. These layers are technically known as the aleurone, nucellus, testa and pericarp, although these blend more or less into each other according to the condition of maturity of the grain.

The wheat plant.—The wheat plant is strictly of artificial character and habits. This is well-illustrated by the nature of its growth. It is probable that if cultivation should cease for even a few years the plant would perish from the face of the earth. Under normal conditions wheat completes its round of growth within the limits of each recurring season. Seeded in the spring it will mature a crop in twelve to twenty weeks, according to season and variety. Its nature has been so adjusted, however, that what are called fall or winter varieties are cultivated, to a large extent, throughout much of the producing area of the world. These varieties are sufficiently hardy to withstand the winter season, and when planted in the fall will mature the following year, one to two months earlier than those seeded in the spring. There is relatively no variation in the different types and varieties so far as manner of life and growth are concerned.

In germinating, the seed or grain of wheat throws out a whorl of three temporary roots. With the development of the stalk, which immediately takes place, additional whorls are thrown out at each node. The permanent set of roots will be found near the surface branching outward and downward.

If the wheat has been planted deep the stalk may exhaust itself in reaching the surface, and, in the case of alternate freezing and thawing, the slender thread connecting the tiny plant at the surface with the parent seed may be separated too soon and the vitality of the plant be endangered. The roots of the growing plant may penetrate to a depth of four feet or more, a fact which is somewhat contrary to the common opinion.

While the stems of the wheat are hollow, it is not unusual for them to be more or less filled with pith.

In winter varieties the stalks of the plant do not rise above the crown of leaves, which are first produced, until the advent of spring. The mat of blades which covers the ground serves the useful purpose of protecting the plant throughout the dormant period of the winter season.

During the early growth the nodes are close together, but soon the wheat begins to joint or "shoot" and the stalks grow rapidly, while the space between the nodes increases until the full height of the plant is attained. The range of the height varies from two to six feet, and there does not appear to be any close relationship between this height of straw and the yield of grain. The less moisture in the soil the smaller the proportion of straw to grain. As the plant attains development the spike pushes up until it rises above the growth of foliage below, and a mature field of wheat shows a uniform surface of erect spikes. At this stage of growth the leaves at the surface of the ground, together with those attached to each node, wither and fall, the whole plant turning a golden yellow color.

The ability of the wheat plant to tiller or stool, throwing up additional stalks, is a marked characteristic. It often occurs that such stools may show twenty to even one hundred stalks starting from a single grain. This habit of tillering is governed by the variety and also may be modified by the climatic conditions of the season. It will readily appear that what is called the "stand" of wheat may depend in a large measure on the freedom with which the plant may send up these additional shoots.

The wheat head.—A discussion of the variations existing in the different types of wheat as shown by a study of the spike or head will be given under the classification of varieties. A somewhat technical description of the head is, however, necessary in order to make clear many references in this article. The description given is condensed from Bulletin No. 7, Bureau of Plant Industry, United States Department of Agriculture, p. 9.

"The flowering and fruiting cluster at the summit of the stem of a wheat plant is called the 'head' or 'spike.' The part of the stem running through the spike, on which the flowers or kernels are borne, is called the 'rachis.' The rachis is divided by a number of joints, or nodes, and at these nodes on alternate sides of the rachis are attached the spikelets,—the several small secondary spikes which together with the rachis make up the spike proper. The short branch running through each spikelet is known as the 'rachilla.' Inserted on the rachilla are several concave scales which are called the 'glumes.' The two lowest and outermost of these contain no flowers or kernels and are designated as the 'flowerless glumes.' Above these, arranged alternately, are borne the flowers, rarely less than two, or more than five. Each flower and, as it matures, each grain, is subtended by a single glume, known as the 'flowering glume.' Each flowering glume has a longitudinal nerve which at the summit extends into a prominent 'awn' or 'beard.' On the inner or creased side of the grain or berry, filling it very closely, and more or less hidden from view by the flowering glume, is borne the 'palea' or 'palet,' a thin scale with two nerves. The flowerless and flowering glumes and the palets are spoken of collectively as the 'chaff'." In Fig. 893 is shown a floret enlarged.

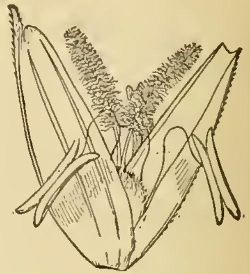

Fig. 893. Floret of wheat (*Triticum sativum*).

In many varieties the outer glumes have their surfaces covered with short soft hairs which give the heads of wheat a velvety appearance. This velvet or fuzz, while present in many very productive types and varieties, is not considered by growers a desirable characteristic.

It would be easy to make a classification of wheat based on the striking differences of the spike, and to some extent these are considered, but such division can hardly be said to have a botanical basis.

Production. (T. L. Lyon.)

The report of the Twelfth census of the United States states that in the decade 1890 to 1900, the area planted to wheat in this country increased from 33,579,514 acres to 52,588,574 acres, or 56.6 per cent. In the preceding decade there had been a decrease of 5.2 per cent. The acreage reported in 1900 was 48.4 per cent greater than that of 1880.

The increase in production of wheat has been about proportional to that of acreage. The largest yield in this country for any one year was 748 million bushels, produced in 1901. The yield per acre for the last three decades has remained practically the same, but the value per bushel and consequently per acre has steadily declined. The cost of producing a bushel of wheat has likewise decreased in amount. These facts are brought out in the following table, taken from the Statistical Abstract of the United States for 1906:

Year	Area	Production	Farm value, Dec. 1	Average yield per acre	Average farm value Dec. 1 Per bushel
	Acres	Bushels	Dollars	Bushels	Cents
1870	18,992,591	235,884,700	222,766,969	12.4	94.4
1880	37,986,717	498,549,868	474,201,850	13.1	95.1
1890	36,087,154	399,262,000	334,773,678	11.1	83.8
1900	42,495,385	522,229,505	323,525,177	12.3	61.9
1906	47,305,829	735,260,970	490,332,760	15.5	66.7

The United States leads all countries in the production of wheat. The other large wheat-producing countries are Russia, India, France and Austria-Hungary, while Canada and the Argentine Republic are rapidly increasing their output. Europe is still the largest wheat-producer of any continent, raising nearly twice as much as North and South America together. [For tables of "Yields of Wheat by Continents," see page 486.]

During the last fifty years there has been a constant movement of the center of wheat production from east to west in the United States. This has proceeded much more rapidly than has the center of population. In 1850, New York was one of the great wheat-producing states, and the Genesee valley was the greatest wheat-growing region in the country. Since that time the wheat production of New York has decreased, according to the Twelfth census report, over 3,000,000 bushels, and its proportion of the total crop has declined from 13.1 per cent to 1.6 per cent, while the four states which now produce the most wheat were, with the exception of Ohio, still unsettled. The latter state was also at one time the leader in wheat production, and the rich Miami valley succeeded the Genesee valley as a wheat region. But while Ohio is still a large producer of wheat, its relative production has declined from 14.4 per cent to 7.6 per cent.

Southern Wisconsin and northern Illinois was once the great wheat-growing region of the country, but this was again superseded by Minnesota and North Dakota. For the last few years Kansas has been producing more wheat than any other state. It seems probable that the great plains area of western Kansas and Nebraska, and of eastern Colorado and Wyoming and perhaps northern Texas, is to be the next great wheat-growing region.

This gradual shifting of wheat-production in some of the wheat-growing states is brought out in the following table (from the Statistical Abstract, 1906):

In Canada, the production of wheat has shown a rapid increase. In 1871 (Canada Yearbook, 1905), the total reported production was 16,723,873 bushels; in 1881, it was 32,350,269 bushels; in 1891, 42,223,372 bushels; and in 1901 it had reached 55,572,368 bushels. The acreage in 1891 was 2,701,246 and in 1901 was 4,224,542. Ontario and Manitoba had much the largest output. The production by provinces for 1901 was: Ontario, 28,418,907 bushels; Manitoba, 18,353,013 bushels; the Territories, 5,103,972 bushels; Quebec, 1,968,203 bushels; Prince Edward Island, 738,679 bushels; New Brunswick, 381,699 bushels; British Columbia, 359,419 bushels; Nova Scotia, 248,476 bushels. As showing further the relative importance of wheat in the different provinces, the average production per farm in 1901 is given: Canada, 117.75 bushels; Manitoba, 576.92 bushels; the Territories, 223.73 bushels; Ontario, 153.24 bushels; British Columbia, 60.51 bushels; Prince Edward Island, 56.12 bushels; Quebec, 15.11 bushels; New Brunswick, 10.86 bushels; Nova Scotia, 5.23 bushels.

Types and varieties of wheat. (Figs. 894–901.)

Cerealists as well as practical producers of grains are gradually losing sight of those classifications of wheat which are based on purely botanical points. While not failing to recognize the scientific value in such analytical arrangements of the various differences discovered, they incline more and more to a study of those influences of soil, climate, moisture and cultivation which are now recognized as being the real causes of the existing differences, and to classify varieties on a geographical rather than botanical basis. Not-

	1882	1885	1890	1895	1900	1906
New York	12,145,200	10,565,000	9,288,000	7,301,069	6,496,166	9,350,180
Wisconsin	23,145,400	15,665,000	13,096,000	8,616,218	13,166,599	4,690,816
Illinois	52,302,900	10,683,000	18,161,000	19,060,712	17,982,068	38,535,900
Minnesota	33,030,500	34,285,000	38,356,000	65,584,155	51,509,252	55,801,591
North Dakota	*11,460,000	*27,913,000	*40,411,000	61,057,710	†13,176,213	77,896,000
Kansas	31,248,000	11,197,000	28,195,000	22,919,566	82,488,655	81,830,611
Nebraska	18,300,000	19,828,000	15,315,000	14,787,024	24,801,900	52,288,692
Texas	4,173,700	6,117,000	3,575,000	2,081,640	†23,395,913	14,126,186
Colorado	1,598,200	2,395,000	1,777,000	2,808,250	7,207,117	8,266,538

*Including South Dakota. † Unusual.

The seven states having the highest production of wheat in 1906, were: Kansas, 81,830,611 bushels; North Dakota, 77,896,000 bushels; Minnesota, 55,801,591 bushels; Nebraska, 52,288,692 bushels; Indiana, 48,080,925 bushels; Ohio, 43,202,100 South Dakota, 41,955,400 bushels.

withstanding this, a statement of the botanical relationships has a proper place in this connection.

Botanical classification.—The classification conceded to be the most acceptable is that made by Hackel, and the outline here given is that arranged by Hunt. (The Cereals in America, p. 48.)

- Triticum
  - monococcum (1) Einkorn.
  - sativum
    - Spelta (2) Spelt.
    - dicoccum (3) Emmer.
    - tenax
      - vulgare (4) common wheat.
      - compactum (5) Club or square-head wheat.
      - turgidum (6) poulard wheat.
      - durum (7) durum wheat.
  - Polonicum (8) Polish wheat.

It will be noted from the above that there are eight types recognized as members of this great family. Some of these are very closely related, while others are so distinct as to refuse to reproduce by cross-fertilization.

Fig. 894. Einkorn (*Triticum monococcum*). Three-fourths natural size.

(1) *Einkorn* (*T. monococcum*). Fig. 894.—This species of wheat has no English equivalent for the German name, nor has the plant been grown except in an experimental way in the United States. It most nearly approaches the assumed wild forms of wheat. The plant grows one and one-half to three feet in height; the leaves are narrow and heavy, stem slender and stiff, in color brownish green. The head is much flattened, compact, and heavily bearded, the grain being compressed until it shows an angular form. Einkorn has yet had no practical value for the American farmer.

(2) *Spelt* (*T. sativum*, var. *Spelta*) Fig. 895.—This is a very ancient form of wheat and has been cultivated for centuries in Europe and Africa. While still important in some European countries, it has been replaced largely by other types of wheat. It grows to the usual height of the wheat plant, according to variety and local conditions. In many varieties it would appear at first glance to be one of the wheats in common use. An examination of the spike will reveal the reasons for its distinct classification. The spikelets do not break off of the rachis and leave a zigzag-shaped terminal to the stalk, as in the case of common wheat, but they hold together, and in separating from the rachis a part is broken off and remains attached to each spikelet.

(3) *Emmer* (*T. sativum*, var. *dicoccum*). Fig. 896.—This is often confused with spelt and not easily distinguished. The stems are usually pithy and leaves covered with velvety hairs. The heads are flattened, two-rowed and bearded. Of the three types mentioned, emmer probably is better adapted to dry regions where spring grain is usually grown. It is valuable as food for stock.

(4) *Common wheat* (*T. sativum*, var. *vulgare*). Figs. 897, 898.—This is the common type of wheat grown all over the world where wheat is produced. Closely akin to it is

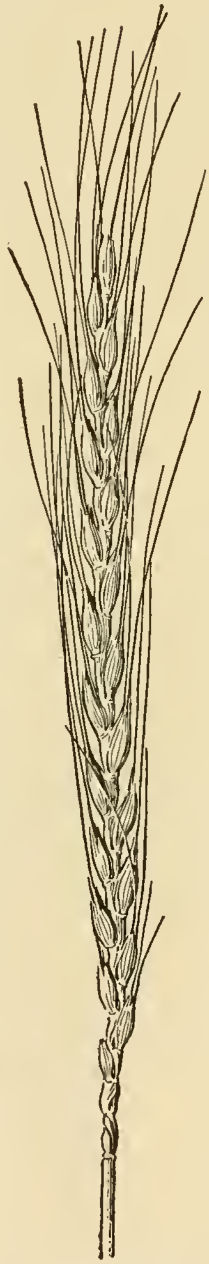

Fig. 895. Spelt (*T. sativum*, var. *Spelta*). Three-fourths natural size.

(5) *Club wheat* (*T. sativum*, var. *compactum*). Fig. 899.—This sub-species has a short, compact head, and is the common wheat of the Pacific coast region, as well as of Chile and a few other countries. These Club wheats are chiefly of spring varieties and differ from the common sorts principally in color and softness of grain.

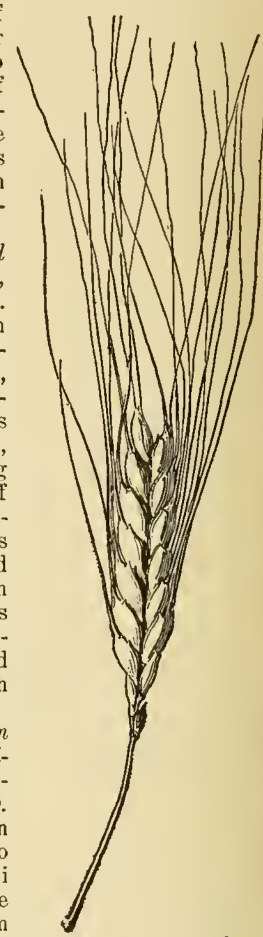

Fig. 896. Short head of emmer (*T. sativum*, var. *dicoccum*). Natural size.

(6) *Poulard* (*T. sativum*, var. *turgidum*).—This is grown in the Mediterranean region, and is distinguished by its broad head, short bristling beards and stiff straw. The variety known as seven-headed or Egyptian wheat belongs to the sub-species. Poulard wheat is much like

(7) *Durum wheat* (*T. sativum*, var. *durum*). Fig. 900.—This is often referred to as Macaroni wheat, since the flour from which is manufactured this and similar products is produced from this wheat. Durum wheat grows tall, and its broad, smooth leaves and heavily bearded heads attract attention. It is easily mistaken for barley, which it much resembles. The grains are large and pointed at each end and semi-transparent since the grain has less starch than common wheat.

"Durum wheat has been imported, tested and distributed by the United States Department of Agriculture and the agricultural experiment stations of a number of states within the last ten years. To some extent varieties of durum wheat had been grown previous to that time under the name of Goose wheat, but had never attained much importance, owing to a lack of knowledge in this country regarding its value in commerce and manufacture.

Through the efforts of these national and state institutions, a ready market for durum wheat has been developed, and the product is now exported to Europe in large quantities, and also utilized in this country for the manufacture of macaroni, spaghetti, and the like, and for blending with softer wheats in the milling of flour. During the season of 1906, a crop of 50,000 bushels of durum wheat was produced.

"The qualities that give value to durum wheat are its ability to withstand drought and its resistance to rust. It is being grown now in regions of light rainfall, under which conditions it produces larger yields than any other spring variety of wheat. It has not so far proved more productive than winter wheat, and consequently has not taken a place among the crops of the winter wheat region.

"Some varieties of durum wheat have proved sufficiently hardy to live through the winter in southern Kansas, and by selection of hardy individuals its production will doubtless be extended northward. It has been grown as a winter wheat in an experimental way at the Nebraska Experiment Station for three years. If it can be developed into a successful winter wheat it will doubtless replace the common varieties in much of the great plains region." (T. L. Lyon.)

Fig. 897. Turkey-red wheat. Two-thirds natural size.

Fig. 898. Jones Winter Fife wheat. Two-thirds natural size.

Fig. 899. Club wheat. Two-thirds natural size.

(8) *Polish wheat* (*T. Polonicum*). Fig. 901.—The Polish wheat is characterized by having the palea of the lowest flower half as long as the flowering glume, while the outer glumes equal or exceed in length the flowering glumes. This wheat may have some value for arid climates, but is not productive. The plant is sometimes called Giant or Jerusalem rye, because of the resemblance of the seeds of the two. It can be used for the making of macaroni. It is grown in southern Europe.

Geographical classification.—The United States Department of Agriculture, in 1895, made a collection of more than one thousand supposedly distinct varieties, but after testing these for several years it was found that very many were identical and that only one-fourth of the number were of any value to the American growers. It will be readily understood that a single variety grown under the wide range of climate and varying conditions which are to be found in this country would in the course of a few generations show widely differing characteristics. Few cultivated plants are so susceptible to such influences.

In his "Basis for the Improvement of American Wheats," Carleton divided the entire country into districts according to the general character of the grains produced in each. A study of these districts reveals the fact that the varieties usually grown in any one given section will all possess so nearly the same values as to warrant their classification together and thus give the product of each district a distinctive character. According to the grouping we will have:

(1) The soft wheat district, including mainly the New England and middle states.

(2) Semi-hard winter wheat district, including the north central states.

(3) The southern district, including the northern part of the southern states.

Fig. 900. Long-bearded durum wheat (*T. sativum*, var. *durum*). Two-thirds natural size.

(4) The hard spring wheat district, including the upper Mississippi river basin.

(5) The hard winter wheat district, including parts of the middle states of the plains.

(6) The durum wheat region, including parts of the southern states of the plains.

(7) The irrigated wheat district, scattered over the Rocky mountain region.

(8) The white wheat district, including the larger part of the Pacific coast states.

This classification recognizes certain qualifications, chief among which are color of grain and percentage of gluten, which form the basis of the arrangement. Since these qualifications are largely affected by the particular section of the country where the types are produced, it is a fair inference to speak of such a classification as a geographical one.

Fig. 901. Polish wheat (*T. Polonicum*). Two-thirds natural size.

From such a study as the above it can readily be seen that there is no single variety or even type that can be suggested as the best for the whole country, and even if a single variety were universally adopted it would be but a few years until it would be found as varying in character as the many sections where grown. So marked is this that markets have been created, and with the opening up of new areas, producing grain of unusual character, the milling industry has at times undergone a complete change.

The production of varieties.

The greater number of the common varieties of wheat are the result of chance rather than of any scientific effort for improvement. Wheat is a self-pollinating plant, and because of this, rarely fails to reproduce true to its characteristics. As every grower knows, however, there will occasionally appear a new or even unusual form in a field of grain which may or may not resemble the variety among which it may be growing. Such forms are known as "sports," and are the result of accidental crosses between plants of the same or different varieties. It is probable that these occur more frequently than they are discovered and that close observation would reveal many new and superior varieties that are never isolated and reproduced as distinct varieties. Without doubt the great majority of our commonly known wheats have thus originated, and it is only within a comparatively recent period that what are known as "pedigree" or scientifically produced varieties have been placed in the hands of growers. Every wheat-growing region of the world has been explored for the best varieties it was able to produce, and it is safe to say that few promising varieties which can be found anywhere remain to be tested. Vast improvement to the wheat crop has thus resulted, particularly through the introduction many years ago of what are known as Mediterranean varieties. With the reaching of the limit of possible improvement by this means, attention is being more directed to the artificial production of new varieties and the future improvement of wheat, for particular purposes as well as increased yield, will be secured by these means.

As has already been proved, the varieties introduced from foreign lands have been found to be most valuable for producing new varieties by crossing. These wheats, coming as they do from those regions near the original habitat of the wheat plant, are found to have many of the very features it is desirable to reproduce.

A study of the needs of any region is always the first requirement when new creations are to be produced. If the region needs a hardier variety or one able to withstand some insect pest or disease ; if it needs a stiffer straw, or a head less likely to shatter, the proper combinations must be made to secure these.

The second natural step will be the study of those varieties which may show the desired characteristics. It is not always the case that a perfect combination will result even when the parents with which the crossing is effected present the desired characteristics. The resultant cross may show a weakening instead of a strengthening of some desired quality.

Rigid selection is the third step which must follow hybridization. It is not a difficult thing artificially to produce new wheats, but the real task is found in selecting those of value and growing them true to the type secured.

The good results secured by cross-fertilizing wheats in order to produce new varieties are numerous. Among these which almost always follow, are two : increased vigor and greater productiveness. On the other hand, so great is the disturbance caused by the crossing that difficulty often follows the effort to select fixed types.

Hybridizing wheats.—The first step in cross-fertilizing wheat is to remove the anthers from all the flowers on the spike to be fertilized. This must be done while the anthers are yet green and the pollen immature. If the head of wheat is compact it is well to remove each alternate spikelet and also the less perfect ones at the base and tip of the spike. The work is done by using ordinary botanist's tweezers. Care must be taken not to break any of the anthers. It is best to protect the emasculated head by wrapping it with tissue paper. In a few days when the flowers on adjoining plants are seen to be ready to open, pollen may be brought from the chosen variety and deposited on the stigmas of the emasculated head, and this again protected as before. When ripe, the heads are threshed out by hand and the matured grains planted the following season. It often happens that the head is so injured in the process that the grain is shrunken or defective although still retaining vitality. Often it will be found that the work has

Plate XXV. Field of wheat in the East

not been properly timed and cross-fertilization has not followed. By making several identical crosses a sufficient number of seeds can be secured for further plantings.

Various methods of growing such seed are suggested. Whatever the method followed, it should permit of the greatest possible development of the plants from each individual seed. It will be found that a great difference will appear in the plants succeeding from the first cross. A close study of these will reveal that only certain ones will possess the characters desired, and when these are planted and another generation secured, some will be found to reproduce as fixed types while others will show an unstable character. It is generally conceded by wheat-breeders that four to five years are necessary firmly to fix any desired type so that it will reproduce itself perfectly.

Selection.—It is possible from a single cross to secure a considerable number of new varieties. As soon as these are secured they must be carefully studied before being finally selected as desirable types. This study may reveal that further crossing with either of the parents or other types is needed to effect the improvement desired. In fact, many of the standard pedigreed wheats of the country are the product of successive crosses and inbreeding. This is well illustrated in the well-known variety, Genesee Giant, which is the result of no less than eight successive cross-fertilizations. This process increases the necessity for the important work of selection since the variations secured are so numerous.

Selection must begin with the individual plants. From these may be chosen the best and most perfect heads. In any number of plants which are the result of a single cross the most vigorous and productive can easily be noted. When a fixed type is secured and decided on as worthy of propagation, the next step will be to increase the amount of seed as quickly as possible. Selection should not cease even then, for further improvement in the quality produced is possible.

Practical methods of improving seed wheat.

It is contended that the larger grains found in any variety are capable of increasing the yield, and many experiments go to show that this is a fact. It is probable that size alone cannot be depended on, but rather weight of the grain. For this reason a machine has been devised to take the place of the screening machines usually employed. This machine has a cylinder which throws the grain by centrifugal force. The heavier grains naturally travel the farthest and the grain is graded by a series of receptacles into which it falls. Screening either by the use of a fanning mill or a perforated cylinder is also a good practice.

Other factors enter into the improvement of wheat. Among these will be its treatment for preventing smut and the use of fertilizers. It may also be benefited by being changed to a more congenial climate or soil.

Soil.

Wheat grows in a very great variety of soils, ranging from the stiff clays of the New England region to the volcanic ash of the Pacific coast. With such a great variation no set rule or method for preparation can be advised. In general, soils which are full of organic matter, loose in texture and dark in color are not so well suited for wheat-growing as the lighter clay and drift soils. As a rule, over much of the area devoted to wheat-growing, crop rotation or the use of some amendment to the soil is essential. In regions where this is not followed it is often customary to practice what is known as summer-fallowing.

Land intended for winter wheat should be plowed as early in the preceding season as possible. This permits of more thorough preparation of the soil and also of the absorption of moisture during the summer. Surface cultivation should be followed, particularly after each rain. The depth of the plowing should not be less than four inches nor more than eight inches. In regions where corn is a leading crop it is customary to seed such fields without replowing, specially designed tools for preparing the soil and seeding between the rows of corn being used. This allows of the economical use of the land, and the crops secured are generally equal to those secured by more expensive methods of preparation. Fig. 902 shows a field terraced to prevent soil washing.

When spring wheat is grown, the land should be plowed in the fall preceding or as soon as possible in the spring. Thorough preparation of the soil is important in all cases.

Fertilizers. (T. L. Lyon).

On the older soils of the eastern states, extending as far west as Ohio and Kentucky, barnyard manure or commercial fertilizer is commonly applied to the land for wheat or for some crop in the rotation of which wheat forms a course. The same is true of eastern Canada, including the province of Ontario. West of this, commercial fertilizers are used very little, although barnyard manure is used on grass-land and for cultivated crops in all the country lying east of the semi-arid region. On the light soils of the prairie region barnyard

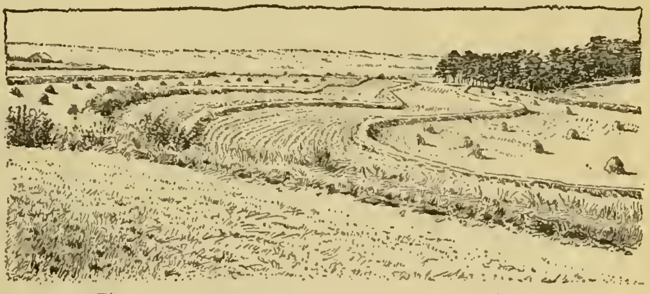

Fig. 902. Terrace-farming to prevent soil washing.

manure plowed under immediately before seeding to wheat is likely to make the soil too loose for the best yield of that crop.

Summer-fallowing is practiced extensively in the semi-arid regions, where the crop is not irrigated. A considerable proportion of the wheat of North America is now produced in regions having an annual rainfall of less than twenty inches. The soil of these regions is usually very deep, so that there is little loss of moisture by percolation; almost all of the rainfall that does not run off the surface or pass through the tissues of the plant is lost by evaporation from the soil. The effect of the summer-fallow is to conserve a large part of the rainfall during the year the land is kept fallowed, and thus greatly to increase the supply of soil moisture for the following crop. In very dry regions it is customary to fallow every other year, but where the rainfall is not so meager, two or three crops intervene. Summer-fallowing is very destructive to the humus, but it increases the supply of easily soluble plant-food materials, and these, with the greater moisture supply, produce much larger crops than can be secured when the land is cropped continuously. Barnyard manure cannot be used in this region for the wheat crop.

Wheat is raised under these conditions in central and western Kansas, Nebraska, most of the Dakotas, eastern Washington, Oregon and California, and in Manitoba, Alberta and Saskatchewan. Experiments indicate that the use of commercial fertilizers for wheat or other cereal crop is not of immediate profit in this region, and as barnyard manure dries out the soil the problem of maintaining fertility is a serious one. Doubtless it is to be accomplished by seeding to perennial grasses or legumes for a period of years. In the eastern states, where the rainfall is ample and where the soluble plant-food materials are continually leached from the soil, commercial fertilizers are used with profit, either on the wheat crop direct or on a preceding crop. Throughout much of this region wheat is grown because it is useful in filling out a rotation or in providing a nurse crop for grass and clover rather than because it is profitable in itself.

If wheat follows corn the land should receive ten to thirty loads of barnyard manure before plowing for the latter crop. This is much better than applying manure directly to wheat, which, however, will generally be benefited by an application of commercial fertilizer. The nature and amount of such fertilizer will depend largely on the character of the soil. The only accurate method of ascertaining the manurial requirements for any particular soil is to conduct a test on the soil in question.

A complete fertilizer, that is, one containing nitrogen, phosphoric acid and potash, is generally preferable to one containing only one or two of these substances. On a light, well-drained soil, relatively more phosphoric acid is needed, while on a heavy moist soil more nitrogen, preferably in the form of nitrate, should be used. Two to four hundred pounds of what is known to the trade as a 4–12–4 fertilizer is frequently used. The form in which the phosphoric acid is combined does not make much difference if the material is very finely ground.

Place in the rotation. (T. L. Lyon.)

Wheat should always be grown in a rotation with other crops. It is particularly benefited by such treatment and suffers in productiveness very rapidly when grown continuously on the same soil. Wheat yields begin to decrease on the prairie soils within a few years after they are broken, while corn will continue to yield without diminution for ten, twenty or even thirty years on some of the rich prairie soils.

The rotations in which wheat is grown vary in different parts of the country. In the New England and north Atlantic states, where corn is raised largely for silage, a system consisting of corn, wheat, clover is frequently followed. This is well suited to dairy-farming. Where oats are needed, they usually follow directly after corn and precede wheat, making the rotation corn, oats, wheat, clover. Potatoes are frequently substituted for corn.

In the corn-belt states, when wheat is raised the rotation is usually corn two years, oats, wheat, clover, except where spring wheat is grown, when it is often used to alternate with corn; thus,—corn, spring wheat, using no other crop in the rotation. This is not an ideal system, but experience has shown that it is better than raising corn continuously. This method is also being followed at present with winter wheat by drilling the wheat between the corn rows with a one-horse drill. The cornstalks are pastured in winter, so that the wheat can be harvested the following summer.

In the semi-arid region the tendency is to rotate wheat with a summer-fallow, using the latter every two to four years. It is probable that this will be replaced in time by a rotation including a perennial grass or legume left on the land for several years, and alternating wheat with other small grains suited to the region as well as the summer-fallow.

On the irrigated lands, sugar-beets or potatoes are usually the cultivated crops. These follow alfalfa, which has been down for at least three or four years. Wheat follows the cultivated crop. A typical rotation is alfalfa (three or more years), sugar-beets, wheat. Where peas are raised for sheep, as is becoming common in Colorado, a good rotation is peas, potatoes, wheat.

Seed and seeding.

The great importance of securing good seed is evident. While efforts should not be neglected to improve the character of well-known varieties and to create new ones of superior merit, it must not be forgotten that the maximum of production from the varieties now in common use has by no means been reached. Much remains to be learned of the adaptability of existing wheats and the best methods of cultivating and handling the crop.

The wheat-grower cannot be too painstaking in the selection of his seed wheat. By employing the methods previously mentioned of cleaning and grading the seed, improvement is sure to follow. Shriveled wheat will germinate, but the best results cannot be expected from such seed. In many regions it is absolutely necessary to treat the seed with some chemical to destroy the germs of smut. [See below under *Enemies*.]

Seeding.—The time for sowing will depend on the climatic variations and on the dangers of attack from the Hessian fly. With fall wheat, time must be allowed for sufficient growth of the young plants to be able to withstand the rigors of winter. Wheat has the ability to germinate and grow at comparatively low temperatures, but due care should be exercised not to subject the early growth either to severe frost or to sudden changes of the season. No best time for seeding can be given for any locality. As a rule, the depth of seeding will vary with the porosity of the soil—the lighter the soil the greater the depth. The seed should be planted not less than one nor more than three inches deep, and by the use of such machinery as will place it uniformly and secure perfect covering by the soil.

Many factors enter into the question of the proper amount of seed to sow per acre. The yield will not depend on the quantity of seed sown, for the differences in varieties are very great; size of seed, quality, condition of seed-bed and time of seeding, character of the soil and climatic influences all have to be considered. Repeated experiments in many states lead to the conclusion that six to eight pecks would be the proper range for quantity.

As a rule, wheat is not cultivated after being planted. The practice of harrowing, once followed in England, has never been universally adopted in America. There are some wheat-growing sections where it is an advantage to harrow winter-sown land in the spring in order to break up the crust on the surface and thereby retain the moisture, as well as give the plants better conditions for growth.


Fig. 904. A Pennsylvania wheat-field.

Harvesting (Figs. 903, 904).

The period of growth needed to bring the wheat plant from seeding to maturity varies greatly. With fall-sown grain there is a long dormant period of almost if not quite half a year when there are few indications of activity or even life. With spring-sown grain where the growth is continuous and unbroken, the period will range from ninety to one hundred and twenty days. In the United States, harvesting begins in Texas as early as May, but may continue as late as September or even October in North Dakota and Washington. In the eastern states grain must be cut as soon as sufficiently ripe, and the entire crop must be put in the shock within a brief period. West of the Rocky mountains, where little or no rain falls during the summer months, harvesting is pursued more deliberately, and as the Club varieties are largely grown in these regions, the fields are often left standing for weeks or even months after the wheat is fully ripe.

Harvesting machinery.—The methods employed in harvesting wheat have undergone great changes during the past century. From the hand sickle, with which it was possible to reap but a small area each day, to the perfected harvester or the great combined machine, is but a brief step in point of time, but it represents a wonderful advance in human invention and application. At the present time machinery of some kind is universally used in America for harvesting wheat. So perfect is this that the grain is scarcely touched by the human hand during the entire harvesting process. Until within twenty years of the close of the past century the most perfect machine in use was the self-rake reaper, which mechanically cut and placed the wheat in bundles on the ground ready to be bound in bundles by hand. This machine was replaced by the self-binder, which at first used


Fig. 903. Wheat stacks. Farm of Alex. Speers, on the Eagle Hills, Sask.

wire instead of twine. When a proper knotting device had been devised, the self-binder made possible a great expansion of the wheat industry. In many parts of the West the header is commonly used, but only in those regions where the wheat can be left standing after maturity until it can be harvested. With this machine only sufficient straw is cut to insure gathering the heads of the grain. The header cuts ten to twelve feet wide, and is pushed forward through the grain by six or eight horses. The headed grain may be taken immediately to the thresher or shocked.

The threshing of grain where the header or self-binder is used is generally done by threshers operated by steam- or horse-power. Various devices calculated to reduce manual labor to a minimum are employed in this connection: self-feeders, band cutters, straw carriers, elevators and sackers are all used, and even attachments to bale the straw for market directly from the thresher. By far the larger part of the wheat crop in the United States is cut by the binder and threshed directly from the field.

Fig. 905.
Hessian fly (*Mayetiola destructor*); adult female. (From Webster.)

Fig. 906.
Hessian fly; adult male. (From Marlatt.)

Fig. 907.
Hessian fly; side view of female. (From Burgess.)

Enemies.

Insects.—The wheat plant has many enemies to contend with in the form of insect pests, fungous diseases and weeds of many sorts. The two most injurious insect enemies are the chinch-bug and the Hessian fly (Figs. 905–907). The annual losses caused by these two pests in the wheat-fields of the United States is beyond estimate, but will run into millions of dollars. Remedies to counteract their ravages are largely preventive; in the case of the chinch-bug, by clean tillage and rotation of crops, and of the Hessian fly by late seeding, burning stubble and otherwise hindering the propagation of the brood. Other insect pests may at times cause local damage to the wheat crop, but are of less importance.

Diseases.—Two rusts commonly occur on wheat, the early orange leaf-rust (*Puccinia rubigo-vera*) and the late stem-rust (*Puccinia graminis*, occurring also on oats). These rusts may also destroy the crop within a few days. Rust is now being controlled by growing resistant varieties. Of wheat smuts there are two: The loose smut (*Ustilago tritici*) matures its spores at blossoming time, the succeeding crop becoming infected through the blossoms. No satisfactory treatment has as yet been worked out. The stinking smut or "bunt" (caused by *Tilletia tritici* or *T. fœtens*) destroys only the kernel. It may be prevented by the use of either of the following solutions:

(1) Formalin: Use a solution of one pound of formalin to fifty gallons of water. Sprinkle the wheat, covering afterwards with cloths soaked in the solution, or immerse the sacks for thirty minutes.

(2) Blue Stone. Make a solution of copper sulfate at the rate of one pound to five gallons of water; immerse the sacks for ten minutes and then drain and dry. Care must be taken to apply the solution to all vessels and machinery used wherever the seed might become infested by contact.

Loose smut is not controlled by either of these methods. No entirely satisfactory method is known. A modified form of hot-water treatment is recommended.

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If there is any disagreement between the index and the text in the rendering of a binominal Latin name, the index is to hold. A very few names are affected in spelling or capitalizing.