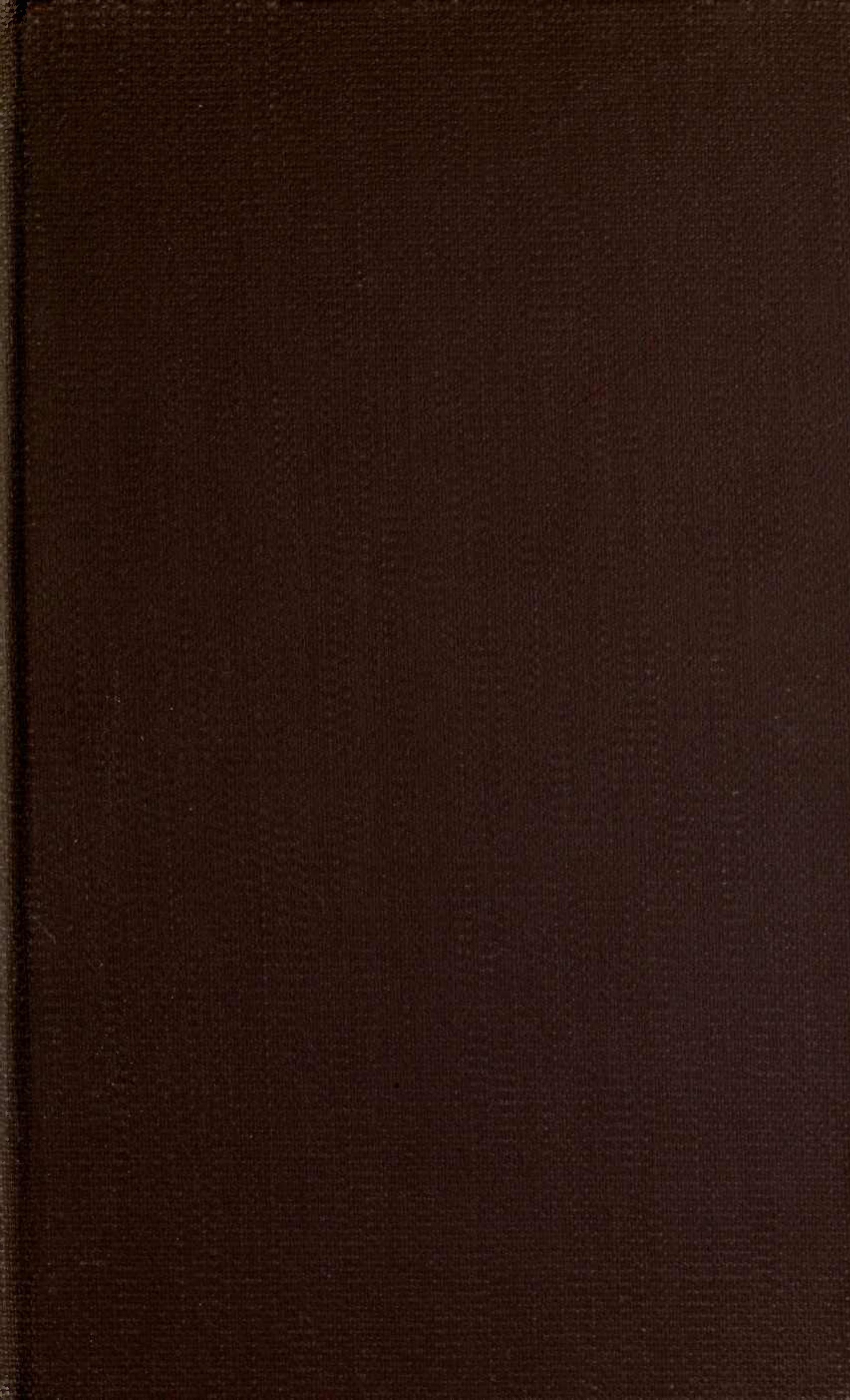

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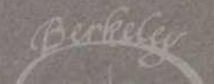

COCOA

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COCOA

BY

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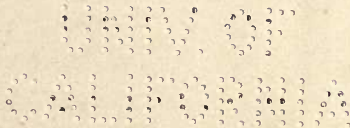
BUITENZORG, JAVA

WITH ILLUSTRATIONS AND MAP



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PREFACE

In writing this handbook I have done my best to make it practical.

This does not mean that the intention of the book is to teach the reader cocoa-planting, and it is not expected that any one unacquainted with cocoa-culture will become a cocoa-planter by reading the book from beginning to end.

The practical planting-work must be learned in the field, and I could quote here what has been written on the first page of Chapter VI.

Many planting operations, however, are not always well understood; often the practical man knows, *how* he has to treat his trees or his soil in order to get the best result, but not *why*. For this reason, different operations, like weeding, shading, manuring, and fermenting, have been explained more fully than is done in most agricultural handbooks.

Other subjects have been treated in detail which cannot be learned in the field, especially the varieties of cocoa, the botanical characters, and the diseases and their treatment.

It is a golden rule that the cultural methods must always be entirely dependent on local conditions.

Generalising is one of the most dangerous things in agriculture. I therefore considered it instructive to devote a special chapter to the description of the culture of cocoa in the different countries separately.

During the writing of this book I have been favoured by the cordial help of many friends who assisted me by giving information and photographs of the cocoa-industry in their countries. I need not mention them all, but I cannot omit rendering my sincere thanks to Mr. van Overzee (Amsterdam) who completed and corrected Chapter X., Mr. M. E. Seminario (Guayaquil), Mr. Monteiro de Mendonça (Lisbon), the Agricultural Society of Trinidad and its Secretary, Mr. Edgar Tripp, Mr. Jacobson (Trinidad), Mr. van Beek (Surinam), and Dr. Roepke (Salatiga). For the correction of a part of the manuscript I am indebted to my friend Frank Evans, late Assistant-Superintendent of Agriculture in Southern Nigeria.

Finally, I must mention especially the great help afforded to me by Sir Daniel Morris, who kindly assisted me with the correction of the proof sheets.

C. J. J. VAN HALL.

BUITENZORG,
February 19, 1914.

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CHAPTER I

HISTORICAL [1]

It is impossible to say how long the cultivation of cocoa has existed, but it certainly goes back to very ancient times.

In Europe both the plant and its produce were unknown till the beginning of the sixteenth century, when Cortez and his soldiers became acquainted with it on their landing in Mexico. In his fifth letter to Charles V., Cortez writes that the cocoa plant is cultivated to a large extent in the provinces Çupilcon and Tatuytal; he calls the tree "cacao" or "cacaguata." There is no doubt that the Indians had cultivated cocoa for many centuries before this, for it played an important rôle in their popular traditions and legends. They believed that the plant was of divine origin, and that Quatzalcault, a prophet of the Indian mythology, had brought the seeds from Paradise and sown them in his gardens at Talzitepec. By eating the fruit he acquired universal knowledge and wisdom, and was held in great reverence by the people. This legend shows how highly cocoa was appreciated by the Indians of Mexico, who honoured its produce in the same way as afterwards did Linnæus, when he gave it the name of "theobroma," signifying "the food of the gods."

[1] An interesting chapter on the history of cocoa is given by Jumelle in his book, *Le Cacaoyer*, and still more interesting particulars and illustrations are to be found in a little book by Van der Wielen, *Cacao, Cultuur en Bereiding* (Amsterdam, 1906).

At the time of Cortez, cocoa was not only highly appreciated by the Indians as a beverage, but was also used as a substitute for money, in the same way as the kola-nut is still used in Africa. That it was

Van den Boom die de Cacavate draegt, dat haer Geldt is, en hoe de Indianen uyt twee Houten Vyer krijgen.

Cacavate 't welck hun gelt is / den boom die dit draecht en is niet seer groot / hy en wast niet dan in heete plaetsen / doch in schaduwe / want wiert hy beschenen van de Sonne hy soude vergaen : Daerom plant men hem in de bosschen daer 't vochtich is / en vreesende of dit niet genaeg en waer planten sy hem by eenen boom die hoger is / welcken sy al wassende daer over buygen / en verbreyden synen top / so dat hy groot wesende hem bedeckt / dus krygt hy over al schaduwe / so dat hem de Son in geender voegen hindert. Als sy Vuyr willen maecken / soo nemen sy 2. Houtjes van desen Boom die sy so lang tegen malkander wryven tot datse branden / en dit is de Manier van Vuyr maecken in gansch Indien / onder de Indianen geweest.

FIG. 1.—The Cocoa Tree.

From the Dutch edition of Girolamo Benzoni's *History of the New World*.

The following is a translation of the inscriptions :—

"Of the tree which bears Cacavate, which is money, and how the Indians obtain fire from two pieces of wood."

"Cacavate, which is money. The tree which produces it is not very large. It grows only in hot places, but under shade, for if the sun were to shine on it, it would die. Therefore they plant it in forests where it is humid, and, afraid that this is not enough, they plant it next to a tree which is higher and which they bend over it, spreading out its top so that it covers the cocoa tree, which thus gets shade all over it, so that the sun no longer does any harm. When they want to make a fire, they take two pieces of wood from this tree and rub them against each other till they catch fire; and throughout India this is the method of making fire used by the Indians."

valued very highly is apparent from the fact that a rabbit could be purchased for ten, and a slave for one hundred beans. The different provinces paid their tribute to the Chief in cocoa, and when the Spaniards

defeated Montezuma, they found in his palaces great quantities of the beans, which represented a great part of his property and which were, of course, also drawn upon to prepare the beverage, which was always kept ready in golden beakers for his personal use. "He used to take this strengthening drink," says Bernal Dios de Castillo, "when he intended to visit his serail."

As cocoa was so valuable, the common people could only afford to mix a little of it as a spice in their ordinary food, called "atolle," a sort of soup or porridge made with corn-meal. The real beverage, called "chocolatl," was only used by the rich. This "chocolatl," however, was quite a different thing from our cocoa or chocolate. It was made of corn and cocoa, roughly ground between two stones and boiled with addition of red pepper. At first the Spaniards could not appreciate this mixture, and consequently did not regard the plant as valuable; and in the same way the Dutch corsairs, when they had captured some of the produce, threw it into the sea, calling it in bad Spanish "cacura de carnero" ("sheep's excrement"). Accordingly it was not until the end of the sixteenth century that a small quantity was sent to Europe, and this only as a curiosity. Soon after that time, however, the Spaniards began to appreciate cocoa when they learned to add sugar to it, and gradually they understood how to make from it a drink pleasant to their taste by mixing it with vanilla and cinnamon. This is said to have been an invention of the nuns of the nunnery of Guanaca. Prepared in this way cocoa soon became popular among the Spaniards in America, and these taught it to the people at home by importing to Spain chocolate cakes, prepared with sugar, vanilla, and cinnamon.

As long as possible the Spaniards in America kept the secret and the monopoly of the manufacture of these cakes in their own hands. It turned out, however, to be very difficult to prevent the export of unprepared beans, and gradually the first European

chocolate factories arose in Spain. One of the oldest recipes for chocolate cakes is given by the physician Bartholemy Maradon, as follows:—Seven hundred cocoa beans, one pound and a half of sugar, seven ounces of cinnamon, fourteen grains of pimento, two ounces of cloves, three pieces of vanilla or seven ounces of aniseed.

FIG. 2.—Indians roasting and kneading cocoa.

From the Dutch edition of Girolamo Benzoni's *History of the New World*.

From Spain the use of cocoa spread to Italy, where it was introduced by a Florentine, Antonio Carlotti.

In France it became especially popular after the marriage of Louis XIV. with Maria Theresa, who was of Spanish origin. One of her Spanish servants was very good at preparing chocolate, and Maria Theresa herself was so fond of it that a French historian wrote: "Le roi et le chocolat furent les deux seuls passions de Marie Thérèse."

About 1660 chocolate was also a popular drink in

Holland, especially in Amsterdam, and together with the "coffee-house" arose the "chocolate-house," recognisable by its sign-board: "Hier schenckt men Seculate" ("Here chocolate is served").

In those times, however, cocoa was still a rather expensive drink. In France about six francs was paid for half a pound, and Louis XIV., who started the practice of serving chocolate to the guests at his receptions, soon decided to abandon the custom on the score of its expense. In the middle of the eighteenth century the price of cocoa fell considerably. This cocoa, however, was no longer a product of Mexico. Venezuela had become by far the most important cocoa-producer. This country began to ship cocoa to Europe in 1634, and the trade grew rapidly to such importance that the Spaniards prohibited the export to any other country but Spain, in order to help the cocoa industry in that country. But this prohibition had not much effect.[1] The Venezuelans considered it more advantageous to do business with other nations, and went on selling cocoa secretly to Dutch and English merchants. This secret commerce became so great that towards the end of the seventeenth century Spain received no "Caracas cocoa" whatever; it all went to Amsterdam. The export at that time was estimated to be not less than 65,000 quintals, or 3,250,000 kilograms.

In the seventeenth century the Windward Islands began to become important as cocoa-growing countries. In Trinidad the first cocoa trees had been planted by the Spaniards as early as about the year 1525. These were entirely of the Criollo variety, and the produce was much appreciated and even preferred to the Venezuelan ("Caracas") cocoa.

In the Leeward Islands the cultivation was taken up later. In 1655, as old writers inform us,[2] the Caribbean Indians showed a Mr. du Parquet the cocoa

[1] Jumelle, *Le Cacaoyer*, p. 145.

[2] *Histoire naturelle du cacao et du sucre* (à Paris, rue de la Harpe, chez Laurent d'Houry, MDCCXIX.); no author's name.

tree growing wild in the forests of the north-eastern district of Martinique (the part called "Capesterre"), and it is probable that the original Forastero, grown at Martinique and Guadeloupe, the "Guadeloupe Creoule," is descended from these wild-growing trees. On the other hand, it is said that seeds from Venezuela were imported into Martinique in 1664 by a Jew named Benjamin Dacosta; probably these were Criollo seeds.

Of the West Indian Islands, which in the seventeenth century became important as cocoa-growing countries, mention must be made of Jamaica and Haiti. In Haiti, however, the prolonged wars, which ended in 1664 by the occupation of a part of the island by the French, naturally caused a decline in the cultivation. When the English took possession of Jamaica in 1655, cocoa had already been grown fairly extensively by the Spaniards, and, according to Long (*History of Jamaica*), "there were (in 1671) as many as sixty-five walks in bearing."

The year 1727, however, was very disastrous for cocoa all over the West Indies. In Jamaica, as well as in Trinidad and Martinique, and probably in all the other cocoa-growing Antilles, the plantations were wholly destroyed by a "blast." It seems very probable that Morris is right in taking this "blast" to have been a hurricane; but there are writers who give another explanation to the word, and assume that this "blast" was a blight, a disease which destroyed the trees.[1] It is, however, hardly conceivable that such a disease would appear so suddenly, and in the same year, on islands so far away from each other as Jamaica, Trinidad, and Martinique, and also be equally destructive in all. On some of the islands the cultivation was re-established comparatively soon, but on others the process of restoration was slower. About thirty years after the hurricane cocoa was reintroduced into Trinidad by some Aragonese Capuchin Fathers; they imported from Venezuela

[1] Hart, *Cacao* (1911), p. 8.

seeds of a new variety, the Forastero, which was soon cultivated to a large extent. In Jamaica, however, cocoa culture remained abandoned until the latter half of the nineteenth century. In 1882 the plant was only grown in isolated instances, but since that time the cultivation has again made great progress. In Haiti the many revolutions made regular development of the cocoa culture impossible. The production continued with ups and downs, until at the end of the nineteenth century steadier progress began to be made.

The cocoa industry of Cuba is of quite recent date, for though much cocoa was consumed in the island, it was not till the beginning of the nineteenth century that the first seeds were imported from Venezuela. In 1847 about 44,000 kilograms were produced, but this was only enough to satisfy the local demand. Since that time the annual export of cocoa has increased with more or less regularity, and now amounts to about 2 million kilograms, though the yield varies considerably in the different years.

The first cocoa plants were imported into Surinam (Dutch Guiana[1]) in 1684 by Chevalier de Chatillon from the basin of the Orinoco, and in 1725 the first cocoa was exported—about 180,000 kilograms. Gradually the importance of this crop grew, but at the beginning of the nineteenth century there was a decline, and the cultivation was almost abandoned until about the middle of the century.

Brazil, which in 1909 actually exported even more than Ecuador, is one of the youngest cocoa-growing countries. It is true that the cocoa tree grows wild in the basin of the Amazon and that it has been cultivated in the State of Pará since the middle of the eighteenth century; but that this culture was of no importance is clear from the fact that only 7000 trees had been planted in Pará up to 1749. In the case of the State of Bahia, which is now of far greater importance than Pará, the

[1] The Netherlands colony which in England is called "Dutch Guiana" is throughout this book given its Dutch name, "Surinam."

first cocoa plants were imported in 1780. In the first half of the nineteenth century the export was not very important, and it was only about forty years ago that a remarkable extension of the cultivation took place.

While the "old" cocoa countries are to be found in South and Central America—Mexico, Venezuela, Trinidad and other Antilles, Ecuador, Surinam, and Haiti, together with some of more recent importance, such as Brazil (especially the State of Bahia), San Domingo, and Jamaica—in Africa and Asia only "young" cocoa countries are to be found. The most important of these are San Thomé, the Gold Coast, Ceylon, and Java.

In San Thomé, the fourth most important cocoa-growing country, which now exports not less than 34 million kilograms per annum, the cultivation of cocoa was only begun in 1870. It is true that the first cocoa was planted much earlier (in 1822), but up till 1870 the industry was of no importance, the export in the latter year amounting only to 44,000 kilograms. Twenty-five years later, in 1895, the export had already reached the important figure of 7 million kilograms, and sixteen years later it amounted to 34 million kilograms.

The growth of cocoa on the Gold Coast has been still more remarkable. The first shipment was made in 1891—only 40 kilograms; twenty years later, in 1911, the export amounted to 40 million kilograms. This great increase is the more interesting because in the Gold Coast the cocoa is only cultivated on small plantations.

The cocoa now grown in Ceylon is most probably to a great extent descended from the plants obtained from Trinidad by Sir R. Horton in 1834–5, and also from varieties imported in 1880 from the same place. A few plants must have been present on the island before 1834; at any rate the Botanical Garden contained some specimens. The first, but very small, export took

place in 1872, and in 1875 it only amounted to 508 kilograms. Since that time the export has gradually increased, and now amounts to about 3½ million kilograms.

Though cocoa plants were imported at an early date into the Dutch East Indies — it is said they were introduced into Celebes by the Spaniards as early as 1560—the cultivation was for a long time of very little importance. About the middle of the nineteenth century, regular but small shipments were sent to Amsterdam from Celebes, but nowadays the export from this island is of no value at all. During the last thirty-five years, however, Java has become a cocoa-growing country of some importance. When the cultivation of coffee began to decline, about 1880, many coffee fields were replanted with cocoa, and a steady increase of this area has since taken place. The industry would certainly have become still more important if it had not been hindered by different insect-pests, especially the cocoa-moth and the *Helopeltis*. The export now amounts to about 2½ million kilograms.

The foregoing figures will already have given an impression of the enormous extension of the cultivation and use of cocoa in the last fifty years. This extension is to a great extent the consequence of the invention, in the year 1828, by the Dutch manufacturer, C. J. van Houten, of a method of preparing cocoa-powder, by which a great part of the cocoa-butter is removed. The cocoa beans contain about 50 per cent of cocoa-butter, and the old-fashioned cocoa drink was therefore a heavy, though very nourishing food. By the removal of a great part of the fat it is made much more fit for general use, being lighter and more pleasant, and also cheaper. In this way the chocolate-cake industry was succeeded by the "cocoa-powder" industry—*i.e.* the preparation of a powder of pure cocoa containing only a small amount of fat, and soluble in water and in milk; and this "cocoa-powder" or "cocoa" gradually took the place of the old chocolate cakes.

In addition, the greater facilities for export, the vastly improved methods of preparation with powerful and scientifically-arranged machinery, and the lower duties have all helped to make cocoa more popular every year. The following figures show the increase in the consumption of cocoa in England:—[1]

Year	Lbs.	Year	Lbs.
1822	523,000	1870	6,943,000
1830	976,000	1880	10,566,000
1840	2,042,000	1890	20,224,000
1850	3,081,000	1909	88,133,000
1860	3,231,000		

The next table (p. 11) shows the progress which has been made in the production of cocoa by the principal countries concerned, during the last eighty years. The figures indicate tons of 2200 lbs. (= 1000 kilograms). It must be remembered that most of the figures are only approximate. No accurate statistics existed of the earlier dates given, and in addition different sources often yield different figures.

In this list the various countries are arranged according to the amount of cocoa they export. It is true that in 1909 Brazil exported more than Ecuador; but this was exceptional, and Ecuador has still to be regarded as being the most important cocoa-growing country; Gold Coast follows as second, Brazil as third, San Thomé as fourth, etc. The black vertical lines indicate that no export of any importance took place. The countries with these lines are therefore of recent importance from a commercial point of view. Two of them, however, Surinam (Dutch Guiana) and Martinique with Guadeloupe, grew cocoa centuries ago, and were at one time of some importance on the cocoa market, but became backward and eventually disappeared from the market, Martinique with Guadeloupe in the end of the eighteenth century, Surinam in the beginning of the nineteenth century. The very rapid growth of the

[1] *Cocoa: All about it*, by "Historicus" (London, 1896).

THE WORLD'S COCOA PRODUCTION (IN TONS = 1000 KILOG.)

	Ecuador.	Gold Coast.	Brazil.	San Thomé and Principe.	Trinidad.	Venezuela.	San Domingo.	Grenada.	Ceylon.	Jamaica.	Cuba.	Haiti.	Java.	Surinam (Dutch Guiana).	Martinique and Guadeloupe.
1830–39	5,400	—	26	—	900	4,000	—	?		—	?	200	—		—
1840–49	?	—	200	—	1,500	5,000	—	?		—	?	400	—		—
1850–59	?	—	500	—	2,500	5,500	—	?		—	400	700	—		—
1860–69	?	—	600	200	5,500	3,500	?	?		—	?	900	—	500	—
1870–79	9,800	—	1,200	500	7,000	6,500	?	?	1	40	?	1,200	—	800	—
1880–89	10,300	—	6,300	1,500	8,000	7,000	?	?	300	200	900	1,500	12	1,000	—
1890	10,400	—	5,600	2,800	9,000	7,300	1,400	2,500	1,000	400	1,000	2,000	150	2,100	500
1900	18,900	500	?	13,900	14,500	11,900	5,900	4,800	1,900	1,200	1,700	2,000	1,300	2,900	850
1909	30,600	20,500	33,800	27,800	23,300	17,500	14,800	6,400	3,600	3,200	2,700	2,500	2,200	1,900	1,500
1911	40,000	40,000	35,000	34,000	21,200	17,400	19,800	5,900	3,100	2,800	1,200	2,300	2,300	1,600	1,600
1918			48,000												

cocoa export from the Gold Coast, San Thomé, Brazil, and San Domingo, is especially conspicuous as compared with the comparatively slow increase of Venezuela and Haiti, both of which lost much of their importance on the market during the latter part of the nineteenth century.

CHAPTER II

GEOGRAPHICAL DISTRIBUTION AND CLIMATIC CONDITIONS

Geographical Distribution.—It is most probable that the home country of cocoa is the region of the basins of the Orinoco and the Amazon, with the valleys of their tributary streams.[1] It is true that it has been reported as growing wild in the forests of various other regions —*e.g.* Mexico, Trinidad, Martinique, Guiana, Ecuador, Colombia—but there is no proof that its presence in these countries is really spontaneous. On the other hand, it might be maintained that it is also doubtful whether cocoa is indigenous to the forests of the Orinoco and the Amazon region; but the much larger number of trees growing wild there make this more probable.

The difficulty of tracing the place of origin is due to the fact that at the time of the discovery of America, cocoa had already been cultivated for centuries by the Indians, whose nomad life helped to spread the valuable tree, which they appreciated so highly, all over tropical America. Moreover, the ease with which cocoa seeds are disseminated by different animals—especially monkeys, which often carry the fruits miles away—affords an explanation of the fact that in almost every country where cocoa is grown, it is also found growing wild in the forest, generally in groups of several trees. This makes it impossible, when we find cocoa growing wild, to say whether this growth is spontaneous or not.

[1] De Candolle, *L'Origine des plantes cultivées*, part ii. chap. v.

In the tropical parts of South and Central America, and more especially in the coast region of the continent and in the Antilles, cocoa has been grown for several centuries and is found growing wild in many places. How the cultivation has spread and developed in this part of the world and how it was conveyed to Africa and Asia, has been described in Chapter I., but only the most important cocoa-growing countries were mentioned. A more complete list of these countries is now given, though several of them are of no importance from a commercial point of view. The countries where only a few trees have been planted as an experiment have been omitted from the list.

Central America.—Mexico, Guatemala, Honduras, San Salvador, Nicaragua, Costa Rica, Panama.

South America.—Pacific coast: Colombia, Ecuador, Peru, Bolivia. *Caribbean and Atlantic coast*: Venezuela, Surinam (Dutch Guiana), Brazil (the States of Pará, Maranhâo, Bahia and Pernambuco).

Antilles.—Cuba, Haiti and San Domingo, Jamaica, Guadeloupe, Martinique, Dominica, St. Lucia, St. Vincent, Grenada, Trinidad, Tobago.

Africa.—San Thomé, Principe, Fernando Po, Gold Coast, Togo, Lagos, Kamerun, Belgian Congo, German East Africa, Madagascar, Réunion.

Asia.—Ceylon, Indo-China, Philippines, Java, Samoa.

Temperature.—Cocoa can only be grown in the tropics, for it is very particular about temperature and soon suffers from cold. In most countries it takes harm when the temperature falls below 60° F. (about 15° C.), or at any rate when this happens repeatedly. It is thus essentially a tropical plant; it will not grow in the sub-tropics, and is only found in countries situated between 20° north and 20° south latitude.

In this respect it is more exacting than coffee (*Coffea arabica*), though the two plants are very similar in regard to other conditions of cultivation. Coffee, however, can stand a cool climate better, and it is therefore possible to grow it in latitudes where cocoa cannot thrive—for instance, in Brazil above 20° southern latitude, and in Africa north of the limit of

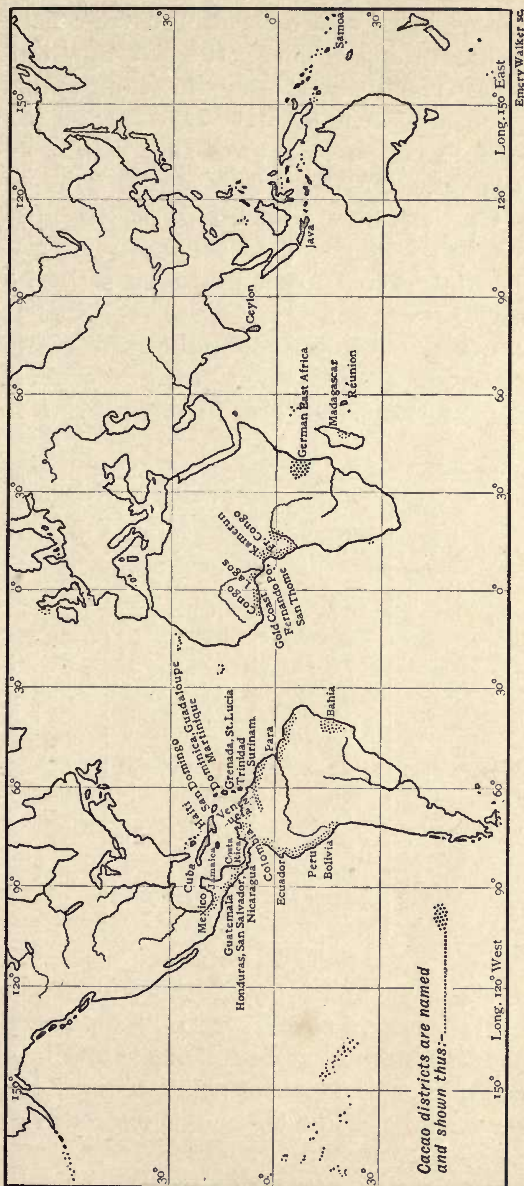


FIG. 3.—Map of the World, showing the distribution of the cocoa-growing countries.

cocoa cultivation. This fact is well exemplified in Java, in those places where cocoa and coffee are grown up in the mountains. There the average daily temperature sinks rapidly with the elevation, and speaking generally, cocoa does not thrive above 1800 feet above sea-level, while coffee is grown successfully on much higher altitudes. Further, it is well known in every Botanical Garden how difficult it is to grow cocoa trees satisfactorily in greenhouses, and how very seldom they flower and give fruit, while this is by no means the case with coffee.

The monthly maximum and minimum temperatures (shade), in degrees Fahrenheit, of a few well-known cocoa-growing countries, are given in the following table :—[1]

	Trinidad (Bot. Gardens).	Surinam (Exper. Garden).	Gold Coast (Aburi).
January . .	69–86	71–84	65–83
February . .	70–87	72–85	68–84
March . . .	70–88	73–84	68–87
April . . .	69–86	74–85	66–84
May . . .	70–88	73–84	67–85
June . . .	70–87	72–86	66–82
July . . .	69–87	73–87	67–81
August . . .	70–88	74–89	66–81
September . .	70–88	74–91	66–84
October . .	70–88	73–91	65–86
November . .	69–88	73–89	69–86
December . .	70–89	72–87	68–85

Rainfall.—The humidity of the soil is also of the greatest importance to cocoa. It is of course impossible to state a minimum amount of rainfall which is necessary in order that cocoa may thrive, because so much depends on the depth and the water capacity of the soil.

[1] Wright, *Cocoa*, p. 15; *Gold Coast Annual Reports*, 1908 and 1909; *Meteorologische Waarnemingen* (Dept. of Agriculture, Surinam).

In Surinam, for instance, the soil is rather poor in humus and very shallow, and the roots cannot go deeper than 1½ to 2 feet. The result is that, in spite of the considerable water-retaining power of the soil, the cocoa sometimes suffers from drought. Fortunately, severe and continuous droughts are rare in this country, and even in the driest months (September and October) an occasional shower generally falls, making the average rainfall in those months about 70 mm. (2·75 in.).

Severe droughts, lasting several months, are sometimes experienced on some of the cocoa plantations in Java, but here the soil is deeper and generally richer in humus. The cocoa can accordingly have a deep root-system, and this enables the plant to stand the droughts without damage.

In other countries, again, the rainfall is very small, but the necessary amount of water is supplied by means of irrigation. This is especially the case in the coast region of Venezuela, between La Guayra and Puerto Cabello. Here the famous Venezuela Criollo is grown in narrow valleys, where the soil is rich in humus, but where the rainfall is estimated to amount to no more than 1200 to 1500 mm. (47 to 59 in.) per annum. Water is supplied mainly by means of a primitive irrigation, the brooks being dammed by little walls of stone and conducted to the cultivation area through open trenches.

Another country apparently with a small rainfall is San Thomé; but few reliable figures are available.[1] The total annual rainfall seems to range between 1000 and 2500 mm. (39 and 98 in.), while in the months of June, July and August long droughts may occur. The effect of these, however, is apparently not very serious, principally in consequence of the fact that the sun is not very strong and the sky mostly cloudy. Under other conditions so little rain would be detrimental.

On the other hand, too much rain can equally be an impediment to successful cocoa-growing. No limit

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain*, pp. 27-29.

to the rainfall can be given, however, because here again it depends wholly on different circumstances whether the cocoa suffers or not. Generally speaking, however, a rainfall of more than 5000 mm. (196 in.) is unfavourable. When the rain falls in heavy showers, which last only for a short time, while the rest of the day is bright and sunny, the effect of a heavy annual rainfall is not so detrimental as when the rain falls more slowly but more continuously; and when the soil is porous and drains quickly, a heavy rainfall will not be so harmful as on a stiff, compact soil, which gives off the water slowly.

Thus in Surinam, where the soil is very compact, months with a rainfall of 400 to 500 mm. (15·5 to 19·5 in.) are decidedly unfavourable, and in the rare cases when more than 500 mm. (19·5 in.) of rain has fallen (for instance, in February 1902 and April 1907), much damage was done. In Java, however, even larger amounts are not at all an exception on several estates, and the cocoa does not show any ill effects when the soil is porous and the drainage perfect. At the plantation "Widodaren," for instance, the following quantities of rain were experienced without harming the cocoa:—

	January.	February.	March.
1900	615 mm.	425 mm.	711 mm.
1902	479 „	803 „	521 „
1903	523 „	296 „	919 „
1905	687 „	649 „	360 „
1906	675 „	548 „	554 „

From the foregoing it will be clear that a simple statement of the total amount of rain per month or per year conveys only a very imperfect idea as to the humidity of the soil, especially with regard to its capability for the cultivation of cocoa. A few examples may, however, be given, and further details as to the peculiarities of the different cocoa-growing climates will

be found in Chapter IX. The following average monthly figures [1] are in millimetres [2] :—

	Trinidad (St. Clair).	Grenada (Richmond Hill).	Dominica (Botanic Station).	Surinam (Paramaribo).	San Thomé (City).	San Thomé (Estate "Monte Cafe").	Gold Coast (Tarkwa Station).	Ceylon (Botanic Gardens).	Ceylon (Dumbara).	Java (Widodaren, East Java).	Java (Getas, Central Java).
Jan.	73	108	105	237		104	41	210	119	510	414
Feb.	39	98	75	152		20	52	81	59	473	322
March	48	49	72	157	153	377	174	120	87	490	397
April	50	78	58	223	149	405	183	182	189	332	247
May	98	130	110	258	111	481	245	172	149	213	189
June	207	251	210	280	22	69	327	201	228	150	152
July	228	272	270	201	550	80	126	156	171	77	100
Aug.	245	213	253	166	800	90	21	107	143	72	92
Sept.	183	184	232	84	23	223	120	148	142	92	108
Oct.	167	230	206	75	124	481	204	297	275	243	196
Nov.	173	164	165	137	160	312	175	272	267	464	332
Dec.	121	151	164	251	64	138	76	320	224	484	386
Total	1632	1928	1920	2221	2156	2780	1744	2266	2053	3600	2935

[1] *Reports of the Botanic Station, etc., Grenada, 1909–10*; average rainfall in nineteen years at Richmond Hill (1891–1909).

Reports of the Botanic Station, etc., Dominica, 1909–10; average rainfall in seventeen years at the Botanic Station (1893–1909).

Chevalier, *Le Cacaoyer dans l'Ouest africain*, pp. 27-29.

Report of the Agricultural Dept., Govt. of the Gold Coast, 1909; average rainfall in five years at Tarkwa Station (1904–1908).

Royal Botanical Gardens, Ceylon, Report for 1909; average rainfall of twenty-six years (1884–1909).

Wright, *Cocoa*, p. 15.

Rain Records of the Estates "Widodaren" (Djember) and "Getas" (Salatiga); the figures of "Widodaren" are averages of twenty-four years (1886–1909), the figures of "Getas" averages of ten years (1900–1909).

Nederlandsche Meteorologische Jaarboeken; average rainfall of twenty-four years at Paramaribo.

[2] 25·5 mm. = 1 in.

CHAPTER III

THE CHEMISTRY OF COCOA AND COCOA SOILS

In this chapter the different chemical data in regard to soil, plant and produce are stated as concisely as possible; but, as our knowledge of the various chemical questions involved is very imperfect, the reader will find that this compilation does not take the form of a rounded-off survey. Moreover, the figures as to the mineral constitution of soil and tree, though quite reliable, have very little practical value, for it is a mistake to imagine that a knowledge of these constituents will give indications of any value as to the manure required. As to the various and important constituents of rather complicated composition, which occur in the seed before and after fermentation, the methods applied by different analysts often give different results, owing to several of the methods employed being imperfect. Accordingly many of the figures about the amount of these constituents must be accepted with reserve.

The Soil

The question of the value of figures as to the chemical constituents of a soil in giving an impression of its qualities, especially its fertility, is discussed in Chapter VI. The conclusion there arrived at is that, speaking generally, their value is very small. At any rate, we are as yet unable to say, from a consideration of such figures, what constituents are present in

sufficient quantity and what constituents have to be supplied by manuring in order to obtain a maximum yield. It may be, however, that later on figures of this kind will gain in importance when our knowledge of this branch of agricultural chemistry has made more progress.

The following types of good cocoa soils of different countries were analysed by Professor Harrison (Demerara):—[1]

	Grenada.	St. Vincent.	Trinidad.	Surinam.	Nicaragua.
* Organic matter and combined water .	7·644	3·046	3·768	15·452	10·815
Phosphoric anhydride	0·082	0·114	0·084	0·139	0·293
Sulphuric anhydride .	0·118	0·055	traces	0·047	0·141
Chlorine . . .	traces	traces	nil	traces	0·007
Iron peroxide . .	9·085	9·574	3·910	5·952	7·000
Alumina . . .	13·628	8·889	2·038	16·076	4·717
Manganese oxide .	0·191	0·435	0·127	nil	0·163
Calcium oxide . .	1·335	4·981	0·356	0·495	2·250
Calcium carbonate .	0·236	nil	nil	nil	nil
Magnesium oxide .	1·367	2·418	0·495	1·071	0·217
Potassium oxide .	0·254	0·178	0·118	1·072	0·619
Sodium oxide . .	0·393	0·369	0·278	0·258	1·184
Insoluble silica and silicates . .	65·667	69·941	88·826	59·438	72·594
	100·000	100·000	100·000	100·000	100·000
* Containing nitrogen	0·309	0·205	0·100	0·306	0·228
Water retained by air-dried soil . .	8·500	8·100	1·800	11·000	8·000

Hart also gives several analyses of soils which are considered to be poor cocoa soils. Some of these, containing only 0·02 per cent of phosphoric anhydride, may possibly be deficient in phosphorus, but in others the analysis gives no explanation of their unsuitability. One example may be given—a soil from Grenada:—

[1] Quoted in Hart, *Cacao* (1911), pp. 188-189.

	Per cent.
* Organic matters and combined water	8·035
Phosphoric anhydride	0·120
Sulphuric anhydride	0·028
Chlorine	traces
Iron peroxide	9·642
Alumina	15·403
Manganese peroxide	0·083
Calcium oxide	0·196
Calcium carbonate	0·152
Magnesium oxide	0·160
Potassium oxide	0·097
Sodium oxide	0·360
Insoluble silica and silicates	65·723
	100·000
* Containing nitrogen	0·109

In this soil the proportions of phosphorus, potassium, calcium and nitrogen may all be said to be sufficient. The amount of phosphoric anhydride (0·120 per cent) is greater than that in seven out of ten soils mentioned as good cocoa soils, the proportions in these seven cases varying between 0·044 per cent and 0·114 per cent; the amount of potassium oxide (0·097 per cent) is not high, but is nearly as high as in a good Trinidad soil mentioned (0·118 per cent); the amount of calcium as oxide (0·196 per cent) and as carbonate (0·152 per cent) is rather high, while nitrogen (0·109 per cent) is present to a higher degree than in some good cocoa soils (two Trinidad soils mentioned as good contained 0·100 per cent and 0·107 per cent). In the poor soil from Grenada, already mentioned, it may be that a great portion of the phosphorus or the potassium is present in an unavailable form, but the figures of the analysis do not furnish this information.

In various handbooks we find the statement that "the most important point chemically is that the soil should contain an ample supply of available potash, a fair supply of nitrogen and a medium one of phosphoric anhydride and of lime."[1] This assertion may be true

[1] Hart, *Cacao* (1911), p. 190; other authors express similar opinions.

—at any rate nobody is able to contradict it—but, on the other hand, nobody can prove it to be correct as long as we are unable to tell by analysis how much *available* potash, nitrogen, phosphorus, and lime is present. While this continues to be the case, such statements, as well as the figures of chemical analyses of soils, are from a practical point of view worthless.

Wright[1] gives a concise review of the quantities of the principal elements present in good cocoa soils of different countries. Some examples may be of interest[2]:—

	Potassium oxide.	Phosphoric anhydride.	Nitrogen.	Calcium oxide.	Calcium carbonate.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Guadeloupe . .	0·111	0·124	0·205	0·173	?
Martinique . .	0·111	0·243	0·211	1·300	?
St. Vincent . .	0·178	0·114	0·205	4·981	nil
Grenada . . .	0·254	0·082	0·309	1·335	0·236
Trinidad . . .	0·118	0·084	0·100	0·356	nil
Do. . . .	0·267	0·117	0·140	0·124	?
Venezuela . .	0·392	0·147	0·071	0·594	nil
Surinam . . .	1·072	0·139	0·306	0·495	nil
Nicaragua . .	0·619	0·293	0·228	2·250	nil
Réunion . . .	0·580	0·400	0·300	0·350	?
Ceylon . .	0·03 to 0·4	traces to 0·1	0·1 t 0·5	0·02 to 0·35	?

It is worth mentioning that the cocoa tree can stand a good amount of salt (sodium chloride) in the soil. In Surinam it is well known that cocoa can be cultivated successfully even on soils which are continually impregnated by brackish river water. This condition prevails, for instance, on the cocoa fields of many small proprietors, situated along the Surinam and Commewyne rivers, where the brackish water of the rivers is only imperfectly retained by a primitive embankment and a primitive sluice, through which at high tide

[1] Wright devotes considerable space (pp. 141-150) to the composition of soils.

[2] The figures for Guadeloupe are from Boname, and for Martinique from Rouf, and are given here as quoted by Wright; the figures for Ceylon are also taken from Wright; the other figures are all from analyses by Harrison, as quoted by Hart.

the water oozes easily. Also, in San Thomé, near San Miguel, there are plantations which are often flooded at high tide and where the soil doubtless contains a relatively large amount of salt.

In these cases the plant has become accustomed to this condition, having been grown on this salt-containing soil from the beginning. If, however, this is not the case, cocoa is very sensible to salt or brackish water. On well-drained and well-embanked plantations in Surinam, where the soil does not contain chloride of sodium or only traces, cocoa is soon injured when brackish water flows into the plantation through a breach in the embankment or otherwise.

As regards physical composition, it will be obvious that the different cocoa soils show in this respect great differences, and the plant cannot be said to prefer the stony soil of San Thomé, the heavy alluvial clay of Surinam or the volcanic, porous soil of the Antilles and Java.

Constituents of the Tree and Fruits

Marcano and Cockrane went to the trouble of calculating the weight of different parts of the trees planted on one hectare and the constituents of those parts. The object of this calculation was to ascertain what quantity of the different mineral constituents is taken from the soil, in order to obtain an idea of the amount of the different elements which should be restored by manuring. Though this aim can never be attained by such a calculation (see the discussion on the point in Chapter VI.), some of the figures arrived at by these investigators are interesting enough to be quoted.[1]

Marcano first calculated the weight of the different parts of the tree (stem, branches, leaves, seeds and husks) on one hectare, but his figures are hardly important

[1] Marcano's figures are taken from Jumelle, *Le Cacaoyer*, pp. 88-91, Cockrane's from Wright, *Cocoa*, p. 152.

enough to be detailed.[1] The analyses of the different parts is of more interest. The figures of Cockrane are given in a simplified form in the following table, but they must be looked upon as only approximate :—

		Stem and branches.	Twigs and leaves.	Seeds.	Fruit husks.
Mineral constituents.	Silica . . .	0·5	28·0	2·0	2·5
	Lime	29·5	26·0	7·0	9·0
	Magnesia . .	10·0	6·0	17·0	7·0
	Potash . . .	29·0	19·0	36·0	49·0
	Phosphoric acid	4·0	3·0	31·0	4·5
Other constituents . .		27·0	18·0	7·0	28·0
		100·0	100·0	100·0	100·0

It is rather striking that the amount of potash, especially in the fruits (seeds and husks), should be so large.

The following table shows the total amounts of the different elements contained in the trees per acre, and the quantity of each which is found each year in the crop :—

	Quantity contained in the trees.		Quantity annually contained in the crop.	
	According to Marcano (Venezuela).	According to Cockrane (Ceylon).	Seeds, according to Harrison (Guiana).	Fruit husks, according to Harrison (Guiana).
	lbs.	lbs.	lbs.	lbs.
Nitrogen . . .	201	123	7–12	9–12
Lime . . .	400	313	0·5	2
Magnesia . .	111	86	2–3	3–5
Potash . . .	251	277	3–6	22
Phosphoric acid	95	42	4–5	4–6

[1] Besides, I fear that these figures are not reliable. According to Marcano, 0·7 hectare produces 319·354 kilograms of dry-substance seeds (including seed coats) and 457·076 kilograms of husks, or 456 kilograms of seeds and 653 kilograms of husks per hectare. One hectare, however, produces about 550 kilograms of dry cocoa ; 25 to 40 fruits are necessary for 1 kilogram of cocoa,

It must not be forgotten, however, that the amounts of the different elements contained in the trees and in the crop may vary considerably, according to the soil, the bearing power of the trees and the variety cultivated. Moreover, the figures are of no importance at all in the direction of indicating the kind of manure required for cocoa soils. They could even lead us astray. For instance, the large amount of lime contained in the cocoa tree might lead to the conclusion that a satisfactory yield can be obtained only on soils rich in lime, or that the yield can be increased by an application of lime to soils which are poor in calcium. But this is by no means always the case; in Surinam the soil is poor in lime, but still it gives high yields of cocoa, and manuring with lime, though often tried, has never met with any success.

The relative weights of the different parts of the fruits were measured by Harrison as follows:—

	"Calabacillo."	"Forastero."
	Per cent.	Per cent.
Husk . . .	80·59	89·87
Seeds with pulp . .	19·41	10·13
	100·00	100·00

The absolute weight was not given.

A few hundred pods of a typical Surinam Amelonado type were weighed by the present writer, and the average was found to be as follows:—

Husk	431 grams	=	77 per cent.
Seeds with pulp . .	128 „	=	23 „
Whole fruit . .	559 grams	=	100 per cent.

say 30 fruits. One hectare would therefore produce 16,500 fruits. One fruit contains about 100 grams of seeds (about 25 grams dry substance) and about 400 grams husks (about 68 grams dry substance). This amounts to 412½ kilograms of seeds and 1022 kilograms of husks (both dry substance) per hectare. I agree that estimates may differ a little, and Marcano's figure of about 456 kilograms of seeds corresponds fairly well with my figure of 412½ kilograms. But the figure of 653 kilograms of husks is certainly too low, if 456 kilograms of seeds are produced.

Speaking generally, the finer types of Forastero show a smaller percentage in weight of seeds and pulp, while the coarser varieties have generally a larger amount of pulp, so that the weight of seeds with pulp represents a larger percentage of the weight of the whole fruit.

With Criollo it is again different. Java Criollo was found to yield as follows :—

Husk	370 grams	= 79 per cent.
Seeds with pulp . .	97 „	= 21 „
Whole fruit. .	467 grams	= 100 per cent.

As regards the relative weight of the different substances of the fresh seeds, the following figures were obtained by Harrison :—

	"Calabacillo."	"Forastero" (probably Angoleta or Cundeamor).
	Per cent.	Per cent.
Pulp	39	42
Cuticles of beans. .	9	5
Kernels of beans. .	52	53
	100	100

Probably more numerous measurements would confirm the conclusion that the coarser varieties of Forastero (as the "Calabacillo" of Harrison) have relatively heavier cuticles than the finer ones (as the "Forastero" of Harrison); but the quantity of pulp is generally greater in the coarser varieties—a fact which leads again to the warning not to consider the above results as standard figures.

Numerous analyses have been made of the fruits of different varieties. Harrison examined separately the kernels of the beans, the cuticles and pulp, and the husks; this was done with the fruits of a "Calabacillo" and with fruits of a "Forastero" (probably Angoleta or Cundeamor), both types from Demerara. In con-

sidering these analyses, it must not be forgotten that they are not to be considered as giving the average constitution of the Calabacillo type and of the Cundeamor or Angoleta type. Probably the fruits of different countries are rather different as regards constitution, and it may be, for instance, that the Amelonado type from Arriba (Ecuador), the Surinam Amelonado and the San Thomé Amelonado show greater differences than the "Calabacillo" and the "Forastero" mentioned here. But no data are available for a concise review of the average constitution of the different types of different countries, and we shall therefore only give the results arrived at by an authority such as Professor Harrison :—

[Table

	Kernels of beans.		Cuticles and pulp.		Fruit husks.	
	"Calabacillo" type (Demerara).	"Forastero" type (Demerara).	"Calabacillo" type (Demerara).	"Forastero" type (Demerara).	"Calabacillo" type (Demerara).	"Forastero" type (Demerara).
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Water	37·6	36·6	87·6	83·0	82·9	84·5
Albuminoids	6·7	4·8	0·9	0·3	0·8	1·0
Theobromine	1·4	0·8	0·2	0·05	0·1	0·1
Caffeine	0·1	·2	0·3	nil	nil	nil
Indeterminate nitrogenous matter	0·5	2·8	traces	0·05	0·2	0·0
Fat	29·3	30·6	0·4	0·4	0·1	0·1
Glucose	1·0	0·9	0·7	0·1	0·1	nil
Saccharose (sugar)	traces	0·2	0·1	1·0	traces	1·0
Starch	3·8	6·0	0·9	1·3	0·5	0·4
Astringent matters	5·0	4·9	0·4	0·1	2·2	0·2
Pectin, etc.	0·7	1·4	0·8	1·1	1·7	1·0
Cocoa-red	3·0	1·5	0·5	0·7	0·7	0·6
Digestible fibre	5·1	2·8	4·7	6·6	5·4	4·0
Woody fibre	3·0	3·5	1·3	2·5	3·3	5·3
Tartaric acid, free	0·1	0·0	0·4	0·6	0·3	0·3
Acetic acid, free	nil	nil	nil	traces	0·1	0·1
Tartaric acid, combined	0·5	0·5	0·3	0·35	0·8	0·6
Iron peroxide	0·03	0·03	0·00	0·01	0·01	0·01
Magnesia	0·32	0·45	0·11	0·07	0·10	0·10
Lime	0·05	0·11	0·05	0·03	0·04	0·04
Potash	0·84	0·64	0·19	0·25	0·45	0·36
Soda (Natrium)	0·24	0·07	0·04	0·01	0·04	0·07
Silica	0·02	0·02	0·00	0·00	0·01	0·01
Sulphuric anhydride	0·08	0·05	0·02	0·03	0·04	0·03
Phosphoric anhydride	0·75	1·05	0·12	0·10	0·08	0·10
Chlorine	0·02	0·03	0·02	0·06	0·03	0·03

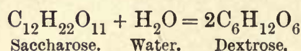
These figures show the low percentage of mineral constituents in the seeds, and this makes the total quantity of such constituents in the yearly crop comparatively small.

Interesting chemical differences between the two cocoa types investigated by Professor Harrison cannot be deduced from the figures just given; but it is an interesting fact that many substances contained in the kernels are also contained in the cuticles and pulp, though in smaller quantities. This is especially the case with theobromine, caffeine, fat, astringent matters and cocoa-red, and is the explanation why the cuticles are used as a substitute for, and as a means of adulterating, the kernels.

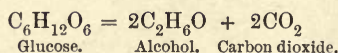
Changes during Fermentation

In Chapter VII. the cause and the principal effects of fermentation are discussed. Some of the chemical processes involved may be dealt with here.

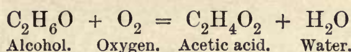
Fermentation is always started by the action of a yeast organism which changes the sugar of the pulp into alcohol and carbonic acid. The sugar contained in the pulp is principally ordinary cane-sugar or saccharose ($C_{12}H_{22}O_{11}$). This is first split up by the invertase of the yeast into dextrose (the sort of sugar contained in grapes and other fruits), according to the equation :—



This process is closely followed by the splitting up of the dextrose into alcohol and carbon dioxide, according to the equation :—



The alcohol is again oxidised into acetic acid by a second organism, a bacterium, the chemical process being indicated by the equation :—



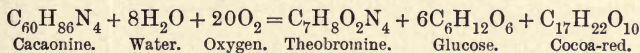
$$C_2H_6O + O_2 = C_2H_4O_2 + H_2O$$

Alcohol. Oxygen. Acetic acid. Water.

This process takes place together with the development of heat. In the fermenting-boxes the temperature is usually allowed to rise to about 45° or 50° C. (113° or 122° F.). This temperature kills the protoplasm of the kernel, and accordingly the different substances contained in the seed are allowed to act upon each other; a direct and important influence of the acetic acid upon the substance in the seed has not been demonstrated. Many of the changes and chemical reactions in the seed during fermenting and drying are still unknown. A large and interesting field of investigation for the analyst is here unexplored.

Three of the important chemical reactions, which have been more or less carefully studied, may now be described:—

(1) *The formation of cocoa-red and theobromine.*—The manner in which these substances originate is not yet properly determined. It may be that it takes place by oxidation of a glucosid, cacaonine,[1] but several investigators (among them Ultee and van Dorssen) deny or doubt the presence of a glucosid in the cocoa seeds. Others accept the presence of the glucosid cacaonine, which they presume to be split up and at the same time combined with oxygen under the influence of an enzyme. The result of this reaction would be theobromine and cocoa-red, according to the equation:—



$$C_{60}H_{86}N_4 + 8H_2O + 20O_2 = C_7H_8O_2N_4 + 6C_6H_{12}O_6 + C_{17}H_{22}O_{10}$$

Cacaonine. Water. Oxygen. Theobromine. Glucose. Cocoa-red.

The theobromine is important, as it is the principal substance which gives the cocoa its tonic properties. The cocoa-red causes the reddish colour of the prepared bean; it was formerly regarded as important as giving the cocoa its peculiar flavour. This however is not the case, as cocoa-red is tasteless and flavourless.

[1] Sack, "Bydragen tot de kennis van het fermenteeren der cacao" (*Bulletin No. 10 of the Dept. of Agriculture, Surinam*).

(2) *The formation of the essential oil.*—The fact that fermented and dried cocoa yields a peculiar and fragrant smell when boiled points to the fact that it contains an essential oil. This oil can be obtained by distilling the cured cocoa by means of water vapour.

(3) *The disappearance by oxidation of a part of the bitter-tasting or astringent matter.*—It has been accepted by most authors that the cause of the bitter taste of the fresh bean, which to a great extent disappears during fermentation and drying, is caused by the presence of a tannin substance. The investigations of Ultee and van Dorssen,[1] however, have demonstrated that this bitter-tasting substance is not a tannin, for it lacks the characteristic property of the tannin substances to precipitate albuminoids and alkaloids. These investigators accept the following formula for this bitter-tasting substance, which they call *cacaool*: $C_{16}H_{16}O_6 . C_8H_{10}N_4 . 5H_2O$. By oxidation the cacaool changes into a coloured substance, which Ultee and van Dorssen presume to be identical with the cocoa-red.

Professor Harrison analysed the beans before and after fermentation, but though his figures are interesting, they do not contribute essentially to a better understanding of the processes of fermentation. The analysis of the kernels, which are from a commercial point of view much more important than the cuticles, gave the following results :—[2]

---

[1] Ultee and van Dorssen, "Over de zoogenaamde looistof der cacao" (*Cultuurgids*, Part ii., 1909).
[2] Hart, *Cacao* (1911), pp. 194-195, 206-207.

[TABLE

	Guiana Forastero.		Loss.
	Kernel of the fresh bean.	Kernel of the fermented and cured bean.	
Water	36·6	3·7	32·9
Albuminoids . . .	4·8	3·6	1·2
Indeterminate nitrogenous matters	2·8	1·5	...
Theobromine . . .	0·8*	0·9	*
Caffeine	0·2*	0·2	*
Fat	30·6	30·6	...
Glucose	0·2	0·3	...
Sucrose	0·9	nil	0·9
Starch	6·0	4·0	2·0
Astringent matters . .	4·9	2·0	2·9
Pectin	1·4	0·5	...
Cocoa-red	1·5*	1·7	*
Digestible fibre . . .	2·8	3·4	...
Woody fibre . . .	3·5	3·6	...
Tartaric acid, free . .	0·0	0·2	...
Acetic acid, free . . .	nil	0·4	...
Tartaric acid, combined .	0·5	0·4	...
Mineral matter . . .	2·44	1·78	...
Total . .	100·0	58·7	...

These figures need explanation and, to a certain extent, correction. As has already been explained, neither cocoa-red nor theobromine occur as such in the fresh seed, and the fact that they appear during analysis must be due to the splitting up of the compound in which they are present, whether this is cacaonine or some other substance. In reality there has thus been a loss of the compound mentioned (cacaonine ?) and a gain of 0·9 theobromine, about 1·6 cocoa-red and probably 0·2 caffeine in each 100 parts of fresh seed. For this reason the figures of these three substances have been indicated with an asterisk (*).

The following facts which result from Professor Harrison's figures are worthy of note. A hundred parts, by weight, of kernel of the fresh bean are reduced

during curing to about 58·7 parts, while 41·3 parts are lost. By far the greater portion of this loss is water (32·9 parts); a small proportion goes in albuminoids (1·2); 2 parts of starch are lost, out of 6 parts; and 2·9 parts of astringent matters (cacaool) disappear out of 4·9. The rest (1·4 parts) is lost in other substances (fibre, pectin, indeterminate nitrogenous matter, etc.). The sugar of the kernel is doubtless lost mainly as acetic acid (like the sugar of the pulp), and the starch also, after conversion into sugar. The differences in the mineral substances are of no great importance.

Chemistry of the Marketable Bean

The relation between the weights of cuticle and kernel in the marketable bean is about 1 to 5, the weight of the cuticle being about 16 per cent of the weight of the seed. But there is much variation, and Zipperer[1] found the amount of cuticles of a few different sorts to be as follows: Caracas 20 per cent, Trinidad 14 per cent, Puerto Cabello 15 per cent, Soconusco 19 per cent.

A short review may now be given of the chemical constitution of the marketable bean, which has been the subject of investigation by several analysts. Only the main facts, however, and the analyses of the more recent investigators, are of importance for the purposes of this handbook.

The analysis of Forastero kernels made by Professor Harrison has already been given (see p. 33). It is convenient to repeat his figures here in the form of percentages, and to compare them with a combination of the figures found by Zipperer:—

[1] *Die Schokoladefabrikation*, p. 74.

[Table

	Guiana Forastero (Harrison).	Different Varieties (Zipperer).
	Per cent.	Per cent.
Water	6·3	7·0– 8·0
Fat	52·1	50·0–54·0
Albuminoids	6·1	12·0–21·0
Amylum	6·8	6·0–11·0
Theobromine	1·7	0·3– 0·8
Astringent matter (cacaool ?) and cocoa-red	6·3	10·0–14·0
Mineral matter	1·8	3·0– 4·0
Other substances (principally cellulose)	18·9	2·0– 3·0
	100·0	100·0

It is obvious that in some respects the figures of Harrison and Zipperer are widely different. Zipperer, for instance, found in seven sorts of different origin never less than 12 per cent, and sometimes as much as 21 per cent, of albuminoid substances, while Harrison found only 6 per cent. Zipperer never found more than 0·8 per cent of theobromine, and sometimes as little as 0·3 per cent; Harrison found as much as 1·7 per cent.[1] In the same way the differences in the amount of astringent matter, cocoa-red and mineral matter are important. In reality there is agreement only in regard to the amount of fat and the amount of starch. The differences must probably be attributed to the use of different methods of analysis. The imperfection of many of these methods has already been mentioned, especially those for the determining of theobromine, caffeine, astringent matters and cocoa-red.

Cocoa-fat or Cocoa-butter.—One half or even a little more of the total weight of the marketable bean consists of a fat, generally called cocoa-butter. This substance has an important commercial value, and is used in the chocolate industry as well as in the making of perfumes, and for pharmaceutical purposes.

It is a yellowish-white, rather firm fat with an

[1] As regards theobromine, Zipperer's figures are doubtless too low, and Harrison's figure may be correct.

agreeable taste and smell. Chemically it is a mixture of glycerids of different fatty acids, and consists principally of stearin, palmitin, laurin and also the glycerid of arachin-acid.

The qualities of this substance vary according to the manner in which it is obtained—*i.e.* whether by extraction (by means of ether or other solvent fluids) or by pressure. The specific gravity of the extracted butter is about 0·95 to 0·99; of the pressed butter, 0·85. The melting-point of the latter, when kept for some time, is 34° to 35° C.; the melting-point of the former is slightly lower. The melting-point of unadulterated cocoa-butter is never below 32° and never above 35°.

The fat is contained not only in the kernels but also in the cuticles, from which it is also obtained by extraction and comes to the market as a second-quality cocoa-butter.

Theobromine.—The methods formerly applied by analysts for determining the amount of theobromine were all more or less imperfect, and accordingly widely varying figures were obtained. These methods were critically reviewed by Dekker,[1] who invented a new and reliable method. The complete unreliability of the results obtained by the old methods may be seen from the figures obtained by four analysts, the amount of theobromine contained in one sample of cocoa: 0·71 per cent (method of Kunze), 0·81 per cent (method of Zipperer), 2·00 per cent (method of Beckurts), 2·78 per cent (method of Bell). It turned out, however, that the real quantity (by the Dekker method) amounted to 1·69–1·73 per cent. By the methods of Kunze and Zipperer part of the theobromine was destroyed, and therefore the figures obtained were too low; by the methods of Beckurts and Bell the theobromine obtained was not pure, and accordingly the figures obtained were too high.

[1] *Über einige Bestandteile des Cacao und ihre Bestimming*: Inaugural-dissertation (Amsterdam: de Bussy, 1902).

Opinions differ greatly as to the way in which theobromine occurs in the fresh seed, and this point is not yet wholly elucidated. It may be that it occurs combined with glucose in the form of a glucosid (though this is not probable), or that it is combined with the bitter substance cacaool, as Ultee found was the case with the closely related caffeine. At any rate, in the fresh seed it is not present in a free condition, but is set free during fermentation and drying.

The chemical formula is $C_5N_4H_2O_2\ (CH_3)_2$.

Theobromine is responsible for the stimulating effect of cocoa, as the caffeine is in coffee and the thein in tea.

It occurs not only in the kernels of the seeds but in the cuticles, though only to a small amount, and finally also in the leaves. The quantity found by Dekker in the young leaves of Java cocoa amounted to no less than 0·5 per cent, in the older leaves to 0·3 per cent, while full-grown leaves were almost free from the alkaloid.

Caffeine, a substance closely related to theobromine (formula: $C_5N_4HO_2\ (CH_3)_3$), is of much less importance in the cocoa plant. According to Zipperer, the quantity present in marketable cocoa is about 0·05 to 0·36 per cent; in Guiana cocoa (fermented and cured) Harrison found in the kernels 0·06 to 0·41 per cent, in the cuticles 0·24 to 0·54 per cent. The methods used and the figures obtained need, however, to be revised.

Cacaool and *cacaonine* in the fresh seeds and *cocoa-red* in the fermented and cured seed (better: in the dead seed) have already been mentioned.

It may be added, finally, that Trojanowski put forward a method of distinguishing the different kinds of marketable cocoa by means of chemical reactions. His determining table, which is to be found in various handbooks,[1] is, however, quite unreliable.

[1] Jumelle, *Le Cacaoyer*, p. 57, etc.

CHAPTER IV

THE BOTANICAL CHARACTERISTICS OF THE COCOA PLANT

THE plant which produces the commercial cocoa, and which has received from Linnæus the name of *Theobroma cacao*, L., belongs to the family of STERCULIACEAE.

This family of plants is recognised by the following characteristics: the five sepals are not separate but grown together at their base; also the stamina are grown together at their base, to a short tube; the outer circle stands opposite the petals, and of this circle of five stamina, each stamen is often doubled or tripled; the anthers are turned to the outside; the inner circle of stamina stands opposite the sepals, these stamina, however, being so-called staminodes, which means that they do not bear anthers and do not produce pollen; the leaves are simple (not composed) and bear stipules which soon fall off.

The family of STERCULIACEAE is closely related to the family of MALVACEAE, to which belongs the common mallow, which has the stamina grown together to a tube, and to the family of TILIACEAE, to which belongs the common linden tree. Besides the cocoa (*Theobroma cacao*) it contains several other species of *Theobroma*, and the kola tree (*Cola acuminata*).

The genus *Theobroma* is characterised by the peculiar shape of the petals, which are concave or cup-shaped at the base, narrowing to the top, and sometimes enlarged at the end as a spoon or spatule (see Fig. 14).

To this genus *Theobroma* belong, first, the two species which produce the commercial cocoa, namely, *Theobroma cacao* and *Theobroma pentagona*, which is sometimes considered as a variety of the former; then some twelve other more or less well-known and well-described species, which do not produce a marketable article and are not cultivated; and, finally, some four other species, which are very imperfectly known.

Schumann[1] has made a thorough study of the systematic characteristics of these different species of the genus *Theobroma*, and has composed a dichotomic table, by which the fourteen more or less well-described species can be determined. This table is given here, slightly modified and reduced so as to be also intelligible to the non-botanist:—

Leaves palmate; stamina with six anthers (sub-species *Herrania*).

Margin of the leaflets dentate :

Flowers purplish-yellow . .	*T. Mariae*, Gond.
Flowers carmine ; the hairy fruits have ten prominent ridges .	*T. pulcherrima*, Gond.
Flowers white with purplish veins; glabrous fruits with ten prominent ridges . . .	*T. balaënsis*, Preuss.
Flowers white ; hairy fruits with ten prominent ridges . .	*T. albiflora*, Gond.
Margin of the leaflets lobate . .	*T. lacinifolia*, Gond.

Leaves not lobed nor divided, stamina with four anthers; *limbs of the petals two or three times as long as the cup-shaped basal part* (sub-species *Eutheobroma*).

Limb of the petal spoon-shaped :

Fruit with ten sides or ridges .	*T. cacao*, L.
Fruit with five sides and five prominent ridges . . .	*T. pentagona*, Bern.
Limb of the petal small, disk-shaped	*T. bicolor*, Humb. et Bonpl.

[1] Schumann, *Flora brasiliensis*: Sterculiaceae. See also: Jumelle, *Le Cacaoyer*, pp. 10-38; De Wildeman, *Les Plantes tropicales de grande culture*, pp. 83-98.

Leaves integer (not lobed nor divided), stamina with six anthers (sub-species *Bubroma*).

- Staminodes awl-shaped:
  - Foot-stalk of the leaves 1·5 to 6 cm. long; leaves reaching a length of 25 cm. and a breadth of 10 cm.; fruit large . . . *T. speciosa*, Spreng.
  - Foot-stalk of the leaves short, not longer than 1 cm.; leaves long, 10–17 cm., and broad, 5 cm.; fruit small . . . . . *T. microcarpa*, Mart.
- Staminodes petaloid:
  - Staminodes pointed
    - Staminodes abruptly pointed . *T. grandiflora*, K. Schum.
    - Staminodes with a gradually diminishing point, curled . *T. subincana*, Mart.
  - Staminodes blunt
    - Fruit with five sides, very warty, irregularly lobate, leaves wedge-shaped at the base . *T. angustifolia*, D. C.
    - Fruit when ripe without marked sides, smooth; leaves round or slightly heart-shaped at the base . . . . *T. simiarum*, Donn.-Smith.

In addition the following four very imperfectly known species may be mentioned: *Theobroma glauca*, Karsten (which perhaps may be the same as *T. subincana* above mentioned), *T. sylvestris*, Mart., *T. Martii*, K. Schum., and *T. alba*, Bern.

The Two Cultivated Species

Theobroma cacao, L.

General appearance.—The cocoa tree never grows very high. In three years it reaches, generally speaking, a height of from 6 to 10 feet, and in ten or twelve years, when full grown, a height of about 13 to 23 feet. In the alluvial zone of Surinam, along the sea-coast, on heavy clay soil, the trees seldom grow higher than 20

feet, and even this height is rarely attained; in the hilly inlands, on a lighter soil, where the water keeps a lower level, they get a little bigger, and the largest trees here reach a height of 26 feet. This height is also attained in Java.

According to Hart[1] the average height in Trinidad is 15 to 25 feet, but in some countries he observed trees of 30 and even 40 feet in height. In Grenada, Tobago and St. Vincent the trees seem to be smaller than in Trinidad; in Grenada this may be partly due to the absence of shade trees.

When normally developed, the full-grown tree makes its main ramification at a height of about 3 to 5 feet. The stem ramificates into three, four, or five main branches (rarely into less than three or more than five), which soon make side branches and form a foliar system which, when it develops quite freely, may attain an average diameter of 20 to 26 feet. The foliar system is very dense.

Sometimes one of the main branches—or the stem just under the ramification—makes a "sucker" or "watershoot," which grows quickly and behaves like a continuation of the main stem, ramificating again on reaching a certain height, so that in this way the tree may form two systems of branches above each other.

The two varieties Forastero and Criollo behave differently as regards their method of ramification and also in some other respects regarding the vegetative parts. These differences are described in Chapter V.

Watershoots sometimes develop in large numbers on vigorous specimens, especially at the foot of the stem, but also along the stem and even on the branches.

The leaves, when just unfolded, have a pale rosy hue and are soft and limp; soon their colour becomes light green and they take on a leathery appearance, the colour gradually growing darker. Trees which produce red fruits have darker coloured leaves than those with yellow fruits; thus it can be told whether the

[1] Hart, *Cacao* (1911), p. 1.

tree belongs to a red or a yellow variety, even when there are no fruits on it.

The root.—The root-system develops in very different ways according to the soil in which it grows. In a loose soil, in which the level of the water never or very seldom gets high, for instance on the slopes of

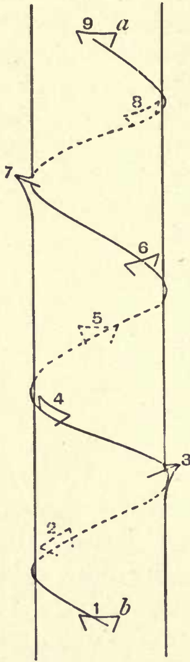


FIG. 4.—Diagram showing the position of the leaves on the stem of a young cocoa plant.

A spiral has been drawn ascending the stem and passing through the successive scars which mark the position of the leaves from 1 to 9. The dotted lines and scars represent those on the other side of the stem. It will be noticed that scars 1 and 9 are vertically above each other.

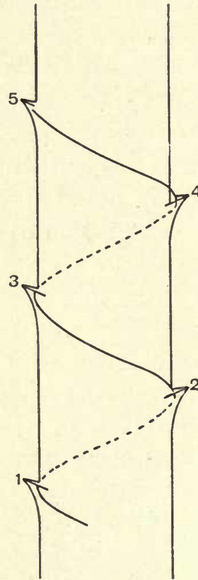


FIG. 5.—Diagram showing the position of the leaves on the branches of the cocoa plant.

It will be noticed that the scars 1, 3, 5, etc., are vertically above each other, as also the scars 2, 4, 6, etc.

the mountains, a long tap-root is formed and the side-roots penetrate deep into the soil. In a stiff clay soil, however, in which the level of the water is high during a part of the year—as for instance in most of

the Surinam cocoa plantations—no tap-root can be detected on trees of a certain age, and the side-roots are all developed near the surface.

The branches and leaves.—The young plant makes a little stem, which grows straight upwards till it has attained a height of about 3 or 5 feet. The leaves on the stem are arranged according to the formula $\frac{3}{8}$.

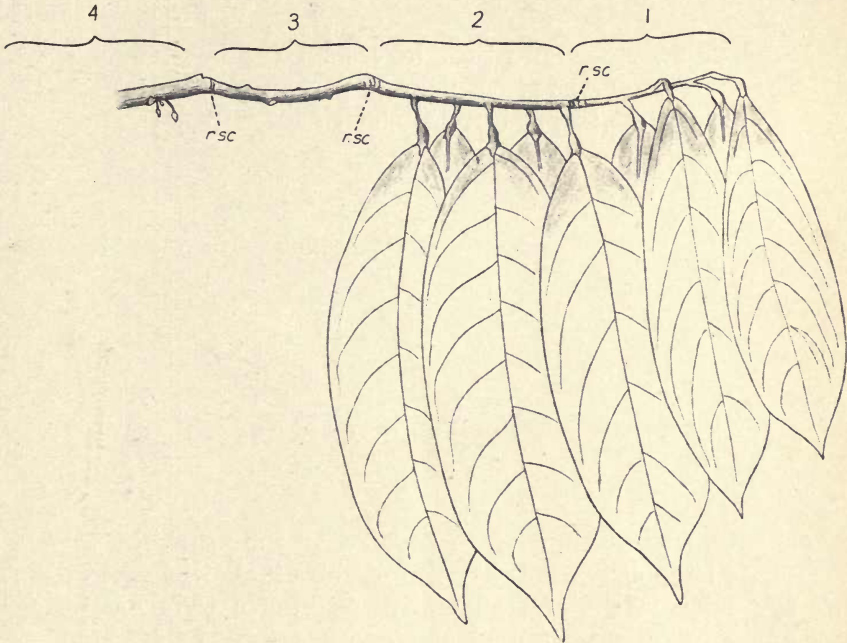


Fig. 6.—A cocoa twig with four shoots.

This means that if one looks at two leaves (called *a* and *b*) which are found vertically above each other, and traces a spiral along the stem from leaf *a* to the following leaf and so on till leaf *b*, this spiral runs three times all round the stem and passes 9 leaves (inclusive of *a* and *b*), so that if leaf *a* is No. 1, leaf *b* is No. 9. The illustration will make this clear (Fig. 4).

The main branches and their side branches have

another arrangement of the leaves, namely, according to the formula $\frac{1}{2}$. This means that each leaf is always situated on the other side of the branch from that on which are found the previous leaf and the next one, the leaves being thus placed on the branches in two rows, standing alternately on the left and on the right side (Figs. 5, 6). Moreover, the leaves on the branches are always placed more or less in a horizontal plane.

The arrangement of the leaves on the watershoot is the same as on the stem, namely $\frac{3}{8}$ (Fig. 4).

Like most tropical trees, the cocoa puts forth new

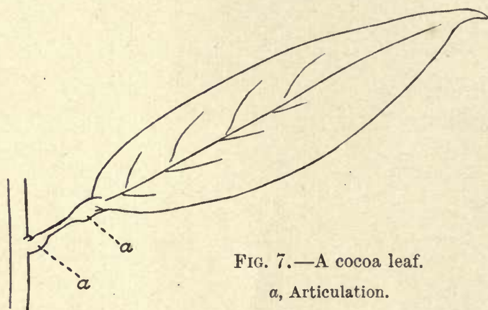


FIG. 7.—A cocoa leaf.
a, Articulation.

shoots several times in the course of the year, but the new shoots are not always formed on all the twigs or on the same twigs, and generally speaking a twig has on an average only two shoots every year. Each shoot ends its growth by the formation of a terminal bud, which is enclosed in its scales. When this bud again develops into a new shoot, the scales fall off and leave at the base of the young shoot a number of closely standing scars, which form together the so-called "ring-scar," the boundary between the two shoots.

In full-grown trees of normal growth generally the *third-eldest* shoots drop their leaves (Fig. 6), but on young trees the leaves remain longer.

A peculiarity of the cocoa leaf is the presence of two articulations at the base and at the top of the leaf-

stalk (Fig. 7). These articulations enable the leaves to make movements in different directions, in order that their upper sides may always be turned towards the side from where the strongest light comes. A simple experiment shows this clearly. If a cocoa plant is placed in a box closed on all sides except one, which is facing the light, after six to twelve hours all

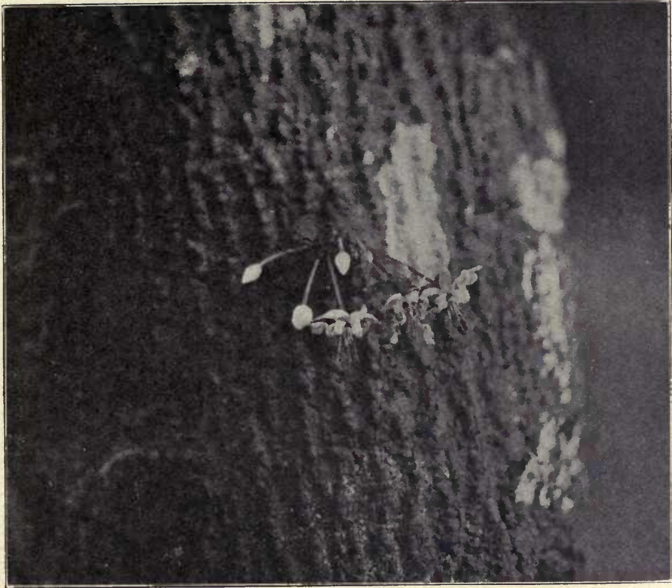


FIG. 8.—Flowers on the stem of a cocoa tree.
The flowers all arise from the same "cushion."

the leaves will have turned with their upper sides facing the light. This influence exerted by the rays of light is called *heliotropism.*

A further characteristic of the just unfolded leaf is the presence of two small leaflets near the base of the leaf-stalk. These leaflets, called *stipules*, fall off very soon, generally even before the leaf is full-grown. It is questionable if these stipules are of any use to the plant; it may be, however, that they protect the bud against the rays of the sun or

against droughts or other noxious influences when the shoot is young.[1]

The flower.—In most handbooks hardly anything is said about the flowers of the cocoa plant, save that

FIG. 9.—Flowers and fruits on the main branches of a cocoa tree.

the cocoa tree is "cauliflorous." This means nothing more than that the flowers develop on the stem (Fig. 8)

[1] Readers who wish to know more about stipules may be referred to Lord Avebury's interesting little book, *On Buds and Stipules.* It mainly deals, however, with trees of the temperate zone.

and the older parts of the branches (Fig. 9), the young twigs bearing no blossoms. This fact, however, is neither peculiar nor essential, for closely related species differ from the cocoa plant in this respect. Take the case of *Theobroma bicolor*, which grows in Central America; this species has no importance from an industrial point of view, but the way in which it forms its blossoms helps us to understand the flowering of the

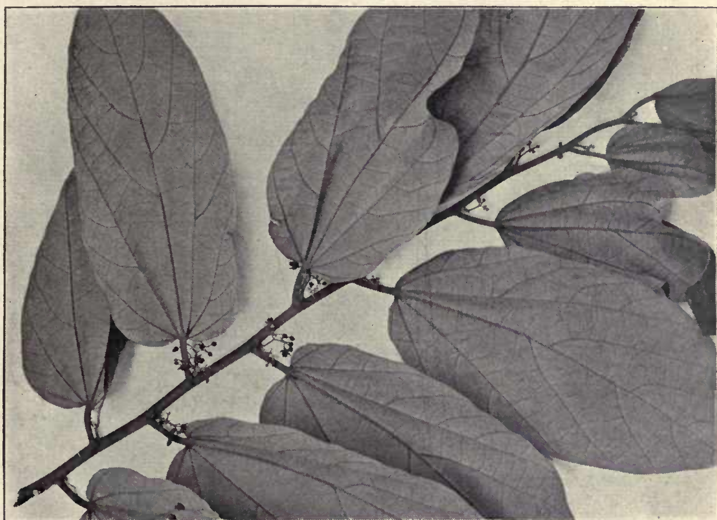


FIG. 10.—Young twig of *Theobroma bicolor*, showing the arrangement of the blossoms in the axils of the young leaves.

cocoa plant. Like the ordinary cocoa plant, *Theobroma bicolor* puts forth new shoots several times each year, but these shoots bear the flowers in the axils of the young leaves (Fig. 10). The flowers themselves are arranged in clusters which show a central (or primary) axis which bifurcates into two lateral shoots (secondary axis) of nearly equal strength, which generally bifurcate again, and so on. This sort of flower cluster is called in botany a *dichasium* (Fig. 11).

In the ordinary cocoa plant (*Theobroma cacao*), the flowers are formed in the same way, but the appearance

and the arrangement of the clusters is not so clear, and this for two reasons :—

(1) In the ordinary cocoa plant, the flower-cluster is not so clearly a dichasium. The axes, the primary as well as the secondary, tertiary, etc., are generally so short that the whole is no longer to be recognised as a dichasium, and the flowers appear to arise irregularly from a common axis, or from the same spot on the branch or stem, close together but not even on a common axis. Fig. 12 illustrates this. In A the dichasium is clearly recognisable,

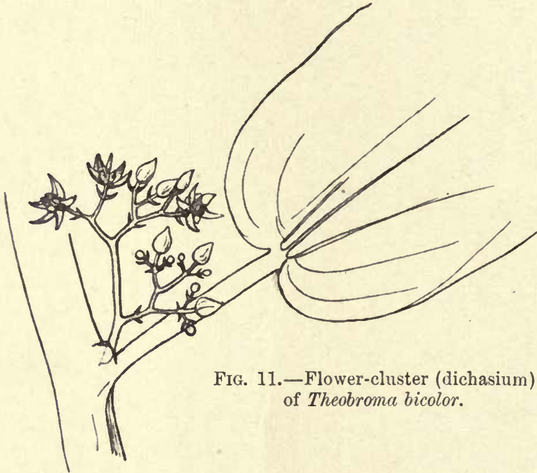


FIG. 11.—Flower-cluster (dichasium) of *Theobroma bicolor*.

but such a distinct dichasium is rare in cocoa; in B the axis is much reduced and the dichasium is no longer clearly distinguishable, though it can still be seen that the blossoms arise from a common axis; in C this axis has wholly disappeared and the flowers seem to arise separately.[1]

(2) In the ordinary cocoa plant the blossoms are formed just as in *T. bicolor*—*i.e.* in the axils of the leaves—but generally they do not develop until the leaf has fallen off. They are also formed in the axils of the bud-scales (on the "ring-scars," Fig. 6).

It may be said, then, that on the cocoa plant the flowers appear in reduced dichasia from buds, developed

[1] Flower-clusters which are infected by the "witch-broom" fungus (*Colletotrichum luxificum*) sometimes produce very nice dichasia, resembling those of *Theobroma bicolor*.

in the axils of the leaves, and generally only develop into blossoms after the dropping of the leaf—*i.e.* on the leafless parts of branches and stem.

As we shall see when we come to discuss the development of the fruit, the basal part of the central axis of the dichasium, and sometimes also the basal part of the secondary axis, remains on the tree after the fruit drops off, and from this remaining part young dichasia with flowers will arise again next year. So what we called a dichasium turns out to be a perennial organ.

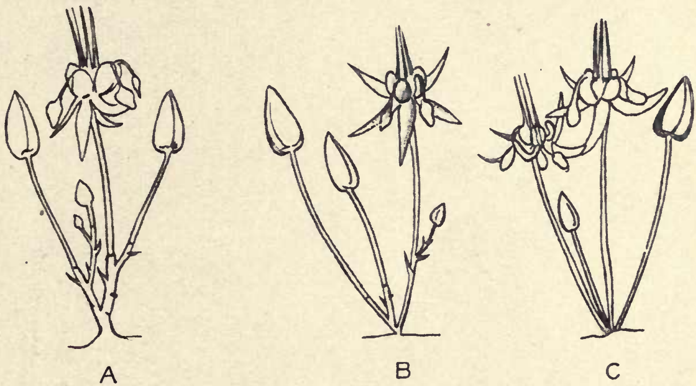


FIG. 12.—Different forms of flower-clusters (enlarged $1\frac{1}{2}$).

In A the dichasial ramification is very apparent; in B the axis is much reduced; in C the axis has wholly disappeared.

From this point of view it is better to regard it not as a flower-cluster, but as a twig which bears flowers.

It must not be forgotten that the leaf-bearing twigs also develop from buds situated in the axils of the leaves; and it is an interesting question, though one of purely theoretical importance, whether or not these buds have the same origin as those which develop into flower-clusters — in other words, whether twigs and flower-clusters develop from *different* buds, both situated in the axils of the leaves, or whether the *same* bud can develop into a twig or into a blossom-dichasium according to circumstances.

To the present author it seems that the latter

supposition is the correct one, and it may not be out of place to give one instance which supports this view. We sometimes find on the branches of cocoa plants very small twigs, only a few millimetres long, which bear flowers. These twigs no longer look like dichasia, because they are woody, and in addition they bear small scales, arranged according to the formula $\frac{1}{2}$, in the axils of which the flowers appear (Fig. 13, A). By

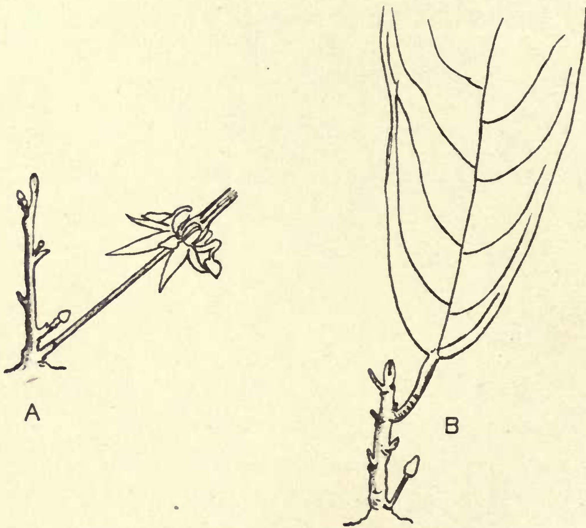


Fig. 13.—Very small twigs such as sometimes appear on the branches and stem (enlarged $1\frac{1}{2}$).

They bear scales arranged in the same way as the leaves on the normal twigs (see Figs. 5 and 6), and one flower or one flower-bud in the axil of each scale. In the twig in B one of the scales is replaced by a leaf.

this arrangement of the buds, those small twigs resemble leaf-bearing twigs; and this is still more the case when such a twig bears not only flowers, but also leaves, though the latter are always small. An instance of such a case is given in Fig. 13, B. Thus these twigs form apparently a link between the true leaf-bearing twig and a true blossom-bearing twig (called also flower-cluster or dichasium).

In trees of five years old or more the third-eldest

shoots generally drop their leaves, but sometimes they keep them till they become the fourth-eldest shoots. Sometimes, also, the blossoms appear on the third-eldest shoots, but more generally on the older parts of the branches and on the stem (Fig. 6).

Healthy, vigorous trees generally begin to bear blossoms when three years old, but no or only a few fruits are formed at this early age. On full-grown trees (ten years and older) the number of blossoms produced is very great, but only $\frac{1}{4}$ to $\frac{1}{2}$ per cent—or one out of every 200 to 400—develop into fruits.

Structure of the flower.—The flower of the cocoa plant has five sepals, white or rosy-coloured (*s* in Fig. 14), and five petals (*p* in Fig. 14). The petals are of a very peculiar form, and consist of a basal, cup-shaped part, to which is attached a ribbon-shaped part which is spatulate at its end; the basal part is white or rosy, with two dark-carmine ridges running longitudinally on the inside, while the ribbon-shaped part is yellowish.

The stamina (*sta* in Fig. 14 and Fig. 15, A) are five in number, and are ranged alternately with five staminodes—*i.e.* stamina which do not produce pollen (*sto* in Fig. 14 and Fig. 15, A). The five stamina and the five staminodes are united at their base so as to form a tube. The staminodes are dark-carmine coloured, elongated, awl-shaped, and protrude above the petals like five little tongues; the five stamina are whitish, much shorter than the staminodes and curled, so as to hide the anthers in the cup-shaped part of the petals (Fig. 14).

Each stamen (Fig. 15, B) bears four anthers, a rather rare occurrence among flowers; the explanation is that each stamen consisted originally of two, which now grow together. It may be recalled here that of the other species of *Theobroma*, *T. bicolor* and *T. pentagona* also have stamina with four anthers, while in the case of all the rest each stamen is a concrescence of three and bears six anthers.

The ovary of the cocoa flower is a "superior" one, and bears one pistil (*pi* in Figs. 14, 15, A, and 15, C), with five indistinct stigmas (*sti* in Fig. 15, C). These are always more or less grown together; sometimes

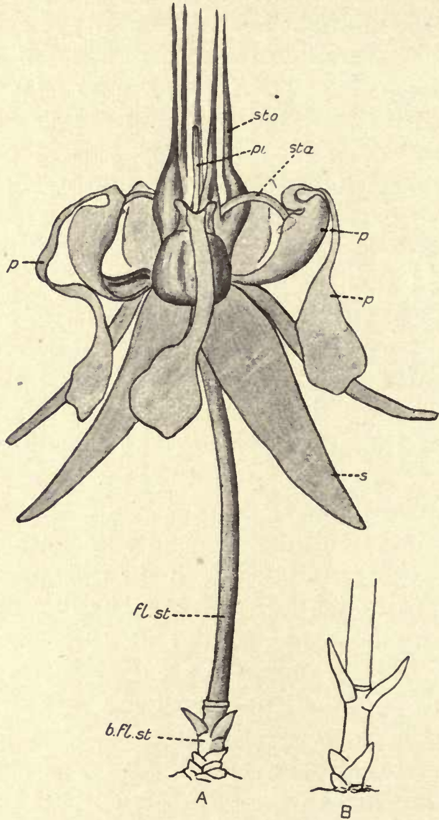


FIG. 14.—A, Flower of the cocoa plant (enlarged 6⅓ times).

s, sepals.
p, petals.
sta, stamina.
sto, staminodes.
pi, pistil.

B, Foot of the flower-stalk, bearing small scales (enlarged 12⅔ times).

they remain all together and form only one blunt column, sometimes a few of them grow free from the others.

Shortly after the flower has opened, the anthers

open, and after half a day the stigmas, if these open at all.

Pollination.—For a long time nothing was known of the pollination of the cocoa flower, and the question as to how the flowers were pollinated was a very puzzling one. Wright[1] says that Dr. Uzel carried out a few experiments on the subject in Ceylon. In the

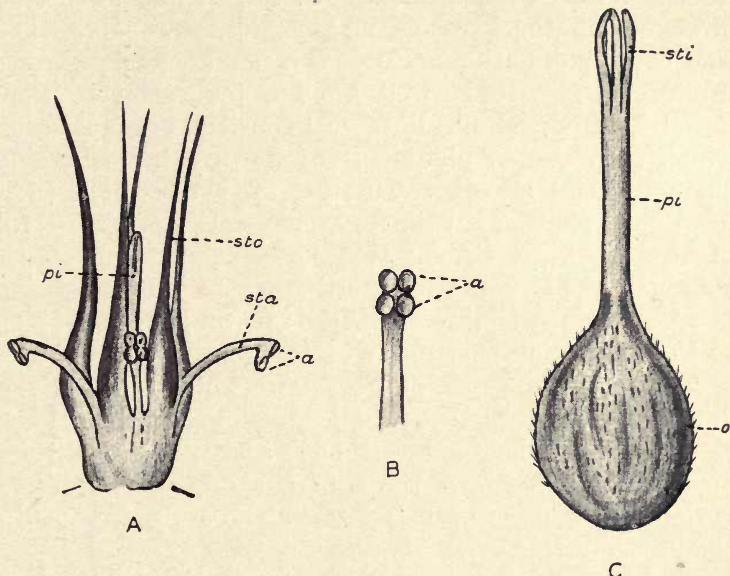


FIG. 15.—Parts of the cocoa flower.

A, The flower after removing the sepals and the petals, showing the stamina (*sta*), the staminodes (*sto*), and the pistil (*pi*). Enlarged 8 times.
B, One stamen with the four anthers (*a*). Enlarged 16 times.
C, The ovary (*o*), with the pistil (*pi*) and the stigmata (*sti*). Enlarged 16 times.

flowers examined, large numbers of thrips were found, and Dr. Uzel was of opinion that flowers were pollinated by these insects. By another author, Green (also mentioned by Wright), the common aphis is regarded as playing a rôle in the pollination. By others the different species of ants which live on the cocoa plant have been claimed to be the chief agents.

There are, however, facts which indicate that none

[1] Wright, *Cocoa*, p. 24.

of these insects play a rôle of any importance in the pollination.

First, though the insects mentioned often occur on cocoa, they are not invariably found on it. Thrips is always, at least in the West Indies, a very noxious insect, which happily does not occur on all cocoa trees; and the same may be said of the aphides, though they do not cause as much damage as the thrips. There is, however, another reason making it improbable that they cause pollination. Cocoa is a plant showing strong intercrossing. It is well known, for instance, that varieties imported into Botanical Gardens produce seeds which give rise to plants often showing unmistakable characteristics of other varieties next to which they have been planted; while inferior varieties of Forastero, planted between Criollo trees, give a progeny which clearly shows Criollo characteristics.

A study of the different types of Forastero also leads to the conviction that many of them are hybrids. The great number of types of Forastero, which contain the different characteristics in all kinds of combinations, cannot be understood without accepting a strong inter-crossing between the different original Forastero varieties. This subject is more elaborately treated in Chapter V.

This strong intercrossing indicates that the pollen can be transported from one tree to another. The transport might be effected in two ways, either by wind, or by flying insects such as butterflies, wasps, bees, flies—but not by thrips, aphides, or ants, none of which fly at all, and of which thrips and aphis can only move very slowly.[1]

The question whether pollination takes place by wind or by flying insects seemed at first difficult to answer, because the flower of the cocoa does not appear to be adapted to wind-pollinisation, and flying insects

[1] We may leave out of consideration the flying sexual *individua* of ants and aphides, because they only appear at certain times and are not common visitors of cocoa flowers.

were never found. Accordingly, the whole question for long remained a puzzle. Happily, however, a thorough investigation has lately been carried out by Dr. von Faber at Buitenzorg (Java), and this investigation solved the question.

Dr. von Faber has kindly given the present writer a short summary of his results, with permission to incorporate it here. He writes as follows :—

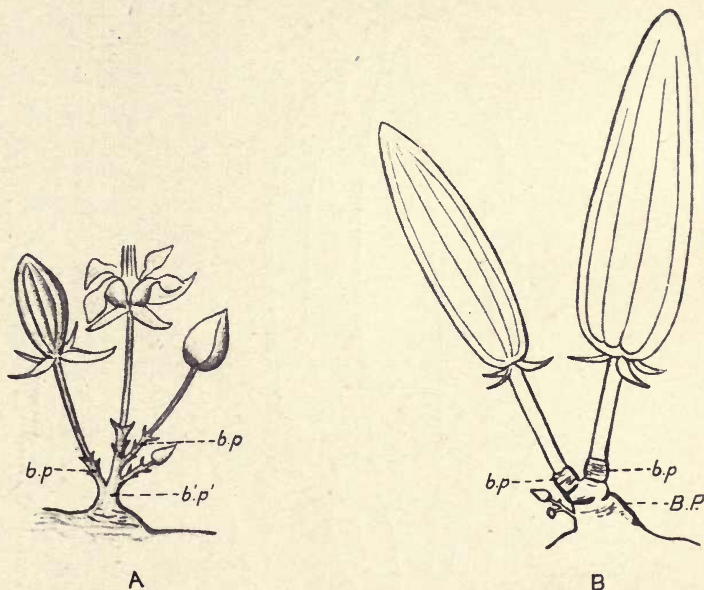


Fig. 16.—The development of the fruit and the fruit-cushion.

A, The cluster of blossoms, each flower with its flower-stalk attached to a basal part (*b.p*), while the flower-stalks are attached to a common axis (*b'.p'*).

B, Two young fruits. The basal parts of the fruit-stalks (*b.p*) develop into new fruit-cushions. The two fruit-stalks are implanted on the old fruit-cushion (*B.P.*).

"Though the structure of the flower seems to eliminate the possibility of self-pollination, this is really not so. The long and supple flower-stalk facilitates the swinging to and fro of the hanging flower by the wind. Experiments proved that by this movement pollen easily falls from the anthers on the pistil of the same flower, and it could be demonstrated that isolated flowers were easily self-pollinated in this way. Self-pollination may therefore be regarded to be the rule in the cocoa-flower. When, however, neighbouring trees stand close to each other, it is also

possible that the pollen falls from the hanging blossoms and settles on the pistil of flowers of the neighbouring tree. In this way cross-fertilisation is possible when the trees stand in close proximity, as is the case in all plantations."

The fruit and the fruit-cushion.—After pollination

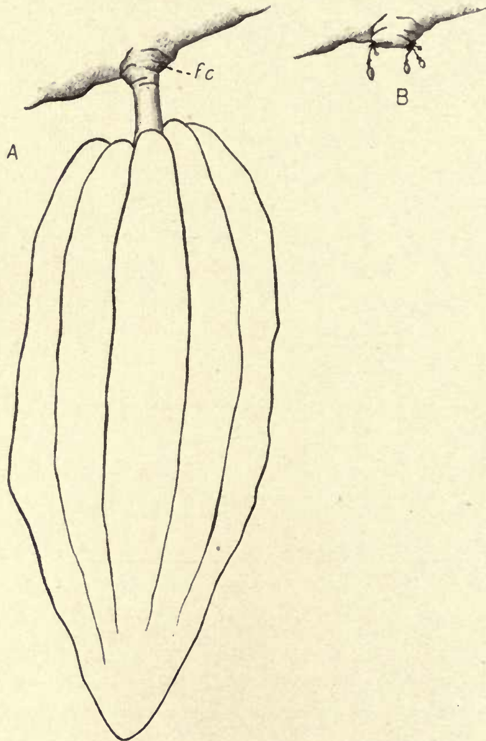


FIG. 17.—The fruit-cushion.

A, Ripe fruit with the basal part of the fruit-stalk developing into the new fruit-cushion.
B, The same fruit-cushion, after the fruit has been picked, bearing new blossoms.

the ovary develops into the fruit, while the flower-stalk becomes woody.

It has already been pointed out that the flowers are arranged in clusters—either a number of them are attached on a common axis (Figs. 12, A and 16, A), or the common axis may be much reduced (Figs. 12, B and 12, C).

However this may be, the stalk of each flower is always composed of two parts, a basal part and the true stalk. This is especially clearly to be seen in Figs. 14 and 16, A.

While the fruit is growing, the fruit-stalk becomes woody, while the scales on the basal part, which are to be compared with the leaves of an ordinary twig, fall off, leaving only scars as superposed lines or stripes (Figs. 16, B and 17, A).

When the fruit has been picked, the basal part remains wholly or partly on the tree and forms a cushion, from which flowers will arise again at the next blossoming (Fig. 17, B). The basal part is therefore really a perennial organ—a branch bearing no leaves, but scales, and terminally one flower. From the axils of the scales new blossoms appear again.

This description is not affected by the fact that the blossoms are generally arranged in clusters or dichasia. In these cases the fruit-cushion is not formed by the growth of one basal part, but simply by a combination of basal parts (Fig. 16, A).

Theobroma pentagona, Bern.

This species is indigenous to Central America and is only cultivated in Mexico, Guatemala and Nicaragua. On account of the irregular warty structures on the fruit, which resemble the scales of an alligator, this cocoa is called in those countries "cacao lagarto," or "alligator cocoa" (Fig. 18).

The fruits differ from those of the ordinary cocoa, not only by these warty excrescences but also by five prominent longitudinal ridges. In other respects it is very much like the ordinary cocoa, more especially the Criollo variety.

The tree is generally described as being not higher than some 4 metres (12 feet) with small flowers and small leaves. Preuss, however, states that he saw very strong and vigorous trees in Guatemala; and the young trees in the Botanical Gardens in Surinam, as well as

the older ones at the St. Clair Experiment Station in Trinidad, did not give the present writer the impression of a weaker growth than the ordinary cocoa. It is probable, however, that this species is more particular about soil than the ordinary *T. cacao*.

FIG. 18.—*Theobroma pentagona*.

Reproduced from Fauchère, *Culture pratique du cacaoyer*.

The fruits have a thin bark and are yellow or red when mature; the seeds are white or violet.

This variety of cocoa is not very productive; Preuss reports that the average yield per tree is ½ kilogram (1 lb.).

THE NON-CULTIVATED SPECIES

Theobroma bicolor[1] (Figs. 10, 11, 19 and 20).—Until

FIG. 19.—*Theobroma bicolor.*

Young tree three years old, bearing two fruits (Botanical Garden, Paramaribo).

quite recently *Theobroma bicolor* was regarded as a species

[1] Preuss, *Expedition*, pp. 250, 256 ; Hart, *Cacao* (1911), p. 12.

which produced commercial cocoa, and it is mentioned in several handbooks as being cultivated in Colombia and Mexico. This, however, is an error. The seeds have no commercial value, as they contain only a very small quantity of theobromine, viz. 0·1395 per cent (according to an analysis by Mannich[1]), while the seeds of commercial cocoa contain from 1 to 2 per cent. Hart[2] and Preuss,[3] having observed the species in Central America, reported that it has no commercial value and is not cultivated. However, on account of the sweetish and agreeable taste of the seeds, which resemble nuts or almonds, the tree is appreciated by the inhabitants of the countries where it grows wild. In Ecuador the wild-growing "cacao blanco," as it is called, is always saved when the forest is cleared, and so the plantations contain a good number of trees of this sort. The same is the case in Mexico, Guatemala and Nicaragua.

T. bicolor is spread over whole Central America from Ecuador to Mexico. In Mexico, Guatemala and Nicaragua it is known under the name "pataste," "pataschte" or "patastle"; in Ecuador it is called "cacao blanco"; in Colombia, "bacao," according to Preuss; while Hart reports that he found it indigenous in the province of Veragua, where it is known as "tigre cacao," on account of the rank smell of the seeds.

T. bicolor is characterised by its hanging branches (Fig. 19) and large leaves, greyish-coloured on the back; in the axils appear the small clusters of little reddish flowers (Figs. 10, 11).

In Ecuador the tree attains a considerable size and grows as high as 39 feet.

The large oval-shaped fruits (Fig. 20) have a very thick and hard fruit-wall. They have five prominent ridges, between which are five less prominent ones.

[1] Preuss, *Expedition*, p. 258.
[2] Hart, *Cacao* (1911), p. 13; Hart, *Bulletin No. 56* (1907), p. 289.
[3] Preuss, *Expedition*, p. 258.

From these ten main ridges a number of other small ones arise, irregularly arranged, and cover the surface of the fruit. The fruit remains green until it is fully

FIG. 20.—*Theobroma bicolor.*
Branch with fruit, and fruit alone.

ripe, when the colour becomes slightly yellowish or brownish. The pulp is much developed and takes up a great part of the interior of the fruit; it is not so

fluid and soft as the pulp of the ordinary cocoa, but more solid and sometimes a little fibrous.

Hart brought the tree to Trinidad and planted it in the Botanical Gardens, where it has grown to be a much larger tree than *T. cacao.* It was planted out in 1893, and gave fruit for the first time in 1905. The fact that it stands drought better than *T. cacao* has led Hart to suggest that it could perhaps be used as a grafting or budding stock for other weak-growing varieties.

Theobroma simiarum, Donn.-Smith.—This species has only been found in Costa Rica, where it is called by the inhabitants "cacao de mico."

Theobroma Mariae, Gond.—This species grows in the forests of the Upper Amazon and most probably also in the basin of the River Pará. The seeds have been found occasionally as an adulteration of Pará cocoa; they are called "cacaito" or "cacaoti," and are easily to be distinguished, macroscopically as well as microscopically, from the real cocoa.[1]

Theobroma pulcherrima, Gond.—This species has been found by Gondot in Colombia near the Upper Orinoco, in the country situated between the Meta River and the Guayabeira. There it is known by the Indians under the name "cacao cahonai," and by the Colombians as "cacao quadrado" or "cacoito de monte." So far as is known, the seeds are not used for any purpose.

Theobroma speciosa, Spreng.—This species occurs in the province of Pará (Brazil) and has lately been found in Surinam. Like its varieties *quinquenervum* (Bern.) K. Schum. of the Rio Negro (Brazil) and French Guiana (Cayenne), and *Spruceana* (Bern.) K. Schum. which has been collected in Pará, *Theobroma speciosa* has no practical value. In Surinam the Indians like to suck the seeds, which are surrounded by a sweetish pulp.

In Surinam this species has been found to be very

[1] De Wildeman, *Les Plantes tropicales,* p. 86.

liable to the disease of hypertrophied twigs, generally called "witch-broom," and in this regard its presence in the forest may be considered as dangerous. Most probably it is also attacked by this disease in the forests of Pará.

Theobroma microcarpa, Mart.—This species, which occurs on the Upper Amazon, is distinguished from all other species of *Theobroma* by its very small fruits. It has no practical value.

Theobroma grandiflora (Wild.), K. Schum.—This is a large tree with rather large flowers, which has been found on the Upper Amazon and in the province of Pará (Brazil), where it seems to be known under the name "cupuassie." So far as is known the seeds are not used in any way.

Theobroma subincana, Mart.—This species has been collected in Brazil (Rio Negro), Peru, Guiana (?) and Mexico. It is little known, and does not seem to have any practical value.

Theobroma angustifolia, Sess. et Moc. (D. C.).—This species, like *T. bicolor*, was for many years regarded as producing a cocoa of high quality, and was said to contribute to the famous "Soconusco cacao" (Mexico) and the not less renowned "Esmeraldas cacao" (Ecuador). It has, however, no commercial value.

Theobroma balaënsis, Preuss.—Preuss[1] found this species on a cocoa plantation near Balao in Ecuador. The sugary pulp which surrounds the seeds has an agreeable sour-sweet taste and is therefore appreciated by the inhabitants, who call this tree "cacao del monte." Otherwise this species has no practical value.

Theobroma albiflora, Gond.—According to Gondot, who collected this species near Mazo (Colombia), the seeds are mixed with those of the commercial cocoa for home use; they are said to improve the taste of the chocolate. The seeds are also used, unmixed, for

[1] Preuss, *Expedition*, pp. 80, 253.

the preparation of a very bitter product, which is used by the population as a febrifuge.

Theobroma lacinifolia, Gond.—This species is very imperfectly known; it was collected by Gondot in Colombia, in the valley of the Magdalena River.

CHAPTER V

VARIETIES OF COCOA

It has been seen that the cocoa trees of the whole cocoa-growing world show little variation as regards their habits and the characteristics of the vegetative parts (stem, branches, leaves) and blossoms. In these parts we find, indeed, only slight differences between the various types of cocoa. In the fruits and seeds, however, great variations are at once evident. As soon as we compare the types grown in different countries, important distinctions are discovered. Along the coast of Western Venezuela, for instance, we find a variety with a very warty and irregular fruit-wall, which is soft and easy to cut; the beans are round and plump, white in colour, and only slightly bitter in taste; and the resulting product is very fine. In Madagascar, Nicaragua, and a few other countries, we find very similar varieties. These are all Criollo varieties (Fig. 21). Quite another type, again, is grown in San Thomé. The fruit-wall is hard and smooth in surface; the beans are flat, deep violet in colour, and very bitter in taste; and the resulting product is only of medium quality. In Surinam, Ecuador, Brazil, Eastern Venezuela (the Orinoco district), and many other countries, we find similar varieties, which are all called Forastero. There is still another group of varieties which possesses characteristics both of the Criollo (for instance, large white beans), and of the Forastero (for instance, a smooth or a very hard fruit-wall). These intermediate forms, which

are very numerous, are also included in the Forastero group.

Thus the Forastero group contains many types, some of which have, in a greater or smaller degree, Criollo characteristics, and the first impression is that the Forastero are a mixture of innumerable types which exhibit the different characteristics in every imaginable combination. We find, for instance, types with fruits which are slender, not constricted near the stalk, with deep furrows of the fruit-wall and large light-coloured seeds; others with short fruits, constricted near the stalk, with shallow furrows, and small dark-coloured seeds; others again which show another combination of characteristics—*e.g.* slender-shaped fruits, constricted near the base, with deep furrows and small, dark-coloured seeds.

In order to make a logical and natural system of all these types of Forastero, we ought first to ascertain which are the original types and then which are the descendants of each. If the various original types could still be found—for instance, as wild trees in the forests of different countries—this would be a great help, but unfortunately this is no longer possible. Attention has already been directed (Chap. II.) to the insuperable difficulty of proving, when cocoa is found growing wild, whether the growth is really spontaneous or not. The variety found by Aublet in the forests of French Guiana,[1] the variety found by Hart in the forests of Trinidad,[2] and many others found in a wild state, are therefore without any value for the classification of the varieties, and cannot be regarded as primitive varieties, ancestors of the cultivated ones.

Accordingly, the only thing to be done is to group and classify the cultivated types as well as possible, in order to obtain at least a clear survey, and to build up a more or less artificial system of cocoa in the same way

[1] This cocoa was called by Aublet *Cacao guyanensis*, and later *Theobroma guyanensis*, but it is nothing else but the ordinary cocoa (*Theobroma cacao*).

[2] Hart, *Cacao* (2nd edition, 1900), p. 52; Hart, *Annual Report, 1906–7*, p. 19.

as many years ago Linnæus did for all the species of plants. This has been done by using as criteria the shape of the fruit and its surface. The Forastero types, with rather large fruits, with a constriction near the stalk and a warty surface, were distinguished as "Cundeamor" (Fig. 26); the same without constriction, as "Liso" or "Angoleta" or "Ordinary Forastero" (Fig. 25); "Amelonado" is the name for many types with rather short fruits with or without a constriction near the stalk, and a comparatively smooth surface (Fig. 27); "Calabacillo" is the name for types with short, almost ball-shaped fruits without any constriction, and with a very smooth surface (Fig. 28). These varieties are, however, not sharply defined, but form a continuous series.

This classification, first given by Morris,[1] has been accepted in its main points by all the later authorities as being both logical and practical, though he did not enter into many details as to the different varieties:—

1. *Cacao Criollo.*
2. *Cacao Forastero.*
   - *a.* Cundeamor verugosa amarillo.
   - *b.* Cundeamor verugosa colorado.
   - *c.* Liso amarillo.
   - *d.* Liso colorado.
   - *e.* Amelonado amarillo.
   - *f.* Amelonado colorado.
   - *g.* Calabacillo amarillo.
   - *h.* Calabacillo colorado.

The division of each variety into a yellow and a red sub-variety (indicated as "amarillo" and "colorado" respectively) may be omitted. It is true that in each variety red as well as yellow forms occur, but this characteristic of colour is so unimportant that it may be neglected in a general classification.

Hart proposed a slight modification of Morris's system, viz. the separation of the Calabacillo as a group apart from the Forastero. As we shall see later, this

[1] *Cacao, how to grow and how to cure it*, Jamaica, 1882, p. 12.

modification is unnecessary and not even practical, for the sub-varieties of Forastero and Calabacillo form a continuous series, running from the highest (Angoleta) to the lowest (Calabacillo). Moreover, Hart caused much confusion by his use of the term "Criollo," and what he calls "Trinidad Criollo" has no right to the name.

Hart's system[1] was as follows, omitting the division of each variety into two sub-varieties, "amarillo" and "colorado":—

Class I. Criollo, or fine thin-skinned.
Class II. Forastero, or thick-skinned.
1. Var. Cundeamor verugosa.
2. Var. Ordinary.
3. Var. Amelonado.
Class III. Calabacillo, or small-podded, thick, smooth-skinned, flat-beaned.

However different the sub-varieties may be, Forastero is always distinguishable from Criollo by the consistency of the fruit-wall, which is hard and firm and difficult to cut. The furrows of the fruit-wall are never so deep as in Criollo, nor are the ridges so prominent and warty. The beans are generally more or less flat. They are coloured light purple to dark violet, sometimes white, and need a rather long fermentation. In the finer sub-varieties, such as the Cundeamor and Angoleta, the fermentation takes some three to five days; in the coarser varieties, such as the Calabacillo and many Amelonado types, eight days or even more. The quality of the product is never so fine as that of the Criollo, though in some countries fine varieties of Forastero yield a very fair cocoa.

The Forastero varieties are strong growers, with fewer requirements than the Criollo. Therefore Forastero varieties are successfully grown in countries where Criollo cannot thrive. They also give their first crop earlier; on fertile soils the first fruits may be

[1] Hart, *Cacao* (1911), pp. 2-3.

expected in the third year, and a crop of some importance may be gathered in the fifth year, while full production may be reached in the eighth to tenth year. The full-grown Forastero tree gives a larger yield than the Criollo.

The original home of the Forastero is unknown. From the fact that the various types of Forastero are better known and distinguished in Venezuela than in any other country, one would be inclined to conclude that Venezuela, more especially the eastern part, the basin of the Orinoco, was the home of the Forastero. This is not improbable from other considerations. In Venezuela it is not called Forastero, but "Trinitario" (or "Carupano"). This name, "Trinitario," must not lead, however, to the assumption that the Forastero came originally from the island of Trinité or Trinidad, for historical facts show conclusively that Trinidad imported the Forastero from Venezuela; as we shall see in Chapter IX., this variety was imported from Venezuela to replace the Criollo, which was devastated by a disease.

I. Criollo

Before discussing the characteristics of these varieties and the modifications which have been made in Hart's definitions of the main varieties, a few words may be said about the word "Criollo," for different authors use this word in different senses, with the result that much misunderstanding has arisen.

"Criollo" is a Spanish word which means "Creole." Hart is quite right in saying that the true interpretation of the word "Creole" is "one born in a country or one belonging to a country." For instance, a child born either of white or coloured parents in Trinidad is a "Trinidad Creole"; if born in Venezuela, it is a "Venezuelan Creole," no matter whether it is white or coloured. In fact, "Creole" should be translated by "native" and not by "wild" or "coloured." [1]

[1] Hart, *Cacao* (2nd edition, 1900), p. 54.

"Cacao Criollo," or simply "Criollo," means, therefore, "native or indigenous cacao," and in this sense it was used in Western Venezuela, where the term arose, to indicate the variety which was originally cultivated there — in contradistinction to "Forastero," which meant the "foreigner," or imported variety. "Criollo" means, therefore, "Venezuelan Creole cocoa."

As regards the way in which the word "Criollo" must now be used, Preuss is very clear and his definition is correct: "The word 'Criollo cacao' has no other signification than that of a cacao, cultivated since the memory of man,[1] the origin of which is not known; a cacao, which has been found there in its present state, but which has—and this is the main point—most distinct characteristics of habit, fruit, size of the leaves, and especially of taste, form and appearance of the seeds."[2]

The last part of this sentence is indeed the main point, for, if every separate cocoa-growing country called the old, primitive variety "Criollo," and the foreign imported variety "Forastero," the confusion would be unending; for a variety called "Criollo" in one country would be called "Forastero" in another, being in the one the primitive variety and in the other the imported one. It is therefore agreed in our system of classification to call "Criollo" only the group to which belongs *the Venezuelan Creole cocoa or Venezuela Criollo.*

It is to the credit of Preuss that he established clearly the characteristics which distinguish the Criollo from the Forastero. Merit must also be credited to the work of Zehntner,[3] and Lock[4] has contributed to the knowledge of the varieties cultivated in the Botanical Gardens at Peradeniya.

[1] To be added: "in Western Venezuela."

[2] *Expedition*, p. 199.

[3] Zehntner, "Mededeelingen betreffende op Java aangekweekte cacao-variëteiten" (*Proefstation te Salatiga*, *Bulletin No. 9*, 1905).

[4] Lock, "On the Varieties of Cacao existing in the Royal Botanic Gardens and Experiment Station at Peradeniya" (*Circulars and Agr. Journal of the Royal Botanic Gardens, Peradeniya*, vol. ii. No. 24, October 1904).

Venezuela Criollo may, then, be considered as the typical Criollo. As Preuss says: "Venezuela is the classical home of the Criollo. From there alone does it come into the market under this name. Every Venezuelan planter knows how to distinguish 'Criollo' from 'Trinitario' or 'Carupano'" ("Trinitario" and "Carupano" are the Venezuelan names for "Forastero").

The main characteristics of the Criollo (Figs. 21, 22) are (1) the shape of the seeds, which are plump

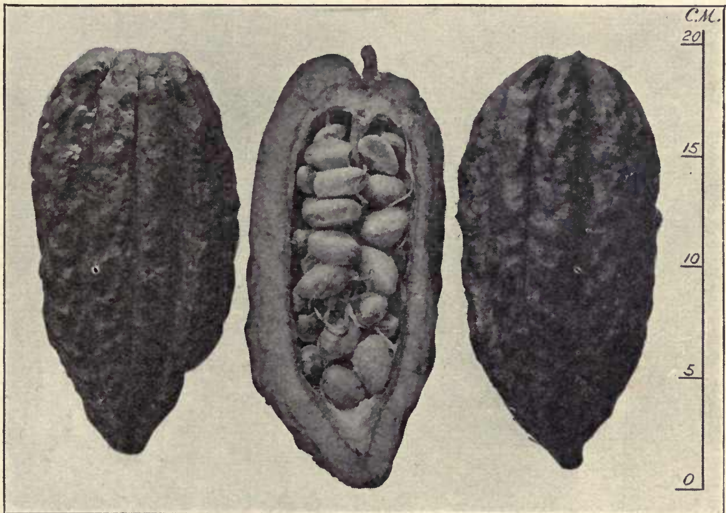


Fig. 21.—Typical Criollo fruits (Java), slightly larger than the average.

and not flat but round; (2) the consistency of the fruit-wall, which is always comparatively soft and easy to cut; and (3) the surface of the fruit-wall, which has ten distinct furrows, five of which are deeper than the other five between them (Fig. 22), while the prominent ridges running between the furrows are very warty and irregular. The size and shape of the fruit vary a little, and are slightly different in the different local types of Criollo, but the fruit is always broad at the stalk-end, and never constricted, and tapers generally —not always—to a more or less sharp point.

The colour of the beans is paler than in Forastero, and runs from white to pale violet. The taste is rather sweet, at any rate only slightly bitter, and the beans need only a short time for fermentation, while the quality of the product is always very fine and the market price high.

As regards the habits of the tree, the Criollo often shows a rather weak growth, at any rate in comparison with the strong, vigorous growth of the Forastero

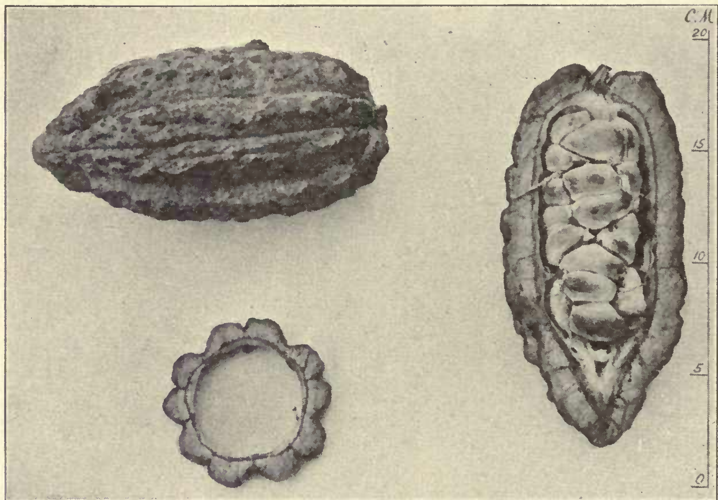


Fig. 22.—Java Criollo.

varieties; and accordingly the leaves are rather small and not very numerous, making the foliage system rather thin. Preuss considers it a typical characteristic of this variety to bifurcate at a low height and to have only a few, generally two or three, main branches. These differences, however, are apparent only when Criollo is grown under conditions which are not in every sense quite favourable. There is no doubt that Criollo is more particular about soil and climate than Forastero, and when the soil is not of best quality, or the conditions are in other respects not first-rate, Criollo

does not thrive and its growth is weaker than that of Forastero. Under really favourable conditions, Criollo grows in vigorous trees, with a big stem and a dense foliage system.

In some countries there are found a few local types of the true Criollo, each with its own characteristics. These are the *Venezuela*, the *Nicaragua* (Fig. 23), the *Java* (Figs. 21, 22), the *Ceylon*, the *Samoa*, and the *Madagascar* Criollo. In addition, one sub-variety of the Criollo is known, very different from the typical Criollo. This is the so-called "Porcelaine" variety (Fig. 24).

All the other varieties of the cocoa plant belong to the Forastero group (Figs. 25-33). This comprises several sub-varieties, which form a series beginning with those which stand nearest to the Criollo (with rather round beans, a warty fruit-surface with deep furrows, yielding a product of very good quality), and ending with the so-called "Calabacillo variety," with very flat beans and a smooth fruit, yielding an inferior kind of cocoa.

Local Types and Sub-Variety of Criollo

(*a*) *Local Types*

Venezuela Criollo.—The fruits of the Venezuela Criollo are medium-sized. Their form is generally plump and asymmetrical. According to Preuss, the typical Venezuela Criollo has a medium-sized, slanting point, curved to the stem of the tree when the fruit is grown at the stem. Towards the stalk the fruit ends more or less abruptly with a broad end, which often stands obliquely to the stalk. Sometimes the shape is so irregular that the fruit gives an impression of being misformed.[1]

In most cases the colour of the fruits of the Venezuela Criollo is red, but a classification has been made into *Criollo legitimo*, with fruits of a deep red

[1] Preuss, *Expedition*, p. 225.

colour and whitish-violet seeds; *Criollo amarillo*, with yellow fruits and white seeds; and *Criollo mestizo*, which is a sort of intermediary between the two other ones, but which seems to be rare. This classification, however, is of no great importance.

In Venezuela the Criollo is mainly cultivated near the coast between the two rivers, Rio Yaracuy and Rio Tuy. The local name is "cacao dulce," which means "sweet cocoa," in opposition to "cacao amargo" or "Trinitario amargo," which means "bitter cocoa" or "bitter Forastero," and which comprises all the different Forastero varieties.

Ceylon Criollo.—Ceylon Criollo—or, as it is generally called, "Old Red Ceylon"—seems to be nothing but a true Venezuela Criollo, which has perhaps changed a little in the course of the seventy years it has been grown in Ceylon. Most probably[1] the "Old Red," also called in Ceylon the "Caracas variety," was the only variety cultivated in the island before the introduction of the Forastero in 1878. In his Report for 1884, Dr. Trimen, at that time Superintendent of the Botanic Gardens, wrote: "Cacao was grown at the Botanic Gardens at Kalutara in 1819, and may have been introduced by Moon, the Superintendent. But most of the present cultivated cacao seems to have been a consignment from Trinidad, obtained by Sir R. Horton in 1834–35." As "most of the present cultivated cacao" in 1884 was "Old Red," it is very probable that this variety was imported some seventy years ago from Trinidad. At that time, however, true Criollo was most probably no longer to be found in Trinidad, as it was wholly destroyed by a blight in the beginning of the eighteenth century. It is therefore very probable that the "Old Red" was imported through Trinidad from Venezuela.

The pods of the "Old Red" are, like those of the Venezuela Criollo, usually red in colour, seldom yellow, the size generally small, the surface rough, the furrows

[1] Lock, *Circular*, p. 391.

deep; they are pointed at the apex but not acuminate, and the base is, as in all Criollo, unconstricted.

The seeds are as a rule nearly circular in transverse section, though there is a good deal of variation in this respect. Generally the colour is white, but a certain percentage is bright purple or crimson within.[1] It is estimated that a little more than 50 per cent contain only white seeds, some 40 per cent contain mixed seeds, and a very small percentage have only purple seeds. The average number of seeds per pod is about twenty-nine.

Lock remarks that "the trees of this variety are of a distinctly smaller and weaker habit than those of the Forastero kinds; they are also reputed to bear smaller leaves, but according to my experience this distinction is not clearly marked."

It seems that the true "Old Red" is no longer so very common in Ceylon, and that it is being replaced more and more by the Forastero.

Java Criollo (Figs. 21, 22).—This variety has been for many years the only one grown in Java. A very interesting and thorough investigation of this variety has been made by Zehntner,[2] who gives a clear review of its characteristics. It is very pure and constant, closely resembling, if not identical with, the Venezuela Criollo. This is remarkable, because all the trees at present grown in Java are descendants of a few trees, perhaps even of one tree, imported as early as the sixteenth century. The fact that the characteristics of Venezuela and Java Criollo are still so much alike shows that both varieties have changed very little in the course of three centuries. This gives support to Preuss's view[3] that the Criollo in Venezuela is very constant and has no tendency to be spoiled by mixing with Forastero.

"The pods of Java Criollo are broad, not narrowed

[1] Lock, *loc. cit.* p. 389.
[2] Zehntner, "Mededeelingen, etc." (*Proefstation te Salatiga, Bull. No. 9*).
[3] Preuss, *Expedition*, p. 226.

at the base (the part where the stalk is fixed). Towards the middle of the longitudinal axis they get a little broader, tapering towards the apex, which ends in a short, slightly curved point. The point is sometimes sharp, sometimes more or less blunt. The fruit-wall is red, warty, with ten prominent ridges, which are separated by deep narrow furrows. The consistency of the fruit-wall is soft." The colour of the fruit is generally deep red, rarely yellow.

The seeds are round in section or short-oval, white, with sometimes a violet tinge along the edges.[1] The following average figures were obtained by measuring a great number of fruits :—

Length of pod.	Diameter of pod.	Weight.	Weight of the seeds.	Number of seeds.
170 mm. (162 to 182)	81 mm. (66 to 90)	467 gr. (321 to 478)	97 gr. (70 to 109)	31·4 (29 to 33)

Weight of one seed.	Weight of one prepared seed.	Number of fruits necessary to obtain 1 kilog. of marketable cocoa.
3·0 gr. (2·1 to 3·5)	1·14 gr. (1·09 to 1·30)	35

The percentage of worthless seeds is very small, being on the average 2·2 per cent.

Attention may be drawn to the fact that, as Zehntner's figures prove, Java Criollo shows little variation.

Samoa Criollo.—Cocoa is cultivated on a small scale in Samoa, most of the trees belonging to a pure Criollo type, which stands near the Java Criollo and the Ceylon "Old Red."

As to the quality of the cocoa, the Samoa Criollo is, according to Preuss,[2] to be preferred to the other two.

[1] Zehntner, *loc. cit.* p. 13.

[2] Preuss, *Samoa*, p. 39.

Madagascar Criollo.—This variety has been described by Fauchère. The description and the excellent photographs[1] leave no doubt as to the pure Criollo character of this variety.

The length of the pod varies between 16 and 20 cm., the diameter between 6 and 9 cm. The pod contains 30 to 35 seeds, the length of which varies between $1\frac{1}{2}$ and 2 cm.; they are plump and in section nearly circular. The colour is white and the taste only slightly bitter. The colour of the pod is generally red, seldom yellow.

According to Fauchère this cocoa was most probably imported from Réunion, and this island apparently got

FIG. 23.—Nicaragua Criollo (after Preuss).

it from Ceylon, so that the Madagascar Criollo would seem to be a descendant of the "Old Red."

Nicaragua Criollo (Fig. 23).—This variety has been studied by Preuss in its native country. Like the Venezuela Criollo it has fruits with a warty surface and deep furrows; towards the stalk the fruit ends with a broad side; the shape is often asymmetrical. All these characteristics are the same as those of the Venezuela Criollo; but in addition the Nicaragua Criollo has other characteristics which differentiate it more widely from the Venezuela Criollo than any of the others mentioned, and which give it a place by itself among the Criollo varieties.

[1] Fauchère, *Culture pratique*, p. 10 and Figs. 2, 3.

The most typical characteristic is the size of the seeds, which are larger than in any other variety: the length is 4 to $4\frac{1}{2}$ cm., the diameter about $1\frac{1}{2}$ cm. Another typical characteristic is the long tapering point, which is longer and sharper than in the other Criollo varieties, and which gives the fruits a more slender shape.

The taste and colour (white to pale purple) of the beans are very fine, but the aroma is rather weak and not so strong as in the Venezuela Criollo.

This variety is grown in Nicaragua; also in Guatemala, and perhaps to a small extent in Mexico. It is likely that it contributes to the so-called "Soconusco" and "Tabasco" cocoa. In Nicaragua it is called "cacao del pais" (cocoa of the country), in opposition to "cacao estrangero" (cocoa from abroad), by which name the Forastero is indicated.

From Nicaragua Hart imported it in the year 1893 into Trinidad. It is also grown in the Botanic Gardens at Peradeniya (Ceylon) and in the Botanic Gardens of Buitenzorg (Java). The trees grown at Buitenzorg have been described by Zehntner. Though it may be that these few trees do not represent exactly the average type, the figures given by Zehntner are still worthy of mention. He describes the fruit as being rather short (155 mm.), but broad (86 mm.) and heavy (557 gr.). The weight of the seeds is greater than in any other variety (203 gr.), being $36\frac{1}{2}$ per cent of the weight of the whole pod. The seed-coat is described as very thin, soft and light. The average number of seeds per pod was 28, of which about 2 (8·2 per cent) were worthless. The average weight of the fresh seeds was 7·1 gr., that of the prepared bean 1·79 gr.

(b) *Sub-Variety*

Porcelaine variety (Fig. 24).—The only sub-variety of Criollo is the Porcelaine variety. The outer appearance of the fruit is so different from the true Criollo that nobody would at first appearance recognise it as

a sub-variety. The smooth surface and the lack of prominence of the ridges give it a strong resemblance to the Amelonado, a Forastero sub-variety, but the thin fruit-wall and the rather plump seeds show that it is really a Criollo. This is also proved by the fact that it was found in the Criollo plantations in Java before the introduction of the Forastero.

Hitherto the Porcelaine variety has received but little attention. In one sense this is not to be wondered at, because from an agricultural or com-

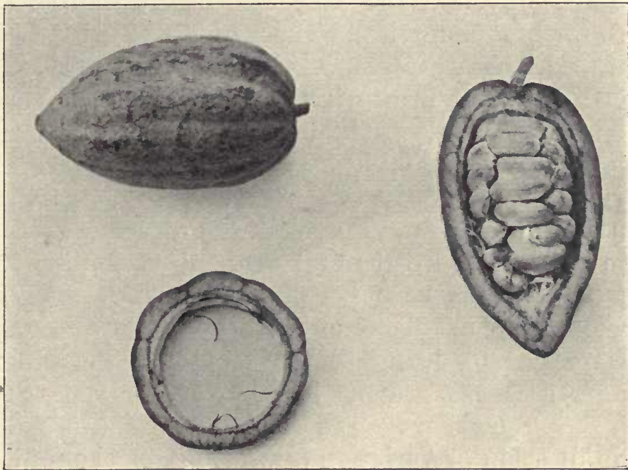


Fig. 24.—Java Criollo, Porcelaine variety.

mercial point of view it is unimportant; but it is all the same a very interesting variety. In twenty fruits Zehntner found 68 per cent of round beans. Further, all the seeds were white—another Criollo characteristic. The fruit-wall of the Java Porcelaine is very thin and easily cut.

It is impossible to give any definite reason for the possession of a smooth surface in this Criollo variety. It is probable that it has suddenly appeared as a mutation, as a child of true Criollo parents, among many sisters which were true Criollo like their parents. At any rate it is not necessary to assume, as Zehntner does, that

a smooth skin being a Forastero characteristic, the Porcelaine variety must have been caused by a mixing with Forastero. This is most improbable, because the Porcelaine has no other Forastero characteristics, and moreover it was present in Java before the Forastero was introduced.

II. Forastero

While the countries where true Criollo is to be found are only few, the Forastero is grown in all the cocoa-growing countries, either together with Criollo (Venezuela, Java, Ceylon, Nicaragua, Samoa, Madagascar), or alone in different sub-varieties (Ecuador, San Thomé, Trinidad, Gold Coast, Surinam, Antilles, etc.). And while Criollo is very uniform, having, aside from local types, only two varieties, the true Criollo and the unimportant Porcelaine, Forastero is a collective name for a great number of sub-varieties.

It has already been pointed out that it is difficult to make a clear classification of the sub-varieties of the Forastero group, owing to the fact that the different characteristics are present in the various types in all sorts of combinations. Whether this is a consequence of hybridisation or variation (mutation), or the influence of local conditions, has not been investigated; but since von Faber has proved that trees standing close together can easily be pollinated by each other, it is very likely that this mixture of types has been caused by hybridisation. We have therefore probably to regard a great number of types of Forastero as hybrids of different Forastero varieties, and an equally large group as hybrids of Criollo with varieties of Forastero.

This view is supported by the fact, observed both in Venezuela and in Java, that the offspring of inferior types of Forastero planted in Criollo fields have distinct Criollo characteristics, and show therefore a marked improvement over the mother tree. Amelonado with small, flat, bitter seeds planted between Criollo gave

in Venezuela an offspring with fruits which had the Amelonado shape, but contained large, round seeds with the bitter principles much less developed. In dealing with the introduction of Forastero types into the Criollo fields of Western Venezuela, Preuss writes:[1] "I saw with astonishment the modification which had occurred here in the inferior cacao. It is true that the fruit-walls were very thick, but the beans could only be distinguished from Criollo by very trained men." In Java the first Forastero introduced was an inferior type, a sort of Cundeamor bearing small fruits with a very pronounced bottle-neck near the stalk. Planted between Criollo, it has produced an offspring for the greatest part of superior type with distinct Criollo characteristics.

The most practical classification is obtained when the form of the fruit is used as a basis in the following way:—

Ridges deep, surface warty or rather warty, largest diameter of the fruit generally not more than 50 per cent of the length; no constriction near the stalk . . . . *Angoleta.*

Ridges deep, surface warty or rather warty, largest diameter of the fruit generally not more than 50 per cent of the length; fruit constricted near the stalk ("bottle-necked") . *Cundeamor.*

Ridges shallow or rather shallow; surface not very warty or rather smooth; largest diameter of the fruit always longer than 50 per cent of the length; the constriction near the stalk may be present or absent . . . . . . *Amelonado.*

Ridges very shallow, surface very smooth; diameter 60 to 75 per cent of the length of the fruit . . . *Calabacillo.*

It must again be emphasised, however, that both this classification and the characterisation of the types are wholly conventional. The different types are not sharply separated from each other. They form a continuous series, beginning with the finest *Angoleta*, which is very much like the Criollo, and running through the *Cundeamor* and the *Amelonado* to the smoothest *Calabacillo.*

[1] Preuss, *Expedition*, p. 225.

The most usual appearance of these types may now be briefly described.

A. Angoleta

The typical Angoleta variety (Fig. 25) is characterised by large, regularly-formed fruits, with a thick fruit-wall, generally deeply furrowed and very warty; the apex is rather long and attenuate; at the stalk end the fruit is not constricted. These last characteristics bring the Angoleta near the Criollo. Moreover, the beans generally resemble those of Criollo; though not

Fig. 25.—Java Forastero, Angoleta variety.

as large and round, they are still rather large and plump. Their colour is generally light violet.

The quality of the product of several types of Angoleta is superior.

The Angoleta variety is to be found in Venezuela, in Trinidad, and most probably also in Central America; it also occurs in several other countries, but never to a large extent or in a pure form.

B. Cundeamor

The Cundeamor (Fig. 26) is in many respects much like the Angoleta, but the furrows of the fruit-wall are generally not so deep and the warts less prominent. The most characteristic feature is the constriction of the fruit near the stalk-end, which gives the fruit more or less the shape of a bottle ("bottle-necked"). The

colour and shape of the beans are generally about the same as in the Angoleta, but there are also Cundeamor types with flat, dark-coloured beans.

The Cundeamor variety is cultivated in Venezuela, in Trinidad, in the province of Esmeraldas in Ecuador, and in Java.

C. Amelonado

The Amelonado (Fig. 27), which is generally called

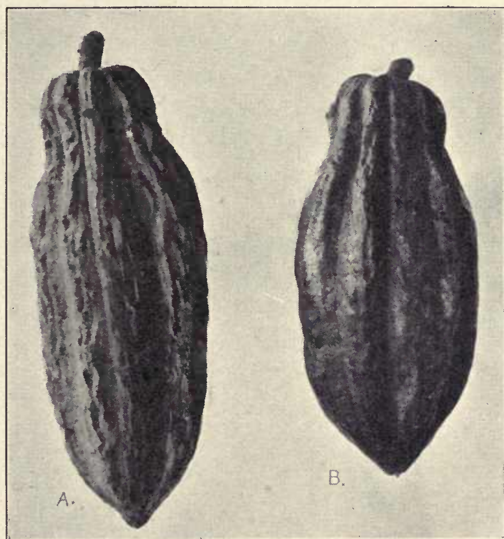


Fig. 26.—Forastero, Cundeamor variety.

Two types: the type B is more like the Forastero Amelonado than type A.

"Sambito" in Venezuela, is the most widely cultivated sub-variety of Forastero. By far the largest part of the world's crop of cocoa comes from this variety.

The difference between the many local types is rather great, but, speaking generally, the Amelonado variety is characterised by its broad and short fruits, which have more or less the shape of a water-melon or an egg. They may be bottle-necked (Fig. 27, B) or not (Fig. 27, A). The apex is sometimes shortly acuminate

(Fig. 27, B), sometimes blunt (Fig. 27, A); the fruit-wall is generally more or less smooth, though the ten ridges and furrows are always clearly marked. The seeds are generally flat, deep violet in colour, and bitter in taste; but there are exceptions to this rule, and some Amelonado have seeds which are rather plump, light violet, or even white in colour, and sweetish in taste. Generally this variety requires some six or seven days

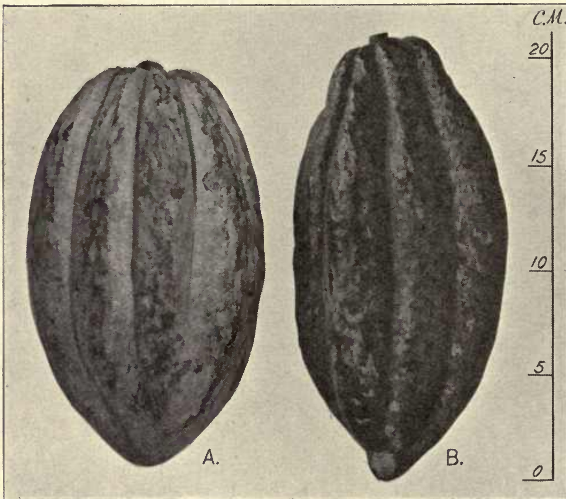


Fig. 27.—Forastero, Amelonado variety.

Type A is not bottle-necked, and has a blunt apex; type B is bottle-necked, with a pointed apex and comparatively deep ridges.

for fermentation, and yields a product of medium quality; but there are local types which need only a short fermentation and yield a product of superior quality.

Amelonado is grown in Ecuador (with the exception of the province of Esmeraldas), San Thomé, San Domingo, Gold Coast, Surinam, and other countries as *the* local variety. In addition, it is to be found together with other Forastero, especially Cundeamor types, in almost all the cocoa-growing countries.

D. Calabacillo

The Calabacillo (Fig. 28) is the lowest Forastero variety. It has the shortest fruit and the smoothest fruit-wall of all the varieties of cocoa; the furrows are very shallow; the apex is shortly acuminate, sometimes blunt. The beans are very flat, deep violet in colour, and very bitter in taste; fermentation requires eight days and sometimes even more.

This variety, though to be found in every cocoa-

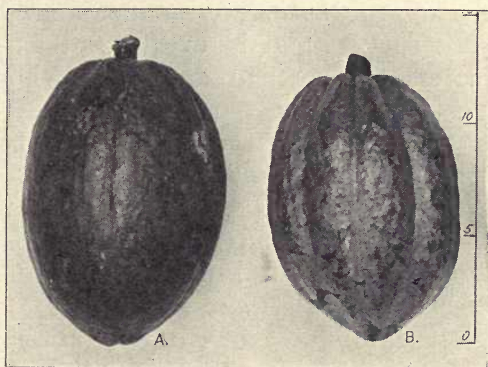


Fig. 28.—Forastero, Calabacillo variety.

A, typical Calabacillo; B, the surface of this type is not so smooth and it therefore is more like the Amelonado.

growing country, is never grown purposely. On the contrary, the planter avoids using Calabacillo seeds, knowing that the quality is very poor and that it ferments slowly. This sometimes makes it even necessary, when the number of Calabacillo fruits harvested is rather large, to keep them apart from the others and to have them fermented separately, as they would otherwise delay the fermentation of the whole crop.

In Venezuela the Calabacillo is called "Trinitario amargo" ("bitter Forastero") or "Cojon de toro" ("bull's testicle").

Local Types

Venezuela Angoleta.—A detailed description of this type has not yet been given, and the reader can only be referred to what has been already said regarding the Angoleta variety in general.

Among the group of local types grown in the basin of the Orinoco and indicated as *Carupano Cacao*, we find types called *Carupano grande* or *Carupano grande mejor*, which are much like typical Angoleta in their outer appearance, but the fruit-wall is less warty, the furrows are not so deep, the beans are smaller and flatter, the quality is not so fine, and in every respect these types show characters of Angoleta and of Amelonado combined. As they generally resemble the Amelonado more than the Angoleta, they are best considered as belonging to the former variety.

Trinidad Angoleta (Fig. 29) has been mentioned by Hart[1] under the name of "Trinidad Forastero." It is generally met with in the estates in Trinidad together with other varieties of Forastero.

Through the kindness of Mr. Augustus, Manager of the Government Cocoa Plantation, "River Estate" (Trinidad), I have obtained the following average figures of a large number of pods of "Trinidad Forastero," collected on that estate and belonging to two Angoleta types:—

	Length.	Diameter.	Weight.	Number of seeds.	Weight of seeds.	Length of one seed.	Weight of one seed.
Red .	21 cm.	9 cm.	765 gr.	37·5	93 gr.	2·2 cm.	2·5 gr.
Yellow .	10 cm.	9 cm.	585 gr.	34·3	73 gr.	2·1 cm.	2·0 gr.

Java Angoleta is now the most common Forastero in Java. It is a hybrid between the originally imported Forastero Cundeamor and the Java Criollo. The original Cundeamor was one tree with fruits of an

[1] Hart, *Cacao*, Figs. Z and A.

inferior type, small, and with a very pronounced bottle-neck.

Venezuela Cundeamor has large fruits with deep furrows, a very warty surface and a long, slanting point.

Fig. 29.—Trinidad Angoleta (Hart's "Forastero").

It is always distinctly "bottle-necked." The colour is red or yellow. The nibs are pale violet, as in the Venezuela Angoleta, but darker than in the Criollo. Preuss gives an illustration but no figures of this variety.

This variety is much appreciated by the planters in Venezuela. It gives a fine quality of product, and resists disease better and is a stronger grower than the Criollo.

Trinidad Cundeamor.—This is a typical Cundeamor with all the characteristics already mentioned. Hart mentions it under the name "Trinidad Criollo," because he looks upon it as the variety originally grown in Trinidad; but whatever the variety may have been which was first grown in Trinidad, it is obvious that this bottle-necked Forastero cannot be called "Criollo." No Criollo is grown in Trinidad, and the name of this type must be "Trinidad Cundeamor."

Mr. Augustus has kindly given me the following average of the fruits collected on the "River Estate" (Trinidad):—

	Length.	Diameter.	Weight.	Number of seeds.	Weight of seeds.
Red Pod .	19½ cm.	7½ cm.	495 gr.	41·8	73 gr.
Yellow Pod	21 cm.	7½ cm.	495 gr.	39·5	75 gr.

As regards the seeds, the following figures were obtained: average length, 2·1 cm.; average weight, 1·7 gr.

Ecuador Cundeamor or *Esmeraldas Cundeamor* is cultivated only in the province of Esmeraldas in Ecuador. The plantations in this province are not numerous, and the total number of trees is estimated to be only 700,000. The fruits are of a slender shape, with a long point, with deep furrows and rather strongly constricted near the stalk-end. The colour is yellow or brownish-red; in the first case the nibs are sometimes entirely white, showing a great resemblance to Venezuela Criollo.[1]

Ecuador Amelonado (Figs. 30, 99), or, as it is called in Ecuador, "cacao nacional," may be regarded

[1] Preuss, *Expedition*, p. 241.

as the most important Amelonado. It now produces per annum not less than 20 to 30 million kilograms of cocoa, or about one-eighth of the whole production of the world. This variety is almost exclusively grown in the provinces of Los Rios, Guayas, El Oro, and

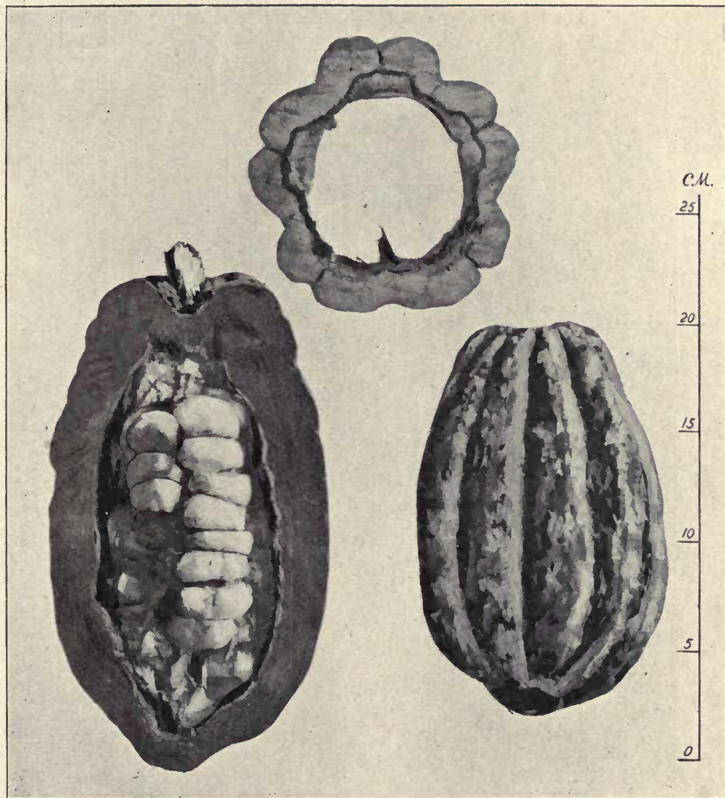


FIG. 30.—Ecuador Amelonado ("cacao nacional").

Manabi, producing the four market cocoas, "Arriba," "Balao," "Machala," and "Manabi."

This Amelonado stands closer to the Cundeamor than to the Calabacillo; for an Amelonado its fruit-wall has rather deep furrows. Though exact figures giving the average of a great number of fruits are not

available, we may take it that the length of the fruit is about 19 to 23 cm., the diameter about 10 to 12 cm. The apex is blunt or with a short, indistinct point. Generally they are slightly bottle-necked.

Fig. 31.—San Thomé Amelonado.

Reproduced from Chalot and Luc, *Le Cacaoyer au Congo français.*

The type is remarkably constant throughout all the four provinces mentioned, and we do not find trees of other Forastero types mixed with it. Such a uniformity of fruit is rare in cocoa-growing countries. Curiously enough, although exactly the same variety

is grown in all four provinces, the resulting products are of quite different qualities.

San Thomé Amelonado (Fig. 31) has been described by Chevalier.[1] The fruits, which are citron-yellow when ripe, are elliptical and elongated, generally more or less constricted at the base; they end in a blunt point or mamelon. The fruit-wall has ten shallow furrows, and is smooth or slightly warty. When unripe, the fruits are completely green or slightly rose-tinged at the base; the furrows are always of a lighter colour. Gradually they become yellowish-green and finally yellow.

Chevalier gives the following average figures: length of the pod, 14 cm.; diameter, $7\frac{1}{2}$ cm.; weight, 300 gr.; number of seeds, 42; weight of seeds, 91 gr.; weight of one seed, 1·9 gr.

In San Thomé this variety is called "creoulo," as it is the oldest type grown there.[2] It is uncertain whence it was imported to San Thomé, but perhaps de Almada Negreiros is right in assuming that it came from Bahia in Brazil. It is grown not only at San Thomé, but also at Principe and throughout West Africa.

Surinam Amelonado (Figs. 32, 136) is the common variety grown in Surinam. The two Amelonado types just mentioned are fairly constant in their particular countries, but the Surinam Amelonado on the other hand is rather polyform. It is, therefore, difficult to fix the type, for it is different on different plantations. On one plantation a type with small fruits may be the most common one, but on other estates the type is larger; on some estates a more or less bottle-necked variety is prevalent, on others fruits which lack this character are generally found. Fig. 32 shows the most common form. With this Amelonado variety inferior sorts of Angoleta and Cundeamor varieties are to be found, generally in small numbers, but sometimes more numerous.

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain*, 1908, p. 130.

[2] It will now be seen how confusing it would be if we called this type "Criollo," as Hart did with the Trinidad Cundeamor!

The most typical Surinam type (Fig. 32) is a medium-sized Amelonado, smaller than the Ecuador one, but larger than the San Thomé Amelonado. The average length is 16 cm., the average diameter 8½ cm. The following average figures were obtained from 105 typical fruits collected on the estate "Clevia": weight of the fruit, 559 gr.; weight of seeds, 128 gr.; weight of one seed, 3·1 gr.; number of seeds, 41. The colour of the seeds is dark violet.

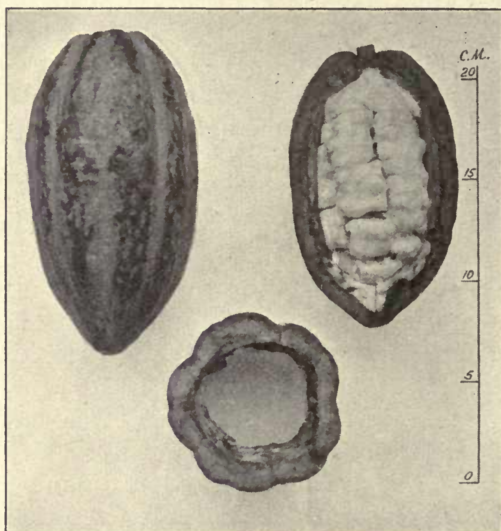


Fig. 32.—Surinam Amelonado.

The present writer considers the non-bottle-necked to be the most typical, but it is true that many trees are to be found with fruits which show a distinct constriction near the fruit-stalk. The colour is red or yellow or yellowish-brown.

The *Venezuela Amelonado* is generally called "Sambito." As has already been mentioned, the intercrossing of Sambito and Criollo (pollination of Sambito by Criollo) has given rise to the occurrence in Venezuela of Sambito types with large round seeds. Such a type is to be seen in Fig. 33.

The *Guadeloupe Amelonado,* which is considered there to be the oldest variety on this island, was imported long ago from Martinique and is called "cacao creole."

Local types of the *Calabacillo* are not worthy of description, as this coarse variety is nowhere of any importance.

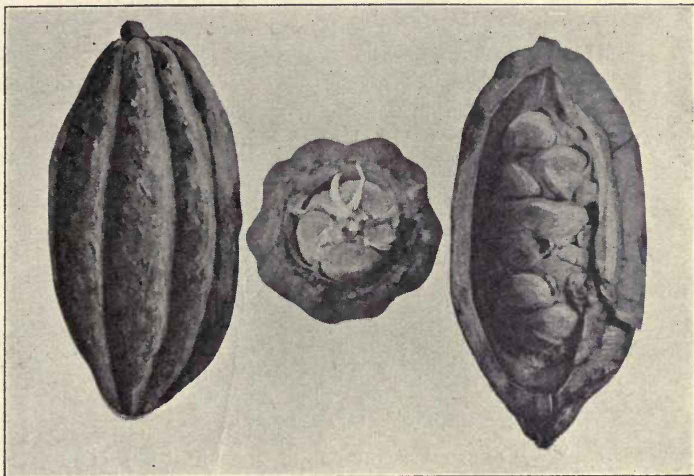


Fig. 33.—Venezuela Sambito (=Amelonado), with large seeds.

Summary

In this chapter we have tried to enumerate and to describe the different varieties with their local types. It must not be thought, however, that our enumeration of these local types is complete. Of a great number of local types no description exists, and of the types described only a few have been the subject of thorough investigation; the number of local varieties for which figures have been collected in regard to the size, weight, etc., of the fruits is very small indeed.

The following list gives a summary of the varieties and the local types described, with the local names :—

I. CRIOLLO.
- A. *Criollo types.*
  - Venezuela Criollo.
  - Ceylon Criollo ("Old Red").
  - Java Criollo.
  - Samoa Criollo.
  - Madagascar Criollo.
  - Nicaragua Criollo ("Cacao del pais").
- B. *Porcelaine.*
  - Java Porcelaine.

II. FORASTERO.
- A. *Angoleta.*
  - Venezuela Angoleta.
  - Trinidad Angoleta ("Trinidad Forastero").
  - Java Angoleta.
- B. *Cundeamor.*
  - Venezuela Cundeamor.
  - Trinidad Cundeamor ("Trinidad Criollo").
  - Ecuador Cundeamor ("Esmeraldas").
- C. *Amelonado.*
  - Ecuador Amelonado ("Cacao nacional").
  - San Thomé Amelonado ("San Thomé Creoulo").
  - Surinam Amelonado.
  - Guadeloupe Amelonado ("Guadeloupe Creolo").
  - Venezuela Amelonado ("Sambito").
- D. *Calabacillo.*

The figures for some of these types may also be summarised here :—

	Length of fruit in millimetres.	Diameter of fruit in millimetres.	Proportion of diameter to length.	Weight of fruits in grams.	Weight of seeds in grams.	Proportion of weight of seeds to weight of fruit.	Number of seeds.	Weight of one seed (grams).
			Per cent.			Per cent.		
Java Criollo	170	81	48	467	97	21	32	3
Madagascar Criollo	160–200	60–90	38–45	...	...	...	...	...
Nicaragua Criollo[1]	155	86	55	557	203	36	...	...
Trinidad Angoleta	190–200	90	45–47	585–765	73–93	12	37	2–2½
Trinidad Cundeamor	195–210	75	36–39	495	73–75	15	43–44	1·7
Ecuador Amelonado	190–230	100–120	52–53	...	...	...	...	...
San Thomé Amelonado	140	75	50	475	89	19	48	1·9
Surinam Amelonado	160	85	53	559	128	23	41	3·1

[1] These figures, which are quoted from Zehntner, are for Nicaragua Criollo grown in the Botanical Gardens at Buitenzorg. It may be that they do not represent the average of Nicaragua Criollo grown in Nicaragua.

CHAPTER VI

THE CULTIVATION OF COCOA

In this chapter we propose to describe the different operations which have to be carried out during the establishment and running of the plantation.

While it stands to reason that the experience gained in other countries should give the practical man hints for the improvement of his methods in some way or other, still too great reliance on such experience is a fruitful source of mistake, and a good dose of conservatism is the first thing needed for every grower of cocoa. In establishing and running a plantation, the newcomer would do well to follow the methods locally adopted. These methods may contain faults, but the latter can be found out only in the course of years by close observation of the home plantation and those around it. An enormous amount of money has been lost, and is still being lost, by men without local experience who want to improve on the old-fashioned way at once, or who adopt in the tropics, without thorough experiment, methods used in temperate climates. In reading this chapter, therefore, the reader should remember the final exhortation of an old teacher of agriculture after he had delivered his last lecture to his students: "And now, gentlemen, go into the field and see how others do."

A. Establishment of the Plantation

Clearing the forest.—The land selected for the plantation will in most cases be virgin land covered with

forest, or land abandoned many years ago and covered with secondary bush. The first work to be taken in hand, therefore, is generally the clearing of the forest or bush. The smaller trees and shrubs are cut down first, and then the big trees. The wood is then arranged into heaps or rows, so as to clear the space where the plants are to be planted.

Here the question arises whether the planter should burn the wood or not. Burning has several practical advantages. It clears the surface of the soil and kills the weeds, as well as many other enemies. Moreover, it is easier later on to weed burned land, while the heaps or rows of unburned wood give rise to the growth of troublesome weeds, and in many countries of vines, which tend to entangle the young plants. Another drawback of not burning lies in the fact that some trees are very hardy, and when cut down and not burned repeatedly produce roots and suckers. Finally, the heaps of unburned wood being favourite shelters and breeding places for all sorts of injurious insects, the burning kills a lot of enemies of the young plants.

On the other hand, however, burning has the disadvantage of destroying a good part of the humus which is incorporated in the upper layer of the soil, while the fertilising effect of the fallen trees and shrubs is reduced; the wood gradually rotting adds much more to the fertility of the soil than when burned to ash, of which, especially on hillsides, a great deal may be washed away by rains or blown away by wind. It is a curious fact that the bad effect of burning is especially felt on soils which are very rich in humus, and are more or less peaty. So much of the humus may be destroyed in burning, and at the same time the soil may cake together in such a way, that it is hardly possible to grow any crop on it without the expenditure of much labour and expense in bringing it back to proper condition.

Generally speaking, however, the planter will consider it more practical or even essential to burn the

wood. Accordingly, the dry season is usually chosen for clearing the forest, for it is always necessary to leave the wood lying in the sun for a few days if it is to burn well.

In some countries, in clearing the forest, the bigger trees or special kinds of trees are left standing in order to give immediate shade to the young plants, but this method is not generally adopted, and is certainly not advisable. Only very special kinds of trees are suitable as shade trees, and it seldom occurs that these are to be found in the forest; moreover, in a good plantation the planter wants his shade trees to stand at regular distances apart; and, finally, the shade given by forest trees is not the kind needed by the young cocoa plants, which require the greater protection afforded by temporary shade plants such as bananas or tannias. Hence it is not advisable to plant cocoa in old coffee fields, leaving the shade trees standing, as is generally done in Java. When the cocoa plants grow up under the only shade which these trees afford, they result in short trees with an irregular, bushy or compact branch system, and with a stem liable to split when the branches bear much fruit (Fig. 35). Bananas, also, do no better in such circumstances, for they have only a poor and slow growth under shade. It is therefore advisable to cut away the old shade trees and to plant a new temporary shade when a coffee field has to be changed into a cocoa field. But of course this involves a greater expenditure.

The cocoa tree is very sensitive to wind. If, therefore, the piece of land chosen is bounded by open land, by savanna, or by a river, on the side of the prevailing wind, it is advisable and sometimes necessary to leave a border of forest as a wind-break. Thus in Surinam, for instance, wherever cocoa is cultivated near the riverside, the plantation is never extended close up to the river—at any rate not when the latter runs on the windward side (*i.e.* on the east), and a border of forest is always left along the bank.

In very windy countries it may be advisable to leave such rows of wind-breaks at regular distances facing the prevailing direction of the wind. In such cases Fauchère[1] considers it absolutely necessary to have a series of shelter-belts 100 metres (say 110 yards) apart, each at least 10 metres (11 yards) broad. This recommendation, especially as to the width of the shelter-belts, is well worth consideration. In such countries it is sometimes even necessary to plant only on the leeward side of the hills or mountains. This is, for instance, the case in some parts of Java. However, the method of leaving parts of the forest as wind-breaks has a drawback. It has been found by experience, especially when only narrow belts of the forest are left, that some of the trees are liable to die early, and that, standing unsheltered and in the open, the tall trees may fall down, causing damage instead of preventing it. For these reasons it is sometimes better to clear the whole forest and to *plant* wind-breaks. The planter is then in a position to choose those species of trees which are specially advantageous as wind-breaks, and sometimes even trees which are themselves productive. The planting of such wind-breaks will be discussed later.

Management of the land after the clearing of the forest.—The fertile virgin soil quickly loses a great part of its fertility when left unshaded. Under the direct influence of the sun and the consequent high temperature, and also because of the free circulation of the air, the texture of the soil changes, mainly in consequence of the destruction of the humus. It is therefore necessary, immediately after the clearing of the forest, to plant some quick-growing plant in order to have the soil shaded as soon as possible. Corn is often used for this purpose, and sometimes plantains, bananas, or cassava, according to the character of the soil, the climate and the needs of the country. In many districts corn is sown out, and plantains or bananas are planted at

[1] Fauchère, *Culture pratique*, p. 32.

the same time; after the harvesting of the corn (in three to four months), the plantains or bananas have reached a height of a few feet, and as they grow up quickly, they may give useful shade to the soil within a few months, if not planted too wide apart (say at a distance of 12 feet). It is, however, absolutely necessary that the corn should not grow too close to the bananas; otherwise these are so checked in their early growth that the plants remain weak and slow-growing for a long time. It is advisable to keep an open space of at least 2 to 3 feet in each direction round the plantains or bananas.

Planting of wind-breaks.—As has been pointed out, it may sometimes be considered advisable not to leave belts of the original forest as shelter-belts, but to plant belts of trees specially adapted to act as wind-breaks.

The drawback of this method, however, lies in the fact that good, strong, wind-breaking trees are always slow growers, so that several years must elapse before the trees planted can serve their purpose. It is therefore advisable to plant in addition a quick-growing kind of tree to provide shade during the first few years. Very quick growers are: *Albizzia moluccana*, *Adenanthera pavonina* and *Adenanthera microsperma*,[1] but their wood is so brittle that they are only to be relied upon in the first two or three years, and their lifetime is very short. Fairly quick growers with less brittle wood are: *Erythrina umbrosa*, *Erythrina velutina*, *Gliricidia maculata*, *Swietenia macrophylla*, *Cedrela odorata*, *Pithecolobium Saman*, *Peltophorum ferrugineum*, and others. Slow growers but with very strong wood are: the mango (*Mangifera indica*), the sapodilla (*Achras Sapota*) and many timber trees, of which different kinds are to be found in every country. Seed is always easily to be had from the mahogany (*Swietenia mahagoni*) and other trees of like character.

[1] The well-known *Cassia florida*, though a quick grower, cannot be recommended, because for some reason or other it exerts a bad influence on other trees in its neighbourhood, checking their growth.

Among the useful plants which can be used as wind-breaks the rubber trees may be particularly mentioned, though their wood is not very strong—for wet countries the Pará rubber (*Hevea brasiliensis*) and the *Castilloa elastica*; and for dry countries, *Manihot Glaziovii* and other rubber-producing species of Manihot. It is questionable, however, whether the latter can thrive in countries wet enough for cocoa.

Many of the trees just mentioned lose their lower branches in a few years and develop long branchless trunks. If planted in a few rows and not very closely, such trees allow the wind to blow between their trunks, and it is therefore advisable to plant before or behind them a few rows of other trees which retain branches at the base of the stem. Suitable trees for this purpose are: the "rose-apple" (*Eugenia Malaccensis*), the Liberian coffee (*Coffea liberica*), the "morinda" (*Morinda citrifolia*). The "rose-apple" is a particularly useful wind-break. In many cases, however, another plant will be more useful than any of the trees mentioned—viz. the bamboo. This plant would, indeed, be the first to be recommended, if it had not the drawback of extending its roots, thus taking possession of a larger area of soil every year. In some situations, however—for instance, on dams which are not planted with any other plant—this drawback is not great, and in such cases the bamboo is very valuable indeed, though even then it must be kept in check.

Other trees which have been recommended by different authors as wind-belt trees may be mentioned here:[1] *Albizzia Lebbek*, *Albizzia odoratissima*, *Erythrina lithosperma*, *E. oralifolia*, *Artocarpus nobilis*, *Cassia siamea*, *Filicium decipiens*, *Melia dubia*, *Mesua ferrea*, *Pterocarpus indicus*, *P. marsupium*, *Vateria acuminata*, *Acacia pycnantha*, *Cedrela serrata*, *C.*

[1] See, for instance, Wright, *Cocoa* (1907), pp. 67-70, and Dybowski, *Traité* (1902), p. 88.

Toona, Myristica laurifolia, Azadirachta indica, Thespesia populnea, Acacia Cyclops, Schinus terebinthifolius, Caesalpinia sapan.

Drainage.—The labour to be expended on the drainage of the plantation varies much in different countries. Where the rainfall is comparatively small and the land sufficiently inclined to allow the surplus water to run away, no drains have to be put in. This seems, for instance, to be the case in San Thomé. In other countries where the rainfall is greater, as for instance Trinidad and Ceylon, and the natural drainage insufficient, attention has to be paid to the digging of small trenches. Finally, in countries such as Surinam, with a heavy rainfall and flat land, a whole system of canals and trenches has to be dug in order to obtain a proper drainage of the soil.

It is always advisable to put in the drainage at the same time as the planting of the catch-crop; and where drainage is essential to the growth of all plants (as is the case in Guiana), this is not only advisable but necessary. In many instances the slow digging of the drainage has resulted in a slow growth of the catch-crop, the spoiling of the virgin soil, and a poor growth of the young cocoa.

In comparison with other crops—such as sugar-cane, cassava, bananas, citron trees and coffee—cocoa may be considered as a plant which is not very particular about drainage. All the same it feels the bad effects of a too high water-level, and wherever the natural drainage of the soil is deficient, it is useful to keep the water down to a depth of at least 2 to 3 feet. This, however, is not always done by cocoa planters, and it must be confessed that cocoa often thrives well on lands which are not properly drained and which are soaked with water for several months in the year. The fields of many small proprietors in Surinam offer an example of this, and according to Wright the same condition is observed in Ceylon, where on many estates drainage is neglected to a remarkable degree, while the

cocoa still "grows luxuriantly in spite of undrained and sour condition of the soil."

This can only occur, however, on exceptionally good and rich land, and the careful planter will always have his soil drained as well as possible. The good results of his care will be evident in a longer life of his trees and a greater power of resistance against certain diseases (*e.g.* canker), especially in years with a heavy rainfall.

In hilly countries, where the soil is porous, it will be sufficient to make shallow drains of, say, 1½ to 2 feet deep, made almost at right angles to the slope and on a small incline (this incline is generally made about 80°). When, however, the soil is compact and the air penetrates only with difficulty, deeper drains may be recommended, both to get rid of the water and to aerate the soil to a greater depth.

In Guiana, and especially in Surinam, the drainage question is more important than in any other cocoa-growing country. The system adopted there will be discussed in Chapter IX.

It is useful and instructive for the planter to obtain an idea of the level of the water in the soil at different times of the year and on different parts of his estate. By digging holes or short trenches he will see that, especially in the rainy season, this level is at some places much higher than he expected, the reason being that at those places the subsoil has a low grade of permeability. Where he expected to find water standing only at a depth of 4 feet or more, after a shower in the rainy season he may find it at a depth of 1 foot for several days. In such a case it is advisable to improve the drainage by digging trenches 2 to 3 feet deep.

In some countries, where the rivers rise considerably during a season of the year, it is impossible to keep down the water-level. In such cases it is often found that occasional floods are very well endured by the cocoa, at any rate when they do not last too long

and when the soil can afterwards drain out properly. Wright[1] gives some good examples of this condition: "Cacao trees, when once established, appear to be able to stand occasional floods. Several acres of mature cacao at Peradeniya are subject to floods once or twice a year; the water rises to a height of three or more feet above the bases of the trees, and remains in a similar condition for a few days; nevertheless, these plots yield fairly good harvests of two to three hundred pounds of cacao per acre per annum. In the Amazon valley cacao trees often grow wild in districts which are periodically flooded, and the cacao trees, it is said, have their stem under water for as long as three months at a time. The same occurs for periods of a few days on some plantations of healthy cacao in Venezuela and in several parts of Ceylon." How long the trees will stand such a flood depends on the quality not only of the soil, but also of the water. On compact retentive soils, the cocoa will not stand floods so well as on porous soils with a smaller water-retaining power; and standing water does greater harm to the plants than water which is continually moving more or less.

Variety to plant.—In establishing a plantation the planter will obviously try to plant the finest variety of cocoa producing the best quality of product. From this point of view the Criollo and the *pentagona* would always have the preference. Unfortunately, these fine varieties have certain drawbacks. They are so particular about climate and soil that they only thrive in a few countries. It may be said, speaking broadly, that only in Venezuela and Java is the Criollo cultivated on anything like a large scale, while no large plantations at all of *pentagona* seem to exist. On a small scale the Criollo is cultivated in several countries, especially Nicaragua, Guatemala, San Salvador, Samoa and Madagascar.

Further, the area planted with the Criollo variety does not increase. In some countries it has already

[1] Wright, *Cocoa*, p. 61.

given place wholly to the less fine but hardier Forastero varieties. This is the case in Trinidad, and to a great extent also in Java and in Ceylon; and even in Venezuela the Forastero seems to be gradually taking the place of the Criollo. This is not to be wondered at. The difficulties connected with the cultivation of the Criollo are numerous, and not always compensated for by the higher price of the product. The Criollo, especially when young, requires in every respect much greater care than the Forastero, and it is also more liable to disease. It begins to bear two or three years later, and the yield per acre is smaller than with the Forastero.

For these reasons the planter will generally prefer a good variety of Forastero, and will only decide on Criollo in places where the conditions are exceptional—where the soil is very fertile, rich in humus and of fine texture; where the climate is favourable in every respect; where the situation is a sheltered one; where no destructive diseases are prevalent; where intelligent labourers are available.

The question as to which type of Forastero should be recommended is a difficult one. Types which are fine in one country often lose their good qualities in another. So, for instance, the Trinidad Forastero (an Angoleta type), as well as Hart's "Trinidad Criollo" (which is really a Forastero of a Cundeamor type; see Chapter V.), both give in Trinidad a very good product which is much finer than the Surinam cocoa; but when imported into Surinam, they turned out to be of no especial value in that country, and in several respects inferior to the common Surinam Amelonado.

Accordingly, the safest plan for the planter who establishes a plantation in a country where cocoa is already grown, is to study the local variety and try to find its best and most profitable types. He should also examine the varieties grown in neighbouring countries, where the conditions of soil and climate are not very different. At the same time, the study and comparison of the different good varieties from all parts of the

cocoa-growing world is work which should be done by Experiment Stations and Botanic Gardens rather than by the individual planter.

Whatever type be finally chosen for the plantation, it is always advisable to plant only one variety. A mixture of different varieties is very troublesome, not only in the cultivation, which should be as far as possible uniform, but also in the curing of the product, as different varieties require different methods of curing. Preuss[1] is therefore quite right in saying that the system of those planters is wrong, who, unable to decide between Forastero and Criollo, think that the safest way is to plant both.

A few remarks may be made about the best way of procuring varieties from distant countries. The well-known method of sending young plants in Wardian cases may be considered as the safest, provided that some care is taken of the plants during the voyage; but this method is expensive. If the ripe pods are sent without any further preparation, they only keep for a very short voyage, and soon become mouldy; but if treated by the paraffin method they will often keep for a long time.

The way in which the present writer applied this method was as follows:—The ripe pods were first thoroughly cleaned with a tooth-brush and soap. Then they were dipped, by means of a little string attached to the stalk, in a 0·5 per cent alcoholic solution of corrosive sublimate (5 grams of sublimate in 1 litre of alcohol). In this solution they remained for three minutes. Then they were left hanging till the alcohol had evaporated and the fruits were completely dry; and, finally, they were dipped into liquid paraffin at a temperature of 60° to 80° C. (140° to 175° Fahrenheit); for this purpose a paraffin of a high melting-point was used. The pod remained in the paraffin only for one second. Care must be taken to dip the pod, including the stalk-end, entirely in the paraffin, and to hold it only by

[1] Preuss, *Samoa*, pp. 45-46.

means of the string without touching it. The pod is then hung up in the room on a little stick, so as to hang absolutely free. When the paraffin layer is solid and cooled, the pod is ready to be packed. The paraffined pods must be packed in a suitable mixture which will not break, bruise or scratch the paraffin layer. Peat-dust or fine, sifted sawdust may be used.

The author shipped pods treated in this way with success from Surinam to Java, a voyage of about seven weeks; but it is true that the method is not quite reliable. Sometimes, for instance, gas-bubbles are developed under the paraffin layer, which bursts at these places; and where a burst occurs, decay generally soon sets in. It is not known under what conditions these gas-bubbles are formed, or what is the cause of their formation. It has only been proved that the fruit-wall must not show the slightest black spot, which indicates the beginning of a too ripe condition, and it is therefore better to pick the pods a week before they are really quite ripe.

Seed selection.—Wherever the local variety of cocoa is to be planted, and especially when a plantation with full-grown trees has to be extended, the planter is in a position to select his seed carefully. As a rule, however, very little attention is paid to this point.

It should be a golden rule to the planter, to plant only seed *from the best bearing, healthiest tree* of his own plantation or of the plantations from which his seeds are obtained. The great difficulty, however, is that generally no exact data are available for ascertaining which particular tree is the best. Some trees in a plantation may have the reputation of always giving a high yield, but exact, convincing figures are almost always lacking. It is therefore most important for the planter to study carefully in his plantation a certain number of trees which are strong and healthy and which seem to be good bearers, and to note down every year exactly what is the yield of each of these trees, together with any

other data as to time of bearing, liability to disease, etc. This would enable him to know exactly which trees are the best.

An Experiment Station, of course, would adopt another method of obtaining a good bearing strain of cocoa. One part of the work of such an institution is to pick out the best trees, and to sow the seeds of each selected tree in a separate plot, thus obtaining plots of, say, a hundred trees each, which represent the offspring of each one of the selected trees. These plots will give a better idea of the qualities of the strain than the mother-tree itself. The best of the plots will be kept for further selection. Details of this method would bring us too far from our subject; for the practical planter it is too tedious and requires too much study; he will do enough—and more than most planters do—if he watches the best of his trees, keeping the figures and other data, and using the seed of the one which after some years shows itself to be the best of all. No conclusion as to the bearing power of a tree should be drawn after only one year, or even a few years, for a study of the trees extending over a series of years will show that the annual yield of individual trees varies a great deal.

The pods used for planting must be well matured. Unripe seeds give poor seedlings. It is furthermore necessary to use only big, well-formed seeds; the small ones near both ends of the pod should always be avoided. Before sowing the viscous pulp should be removed from the seeds by rolling them in dry earth or ash; lime will also answer the purpose. Thus treated, the seeds are less liable to attack by insects.

Temporary shade.—The temporary shade must be planted before the cocoa. Like so many other young trees in the tropics, the young cocoa plant must have shade; although sometimes, under special conditions, cocoa can afterwards be grown without shade trees, shade is almost always considered to be necessary in the first two to four years. Only here and there in

some countries—for instance, in Brazil and sometimes in Ecuador—is temporary shade done without, and the

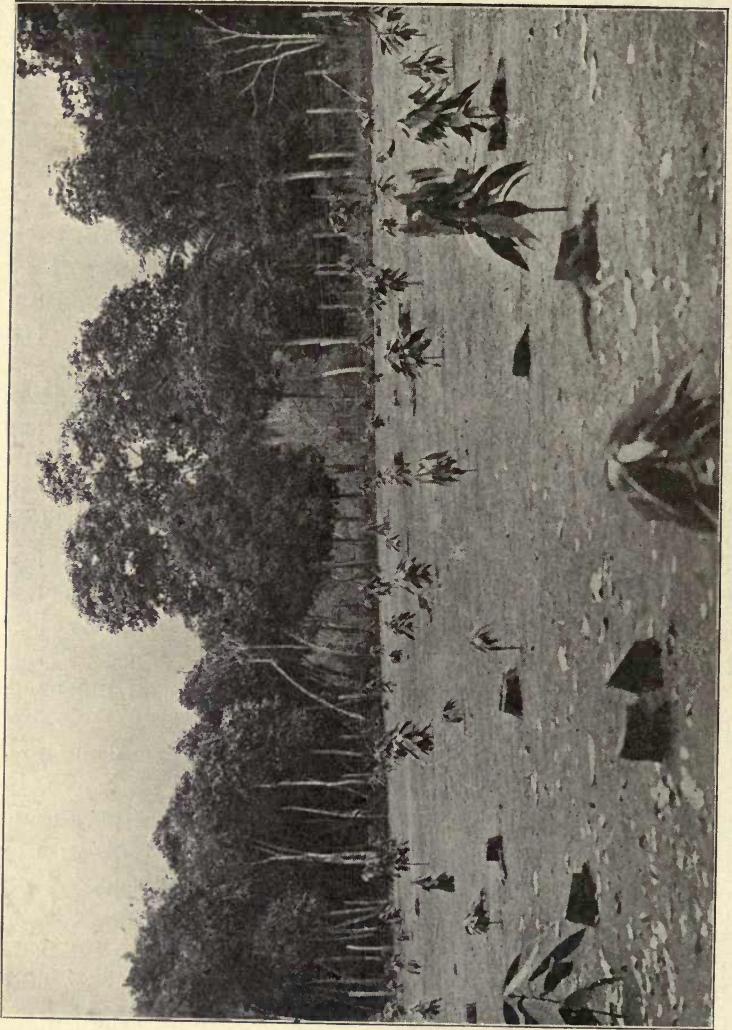


Photo. supplied by Mr. M. E. Seminario.

FIG. 34.—Young cocoa plants grown without temporary shade (plantation "La Elvira," Ecuador).

young cocoa plants allowed to grow up without protection. Fig. 34 gives an illustration of this way of cultivating, as adopted on the plantation "La Elvira"

in Ecuador. Though it must be admitted that under especially favourable conditions of soil and climate this method can be followed with success, it cannot be recommended. The young cocoa plants, and still more the soil, will be benefited by the shade of bananas or some leguminous plant.

Shade trees are not well suited for the temporary shade of the young cocoa. It is true that in some

FIG. 35.—Cocoa grown in an old coffee field under large shade trees.

The low ramification is noticeable. The large, old shade trees are *Albizzia*, the small ones *Leucaena*.

countries trees of the original forest are left standing, and that in those countries (San Thomé, Ecuador, etc.) the young cocoa is grown under the shade of those trees, while in other countries (*e.g.* Java) cocoa is often planted in old coffee fields without removing the old shade trees. Nevertheless this sort of shade is not to be recommended; the young plants grow a weak wood and a stem which easily splits, the stem ramificates too low, and the branch system becomes bushy and compact (Figs. 35, 59).

To obtain a strong stem and well-formed, regular

trees a special kind of shade is necessary during the first three years—not that afforded by shade trees, but

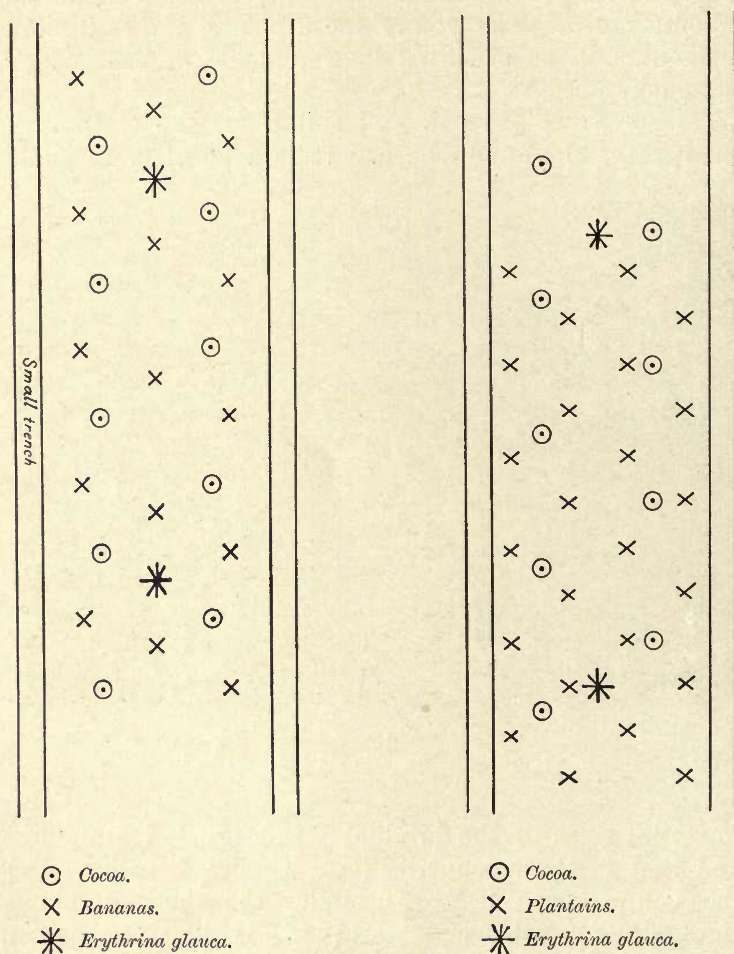


FIG. 36.—Two schemes of planting cocoa under temporary shade of bananas and plantains, as applied in Surinam.

that given by bananas or high tannias, plantains, cassavas, or pigeon peas. In most countries bananas are preferred for this purpose, but on rich soils plantains

may do just as well.[1] Still the banana is always easier to grow than the plantain, and as its roots go deeper it acts at the same time as an improver of stiff soils. The plantain may, however, be preferable from a financial point of view, as on many local markets its fruit fetches a higher price than the banana.

The bananas may be planted as temporary shade at a distance of 10 to 15 feet apart; the plantains are

Photo. Auguste Curiel.

FIG. 37.—Cocoa field of a small proprietor (a British Indian immigrant) in Surinam. The plantains are dying, and the cocoa is without sufficient shade.

better planted a little closer, 8 to 12 feet apart. Fig. 36 shows two schemes of planting adopted in Surinam.

A drawback of the plantain is its short lifetime on soils which are not very rich, so that if this plant is used, the planter must always be careful to plant the permanent shade trees in time, otherwise it may happen that when the plantains suddenly begin to decline, the cocoa will stand without shade. This is not a rare

[1] The banana (often called in South and Central America "bacoba," "bacouba," "bacove") is eaten raw as a fruit; the plantain (often called "bana" or "banana" by the Creole people in tropical America) is only eaten cooked, roasted or baked.

occurrence in the cocoa fields of small proprietors in Surinam (Fig. 37), and the cocoa is often to be seen greatly damaged by the sudden lack of shade.

In Java the "lamtoro" (*Leucaena glauca*) is often used successfully for temporary shade for cocoa and

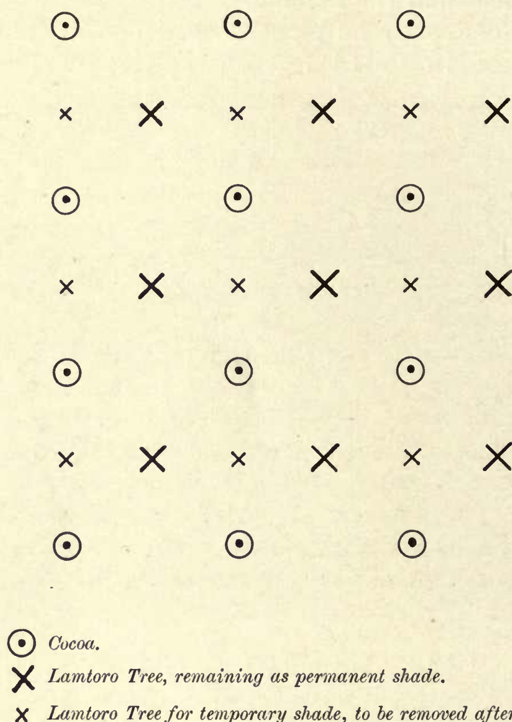


FIG. 38.—Scheme of planting cocoa under the shade of "lamtoro" (*Leucaena glauca*).

The cocoa trees stand at a distance of 17 feet apart.

coffee. A scheme of planting is given in Fig. 38, and see also Fig. 35.

Too close planting will give too much shade for the cocoa, and will result in tall, spindling plants (Fig. 39).

The best time for planting the banana is the time of the first rains after the dry season, or even the end of the dry season a month or so before the commence-

ment of the wet season. It is very advisable at the beginning of the dry season to fork the places where the bananas will be planted, in order that the sun and the air may render the soil loose and friable during the drought.

The cassava plant (*Manihot utilissima*) is in many countries considered useful as temporary shade, but it

Photo. Auguste Curiel.

FIG. 39.—Cocoa grown under too dense shade of closely-planted plantains (cocoa field of a small proprietor in Surinam).

The little cocoa tree, 5 feet high, has not yet ramified, and is bending towards the light.

is not so suitable for cocoa as the banana. It has, not without reason, the reputation of rapidly exhausting the soil, while in stiff clay soils its growth is poor. It does not act as a soil improver like the banana, and it is more particular about the conditions of the soil. In some countries it has the further disadvantage of attracting animals which eat the tubers, as in Madagascar the wild hog, which seems to be able to cause enormous damage in this way by digging up the roots of the young cocoa and by destroying the shade.

In many countries, however, cassava is used to a large extent as temporary shade, especially by the small proprietor, for whom this plant has a greater household value than the banana. The cassava cuttings may be placed three in number round the place where the cocoa will be planted, at a distance of 1 to 2 feet from this point.

The pigeon pea (*Cajanus indicus*) does not appear to be greatly used anywhere, the reason probably being that it is not so useful as the banana or the cassava. It is not eaten in such large quantities, is not such a daily food, and the gathering is a tedious work which takes much time. Further, it has no use as a forage crop, although several authors assert the contrary. In other respects, however, the pigeon pea is very useful; it grows well even under unfavourable conditions of soil; it improves stiff and sour soils remarkably quickly; and as it can stand very rough pruning without damage, the exact amount of shade required can be obtained.

Other plants sometimes used for the purpose of temporary shade are the tannia (species *Xanthosoma* and *Colocasia*) (Fig. 40), and the castor-oil plant (*Ricinus communis*), the latter, however, never to a large extent.

Planting of inter-crops.—In most systems of establishing a plantation, the growing of catch crops is not possible. Other crops cannot be cultivated under the shade of bananas or other temporary shade plants, when regularly planted, and this is also the case later on, when the permanent shade trees have grown up. Inter-crops, however, come into consideration in places where no bananas are used for temporary shade, and the planter will look out for another plant which will preserve the soil and if possible yield some paying product.

As soil improvers, leguminous plants belonging to the order of *Leguminosae*—*e.g.* all sorts of beans, peas, ground-nuts, mimosa, etc.—are always to be preferred, but sometimes plants belonging to other families have been used with apparent success. On the plantation

"Siloewok Sawangan" in Java, for instance, the sweet potato (*Ipomaea batatas*) is used as a soil-preserver between cocoa and under the light shade of the "kapok" (*Eriodendron anfractuosum*) (Fig. 40). The sweet potato gives no room for weeds, and troublesome grasses are in particular well kept down. The soil on this plantation is very fertile, rather heavy and rich in humus.

FIG. 40.—Sweet potato (*Ipomaea batatas*) used as a soil preserver for young cocoa planted under "kapok" (*Eriodendron anfractuosum*), with tannia for temporary shade (Java).

The "lamtoro" (*Leucaena glauca*) (Fig. 35), a few species of indigo (*Indigofera tinctoria* and others), the "rorako" (*Ormocarpum sennoides*) and the "roempoet toeri" or pigeon pea (*Clitoria cajanifolia*) also suit the purpose perfectly well.

In Surinam the pigeon pea (*Cajanus indicus*) would be suitable, but the dense shade, first of bananas, and afterwards of the permanent shade trees, make the use of leguminous inter-crops impossible.

More paying, but not so useful as a soil preserver and improver, is the cassava. This plant has already

been mentioned as a temporary shade plant, but it is considered in different countries to exhaust the soil quickly. By small proprietors it is often planted irregularly between the young cocoa and the bananas.

Sometimes lemon grass, ground-nuts, chillies, and (in

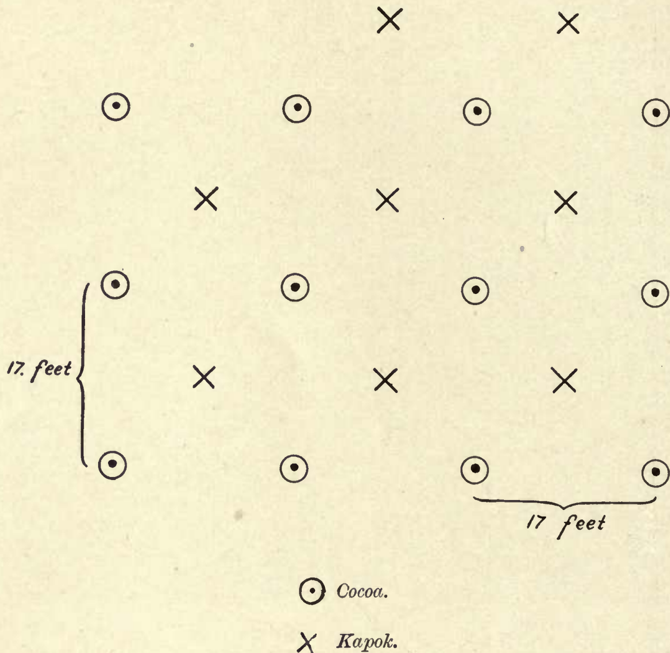


FIG. 41.—Scheme of planting cocoa and "kapok" (Java).

The cocoa trees are 17 feet apart, and the "kapok" the same.

some parts of Ceylon) even cotton [1] are used as inter-crops, but they cannot be recommended.

It has been a subject of investigation in different countries whether it is possible to replace the ordinary shade trees by trees which yield a product of value, such as rubber (*Hevea*, *Manihot* and *Castilloa*), "kapok" (*Eriodendron anfractuosum*), citrus, and also camphor, nutmeg, or even coconut trees. In most cases, the

[1] Wright, *Cocoa*, p. 83.

shade afforded by trees of this kind is not the most suitable for the cocoa, but practical results have been obtained in Ceylon with cocoa under the shade of Pará rubber (*Hevea brasiliensis*), while in Java cocoa is successfully interplanted with "kapok" (*Eriodendron*

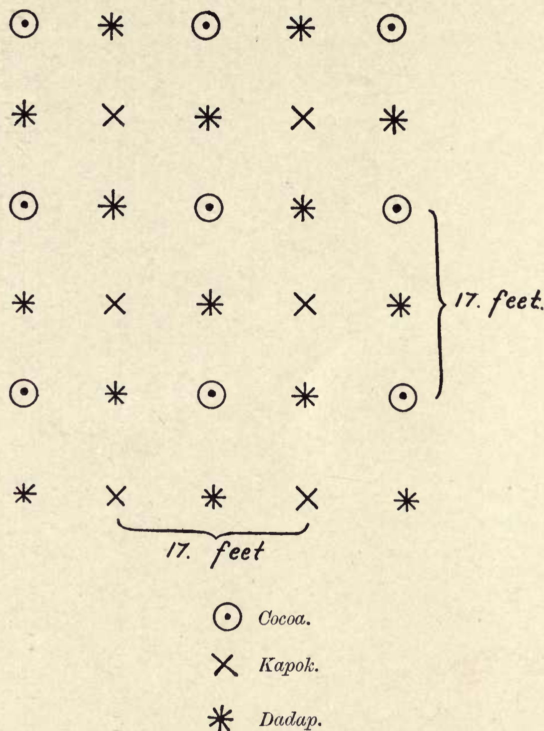


FIG. 42.—Scheme of planting cocoa and "kapok," interplanted with "dadap" (*Erythrina lithosperma*)—Java.

anfractuosum), and also with Castilloa ("Central America" or "Panama rubber").

Several estates in Ceylon have obtained satisfactory results by planting cocoa and *Hevea*, the cocoa and the rubber being planted from 15 to 25 feet apart, according to local conditions. The most usual plan is to plant the trees 20 feet apart, so that there are 100 trees of each kind per acre. With this system estates with

Pará rubber trees, eight to eleven years old, planted amongst slightly older cocoa, are now obtaining a yield of about two hundred lbs. of rubber and the same of cocoa per acre per year.[1]

Interplanting with Castilloa does not appear to have

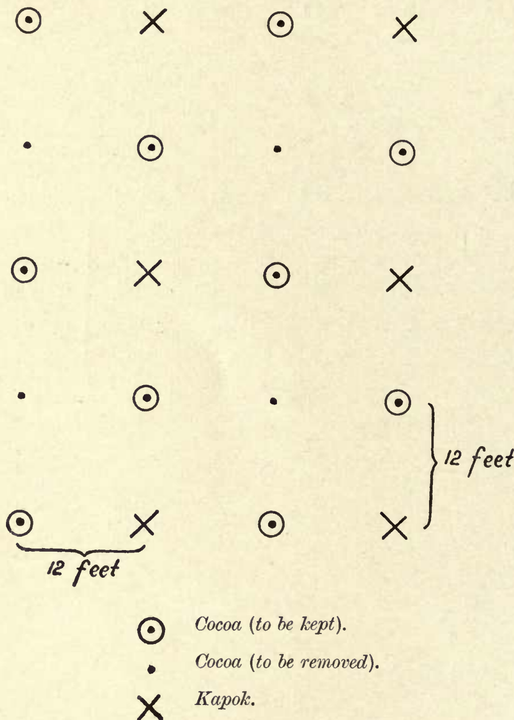


Fig. 43.—Scheme of planting cocoa and "kapok."

In the rows where no "kapok" has been planted, every other cocoa tree is removed when five years old (plantation "Siloewok Sawangan," Java).

met with much success in Ceylon, while the Ceara rubber (*Manihot*) is considered to be decidedly detrimental to the cocoa.[2]

In Java interplanting with "kapok" (*Eriodendron anfractuosum*) is to be found on many plantations. Different distances have been adopted, but the best

[1] Wright, *Cocoa*, pp. 87-88. [2] *Ibidem*, p. 93.

arrangement is when both the cocoa trees and the "kapok" are 17 feet apart (Fig. 41). This system is a profitable one when the climate is not too wet for the "kapok"; yields of about 400 lbs. of cocoa and 300 to 400 lbs. of "kapok" are often obtained. The soil, however, is not sufficiently protected, at any rate when the cocoa plants are young, and it is therefore advisable to plant some leguminous crop, as previously mentioned.

Fig. 44.—Cocoa field planted as indicated in Fig. 43, sweet potato being used as a cover-crop.

If this is neglected, the soil soon becomes spoiled and covered with grass and noxious weeds.

Instead of a low inter-crop, shade trees may be used; these must not be allowed to grow too high, and should remain lower than the "kapok" trees. The "dadap" (*Erythrina lithosperma*) is sometimes used for the purpose (Fig. 42).

On some plantations the "kapok" and the cocoa are planted closer, 15 or even 12 feet, but the results seem to be better when they stand 17 feet apart. A very good scheme is to plant the cocoa trees as indicated in Fig. 43, and to thin out every other one

when they are five years old. The cocoa trees in each row are finally 24 feet apart, while the rows are 12 feet apart (Fig. 44).

In Java the author has seen Castilloa successfully used as an inter-crop (Fig 45). The cocoa trees were planted 18 feet apart, the Castilloa 36 feet apart; in some fields the distances are smaller, the cocoa 12 or 15 feet apart and Castilloa 24 or 30, but speaking generally this is not to be recommended.

Planting distance.—The planting distance varies in the different countries to a great extent, and in every country conflicting opinions are met with as to the best distance. This is not to be wondered at, as every condition which influences the growth of cocoa—*e.g.* the kind of soil, the drainage, the climate, and not least the shade—influences also the solution of the problem of distance.

Speaking generally, it may be said that the distance should be chosen so that a little less space will be given to each tree than is required for its full development. This general rule may at first sight be considered illogical, as it would naturally be expected that the distance should at any rate be chosen so that a full development of each tree is possible. This would be the case if cocoa were cultivated as an ornamental tree, when full development would be essential. It would also be the case if it were a tree which needed a great amount of sunlight to give its highest yield of blossoms and fruit—as, for instance, the orange, the mango and many other fruit trees. In those cases each tree has to have sufficient space for the entry of the maximum amount of sunlight. The cocoa tree, however, has not these requirements, and forms its flowers and develops its fruits well even in shady positions.

It would therefore be uneconomic to plant the trees at distances so as to allow a quite free development, for in this way the highest return per acre would not be obtained. The yield of each tree is not lower

if its branches are partly covered by those of its neighbour.

Photo. Hisgen, supplied by the late Mr. C. MacGillavry.

Fig. 45.—Cocoa and Castilloa (plantation "Djati Roenggo," Java).

The close planting must not, however, be over-done. It is true that even very closely-planted cocoa trees

frequently thrive well and give good returns, but the drawback to this system lies in the difficulty of cultivating the trees and also, though to a less extent, of picking the crop. Cleaning the trees of dead or dying branches, pruning, and removing parasites or insects (as, for instance, grubs which bore into the branches) are difficult operations when the trees are planted very close together. Accordingly, in places where a great deal of care has to be given to the trees, there will be a tendency to plant them wide apart (*e.g.* in Surinam), while in countries where cocoa grows very easily and where very little care is necessary, it is generally the custom to plant closely (*e.g.* in Ecuador) and this without disadvantage. It is clear, therefore, that general rules cannot be given, and that the right distance must be found out by the planter himself, as it will vary according to circumstances. The extremes are 9 feet and 20 feet, 12 to 17 feet being the most usual.

The right distance depends also on the growth of the trees and the dimensions they adopt, and is therefore affected by all the conditions which influence this growth. The most important of these conditions are: (1) the climate; (2) the soil; (3) the variety planted; and (4) the shade given.

As regards climate and soil, it may be said that where the climate is very suitable and the soil very fertile, the growth will be luxuriant and the distance may be large; but the author considers 20 feet generally as the maximum. Wherever climate or soil are deficient in one respect or other, closer planting is advisable. As Wright very correctly says: "In countries where cacao is grown at various altitudes the trees at the higher elevation are rarely so well developed as those in more suitable climes; similarly the growth on cabooky or gravelly soils is less pronounced than on rich alluvial flats. It is obvious that the trees, which either in virtue of the climate or soil, cannot develop a vegetative system as

large as those growing under more favourable conditions, will not take possession or protect as wide an area of land, and can therefore be planted closer together."[1]

Thus in Surinam the trees are planted closer on sandy soil than on rich clay soil; on the latter a distance of 15 feet is generally considered too small and 18 feet is preferred, but on the sand 15 feet or even a little less seems the best distance. In Trinidad the soil is not so rich as in Surinam, so that the trees are accordingly planted closer together, and still closer on ridges and elevations where the soil is poorer than on flat lands. The distances vary, generally speaking, from 12 to 15 feet.[2]

The different varieties develop their branches and foliage in different ways. The Criollo and *pentagona* have often a comparatively weak growth, and accordingly the space required by these varieties, and the planting distance to be given, are smaller than in the case of Forastero varieties. The figures of 15 and 18 feet given above for Surinam apply to the only variety grown there, viz. Surinam Amelonado. In countries where the finer varieties are grown, especially in Venezuela, the planting distance is generally smaller, and Preuss[3] states that in that country the trees are generally planted at a distance of 12 feet, sometimes less, but very rarely more; and this seems to be a well-chosen distance. In Java, however, the Criollo makes strong and big trees on suitable soil and the foliage system is not thin; but the trees do not spread out their branches as Forastero does, and 15 feet is generally considered to be the best distance.

The shade given has to be carefully taken into account in deciding the planting distance, and ignorance of this is one of the main reasons why experiments with the cultivation of cocoa without shade have failed in so many cases. As will be pointed

[1] Wright, *Cocoa*, p. 65.
[2] Olivieri, *Treatise* (1903), p. 60; Hart, *Cacao* (1911), p. 36.
[3] Preuss, *Expedition*, p. 229.

out in discussing the question of shade, cocoa requires in the first place a shaded soil. This shade for the soil is obtained partly by the foliage of the shade trees and partly by the foliage of the cocoa tree itself. Therefore, if the shade trees afford a fairly dense shade, the cocoa trees may be planted wide apart without injury to the soil; but if the shade is light, or if there are no shade trees at all, the cocoa trees must be planted close together so as to afford the necessary shade to the soil by means of their own foliage.

Accordingly, it is not surprising that in Grenada, where no shade trees are used, the cocoa trees are generally planted 9 feet, or at the most 12 feet, apart. So in Ecuador—where, at any rate in the older plantations, no shade trees are planted, though forest trees are left in clearing the forest—this irregular and light shade of the shade trees accounts for the fact that the cocoa is planted there as close as 7 to 9 feet in the old fields and 10 feet in the new fields. Wherever experiments are made in growing cocoa without shade trees or with less shade than usual (*e.g.* by using *Hevea brasiliensis*), it will generally be found necessary to plant the trees closer than is otherwise customary.

Finally comes the question whether it is advisable to plant closely with the intention of thinning out afterwards. So far as the author is aware, this practice is not adopted in any country to any extent, but it has its advantages in places where the young cocoa plants grow easily and do not want much care. It is clearly an advantage to be able, in the fourth, fifth and perhaps sixth year, to pick from a greater number of trees; and it is also an advantage that the closely planted trees quickly shade the soil. If the superfluous trees are thinned out at the right time and are not left standing too long, no inconvenience may be experienced. Here, however, comes the trouble. It is only too well known how a planter dislikes to cut down well-developed trees in bearing, and he is often inclined to leave the additional trees standing too long, in order to obtain

a few more crops from them. This eventually ends in loss, for if the superfluous trees are thinned out too late, the others which have to remain permanently will already have adapted their leaf and branch system to their close quarters and will not again assume their right form. This is so much to be dreaded, and it happens so often, that the system cannot be considered suitable for general adoption.

As has already been pointed out, it is only in countries where the young plants grow well without much care and where they are not troubled by animals or fungus diseases, that a very careful manager, who will not yield to the temptation to leave the superfluous trees too long, may profit by the adoption of this system. In Fig. 43 a good system, followed on the plantation "Siloewok Sawangan" (Java), is represented.

When the other system is followed and the trees are from the beginning at their proper, permanent distance, more care has to be given to the temporary shade plants, such as bananas, cassava, etc., for it is very important to keep the soil well shaded and to prevent it being washed away.

Sowing out in the open field and the nursery system.—When the plants used for temporary shade are already grown up so as to afford the necessary shade, the cocoa can be sown out. With bananas or plantains the shade will not be sufficient before a year after planting; with cassava and tannia, especially when they are planted fairly close to the cocoa, the shade afforded may be sufficient a little earlier, say after six months.

As regards the question which is to be preferred, sowing out in the open field or planting from nurseries, it may be said that both methods have their advantages and that local conditions must decide which method is to be adopted. Speaking generally, it must be obvious that sowing out in the open field—or planting at stake, as it is often called—is the simplest, the most practical, and in many cases the best for the growth of the young plant. When no special reasons for planting

out from nurseries exist, it is difficult to see why planting at stake should not be generally adopted. This simple and natural method has the advantages that the plants are not disturbed in their growth, that a free development of the root system is obtained, and that a saving of labour is effected.

In many cases, however, when planting at stake is practised, it is advisable to have a nursery made ready in order to supply plants in case those in the field should for any reason fail to succeed. The nursery system, moreover, is indispensable when the plants require special care in infancy—for instance, when they are liable to attacks from animals (insects, rats, etc.) or parasites, which do not damage the plants after they have attained a certain height but against which the very young plants must be protected.

In some countries rats are very troublesome to the young plants; they destroy them by eating the seed-lobes, of which they are very fond. In other countries the mole-cricket (*Gryllotalpa*) destroys the young plants by cutting the young stem a little above the soil, also with the object of eating the seed-lobes. In the open field such enemies are fought with difficulty, but in the nurseries precautions can be taken against them. The nurseries can be protected against rats by wire-netting, or can be established in a place which is difficult for the animals to reach. The mole-crickets, too, will rarely cause serious damage in nurseries, as their habit is to wander through the fields and pick up whatever edible plants they find. Still, if these or other insects are to be expected in the nursery, the plants can be treated with some poisonous spray (see Chapter VIII.). Such preventive means can only be applied in nurseries, where the plants are all together; in the open field, the same remedies would be hardly possible or at any rate very expensive.

Another advantage of nurseries is that a selection can be made, the weak plants being rejected and only the strong ones planted out in the field. This advantage is

not, however, very important, for if when sowing out in the field three or four good, carefully selected seeds be placed at every spot, the planter may be confident that at least one or two plants will be strong enough and give good healthy trees.

Finally, with some soils—for instance, heavy clays—there may be an advantage in transplanting a young tree just at the right season (at the beginning of the rains after the dry season) in a carefully prepared, well-tilled place. The growth of the transplanted tree is then often very luxuriant.

The disadvantage of the nursery system lies in the damage which the plants often undergo in transplanting and which may be serious if skilful labourers are not available; and as it requires more labour, it is more expensive than planting at stake.

Generally speaking, the best way in most cases will be to plant at stake and to have a nursery ready for supplying.

The best season for planting is the season of the rains following after the drought. Where the soil is loose and porous, the planting of the seeds may be done without any special preparation; but when the soil is stiff, as for instance in Guiana, it is very advisable to prepare the place where the seeds are to be sown out. For this purpose every planting place is forked at the beginning of the dry season over a surface of about 4 to 9 square feet, and it is left to pulverise by the drought and the rains following it. In this way the soil is made friable, and the young plant will grow more easily than in the compact clay soil.

Three or four seeds are generally sown at each spot where one cocoa tree is wanted, these seeds being placed at some 12 inches distance from each other. In this way three or four seedlings are obtained, from which one can be selected. The young plants are liable to be attacked by insects, and in many cases several of the young seedlings are lost; but if three or four seeds are planted in this way, there is more chance of obtaining

at least one healthy plant at each spot. In countries where the trees have to be carefully cultivated in order to give a good yield, and where, accordingly, close planting is avoided, only one tree out of the three or four is finally left. Where the cultivation is not so difficult, and the trees do not need to be pruned and cleaned so carefully, as is the case in Ecuador, the trees often are all allowed to remain; in this way three or four trees will grow up together at each spot.

In choosing a suitable site for the establishment of the nursery, the planter not only has to consider whether the site will permit a good and strong development of the young plants, but also must take care that it is as close as possible to the place where the plants have to be planted out. When the plants have to be brought a considerable distance from the nursery to the field, many of them will sustain damage to their root-system, and will show a poor growth, or even die, after the transplanting. It may therefore be desirable to establish several nurseries on different parts of the plantation, and this will always be necessary when a large area has to be planted; one nursery to every 5 hectares (12½ acres) or at the utmost 10 hectares (25 acres) may be recommended. It is possible, of course, that labour conditions may make this system too expensive in particular localities.

The young plant in the nursery must grow up under shade, at any rate in the first period of growth. Accordingly, the nursery may be placed under shade trees, for instance on a spot near the house or even in the plantation itself under the shade trees. This method, though cheap and easy, is not to be recommended. The roots of the trees make it difficult to prepare the soil of the nursery with all the care it demands, and a still greater drawback is the impossibility of regulating the shade under these conditions. It is therefore advisable to establish the nurseries on open spots and to shade them artificially.

The next consideration is the soil to be used in the

nurseries. Of course it must be fertile and friable, but it is sometimes a question whether light or heavy soils should be used. The latter are generally preferred, owing to their capacity for adhering to the roots and thus allowing the plants to be transplanted together with a lump of soil. Still there is sometimes an advantage in a light sandy soil, provided that it is fertile. The transplanting from plants grown in such a soil must be done in a different way. In transplanting from a heavy soil the object must be to keep a good lump of earth around the roots, but when transplanting from a sandy soil the object is to keep the roots intact with only very little earth adhering to them. Local conditions help to settle the question, and the planter must himself find, in this as well as in so many other matters, which method gives the best results.

The spot chosen for the nursery must be well drained by making as many small drains as seems necessary; they will generally be required at a distance of, say, 30 feet apart, running out into a common main drain.

A thorough cultivation either by hoe or by fork must be given to the soil to a depth of 9 inches to 1 foot; and whether the soil is heavy or light, an application of compost or farmyard manure will always be beneficial. This should be done in the dry season. When the soil is compact it will pay to go over the place a second time before the rain comes, and to break the lumps by means of the hoe. Narrow beds are made, 4 feet broad, and separated by gangways of 1½ or 2 feet, to facilitate the work of weeding, watering and removing the plants.

As has already been pointed out, artificial shade is preferable to shade trees, and the best way to obtain it is to make a roofing of palm leaves, which can be made denser or lighter at convenience. For this purpose strong posts 8 or 10 feet long are cut and placed in the soil at regular distances of some 8 feet. They are sunk 1 or 2 feet deep so as to make good supports 7 or 8 feet high. The posts must be forked at the upper end;

they bear the horizontal posts, which are fastened to each other by cord or some strong fibre such as in most cases can easily be found in the tropical forest. On this horizontal frame light sticks are laid as a support for the palm leaves which are used to form the roof. Almost all kinds of palms can be used for this purpose, but those with broad and stiff leaflets have the preference; and other leaves may also be suitable, if they are stiff and broad and do not shrink much in drying. Low shrubs with many ramifications may sometimes be useful. The only thing to be regarded is to obtain a roof which will last for some time, and which can easily be regulated so as to afford more or less shade.

When the nursery is ready the seeds are sown out on the beds in rows, both the rows and the seeds in each row being one foot (30 cm.) apart.

The work tc be done in the nursery after the sowing out wholly depends on the kind of soil and on the season. In many cases the nursery will not require much care, only regular and careful weeding being necessary.

When the soil is very light, however, it is advisable to apply manure a second time, namely when the plants have reached a height of 6 inches and have made the first pair of leaves. Well-decomposed pen manure or compost may be applied as a loose layer one or two centimetres thick on the surface of the beds. If the season is dry, it keeps the moisture in the soil, and if rain falls, it adds to the fertility of the soil and helps to secure a healthy condition and strong growth of the plants.

On stiff clay soil the same method will be found useful, but before applying the compost or manure, it is a good thing to loosen the surface of the compact soil superficially, either by means of a small, pointed wooden stick or any other instrument which allows a prudent loosening of the soil without damage to the young plants or their roots. This work can, of course,

only be done when the weather has been dry for a few days and the soil is not too wet. But even without this rather expensive labour the application of a thin layer of compost or manure, when the plants have made their first growth, is useful on clay soils. It loosens the surface of the soil, and keeps it loose even after heavy rains.

During persistent drought, especially in the very first period after germination, watering may be necessary to keep the plants alive; but it must be left off as soon as it is not absolutely necessary. Rain has a much better influence on the growth of the plants than water applied artificially.

The methods which have to be followed when insect pests or diseases have to be fought in the nursery will be discussed more thoroughly in Chapter VIII. In many cases, however, no special measures of this kind are necessary, as the number of fungus diseases and insects or other animals which attack young cocoa plants is not great. Still it may happen that a fungus disease, like the "witch-broom" disease (caused by a fungus, *Colletotrichum luxificum*; see Chapter VIII.), attacks the plants in nurseries. If this is to be feared, it may be advisable to spray the plants with Bordeaux mixture; and if the disease makes its appearance in spite of spraying, to remove the diseased parts immediately.

In Surinam the mole-cricket (*Gryllotalpa didactyla*) —called there "cotti-cotti" in negro-English, because it cuts the little stems—can be very troublesome in the nursery. The number of plantlets killed by these insects is sometimes very great and the damage very serious. The best thing to do is to look for the nests, which can often be traced at places where many plants have been damaged. The nests must be carefully removed, so as not to lose the eggs, and must be destroyed. It is also useful to place flower-pots, closed underneath with a cork, in the soil with the edge just under the gangways made by the insects; in this way a good number of insects may be caught. The plants are liable to the attacks of this

enemy only when they are very young, and when the seed-lobes have shrivelled up and the first three leaflets have been developed it is no longer to be feared.

Ants sometimes damage the young plants. Though cocoa is not one of its favourite plants, the parasol ant (*Oecodoma cephalotes*) sometimes attacks it when no other food is close at hand. This is the case in Guiana, where this ant does more damage to citrus plants (oranges, mandarins) and coffee plants; but in Trinidad it is regarded as a very serious enemy of the cocoa. The only remedy is to destroy the nests, and as the damage done in a single night may be very serious, it is advisable to prevent the attack by destroying beforehand, by means of carbon bisulphide, all the nests to be found in the neighbourhood and to isolate the plantation from the surrounding bush and forest by means of deep trenches, in which water is kept standing as much as possible.

Another sort of ant is sometimes troublesome in Surinam to all sorts of young plants. It is a small reddish-brown animal, and is there called "brand mier," which means "burning ant," as its bite is rather painful. It makes small nests situated on the surface of the soil round the stems of the plants, and attacks the roots as well as the stems and leaves, biting and sucking the sap of all young parts. In Surinam carbon bisulphide has not been effectual in destroying this pest, but Mr. Wigman, the Director of the Botanical Gardens, has tried with great success a household medicine, naphthalin, which he spread on the nests round the young plants.

In some countries rats and mice are troublesome in the nurseries, and are not easily got rid of. Sometimes they suddenly appear in districts where they have not been seen in large numbers for several years. Where they are a common plague, it is a good thing to surround the nursery by wire-netting and to keep a regular fight against them by means of poison or carbon bisulphide, as described in Chapter VIII.

The plants may be transplanted from the nursery when they have attained a height of 1 to 2 feet. Every care should be taken not to injure the roots. When the nursery is on stiff soil, they must be transplanted with a good lump of earth, about one foot in diameter. The plants must be carefully dug out by means of a sharp spade, with the lump remaining in its original place round the roots; shaking causes the root-system to break. It is therefore advisable, immediately the plant has been dug out, to envelop the lump with a banana leaf fastened with dry banana-fibre. The Javanese workmen are very handy at this work; transportation even for long distances is managed without injury to the plants.

When the soil of the nursery is very loose, the same care is required in digging out, so as not to injure the roots, but then the earth falls off easily. In these circumstances the plants are placed with their roots in water and all the earth is allowed to wash away save only those particles which adhere very closely to the roots. The plants should be packed in loose bundles and kept in a cool, well-shaded place, with their roots wet, during the transportation. In this case the making of the holes in the field to receive the plants requires more care than if the plant is transplanted with a lump of earth; the holes must be filled with rich, friable soil, so as to give the plant, at any rate for its first growth, a very fertile and loose soil. In the case of transplanting with a lump, a well-forked plant hole of 2 or 3 feet diameter will serve the purpose quite well.

It is sometimes preferred to grow the plants in the nursery in pots or baskets. With this method the transportation from the nursery to the field is easily effected without injury to the plants, and the planter is thus enabled to have the nursery at a greater distance from the field where the plants are to be planted out. Pots made of bamboo are very convenient. When big, old bamboo stems of 5 or 6 inches diameter are available, they may simply be cut into pieces 30 cm. (12 in.) long

and left intact longitudinally. In the bottom, which is formed by the partition present at every node of the bamboo stem, a hole is made in order to prevent the water from standing in the pot. When broad bamboo stems are not available, thinner stems may be split and a pot the desired size is made by tying the pieces by means of two strings (Fig. 46).

FIG. 46.—Pots made of pieces of bamboo held together with two strings (plantation "Getas," Java).

Instead of pots little baskets may be used (Fig. 47). In Surinam the plants are brought from the nursery to the field in their baskets, and are simply planted, basket and all, at the proper place. This is a very simple and practical method; the roots of the young plant are left wholly undisturbed, and the baskets very soon decay in the soil, and thus present no hindrance to the free development of the roots. In Java, however, the baskets would be a great attraction to white ants, which after having destroyed the baskets, would be apt to damage the young plants as well.

One thing must not be overlooked in placing the plant in its permanent place; too deep planting must

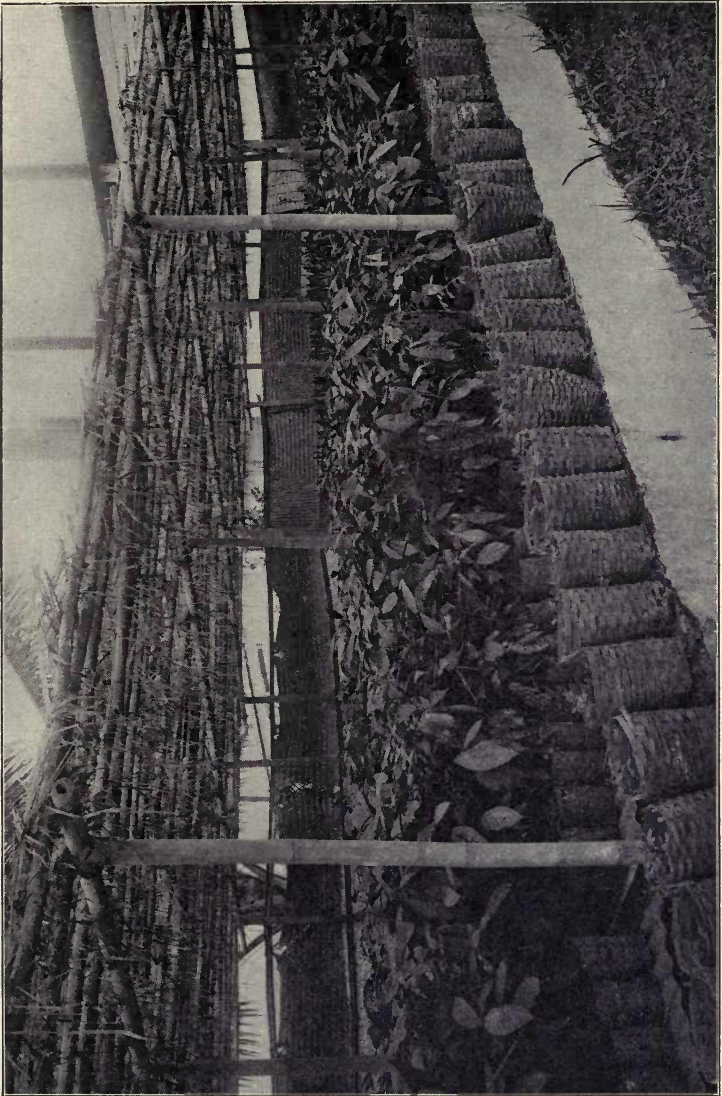


Photo. Hisgen supplied by the late Mr. C. MacGillavry.

FIG. 47.—Nursery with the young plants in baskets (plantation "Djati Roenggo," Java).

be carefully avoided, and, as a general rule, it may be recommended that the plants be placed at just

the same height above the soil as they were in the nursery.

Layering (marcotting), grafting and budding.—Grafting, budding and layering (marcotting) experiments have been conducted in several countries, especially at Experiment Stations. None of these methods has so far been put into general plantation practice, and there is no definite information as to how plants propagated in such manners will be able to resist disease, what yield may be expected, what age they will attain, etc. As long as our knowledge is at this stage, budding, grafting and marcotting of cocoa may be an object of study and experiment in Botanic Gardens and Agricultural Departments, but the time has not yet come to recommend the planter to apply any of these methods of vegetative propagation on a large scale.

There are, however, probably some planters who would like to try these methods and to form their own opinion as to their advantages and disadvantages. For this reason the different methods will be briefly described.

First of all, what is the use of marcotting and grafting, or, in a general term, "vegetative propagation"? The aim is simply to obtain an offspring which is wholly like the mother tree.

There is a large group of plants in which the offspring is generally different from the mother plant. This is the group of *hybrids*. When, for instance, a Liberia coffee tree is pollinated by an Arabica coffee tree, the offspring are hybrids, which have characters both from the Liberia mother and from the Arabica father; they are uniform among each other, and more or less intermediate between the two parents. When, however, we sow out the seeds of these hybrids, we obtain an offspring which is not at all uniform; it contains very different plants, some more like the Liberia grandmother, others more like the Arabica grandfather; but almost every tree is different, and each contains Liberia and Arabica characters in a new combination.[1]

[1] Some hybrids are "constant," and remain the same in their progeny.

In such cases, in which a good character of a plant is not always present in its seedlings, vegetative propagation is indicated—*i.e.* grafting, budding, layering (marcotting) or propagating by means of cuttings. By these methods twigs of the mother tree are induced to grow to new trees, which will show very little variation and be very much more like the mother tree than her seedlings would be.

This advantage of multiplying by grafting or budding—viz. the obtaining of trees which have the same good qualities as the mother plant—is the principal, but not the only one. It is also advantageous to have a plantation consisting of trees which not only yield a product of first quality but also among each other of exactly the same quality. The fermenting and curing is easy, for the whole lot of fruits gathered require the same degree of treatment, and no uncertain results are to be feared.

(*a*) Grafting.—A slow-growing, hard-wooded plant like the cocoa plant always presents more difficulty to grafting or budding than quick-growing trees with "soft" wood. The methods of grafting which are usually recommended, and which give the best results—*e.g.* splice-grafting or saddle-grafting—cannot be followed with such trees; their growth is too slow and the stock and graft do not grow properly together. With trees like cocoa and mango the method of grafting by approach has to be followed. The result, however, is always more or less uncertain, and is never so satisfactory as with the splice-grafting or saddle-grafting, which can be adopted with quick-growing trees.

In grafting by approach[1] the stocks must be grown in pots, baskets or bamboo pots, and the scion is not cut from the mother tree before grafting, but remains attached to it. A slice is cut longitudinally from the twig, and also from the stem of the stock-plant (Fig. 48). They are then brought together, the stock being placed

[1] Jones, "Grafting of Cacao" (*West Indian Bulletin*, viii., 1907, p. 137, and ix., 1908. See also *Agriculture News* (Barbados), vii. (1908), pp. 197 and 213.

for the purpose on a stalk. Grafting by approach will only meet with success when the stock is still in the seedling stage.

Grafted trees bear fruit at an earlier age than seedlings, and at the Experiment Station at Dominica grafting of "Alligator" cocoa (*Theobroma pentagona*) gave thirty to forty pods per tree two and a half years after grafting. This result is certainly encouraging, but it is still questionable whether grafted trees would be as

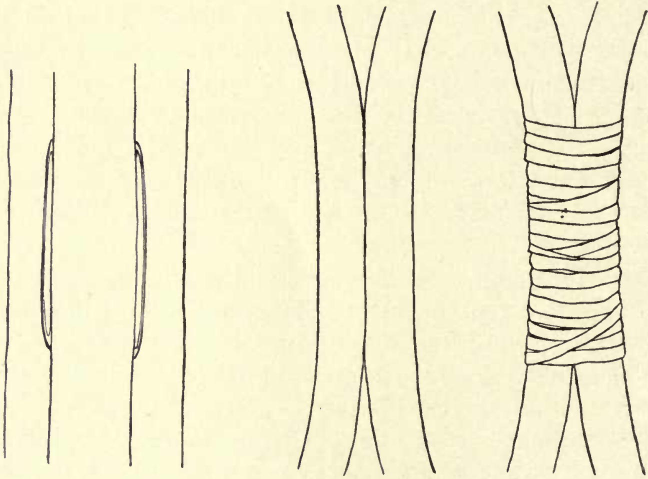


FIG. 48.—Sketch of the method of grafting by approach.

prolific as seedlings in the end, and whether a plantation consisting of such trees would yield as big a crop as a plantation consisting of seedlings.

The habit of grafted trees differs from that of seedlings. They do not have an upright stem, branching at 3 to 4 feet above the ground, nor the regular branch-system, but begin to branch a few inches above the point of union, and generally make an irregular branch-system. Such dwarf trees have the advantage of making the picking of the fruit easy, and in windy countries, like Dominica, their low growth is a protection from the wind. Still these trees require as careful a

pruning as trees obtained by marcotting, otherwise irregular, bushy trees are obtained. Another drawback of the system is the skill and care necessary to get the plants grafted. As already pointed out, a slow-growing, hard-wooded plant like cocoa always presents more difficulty in grafting than quick-growing trees with soft wood. Still the experiments carried out in Dominica and elsewhere have shown that grafting of the cocoa plant by approach may no longer be regarded as a very difficult operation, which succeeds only in a small number of cases.

The method is still so recent that no data are as yet available as to several important points: in particular, the question of the productiveness of grafted trees is still quite uncertain. It would not be at all surprising if grafted cocoa trees prove to be much behind seedlings in this respect, for with other kinds of trees (orange, mango, coffee, etc.) it is a well-known fact that grafted or budded trees never develop to such an extent as seedlings, and that their productiveness is inferior.

(*b*) Budding.—The experiments of Mr. Heyl at Buitenzorg[1] and Mr. Harris in Jamaica[2] have proved that budding is an excellent method of propagating the cocoa plant.

As it is generally performed, the operation of budding consists in removing a small piece of bark from a branch of the selected tree, making a ⊥-shaped incision in the bark of the stock-plant, and pushing a piece of bark of the selected tree into this ⊥-shaped incision and under the bark of the stock-plant. This method, though it gives excellent results with many other trees (it is, for instance, widely applied to citrus trees), is not suitable for the cocoa plant. In Mr. Heyl's experiments at Buitenzorg only 7 to 8 per cent of such buddings succeeded.

[1] Heyl, "Eenige opmerkingen," etc. (*Teysmannia* (1905), p. 411).

[2] Harris, "On the Budding of Cacao" (*Bull. of the Dept. of Agriculture of Jamaica*, Nov. 1903). See also: Casse, "Cacao in Haiti" (*Tropical Life*, vi. 1910), p. 138.

Much greater success was obtained with another method of budding, *i.e.* patch-budding. A square piece of bark with a bud is taken from the selected branch or

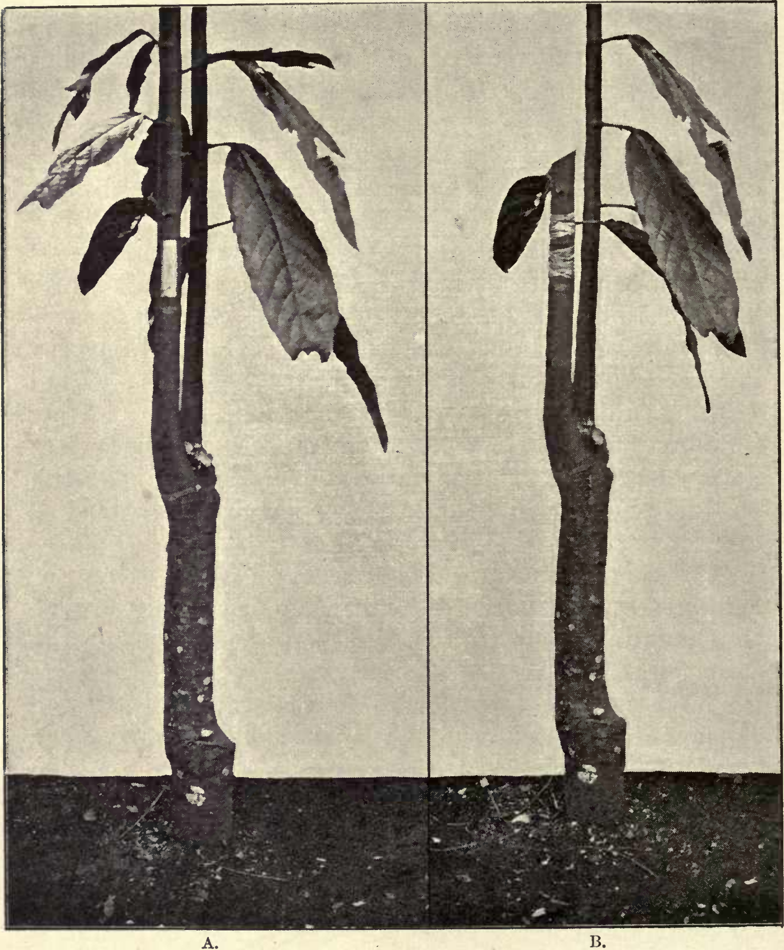


Fig. 49.—Budding on watershoots.

In A a piece of bark has been removed; in B a new piece of bark of the selected tree has been fixed to the open place.

watershoot, while a piece of bark of the same size or a little larger is removed from the stock-plant. The piece of bark of the selected branch is then fixed on the

open place of the stock-plant and firmly tied to it by means of raffia or other string (Figs. 49, 50).

Mr. Harris prefers watershoots, both for taking the buds from and for budding upon, and when the tree which it is desired to propagate by budding has not sufficient watershoots to yield the number of buds required, he recommends that it should be cut down, leaving only the stem a few feet high, and that the growth should be fostered as much as possible, by manuring where this is found useful, or by forking or otherwise, in order to obtain several strong, quick-growing watershoots. Mr. Harris also considers watershoots the best kind of branches to bud upon; but young plants are also quite suitable as stock.

If the trees which are chosen to bud upon are rather old, they are also cut down and watershoots allowed to grow up. Of these two are left. One of these is used to bud upon and the other is left "to keep up the root," *i.e.* to foster the vitality and growth of the plant. When the bud is firmly established and has grown out to a strong shoot, this second watershoot is removed.

The details of the operation may be gathered from the illustration (Fig. 49).

When the watershoots have a diameter of $\frac{3}{4}$ to $1\frac{1}{2}$ inch, they are fit to be budded upon or to be used as bud-wood.

Mr. Heyl, however, obtained equally good results with buds taken from twigs as with buds from watershoots, and prefers to bud upon young plants. As bud-wood strong twigs, about one year to one year and a half old, and with a diameter of about 1 cm., should be used, while the plants to be budded upon should also be one to one year and a half old, and about the diameter of the little finger. Before budding the young cocoa plant is cut a few centimetres above the soil, and the bud is inserted on the part remaining. The piece of bark is firmly attached by means of raffia string, but care must be taken to leave the bud itself free (Fig. 50). If a leaf is still present under the bud, the leaf must be cut, so as

Fig. 50.—Budding of a seedling.

to leave only a little piece of the leaf-stalk; and if this remaining part of the leaf-stalk can be easily loosened after a few days, this is generally an indication that the budding has succeeded.

Photo. by the late Mr. C. MacGillavry.

Fig. 51.—Marcotting of watershoots (plantation "Djati Roenggo," Java).

Of all the buddings done in this way, 90 to 95 per cent were successful.

It will be obvious that the piece of bark with the bud of the selected tree may be a little smaller than the piece removed from the stock-plant, but never larger.

When it is smaller, it is useful to fill the remaining little furrows with budding-wax.

The following rules must further be observed: (1) bud only in a season when the growth is rapid; the dry season and the very rainy time of the year are therefore generally unsuitable; the rainy season immediately after the drought is generally the best; (2) be especially careful not to choose twigs or shoots or stems which are

Photo. by the late Mr. C. MacGillavry.

FIG. 52.—Marcotting of branches (plantation "Djati Roenggo," Java).

too young; and (3) tie the bud tightly, but not roughly so as to damage the bud or bark.

(*c*) Layering or marcotting.—Layering is generally regarded as being impracticable with cocoa. This is, however, not the case. In Java, on the plantation "Djati Roenggo," the author has seen cocoa marcotted easily in the ordinary way.

For this purpose branches as well as watershoots were used see (Figs. 51, 52), and no special care was taken in selecting these. Branches of 2 to 4 centimetres in diameter were regarded as suitable, but watershoots

of different ages and sizes were also successfully marcotted. The operation is very simple. Over a distance of 5 to 10 cm. (2 to 4 inches) the bark is stripped off and carefully removed up to the wood, not a single little thread of the tissue of the bark being allowed to

Photo. by the late Mr. C. MacGillavry.

Fig. 53.—A marcotted branch.

After six weeks this branch was cut off and the earth removed to show the development of rootlets.

remain. A little lump of earth—not stiff clay, but good earth, rich in humus—is applied all round this part of the branch, and is held together by means of a piece of coconut rind. In this position it remains, and after some six weeks the little rootlets appear through the crevices of the coconut rind (Fig. 53).

The branch is then removed from the tree and carefully planted.

In order to obtain a well-formed stem it is always preferable to have marcots made from watershoots; but even then great care is necessary to give the young tree obtained by marcotting a good form. When this is not done and the tree is allowed to grow, a bushy shrub is the result.

Though as yet it is not possible to say with certainty which method is the best, the present author has more confidence in the budding methods of Mr. Heyl and Mr. Harris than in grafting by approach or marcotting. The results obtained five years ago at Buitenzorg are very good, as is shown by a photograph of the budded trees when five years old (Fig. 54).

Shade trees.—In almost all cocoa-growing countries cocoa is cultivated under shade. In the little island of Grenada, in Brazil (Bahia) and San Domingo it is often grown without shade trees, and also here and there in several other countries.

In Surinam two closely allied species of shade trees are used, *Erythrina glauca* and *E. velutina*, both called "koffie-mama" ("mother of the coffee"), from the fact that they were formerly used as shade trees for the coffee. When plantains or bananas have been grown for two or three years and cocoa has been planted between them at a distance of 15 to 18 feet, large cuttings of the Erythrina are planted at a distance of 60 feet apart. After a few years the foliage of the Erythrina forms a continuous roof above the cocoa. In Surinam *Erythrina glauca* is mostly used.

The *velutina* is also used in the low-lying lands of Trinidad; it is called here "bocare," and is generally planted at a distance of 30 to 40 feet. In the higher lands of Trinidad another closely allied species of Erythrina is used, the so-called "anauco" (*Erythrina umbrosa*). This "immortelle" ("immortelle" is in Trinidad the vernacular name for both kinds of shade trees) develops into large, tall trees with an extensive,

Fig. 54.—A budded tree five years old (Experimental Garden, Buitenzorg, Java).

but rather light, foliage system. The trees are planted at a distance of 40 to 45 feet apart.

In Venezuela the same two species of Erythrina are used, but the so-called "guamo" is also planted to a great extent for shading both coffee and cocoa. The "guamo" is a sort of Inga, probably *Inga laurina.* Here and there the "saman" (*Pithecolobium saman*) is used.

In Java and Ceylon, also, some species of Erythrina are planted, especially *Erythrina lithosperma*, called in Java "dadap serep," and considered there as the most suitable tree for the purpose. In Java, however, disease and insect pests have lately attacked this tree to such a degree that in many cases other trees have been used, principally *Deguelia microphylla*, also *Caesalpinia dasyrhachis*, the "lamtoro" (*Leucaena glauca*), *Albizzia stipulata* and *Albizzia moluccana.* The Albizzias are also sometimes used in Ceylon, and according to Wright several other trees—viz. *Erythrina umbrosa*, *E. velutina*, and *E. lithosperma*, and lately the rubber trees *Hevea brasiliensis* and *Castilloa elastica.*

In some other countries the planting of shade trees, all of the same kind and at regular distances, is not generally practised, recourse being had to forest trees left in clearing the land. These serve the purpose either without or with the aid of planted trees. This primitive method is followed in the old plantations of Ecuador, in San Thomé, the Gold Coast, the Belgian Congo, and Central America (Nicaragua, San Salvador, Guatemala).

As previously stated, cocoa is grown without shade in Grenada, Brazil, San Thomé, and here and there in other countries — for instance, on one estate in Surinam and on a few fields of certain estates in Trinidad. These facts show that shade from shade trees is not to be considered as absolutely necessary, nor the cocoa as a plant which cannot stand direct sunlight. This raises the question : What is the reason

that in most countries shade trees are considered necessary and that attempts to cultivate cocoa without shade have failed, while in the places just mentioned cocoa is successfully cultivated without shade?[1]

Most planters and authors on cocoa culture seem to think that the use of the shade trees is primarily to afford shade to the cocoa tree. They consider cocoa to be a plant which in its wild state grows under the shade of the higher forest trees and which will not thrive when exposed to the untempered sun. This may be the case in some countries, but the examples of cocoa grown without shade prove that it cannot be regarded as a general rule.

There is another fact which shows that this is not the primary use of shade trees. If we examine the trees used for shade, we are at once struck by the fact that in every country where cocoa is carefully and systematically grown one or two kinds of trees are considered to be the most suitable as shade trees and are generally used. Other kinds are considered less suitable, and all the rest as quite unsuitable for the purpose. Yet the shade afforded by these different kinds of trees is in the majority of cases the same. How is it possible, then, that two kinds of trees, affording practically the same shade, are still so different in value as shade trees for cocoa?

The way in which the plant is cultivated in Grenada without shade is instructive, and gives the key to the puzzle. As is the case everywhere else, in Grenada the young plants are cultivated under the shade of bananas, which are kept growing during the first three or four years; the cocoa is planted closely, at a distance of 9 to 12 feet. But much more care is given to the tillage of the soil and to manuring than in most other countries. On some plantations forking is done every year; on others hoeing is preferred, but tillage is never neglected. As a rule, the cultivation is heavily manured with pen

[1] See *Bulletin No. 7 of the Department of Agriculture, Surinam,* Sept. 1906, noticed by De Wildeman in *La Semaine coloniale.*

manure, either cattle- or sheep-dung, great quantities being applied at the beginning of the rainy season.

We see, therefore, that close planting and careful tillage and manuring are considered necessary where cocoa is grown without shade; while in countries where shade trees are used, the planting is generally wider and the tillage and manuring often neglected when once the trees are established. These facts indicate that in these countries the shade trees must do what is done by man in Grenada.

We have already referred to the remarkable fact that in every country one or two kinds of trees are regarded as being the most suitable as shade trees. Another fact is not less important: the Erythrinas of Surinam and the Antilles, Venezuela and Java, the Ingas of Venezuela, Central America and Ecuador, the Gliricidias of Central America, the "saman" of Venezuela, the Albizzias of Java and Ceylon, all belong to one order of plants, the so-called *leguminous plants* (Leguminosae). Plants of this order have long been recognised as soil improvers on account of their power to increase the amount of nitrogen.

In view, then, of the facts (1) that the growing of cocoa without shade trees is, generally speaking, unsuccessful when the soil is not tilled and manured thoroughly, and (2) that tilling and manuring are omitted in most countries where shade trees are used, we may conclude that the use of the shade trees is in the first place *the improvement, or at any rate the conservation, of the good qualities of the soil.* As they belong to the leguminous order of plants, the shade trees enrich the soil with nitrogen and make it friable with their extensive root-system, while they afford humus by means of the fallen leaves and flowers, and preserve the humus and the texture of the soil by the shade which they afford.

It is a well-known fact that in tropical countries an unshaded soil, exposed to the direct influence of the rays of the sun, rapidly deteriorates. For instance, places

near houses, which are constantly weeded in order to prevent the formation of secondary bush, are soon in a very bad condition, and if the soil consists of compact clay nothing but poor, sour grass will grow on it. When such places have to be taken into cultivation, much work must be done in order to improve the structure of the soil—tilling, manuring, the growing of soil-improving plants—before they are again suitable for use. This injury to the soil caused by its unshaded condition is of course specially noticeable in the tropics, but it is also well known in cooler climates, especially in forestry. Where open places are found in a forest in consequence of the death of trees, the forester is anxious to have such places replanted as soon as possible by suitable plants in order to prevent the soil being spoiled. This bad influence exercised on the soil by want of shade must be attributed, at any rate for the greater part, to the oxidation and destruction of the humus by the direct influence of the sun's rays, the high temperature in the daytime, and the free access of oxygen.

The shading of the soil is therefore the most important function of the shade trees, and the close planting of cocoa trees, where shade trees are not used (*e.g.* in Grenada), is simply a means of obtaining the shade otherwise afforded by the shade trees. Wide planting of cocoa trees without shade will always result in a spoiling of the soil, soon followed by the death of the trees, at any rate if care is not taken to keep the soil in good condition by intensive tillage and heavy manuring.

These considerations may be briefly summarised as follows :—Though it is possible that in some countries the cocoa tree will not thrive in untempered sunlight, we may assume that in most countries this is not the case, and that the untempered sunlight is not in any way detrimental to the tree. The usefulness of the shade trees lies not in giving shade to the *tree* but in giving shade to the *soil* ; in enriching the soil with nitrogen, by means of the nodules of the roots, and with

humus, by means of the fallen leaves and flowers; and finally in loosening the soil by means of the widely developed root-system. When cocoa is grown without shade, the planter has therefore to shade the soil by close planting of the cocoa trees, to add nitrogen and humus to the soil by means of manuring with pen manure, and to keep the soil porous and loose by means of forking or hoeing. In these circumstances green-

FIG. 55.—Healthy cocoa under "kapok" (plantation "Getas," Java).

manuring, or the growing of low leguminous shrubs or other low shading plants, is also useful.

Generally speaking, it is easier and cheaper to grow cocoa under shade trees than without; but it must not be forgotten that when grown without shade, the tree begins to bear at an earlier age, gives heavier crops, and is less liable to different diseases; its lifetime, however, is shorter. In most cases, especially where labour is expensive, the use of shade trees is advisable.

It is rarely profitable to use economic trees for shade, or to interplant trees which give some valuable product, but there are cases where this has been made to pay.

It has already been mentioned that on several plantations in Java cocoa grows well under "kapok" (*Eriodendron anfractuosum*); another illustration of such a case is given in Fig. 55.

Where interplanting of useful trees is profitable, there is sometimes a tendency to overdo it. Fig. 56 gives an example of this—cocoa is being grown under "kapok," with interplanting of nutmeg trees (on the

Fig. 56.—Cocoa grown under "kapok," with interplanting of nutmeg trees (on the left) and Castilloa, while the "kapok" is used as support for pepper plants.

left of the illustration) and Castilloa, while the "kapok" is used as support for pepper plants.

B. Fieldwork on the Established Plantation

Weeding.—Though many widely different opinions are held concerning the treatment of the cocoa fields on the established plantation, all planters will doubtless agree on one point—viz. the necessity of weeding.

The influence of weeds on the soil and on the cocoa

plant is, however, often misunderstood. At first sight it may seem obvious that, when a definite part of the soil is destined for one cocoa tree, this tree will not obtain so much food if a certain number of weeds also feed on the same spot, as it would if it stood quite alone. And of course it is the case that the weeds take different constituents from the soil, namely: (1) solid plant-food (salts of potassium, etc.); (2) water; and (3) oxygen. Let us see to what extent this robbery by weeds prejudices the cocoa tree.

The solid plant-food taken by the roots of the weeds from the soil is deposited in the stem, the leaves, the flowers and the fruits of the weeds. It is true that a certain amount of this food is always lost when the fruit or seeds are carried away by the wind, or by birds or other animals; but, on the other hand, seeds and fruits from other places (or their constituents) are probably deposited on the spot by the wind and by means of the excrement of other birds. It may be said, therefore, that no loss of solid plant-food results in the end. Further, if the weeds are cut down before they have had time to make seeds, no solid plant-food at all goes to other places, and the stems and leaves of the rotten weeds and their constituents return again into the soil. Even more, indeed, is restored to the soil than was taken out, so that there is no loss but a gain; for in addition to the compounds just mentioned, which were originally taken from the soil, the weeds also contain other compounds in the leaves and stems, which were made by the plant from the carbon dioxide of the air. These contain mainly carbon and oxygen, and constitute even the greatest portion of the plant. They are called the "organic constituents," and when they are incorporated into the soil they form the humus. These facts may be summarised as follows: The plant takes different salts from the soil ("inorganic constituents") —*e.g.* salts of potassium, phosphoric acid, etc.—and also forms "organic constituents"—*e.g.* sugar, amylum, albumen, etc.—by means of the carbon dioxide of the

air. These "organic constituents," which form by far the greatest portion of the plant, form humus when decaying in the soil. After weeding, the "inorganic constituents" as well as the "organic constituents" are returned to the soil.

As regards solid constituents, we may therefore say that the weeds do not in fact rob the soil, and that, when not removed from the field or destroyed by fire, they even return more to the soil than they took from it. In this respect, accordingly, a soil, on which weeds are allowed to grow and are regularly cut, has a great advantage over a soil which is wholly free from weeds.

We now have to deal with the water which the weeds take from the soil. Every plant takes a large amount of water from the soil by its roots; this water spreads through the whole plant and is again evaporated, principally by the leaves. There is thus a continuous movement of water, which goes from the soil into the plant and, being evaporated again, is lost into the air as invisible vapour. The amount of water lost in this way by the soil through the agency of plants is very important. It has, for instance, been calculated that one plant of the sun-flower (*Helianthus annuus*) evaporates during one summer 66 kilograms of water; an old beech evaporates 9000 kilograms during summer time, and one hectare, planted with 400 of such trees, loses during this time 3,600,000 kilograms of water, simply through the evaporation of the trees. On the other hand, the amount of water which a soil evaporates *directly* under the influence of the sun is of course smaller when a soil is covered with plants and consequently shaded, than when no plants are growing on it.

It is clear, then, that in the case of a soil on which plants are growing, the direct evaporation is small, but the evaporation through the plants is important; while in the case of a soil without plant growth, the direct evaporation is important, and indirect evaporation through plants is of course not present. There remains the question on which of these two soils is the total

amount of evaporation the greater. This has been elucidated by special experiments, and it has been demonstrated *that on a soil with plant growth the evaporation is greater than on a soil without plant growth.*

Accordingly, in a plantation with weeds the evaporation is greater, and in times of drought the cocoa trees will suffer more from drought than in a plantation which is free of weeds. This fact cannot be emphasised too strongly, because so much misunderstanding exists in regard to the question, not only among planters but also in handbooks. For instance, Chevalier's excellent book[1] recommends the planter to leave the weeds standing during the dry season, and even to plant some catch-crop plants such as beans, taro or sweet potato at the end of the rainy season. Apart from the fact that beans and sweet potatoes would not grow under shade trees, the result of this would only be that the cocoa would suffer still more from drought. The practical and interesting little book by Olivieri[2] also gives currency to the erroneous opinion that the "destruction of grass tends to increase exposure and dryness."

In connection with these facts it may be pointed out that a tree without leaves evaporates less water than a tree with leaves, and it is therefore *an advantage to have a species of shade tree which defoliates in the dry season.* This fact is also often misunderstood, and even some authors on cocoa incorrectly assert that a shade tree should keep its leaves during the dry season in order to keep the soil moist.

Finally, we have to deal with the influence of weeds on the aeration of the soil—a very important point. Every part of every living plant needs oxygen from the air; day and night the leaves, the stems, and the roots of the plants absorb oxygen from the air and return carbon dioxide. This is the respiration of plants.

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain* (1908), p. 122.
[2] Olivieri, *Treatise* (1903), p. 82.

It is therefore necessary, in order to supply oxygen to the roots, that the soil should be sufficiently aerated.

It may be taken for granted that in a well-aerated soil the amount of air, and the circulation of that air, is sufficient to supply the roots of the cocoa, of the shade trees, and of the weeds with oxygen; and accordingly weeds do no harm of any importance by taking a portion of the air in the soil. But they are harmful to the free respiration of the cocoa roots in another way, for they cover the soil with a layer, which is more or less close according to the sort of weed. Grasses, for instance, make a hard and compact layer of stems and roots, while other weeds (*e.g.* those of the family of the black pepper or *Piperaceae*, of the *Compositae*, of the banana family or *Musaceae*, of the *Papilionaceae*, of the ginger family or *Zingiberaceae*, etc.) have only a slightly developed root-system and do not appropriate so great a part of the surface. Planters distinguish these two kinds of weeds very clearly: they know that the former—the "noxious weeds," as they call them—are harmful, as they keep the soil compact and prevent the free access of air, while the latter are much less noxious and are called "harmless weeds."

Summarising this discussion, we may say that weeds are partly noxious, partly harmless, partly even useful. They are noxious: (1) by preventing the free access of air to the soil; (2) by absorbing and evaporating water from the soil, thus making the soil still drier in times of drought.

They are harmless as regards the absorption of plant-food from the soil.

They are useful by giving humus to the soil.

There are, however, other influences of the weeds which must be considered. One is a useful influence which hardly needs explanation: this lies in preventing the washing away of the soil on sloping land. Cocoa plantations are often established on the slopes of mountains, and the steeper the slope the more care must be taken to prevent the soil being washed away.

Planters are mostly agreed that in such circumstances clean weeding is not to be advocated, as the weeds are necessary to keep the soil together. The other influence of weeds to be mentioned here is doubtless an important one, but it is by no means so clear or so easily understood. The detrimental effect of weeds on the growth of trees cannot be attributed wholly to their drying effect on the soil and to the prevention of the free access of air. It has been proved by experiments that *still another noxious influence must exist*, and the only possible explanation seems to be that the roots of the weeds produce some substance which is poisonous to the tree. However interesting this subject may be, there is no room in this handbook to go into further detail.[1]

It will now be clear that the presence of weeds has great disadvantages, but also a few advantages; that the system of "clean-weeding," *i.e.* the destruction of all weeds as thoroughly as possible, is in some cases advantageous but generally unsuitable; and that while sometimes the planter's motto should be "Kill the weeds," there are more cases in which it should be "Save the weeds." Which is the right one depends wholly on local conditions.

These conditions also control the question whether the ordinary method or "clean weeding" is to be preferred.

"Clean weeding," *i.e.* the systematic absolute destruction of all weeds, has advantages, and the reader will understand from what has been said that it is especially advocated when there is no fear of a deficiency of humus or of the soil being washed away. This is the case on flat lands or on not too steep slopes, where cocoa is grown under suitable shade trees which afford sufficient humus by their fallen leaves and

[1] Readers who take an interest in this subject may be referred to the articles by Milton Whitney ("On Soil-fertility," and other Bulletins of the Division of Soils of the U.S. Dept. of Agriculture, Washington). The subject is also treated by Willis, Harpenden (*Gardener's Chronicle*, 1909, p. 337), and by Fletcher (*Memoirs of the Dept. of Agriculture in India*, vol. ii. No. 3).

conserve this layer of leaves by affording sufficient shade. Under such conditions "clean weeding" cannot be other than beneficial to the cocoa trees, and planters are strongly recommended to try the system. As yet, however, "clean weeding" is rarely met with on cocoa plantations, though it has long ago been adopted on many coffee and rubber plantations as being in every sense preferable to the system of leaving the weeds and cutting them once or twice a year. The reason may be that the cocoa tree does not suffer so much damage from the presence of weeds as coffee and rubber; but one great advantage of the system is just as important in cocoa as in coffee or rubber culture, namely, its *cheapness*. When once a plantation is free of weeds, it requires little labour to keep it clean. On one coffee estate in Java, for instance, from 20 to 33 guilders per baw (about 20s. to 30s. per acre) were spent each year when weeding was done in the usual way; when "clean weeding" had been adopted, the cost was reduced from 7·40 to 10 guilders per baw (about 7s. to 9s. per acre).

When it is intended to adopt "clean weeding," the planter is strongly recommended to begin immediately after the clearing of the forest. The weeders should go over each field at short intervals—at the beginning, every ten or fourteen days; later on, every three weeks. In this way the weeds never have time to make seeds and to "infect" the field. Even where the ordinary system of weeding has at first been followed, it is later on possible to eradicate the weeds completely. In such cases the dry season is the best time to attack the weeds and to destroy them by repeated weeding, if necessary with the help of the hoe. This instrument will be indispensable for such work on stiff soils.

A drawback of the system of "clean weeding" is experienced in countries where the planter cannot be sure of always having the necessary number of labourers at his disposal. Wherever this is the case,

he runs the risk that at some particular time enough labourers may not be at hand to keep the fields clean, and the weeds may be able to make seeds and to spread over the fields.

As has already been said, where the slope of the land is steep, weeds may help to prevent the soil being washed away, and "clean weeding" is not to be recommended. In such cases it is advisable, after weeding, to arrange the weeds in rows which run perpendicularly to the slope. The showers always carry a certain amount of soil with them, and this will then be retained by the rows of weeds. A simple kind of terracing is thus obtained.

If the most common system of weeding is followed and the weeds are cut down one, two, or three times a year, it is best to have the weeds spread equally all over the soil, so that the latter may obtain the greatest benefit from the mulching. In several countries, however, it is considered preferable to have the weeds brought together into heaps or rows, as the work of weeding can in this way be better controlled, for it can then be easily seen whether the work is being done thoroughly or not.

Soil management.—While on every established plantation in every cocoa-growing country of the world weeding is considered one of the essential operations, tillage and soil management are not seldom wholly neglected and regarded as superfluous. It is in many cases found not only that big yields are obtained and that the trees thrive without tillage, but also that on many soils no improvement is noticeable when tillage is applied. There are, however, exceptions. On heavy, compact clay soils, though the trees grow and bear very well without tillage, forking or hoeing is beneficial. This is especially the case when the trees have, from some cause or other, gone backward; in such cases the trees show the good effect by the quick formation of a new foliage system, and of long and strong new twigs with large leaves.

It is not necessary here to go into details as to

the effect of tillage, but it may be remembered that the surface parts of the soil are always more or less pressed together and are more exposed to the air than the underlying parts, and that in this way the different layers of the soil have a different composition. Tillage makes the soil more uniform. Moreover, the bacterial life in the soil is beneficially influenced by aeration, and the number of bacteria increases. This is, generally speaking, beneficial to the plants, because the bacteria play an important rôle in decomposing the soil and in making plant-food available. It is still more important that a special kind of bacteria should multiply by the free access of air—viz. the so-called "nitrifying" bacteria, which oxidise the nitrogen of the nitrogenous plant-food. In many cases also tillage certainly improves the structure of the soil, but too great a value is often attached to this effect. Tillage is frequently not useful at all in this respect, and sometimes the effect is even bad, as the structure of the untilled soil is better—that is to say, tillage sometimes pulverises the particles of the soil too much, so that after a few showers it becomes more compact than before. In the case of heavy clay soils, however, this is not so much to be feared when the soil is left divided in large lumps; and tillage, thus performed, may be very useful in improving the structure of soils of this kind.

In cocoa plantations the operation of tillage is generally done in such a way as to leave unforked a space 3 to 4 feet in radius round each tree, while the large roots of the tree are cut at this distance by means of a sharp knife so as to obtain a clean wound.

The best time for forking is, of course, the dry season. When the rains begin to lessen, the time has come for the planter to examine the soil carefully to see whether its condition allows of forking. It must not be too wet, for then the labourers are unable to perform the work, and also the effect is not so good; but, on the other hand, the planter must be careful not to wait too long, and not to allow the soil to get too dry,

otherwise it becomes so hard that forking is no longer possible. There is also another advantage in forking at the early beginning of the dry season. This is, that in the fairly wet soil and with the help of the few occasional showers which are still falling, the tree is able at once to restore its root-system, and in the coming dry season will not feel any bad effects from the pruning of the roots.

Therefore in Surinam, for instance, the best time for forking is generally August. After the heavy rains in May, June and July the soil is generally dry enough to be forked in August—sometimes not till September —while in October it has become too dry and hard. Often, however, the planter may not be able to fork all his fields at this one particular time; when this is the case, he must during the rest of the year be on the look-out to get the work finished in some other season, when the soil is not too wet nor too dry. In Surinam there is frequently an opportunity to do this in the months of February or March, when for some weeks the rainfall is fairly small and the soil is never so wet as during, or after, the heavy rains of April, May and June. There is no doubt, however, that the beginning of the dry season is always the best time; during the drought the soil gets pulverised, and when the rain begins to fall again the plant finds a well-aerated, porous soil in which to develop its new roots.

It is a question whether it is best to break the large lumps of earth again after forking. Generally speaking, it is not necessary and even not advisable, because a soil which in the dry season is pulverised into too small particles becomes "packed" again quickly after a few rains. It is, therefore, generally preferred to leave the soil in big lumps; but when dealing with exceptionally compact soils, it may sometimes be advisable to break the lumps by means of the hoe a few days after forking.

Forking shortly before the dry season, however, has also its drawback. When no more showers come, or

when the drought is very rigorous, it may happen that the root-pruning causes the tree to suffer from drought. In countries where this is to be feared the method of "alternate forking" may be recommended. This consists in forking only every other space between two rows (see Fig. 57)—*e.g.* the spaces between rows 1 and 2, between rows 3 and 4, and between rows 5 and 6,

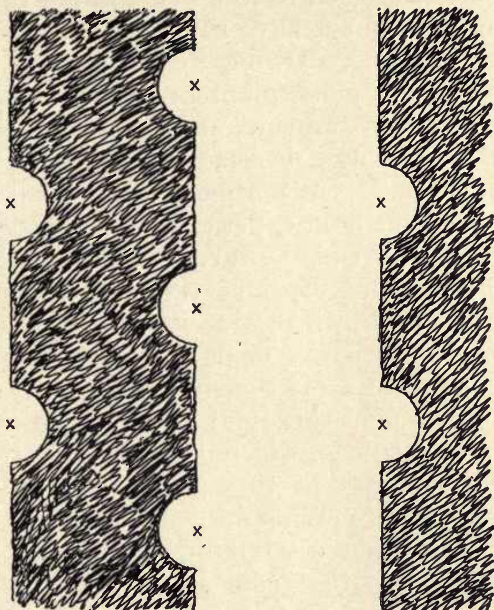


Fig. 57.—Sketch of "alternate forking" (white = unforked; shaded = forked).

The cocoa trees are indicated by ×; the rows are planted at a distance of 15 feet, and the trees in each row are 18 feet apart. Round each tree a distance of 2 feet is left unforked, and the spaces between the rows are alternately forked and left unforked.

but leaving unforked the spaces between rows 2 and 3, between rows 4 and 5, and between rows 6 and 7, etc. In this way only one half of the root-system of each tree is pruned, so that if a drought begins before the pruned part has made new rootlets, the unpruned part is still there to prevent the tree suffering from drought.

It has been mentioned that forking is neglected in

many countries and considered as being of no importance. In others, however—*e.g.* Surinam—it is regarded as advantageous, but as labour is scarce it is rarely carried out. In other countries, again, it has become a part of the regular plantation work. This is, for instance, the case in St. Lucia; in the Annual Report for 1904–1905 the Agricultural Superintendent states: "Many planters seemed to fear that forking the ground injured the trees, but I have never seen any bad result from careful forking. Owing to the results obtained on the experiment plots, planters in St. Lucia are now importing basic slag and sulphate of ammonia; pruning and forking have now become a recognised part of cacao cultivation." In Surinam, also, no bad effect of forking has ever been experienced.

Some agriculturists, however, dislike the ordinary way of forking, and consider the destruction of and damage to the roots which always accompanies forking in the established cocoa field as objectionable. Mr. Barrett, who was for some time in Trinidad to advise the cocoa planters, was of this opinion, and he recommended another way of tillage, which he calls "vertical forking."[1] This consists in thrusting the fork vertically into the soil, then moving it gently to and fro, and withdrawing it again without lifting up the forkful of earth. In this way the roots are certainly left almost undisturbed, but it must not be forgotten that the aeration of the soil is much less thorough than when forking is done in the ordinary way; and, in the present writer's opinion, the noxious effects of the root-pruning with the ordinary forking are apt to be over-estimated. However this may be, the method of vertical forking is certainly worth trying.

These different ways of forking all result in a more or less deep tillage of the soil, and they are desirable wherever the soil is compact and not very porous,

[1] See Barrett, "Cacao Cultivation. Special Report on Pruning and Soil Management" (*Paper No. 257 of the Agricultural Society of Trinidad and Tobago*)

though in countries where labour is expensive it may be a question whether this tillage will pay or not.

Another kind of tillage—*superficial hoeing*—has a different object, namely, to prevent the soil from evaporating too much and becoming too dry. In countries where some part of the year is very dry, and where cocoa often suffers from drought during this period, a superficial hoeing at the beginning of the dry season is useful, and will be specially advantageous if for any reason the layer of mulch on the soil is only poor. Accordingly, this method is specially valuable in fields where cocoa is cultivated without shade. The effect of superficial hoeing consists in covering the soil with a layer of loose earth, through which the underlying soil cannot evaporate its water so easily; for the very small canals, the so-called capillary canals, which run like continuous, more or less vertical tubes through a compact soil, are covered by the loose earth on the top, instead of running up to the surface. In this way evaporation of the soil is much reduced, and in addition the superficial hoeing kills the weeds, especially those which live on a root-stock, and which therefore are not killed by the ordinary weeding.

Manuring.—Many planters are of the opinion expressed in Hart's well-known book: "a tree in good health needs no manure,"[1] and if yearly crops are obtained which are regarded as satisfactory, they often do not trouble themselves with the question whether the yield could still be increased by manuring. On many plantations, therefore, manuring, like tillage, is not regarded as one of the necessary operations.

But though there may be countries where the soil is so rich that even after cocoa has been grown on it for a great number of years no kind of manuring would increase the yield, it is more than probable that systematic experiments would show that in most countries manuring, whether with farmyard manure, mulch, or with some kind of chemical manure, would

[1] Hart, *Cacao* (1911), p. 52.

increase the bearing-power of the cocoa tree. Unfortunately, in the case of cocoa systematic experiments of this sort are as yet rare, and in several countries no manuring experiments at all have been made. We are, therefore, still very ignorant as to the requirements of cocoa on different soils as regards manuring.

Before describing the results which have been obtained, a few words may be said in regard to the general significance of manuring. Broadly speaking, the aim of manuring is twofold :—

(1) To supply the soil with elements which are necessary as plant-food. These may be given to the soil in the form of artificial manures (basic slag, sulphate of ammonia, etc.) or as organic matter, whether of animal origin (pen manure, guano, dried blood, bone-dust, etc.) or vegetable origin (green-dressing, mulch, compost, ground-nut cake, etc.).

(2) To improve the structure of the soil. For this purpose only the organic or humus-affording manures are of importance; the artificial or, as they are sometimes called, the "chemical" manures do not play this part. Among the organic manures the most important improvers of soil structure are farmyard or pen-manure, green-dressing, mulch and compost.

The elements which a plant requires are taken either from the air (oxygen, carbon) or from the soil. Among the latter there are some which are always present in a greater quantity than the plant ever needs (*e.g.* sodium, magnesium, iron),[1] and others which are not always present in the quantity necessary to give the *highest* yield (*e.g.* nitrogen, potassium, phosphorus and lime or calcium). Now it is necessary not only that the soil

[1] The very limited space which can be devoted in this book to these principles of agricultural chemistry makes it necessary for the rules to be stated in very general terms. It is well known, for instance, that cases exist in which iron is present in the soil in too small a quantity, the plant showing the deficiency by a yellowish colour of the leaves. This happens so seldom, however, that it need not be discussed here. The student who is acquainted with the subject will find in this chapter many other rules stated which are not without exception, and which are to be taken only as representing the general idea. Too many details would, it was feared, simply confuse the general reader.

shall contain these latter elements to a certain percentage, but also, if they are to be of use to the plants, that they shall be present *in an available form.*

For instance, the soil may contain potassium compounds which are of no use to the plants, as the latter are unable to absorb them; while there are other potassium compounds which can readily be absorbed by the roots, and are therefore called "available plant-food." The non-available compounds are also called "dormant plant-food," a name which indicates that these compounds can by certain influences be "awakened," *i.e.* changed into available compounds. The elements nitrogen, potassium, phosphorus and lime must thus be present in the soil to a certain quantity in order to provide sufficient food for the cocoa tree, and they must be present in the form of available compounds.

The first purpose of manuring is, therefore, to add to the soil those elements of which available compounds are present in smaller quantities than the plant requires in order to produce the highest yield.

The question now becomes: "How can we find out what is needed?" and the answer is, only by giving the soil larger and smaller quantities of nitrogen, phosphorus, potassium and lime compounds, and seeing whether any increase in the yield is obtained. There was a time, however, when it was expected that chemical analysis of a soil would tell us which elements, and what amount of each, had to be supplied by manure in order to obtain the highest return, and that it would no longer be necessary to carry out manuring experiments, which sometimes require several years to give a clear result. The analysis of soils has, however, not been so useful as was anticipated, for the reason that chemists have not succeeded in discovering a method for ascertaining the quantity of *available* compounds of nitrogen, phosphorus and lime present in a soil. The absolute quantity of these elements can be very accurately determined, but as long as it is uncertain what part of the total quantity found is *available* and what part *dormant* plant-food,

the analysis conveys no clear impression as to the fertility of the soil. For instance, certain soils which, according to the analysis, contained up to 3 per cent of potassium (a very high amount), turned out to be of very little fertility; but their productiveness could be greatly increased by manuring with sulphate of potassium, it being therefore clear that the soil contained very little *available* potassium. The very fertile mud of the Nile, on the other hand, contains only 0·5 per cent of potassium, but the yield of the crops cannot be increased by potassium manuring; the potassium in the soil is, therefore, almost wholly present in an *available* form.

Many analysts have tried to find a method by means of which the *available* quantity of the different elements can be ascertained, but they have met with little success. It is true that in some cases the analysis of an extraction of the soil with 1 per cent citric acid gave figures which seemed to agree fairly well with the results of the manuring experiments, and to indicate approximately how much available food was present; but for general use this method also is unreliable. It may therefore be said that the chemical analysis of a soil is as yet unable to give us reliable data as to the quantities of the different elements which are available for a definite species of plant—for another circumstance which complicates the problem is the fact that a compound which is to a certain extent available for one species of plant may not be available for another species.

Up till now we have been dealing only with one side of the question of manuring—viz. the supplying of the soil with elements which are used by the plant as food—but, as has already been mentioned, manuring is in many cases also applied to improve the structure of the soil. For this purpose only the humus-producing manures are of importance: farmyard manure, green-dressing, compost and mulch of leaves and grass. These manures are of the greatest value in the tropics, where

the humus of the soil is quickly destroyed by the influence of the high temperature.

Finally, it may be added that some kinds of manures —especially lime—are also useful for converting compounds, which are not *available* plant-food, into another form which can be absorbed by the plants.

A few of the most important manures for the tropics may be mentioned here :—

A. Soil-improving (humus-affording) manures.

1. Farmyard manure or pen manure (of cattle, horse, pig, sheep and goat; contains about 3 to 5 per cent nitrogen, 2 per cent phosphorus, 4 to 6 per cent potassium, 2 to 6 per cent lime).
2. Compost. } Composition very variable, depending on the
3. Mulch. } plants from which it is made.

B. "Chemical" or "artificial" manures.

a. Containing phosphorus and nitrogen :—

1. Bone-dust (contains about 20 to 24 per cent phosphoric acid and 4 per cent nitrogen).
2. Peru guano (about 14 per cent phosphoric acid and 7 per cent nitrogen).

b. Containing nitrogen :—

1. Sulphate of ammonia (20 per cent nitrogen).
2. Dried blood (12 per cent nitrogen).
3. Chile saltpetre (in the tropics generally not so suitable as sulphate of ammonia, though much used in temperate climates; contains 15½ per cent nitrogen).

c. Containing phosphorus :—

1. Basic slag, also called basic phosphate or Thomas phosphate (contains between 14 per cent and 20 per cent phosphoric acid and 50 per cent lime).
2. Superphosphate (like Chile saltpetre, much used in temperate climates).

d. Containing potash :—

1. Sulphate of potash (40 to 50 per cent potash).
2. Kainit (about 14 per cent potash).

e. Containing lime :—

1. Quicklime.
2. Carbonate of lime.

Before describing the manner in which manuring experiments are carried out, one point regarding the exhaustion of the soil by the crop grown on it has to be discussed, as it has given rise to much confusion, and even to erroneous statements in handbooks on the subject.

It is often said that manuring is indispensable to every cultivation, because a certain amount of the various necessary elements (in the first place, nitrogen, potash, phosphoric acid and lime) are always taken from the land in the crop. If therefore we desire the land to maintain its original richness, we must return to it the plant-food we take from it in this way. Some writers on cocoa, indeed, go so far as to analyse the seeds and to conclude from this analysis what sort of manure has to be given to the soil. In this reasoning one thing is always forgotten—viz. the fact that every year a part of the dormant (or non-available) plant-food is converted into available food by means of the different atmospheric influences, and also by means of the action of the plant roots themselves.

Especially in the tropics, where weathering of the soil goes on quicker than in cooler climates, it is not at all exceptional for a soil to keep its original fertility without manuring: that is to say, the quantity of available plant-food converted every year from dormant plant-food is equal to the quantity extracted from the soil by the plants. If this quantity is sufficient to make the plant give its highest yield, it will obviously be impossible to increase the yield by manuring; and this will be the case not only in the first few years of cultivation, but also after many years of production. It is far from the author's intention to make planters believe this to be the rule, and to encourage them to regard manuring as generally superfluous, but it cannot be too clearly stated that the quantity and composition of the crop reaped cannot give any reliable indication as to the particular kind of manure required to increase the bearing power of the trees. The

composition of the crop is, in this respect, of still less use than chemical analysis of the soil. There remains, therefore, only one way of ascertaining whether we can increase the yield by means of manuring; and if so, what kind of manure must be given. This is by manuring experiments.

Manuring experiments.—It is often hardly possible for the planter to make these experiments himself, and, generally speaking, they should form part of the work of Experiment Stations. The experiments will be much more useful, their results will be obtained more quickly and will be more reliable, when they have been directed and controlled by experts in the science of agriculture. But the planter has not always an Experiment Station or an Agricultural Department at his disposal; a few indications as to the general method to be pursued may therefore be given here.

Where farmyard manure or compost or mulch is to be had, it is obvious that the effect of these should first be tried. In Europe 12 tons of farmyard manure per acre (30 tons per hectare) is considered to be an average dressing. When such a quantity cannot be obtained—and this is generally the case—the experiment has perforce to be made with as much farmyard manure (or compost or mulch) as can be given per acre.

Next, we have to find out whether an addition of phosphorus or potash or nitrogen in some form is useful; and when no organic manure at all is available, we have to make the experiments with artificial manures alone. When this is the case the following quantities may be recommended:—

As phosphorus manure .	200 kilograms of basic slag per acre (500 kilograms per hectare).
As potash manure .	80 kilograms of sulphate of potash per acre (200 kilograms per hectare).
As nitrogen manure .	60 kilograms of sulphate of ammonia per acre (150 kilograms per hectare).
As lime manure . .	400 to 600 kilograms of carbonate of lime per acre (1 to 1½ ton per hectare).

On heavy clay soils, however, the potash manure may be omitted, as clay soils are always rich in potash; and when the chemical manures are given together with farmyard manure, the above quantities should be reduced.

In carrying out manuring experiments a few "golden rules" should be remembered :—

1. Always include in the series of plots a sufficient number of unmanured "control plots," in order to be able to compare the yields on manured and on unmanured soil.

2. Do not make the experiments on too small a scale; do not have the plots smaller than one acre each.

3. Do not forget that the soil shows great variations over a surface of several hundred acres; therefore do not draw general conclusions from a single series of experiment plots at one place, but carry out experiments at different places.

4. Do not draw conclusions from the results of the experiments after one year, but wait till the results of some four or five years have been obtained.

It is always a good thing to ascertain by a separate series of experiments the effect of the addition of lime to the soil. For this purpose the series of experiment plots may be arranged as follows :—

Plot 1.	Plot 2.	Plot 3.	Plot 4.
No lime.	400 kilograms of carbonate of lime per acre.	No lime.	600 kilograms of carbonate of lime per acre.

Each plot should be one acre in size.

In this connection, however, it must not be forgotten that lime not only has the faculty of "sweetening" sour soils, but also acts at the same time as a liberator of plant-food, converting dormant plant-food into available compounds. This faculty, though enriching the soil temporarily, makes it poorer in the future, so

that it is sometimes said that lime "makes parents rich, but children poor." It also accelerates the decomposition of the humus. It is, therefore, not advisable to give lime to the soil year after year without other manure; but it often produces good results if it is combined with organic manures (mulch, compost), or is followed by the application of farmyard manure. But lime, or lime-containing compounds or mixtures, must never be applied at the same time as, or mixed with, farmyard manure, sulphate of ammonia, or other ammonia-containing manures, because lime liberates the ammonia from such manures and allows it to escape into the air. There should be an interval of some six weeks between the applications of such incompatible manures.

To simplify the explanation of the experiments with the other manures, let us take as an example a clay soil, rich in potash, so that this element may be omitted. Two cases may be considered: (A) when no farmyard manure or other organic manure is available, and (B) when sufficient farmyard manure is available to apply 3 tons per acre.

(A) When no organic manure is available, the series of experiment plots should be arranged as follows:—

Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
200 kg. basic slag.	No manure.	60 kg. sulphate of ammonia.	No manure.	200 kg. basic slag and 60 kg. sulphate of ammonia.	No manure.

In plot 5 the basic slag is not, of course, given together with the sulphate of ammonia, as it contains lime; the basic slag is applied first, and six weeks afterwards the sulphate of ammonia.

If we had not omitted the potash manure, a trial could have been made with an application of 60 kilograms of sulphate of potash per acre, also in combination with the other manures.

(B) When sufficient farmyard manure is available to apply, say, 3 tons per acre, a series of experiment plots should be arranged as follows (it is again understood that the soil is rich in potash and that, therefore, no experiments with applying potash have to be made):—

Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.	Plot 7.
No manure.	3 tons farmyard manure.	3 tons farmyard manure. 100 kg. basic slag.	No manure.	3 tons farmyard manure. 30 kg. sulphate of ammonia.	3 tons farmyard manure. 30 kg. sulphate of ammonia. 100 kg. basic slag.	No manure.

In the plots 3 and 6 the basic phosphate has to be applied first and the farmyard manure and the sulphate of ammonia six weeks later.

The manner in which the manures are applied is not without importance. Artificial manures are often mixed with dry earth before application, which allows them to be more easily and more equally distributed over the land. They may also be incorporated in the soil by superficial hoeing; but this is not so necessary with potash and phosphorus manures as with ammonia-containing manures. Organic manures will always have a much better effect when incorporated into the soil by means of the hoe or the fork than when left on the surface; this is especially the case with farmyard manure, which contains a large proportion of compounds of ammonia.

As regards the time of the year, the best effect will generally be obtained if the manure is given when the dry season is just over and the first few rains are bringing new life to the root-systems. This time of the year may be compared with our spring-time; the whole tree is in a state of great activity, and new roots, new twigs, new leaves are formed. In some

cases, however—*e.g.* in countries where the dry season is long but not severe—the young fruits of the cocoa are formed in the dry season, so that the tree bears a good number of very young fruits when the first showers begin to fall and the tree begins to make new leaves and twigs. If nitrogenous manure—sulphate of ammonia or farmyard manure—is applied at this time, the consequence is sometimes that the tree spends all its force in making many strong new twigs and leaves, and drops many of its young fruits. In such circumstances it is advisable to stop the application of nitrogenous manures, or to increase the application of phosphorus and potash manure, or to apply the nitrogenous manure at another season.

As has already been mentioned, farmyard manure, and compost or a mulch of leaves and grass, are useful in a double sense: they improve the structure of the soil, making it porous and loose, and at the same time add plant-food to the soil. This improvement of the structure is useful in more than one sense:—

(1) The loose and porous condition makes it especially suitable for the growth of the roots of plants; at the same time the air penetrates more freely into the soil, thus making the roots healthy and vigorous.

(2) The water-holding capacity of the soil is increased, and therefore it does not dry up so quickly in the dry season.

(3) Its elasticity is improved, so that it does not "pack" so readily in the rainy season nor split so easily in the dry season.

In fact, while artificial manures are useful only to the extent that they give the soil a special form of plant-food, farmyard manure, green-dressing and compost are useful in several directions. Their advantages over "chemical" or "artificial" manures are especially conspicuous in the tropics, where the soils are often poor in humus. Farmyard manure and compost would doubtless play a more important part in the cultivation

of cocoa if they were more easily to be obtained in large quantities.

In one case, however, this kind of manure is indispensable, viz. when cocoa is grown without shade trees. In Grenada, where this manner of cocoa-growing is general, every plantation has a good number of cattle to supply the amount of manure necessary for the soil. This fact shows clearly that the most important function of the shade trees is to provide new humus by its fallen leaves, and to preserve the humus by shading the soil.

The regular application of farmyard manure or compost is, so far as can be ascertained, not carried out in any other cocoa-growing country except Java. But that it would have excellent results in other countries is shown by several fertilising experiments.

In Dominica such experiments were started in 1902.[1] Plots were treated with artificial manure alone (basic slag and sulphate of potash); with these mixed with dried blood; and with mulchings of leaves and grass. The result was that the greatest increase in yield took place on the mulched plot, the average increase during eight years being not less than 616 lbs. per acre per year. The manuring with basic slag, sulphate of potash and dried blood also gave good increases, but not as big as the mulching, the expense of which was much smaller than in the case of any of the others. It should be pointed out, however, that the effect of the mulching is not so quickly seen as those of the chemical manures and the dried blood, but it increases gradually. The superiority of the mulching is, therefore, especially apparent in the fourth and following years.

The following figures give an outline of the results of the experiments :—

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[1] "Results of the Recent Experiments with Cacao in the West Indies" (*West Indian Bulletin*, vol. ix. pp. 138-148); *Report on the Botanic Station, etc.*, Dominica, 1909–1910, p. 24.

[TABLE

	Average yield of cured cocoa in lbs. per acre obtained from 1902 to 1909.	Yield of cured cocoa in lbs. per acre obtained in 1909.
Plot 1. No manure . . .	1·159	1·272
Plot 2. 4 cwt. basic phosphate 1½ cwt. sulphate of potash per acre	1·387	1·395
Plot 3. 4 cwt. dried blood per acre .	1·325	1·361
Plot 4. 4 cwt. basic phosphate 1½ cwt. sulphate of potash 4 cwt. dried blood	1·567	1·835
Plot 5. Mulched with grass and leaves	1·775	2·068

The good effect of the mulching was shown not only by the high yield but also by the fact that the individual trees on the mulched plot were much finer and better developed than those on the other plots.

Attention should further be drawn to the fact that the yields are high on all the plots of this field, and on plots 4 and 5 even abnormally high: a yield of 1800 to 2000 lbs. (800 to 900 kilograms) per acre is certainly exceptionally large.

In two other series of experiment plots, where the different effects of pen manure and various others (compost, bone-meal, dried blood and some chemical manures) were compared, the result was in favour of the pen manure, which gave the highest profits. In Grenada the experiment plots gave the highest yield when pen manure was given.

It has already been mentioned that the difficulty

is to obtain the necessary amount of pen manure, and in the case of large plantations this manure will hardly anywhere play an important part—except in the rather small plantations of Grenada, where cocoa is grown without shade and not less than one-fifth of the total area of each plantation is used as pasture for the cattle, and in Java, where farmyard manure is very cheap.

Mulching with grass and leaves from adjoining vacant lands is probably more often practicable than the application of pen manure, but very often even mulching is not feasible, because the amount required to give good results is not small. The Agricultural Superintendent of St. Lucia states that a mulch of 10 tons per acre is hardly sufficient to cover the soil thoroughly, and he considers a larger quantity most advisable. The labour required to gather so much mulch and to spread it out over the ground is certainly not insignificant, and the expense will be high unless labour is cheap and there is enough vacant soil from which to obtain the mulch. These two conditions are, however, not often found together.

As regards farmyard manure, 12 tons per acre (30 tons per hectare) is in Europe considered to be an average quantity. To obtain this quantity a large number of cattle is necessary. The conditions in Java are favourable for obtaining this manure at a fairly low price, either from the cattle and horses of the plantation or from the Javanese people in the neighbouring villages. When obtained in the latter way, however, it is of inferior quality and larger quantities are necessary to get an appreciable result. Generally about two kerosene tins are given per tree; this amounts to 50 or 60 kilograms of fresh manure, or 35 to 40 tons per hectare (about 15 tons per acre), as the trees are usually planted fairly closely to the number of about 700 per hectare.

The general opinion of the planters in Java is strongly in favour of the application of humus-affording manures, and the effect of artificial manures

is considered inappreciable. Besides farmyard manure, other sorts of humus-affording manures are regarded as useful. On one estate, for instance, good results were obtained by the application of undergrowth (herbs and shrubs) from the virgin forest; but this method, though good in itself, could not be applied every year and over the whole plantation, as the undergrowth from 4 to 5 acres is necessary to cover the soil of one acre in the cocoa fields. Another kind of humus-affording manure is regularly given on different estates in Java, viz. "boengkil," *i.e.* "ground-nut cakes," or cakes made of castor seeds after extraction of the oil. Little can as yet be said, however, as to the effect of this manure for cocoa, for systematic experiments have only lately been started. Generally about one to two kerosene tins of "boengkil" are given per tree.

In many countries, however, organic manures are not to be had at a reasonable price, and the planters have no option but to try artificial manures. This, for instance, is the case in St. Lucia. The Agricultural Superintendent wrote: "Pen-manuring is undoubtedly the best system, but the difficulty of transportation prevents its general adoption." Experiments were therefore made with artificial manures, and these experiments have shown that in St. Lucia the soil needs no addition of potash, but that phosphorus and nitrogen produced good effects. On the experiment plots the best results were obtained by the application of 200 kilograms of basic slag and 50 kilograms of sulphate of ammonia to the acre.

In Victoria (Kamerun) manuring experiments were started in 1904, and the results of the first crops of the different plots were published in the following year.[1] Though results after only one year cannot be regarded as conclusive, it may be mentioned that on two experiment fields an application of potash and phosphorus seemed to have the best success (about 220 kilograms of kainit and 100 kilograms of super-

[1] Strunk, "Kakao Dingungsversuche" (*Tropenpflanzer*, 1906, p. 516).

phosphate were given to the acre). Slaked lime and sulphate of ammonia seemed to have less effect.

In the case of Grenada the results of certain experiments at the "Nianganfria" Estate are available. Though these experiments would have been still more interesting if control plots had also been present, some of the results are well worth mentioning.[1] The plot A, where pen manure was applied, was not so productive as the plots where artificial manures were applied, and is here omitted:—

YIELD PER ACRE IN KILOGRAMS

Plot.	Manures applied per acre.	Crop 1900–1901.	Crop 1901–1902	Crop 1902–1903.	Crop 1903–1904.
B	*August* 1900. Basic slag, 400 kg. *February* 1901. Sulphate of ammonia, 75 kg. *May* 1902. Basic slag, 400 kg. *August* 1902. Sulphate of ammonia, 75 kg.	504	784	693	756
C	*August* 1900. Basic slag, 400 kg. *February* 1901. Nitrate of soda, 75 kg. *May* 1902. Basic slag, 400 kg. *August* 1902. Nitrate of soda, 75 kg.	399	598	588	672
D	*August* 1900. Basic slag, 400 kg. Sulphate of potash, 50 kg. *May* 1902. Basic slag, 400 kg. Sulphate of potash, 50 kg.	392	672	672	735

[1] *Agricultural News*, 1904, p. 347.

Here the superiority of sulphate of ammonia over nitrate of soda seems well demonstrated, and the application of sulphate of potash appears to result in an important increase of the crop. The effect of the basic slag, however, is uncertain, owing to the absence of control plots.

Finally, it may be mentioned that in Ceylon, according to Wright,[1] good results have been obtained by the application of 250 kilograms of basic slag and 100 kilograms of sulphate of ammonia per acre.

Pruning and cleaning the trees.—The object of pruning any kind of tree—whether it be a European fruit tree or a cocoa tree or a coffee tree—is first of all to induce the tree to use its force as much as possible for the production of fruit, and to obtain the most advantageous form and proportion of the foliage system for this purpose. In other words, pruning aims at modifying the growth of the tree by reducing the amount of branches and leaves, and by giving the tree a more regular form in order to obtain a higher yield.

In pruning, therefore, the removal of all useless branches is first of all necessary; and then it has to be considered whether by reducing the number of branches the remaining ones will be so strengthened as to produce more fruit than when all the branches are allowed to remain on the tree. On this point opinions are very different. On one side we have those who advocate the removal every year of a good number of twigs; on the other side we have the "anti-pruners," who are convinced that the highest yield will be obtained when nothing is removed but the dead twigs and the superfluous watersuckers. This controversy is not surprising, for, apart from the differences in the varieties of cocoa cultivated, the composition of the soil varies greatly on different estates; while on one soil the trees grow luxuriantly and have more branches and leaves than are necessary in proportion to the quantity of fruit which it is able to produce, on another

[1] Wright, *Cocoa*, p. 183.

kind of soil the growth is less luxuriant, and in order to give its maximum yield the tree will need all the branches and twigs it can form. It is therefore impossible to give general rules which can be simply

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Fig. 58.—An example of the Ecuadorian system of allowing the watershoots at the base of the stem to grow up.

followed. The planter must investigate and ascertain for himself whether pruning increases the bearing power to an appreciable degree.

Though no general rules can be given as to the

removal of healthy twigs, it is easier to give some positive advice as to the removal of weak and diseased twigs and watersuckers. This operation is better called *cleaning* than *pruning*. As a rule such twigs, as well

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FIG. 59.—Another example of the Ecuadorian system.

as watersuckers, should all be removed. It is true that in some countries watershoots, arising from the foot of the tree, are sometimes left standing. In this way a tree with several stems is obtained. This

is done, for instance, in Ecuador (Figs. 58, 59), and sometimes in Ceylon and in Java (Fig. 60). In Java, however, very often only one watersucker is left, arising from just under the ramification or on one of the main branches near the ramification. In this way two foliage systems are formed, one above the other (Fig. 61). The present writer is unable to see a single advantage in either of these two systems. If in an Ecuadorian

Fig. 60.—The Ecuadorian system (see Fig. 58) adopted on the plantation "Djati Roenggo," Java.

plantation it turns out that the tree with many stems really yields more than the tree with one stem, this is simply an indication that the trees should be planted more closely. And the system often followed in Java (Fig. 61) has been adopted especially in fields where the cocoa has made a very short stem, and accordingly its main ramification is at a low height (Fig. 35), this being a consequence of the lack of sufficient temporary shade (see the section dealing with Java in Chapter IX.). In such circumstances it may be necessary to adopt this system, and to allow one sucker to grow up and

thus to make a prolongation of the stem; but the system is also often followed in Java when this necessity is not present. In such cases it must possess decided disadvantages. The fruits have to be picked

FIG. 61.—The system of allowing one sucker, near the main ramification, to grow up.

This system is often followed in Java. The low height at which the tree has ramified is apparent.

from a greater height, and all operations, such as cleaning the trees, fighting diseases, looking for noxious insects, etc., are more troublesome than when no sucker is left growing and the whole branch and foliage system is formed by the main ramification of the stem.

In San Thomé, also, one sucker is sometimes allowed to grow up if the stem has made its ramification at a height of about 60 centimetres (24 inches), which is considered to be too low. The sucker is then left growing in order to form a new ramification above the first one. The lowest branches are left until the top one is bearing—generally in the second or third year of its formation—and then the lower branches are cut quite close to the stem.[1] Though this system seems to have more to recommend it than that of either Java or Ecuador, because the result is only one stem with one main ramification, its general adoption is not to be advised. In most countries the planter is able to regulate more or less the height of ramification. If the young tree is grown under dense shade—of bananas for preference—it will grow higher up before it ramifies; if the shade is light, the ramification takes place lower. Probably the system adopted in San Thomé is only a consequence of leaving forest trees standing in clearing the forest and planting no special trees to act as temporary shade—as we have seen, a very inadvisable plan. The same bad method is followed in Java when cocoa is planted in an old coffee field to replace this no longer paying crop. In this case it is generally the "dadap" (*Erythrina*) which is left standing, and the young cocoa is grown under this tree, which is splendid for permanent shade, but, like all high trees, unsuitable as a temporary shade for the young plant.

The author's conclusion is, therefore, that there is only one case in which it is either necessary or desirable to let a sucker grow up. This is when a tree has been severely injured or damaged in its stem or branches—*e.g.* by borers or otherwise—while the root-system is still healthy. In such a case the tree may be quite rejuvenated by allowing a sucker to grow up from the foot of the stem and cutting away the old tree when the sucker seems strong enough, or by cutting away the old tree first, leaving only a short stump on

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain*, pp. 118-120.

which one sucker is allowed to grow to form a new tree.

While the Java and the Ecuador systems leave water-shoots which ought to be removed, there are other systems, equally bad, in which branches and twigs are removed which ought to be left on the tree. A common system, which is to be found here and there in almost every cocoa-growing country, is the system of "trimming up." When the cocoa tree has made its principal ramification, the main branches throw out side branches, some of which grow in a downward direction towards the soil. Though these are neither harmful nor useless, they have to be removed in order to allow a free passage under the tree; all sorts of manipulations (picking, pruning, cleaning of the trees, etc.) would be very difficult if these branches were left. But many cocoa growers, especially small proprietors, have a tendency to go much too far in this direction. When all the branches which were hanging to the ground have been removed, they still go on removing side branches, leaving the main branches standing in the air like sticks and bearing side branches only at the top. Sometimes even the tops of main branches are cut away in order to make the branch system grow more in an upward direction. In this way are obtained trees in which all the lower part of the branch and foliage system is awanting. This offers not a single advantage and several disadvantages, especially a reduction of the crop, difficulty in picking, cleaning, pruning, etc.

As regards the removal of weak and diseased twigs, few planters will consider this useless, but, on the other hand, many are not convinced that it is really very necessary. In so many plantations the trees are loaded with a lot of poor, almost useless twigs, the leaves of which are of very little value to the tree and simply take space and food which might be better used by healthier twigs.

Regular treatment is accordingly necessary, once a year or if possible twice a year, always in the dry season

when the tree is resting. The advice "prune often but little at a time" is indeed good in several respects, but in the tropics the dry season is the only season suitable for this work. At this period of the year the wound dries quickly and parasites do not penetrate easily; moreover, when the operation is done while the tree is at rest, a more regular reaction follows than in other seasons when all the buds in the neighbourhood are ready to develop at once as soon as a twig has been cut.

As regards the organisation of the work of pruning and cleaning, it is best to have a gang of labourers going round in the dry season to cut away the suckers and the diseased twigs. This *cleaning* of the tree may be considered fairly simple work, which only needs care but no special skill. The gang of men must be numerous enough to finish this very necessary work in the dry season. In some cases, when twig disease is prevalent, this gang has to go round the plantation several times a year, or even continually. This is, for instance, the case in Surinam, when the plantation, after it has once been cured of "witch-broom disease" by special treatment, has to be kept clear of "krulloten" ("witch-brooms") and "hardened" pods.

Besides the gang of cleaners, a smaller gang of pruners has to be at work in the dry season, looking after the cleaned trees and removing superfluous twigs when the foliage system is considered to be too dense. In doing this they should at the same time try to give the tree a more regular form by removing the irregular twigs and leaving the others.

What twigs are too weak to be allowed to remain on the tree, and when is the system of foliage so dense that the removal of some healthy twigs is advisable? These questions are difficult to answer. When the planter has answered them for himself, he should teach a few of his best labourers to do the work, and he will especially have to impress upon them that each tree must be treated individually, and that it is better to work slowly and carefully than to hurry. The gang of

pruners must therefore be a select one, consisting only of a small number of skilled and competent workmen. If the planter has not enough skilled labourers to get his whole plantation pruned in time—*i.e.* before the end of the dry season—he will do better to leave some fields unpruned than to allow the work to be done by incompetent labourers, who would probably cut away twigs which ought to remain.

It is hardly necessary to point out that, in cleaning, the dead and diseased twigs and branches, as well as the watershoots, must be cut quite close to the branch or stem to which they are attached, so as to leave no stump. Moreover, both cleaners and pruners must carefully cover the wounds with coal-tar, so as to close them against parasites such as fungi and borers.

Prevention of disease.—Diseases occur in all cocoa-growing countries, but in the most important of these (Ecuador, Venezuela, San Thomé and Brazil) the diseases have not yet been the subject of any important investigations, and consequently we are still wholly ignorant about the cause of most of them. Rational methods of preventing and eradicating fungus diseases and insect pests have not yet been arrived at, and in most cases the planters have to help themselves. The result is, of course, that the prevention of disease does not take such an important part in regular plantation work as it should do; sometimes, even, hardly any precautionary measures are taken at all.

In those countries, however, where the diseases have been properly investigated, special precautionary measures have been discovered for the prevalent diseases. Thus in Surinam the continual removing of the "krulloten" ("witch-brooms") and "hardened" pods by a special gang of labourers forms part of the regular work of a well-managed plantation. In Java every year, at the end of the harvest, when the number of fruits attacked by the moth-borer is increasing, the "rampassing" (the picking and destroying of all the remaining fruit) is carefully done. In Ceylon the

control of the canker by cutting out the diseased part of the stem is a matter of continuous care on the part of the planter.

But besides these special methods—different in different countries, according to the special character of the prevalent disease—there are a few "hygienic" measures whose adoption may be recommended for every cocoa-growing country. These may be briefly summarised as follows:—

1. *Make it as difficult as possible for infection to penetrate into the tree, by removing the dead branches and twigs, and by closing the wounds by means of an antiseptic coating*, for which purpose coal-tar is most to be recommended. Several parasitic fungi, as well as noxious insects, find it much easier to enter the tree and attack the healthy tissue when they can begin their invasion with dead wood or at open wounds.

2. *Do not leave the fruit-husks unburied in the plantation.* In every cocoa-growing country the pods are attacked by fungi. Phytophthora (causing the "blackening of pods" and the "canker" of stems) is the most common of the fungi which live and propagate on the fruit-husks. The open heaps of fruit-husks, as they are met with on many plantations, may therefore be considered as sources of pod and stem diseases. The best method of disposing of the husks has been the subject of controversy—whether simply to bury them (Fig. 62) or to gather them into compost heaps, mixed with lime. The latter method, of course, involves more labour, for the shells have to be collected into heaps and later to be spread over the field again. The present author can see no special advantages in this laborious method, and considers the simple method of burying the best. A practical way is to make the holes in which the husks are to be buried between the rows of cocoa, and to alternate with each following picking, in order to divide the husks as equally as possible over the field. The husks are valuable as manure, as they contain about 0·2 per cent

nitrogen, 0·3 per cent potash, and 0·1 per cent phosphoric anhydride, and in the meantime they add humus to the soil.

Another good method is to leave the husks buried for a fortnight or so and then to spread them out where they are thought to be most useful as manure — for instance, round the young cocoa plants. It has been observed that, when the heaps have been made large

Photo. Hisgen, supplied by the late Mr. C. MacGillavry.

Fig. 62.—Burying the husks after breaking (plantation "Djati Roenggo," Java). The tree has been allowed to grow in the Ecuadorian way (compare Figs. 58, 59, 60).

enough, the husks soon begin to ferment, thus causing the temperature to rise high enough to kill noxious insects and fungi.

3. *Do not leave dead trees lying in the fields.* Dead cocoa trees and dead shade trees should be removed as quickly as possible and burned, whether an infectious disease is the cause of death or not. When a tree has been attacked by an infectious disease it is, of course, necessary to remove it in order to prevent the infection spreading, but apart from this, all dead wood

in the fields provides shelter for all sorts of noxious insects (borers, etc.). It is not sufficient to collect the dead trees into heaps at special places. The dead wood must be destroyed as soon as possible, for preference by burning.

These general remarks as to preventive measures against the spreading of diseases and insect pests are sufficient for the moment. In Chapter VIII. the different diseases are described separately, together with the special methods of preventing and eradicating them.

Picking.—The ripening of the fruit is generally indicated by a change of colour. In the red variety the colour changes generally from carmine to vermilion in consequence of the development of a yellow pigment, which alters the carmine to vermilion or even to orange. In the yellow varieties the fruit is green when unripe, changing to yellow; but sometimes this change is very slight and the colour remains green, growing only a little paler as the fruit becomes ripe. Moreover, when the fruit is ripe the seeds become loose from the husks and adhere only to the central stalk, or "placenta," in the middle of the fruit. Accordingly, if a ripe fruit be shaken the seeds can be heard tossing against the husk, and if the fruit-wall be tapped with the finger or a piece of wood a ripe fruit gives a hollow sound. Labourers, however, never use this latter test, as they have learned to judge by the outer appearance of the fruit whether or not it is ripe enough to be picked.

Picking may be considered fairly simple work, but the planter has to take care of two things: that clean wounds are made in picking the fruits, and that the cushions which bear the fruits are not too much injured. The consequences of careless picking are not so serious as has been asserted by some authorities, who regard the remaining fruit-stalks of carelessly picked fruits as the main entrances for parasites, and who consider the injuring and damaging of the "cushions" to result in insufficient production of flowers the following year. As entrances for parasites, however, diseased and un-

healthy twigs play a much more important part, and the number of places where flower-buds may be produced, as well as the number of buds produced on each spot, are so great that too small a number of flowers and young fruit is hardly to be feared when the tree is in good condition and well nourished. All the same, careful picking is, of course, strongly to be recommended. To attain this the planter must have handy and skilful pickers, good tools, and sufficient supervision over the picking gang.

The picking of the fruit on the stem and the main branches is an easy task. It is generally done by means of the cutlass knife, sometimes with large pruning knives. The picking of the fruits on the higher parts of the tree requires more skill, as care has to be taken to make a clean cut without injuring either the cushion or other adjoining fruits. Several forms of cocoa hooks (Fig. 63) have been made to enable the pickers to pull as well as to push, for it is sometimes better to pull when the branch is hanging, while, when the branch is standing, a clean cut is obtained more easily by pushing in an upward direction.

The hook generally used in Ecuador, the so-called "podadera" (Fig. 63, *a*), is only suitable for pushing. This drawback is counterbalanced by the fact that the "podadera" is always made of steel of superior quality, and is always kept very sharp; and in addition the Ecuadorian pickers are very adept at wielding it. The hooks used in Trinidad (Fig. 63, *b*) and Kamerun (Fig. 63, *c*) have the advantage of being handier when a fruit is difficult to reach; for instance, when a ripe fruit hangs between others which are still unripe, and also when pulling is to be preferred. In the West Indies, and to some extent in South America, the hook illustrated by Fig. 63, *b*, is the most popular type. Preuss modified the Kamerun type (Fig. 63, *c*) a little, and suggested the form *d* (Fig. 63). In Java the author saw a hook used (Fig. 63, *e*) somewhat resembling the Kamerun form. It was made by a native black-

smith for the price of fivepence, the shaft being of bamboo. In this way a very cheap and suitable hook was obtained, but still it is preferable to have the hook made of steel of superior quality in order that it may keep longer sharp. Finally, Hart suggested the form *f* (Fig. 63). Of all these different kinds of cocoa hooks, the two illustrated in Fig. 64 are, in the author's opinion, the most to be recommended.

The picking gang goes round as often as seems necessary. When the season is dry the fruit ripens

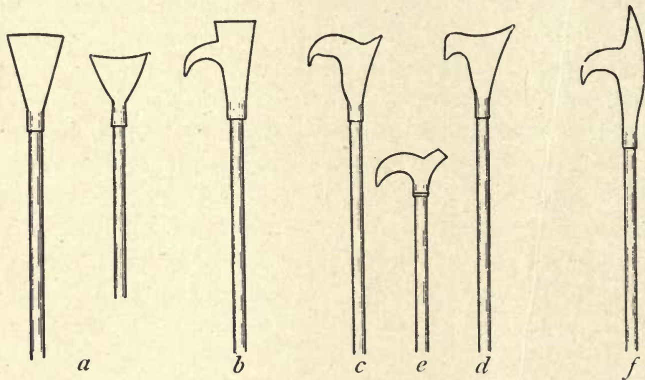


FIG. 63.—Different forms of cocoa hooks.

a. Two forms used in Ecuador ("podadera").
b. Form generally used (Trinidad, Venezuela, Surinam, etc.).
c. Form used in Kamerun.
d. Form recommended by Preuss.
e. Form sometimes used in Java.
f. Form recommended by Hart.

slowly, and the time between two successive pickings is longer than in the rainy season. They may follow each other after three or four weeks, or even, when it seems necessary, after a fortnight.

In Trinidad the picked pods are gathered by women and boys, who follow the pickers and collect the pods into small heaps, which are sometimes collected again into larger ones. The task of the pickers in this country is therefore only to cut the fruit-stalk, the pods falling to the ground.

As a rule, the gang is divided into groups of four

labourers, consisting of two pickers, one woman to gather the pods into small heaps, and one labourer to collect the small heaps into a larger one. It is said that in the full crop season each gang can gather about 3000 fruits daily, giving about 100 kilograms of prepared cocoa.

The fruits are opened the same day or one or two days later. The opening is done preferably when it is not rainy, for the beans do not ferment so easily when they have been wetted by rain.

In Ecuador the "tumbadores" (pickers) are often provided with a simple bag for the picked pods. These

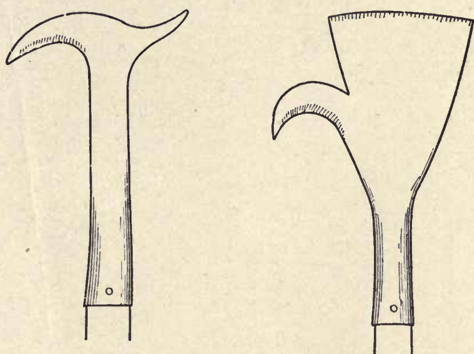


FIG. 64.—Two types of cocoa hooks recommended by the author (one-fifth actual size).

bags are emptied into small heaps, which are later collected into larger ones.

Breaking.—The husks are broken at the large heaps of fruit by labourers, in many countries women (Figs. 65, 66). The contents are put into baskets, which are then taken by mules (*e.g.* in Trinidad, etc.) or in boats (*e.g.* in Surinam) to the fermenting house. The breaking is generally done by means of the ordinary slightly-curved reaping knife or with a special short one. The women often acquire great dexterity in opening the fruits quickly, holding the fruit in one hand, cutting the husks with one stroke of the knife, and opening the fruit with a twist and jerk.

Fauchère[1] gives the following account of the labour involved in Trinidad in picking and breaking about 30,000 fruits, giving about 1000 kilograms of marketable cocoa:—

	s.	d.
Picking (= one man's work for 10 days)	12	0
Gathering (= one man's work for 20 days)	16	0
Breaking (= one man's work for 4 days)	4	10
Extracting seeds (= one woman's work for 15 days)	12	0
	44	10

Photo. Jacobson.

Fig. 65.—Shelling the pods (Trinidad).

Yield.—Generally the cocoa tree bears a few pods in its third year, but with a slower growth the first fruits may not appear until the fourth year. An almost full harvest may be obtained in the seventh or eighth year, but generally the yield continues to increase a little until it reaches its maximum in the tenth, eleventh or twelfth year. The planter is sometimes advised not to allow a young cocoa tree to bear before

[1] Fauchère, *Culture pratique*, p. 80.

it has attained a certain development, generally in its fifth year; but there seems no reason to suppose that the production of a few fruits in the third and fourth years weakens the tree to any extent, and the author consequently sees no reason to recommend this practice.

These statements apply only to the Forastero varieties; the Criollo comes into bearing later, and generally gives no fruit at all before its fifth year.

The age of bearing and the bearing power are

By permission of Mr. Monteiro de Mendonça.

FIG. 66.—Shelling the pods (San Thomé).

influenced not only by the variety of the tree, but also by conditions of climate and cultivation. Very apparent, for instance, is the influence of the amount of shade. When the trees are cultivated without shade, the production is earlier and a full crop is obtained in the fifth or sixth year; and when the cultivation is careful, the yield is also a high one. On the other hand, however, the lifetime of the tree is shortened.

It is easy to obtain a too favourable impression of the productiveness of the cocoa tree, for there seems to

be everywhere a tendency to consider as exceptions those fields which give a low production, and to regard the better fields as the examples from which the average yield is to be deduced. The only way, therefore, to obtain a true average yield is to take the total acreage of all the plantations of one country, and the total production of the country throughout a number of consecutive years. If the same thing could be done for the small proprietors, their average production per acre could also be arrived at; but unfortunately it is generally impossible to obtain reliable data as to the areas cultivated with cocoa by the small proprietors.

In the case of Surinam the exact amount of yield per acre from the plantations has been figured out.[1] For our purpose only the figures from 1893 to 1899 are important, as after the latter year the witch-broom disease began to show its effect in greatly diminished yields.

Year.	Total production of all the plantations in Surinam in kilograms.	Total acreage of plantations.	Average yield per acre in kilograms.
1893	2,788,000	12,700	219
1894	2,645,600	13,302	199
1895	3,166,100	13,632	232
1896	2,440,500	13,675	178
1897	2,829,200	14,435	196
1898	2,218,700	15,041	147
1899	3,395,800	15,370	221

These seven average figures for the years 1893 to 1899 give again a general average of 212 kilograms (471 lbs.) per Surinam acre, which means about 444 lbs. per English acre.

Some figures as to yield in Ceylon are available, though there the investigations have not been so extensive. The yields per acre in certain plantations

[1] Van Hall and Drost, "The Witch-Broom Disease of Cacao" (*Proceedings of the Agricultural Society of Trinidad and Tobago*, December 1909, p. 46).

were recorded from 1900 to 1905;[1] they ranged between 114 lbs. and 1026 lbs., the average being 299 lbs.

Figures obtained in this way are not available for other countries, but in some cases estimates have been made which are regarded by competent authorities as reasonably accurate. Of course such figures are not so valuable as those obtained in the manner which has been described, for even high authorities on the subject have an unconscious tendency to neglect poor yields, and in this way we therefore generally obtain figures which are really too high.

In the case of Trinidad, Hart[2] says: "It is generally considered that a yield of 1·6 lbs. per tree is a first-class yield. Taking our trees to be planted at 15 feet apart, there will be 193 × 1·6 lbs., 308·8 lbs., or say 300 lbs. (135 kilograms)." Others regard this figure as representing not a "first-class yield" but only a "high average"; but this is of minor importance. I think Hart's estimate may be accepted as correct, though it is true that other estimates are generally higher. Mr. de Gannes, a well-known cocoa-planter of Trinidad, stated that a yield of 12 bags of 170 lbs. per 1000 trees planted 12 feet apart was a safe estimate; this amounts to 573 kilograms per hectare or 230 kilograms per acre—*i.e.* almost double Hart's estimate. The estimate of the Royal Commission, however, was again much lower, amounting only to 280 kilograms per hectare or 112 kilograms per acre.

The average yield obtained in San Thomé is estimated by Masui to be 600 to 700 kilograms per hectare, or 240 to 280 kilograms per acre. This is a very high average, and it is questionable whether it would not be lower if the production of a great number of plantations were taken into account. At any rate it does not agree with the estimated yield of about 60,000 hectares, which was the area planted with cocoa a few

[1] Wright, *Cocoa*, p. 186.
[2] Hart, *Cacao*, p. 73.

years ago.[1] For if the yield per acre was, say, 260 kilograms, and the yield per hectare accordingly 650 kilograms, the export would have been about 39 million kilograms. The export, however, never reached any such high figure. With an area of 60,000 hectares and an export of about 22 million kilograms (in 1907) the average yield would be 366 kilograms per hectare or 147 kilograms per acre. These figures show how little we know about the average production of cocoa even in one of the most important cocoa-growing countries.

As regards Brazil nothing at all is known.

In the case of Ecuador the well-known authority, Mr. M. E. Seminario, estimates the average yield for "Arriba" to be about 500 kilograms per hectare or 200 kilograms per acre, and to be a little higher for the Guayas and El Oro. The statistical figures agree fairly well with this estimate, the acreage being about 45,500 hectares and the yearly average export in the last three years 27 million kilograms. This gives an average yield per annum of about 600 kilograms per hectare or 240 kilograms per acre.

All the above figures are intended only to give an impression as to the yield of cocoa which is generally obtained. It need hardly be said that the yield depends greatly upon circumstances—richness of the soil, climate, manuring, cultivation, presence or absence of serious diseases, etc. The influence of manuring has already been demonstrated. The influence of climate is especially clear from the fact that in consecutive years the crops are widely different; and the effect of the mode of cultivating or the influence of diseases on the crop needs no further explanation. It is, therefore, very difficult to state a general average, but, speaking generally, we may call 200 kilograms per acre a normal yield, 100 kilograms a poor one, and 300 kilograms a high yield.

[1] Estimate of Mr. de Almada Negreiros; see Chevalier, *Le Cacaoyer dans l'Ouest africain*, 1908, note 2 on p. 38.

CHAPTER VII

FERMENTATION, WASHING AND DRYING

Fermentation.—The seeds, with their surrounding white slimy mass of pulp, are carried to the fermenting house in baskets covered with banana leaves, and are subjected to the process of fermentation.

In Surinam the quantity of seeds is first measured in boxes specially made for this purpose, 65 cm. (26 in.) in length, 45 cm. (18 in.) in breadth, and 50 cm. (20 in.) in height. The seeds are put into these boxes, and the height of the whole mass is measured; every inch ("duim") indicates about 8 kilograms of fresh seed, yielding about 2½ kilograms of marketable cocoa. In Java the quantity of seeds is also measured in special boxes, but in other countries this measurement of the seeds is not customary.

Although the methods of fermentation vary in the different cocoa-growing countries, they are all based on the same principle and have the same effect. This effect is the *development of an essential oil*, which gives the cocoa its peculiar aroma; the *conversion of part of the bitter-tasting compound*, so as to lessen the bitter taste; and, finally, the *liberation of the theobromine*, the substance which gives cocoa its peculiar tonic and stimulating properties. It must be admitted at once, however, that the chemistry of the bean before and after fermentation is still in its infancy, and that only a mere beginning has been made with the study of this branch of chemistry and of the processes which take place during fermentation and drying.

The fresh beans, with the white pulp, are made into heaps, or put in boxes, and covered with banana leaves. The temperature of the heaps quickly rises, especially in the interior, and no further care is required except to see that it does not rise too high, and that all the beans come sufficiently into contact with the air to finish the process when the beans have acquired the proper heat.

Different varieties of cocoa, however, have different requirements as regards fermentation. The main rule is that the finer, sweeter varieties, such as all the Criollos and the finer Forasteros (*e.g.* those of Western Venezuela) require a slight and short fermentation; the coarser and more ordinary varieties with flat, dark, bitter-tasting beans (*e.g.* San Thomé cocoa, the Samana, the Surinam, the Carupano variety of the Orinoco basin, etc.) need a long and thorough fermentation. This general rule explains many of the differences which exist between the methods adopted in different countries.

As an example, the method followed in Surinam may first be described. The process takes place in a small house, provided with one row of six or seven fermenting boxes (Fig. 67), or with two rows with a gangway between them. Each box is about 5 to 6 feet broad, 6 to 7 feet deep, and 5 to 6 feet high. The boxes, as well as the walls and the roof of the house, are made of wood—preferably the wood of the "bolletree" or bullet tree (*Mimusops balata*), the tree which yields "balata," a sort of wild rubber.

When the fresh seeds have been put into the first box, so as almost to fill it, and have been covered with banana leaves, the temperature begins to rise slowly, and the following morning it is some 15° to 20° C. higher than the temperature of the air, being about 40° C. in the middle of the heap. The beans are then turned over into the second box, being thoroughly mixed in the process, and are again covered with banana leaves. Here the temperature rises a little further, being always highest in the morning when the

beans have been for twenty-four hours in the box, and the time has come to turn them over into the next one. But 50° C. is about the maximum temperature.

This rise of temperature is accompanied by decomposition of the pulpy mass which surrounds the seeds; during the fermentation it develops a strong

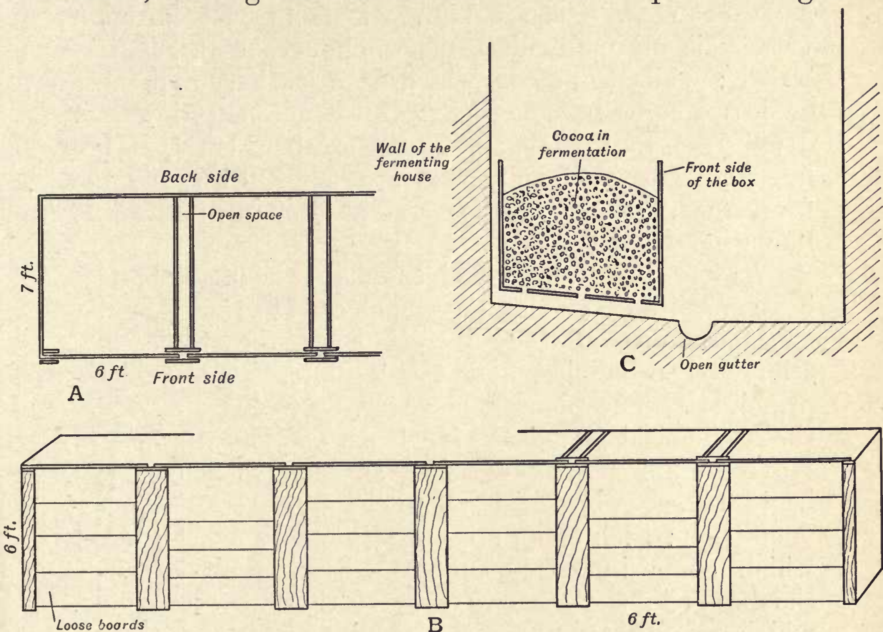


Fig. 67.—Sketch of the arrangement of fermenting house and fermenting boxes, as used in Surinam.

A, Fermenting boxes seen from above: there is a little space between every two boxes.
B, Fermenting boxes, front view.
C, Vertical section of a fermenting house with one row of boxes.

odour of vinegar and becomes more liquid, gradually flowing away as a vinegar-smelling fluid. To allow these products of the decomposition of the pulp to flow away freely, the bottoms of the boxes are perforated and are raised a little off the cemented floor of the fermenting room. This floor, again, is slightly inclined towards a gutter, along which the "cocoa-vinegar," as the planters in Surinam call this fluid, flows away.

In this way the pulp which surrounds the seeds is gradually decomposed and dissolved, and when the beans are removed from the last (generally the sixth) fermenting box, a few fibres and a little mucilage round the seeds is all that remains of the pulp. In the meantime the colour and the consistency of the seeds have changed. The colour, which in the Surinam variety is originally dark-violet, changes to a reddish-brown; while the seeds, which were leathery and more or less tough, become brittle after fermentation and drying, so that they are easily crushed between the fingers. The seed-coat, which adheres firmly to the fresh seed, surrounds the fermented and dried seeds like a loose and brittle skin.

As has already been said, the main chemical changes have resulted in the development of the peculiar chocolate aroma, the liberation of the tonic and stimulant principles, and the lessening of the bitter principles. The planter, however, takes little notice of these chemical changes. He looks only at the colour. He knows, for instance, that as soon as some seeds begin to show brownish spots, he must stop the fermentation; such spots appear principally on the beans which come into free contact with the air—*e.g.* on the beans in the bottom layer of the fermenting box, which are situated above the openings in the planks.

In its main lines the process of fermentation is the same in all cocoa-growing countries, except that in many of them it does not take so long.

The question now comes: What is the cause of this fermentation, which results in those changes in chemical composition, in flavour, in colour, in consistency?[1] The decomposition and dissolution of the sugar-containing pulp into a vinegar-smelling liquid leads at once to the presumption that during the fermentation the sugar of the pulp is converted into acetic acid (the main constituent of vinegar) and that

[1] This question is very clearly treated in a little article by Dr. Sack, published as *Bulletin No. 10 of the Department of Agriculture, Surinam.*

the rise of temperature is a consequence of this process. This conversion of sugar into acetic acid is a fairly simple process. The sugar is first converted into alcohol and carbon dioxide, and the alcohol again is oxidised (combined with the oxygen from the air) into acetic acid. It can easily be demonstrated that the presence of the sugar of the pulp is a *conditio sine qua non* for obtaining fermentation. When the seeds are washed, so as to remove the sugar from the pulp, fermentation does not take place; but if these washed seeds are sprinkled with a solution of sugar they again become suitable for fermentation.

This conversion of the sugar of the pulp into alcohol and carbon dioxide, and, secondly, the oxidation of the alcohol into acetic acid, are both the work of very small living organisms. Just as in brewing, it is in this case also a kind of yeast (*Saccharomyces*) which splits the sugar into alcohol and carbon dioxide; while the oxidation of the alcohol into acetic acid is the work of a bacterium, belonging to the group containing the ordinary vinegar-making bacterium (*Mycoderma aceti*), which causes the conversion of wine or beer or alcohol into vinegar in the vinegar industry. Both these organisms still need thorough investigation, but it has already been proved that fermentation without living organisms is not possible. The addition of a little chloroform or ether to the heap of beans prevents fermentation, or stops it if it has already begun; this addition does not prohibit pure chemical processes, but it prevents the action of living organisms. Its influence on fermentation shows, therefore, that fermentation is the work of living organisms.

In the vinegar industry we know that the work of the vinegar bacterium—namely, the combination of alcohol with oxygen from the air—is always accompanied by a rise of temperature. The extent of this rise is dependent upon various conditions, *e.g.* the amount of alcohol present, the extent to which the air has free access, and last but not least, the hindrance opposed to

the escape of the heat generated. In the fermentation of cocoa the rise of temperature is, as in the vinegar industry, due to the action of the vinegar bacterium, which oxidises the alcohol, formed from the sugar of the pulp, into acetic acid. In this process it is clear that free access of air is necessary, in order to provide sufficient oxygen to oxidise the alcohol.

The reason for turning over the cocoa daily from one fermenting box to the next one will now be understood: its aims are (1) to mix the heap and to bring those beans which were not in a position to get much oxygen (*e.g.* in the middle of the heap) into better contact with the air; and (2) to prevent the temperature rising too high. In the middle of the heap, though the oxidation is there not so very active, the temperature rises all the same, because the heat is not able to escape easily. When the heap is turned over, these parts are cooled and other groups of beans take their place in the middle of the heap. Insufficient aeration of the cocoa during fermenting not only results in slow fermentation but also brings another bacterium into action, the bacterium of butyric acid. This bacterium lives and propagates quickly, when the heap is insufficiently aerated; it produces butyric acid, the bad smell of which is so characteristic of cocoa which is fermented in a primitive way in unsuitable boxes, as sometimes happens with small proprietors.

The changes which the pulp undergoes during fermentation are sometimes called *external fermentation*, while *internal fermentation* denotes the changes which take place in the seed itself. As we have seen, the external fermentation consists mainly in the decomposition of the sugar of the pulp into alcohol and carbon dioxide, followed closely by the oxidation of the alcohol to acetic acid, which is accompanied by a rise of temperature. *This rise of temperature is the cause of the internal fermentation.*

To make this internal fermentation understood, it must be pointed out that no chemical changes of any

importance occur in a seed which is dormant (*i.e.* not yet germinating). The different substances are, so to speak, lying next to each other, but each in its own compartment; so that different substances may be present, which, if they came into actual contact with each other, would bring about important chemical changes. The situation alters, however, as soon as the seed is killed. The structure of the plant-tissue is then destroyed, and the different substances diffuse through the whole seed, and, coming into contact with each other, give rise to many chemical processes.

This is what occurs in the cocoa seed, which is killed during fermentation by the high temperature caused by the external fermentation. Experiments[1] have shown that the temperature which kills the cocoa seeds, the so-called "maximum temperature," is about 43° C. Seeds exposed for three hours to a temperature of 43° C. were all found to be alive and germinated normally; of 10 seeds, exposed for six hours to the same temperature, only 4 germinated; and 10 seeds, exposed for nine hours to this temperature, proved to be all dead. When exposed to a temperature of 44° C. all the seeds proved to be dead after an exposure of six hours. In fermentation a temperature of 43° to 45° C. is reached during the second day, and it may therefore be taken that the seeds in the fermenting boxes are killed on that day. From that time the various substances of the seed begin to diffuse and to act upon each other—that is to say, internal fermentation sets in.

It is possible that products of the fermentation of the pulp, especially the acetic acid, may exert an influence upon the seeds and play a part in the internal fermentation; but this has not been proved as yet, and there is no real indication that it is the case.

As will be explained, the internal fermentation gives rise to three important compounds, "cocoa-red" or

[1] Sack, "Bydragen tot de kennis van het fermenteeren der cacao" (*Bulletin No. 10 of the Dept. of Agriculture, Surinam*: January 1908).

"cocoa-pigment," theobromine, and the essential oil. All these substances are formed if we simply crush fresh cocoa seeds and leave them exposed to the air. This fact shows that the products of the external fermentation do not play any part in the formation of these three important compounds. They are formed by allowing the different constituents of the cocoa seeds to act upon each other, be it by crushing the seeds or killing them by high temperature during fermentation.

One of the most conspicuous changes which occur in the seeds is the alteration in colour. The violet seeds become reddish-brown and the white seeds yellowish-brown. This change takes place gradually, beginning at the outside and proceeding gradually to the inner parts. This is easily understood if it is remembered that for this chemical process oxygen is necessary, for the air obviously penetrates only gradually into the interior of each seed. This change of colour is caused by the formation of a red compound which has received the name of "cocoa-red" or "cocoa-pigment."[1]

Whether this compound must be regarded as important from an industrial point of view is still uncertain, for it is not clear whether a larger or smaller amount present in commercial cocoa has any influence upon the quality. The idea, however, that it is the "cocoa-red" which gives cocoa its peculiar aroma is quite erroneous. "Cocoa-red" can be prepared pure from cocoa seeds. It has the appearance of a reddish-brown powder, which is, however, odourless and tasteless, and is therefore not the cause of the aroma which cocoa assumes during fermentation.

This aroma is due to the formation of another substance, namely, an essential oil. It is obvious that the substance, which gives rise to the aroma, must be a volatile substance, for the aroma develops when the fermented cocoa is boiled, and this strong-smelling essential oil can be obtained pure, or nearly pure, by

[1] The chemical composition of this and other substances is given in Chapter III.

distilling fermented cocoa by means of vapour of water. Very little is obtained, perhaps only 1 cubic centimetre of essential oil from about 20 kilograms of seeds; but the smell is so strong that this small quantity is enough to give to the whole mass of cocoa its peculiar aroma.

Another important substance, theobromine, also appears during fermentation. Like the "cocoa-red" and the essential oil, it is a product of the action upon each other of the different substances which the seed contains and which come into contact as soon as the seed has been killed.

Finally, the substance which gives the bitter taste to the fresh seeds is partially changed into a tasteless product during fermentation. The bitter-tasting product in the fresh seeds used to be generally regarded as a tannin, but this also has been proved[1] to be wrong. It has been given the name "cacaool," and during fermentation it combines with oxygen to form a yellow or reddish-coloured tasteless compound.

The oxygen of the air is thus necessary for all the processes of fermentation. On the other hand, however, when the beans are fermented longer than is necessary, oxidation sets in too strongly, and brown spots appear on those beans which are most exposed to the air and which are at the same time subjected to a high temperature. The appearance of these spots is therefore an indication to the planter that fermentation must be stopped.

The processes of fermentation are not yet thoroughly understood, but it seems that the external fermentation (the fermentation of the pulp) is important only by reason of its production of heat which kills the seeds, with the result that the various substances contained in them act upon each other, some of them becoming oxidised. At the same time, the high temperature assists and accelerates these reactions. These changes take place much more easily in the varieties

[1] Ultee and van Dorssen, "Over de zoogenaamde looistof der cacao" (*Cultuurgids*, 1909, 2e. gedeelte, Afl. 12).

of finer quality, such as the Criollo, the Western Venezuela Forastero, and the "Arriba" cocoa of Ecuador, which need very little fermentation for the development of their aroma and tonic properties. Moreover, in the case of these finer varieties the fresh seeds are less bitter than in the case of the coarser kinds, and for this reason also a short fermentation is sufficient.

It is often said that one of the objects of fermentation is to remove the sugary pulp, but from the foregoing it will be clear that this view is wrong. The disappearance of the pulp may only be regarded as a happy coincidence. Moreover, in the case of those seed varieties which require only a short fermentation, a great deal of the pulp remains adhering to the seeds. This constitutes a drawback, for such cocoa is very subject to mildew when packed in bags, and this is the reason why in Venezuela and Trinidad the cocoa is treated with dry earth after fermentation and drying. This method will be explained later.

The beans are generally subjected to fermentation in fermenting or "sweating" boxes such as those used in Surinam (Fig. 67), and are turned over into a fresh box every day (Surinam) or every other day (Trinidad). This system is in use in Surinam, Trinidad, the other Antilles, San Thomé, and indeed all countries where long and thorough fermentation is necessary.

In Java, on the other hand, larger fermenting floors (Fig. 68) are generally used, perforated like the bottom of the "sweating" boxes and often raised one above the other, like the steps of a staircase. The dimensions vary considerably: sometimes they are about 16 feet long, 7 feet broad, and raised 1½ foot above each other. They are surrounded by a little wall 2 feet high. The cocoa is first brought into a heap on the upper floor, and covered with banana leaves. After twelve or twenty-four hours the heap is shovelled to the second floor; here it again remains for twelve or twenty-four hours; and the third day it is shovelled to the third (lowest) floor. Sometimes four floors are present, when the

fermentation lasts 3½ days; this is especially the case on estates which cultivate Java Forastero.

Fermenting floors are also used in Ceylon, the cocoa being shovelled on to them in heaps.

In Venezuela a short fermentation of only one day is given, either in a box or simply by making a heap of the cocoa and covering it with banana leaves.

Photo. Hisgen, supplied by the late Mr. C. MacGillavry.

Fig. 68.—Fermenting boxes, plantation "Djati Roenggo," Java.

The variety cultivated here is the Forastero ("Djati Roenggo Hybrid"). The fermentation lasts 3½ days, and the beans are turned over into the next box every day. From the last box the beans are shovelled into the washing basin (Fig. 69).

In Ecuador, again, the beans are not subjected to any special fermentation, but are dried immediately after picking and breaking. It is possible that a slight fermentation may set in during the night, after the beans have been heaped together at sunset.

It is often stated that the fermentation has a great influence upon the quality of the product; and in some countries where a cocoa of rather inferior quality is

produced, it has been suggested that the method of fermentation is to blame and should be improved. As yet, however, there is no indication that the quality of cocoa would be changed to any great extent by adopting another method of fermentation. It is of course true that when inferior varieties of cocoa, which need a long fermentation, are insufficiently fermented, the quality of the resulting product is poorer than it might be; and that, on the other hand, superior varieties of cocoa, which need only a short fermentation, can without doubt be spoiled by being fermented too long. The present author, however, considers it a mistake to think that cocoa of mediocre quality can be improved to any great extent by a change in the method of fermentation. The quality of cocoa is almost wholly dependent upon the variety grown and upon unknown characters of soil and climate. In some cocoa-growing countries —*e.g.* the west of Venezuela and the Arriba country of Ecuador—the quality of the cocoa is always good, even when it is carelessly fermented; but other countries —*e.g.* the Orinoco basin, Surinam, the Gold Coast, Kamerun—will probably never produce cocoa of superior quality in spite of the most careful fermentation.

Washing.—In only a few countries are the fermented seeds washed. In Java (Fig. 69) it is adopted everywhere; in Ceylon it is generally done; in Mexico, San Salvador and Guatemala often; and sometimes in Samoa and Kamerun. In all the other cocoa-growing countries—and these include the most important—Ecuador, San Thomé, Trinidad and the other Antilles, Venezuela, the Gold Coast, etc.—no washing is done.

The advantage of washing the fermented beans is, of course, that it cleans the seeds of the remaining pulp. But this effect is in most kinds of cocoa very little appreciated by the merchants, and the price paid for washed Ecuador, Trinidad or Surinam cocoa is very little higher than the price paid for unwashed.

In the case of the more ordinary kinds of cocoa the disadvantage of washing the fermented seeds is

the loss in weight, which is so great that it is not counterbalanced by the slightly better price. In Surinam it has been calculated that with well-fermented cocoa the loss in weight by washing is about 4 per cent. At a price of 60 cts. per kilogram (the average price in Surinam during the years 1904–1906), this means a loss of 2·4 cts. per kilogram; but the merchants paid only

Photo. Hisgen, supplied by the late Mr. C. MacGillavry.

FIG. 69.—The washing basin, plantation "Djati Roenggo," Java.

The beans are shovelled into this washing basin after fermentation.

2 cts. per kilogram more for the washed cocoa. The labour spent on washing resulted therefore in a small loss.[1] This has been found to be the case in most other countries. In Kamerun the loss in weight by washing turned out to be about 3·83 per cent, about the same as in Surinam. The figures found by Preuss were as follows:—

100 unwashed beans . .	121·25 grams
100 washed beans . .	113 ,,
Loss in 100 seeds by washing .	8·25 grams or 3·83 per cent.

[1] Wright, *Cocoa*, p. 131.

A second disadvantage of washing is that washed beans need more care in drying. They dry more quickly, but they cannot stand so high a temperature as unwashed beans; they soon become too brittle and are therefore more liable to damage.

Finally, the flavour suffers from washing. In the case of the ordinary varieties this drawback is not very serious, but in the case of the finer Venezuelan and Ecuadorian (Arriba) varieties, washing would result in a distinct deterioration in quality.

Against these drawbacks must be mentioned the advantage that washed seeds are less liable to become mouldy, either during drying or when packed in bags, for the pulp which remains adhering to the unwashed seeds is hygroscopic and contains a certain percentage of sugar, so that it is a favourable place for fungi. This disadvantage of unwashed seeds is, of course, especially felt in the case of those kinds which are only fermented for a short time—*i.e.*, generally speaking, the finer varieties. For this reason, washing would most probably be adopted in these cases also, and especially with Venezuelan and Ecuadorian cocoa, if it did not unfortunately damage their quality. Another method has therefore to be used in order to avoid the adhering pulp becoming mouldy. In Venezuela this is achieved by coating the seeds with earth—a method followed in Trinidad, though it is not so necessary there. This method will be discussed later.

On the other hand, in Java and Ceylon, where also only a short fermentation is given, the quality and especially the flavour are not so fine, and washing can be done without spoiling the quality. In Ceylon the method was tried of leaving the beans unwashed and drying them immediately after fermentation; but the colour was so dark and the appearance so dirty that the cocoa had to be classed among the inferior qualities. In Java, where the cocoa has little flavour and is practically only valuable for its light colour, there is a double reason for washing it thoroughly; for

not only is mould avoided, but the cleaner the cocoa the more suitable it is for mixing with darker kinds in order to make a light-coloured chocolate.

In Ecuador, where again cocoa is fermented very slightly, no special process is adopted in order to get rid of the adhering pulp. The result, however, is that Ecuador cocoa is more subject to mould than any other, and it would be most advisable for the planters in this country to try some method of avoiding this drawback.

Drying or curing.—Formerly it was considered advisable to dry the cocoa slowly. In Surinam drying was by preference effected in spacious and airy drying-houses, which were not provided with any heating apparatus. Sometimes, however, it was necessary to dry the cocoa in the sun on large floors. It was, however, always preferred to dry it slowly, because it was believed that in this way a product of better quality was obtained; and in the West Indies and Surinam it was on some plantations customary to cover the sun-dried cocoa when the heat of the sun was considered to be too strong.

Nowadays, planters and merchants are no longer so particular as to the way in which cocoa is dried, but there is still a slight preference for sun-dried cocoa above cocoa dried by means of artificial drying apparatus.

(*a*) Sun-drying.—Slow drying in the sun has the advantage of allowing the internal fermentation to proceed a little farther in those beans, or in those parts of beans, where it was not yet quite accomplished. This makes the colour more uniform, and slightly more light-reddish than when dried artificially. Secondly, the drying is uniform; no beans are dried too quickly so as to get too brittle, which often happens in the quick-drying artificial apparatus, especially when the cocoa has been washed.

In several countries where the rainfall is not very heavy and the number of bright, sunny days great enough, cocoa is dried only by sun, and artificial driers are never used.

For sun-drying large floors are generally used, made of brick (Fig. 70) or cement, or wood covered with coir matting (Fig. 71). These floors, however, are a great nuisance in wet weather. When a shower comes, the cocoa must be quickly covered with sheets of canvas; but this is a tedious and troublesome work, and the system of drying-waggons on wheels, or drying-floors with movable roofs, is to be preferred.

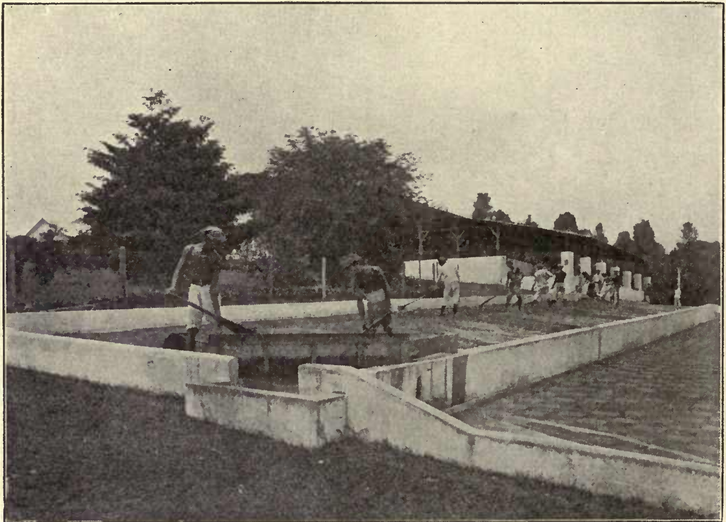


Photo. Hisgen, supplied by the late Mr. C. MacGillavry.

Fig. 70.—Sun-drying on brick floors, plantation "Djati Roenggo," Java.

Drying-waggons are much in use in Surinam. They are always of the same type—large flat wooden waggons with small wheels and running on rails (Fig. 72). When the weather is sunny they are run outside the drying-house; as soon as the rain comes they can be run back in a few minutes under the drying-house, where they take up the ground-floor. The top-floor of this house is generally used as the store-room of the plantation. This system has many practical advantages, but it makes large drying-houses necessary, as the waggons take up a good deal of space.

On some plantations in Java the planters have tried to avoid this drawback by making the waggons run one above the other in the manner illustrated in Fig. 73. In this way the installation is simpler and cheaper; the topmost pair of rails has the largest gauge, the lowest pair the narrowest. Similar drying-houses are adopted on plantations in Guadeloupe, Grenada, and Ecuador (Fig. 74).

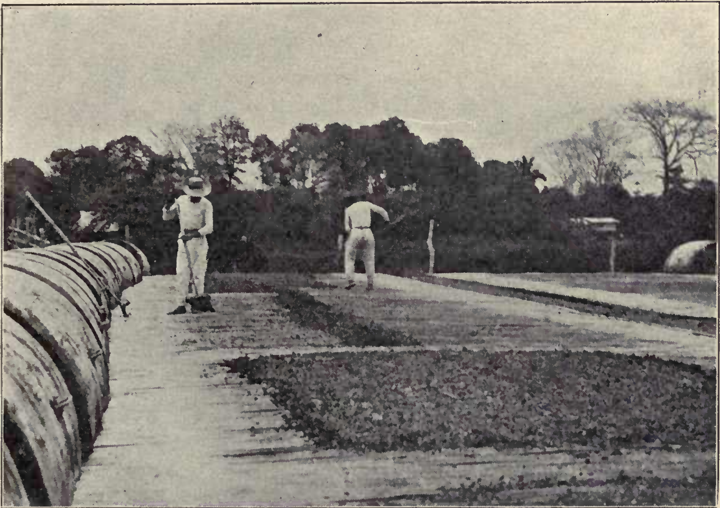


Photo. supplied by Mr. M. E. Seminario.

Fig. 71.—Sun-drying on wooden floors covered with split-bamboo matting (Ecuador).

In Trinidad the system of movable roofs is generally adopted. The drying-floors of wood are fixtures, standing on wooden posts about 2 metres ($6\frac{1}{2}$ ft.) above the soil, and sometimes 20 metres (65 ft.) long and 5 metres ($16\frac{1}{2}$ ft.) broad. A roof moving on rails is pushed over the floor so as to cover the cocoa as soon as rain comes (Fig. 75).

It will be understood that these roofs—as well as the waggons used in Surinam—must be made as light as possible, so as to be easily and quickly pushed by one man. The waggons in Surinam are made wholly

of light wood, but the movable roofs in Trinidad are generally made of plates of zinc on a wooden frame.

Wherever cocoa is dried in the sun, the seeds must be regularly turned over. In Surinam and Trinidad children are often employed for this work, and are busy the whole day moving the beans by means of shovels, made of a stick with a little platter. Towards sunset

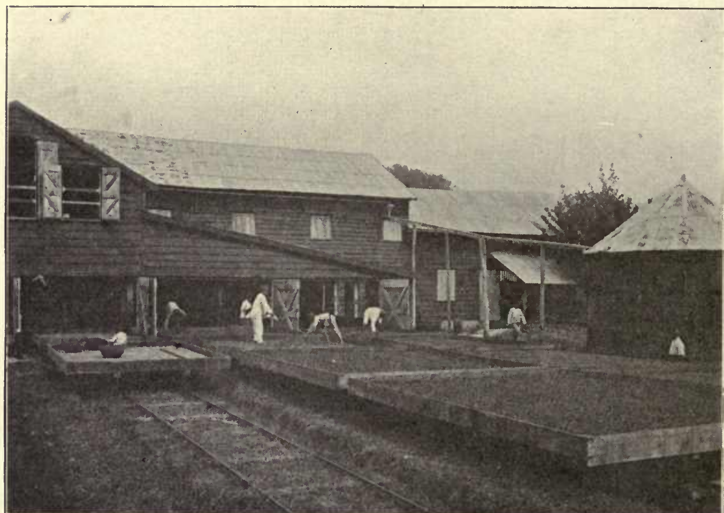


Photo. Auguste Curiel.

Fig. 72.—Sun-drying on wooden waggons, plantation "Susannasdaal," Surinam.

the beans are heaped together and covered with a canvas sheet in order not to be wet by the dew, and the waggons are pushed into the house, or, where movable roofs are used, the roofs are run over the cocoa.

(*b*) Drying by artificial heat.—Though this system has various disadvantages—*e.g.* it makes the beans too brittle, especially on the surface, and darkens the colour —still artificial heat must perforce be used in several cocoa-growing countries where the weather is uncertain, and rainy and cloudy days are so numerous that there would be great risk of the cocoa becoming mildewed if sun-drying were attempted. Accordingly, cocoa-dryers

are in use on many plantations, especially in Surinam and Trinidad.

A few of the best known of these dryers may be shortly described.[1] One of the most simple consists of a large wooden box, slightly inclined, in which a series of sieve-like trays are placed, one above the other. The bottom of the box rests on a furnace, surrounded by a covering of bricks. The hot air escapes through openings in this brickwork and enters the box, leaving it again at the top. It is obvious, however, that if the cocoa were simply placed on these trays and left, it would be very irregularly treated; the beans on the tray nearest to the furnace would be exposed to a much higher temperature than those above it. It is therefore necessary to be continually changing the position of the trays, and workmen must be kept busy removing the trays from below and placing them in the upper part of the box, and *vice versa*. This makes the drying expensive, and calls for continuous superintendence, but the advantage of the apparatus is its simplicity: no steam-engine is needed, and the planter may construct it himself. It is therefore suitable for very small plantations, and a form called "Mayfarth's Patent," made in Germany, is in use to a certain extent in Surinam.

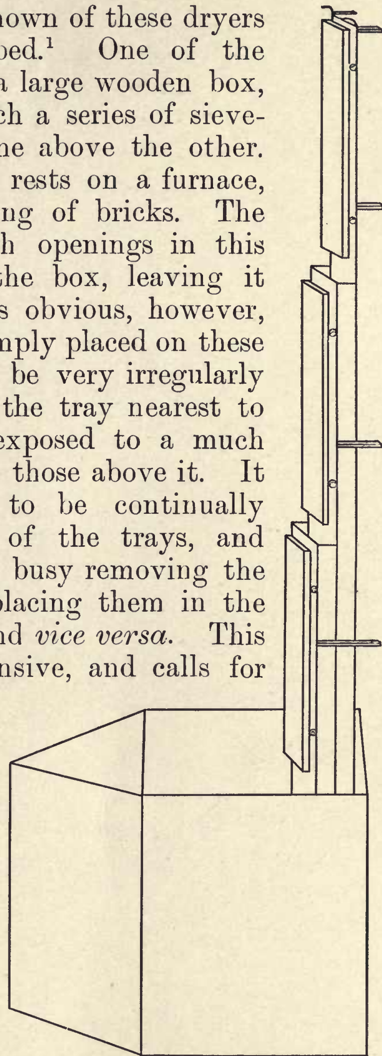
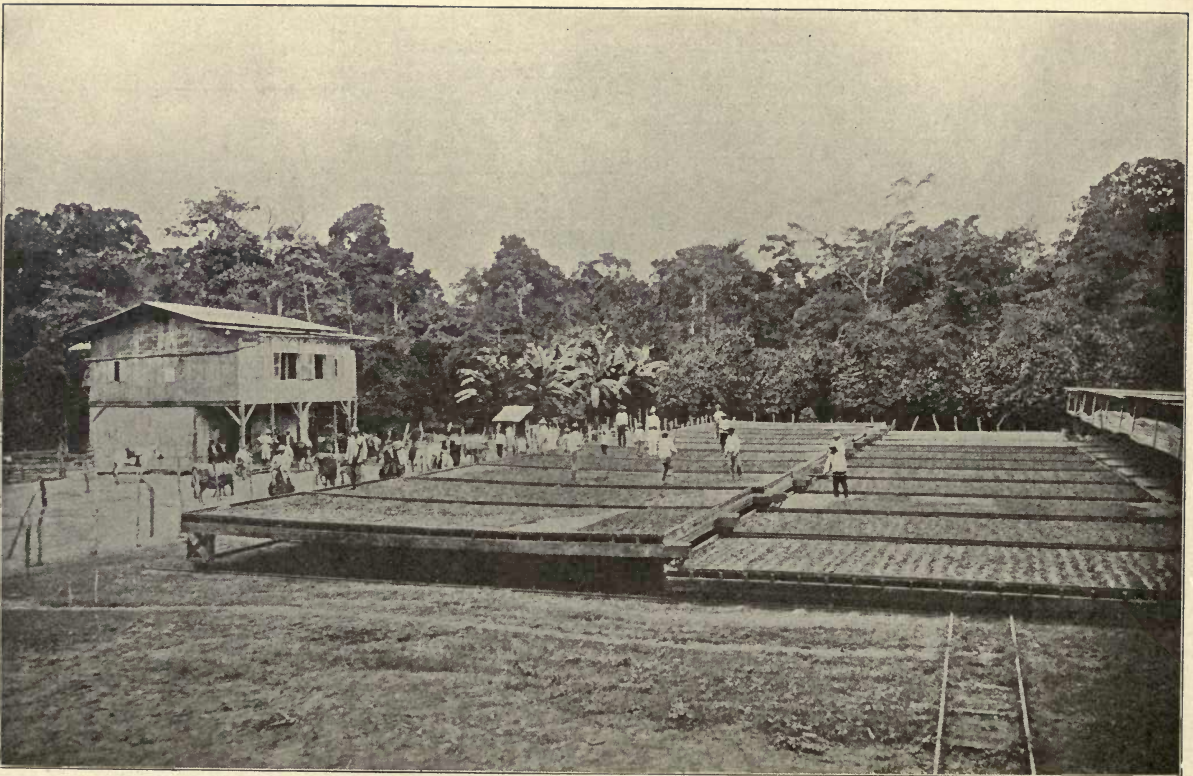


FIG. 73.—Sketch showing drying-waggons running one above the other, as adopted on some cocoa estates in Java.

The cocoa is brought into the apparatus immediately

[1] A good description of a few types is given by Fauchère, *Culture pratique*, p. 107, and by Hart, *Cacao* (1911), chap. xv.



By permission of the Editor of "La Hacienda."

FIG. 74.—Drying-waggons running one above the other, plantation of "Coello Hermanos," Ecuador.

after fermentation. It is left there about three hours, and then spread out and exposed to the air for two days. In the early morning of the third day the beans are again placed in the apparatus, the trays being changed frequently during the day; in the evening the fire in the furnace is extinguished, and the cocoa is left in the box till the following morning. Generally it is then ready for bagging.

FIG. 75.—Drying-floors with movable roofs, as adopted in Trinidad. Reproduced from Fauchère, *Culture pratique*.

For extensive plantations larger driers are necessary, involving the use of a steam-engine. One of the best is the "Guardiola" (Fig. 76)—José Guardiola's Patent, sold by John Gordon & Co., 9 New Broad Street, London. In its main lines the "Guardiola" is a cylinder turning on an axis (Fig. 77). In the centre, along the axis, are one or two conduits through which hot air constantly flows. From this, conduit side-tubes run crosswise through the cocoa in the cylinder; these side-tubes are perforated to enable

the hot air to penetrate into the mass of seeds. It escapes again saturated with vapour through holes in the cylinder, the wall of which is also perforated. Uniformity of heating and drying is secured by the turning movement of the cylinder, which makes the cocoa travel continually from the hot centre of the cylinder towards the cooler outside, and *vice versa*. The

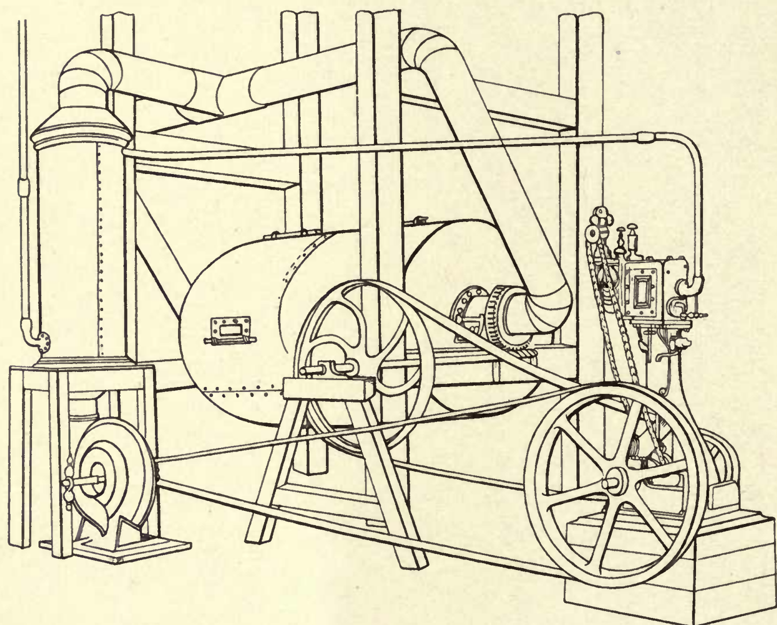


FIG. 76.—The "Guardiola" drying apparatus.
After Fauchère, *Culture pratique*.

cylinder is turned by a steam-motor; the air is heated in a special compartment and is kept in motion by a strong ventilator.

This apparatus has several advantages. The temperature in the cylinder is very uniform and is always about 60° to 65° C., and the machine works quickly and does not require much fuel. Moreover, the continual rubbing of the seeds against each other in the revolving cylinder gives the beans a nice polished appearance.

Before the cocoa is put into the "Guardiola" it is first dried for one or two days in the sun. The largest size of the apparatus is capable of drying about 2000 kilograms of cocoa in 24 to 36 hours.

Another apparatus which also has its advantages is the "Huizer," to be obtained from Messrs. J. A. Ceulen & Co. of The Hague. This is also worked by a steam-engine, which at the same time supplies the necessary heat. It is mainly composed of a large horizontal plate (Fig. 78), which is slowly moved in a horizontal

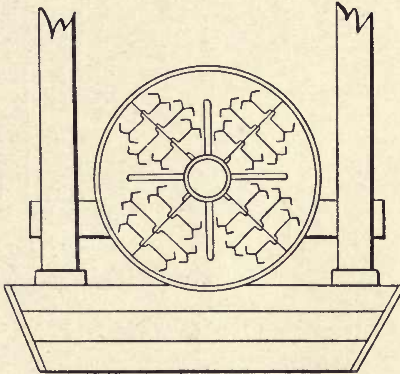


FIG. 77.—Cross-section through the cylinder of the "Guardiola" drying apparatus.

After Fauchère, *Culture pratique.*

direction round its vertical axis. It is perforated by a multitude of little openings, through which hot air is driven. The air comes from a chamber underneath the moving plate, into which it is forced by means of a blowing apparatus, and where it is heated by means of pipes warmed by the steam of the steam-motor or engine. A sort of rake-like arrangement (Fig. 78) is fixed just above the plate for the purpose of moving the cocoa about. While lying on the moving plate, the beans are turned when passing the rake, so as to obtain uniformity of heating and drying; but this movement does not appear to be sufficient, and the beans have also to be turned by hand labour. It must

not be forgotten that the plate is revolving slowly, making one turn in about 15 minutes; thus the beans come in touch with the rakes only every $7\frac{1}{2}$ minutes, and remain for $7\frac{1}{2}$ minutes at the same place unless they are turned by other means. Fauchère therefore recommends that more rakes should be adjusted to the machine; and this suggestion seems well worth trying.

The "Huizer" machine is constructed in two sizes; the large size has a plate 10 metres diameter, and is capable of drying 3000 kilograms of cocoa in three days. The smaller size has a plate 5 metres in diameter.

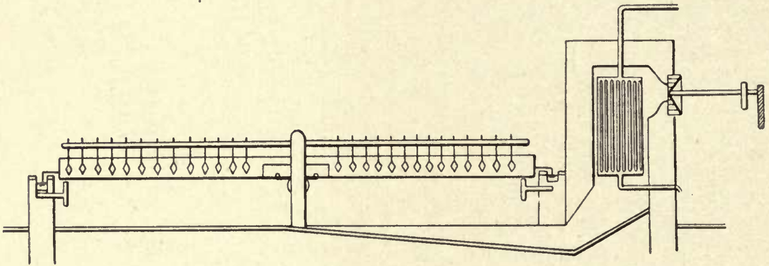


FIG. 78.—The "Huizer" drying apparatus.

Cross-section through the moving plate and the rake which stirs the beans.

After Fauchère, *Culture pratique.*

The drawback of this machine is the rather large amount of fuel required; the advantage, however, is that the cocoa can always be observed and controlled.

In Trinidad other installations are used, which have the advantage of combining sun-drying and artificial drying. Such an installation is described by Fauchère as being in use on the plantation of Mr. Centeno in Trinidad. The drying-floor is constructed in the ordinary Trinidad way, already described, with movable roofs. The space under this floor, however, is not open, but closed by walls, and about 16 inches below the floor there is a system of pipes filled with water. In a special little chamber, outside the drier, is placed the furnace which heats the water in the pipes. About six hours after lighting the fire the

required temperature (about 45° C.) is obtained and then remains nearly constant.

The advantages of this apparatus are, that no steam-engine is necessary, and that, according to the weather, the roofs can be opened and the cocoa sun-dried, or closed and the furnace lighted and the cocoa dried artificially, thus avoiding the necessity of transporting the cocoa to another place when the weather is unfavourable and the heat of the sun insufficient.

On other estates in Trinidad the air under the drying-floor is heated by making it travel along hot pipes, which are heated by a furnace. The hot air passes through the openings of the drying-floor and through the cocoa. This system closely resembles that of the "Huizer" apparatus, but the drying-floor does not move, and the pipes are not heated by hot water, but directly by the heat of the furnace. And, of course, it is at the same time suitable for sun-drying, in the same way as the installation on the Centeno plantation.

In Java and in Ceylon, "curing-houses" generally are used.[1] The most common type consists of two chambers, of which the lower one receives the hot air, the upper one the fermented seeds. The floor of this upper chamber is covered with coir matting. The air in the lower chamber is heated by means of a furnace, and then passes through the drying-floor and the seeds, and, finally, the moist air is drawn off by means of a fan.

Claying and dancing.—In Western Venezuela it is customary before fermentation to dry the cocoa for one day in the sun on the drying-floor. When it is still hot it is gathered into heaps and covered with banana leaves or put into a primitive "sweating" box. It is allowed to ferment for one day only, and then immediately clayed, or stained, as it is sometimes called. This is done in the following way. A certain quantity of cocoa is thrown on to a sheet, held by two workmen. On the cocoa a quantity of a dry, red earth is scattered, and the sheet is then moved to and fro until the earth

[1] Wright, *Cocoa*, p. 137.

is equally divided over the beans. The cocoa is then spread on the drying-floors. Sometimes the staining is done by dipping the cocoa in a sort of mud, made of the red earth and water.

The object of this treatment will be obvious, when it is remembered that in Venezuela fermentation takes only one day. The fine Criollo and Forastero cocoa of the coastal regions will not stand a longer fermentation. The result must be that the pulp is very imperfectly removed or dissolved, and that a great part of this hygroscopic, sugar-containing stuff still adheres to the seeds. Washing these fine cocoas, with their delicate aroma, would certainly damage the quality; therefore another way had to be found to prevent them becoming mouldy or mildewed. This is attained by the method of staining or claying. The coating of dry earth not only kills the fungus already present, or at any rate stops its further growth, but also prevents the germination of new fungus-spores.

Preuss[1] considers, however, that the principal object of the staining is to give the cocoa a good uniform colour and to conceal discolorations. He therefore recommends that the staining should be omitted, and uniformity of colour attained by treating the cocoa more carefully in fermentation and curing. It may quite well be that the uniform colour obtained by staining makes the Venezuela cocoa more attractive to the merchants, but this advantage is of minor importance. The merchants and manufacturers are clever enough to know that qualities other than the outer appearance determine the value of the product, and they readily pay high prices for Ecuador "Arriba" cocoa, which certainly cannot be said to have a good appearance.

The best earth for staining is found at the coast; the planters of Guigue (plateau of Valencia) generally obtain it from Choroni.

In Trinidad another method of claying is followed,

[1] *Expedition*, p. 232.

called "dancing." The purpose is the same: namely, to protect the beans against mould, though this is not so necessary as in Venezuela, since fermentation lasts longer in Trinidad, and the greater part of the pulp is therefore removed during fermentation. Indeed, many planters no longer use the method of claying and dancing, and it appears that the prices they obtain for their cocoa are just as high as those paid for clayed cocoa. Sometimes merchants have even complained that the claying was exaggerated by some planters; and it is at any rate certain that the merchant and manufacturers prefer no claying, or very little, to too much.

The dancing method is usually performed as follows.[1] The beans are exposed to the sun for the first day after fermentation. The second day they are heaped up longitudinally along the centre of the drying-floor, and the next morning the dry powdered earth is sifted over and along the heap with a fine sieve. In the meantime the cocoa is gently stirred about by means of the ordinary cocoa-shovel, in order that the earth may be absorbed as uniformly as possible by all the beans. The cocoa is then cleaned by a woman or boy, who keeps walking through the heap of beans, picking off and removing all the pulpy threads and foreign substances. When this has been done, the beans are brought into heaps and sprinkled with fresh water, till the cocoa becomes slippery. It is then trampled by men with naked feet; and while this is going on the beans which are scattered about are continually brought back to the top of the heap. This "dancing" lasts about an hour, and afterwards the beans are dried.

Loss in weight during fermentation and drying.—Very few reliable statistics in regard to this loss are available. In Surinam the present author obtained the following figures: 30 fruits, yielding 3·8 kilograms of fresh seeds, produced 1·2 kilogram of marketable cocoa; the loss was therefore 68 per cent. Fauchère gives the

[1] The more elaborate description given by Olivieri will be found in Chapter X. under "Trinidad."

following figures, also from Surinam : 377 fruits, yielding 45 kilograms of fresh seeds, gave 15 kilograms of marketable cocoa; the loss being 66 per cent.

In Trinidad the loss is estimated by Mr. Augustus, the manager of the Government Cocoa Plantation ("River Estate"), to be 62 per cent.

In Madagascar, according to Fauchère, 1600 fruits of Criollo gave 100 kilograms of seeds and 40 kilograms of cocoa, the loss thus being 60 per cent.

In San Thomé, according to Chevalier, 1000 fruits of San Thomé Creoulo gave 89 kilograms of fresh seeds and 54 kilograms of cocoa, the loss being only 39 per cent. This is exceptionally low, and it would be interesting to know if this is really the average; it can hardly be correct that less than 20 fruits are sufficient in San Thomé to give 1 kilogram of cocoa.

These different figures may be more easily compared in the following form:—

Country.	Author.	Number of fruits.	Weight of fresh seeds.	Weight of cocoa.	Loss.
			Kilogs.	Kilogs.	Per cent.
Surinam . .	Van Hall	250	32	10	68
Surinam . .	Fauchère	251	30	10	66
Trinidad . .	Augustus	330	26½	10	62
Madagascar .	Fauchère	400	25	10	60
San Thomé .	Chevalier	185 (?)	16½ (?)	10 (?)	39 (?)

Sorting.—This process is neglected in several countries where a cocoa of mediocre quality is produced. Sometimes only a superficial sorting is performed, merely to separate impurities and worthless beans from the rest. In other countries, where the difference in price between first and second quality is important, the cocoa is carefully sorted into three or more classes (Fig. 79).

Summary of methods.—A short review of the methods of fermentation and curing in use in the various cocoa-growing countries may not be out of place.

FIG. 79.—Sorting cocoa in Java, plantation "Djati-Roenggo."

Ecuador.—No special fermentation; the beans are immediately spread out on the drying-floor, and dried during the day; at sunset they are gathered into heaps and covered with banana leaves; they ferment slightly during the night. The following day they are again spread out. This goes on till the beans are dry. No claying or staining, or artificial drying. The consequence of this slight fermentation is that the cocoa is very subject to mould. It has been proposed to ferment more thoroughly; but it seems to the present author that what is wanted is more careful, not longer, fermentation, and that it would be better to try to remove the adhering pulp by washing, or by staining in the Venezuelan way, if suitable earth is obtainable.

San Thomé.—The method of fermentation adopted in San Thomé is, according to Chevalier,[1] still very primitive, and could certainly be much improved. On some plantations the beans are simply put into a "sweating" box, which is closed by a tight-fitting board or covered with banana leaves. Here the beans are left four to six days without being removed. It is very remarkable that this should be possible; in most other countries the cocoa would be wholly spoiled if left so long in the same box. On other plantations the beans are turned over into another box every day, and left fermenting for three to five, or four to six days. Generally speaking, a rather long fermentation seems to be considered advisable. Drying is done on large drying-floors or on movable waggons. In some parts of the island, where the rainfall is heavy, artificial drying is necessary. This is generally done in the Trinidad way, by heating the drying-floors by means of tubes with hot air.

Trinidad.—A system of "sweating" boxes is always used, and after the second day the beans are turned over into the next box; this is repeated every day or every other day. Planters disagree as to the length of time of fermentation. While, for instance, Olivieri[2] declares

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain*, p. 145.
[2] Olivieri, *Treatise*, p. 90.

that "a well-directed fermentation seldom demands more than three days to attain the desired stage," it appears that on the best estates, where the highest priced products are obtained, a longer fermentation is considered to be preferable. Hart even advises a nine days' fermentation. Drying is done on large drying-floors of cement, and on floors of wood provided with movable roofs. Sometimes artificial heat is used, by means of pipes with hot air or hot water running under the wooden drying-floors, making it possible to dry on the same spot either by means of the heat of the sun or artificially. The "dancing" method is often used to clean and polish the seeds, but this may safely be omitted when the fermentation has been carried out carefully and long enough.

Venezuela.—In the west of Venezuela (the coastal district between La Guayra and Puerto Cabello, the district west of Puerto Cabello, and the district south from the lake of Valencia), where the very fine "Caracas" cocoa is produced, a very short fermentation is given. The cocoa is first spread out and left to dry for one day; it is then allowed to ferment for one day, either in a heap or in a "sweating" box, and the third day it is spread out for the final drying. In this comparatively dry country the old-fashioned drying-floors, made of bricks covered with cement, are still in use. Movable roofs are rare, and artificial heat is never used. "Staining" by means of red earth is customary.

Ceylon.—The short and clear description of fermentation given by Wright[1] may be quoted:—

> In Ceylon most cacao-planters adopt what may be termed the natural method of fermenting, which consists in heaping the fresh seeds on the floor or in receptacles and covering them with leaves of the banana, or ordinary cloth, or layers of these alternating with layers of earth. The fermenting floor is usually built with a slope, so that the watery products may escape during fermentation. Each heap may consist of four or more bushels of fresh seeds, which are turned over every day. A period of thirty-six hours to five days or even longer is allowed for fermentation.

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[1] Wright, *Cocoa*, p. 109.

It is customary to wash the seeds after fermentation. After washing, the seeds are dried on large floors, generally covered with coir matting. Sometimes wooden floors with movable roofs are used. Artificial heat is often used, in curing-houses built for the purpose.

Java.—The Criollo is generally fermented for one day and a half, two days, or two days and a half. The cocoa is turned over either once or twice every day. The Forastero is generally fermented for two and a half or three and a half days. Large "sweating" boxes are used, into which the beans are put in heaps or spread out into a layer of comparatively low height. They are then thoroughly washed and spread on drying-floors, and generally finished in drying-houses much like those in Ceylon.

Surinam.—The methods are almost the same as those in Trinidad. Fermentation is done in "sweating" boxes, standing next to each other, about six in number. A long fermentation, lasting generally six to eight days, is necessary. The cocoa is dried on cemented floors, and on many plantations on waggons which can be moved quickly into the storing-house as soon as a shower comes. On several plantations drying apparatus moved and heated by steam-engines is used.

CHAPTER VIII

DISEASES AND ENEMIES

Though a large number of fungi have been described as parasites of the cocoa tree, the parasitic character of many of them has by no means been proved, and in the case of several there is no reason to suppose that they do any harm. The number of diseases caused to cocoa by fungi may accordingly be considered as comparatively small, and the number of insects which attack the plant can also be regarded as being not very large. Among both categories of enemies, however, there are a few which are very destructive and cause enormous loss in the countries where they are prevalent. This is the case in Java with the cocoa-moth and the *Helopeltis*, in Ecuador with the "mosquilla," and in Surinam with the so-called "witch-broom" fungus.

The natures of the diseases to which cocoa is subject in Brazil, Ecuador, Venezuela, San Domingo, and Haiti are almost wholly unknown; and of those occurring in San Thomé and the French colonies, Martinique and Guadeloupe, our information is not more than fragmentary. It is only in some of the English and Dutch colonies (the Antilles, Java, Surinam, Ceylon) that thorough investigations have been carried out and important practical results obtained; but in the last few years competent mycologists and entomologists have begun to study the cocoa diseases in the German colonies (Kamerun, Samoa). A complete review of the diseases and insect-pests of the cocoa plant throughout the whole cocoa-growing world can therefore not be

written at present; all that can be done is to give a summary of the present state of our knowledge.

THE CAUSES OF DISEASE.—Every tree which is not in healthy condition may be called diseased. When the soil is too poor, when the plant is damaged by wind or by sudden lack of shade, when the drainage is insufficient, or any other harmful condition of cultivation is present, the tree may be considered to be a subject for the pathologist. Still these kinds of disease need not be described here: they are avoided when correct methods of cultivation are applied. But there are other diseases which damage the fields in spite of the best methods of cultivation, and which attack perfectly healthy trees just as readily as the weak ones. The cause of many of these diseases was formerly a complete mystery to practical planters, who gave them names without real significance, such as "blight," or "blast," or "rust," or "die-back." Botanists have discovered, however, that most of them are caused by fungi which penetrate into the tissue of the plants and kill or at any rate damage it. These diseases are therefore contagious, because the fungus by means of its spores can spread from the diseased plant to a healthy one.

Apart from this large group of diseases due to fungi, there is another large group caused by insects. These were generally better understood by the planter, who was often able to detect the cause without any scientific aid. Sometimes, however, this was not the case. In Surinam, for instance, the so-called "leaf disease" was well known to the planters for a long time without their suspecting that it was caused by an insect (thrips).

Finally, the cocoa tree is in all countries more or less damaged by larger animals, chiefly birds and mammals.

CLASSIFICATION OF DISEASES

The external symptoms of the different diseases and pests are not sufficiently characteristic to allow of a clear classification being based upon them. In this

respect the cocoa tree is not like the sugar-cane, for instance, for the diseases which attack the latter are so different in their manifestation that in many cases the external symptoms alone enable the cause to be ascertained. The cocoa diseases, however, generally need a thorough investigation before a definite opinion can be formed as to their real character.

Root and stem diseases of the cocoa are usually indicated by a yellowish colour, followed by a more or less general falling-off of the leaves. The way in which this takes place may often enable the initiated pathologist to say whether the tree is attacked by canker, die-back, stem-borers, root-fungus, or other stem or root diseases, but closer investigation is almost always necessary to decide this with certainty. It will therefore be best first to make a classification based upon the different causes of the diseases :—

A (1). *Diseases of the Root caused by Fungi.*

Only a few root diseases are known, and these are not very important.

In Java a fungus sometimes occurs which covers the roots with a white mycelium, with the result that the tree usually dies more or less suddenly . . . . "White-root fungus" (*Fomes semitostus*).

In Samoa, New Guinea, Ceylon, and West Africa, a dangerous root fungus has been observed . . . . "Brown-root disease" (*Hymenochaete noxia*).

In Kamerun a characteristic root fungus was observed by von Faber . . . . (Not yet identified.)

In Trinidad and the other Antilles, and also in Ceylon, root diseases have been observed (Not yet identified.)

A (2). *Diseases of the Root caused by Insects.*

In South America and the Antilles the roots of young plants, especially at the point of junction of stem and root, are not seldom damaged by . . . . The "mole cricket" (*Scapteriscus didactylus*).

B (1). *Diseases of the Stem and Branches caused by Fungi.*

A widely spread disease occurring in America (Trinidad, Surinam, etc.), Africa

(Kamerun), and Asia (Ceylon, Java, Samoa), is the so-called . . . . "Canker" (*Phytophthora Faberi*).

On the Antilles, and in Surinam and perhaps also in other countries, severe losses are caused by a fungus which kills the branches and the stem . . . . "Die-back" (*Diplodia cacaoicola*).

In Java the branches are sometimes attacked by a fungus which covers them with a whitish or reddish overgrowth and eventually kills them . . . . . . "Djamoer oepas" (*Corticium javanicum*).

In Dominica and St. Lucia a similar disease due to an allied fungus has been observed . . . . "Pink disease" (*Corticium lilacino-fuscum*).

In Trinidad, Grenada, and St. Lucia a fungus is found, having the appearance of a tuft of horse-hair caught in the branches . "Horse-hair blight" (*Marasmius equicrinus*).

Another fungus, which covers the branches and leaves with a cobweb-like overgrowth, has been recorded from the West Indies, Kamerun, Ceylon, and Java . . . "Thread blight" or "Cobweb-fungus" (*Stilbella nana ?*).

B (2). *Diseases of the Stem and Branches caused by Insects.*

Here the large group of borers has to be mentioned first. In every cocoa-growing country the cocoa tree is attacked by borers, larvae of beetles, or caterpillars, which bore into the branches and the stem and cause great damage. There are a great many different kinds of borers. In the West Indies and Surinam the most common one is the larva of a beetle . . . . . . *Steirastoma depressum.*

In Java much damage is done by the larvae of the small beetle . . . . . *Glenea novemguttata.*

Other borers are also found in Java, but they are of less importance than the *Glenea*; they are . . . . *Pelargoderus bipunctatus* and *Monohammus fistulator.*

The last mentioned is also found in Kamerun, while less common is in Java the very large larva of the beautiful beetle . . . *Catoxantha bicolor.*

Very noxious in Java is the caterpillar of a Bombycid moth, living as a borer in stem and branches . . . . . . — *Zeuzera coffeae.*

In Kamerun and San Thomé an allied species causes much damage . . . — San Thomé borer (*Zeuzera* sp.).

In Java small beetles, sometimes called "bubuk" (*Xyleborus* sp.), are sometimes found, especially in stems attacked by canker disease.

Several other borers are found in different countries; some of them of comparatively little importance, others not yet thoroughly investigated. They need not be mentioned here.

In Kamerun the young branches are sometimes attacked by a bug, which is especially harmful to the green twigs . . — *Sahlbergella singularis.*

B (3). *Damage to Stem and Roots.*

This is caused in many countries by different mammals.

C (1). *Diseases of Leaves and Twigs caused by Fungi.*

In Surinam the twigs are attacked and deformed by the "witch-broom" fungus. This fungus also attacks the fruits. To avoid misunderstanding, in view of the next mentioned disease, we call this pest . . — "The Surinam witch-broom disease" (*Colletotrichum luxificum*).

In Kamerun another sort of witch-broom disease, much less disastrous, attacks the twigs . . . . — "The Kamerun witch-broom disease" (probably caused by *Taphrina Bussei*).

In Java, Kamerun, Ceylon, and the West Indies both the branches and the twigs and leaves are attacked by the already mentioned — "Cobweb-fungus" (*Stilbella nana ?*)

In Trinidad a wilt disease has been observed, caused by the same fungus which is the cause of "canker" and "black rot" of pods. Probably this disease also occurs in other countries . . . . . — "Chupon wilt" (*Phytophthora Faberi*).

C (2). *Insect Pests on Leaves and Twigs.*

In Java and Ceylon the twigs (and also the fruits) are badly damaged by the well-known bugs	*Helopeltis antonii* and *Helopeltis theivora.*
In Kamerun another bug is harmful in the same way to the young shoots and the fruits (sometimes also to the young branches)	*Sahlbergella singularis.*

The leaves are eaten by the following caterpillars:—

In Java	*Orthocraspeda trima*, *Belippa lohor.*
In Java and Ceylon	*Parasa lepida.*
In most other cocoa-growing countries various caterpillars are more or less noxious to the leaves, but they have not yet been studied.	
In the Antilles and Surinam great damage is done by the thrips, which causes the defoliation and often the death of the trees	"Thrips" (*Physopus rubrocincta*).

D (1). *Diseases of the Fruits caused by Fungi.*

Well known in many, perhaps in all the cocoa-growing countries is the disease called	"Black rot" of pods (*Phytophthora Faberi*) (West Indies), or "Brown rot" (Ceylon).
In Surinam and Demerara enormous damage has been done by the "Surinam witch-broom fungus," which attacks the pods, causing "hardening" ("induration") of pods	*Colletotrichum luxificum.*

D (2). *Insect Pests on Fruits.*

In Java great damage is done every year by the cocoa-moth, which spoils the fruits .	"Cocoa-moth" (*Zaratha cramerella*).
In Java and Ceylon much damage is caused to the fruits by the bugs already mentioned as enemies of the young shoots .	*Helopeltis antonii* and *Helopeltis theivora.*
In Ecuador the worst enemy of the cocoa is a bug which attacks the fruits . .	"Mosquilla" (scientific name not yet given).

D (3). Damage to Fruits by Birds and Mammals.

In different countries the fruits are damaged by rats and squirrels. This is the case in some of the Antilles (Guadeloupe), in Samoa, Java, and Kamerun. Birds are sometimes harmful to the fruits (*e.g.* in Surinam).

E. Pests attacking the marketable Cocoa.

Small caterpillars feed on the seed skin of the marketable bean. They have been observed in the West Indies, in Ceylon, and Java. . . . . "Chocolate moth" (*Ephestia elutella*).

METHODS OF FIGHTING DISEASES AND PESTS

The fight against fungi and insects, the two large groups of plant-enemies, takes place along two lines: (1) preventing the appearance and spreading of the enemy, and (2) attacking and destroying the parasite when it has appeared.

I. The appearance and spreading of the enemy may be prevented or hindered by the following methods:—

(*a*) *By making the condition of the tree as healthy as possible.*—Some parasites do not show a marked preference for weak plants, and as readily attack strong and healthy trees; but there are others which seem unable to get hold of a strong tree and which only attack trees in a weakened condition. This is the case, for instance, with the cocoa thrips, and more or less with the "canker" fungus.

(*b*) *By avoiding the presence of dead wood in the trees*, because it enables parasites to enter more easily into the living branches. This is the case, for instance, with "die-back" fungus and the various borers.

(*c*) *By seeing that the atmosphere of the cocoa fields is not too damp.*—Dampness favours the growth and multiplication of most fungi, and consequently letting in air and sun is often a help in the fight against diseases caused by parasitical fungi ("black rot" of pods, "canker" of stem and branches).

(*d*) *By avoiding the presence of other kinds of*

trees or weeds on which the enemy likes to live.—Thus in Java the presence of "rambutan" trees has to be avoided, as they constitute a source from which the cocoa-moth can contaminate the cocoa fields; and the same with the "bixa" tree, on which the *Helopeltis* likes to live.

(*e*) *By causing conditions which make it impossible, or very difficult for the enemy to live or develop on the trees.*—The method of "rampassing" (removing at a certain time all the fruits in the whole plantation) makes it impossible for the cocoa-moth to develop, while the introduction of many nests of the "black ant," which run in large numbers over the fruits and the twigs, makes it impossible for the *Helopeltis* to live on the tree.

(*f*) *By preventing the germination of fungus-spores,* which settle on the leaves or fruits, by covering these parts of the tree with a coating of Bordeaux mixture. Indeed, spraying with this mixture has the effect of preventing the contraction of fungoid diseases. Thus it has been successfully applied against "black rot" of the pods.

II. The direct fight is carried on mainly in the following ways:—

(*a*) *By catching the enemies and killing them.*—This is only possible with comparatively large insects, such as beetles and their larvae, which live in the stem and the branches, and also with the *Helopeltis* bug. Traps of different kinds may sometimes be useful.

(*b*) *By removing the parts on which the parasite has settled.*—This method is applied more than any other against parasitic fungi, as, *e.g.*, the removal and burning of the whole crown of the tree to fight the Surinam witch-broom disease; the quick removal and burning of the dying branches attacked by the "die-back" fungus, of the fruits attacked by the "black rot" fungus and of the trees, the roots of which are suffering from "white-root fungus."

(*c*) *By killing the fungus by means of fungicide*

mixtures. — Bordeaux mixture, though principally valuable as a preventive, has also some importance as a curative. It is prepared as follows:—3 kilograms (6½ lbs.) of sulphate of copper (bluestone) are dissolved in 100 litres (22 gallons) of water by hanging a bag with the sulphate of copper in the water the day before the application. Just before the application 3 kilograms of quicklime are slaked with a little water and then more water is added to make up 100 litres. The two 100-litre solutions are now poured simultaneously into a third barrel, or the bluestone solution is poured slowly into the lime with continual stirring. The resulting mixture must be used immediately, as it spoils by standing. Only wooden barrels must be used, and all contact with iron must be avoided.

There are many different kinds of spraying machines, which need not be described here. The present author has used those of the following firms: the Deming Company (Salem, Ohio, U.S.A.), Gebr. Holder (Metzingen, Germany), Besnard, and Vermorel, but many other firms make equally good machines. It is only necessary to point out that there is a great advantage in using a machine in which the mixture is put under pressure before spraying is begun, instead of being kept under pressure by continual pumping while spraying. Such a machine enables the workman to devote his attention entirely to careful spraying, without having at the same time to be busy pumping.

Sulphate of copper (3 per cent solution) without the addition of lime is much more effective, and has much stronger fungicide properties, than Bordeaux mixture, but it damages the foliage and can, therefore, only be used for spraying leafless trees. It has proved of great value in the fight against the Surinam witch-broom disease, the spraying being performed after the removal of the leaf-bearing branches.

(*d*) *By killing the insects by means of insecticide mixtures.*—Of the insecticide mixtures three groups may be distinguished:—

(1) Insecticides with which the leaves are treated and which poison the insects when they eat the leaves ("*stomach poisons*"). Formerly Paris green was much used for the purpose, but nowadays arsenate of lead is considered to be preferable. Arsenate of lead is sprayed on the leaves in the proportion of 1 part to 100 parts of water, or even 1 part to 1000 parts of water. As the cocoa does not suffer much from leaf-eating insects, spraying of the whole tree with this solution is rarely necessary. It is sometimes useful in the case of a sudden attack of leaf-eating caterpillars, and it has been tried in the fight against borers.

(2) Insecticides which kill the insects on coming into contact with them ("*contact poisons*"). This group contains the numerous mixtures used against lice, scale insects, mites, etc. Kerosene emulsion has been reported to be successful against thrips in cocoa. It is prepared as follows:—2 parts of water and 1 part of soft soap are mixed and heated till the mixture boils and the soap is wholly dissolved; then it is taken from the fire and 4 parts of kerosene are added, and the mixture is thoroughly mixed for ten minutes by means of a sprayer. This mixture is kept as a stock solution before use, and is diluted to ten or twenty times its original volume.

A great many other contact poisons have been used, especially against scale insects, and it is not impossible that one will be found to be effective against *Helopeltis*.

(3) Insecticides which kill the insects *by intoxication*. Carbon bisulphide and carbon tetrachloride are the important representatives of this group. Carbon bisulphide is used against the larvae of borers; it is injected into the tunnels by means of a small syringe.

Fungus Diseases

Root diseases.—These diseases of the root occur in many countries, but most of them do comparatively little harm, and have not yet been the subject of thorough investigation.

The "white-root fungus" (probably *Fomes semitostus*) is more harmful to the Pará rubber tree (*Hevea brasiliensis*), to tea, to cinchona, and other plants in Java, Sumatra, the Straits, and Ceylon. Now and then it does some harm to the cocoa trees, but almost always only in fields recently established on virgin land.

The fungus appears as a white felt-like cover on the roots; it seems to dislike the deeper layers of the soil, and appears principally on the main root, not far from the surface of the soil, and on the larger side roots near the junction with the main root. Along these parts it creeps with its mycelium in the form of irregular threads and patches, extending not only over the roots and sometimes the basal part of the stem, but also through the surrounding soil, binding together the particles of earth so that they remain adhering to the roots when the tree is dug out. The fungus simply kills the trees without causing characteristic symptoms.

A similar root disease has been found in Samoa,[1] New Guinea, Ceylon, and West Africa; the fungus resembles the one just mentioned, but the mycelium is more or less yellowish or even brownish, and belongs to another species (*Hymenochaete noxia*). It has caused much damage in Samoa.

On the Antilles different root diseases have been observed. A "white-root disease" and a "black-root disease" have been described by South (*West Indian Bulletin*, vol. xii. 1912, p. 479). The fungi which cause these diseases have, however, not yet been identified. A "Thyridaria root rot" has also been described: it has been attributed to *Diplodia cacaoicola* (= *Thyridaria tarda*), but this still requires confirmation.

The root fungus of Kamerun has been described by von Faber.[2] The symptoms of the disease are the same as those of the "white-root fungus" of Java,

[1] Preuss, *Beihefte zum Tropenpflanzer*, vii. (1907), p. 71.

[2] Von Faber, "Die Krankheiten und Parasiten des Kakaobaumes" (*Arb. Kais. Biol. Anstalt*, 1909, p. 223).

viz. a sudden wilting and subsequent drying of the leaves, without falling off. Very characteristic is the longitudinal splitting of the root by radial clefts, the walls of which are covered with a thick felt-like growth of the fungus.

The fight against these different root-fungi follows the same lines in all countries. First of all they need a very wet medium for their development, and they appear to a destructive extent only in fields where the soil is very damp. Accordingly, proper drainage has often been sufficient to cause the disease to disappear. Secondly, the spread of the parasites through the soil is much favoured by the presence of dead wood, on which the fungus feeds, and is thus assisted to pass from the root of one tree to the root of another. This fact is considered of great importance by the rubber planters of Java and the Straits; and on low-lying lands, where the white-root fungus was very troublesome, it has often been considered necessary, even in fields with four-year-old Pará rubber trees, to dig out all the dead trunks and roots, or at any rate the trunks from which the fungus has spread.

The direct destruction of root fungus is not to be neglected wherever it appears. The diseased root-system should be carefully dug out, and it is generally advisable also to dig out the roots of the neighbouring trees, even if they do not appear to have been attacked. When, however, there is no reason to fear a quick spreading of the fungus and the trees are considered valuable, this measure will not be applied before it has been proved to be absolutely necessary, but the infected area should be isolated by a trench 3 feet deep. Finally, it is always advisable to disinfect the soil by means of carbolineum, using one gallon for every 10 square metres (12 square yards). For some time after this treatment (perhaps about six months) the soil will remain unfit for plant growth; the reappearance of weeds generally indicates when it can be planted again, and at this period soil treated in this way is remarkably

fertile. In some countries lime at the rate of 10 kilograms per 100 square feet is applied with success.

Canker.—This is probably the most widely spread cocoa disease. It has been observed in America (the Antilles, Surinam), in Africa (Kamerun), and Asia (Ceylon, Java, Samoa).

When the cocoa tree is attacked by canker, moist spots appear on the bark of the stem and also (but not to the same extent) on the main branches. When the canker has just started and the spots are small, they are easily overlooked; but when they become larger and older, they take on a dark colour, the fluid flows out more freely, and sometimes a gummy exudation is also to be seen. When the spots dry up, a more or less brownish tinge appears. If the outer layer of the bark be cut away, the disease is much more conspicuous (Fig. 80), and the affected parts of the bark appear as light, claret-coloured areas. Later on the claret colour grows darker.

Though it principally attacks the bark, the fungus is not always confined to this part. Not infrequently it penetrates into the wood, which assumes a brownish or reddish colour, and this dark discoloration is sometimes continued in characteristic narrow stripes far under the healthy bark or into the wood.

Trees which are severely attacked are sometimes killed, when the dead tree may be seen still bearing a good number of dead leaves. Generally, however, the decay is slower, the foliage becomes gradually thinner, and it may be a long time, sometimes several months, before the tree actually dies. Very often the tree recovers from an attack, especially when the season becomes dry, and the infection remains confined to one or more larger or smaller spots which dry up and become completely separated from the healthy parts by a layer of wound-cork. In this case it is easily loosened and removed as a whole by means of a knife or some other instrument.

In the discoloured parts of the bark and wood the

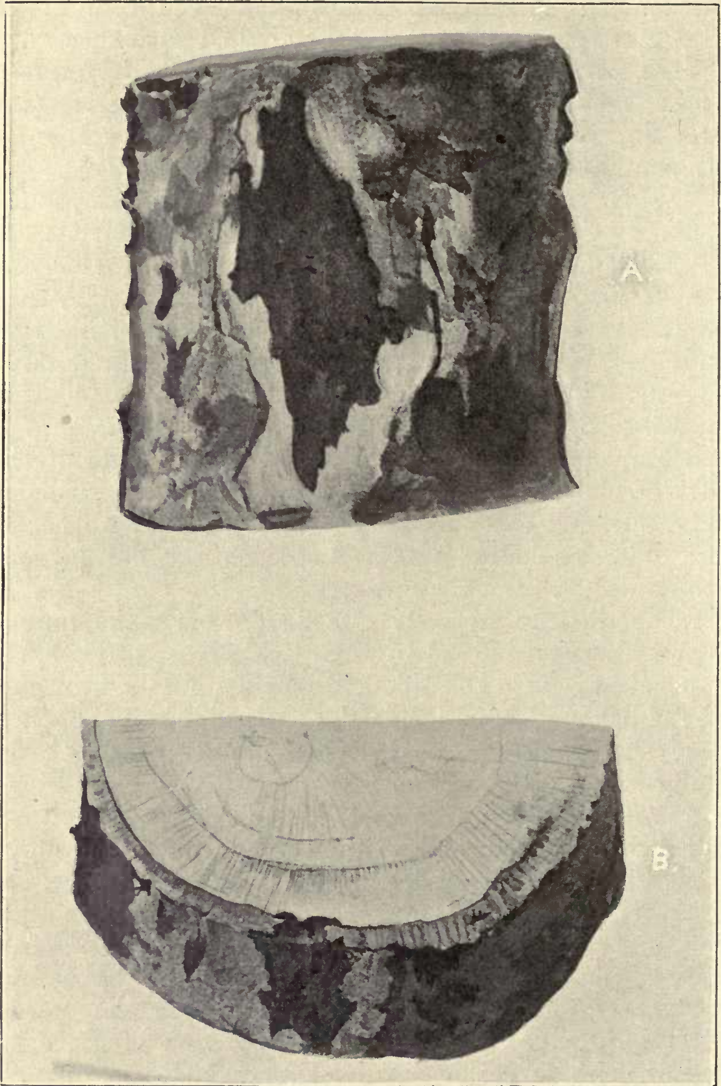

FIG. 80.—Part of a stem attacked by canker.

A, Appearance of the diseased spot after removing the outer layer of bark.
B, Cross-section showing the disease penetrating through the bark into the wood.

mycelium of the parasite is to be found with the aid of the microscope; sometimes it is comparatively scarce, at other times it is found very easily. The investigations of Rorer[1] in Trinidad and Petch[2] in Ceylon have shown that the parasite which causes the canker is no other than *Phytophthora Faberi*, which is also the cause of the "black rot" of pods.

It is a remarkable fact that this parasite is always closely followed by another fungus[3] which, however, does not seem to play a rôle of any importance, and lives in a pure condition (*i.e.* unaccompanied by other saprophytic fungi) in the tissue attacked by *Phytophthora*.

Another remarkable thing is that the blackening of pods and the canker of stem and main branches, though caused by the same fungus, do not at all occur side by side in the cocoa fields. Fields which are suffering every year from canker often show very little blackening of pods, and *vice versa*. Thus in Java several plantations suffer badly every year from canker, but black rot of pods is almost an unknown thing. In Kamerun, black rot of pods is a most serious disease, while canker, though present here and there, is of no great importance. This shows that the conditions which render cocoa liable to attack by *Phytophthora* are different for stem and for pods.

The great influence of cultural conditions upon the canker disease is also demonstrated by the fact that it never makes its appearance in some fields, though badly contaminated fields are adjoining. The conditions which render the trees liable to canker are not yet completely understood, but at any rate dampness and a wet soil favour the disease, which is always most

[1] Rorer, "Pod-rot, Canker, and Chupon-Wilt of Cacao" (*Bull. of the Dept. of Agriculture, Trinidad*, July 1910).

[2] Petch, "Cacao and Hevea Canker" (*Circ. Roy. Bot. Gardens, Ceylon*, v. 13, 1910).

[3] This fungus is a *Fusarium* (*Nectria*) and appears in a few varieties, of which the variety with large spores has been called *Fusarium colorans*, the variety with smaller spores *Fusarium theobromae*; of this variety with small spores there is a strain which makes Nectria-perithecia. These interesting saprophytes have been studied by Rutgers ("Onderzoekingen over Cacaokanker," *Bulletin No. 1 of the Division for Plant Diseases of the Dept. of Agriculture, Buitenzorg*).

prevalent in the rainy season. A moist soil and standing water should therefore be avoided by efficient drainage, and the humidity in the fields should be reduced by thinning out where the trees are planted closely, by pruning where the foliage system is too dense, and by removing as much of the shade as seems necessary.

The direct treatment of the trees by excising the affected parts has great drawbacks; the trees generally suffer considerably, and the remedy is not completely effective. Shaving off the bark superficially is more to be recommended; when this treatment has been applied, the spot generally dries out quickly and the fungus dies. Experiments are now being made in treating the diseased parts with a disinfectant, but satisfactory results have not yet been obtained.

Finally, it must be remembered that the canker spots are in some countries favourite places for the attacks of insects, *e.g.* the "bubuk" beetle (*Xyleborus*) in Java. If treatment with a disinfectant be successful, the effect must be not only to kill the fungus and stop its further growth, but also to make the dead bark poisonous to the insects in question.

Wounds also favour the development of canker, especially those made by borers. In order to get rid of canker, therefore, it is also necessary to fight the borers and to close the wounds by a layer of tar.

Die-back disease.—"Die-back disease" (caused by a fungus, *Diplodia cacaoicola*) is probably very widely spread throughout the cocoa-growing world. It has been observed in the Antilles (Trinidad, St. Vincent, Grenada, St. Lucia, Dominica), Guiana (Surinam, Demerara), Kamerun, Ceylon; probably in Samoa; and perhaps also in Java and Ecuador.

When trees are attacked by this fungus, the leaves become yellow and fall off, with the result that the tree is completely defoliated before it dies. The disease generally begins at the extremity of a branch, attacking twigs which have been weakened by some cause or

other, *e.g.* by thrips or by other insects, by winds or by the witch-broom disease (Surinam). From here it makes its way downward into the branches, finally reaching the stem; but sometimes it stops at the place of junction of a side branch or of a main branch with the stem, thus restraining its ravages to a part of the branch system.

The disease has also been known to appear in perfectly strong and healthy trees after careless pruning, and also after pruning in the wet season, when the rains have prevented a thorough tarring of the cut surfaces.

The disease makes its way much more quickly along than across the branches, and a branch may often be seen attacked over its whole length but only on one side (often the underside); here the rind is dead, but is still fresh along the other side of the branch, which bears fresh green leaves.

Very characteristic is the discoloration of the wood in the diseased parts of branch and stem. It first assumes a light-brown colour, and becomes greyer after death owing to the black colour of the fungus threads, which grow through the tissues. With the microscope the mycelium is to be seen running through the tissues; when young the hyphae are colourless, when older they become darker and give a greyish colour to the wood. It was at first thought that the disease was caused in the different countries by different though closely allied fungi. In Grenada, St. Lucia, St. Vincent, and Dominica a *Diplodia* was found; in Trinidad a *Lasiodiplodia*; and in Surinam a *Chaetodiplodia*. It has been proved, however,[1] that all these fructifications belong to the same fungus, which accordingly may be called *Diplodia cacaoicola* (Fig. 81).

Another higher fructification of the *Diplodia* has been found by Keith Bancroft to develop on the dead wood and has been named *Thyridaria tarda*. As,

[1] Van Hall-de Jonge and Drost, "The Die-Back Disease," etc. (*Recueil des travaux botaniques néerlandais*, vol. vi. 1909); van Hall-de Jonge and Drost, "De instervingsziekte der cacaoboomen" (*Bull. No. 21 of the Dept. of Agr., Surinam*).

however, the name *Diplodia* has already become popular, it has been thought better to retain it for this parasite as well.

The same parasite has often been found in different countries on decaying cocoa fruits, and it has been thought that it attacks not only the branches and the stem, but also the fruits, causing a disease which is called in the West Indies "brown rot of pods." This, however, is not a well-established fact. At any rate it is not easy to inoculate healthy fruits on the tree with *Diplodia*, and when the present author has found *Diplodia* in the field on diseased fruits, it could in

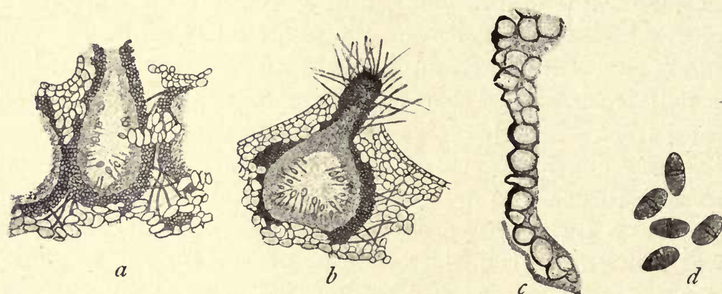

FIG. 81.—Fungus of the "die-back" disease (*Diplodia cacaoicola*).

a, *b*, and *c*, Different forms of fructification of the parasite: *a*, the *Diplodia*; *b*, the *Chaetodiplodia*: and *c*, the *Lasiodiplodia*. The figures are cross-sections through the different fructification or pycnidia (enlarged, *a* and *b* 115 times; *c*, 18 times).
d, Ripe *Diplodia* spores (enlarged 188 times).

most cases be proved that the fruits had first been attacked by the fungus of "black rot" of pods (*Phytophthora Faberi*). Nevertheless, decaying fruits form a source of infection, and as such they are dangerous, just like dead wood or other decaying substance, on which *Diplodia* easily lives as a saprophyte.

It has been found in Ceylon, the Federated Malay States, and Surinam, that the *Diplodia* also attacks the Pará rubber tree (*Hevea brasiliensis*).

The "die-back" often causes considerable loss in the cocoa fields, especially in the case of neglected or carelessly managed plantations.

As the parasite is probably only able to penetrate

into the twigs and branches by means of existing small or large wounds, prevention is best attained by keeping the branch and foliage system in strong and healthy condition, by avoiding enemies like thrips which defoliate the tree, by keeping the wind off, and by seeing that the trees are not suddenly exposed to the full sunlight by removing the shade too abruptly. All dead wood should be quickly pruned off. After pruning the cut surfaces must be carefully treated with black tar, and accordingly pruning should only be done in the dry season. When a branch shows symptoms of the disease, the tree can often be saved by cutting the branch off; and even when the *Diplodia* has already penetrated into the stem, it is often successful to cut the tree down to within a foot or so from the ground.

Djamoer oepas (*Corticium javanicum*).—This parasite is here and there the cause of the death of branches in the cocoa fields in Java and Ceylon.

The fungus starts its growth on the outside of a branch in the form of a tiny cobweb-like overgrowth, which gradually forms whitish or reddish crusts which especially develop on the side turned away from the sunlight (Fig. 82). In this stadium the fungus can penetrate into the wood, and then begins to be harmful to the branch. On these crusts the *Corticium* fructification is formed. Gradually the branch dies, and on the dead branch the fungus often forms another fructification, which was formerly regarded as belonging to another fungus and was called *Necator decretus*. This fructification has a stone-red, waxy appearance, and is formed principally in clefts of the dead branch, especially on the upper side.

The "djamoer oepas" fungus attacks a great number of plants, but the damage it causes varies widely. It is often found on tea, for instance, but seems unable to penetrate into the wood; it only grows superficially on the bark, and the harm done to the tea plant is unimportant.

In Java it is not very common on the cocoa tree,

but when a branch has been attacked, the fungus easily penetrates into the wood and generally causes the death of the whole branch.

The fungus is more common on cocoa, Pará rubber, nutmeg, coffee, and cinchona, but has also been found on many other plants.

Its occurrence in the cocoa fields is hardly ever so

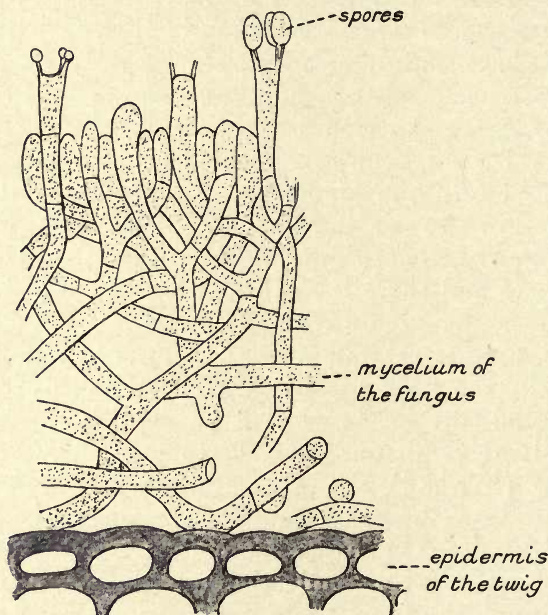

FIG. 82.—Fungus of the "djamoer oepas" disease (*Corticium javanicum*).

The figure shows the fungus in its first growth, living superficially on the twig and having not yet penetrated into the tissue of the plant (enlarged 440 times, after Zimmerman).

serious that measures have to be taken against it; but if this is necessary it is advisable to prune the trees and to let sun and air penetrate into the field as freely as possible by thinning out both shade and cocoa trees.

When the fungus has not succeeded in making a strong growth, it may be destroyed by smearing it with a weak solution of water-soluble carbolineum or any other fungicide. When the disease has already

made some progress, however, it is better to cut the branch off and burn it.

An allied species of *Corticium* was observed in the Antilles (St. Lucia and Dominica). This fungus was called *Corticium lilacino-fuscum.* Perhaps it is identical with *Corticium javanicum.* This disease of the Antilles, called "pink disease," is of no economic importance.

Thread blight or cobweb fungus (*Stilbella nana?*) —This disease was observed in Trinidad, St. Lucia, Dominica, Grenada, Tobago, and British Guiana. A cobweb fungus, probably the same as that of Trinidad, has also been observed in Java, Ceylon, and Kamerun; but in these places it does not seem to cause damage of any importance.

The fungus settles especially on the twigs and leaves, but sometimes it grows also over the branches and even over the stem. It covers these parts with its mycelium in the form of threads, which attain often a diameter of one or even a few millimetres, and this cobweb-like growth is much coarser than the mycelium of the young "djamoer oepas," above mentioned. Later on the colour of the mycelium is white, and finally more or less brownish.

The fungus also attacks tea, *Ficus elastica*, and several other cultivated and wild growing plants.

Horse-hair blight.—This disease occurs in Trinidad, Grenada, and St. Lucia, and resembles a tuft of horse-hair caught in the branches. Opinions are still divided as to the identity of the fungus (probably *Marasmius equicrinus*), and it is also still uncertain whether the disease is really quite distinct from the "thread blight." Occasionally and sporadically it is responsible for considerable damage.

The Surinam witch-broom disease (*Colletotrichum luxificum*).—This disease is happily limited to Surinam and Demerara, but the losses caused in these countries probably surpass those of any other disease of the cocoa plant.

The most conspicuous symptoms are the remarkable hypertrophied twigs, called by the Dutch "krulloten" ("curly shoots"), and in English "witch-broom"—both names inappropriate, but at present popular. These deformed twigs, however, are not the cause of the loss. Their weakening effect on the tree is not so important

FIG. 83.—A hypertrophied twig attacked by the Surinam witch-broom disease. (After Van Hall and Drost.)

as the damage done by the fungus to the fruits. The "hardening" or "induration" of the attacked pods causes a total or partial loss of the seeds, and the number of fruits attacked has often been so great that the yield of the plantation has been reduced to one-tenth of the normal, or even less.

The "witch-brooms" (Fig. 83) are conspicuous by

strong hypertrophy, which makes them much thicker than the healthy shoots and gives them a monstrous appearance. They have also a tendency to grow more vertically, and to make lateral twigs before they themselves have attained their full development. Such a hypertrophied green twig, with undeveloped leaves and bearing a great number of lateral twigs, has some resemblance to the "witch-brooms" of other trees.

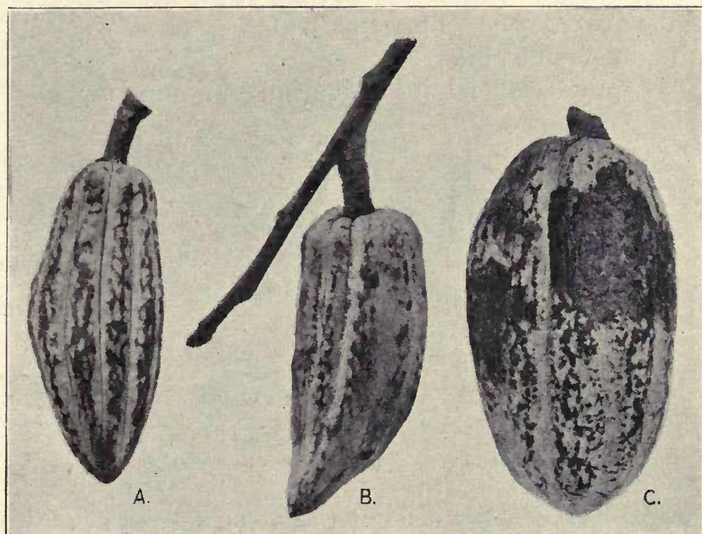

FIG. 84.—Three fruits attacked by the Surinam witch-broom disease.

A, Young fruit with a lump on one side, due to local hypertrophied growth ($\frac{1}{2}$ nat. size).
B, Young fruit with an abnormally thick (hypertrophied) stalk ($\frac{1}{2}$ nat. size).
C, Fruit with a hard, dark-coloured spot ("hardening" or "induration") ($\frac{1}{3}$ nat. size).

The lifetime of the diseased twigs is always very short.

When the young fruits are attacked by the fungus, they often show a hump on one side (Fig. 84, A), due to the hypertrophied growth of that part of the fruit-wall where the fungus has developed. The fruit stalk is also sometimes hypertrophied (Fig. 84, B). Such fruits fall off when still young. Often, however, the fungus develops in the fruit more slowly, without causing any of these symptoms; the fruit develops

normally until, sometimes very suddenly, a black spot appears, often when the fruit is almost ripe (Fig. 84, C). When such a fruit is broken, it is found that the tissue of the fruit wall at the spot is exceptionally hard ("hardening" or "induration" of pods), while the seeds are mostly brown and spoiled.

The fungus is able to penetrate into the fruit-cushions by means of the stalk of the hardened pod. When the fruit-cushion buds, the result is the production of a great number of crowded blossoms which produce worthless fruits, or none at all.

By microscopical investigation the fungus is seen

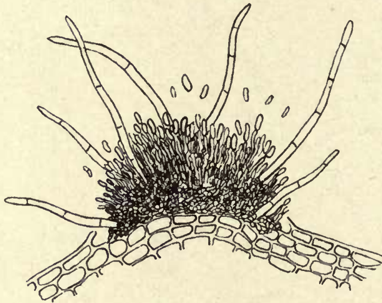

FIG. 85.—Fructification of the Surinam witch-broom fungus.

running between the cells of the attacked parts, and its characteristic mycelium is especially abundant in the hypertrophied tissues. It fructifies (Fig. 85) with whitish or slightly reddish fruiting bodies, which appear sometimes at the base of the hypertrophied twigs, but much more freely on decaying hardened pods. These form, therefore, a much more dangerous source of infection than the "witch-brooms."

The disease has never been found on any other cultivated plant, but the wild-growing *Theobroma speciosum* has been observed to be very liable to it. This plant grows wild in the south of Surinam, and in Brazil in the basin of the Amazon. As in Surinam the disease was probably transferred from this wild *Theobroma speciosum* to the cultivated *Theobroma*

cacao, the Brazilian planters should be careful that the same thing does not happen to them.

The disease has been successfully eradicated on the plantation "Susannasdaal" by a method applied under the direction of the Government Experiment Station. It consists of pollarding, *i.e.* removing the entire leaf-bearing crown of the trees (Fig. 86), so that, when all the leaf-bearing branches have been cut off, nothing remains but the trunks and the leafless main branches.[1] Immediately after cutting, all wounds are treated with black tar. After this operation the only sources of infection left are any spores which may have settled on the trunk and on the uncut branches. To destroy these the trees are sprayed with a 3 per cent solution of blue-stone, or sulphate of copper, without addition of lime. All lopped-off branches and leaves are collected in heaps and burned. In each field a few open spots can generally be found where this can be done without harming the cocoa and the shade trees. In Surinam the trees give no fruits in the first year after pollarding; in the second year an average of 60 kilograms per acre, in the third year 160 kilograms, and in the fourth year the normal crop of more than 200 kilograms is again obtained.

The fields, once treated, must be kept under control. It was at first thought that the regular removal of the few reappearing witch-brooms and hardened fruits would be sufficient, but it is now believed that at least one spray per year with Bordeaux mixture must be added to this treatment.

Experiments are at present being made to see if the infection could also be eradicated without the removal of the whole crown of the tree, but by giving only a very thorough pruning and spraying, removing at the same time all dead and diseased parts. It is hoped that in this way the normal yield may be re-obtained at an earlier date.

[1] Further details of the method may be found in the article on this disease by Van Hall and Drost; it appeared as *Bulletin No. 16 of the Surinam Dept. of Agr.*, and has been translated into English by Dr. Fredholm (*Proc. of the Agr. Soc., Trinidad*, Dec. 1909).

The disease began to be troublesome in Surinam between the years 1895 and 1900, and wandered from

FIG. 86.—Fighting the Surinam witch-broom disease.

The tree is being sprayed with bluestone solution, after having been pollarded.

one district to another. The loss caused may be understood from the figures given in Chapter IX. (Surinam),

and the direct damage is increased by the fact that trees covered with dead witch-brooms are very liable to the attacks of the die-back disease (*Diplodia*). The witch-broom disease has therefore been accompanied by the death of thousands of trees by die-back disease.

The Kamerun witch-broom disease (probably caused by *Taphrina Bussei*).—This disease has only been observed in Kamerun, and must not be confounded with the Surinam witch-broom disease, from which it is quite different. The diseased twigs do not show any hypertrophied growth; there is only an abnormally abundant development of side-branches. Thus a typical "witch-broom" is developed, and the name of the disease is therefore perfectly appropriate. According to the investigations of Von Faber, these branches and twigs contain a mycelium, and on the leaves was found a fructification due to the parasite, which has been given the name *Taphrina Bussei*. Until now the disease has not caused much damage, but it is, of course, advisable to remove and burn the witch-brooms.

Chupon wilt.—Rorer, the Trinidad mycologist, observed that the fungus, which is the cause of the "canker" disease and the "black rot" of pods (*Phytophthora Faberi*), also attacks the young shoots ("chupons"); this disease is called in Trinidad "chupon wilt." Rorer's description may be quoted :—

> This disease was very prevalent on many estates [in Trinidad] last year [1909]. The chupon is generally first attacked in the soft tissue near the tip. A small water-soaked area can be seen on the stem, which gradually becomes sunken and darker in colour and spreads up and down the stem, frequently girdling the shoot and causing the upper part to wilt. The same disease has been observed on young shoots on the upper branches of the tree. The point of attack is generally in the axil of a leaf, though the leaf-blade or petiole may be the first part affected, the disease afterwards running down into the stem. . . . Chupons are also frequently killed by aphides or other sucking insects, and such cases should not be mistaken for the disease of fungous origin. The final appearances of the killed shoots are the same, but the initial stages are quite different.

Probably this disease will also be found in many other countries where "canker" and "black rot" occur.

The black rot of pods (*Phytophthora Faberi*).—This disease is very common, and is probably to be found as a more or less serious pest in every cocoa-growing country. At any rate it has been observed in every country where cocoa diseases have been the object of investigation (the Antilles, Surinam, Kamerun, San Thomé, Ceylon, Java, Samoa).

The fungus may attack pods of any age, but the true parasitic character is particularly clear when large pods are attacked. On such fruits a brownish discoloration appears, which may start anywhere on the surface, but generally at the tip or at the stem end. It spreads rapidly over the whole fruit, which finally becomes black, while white powdery masses begin to appear on the surface, especially along the furrows.[1] These white masses are the spores of the parasite; they are spread by the wind to other fruits, on which they germinate, and into which the fungus penetrates, causing again black rot.

As a rule, the germination of these spores ("conidiospores") does not take place in the same way as in the case of most other fungi. If placed in water they germinate by letting out from 10 to 30 small so-called "zoospores," which swim by means of hair-like organs of locomotion, called cilia. They soon lose these cilia and send out a germ tube, like most spores when germinating. Sometimes the conidiospores germinate directly by means of a germinating tube. Simultaneously with the spore-production on the outside of the attacked fruits, another kind of spore is formed within the tissues of the pod. These are the so-called "oospores" which serve as resting spores, and may retain their vitality for a long time.

Though the growth of almost every fungus is favoured by moisture and humidity, this is especially

[1] A good description has been given by Rorer (*Bulletin of the Dept. of Agriculture, Trinidad*, July 1910).

the case with the "black rot" fungus. Accordingly, countries with a heavy rainfall—*e.g.* Kamerun—suffer particularly from this pest, while many plantations in Java with a comparatively small rainfall are remarkably free. A dense shade and close planting are other conditions which favour the development of the disease. Reduction of shade, a wide planting distance, thorough pruning and good drainage, will help the planter in his fight against the *Phytophthora*, but in spite of these precautionary measures a strong epidemic of black rot will often be experienced in very rainy years.

A direct method of treatment is accordingly necessary in places where the disease is habitually harmful. Spraying with Bordeaux mixture, as already described, has proved to be effective in Trinidad, Ceylon, and Kamerun. Von Faber[1] mentions that in one of the experiments in Kamerun the percentage of diseased pods was reduced from 56 per cent to 22 per cent. In this case Bordeaux mixture was mixed with resin and starch in order to make it more adhesive. This, however, does not seem necessary. Wright[2] notes an instance where 19 per cent of diseased pods was found in the unsprayed field, and 8 to 15 per cent in the sprayed plot. The removal and destruction of the attacked fruits is always advisable, but it must not be forgotten that the fungus grows very quickly, and forms its spores a few days after penetrating into the fruit. The diseased pods must therefore be removed as soon as the first spot is seen. The same fungus is the cause of the "canker" disease of the stem and the branches, and of the "chupon wilt" disease.

Insect Pests

I. *Root Insects.*—The West Indian mole-cricket (*Scapteriscus didactylus*) is only too well known for its ravages on young cocoa and many other plants

[1] Von Faber, "Die Krankheiten und Parasiten des Kakaobaumes" (*Arb. Kais. Biol. Anstalt*, 1909, p. 205).

[2] Wright, *Cocoa*, p. 222

in Guiana (Surinam and Demerara) and in the Antilles. Dr. Fredholm recently published an interesting study of this insect, from which the following particulars are for the most part borrowed.[1]

The ravages on young cocoa plants—especially in the fields, but also in the nursery—are sometimes considerable when no precautions have been taken. The young plants are cut at the point of junction of stem and root. When mole-crickets nibble into a root and find that it is not agreeable to their taste, they quickly abandon it, but not before so much damage has been done as to kill the plant. Often a great number of plants are killed in this way by a few mole-crickets in one night. Happily only the young plants are attacked; when they have reached a height of $\frac{3}{4}$ to 1 foot and developed a few leaves, the stem becomes too hard and is no longer to the taste of the mole-crickets. Trees planted out from a nursery are thus left untouched, and on plantations in Surinam a nursery is often kept principally to supply the gaps where the plants have been killed by the mole-crickets. The front pair of legs of the insect are peculiarly adapted for making tunnels in the earth. These tunnels lie near the surface and ramify in several directions. Some of the side galleries dip down 5 to 6 inches or even a foot or more, ending in chamber-like excavations. In these the females lay their eggs, each depositing 50 to 100 at a time. When first hatched the larvae are white, but soon change to a dark fawn colour. They probably take one or two years to develop into the mature insect. As soon as they are sufficiently strong the larvae commence to tunnel for themselves in search of food. They are seldom seen above ground except if forced to leave their habitations by reason of these being flooded, as occasionally happens during heavy rains.

The mature insects live in the same way, but make more frequent excursions above ground. At times

[1] Fredholm, "The Mole-Cricket" (*Proceedings of the Agricultural Society of Trinidad and Tobago*, vol. xi. part ii., February 1911).

they migrate in numbers for reasons not well understood.

The galleries of mole-crickets are easily located, the raised and loosened soil denoting their presence. They are situated just beneath the surface, and extend for considerable distances.

The food of the mole-cricket is principally vegetable. They always attack succulent roots and stems, and leave the hard, woody parts untouched. Vegetable gardens often suffer greatly, and tomato, turnip, sweet potato, melongene (aubergine), and cabbage are much sought after, also tobacco, rice, and sugar-cane; all of these have much more to suffer from the mole-cricket than cocoa. The attacks are especially destructive in the dry season.

The protection of crops against the mole-cricket is not so difficult when the area planted is small, as is the case with vegetable gardens. It is generally sufficient to keep the place quite clear of weeds, to turn up the soil in due time by hoe or spade, and to surround the place by a deep trench. These same methods may successfully be applied in the cocoa nurseries. After the soil is turned up, the natural enemies of the mole-cricket, *e.g.* fowls, will help to kill a great number of the insects. Attempts have also been made to poison the insects by means of poisoned horse-dung, 3 lbs. of arsenic acid to 100 lbs. of horse-dung being applied to one acre.

These remedies are, however, too laborious for application in the case of cocoa fields. Whenever the appearance of mole-crickets is to be feared, the best way is to raise the seedlings in well-protected nurseries, and to plant them out when they are strong enough to be no longer liable to the attacks of this insect.

II. *Borers.—General Remarks.*—It has already been stated that different species of borers are to be found in most cocoa-growing countries. The life-history of these different enemies varies in details, but in many respects their mode of life is the same, and accordingly

the fight against the various borers proceeds everywhere along the same general lines.

The beetle or moth lays its eggs against the stem or against a branch, often in a little hole made for the purpose in the bark. The larva or "worm" lives for some time in the bark or in the wood, and damages the tree to a greater or smaller extent. Often the presence of one borer may cause the death of a whole branch, which then looks as if it had been killed by fire, all the brown and dry leaves remaining hanging on the twigs. Whole trees, especially young ones, may be killed in this way when the borer lives in the stem.

At present the general way of fighting the borers is to remove the "worms" or larvae, cutting away the bark by means of a knife until the worm is exposed. On many plantations a gang of trained "worm-pickers" is kept for this purpose. If possible these men also collect the perfect insects—whether beetle or moth —but generally the number of captured perfect insects is small in comparison with the number of captured "worms."

There are, however, methods of using "traps," especially for the beetles and their eggs, and perhaps traps for the moths may eventually be found.

Different species of borers.—The *West Indian cocoa-borer* (*Steirastoma depressum*) (Fig. 87) is one of the worst pests in some of the Antilles (Trinidad, Grenada, Guadeloupe, Martinique) and in various countries of the South American continent (Venezuela, Colombia, Surinam, and Demerara). It has been observed for many years, but was only recently subjected to thorough investigation.[1] We are indebted to Mr. Guppy for having given us a clear exposition of the life-history of this pest, and of the methods of combating it, and the following particulars are to a large extent borrowed from his article.

This borer lives not only in the cocoa tree, but also

[1] Guppy, "The Life-history and Control of the Cocoa-beetle" (*Trinidad Board of Agriculture, Bulletin No. 1*, 1911).

in the American "cotton tree" (*Bombax ceiba*) and in another wild-growing tree, *Pachira aquatica*, called in Trinidad "chataigne maron," and in Surinam "wild cocoa" or "forest cocoa." After continued and frequent copulation the oviposition begins. The eggs are laid at irregular intervals during several weeks. For instance, in one of the cases observed by Guppy a female laid 141 eggs in 2½ months' time; 8 eggs were laid in one day, then in three days 12 eggs, and so on. The eggs are laid by preference near or at the fork of the trees, especially young trees, and also near the foot of side-branches and chupons. Young trees are often attacked just above the soil. The eggs are inserted into the bark through an incision which is made by the powerful mandibles of the beetle with much care and deliberation. Ordinary wounds and cracks are never used for the purpose, and the eggs are never simply laid on the bark.

Fig. 87. — The West Indian cocoa-borer (*Steirastoma depressum*). (Natural size.)

After four or five days the larva hatches and soon starts to eat away a roomy chamber within the soft succulent bark. For a couple of weeks it merely enlarges the area of its habitation, but then begins to make a spiral or wavy tunnel through the bark. As a rule it starts under the fork of the tree or the place of insertion of the side branch, and begins to "ring" the branch or the young stem. In old trees the tunnelling operations are carried out in various ways. The length of time during which the larva continues to tunnel is, under favourable conditions (in living trees) about 2 months, under less favourable conditions (in dead or dying wood) 3 to 5½ months.

The pupal stage lasts about twelve days. After issuing from the pupa, the beetle lies for a few days within the tunnel to enable its tissues to harden. Then it leaves the tunnel and lives for about three months flying from tree to tree. The chafed and scarred appearance of the young branches and chupons mark

the activity of the insects, for they are wasteful and careless feeders, and pieces of bark are often bitten out and rejected before anything is consumed.

The beetle is black with whitish-grey or dirty-looking markings; the head, thorax, and wing-covers have numerous ridges and depressions. The greyish colour is caused by numerous, very small, white, bristle-like scales. On the thorax are three longitudinal ridges, and there are stout lateral projections. The wing-covers are strongly ribbed longitudinally with numerous shiny black, pustule-like spots.

The ordinary way of combating the enemy, viz. by excising the larvae from the attacked trees, cannot be regarded as satisfactory; it is often worse than the pest itself, and frequently causes much damage to the trees.

The practice of catching the beetles by hand, wherever they are to be found, is equally inadequate, for the beetles are so well protected by their greyish colour that many are overlooked. Attracting them by means of the bark of the wild cotton tree (*Bombax ceiba*) or the ocro-plant (*Hibiscus esculentus*), as is often done in Surinam, has some success, but even with this method the number of beetles which remain at large is very great.

Guppy recommends the use of branches of the "chataigne maron" (*Pachira aquatica*) as traps. Branches of a diameter of 2½ to 10 cm. (1 to 4 inches) are either placed on the soil under the tree in fair-sized heaps ("heap-traps"), or suspended in the cocoa tree ("suspended traps"), or put leaning against the tree ("leaning traps"), or laid in the "fork" or the "jorquet," just where the beetles are so fond of laying their eggs. Especially are these traps put near, and suspended in, those trees which, as can be seen from the scars on the branches and water-shoots, have recently been attacked by the beetles. In order to induce the beetles to lay the eggs in the "traps" and not in the cocoa trees, the trees are sprayed with arsenate of lead. It is, of course,

not necessary to spray the foliage, but only the stem and the thicker branches, especially the "fork" and the foot of the stem of the young trees. In the dry season, when the branches used as traps dry up rather quickly, the traps must be renewed every two or three weeks, and the used ones burned. Branches pruned off the cocoa can also be used as traps in the same way.

In order to kill the larvae, Guppy recommends the injection of a small quantity of carbon bisulphide into the tunnels by means of a small syringe; the aperture must immediately be filled up with clay. This method, however, is not always successful.

In the meantime the beetles must be picked off as thoroughly as possible. They may be found on the trees as well as on the traps, and the keenest boys and women should always be used for this work. It is advisable to pay them according to the number of beetles caught.

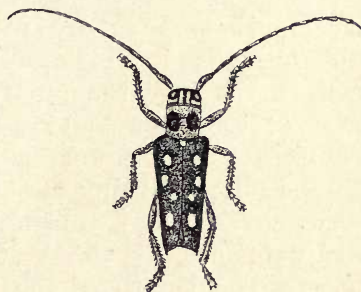

Fig. 88.—The Glenea borer (*Glenea novemguttata*).
(Enlarged two times.)

The *Glenea borer* (*Glenea novemguttata*)[1] is the most common and most destructive kind of borer in Java.

The beetle is no longer than about 11 mm. ($\frac{1}{2}$ inch), blackish coloured, often with a blue metallic lustre, with four spots of a yellowish white colour on each side of the thorax (Fig. 88). The larvae are larger, attaining a length of about 30 mm. (1·2 inch), and are yellowish white in colour.

The beetle lays its eggs one after another in the bark of the cocoa tree, making a separate incision for each egg. Thus the eggs are concealed, and can only be detected by very close and very careful investigation.

[1] Zehntner, *Bulletins 1 and 3 of the Cacaoproefstation, Salatiga* (1901); Roepke, *Bulletin 1 of the Proefstation, Midden Java* (1911).

The average number of eggs laid by one female, and the average time which elapses between egg-laying and hatching of the larvae, have not yet been definitely ascertained.

The tunnels made by the young larvae run close under the surface of the bark. As the larvae grow bigger the broader the tunnel, and finally it is as broad as the bark, running close under the surface and enclosed only by a thin layer of bark. From the outside the presence of the borer is shown by the ejection of chips of wood from the aperture of the tunnel, and often by an exudation of gum.

When the larvae are full grown—after about 2 to 3½ months—they bore into the wood and make an oblong cavity, in which pupation takes place. Zehntner calls this cavity "the pupal cradle." It is about 25 to 30 mm. (1 inch) long and 4 to 5 mm. broad. From this cavity a narrow tunnel runs directly through the bark to the outside, being closed only by a particle of sawdust, covered by a thin layer of bark, so that it can be easily opened by the beetle when it issues from the tree. The length of the pupal stage is about 15 to 20 days. After the beetle has issued from the pupa, it remains some five days in the "pupal cradle" in order to allow the chitin coat and especially the mandibles to harden. So far as we know at present the beetle lives about one month.

Like most beetles, the larvae of which live as borers in the cocoa, the *Glenea* beetle feeds by gnawing here and there the bark of young cocoa twigs.

The Java planter applies against this borer no other measures than the West Indian planter does against his *Steirastoma* borer. The larvae are removed by excision, and as many of the beetles as possible are caught. Wherever this is done carefully, the pest is kept within certain limits. For this purpose the larvae have to be removed as early as possible—as soon as a few of the characteristic wood-particles are to be seen on the bark and while the larvae are still young.

Zehntner also recommended treating the stems and branches regularly with lime, for he repeatedly observed that *Glenea* beetles in cages fixed to limed trees often died within one day, in spite of the presence of unlimed food in the cages.

Dead branches must never be left lying in the field after pruning, as they may serve as hatching places for the borers.

The *Glenea* borer has occasionally been found in "kapok" trees (*Eriodendron anfractuosum*), but as yet in no other trees.

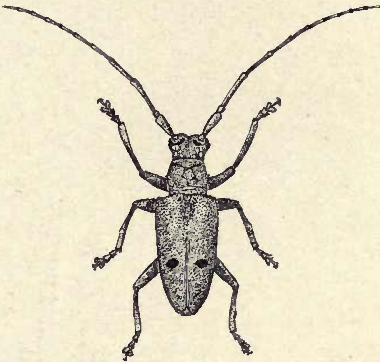

Fig. 89.—The Pelargoderus borer (*Pelargoderus bipunctatus*).

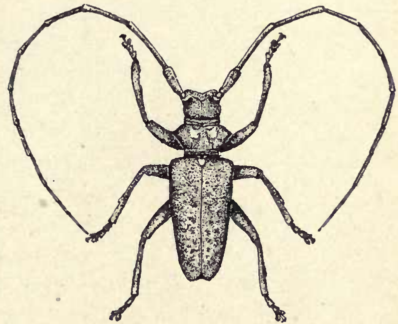

Fig. 90.—The Monohammus borer (*Monohammus fistulator*).

(Both natural size.)

The *Pelargoderus beetle* (*Pelargoderus bipunctatus*, Fig. 89) and the *Monohammus beetle* (*Monohammus fistulator*, Fig. 90) are, next to the *Glenea*, the worst cocoa-borers in Java. In several plantations the damage done by these enemies is very serious. Their life-history, however, has not yet been fully worked out. Both species are known as enemies of various plants; the *Pelargoderus* lives also in canary trees (*Canarium commune*) and in old pepper plants, and the *Monohammus* in coffee trees and in castor-oil plants.

In Kamerun, an allied *Monohammus* borer, *Mono-*

hammus ruspator, has been found as an enemy of the cocoa by Von Faber.[1]

The splendid large Catoxantha beetle (*Catoxantha bicolor*, *F.* = *C. gigantea*, Schaller), Fig. 91, has also been a serious pest in some plantations in Java.[2] Lately, however, it has ceased to appear in the cocoa fields in large numbers. The larvae attain a length of no less than 11 to 16 cm. (4·3 to 6·3 in.). The larval stage lasts for about one year, while the length of the pupal stage is about two months. The whole life-cycle takes about two years. This beetle belongs to the family of *Buprestidae.* Its size is about 7 to 8 cm. (2·7 to 3·1 in.). The

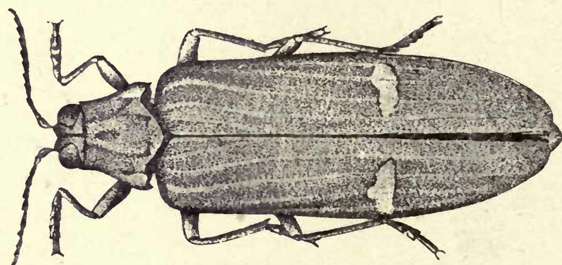

Fig. 91.—The Catoxantha borer (*Catoxantha bicolor*). (Natural size.)

wing-covers, feelers, and legs are of a splendid gold-green colour, and on each of the wing-covers is a spot of yellowish colour and of a transparent or gelatine-like appearance. The *Catoxantha* beetle is also an inhabitant of British India.

In some countries, *e.g.* Trinidad and Java, small beetles of the genus *Xyleborus* have been observed to do more or less damage to the cocoa. These small brown beetles are generally met with in dead wood, but sometimes they also attack living branches and stems, by preference or even almost exclusively, when these parts are already diseased from some other cause.

[1] Von Faber, "Die Krankheiten und Parasiten, etc." (*Arb. Kais. Biol. Anstalt*, 1909, p. 269).

[2] Zehntner, *Bulletin No. 1 van het Proefstation voor Cacao te Salatiga* (1901), p. 8.

Thus *Xyleborus*, called "bubuk" in Java, is sometimes dangerous to trees attacked by canker. They bore into the diseased tissues, and from there into the adjoining parts, and may be the direct cause of the death of the tree.

The larva of a Bombycid moth of the group of the Cossidae (*Zeuzera coffeae*, Nietner) is comparatively common in Java[1] and is now and then the cause of serious ravages (Fig. 92). The caterpillars are 4 to 5 cm. long (1·6 to 2 in.), reddish yellow in colour, with a few short bristles on each segment; on the back of each segment four little black spots are visible.

They live in branches and twigs of

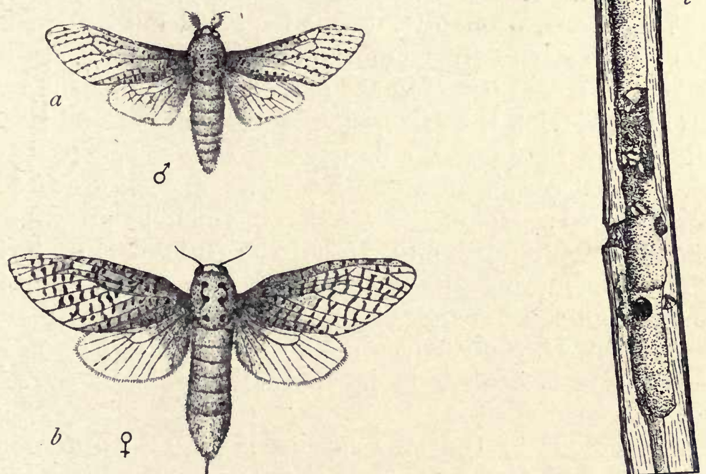

Fig. 92.—The Zeuzera borer (*Zeuzera coffeae*).

a, Male; *b*, female (after Roepke) (natural size).
c, A twig of kola, in which the borer has lived, split longitudinally to show the tunnel. The skin of the pupa, from which the moth has issued, protrudes from the opening (drawing by Kades, supplied by Dr. Roepke).

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[1] Kamerling und Zehntner, "Voorloopig overzicht, etc." (*De indische Natuur, Jaargang* 1900, p. 56.

different age, and make longitudinal tunnels of considerable length, sometimes of 40 to 50 cm. (16 to 20 in.). They generally bore from the basal part of the branch or twig towards the top. Just before the transformation into the pupal stage the caterpillar makes a horizontal side-tunnel, which ends just under the epidermis of the branch. Into this side-tunnel the caterpillar retires and shuts off the main tunnel by means of a stop made of small particles of wood; this precaution is taken in order to keep away enemies and parasites.

The moth has a wing-spread of 4·5 to 5 cm. (1·8 to 2 in.), the length of the body being 3 to 3·5 cm. (1·2 to 1·4 in.). The wings and the body are ash-coloured; dark-green spots are to be seen in great numbers on the wings, and a few also on the body.

The Zeuzera borer is also an enemy of coffee, cinchona, tea, and many other plants. It is possible, however, that different varieties live on different plants.

A *Zeuzera*, probably an allied species, has also been observed in Africa (in Kamerun and San Thomé).

III. *Insects attacking the leaves, twigs, and fruits.*

(1) In Ceylon the *Helopeltis* is the worst of all insect pests, while in Java its damage is only surpassed by that caused by the cocoa-moth.[1] Two species are to be distinguished: *Helopeltis theivora*, which is prevalent in very hot climates, and *Helopeltis antonii* (Fig. 93), which is the more common species in cooler regions. In the very hot coast region of Java the cocoa is principally attacked by *H. theivora*, while on the mountains, where the climate is cooler, it is gradually replaced by *H. antonii.*

The colour of the two species is slightly different. The body of *H. theivora* is greenish; the head and thorax of *H. antonii* are reddish or black, while the abdomen of the male is black and the back of the female green. Very characteristic is the pin-like dorsal processus on the scutellum (Fig. 93, *a* and *c*). With the aid of an ovipositor the eggs are laid in the young fruits, or some-

[1] Zehntner, *Bulletin No. 7 van het Proefstation te Salatiga* (1903).

times in the young and juicy twigs. The number of eggs which a female is able to lay is about thirty.

The young larvae bear much resemblance to the

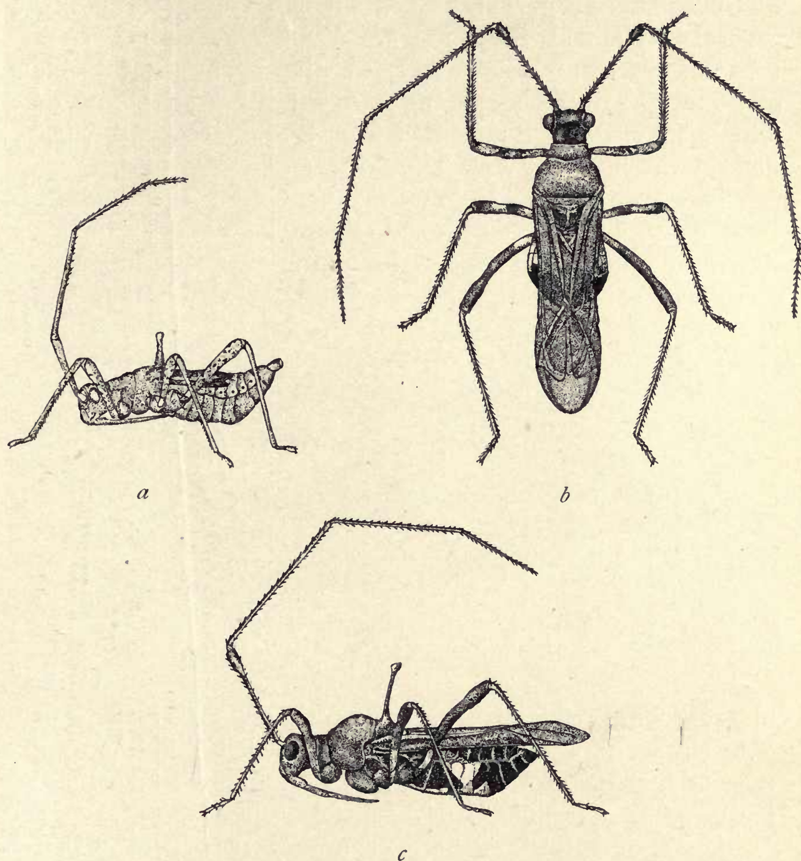


FIG. 93.—*Helopeltis antonii*, enlarged 5 times.

a, The larva in the nymph stadium.
b, Female seen from above.
c, Female seen from the side (notice the pin-like dorsal processus on the scutellum.

adult insect, but are yellower in colour, and the pin-like processus is not yet developed.

The whole development takes about two or three weeks, while the lifetime of the adult insect lasts not less than two and a half to three months.

Fruits as well as twigs are damaged; also the leaf-stalks, but not the lamina of the cocoa leaves. The fruits show the stings of the *Helopeltis* as numerous black specks (Fig. 94), and when the young fruits are severely attacked they are wholly spoiled or develop into deformed, almost worthless fruits. The same black spots appear on the young twigs (Fig. 95), many of which may die. Sometimes the tree is covered with dead and dried-up twigs.

The number of *Helopeltis* about and the damage done by them depends on the time of the year. In the dry season and the months following it, the number is comparatively small, and accordingly the damage is

Fig. 94.—Fruit slightly damaged by *Helopeltis*.

insignificant, while during the rainy season the pest gets worse and worse. In a few weeks the number of insects increases rapidly, and the damage to twigs and fruits quickly becomes very considerable.

In Java the worst months are March to May (the rainy season begins in January and ends towards May or June), while in September and October it often seems as if the *Helopeltis* had wholly disappeared. In Ceylon the pest appears to be at its worst in December and January, and least harmful in August (in this country October and November are the months with the heaviest rainfall).

It has been a subject of discussion how these insects live through the dry season. Green, the well-known

Ceylon entomologist, assumed that special eggs, so-called

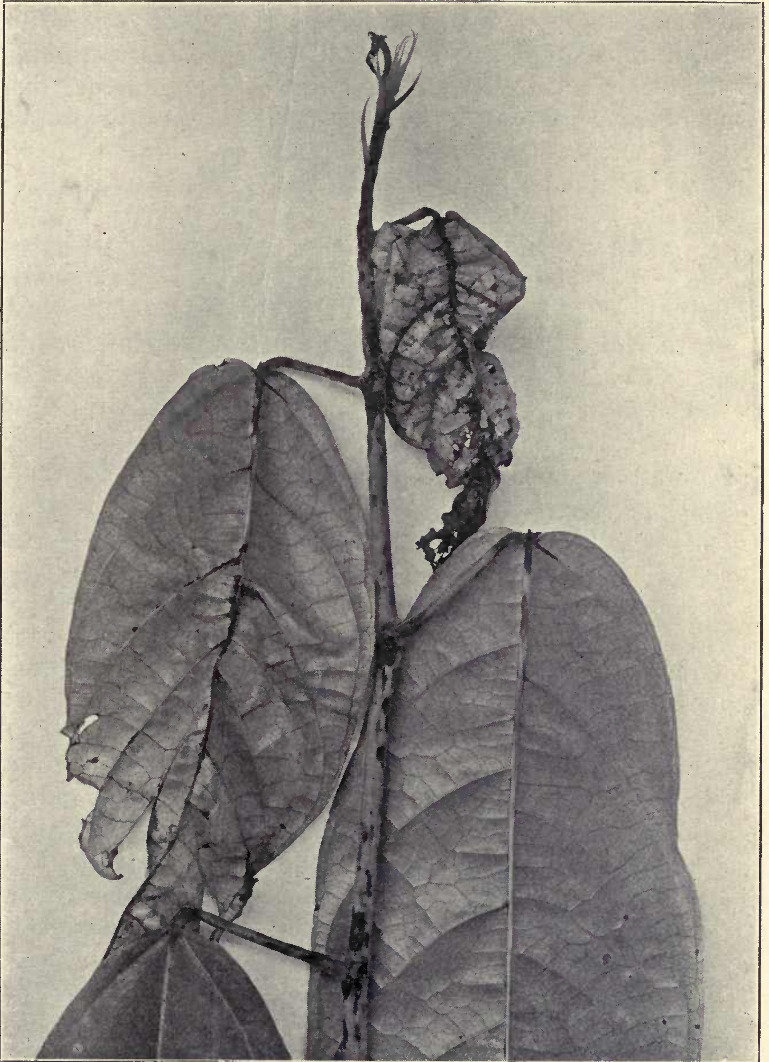


Photo. Roepke.

Fig. 95.—Cocoa twig damaged by *Helopeltis*.

"winter eggs," were laid, from which the larvae only hatched after the falling of the first rains, but this

assumption has not been confirmed by other investigators. Zehntner found that during the dry season the females retired to special shelter-places, generally low, humid spots, often situated near the little streams which run through the plantations. This agrees with the observed fact that at the beginning of the rainy season the pest generally first re-appears in the neighbourhood of such places and quickly spreads from there over the whole plantation.

Where cocoa is grown with little shade the harm done is generally greater. This, however, must not be attributed to better life-conditions for the *Helopeltis*, but to the detrimental influence of the sun and wind on the twigs attacked.

The fight against the *Helopeltis* is rendered difficult by the fact that the insect lives on so many other plants: tea, cinchona "kapok" (*Eriodendron anfractuosum*), pepper, *Bixa orellana* (often used as hedge plant in Java), tamarind, cinnamon, camphor, and many other trees and shrubs.[1]

Different methods are used in Java to combat this pest. On several plantations the insects are caught regularly by a special gang of women and children. For this purpose they use light sticks 20 to 40 cm. (8 to 16 in.) long, made of bamboo, with a ring of bamboo or a kind of fork at the end; the ring has a diameter of 3 to 4 inches (7½ to 10 cm.) and is provided with cobwebs by simply passing the ring through cobwebs. Sometimes sticks are used besmeared with the viscous juice of the jack tree. Such implements are necessary because the *Helopeltis* are remarkably quick. Every day the women and children bring their catch of insects to the overseer; they are generally paid according to the number of *Helopeltis* caught. This method obviously diminishes the number of the insects, but it is far from satisfactory; too many insects remain free in the fields.

The same may be said of the method of killing the

[1] See Roepke, "Helopeltis op kamfer en enkele aanteekeningen omtrent zyn voedsterplanten" (*Cultuurgids*, Part II., 1911).

insects by means of fire. For this purpose the labourers use bamboo-sticks filled with kerosene or some other similar oil and provided with a wick of cotton. The fruits are treated with this torch, and a great number of *Helopeltis* are killed. Some fly away in time, however, others are not reached by the fire, and a still larger number on the twigs or branches are left unharmed. It is worth mentioning that the fruits are not damaged in any way by this method. As the insects like to retire during the hotter hours of the day into shelter places on the branches and under the leaves, the best time for catching as well as for burning the *Helopeltis* is the early hours in the morning.

Other methods have also been tried. Spraying has not yet given satisfactory results, but extensive and conclusive experiments with different mixtures have not yet been made. The insects are not attracted by light, and lamps are therefore of no use for catching them by night. Their natural enemies are few; most carnivorous insects dislike the *Helopeltis* and leave it untouched, and only the spiders and *Mantis* eat a small number of them. So far, no disease has been discovered to attack the *Helopeltis.*

One insect, however—though not a real enemy, as it does not attack the *Helopeltis* itself—has been of great use in combating this pest. It is a species of ant (*Dolichoderus bituberculatus* Mayr), which, on some plantations, has been introduced into the cocoa fields with marked success. The ants were brought into the fields in nests made of bamboo, and a certain number of these nests were hung on every cocoa tree. In some cases the fields have been populated successfully with these ants, and where a great multiplication of the ants was obtained, the number of *Helopeltis* was to a great extent reduced, and the pest decreased in such a way as to be no longer of great importance. On other plantations, however, the introduction of these ants has not met with such success. The cause could sometimes be traced; often the number of ants brought into the

fields was not large enough, or the nests had not been made carefully enough so as to make the ants feel at home and increase quickly in number. But in spite of these failures the method of introducing the black ant into the cocoa fields may be regarded as being very promising, and it will probably become still more popular.

(2) The Rind bug (*Sahlbergella singularis*)[1] is the worst insect pest in Kamerun. It was first noticed in 1902 as a dangerous enemy of the cocoa, and since that time has inflicted serious damage every year. It attacks the young juicy twigs, and penetrates into the rind with its sucker. As with the *Helopeltis*, dark spots appear on the twig, and as the twig grows, the spots become larger and the rind shrivels. The leaf-stalks and the fruits are also damaged. The tree becomes defoliated, and large parts of the branch-system die out.

The fight against this insect is not so difficult as in the case of *Helopeltis*, because it does not move or fly so quickly. In this case, therefore, spraying meets with more success. Good results have been obtained by spraying with a mixture consisting of Paris green (40 grams), kerosene (3 litres), soap (1 kilogram), lime (1 or 2 kilograms), and water (100 litres). A 1 per cent decoction of tobacco has also been used with success. It is further advisable to use torches in the same way as in the case of the *Helopeltis*, as the rind bug is easily killed by fire.

(3) *The Mosquilla* (not yet determined). — The worst enemy of the cocoa in Ecuador is a sort of bug, called there "Mosquilla," which seems to belong to the family of Phytocoridae. A short description of this pest has been given by Rimbach.[2]

The male insect is about 7 mm., the female about 8 mm. long; the head and antennae are black, the rest of the body reddish yellow. The adult insect feeds on the fruits of cocoa, and sucks the juice of the

[1] Von Faber, *Die Krankheiten und Parasiten, etc.*, p. 304.

[2] Rimbach, "Durch Wanzen verursachte Schädigung des Cacao im Kustenlande von Ecuador" (*Zeitschrift für Pflanzenkrankheiten*, v., 1895, p. 321).

fruit-wall. The female deposits the eggs in the fruit-wall; the eggs are provided with a pair of hair-like appendages and these protrude from the little holes in the fruit-wall which contain the eggs. Each little hole is surrounded by a dark coloured border. The larvae, which apparently hatch after about a fortnight, crawl over the fruits and at once begin to suck. Every place where a larva or an adult insect puts its sucker into the fruit begins to discolour and gradually becomes a black spot. The insect remains on the fruit for the whole of its lifetime, and the attacked fruit becomes covered with smaller and larger black spots (ranging between $\frac{1}{2}$ and 4 mm. diameter).

Fruits of all ages are attacked. When the fruit is only attacked on a few places and shows only a few spots, the damage is not important, and the fruit will develop normally. But when a fruit is attacked by a large number of these insects, which remain there till they are full grown, the damage is serious, for the fruit is blackened over a great part of its surface and does not develop properly. This is especially the case when the eggs have been deposited on a young fruit.

This pest has damaged the cocoa in Ecuador for the past twenty-five years. The province of El Oro, near Machala, is especially affected, but the enemy is present over the whole coast region. In the province of El Oro the damage done is sometimes so serious that hardly any sound cocoa is reaped. This was, for instance, the case in 1909.

Rimbach proposes a remedy which is based on the same plan as the "rampassing" method against the cocoa-moth in Java: namely, to pick and destroy all the fruits which are to be found at a time of the year when there are but few fruits on the trees (at Machala the best time would be the months of October, November, and December). The fruits may be destroyed by collecting them into heaps and treating them with quicklime, or by burning or burying.

This method may give good results when the

"mosquilla" does not live on other parts of the cocoa, but its effect would be lessened by the presence in or near the cocoa fields of trees or shrubs which are also liable to be attacked by the insect. Whether the "mosquilla" attacks other plants besides cocoa is not yet known; indeed our knowledge of the insect is still so slight that it has not yet even received a scientific name. Judging from the description, it would seem to be allied with the *Helopeltis.*

(4) *Caterpillars which eat the leaves* are not of great importance as enemies of the cocoa plant, which may be considered to be remarkably free from this sort of pest. In Surinam the very young leaves, when still reddish and limp, are sometimes eaten by little caterpillars of an undetermined *Geometride*, and in Java a few species of *Limacodidae* have been found attacking the leaves (*Orthocraspeda trima*, *Belippa lohor*, *Parasa lepida*).

Thrips (*Physopus rubrocincta*) is a very harmful pest in the cocoa plantations in Surinam and the West Indies.

The life-history of this insect has not yet been studied carefully. The adult insects as well as the larvae live on the underside of the leaves and suck the juice. The affected leaves become yellowish, with numerous little brown spots; they soon fall off, and if the attack is severe, the tree generally is soon completely defoliated. The tree makes new leaves, but frequently it happens that these are also attacked and fall off again. Once more the tree tries to make new leaves, but these are small and weak, and if other conditions are not very favourable, the death of the tree may follow. Often, however, the thrips does not continue its attacks to this extent, but is still indirectly the cause of the death of the tree, the weakened branches being very liable to "die-back" disease (*Diplodia cacaoicola*), and in Surinam it has often been found that in fields first attacked by thrips a large number of trees were lost by "die-back."

It is a remarkable fact that the damage done is often very serious, while the number of thrips to be found on the leaves is very small; very often they are only to be found on the very young leaves. Accordingly the extent of the damage done by this insect is not so much the consequence of their large number, as is the case with *Helopeltis* in Java, but of the serious harm a single insect can effect.

The fruits are also attacked, and grow brownish as they ripen instead of yellow, this being a consequence of the formation of a thin layer of cork on the surface. But they are not damaged in any other way and generally they ripen normally.

Thrips appears especially in fields where the conditions are not very favourable. In times of long drought the insect is especially troublesome, while heavy rains make it sometimes disappear quickly. It is more common on poor soils than on rich ones.

In Surinam spraying with kerosene emulsion, tobacco decoction, or Paris green was unsuccessful, and a direct way of combating the pest has not yet been found, though in Grenada good results have been reported from spraying with kerosene emulsion. In no country, however, has the application of fungicides against thrips become popular, and more extensive experiments with different mixtures should be undertaken by the Experiment Stations.

Thrips has also been found to do damage, to a greater or smaller extent, to the mango (*Mangifera indica*), the canary tree (*Canarium commune*), the cashew (*Anacardium occidentale*), the guava (*Psidium guayava*); it also lives on the Liberian coffee tree, but apparently without doing harm.

In Java the "cocoa-moth" (*Zaratha cramerella*) is, with the *Helopeltis*, the worst enemy of the cocoa, and on many plantations the loss caused by the moth may be considered to be even greater than that caused by the *Helopeltis*.

The small caterpillars of this little moth live in the

cocoa fruits, making their tunnels in the fruit-wall and penetrating into the interior between the seeds. The seeds themselves are not attacked, but are spoiled to a great extent. Much of the life-history has been elucidated by Zehntner.[1] The eggs are laid against the fruit-wall, by preference in the furrows. They are reddish or orange coloured. After six or seven days the larva makes its appearance. It is only 1 mm. long, and begins at once to bore into the fruit-wall. Its colour is yellowish, and browner towards the end of the body. During about fifteen to eighteen days the larvae live in the fruit and

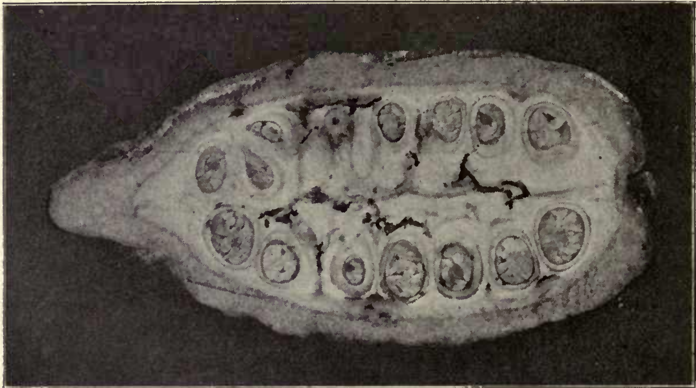


FIG. 96.—Fruit attacked by cocoa-moth.

make their tunnels in the pulp (Fig. 96). Finally they again bore through the fruit-wall, and leave the fruit in order to pupate. For this purpose they choose by preference the leaves, but sometimes also the pupae are found on the fruits. The pupation takes place under a little film, a sort of cocoon made by the caterpillar just before pupating. It covers the pupa well, and protects it against noxious influences. After five to eight days the moth appears. The body, with the wings, is about 7 mm. long and about 2 mm. broad. The lifetime of the moth is not yet well established. Probably it lives

[1] Zehntner, *Bulletins 1, 4, 6, and 7 van het Proefstation voor Cacao te Salatiga*. See also *De Nieuwe Gids*, III. pp. 567-584.

about one month, but it is not impossible that the lifetime is longer.

From the outside the damage done to the fruits is hardly perceptible; only one or a few very small black spots can sometimes be seen, these being the places where the larvae left the fruit. But if the fruit be cut through, the tunnels appear as brown or black lines through the pulp and the fruit-wall.

Not only cocoa, but also the fruits of the "rambutan" (*Nephelium lappaceum*) and of other species of Nephelium are attacked. The larvae of the cocoa-moth have also been found in the fruits of a few other Sapindaceae (*Erioglossum*, *Schleicheria*, *Xerospermum*, *Irina glabra*, *Turpinia*), and the kola (*Sterculia kola*) is attacked.

In the fight against the moth only one method has been successful, the so-called "rampassing" method, which consists in picking and destroying at a definite time of the year all the fruits which are hanging on the trees. The consequence is that for some two months the moths, which are flying through the fields, can find no fruits on which to lay their eggs, and in which the larvae can develop. Very young fruits are not suitable for this development, and it can only take place in fruits of a certain age. Thus the moths which are flying through the fields at the time of rampassing and shortly afterwards, not finding a suitable place for laying their eggs, finally die without leaving any progeny.

The first picking, which begins some five months after rampassing, yields fruits which are nearly all free from moths.[1] Gradually, however, some more fruits are found to be attacked and, generally speaking, each new picking yields a larger percentage of diseased fruits. Finally it amounts often to no less than 90 to 100 per cent.

There is much discussion among planters as to the best and most practical time for rampassing. Theo-

[1] Not infrequently, however, the very first pickings contain a certain number of fruits attacked by moth. Probably these fruits were just old enough to be good breeding-places when the very last living moths were flying through the field.

retically the best moment must be the time of the appearance of the flowers which give the fruits of the main crop (the "main flowering"). When rampassing is done earlier the moth has opportunity to produce several generations before the main crop appears; the percentage of attacked fruit is increasing during this "fore-crop," and when the main crop is picked the percentage has reached a disastrous figure. When, however, rampassing is done late, there is the risk that a part of the young fruit of the main crop is also rampassed, and that the main crop, though very little attacked, is much reduced. It is therefore always difficult to choose the right moment for rampassing.

The following figures may give an impression of the gradual increase of the pest after rampassing in one field :—

	Number of fruits.		Percentage of fruits attacked.
	Not attacked.	Attacked.	
December .	rampassing	...	...
January . .	...	...	...
February .	...	...	...
March . .	...	...	...
April . .	...	...	...
May . . .	1975	301	13
June . . .	4001	875	18
July . . .	1202	1173	49
August . .	173	2106	90
September .	...	3678	100
October . .	...	908	100
November .	...	...	...
December .	...	...	...

The loss caused by the moth is very serious as regards both quantity and quality of product. Some fruits attacked by moth may yield only about one-third of the quantity of marketable product which would have been obtained if they had been healthy, and the quality

is also inferior. To give an example: whereas 45 healthy fruits yielded 1 kilogram of marketable product of first quality, 45 fruits attacked by moth yielded 0·3 kilogram of marketable product of second quality.

Birds and Mammals

Birds.—Different species of birds do a certain amount of damage by making holes in the fruits when ripe or nearly ripe, and eating the seeds. This kind of damage, however, does not seem to be serious in any cocoa-growing country.

Rats and Squirrels.—There is probably no country where the cocoa is not attacked by some rodent or other. Different kinds of rats are the worst; the damage done here and there by squirrels and mice being of less importance.

These rodents climb into the trees, make holes in the fruits, and extract the seeds, sometimes eating only some of them, and scattering the rest all over the ground. These scattered seeds are sometimes so numerous as to be worth gathering (*e.g.* in San Thomé and Ceylon); they yield a product of inferior quality, known as "black cocoa."

In San Thomé the loss caused by rats is very serious every year, and has been estimated to amount to no less than about one-fifth of the whole crop. In Samoa the pest was at one time very troublesome, but now seems to be less serious than before. On the Gold Coast squirrels and rats are responsible for the loss of large quantities of cocoa annually, but the damage is chiefly confined to plantations in a neglected condition. In Ceylon squirrels often do considerable damage. In Java squirrels are also to be found as enemies of the cocoa, but only in certain places; in this country rats are some years troublesome here and there, while in other years no damage of importance is done.

The fight against rats is not so difficult on plantations as in towns or near the dwelling-houses, where

the use of poisoned food is dangerous to children and animals, and the dead and decaying rats are a nuisance to the people. Good results have been obtained with this method on the cocoa plantations of Java and Samoa. Rats, however, are very clever, and when poisoned food is simply placed here and there in the fields, the result is merely that the rats carefully taste a little of it, and, soon feeling that it is not the right food for them, leave it untouched thereafter.

Better results are obtained when unpoisoned food is first placed at definite places every day or every two days. Boiled corn is quite suitable. After a few days the rats know that the food is all right, and return daily to the spots to take their meals. If then poisoned food is substituted, the rats will eat it all and large numbers will die. The same thing can then be carried out again but with another food, bread for instance.

The food may be poisoned by means of carbonate of barium (1 part to 4 parts of food), or strychnine (food dipped into a solution of 2 per cent).

Two other methods of destroying rats have been tried by the cocoa planters: the use of a certain virus, and the introduction of rat-killing animals. Both these methods, however, are unsatisfactory.

Several kinds of bacterial virus have been recommended—the "Virus Danysz," the "Liverpool Virus," the "Rattin," etc.—but with none of these has a wholesale destruction of rats been obtained in any tropical country. Moreover, the method is not easily applied, and a local bacteriologist is necessary in order to have a regular supply of fresh virulent cultures. It is wholly useless to try cultures made in Europe; when these arrive in the tropics their virulence is much reduced, even when kept on ice. But even with virulent, freshly made cultures it is very difficult to cause a real epidemic among the rats, and generally only a small percentage contract the disease.

Against the introduction of rat-killing animals a serious warning is necessary. The consequences of the

introduction of the mungoose are in this respect very instructive.

The mungoose (*Herpestes mungo*) was imported into Trinidad, Barbados, St. Lucia, Jamaica, Mauritius, and Porto Rico. It was clear from the first that the number of rats diminished; but it soon turned out that many birds and other animals were also killed. The killing of fowls caused much loss to the inhabitants; but it was much worse when the mungoose began to devour large quantities of insectivorous birds and small animals, with the result that there was a noticeable increase in all sorts of injurious insects. So much so, that the Government in Trinidad and Barbados had to offer a premium for every mungoose killed, and since that time a large sum is spent every year in this way. The same happened in Mauritius, while in Jamaica it has been attempted to destroy the mungooses by means of a virus.

In Java a rodent larger than the rat, the "badjing" (*Sciurus notatus*), does considerable damage by eating all sorts of fruit, especially coconuts, and also the seeds of cocoa fruits.

In Kamerun damage is done by a kind of hamster (*Cricetomys gambianus*).

Of the larger mammals, species of deer and pigs may be mentioned as troublesome in young cocoa fields. The deer damage the trees by rubbing the bark off the stem. With older trees the damage is seldom serious, but young plants may be badly damaged, and a large number may be killed in this way by a few deer. Different species of deer are to be found in the cocoa-growing countries. In Java it is the "muntjak" or "kidang" (*Cervulus muntjak*) and also the "mendjangan" (*Cervus russa*), which are now and then troublesome in cocoa plantations. Deer are very common in Surinam, and do more damage than in Java.

Though pigs are in a sense useful, as they dig up and devour grubs, the damage done in this way to the

roots of the plants is sometimes of importance; young plants are not infrequently wholly uprooted. Pigs sometimes break off a great many young plants to make their lairs, and where cocoa husks have been buried they often give trouble by digging up the shells and spreading them out over the soil.

CHAPTER IX

COCOA-GROWING COUNTRIES

I. Ecuador

For many years Ecuador was first among cocoa-growing countries, but in 1909 and 1910 its export was surpassed by Brazil.

Very little information, however, has been published in regard to the cultivation of cocoa in this country.[1] As there is no Experiment Station, scientific investigations into the important agricultural questions have not been carried out. We are thus still wholly ignorant as to the composition of the soil and the nature of the prevalent diseases and insect-pests, and even statistics of the rainfall in the different cocoa-growing districts are not available. The *Meteorological Bureau* in Quito only gives figures for the rainfall in that particular town, and these are of no value for our purpose, as Quito is situated in a part of the country where cocoa is not grown.

There is no doubt, however, that the natural conditions are remarkably favourable for the cultivation of cocoa, and the industry is very successful in spite of the primitive methods which are still adhered to by the majority of the planters.

The suitability of the natural conditions is also

[1] Preuss, in his interesting book, *Expedition nach Central und Süd-Amerika*, devotes a chapter to Ecuador and its cocoa industry. For statistics the reports of the Chamber of Commerce of Guayaquil may be consulted (*Memorias de la Camara de Comercio de Guayaquil*). I am much indebted to Mr. M. E. Seminario of Guayaquil, who kindly furnished both information and photographs.

demonstrated by the fact that in clearing the forest wild-growing cocoa trees are often met with, sometimes in large groups. These trees are quite the same as the cultivated ones, and the fruit is just as good. According to the general opinion in Ecuador, such groups (called "Macigale" or "almagicos") have been sown by animals—monkeys or squirrels; but Preuss is inclined to think that these trees are really indigenous to Ecuador and that Ecuador is the mother-country of the "Amelonado" variety.

It does not appear, however, that there is sufficient reason for this opinion. In other countries, where cocoa is cultivated, the trees are found growing wild in the forest, sometimes in great numbers together. This is, for instance, the case in Surinam, and it is said also in Trinidad; but in these cases—at any rate in Surinam—there is no doubt that the cocoa is not native but that the seed has been distributed by monkeys.

Cocoa is grown in five provinces of Ecuador, each of which has its own quality and type of product. They are:—

Los Rios, producing about 25,000 tons per year; the product is known on the market as "Arriba."

Guayas, producing about 6000 tons; the product is known as "Balao."

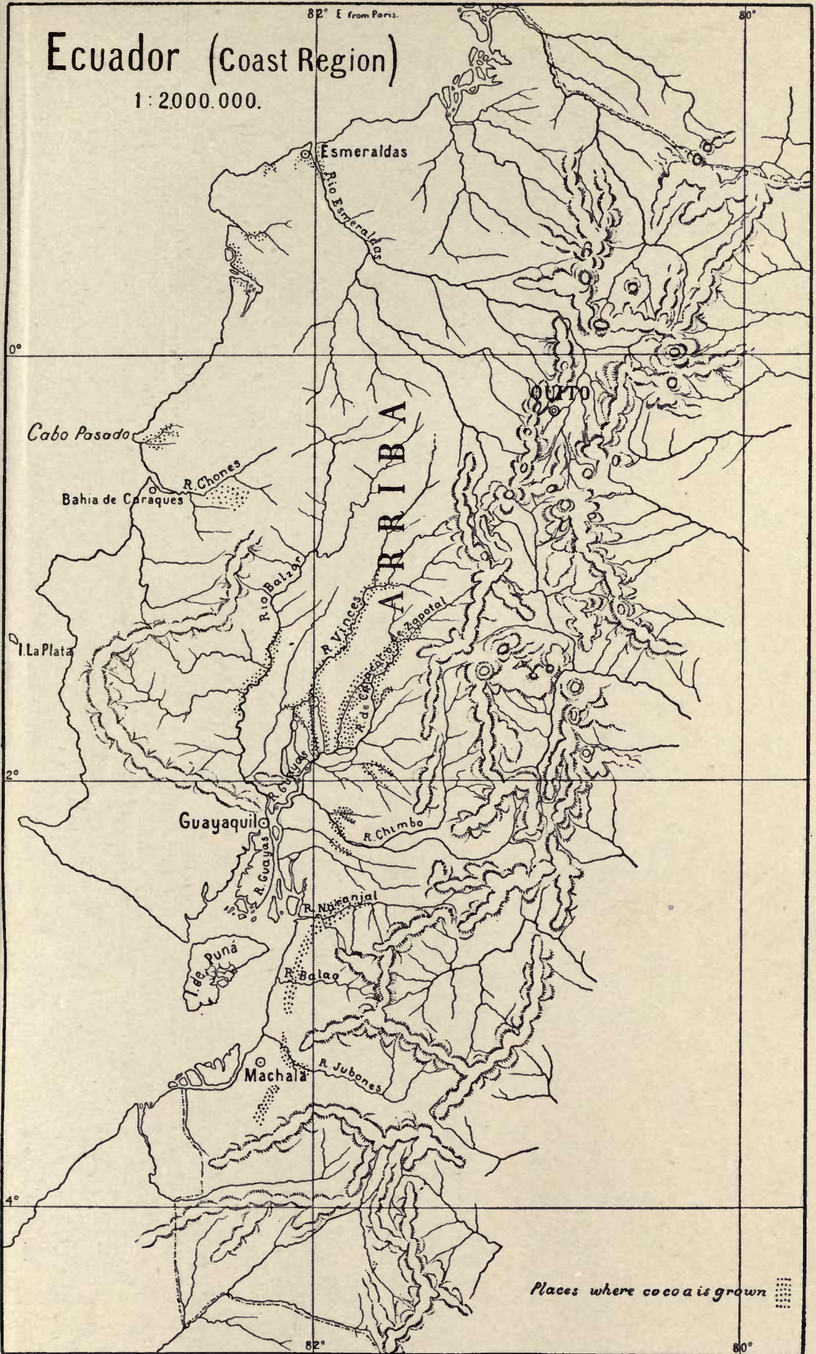
El Oro, producing about 3500 tons; the product is called "Machala."

Manabi, producing about 2000 tons; the product is known as "Manabi" or "Bahia."

Esmeraldas, producing about 75 tons; the product is known as "Esmeraldas."

The province of Los Rios is situated above Guayaquil, and the cocoa is cultivated along the tributaries of the River Guayas, the Rio de Caracol and its tributary the Rio de Puebloviejo, the Rio Vinces, and the Rio Balzar. These regions are all rather elevated, which gave rise to the name "Arriba," which means "above."

The province of Guayas is situated south of the River Guayas, and the cocoa is cultivated along the Rio



Map of the coast region of Ecuador, showing the districts where cocoa is grown.

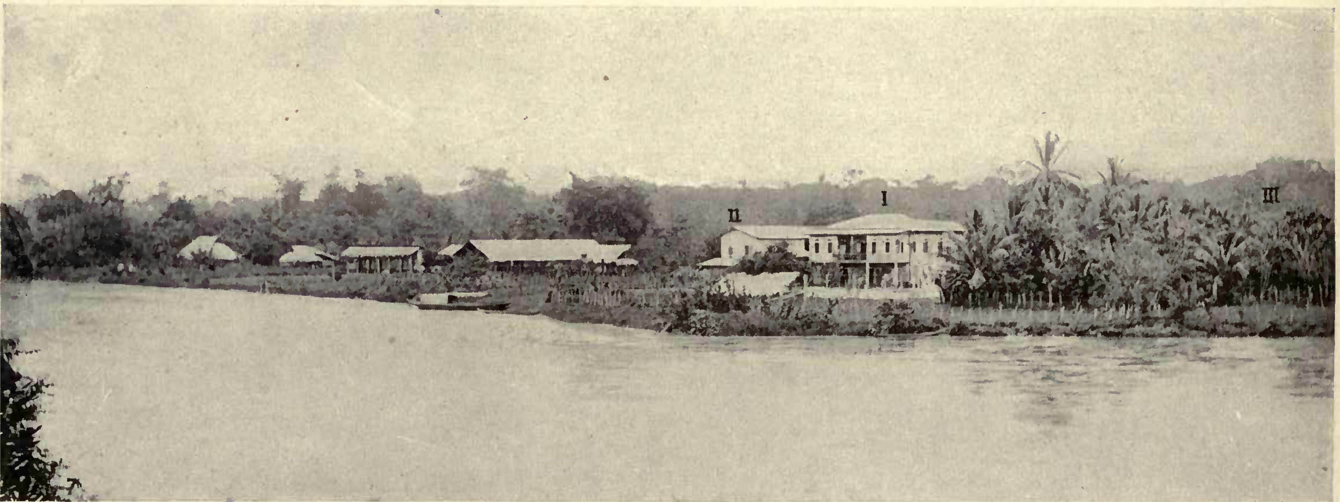


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Fig. 97.—The houses of a plantation in Ecuador, situated near the River ("Santa Rosa").

Naranjal and the Rio Balao, all near the coast. The principal commercial centre is the village of Balao, which has given its name to the product.

Farther south is the province of El Oro, where cocoa is also cultivated near the sea, along the Rio Jubones and south from this river.

The province of Manabi is situated in the north of Ecuador, and here cocoa is cultivated along the Rio Chones. The principal port is Bahia de Caraques, after which the cocoa of the province is sometimes called "Bahia," a name rather inappropriate, as "Bahia" is also the commercial name of the cocoa coming from the province of Bahia in Brazil.

The province of Esmeraldas lies again north of Manabi, and the cocoa plantations are situated along the Rio Esmeraldas. The port is Esmeraldas.

The seasons vary in the different provinces, and accordingly the main crop is reaped in different months. In the case of the "Arriba" the main crop comes in between March and June, while the "Balao" and the "Machala" are picked mostly in September and October.

It should be mentioned that the planters in Ecuador are of opinion that the rainfall has been diminishing during the last few years. This naturally causes some apprehension, but in the absence of rainfall records it is impossible to ascertain whether the idea is correct or not.

The cocoa provinces have mostly a rich alluvial soil; the layer of humus is generally exceptionally deep, probably deeper than in any other tropical country. In choosing land for cocoa cultivation attention is paid in Ecuador to the thickness of the layer of humus and to the wild plants which grow on it. Some of the latter are regarded as indicating richness of the soil—*e.g.* the Guarumo (*Cecropia peltata*), the Bijao (*Heliconia Bihai* and *Heliconia latispatha*), Palo de balsa (*Ochroma piscatoria*), Cana brava (*Guadua latifolia* and *G. angustifolia*), and some members of the Musa family.

The following table shows the annual export of the different kinds of cocoa from Ecuador in kilograms:—

	Arriba.	Balao.	Machala.	Manabi.	Esmeraldas.	Total.
1877	6,337,700	873,200	2,258,200	362,300	17,600	9,858,200
1881	5,477,100	1,264,200	3,243,600	291,900	26,300	10,303,100
1891	6,793,400	1,324,700	1,859,400	696,400	1,300	10,446,200
1892	11,170,500	1,805,500	2,299,900	821,600	3,600	16,101,200
1893	13,491,100	1,836,500	3,170,600	1,420,800	38,200	19,915,500
1894	12,643,900	2,383,500	2,971,800	996,900	31,000	19,027,100
1895	8,960,300	3,013,800	3,638,000	1,067,100	46,800	17,542,000
1896	11,532,200	1,932,400	2,327,500	1,463,500	88,100	17,333,200
1897	10,659,600	1,777,500	2,802,400	1,178,200	59,800	16,477,600
1898	14,215,800	2,227,800	2,958,900	1,370,000	74,400	20,846,800
1899	16,536,100	3,835,400	3,822,700	2,352,900	60,400	26,607,600
1900	12,394,000	2,255,300	2,904,600	1,160,900	206,700	18,921,300
1901	14,416,100	3,906,600	3,873,600	1,257,000	149,100	23,603,400
1902	15,719,700	3,670,300	3,135,400	1,946,100	194,400	24,665,800
1903	14,329,200	3,858,700	3,628,100	1,081,900	66,000	22,963,800
1904	18,793,100	3,967,500	3,027,900	2,235,300	91,600	28,216,200
1905	13,662,100	3,594,100	2,666,200	1,716,500	82,900	21,713,700
1906	14,971,800	4,187,100	2,595,800	1,309,000	76,600	23,140,300
1907	12,168,000	3,771,200	2,572,600	1,136,000	94,400	19,742,600
1908	20,366,900	5,744,800	2,958,400	2,491,600	150,500	31,712,100
1909	21,387,400	4,457,400	2,827,900	2,965,700	130,000	31,768,500
1910	23,229,500	7,204,700	4,347,800	1,868,300	83,000	36,733,300
1911	27,409,200	6,353,300	3,571,200	1,859,200	76,200	39,269,200
1912	24,597,700	5,968,200	3,341,900	2,027,800	51,800	35,987,300

The export of cocoa from Ecuador during the last six years has therefore been on an average 32,000 tons per annum. As the world production of cocoa (or rather the world export) was during these years on an average 210,000 tons per annum, it is seen that Ecuador exports about one-sixth of the whole.

The majority of the plantations in Ecuador are very large, and several belong to the same owner. Among the most important owners may be mentioned the brothers Seminario of Guayaquil, whom Preuss, on account of their large possessions with several millions of cocoa trees, called the "Cocoa kings of the world." The brothers Aspiaza, the firm Morla, and others are also owners of large and important plantations.

Many plantations in Ecuador seem very strange to those who are familiar with the way in which cocoa is cultivated in other countries. Preuss, for instance, says:[1] "I compared the cacao plantations of Surinam to well-managed gardens; those of Venezuela and

[1] *l.c.* p. 239.

Grenada could also be called gardens though a little less clean, and those of Trinidad large plantations. The plantations in Ecuador, however, are forests and partly even bush." Many planters, however, have now begun to use more modern methods of planting and cultivation, and there are some very beautiful plantations, especially some of those belonging to Mr. Seminario, "Clementina" in Arriba, and the plantation in Balao which belongs to the Morla family.

Notwithstanding the primitive methods of cultivation the trees in the Ecuador plantations are very vigorous; they are conspicuous by their large dimensions, and they surpass in height as well as in thickness those of other countries. On an average they grow 8 metres in height, but trees of 9 and even of 10 metres are not rare.

It is customary to plant very closely. In the older plantations the distance between the trees is not greater than 2 to 2½ metres (6 to 7 feet). Two, three, and sometimes five trees are planted in the same hole, and only some of the suckers are removed, so that several stems remain at each planting place, and the whole plantation assumes a very dense, bushy appearance, quite different from the appearance of the plantations in Trinidad or Surinam. (Figs. 58, 59, 98.) The trees lack the regular form which cocoa trees assume when they are allowed to develop freely and the suckers are removed. It must be added, however, that there is now a tendency to plant the trees wider apart, and in the new plantations a distance of 3·3 metres = 10 feet (4 *varas*) is chosen, and only one plant is planted in each hole.

With the exception of the province of Esmeraldas, the variety grown in Ecuador—a Forastero—is the same throughout the whole country, and the size and appearance of the fruits is very uniform, a fact which is the more remarkable because in most other countries where Forastero varieties are grown, the cocoa represents a mixture of many different sub-varieties or types.

The "Arriba," the "Balao," the "Machala," and the "Manabi" are products of the same variety, which is typical Amelonado (Figs. 30, 99). All the fruits are

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Fig. 98.—An example of the Ecuadorian system of planting one tree in each hole and of allowing the watershoot at the foot to grow.

yellow when ripe, and red ones are not to be found. The shape is rather plump, rounded at the top and slightly constricted near the fruit-stalk (slightly "bottle-necked"); the surface is rather warty, with ten low longitudinal ridges. In outer appearance they resemble

the Amelonado types, grown to a large extent in Surinam, Grenada, and St. Thomé, but the beans are larger and the fruit-wall is thicker. The same variety thus produces the four products: "Arriba," "Baláo,"

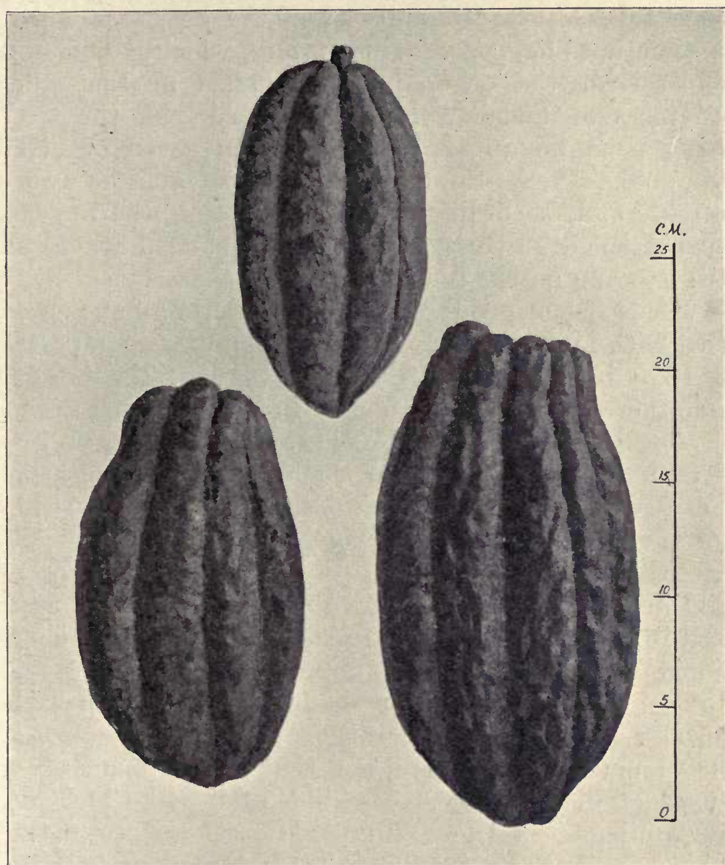

FIG. 99.—Types of fruits of "cacao nacional," Ecuador.

"Machala," and "Manabi," and the variations (in taste, aroma, appearance, consistency) are due to the differences in the soil and climate of the countries where they are grown.

Esmeraldas cocoa is produced by another variety,

with long, slim fruits, elongated and pointed towards the end, and "bottle-necked"; the surface is very irregular, the furrows deep. The colour, when ripe, is yellow or brownish-red; the beans are large and almost round. Sometimes this variety much resembles the Venezuela Criollo, especially when the beans are white, as sometimes happens. This variety, which is finer and nobler than the other, has been tried in the other provinces of Ecuador, but without success, the trees dying from no apparent reason when seven or eight years old. Preuss thinks that the cause must be a root fungus, and, according to his description, the appearance of the dead trees, with the brown dead leaves all still hanging on the branches, is very characteristic.

Seeds from good Venezuela varieties have been tried with more success. The first plants were imported in 1890 by Mr. M. E. Seminario, and at the present time there is a general tendency to use Venezuela seeds.

As regards shade, the old system of leaving a certain number of trees as shade trees when clearing the forest is still followed. Special kinds of trees are preferred for this purpose, especially the "palo prieto," *Erythrina velutina* (or *glauca* ?), which grows wild in Ecuador; this is probably the same tree as is used in Trinidad ("Bocare") and in Venezuela ("Bucare pionio"). This tree is much appreciated in Ecuador, and is considered the very best shade tree. For the same purpose sometimes the "borotillo" (*Erythrina umbrosa*, the "anauca" of Trinidad, and the "bucare anauca" of Venezuela) is left, or various kinds of "guabo" (*Inga*), the "mijagua" (*Anacardium rhinocarpus*), or native rubber species—*e.g.* the "hule" (*Castilloa elastica*), the "palo de leche" (*Sapium utile*), the "tagua" (*Phytelephas macrocarpa*), and the "corosa" (*Attalia Cohune*), etc. Some of these are decidedly not to be recommended, as, for instance, the "Guabo machete," which has very brittle wood and dies easily, while after death the decaying roots are prejudicial to the roots of the cocoa, infecting them with a fungus.

Gradually, however, the planters are realising the evils of the old system, and now prefer to clear the forest completely and to plant the necessary shade trees. For this purpose they mostly choose the "palo prieto" (*Erythrina velutina*) and also the Saman (*Pithecolobium Saman*), which is being more and more appreciated. In the plantations of Mr. M. E. Seminario, both these trees are planted, the Erythrina at a distance of 14 metres, the Saman at 25 metres.

The system of cultivation is still primitive. After clearing the forest, planting places are marked out at regular distances, the soil is superficially loosened at those spots, and the seeds are sown out, *i.e.* planted at stake, generally several at one place. Plant-holes are generally not made. Sometimes, however, the plants are first sown out in nurseries, and then planted out in the open field after some five months.

Between the cocoa bananas are planted, or cassava, corn, and beans. In rare cases no temporary shade is used (Fig. 100).

Weeding is more or less carefully done. Under the old system of planting very little importance was attached to it, but the more intelligent planters now understand its value, and, according to Mr. Seminario, they consider it necessary to weed at least twice a year.

No manuring is done; indeed it would probably be superfluous, considering the richness of the soil.

Although little attention is paid to drainage, a good drainage system would probably be beneficial in this flat country, where the rainfall is considerable. In view, however, of the supposed gradual diminution of the rainfall, experiments have lately been made in the dry season in irrigation by means of pumps, which bring the water from the river into the plantation.

Pruning is only done in a few plantations, and in many cases the only care given to the trees when full-grown is the occasional removal of suckers, called "ladrones." Some of the more progressive planters prune the top of the tree at its centre. Such planters

are also beginning to treat the shade trees more carefully, and to remove the lower branches regularly so as to obtain sufficient space between the tops of the cocoa trees and the lower branches of the shade trees.

Diseases occur in Ecuador as in every other cocoa-growing country, but in the absence of any scientific agricultural institute they have never been investigated, and no methods for combating them have been properly worked out. The consequence is that the annual

FIG. 100.—Cocoa grown without temporary shade (Plantation "La Elvira," Ecuador).

damage done is considerable. The most common diseases are the "mancha" and the "mosquilla."

The "mancha" (which means "spot") is a disease which attacks the pod at all ages. A black spot appears on the pod and gradually extends. It causes the decay of the whole fruit, and is probably caused by a fungus. This malady causes great loss, especially when the rains are heavy, and the difference between the day and night temperature is great. The "mosquilla" (see p. 278) is an insect which attacks the fruits. Both these maladies are prevalent in the coast regions, and the damage is

often serious at Balao, Bahia de Caraques, and especially at Machala, where in 1909 a great part of the crop was lost.

A rather sudden decline of temperature brings on what is called "helada" of the pods, which causes an abnormal growth of pods and beans.

In Ecuador the picking of the fruit requires more skill than in other countries, because of the height to which the trees attain in consequence of close planting and vigorous growth. Accordingly, trained pickers are used, especially for picking the fruits which hang very high. These labourers are called "tumbadores," and use long, thin, light bamboo sticks, to which a knife

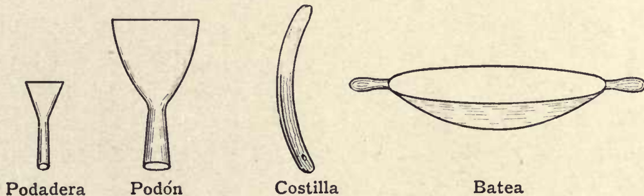

Fig. 101.—Implements used in gathering cocoa in Ecuador.

"Podadera," cocoa-hook; "podón," used for breaking the pods; "costilla," made of bone, used for removing the seeds from the fruits; "batea," for gathering the seeds.

is attached. The knife ("podadera") has the shape indicated in Figs. 63, 101. The "podadera" is attached to a stick ("palanca") about 2 metres long. Besides this "palanca," the "tumbador" carries a number of smaller sticks ("embonos"), which are attached to the "palanca" when necessary in order to make it longer.

Preuss describes the work of the "tumbador" as follows: "By means of the knife attached to the end of the stick, with one push from below he severs the fruits from the stem or branches. Sometimes all the 'embonos' are not sufficient for the height of the trees. In such cases the 'tumbador' throws the stick upwards with a quick jerk, and generally he does this so accurately that the knife cuts the fruit-stalk, the fruit drops, and the stick falls back vertically. This work demands

much skill and is also very tiring, as the labourer has always to keep his face turned upwards. It is a pleasure to see good 'tumbadores' at work."

The fruits are opened with a special knife called "podón" (Fig. 101), and a good labourer should be able to open thirty to forty fruits per minute. The beans are scooped from the fruits with the help of an instrument called "costilla," attached to the hand by a short cord (Fig. 101). This work is generally done

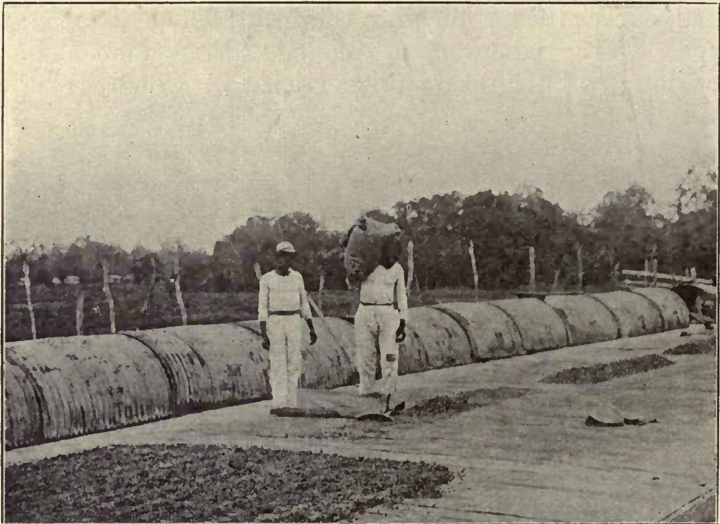

FIG. 102.—Drying floor covered with split bamboo, as used in Ecuador.

by women and children, and the beans are carried to the "hacienda" by mules or donkeys.

The yield in Los Rios ("Arriba") is estimated by Mr. Seminario to be about 11 quintals or 500 kilograms per hectare (200 kilograms per acre); in Guayas and El Oro ("Balao" and "Machala"), by the same authority, about 15 to 20 quintals, or 700 to 920 kilograms per hectare (280 to 370 kilograms per acre). This is about the same yield as is obtained in most other cocoa-growing countries.

The beans are not subjected to any special fermenta-

tion. At the "hacienda" they are at once spread out on the drying places, which are flat floors made with a mixture of earth and sand and covered with split bamboo (Figs. 102, 103). Cement floors are never used. During the daytime the beans are left spread out, and are turned over at frequent intervals, a work done mostly by children. At sunset the beans are gathered together into heaps and covered with banana leaves, sail-cloth or some other light material. During the night the cocoa ferments slightly in the heaps.

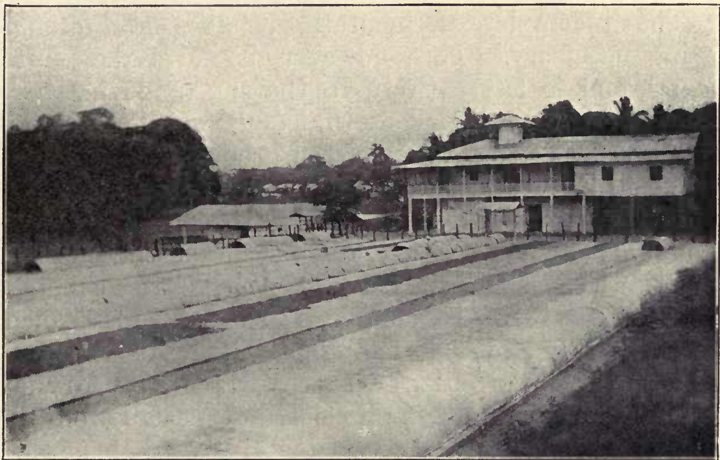

FIG. 103.—Drying floors, Ecuador.

The next morning the cocoa is again spread out. During the main crop the quantities are greater and the heaps larger, and Preuss attributes the better quality obtained from this main crop to the consequent stronger fermentation in the large heaps. It is doubtful, however, whether he is right in this supposition. Mr. Seminario informs the present author that he tried a regular fermentation, as practised in Trinidad and Surinam, but without success. The merchants would not pay a higher price for the resulting product, and the beans had not such a good appearance as when treated in the ordinary way. Mr. Seminario accordingly

reverted to the old method of very slight fermentation.

This may prove that the "Arriba," like all the finer kinds of cocoa, requires only a very slight fermentation to be marketable; but still the quality could be improved if attention were paid to the fermentation so as always to obtain a uniform product. Fermenting in special boxes would probably be advisable; but care would have to be taken to obtain an even, and not too high, temperature and not to leave the beans too long in the boxes.

The incomplete fermentation makes a thorough drying necessary. This, however, is never done artificially, and is left entirely to the sun, and the cocoa is not treated with dry earth, as in Venezuela. It is therefore not surprising that the product often moulds or even rots; in this way large quantities are lost in rainy seasons, but even in dry years large quantities of mouldy Ecuador cocoa are placed on the market. Sometimes the cocoa is dried a second time at Guayaquil by the export houses, and also selected and cleaned. A very peculiar method adopted at Bahia de Caraques is to sprinkle the cocoa with sea-water after drying. This product is much appreciated, especially on the London market.

The labourers on the plantations are mostly natives of Ecuador, though a small number are immigrants from Colombia and Peru. Labour is scarce and wages rather high—about one sucre (2s.) per day of eight hours, with free housing and medical attendance. The result is, as has been described, a cultivation of little intensity. On an area of 5 or 6 hectares[1] only one labourer is generally used, and Preuss mentions a plantation near Balao with a yearly production of about 600 tons of cocoa (and probably about 1000 hectares in extent), where only 150 to 180 labourers were employed. This corresponds with the experience of Mr. Seminario, who estimates that, on the average,

[1] One hectare = 2½ acres.

for every 100,000 trees (90 hectares) 15 labourers, 15 animals, and 15 hectares of pasture-grounds are necessary. The yield from this area would be 15 × 80 quintals—*i.e.* about 55,000 kilograms—while the expenses would be 15 × 960 sucres, or £1440. These figures indicate a yield of about 600 kilograms per hectare, or about 240 kilograms per acre.

The minimum expenditure on an Ecuadorian plantation, once it is established, is 6 sucres (12s.) for every quintal (46 kilograms) of cocoa delivered at Guayaquil; but 7 sucres (14s.) must be allowed when special care is given to the cultivation and the upkeep of the plantation. The cocoa is cleaned and put into bags at Guayaquil; the expense of this, together with export and other duties, makes 5 sucres (10s.) more per quintal. Thus the cost of production for one quintal (46 kilograms) up to the moment when it is put on board the ship at Guayaquil is 12 sucres or 24s. per quintal of 46 kilograms—*i.e.* 6d. per kilogram of cocoa, f.o.b.

According to Preuss, the planters of Ecuador are, generally speaking, intelligent and practical, and much superior to those of Central America. They are well known for their reliability. They are very particular about their implements, which are of better quality than in other countries.

An Agricultural Department with a scientific staff does not exist in Ecuador. In other countries the necessity of scientific investigation and advice has long been recognised as indispensable for the improvement of the cultivation and for fighting diseases, and in the Dutch, English, and German colonies Experiment Stations and Botanic Gardens are doing valuable work and have effected remarkable improvements in agriculture. In Ecuador, however, the most important cocoa-growing country in the world, the planters have to work out their own salvation, and instead of spending money to help the planters, the Government charges an export duty on all cocoa exported. This tax amounts

to $2\frac{1}{2}$ centavos (5s. per 100 kilograms) for cocoa loaded at Guayaquil; at the other ports it amounts to $3\frac{1}{2}$ centavos (7s. per 100 kilograms).

Another circumstance which hinders the progress of the industry is the way in which money is advanced to the planters by the banks,[1] which do not take the yield of the plantation as the basis for lending money, but only the number of trees planted. This often leads to careless planting in order to have a large number of trees so as to obtain a greater loan.

If this were altered and scientific help given to the planters, the cocoa industry of Ecuador would doubtless make still greater progress.

II. Brazil

Brazil does not hold such an important position as Ecuador in the cocoa-market, for the reason that her product is much inferior in quality.

The cocoa is cultivated in the States of Pará and Maranhão (the product being known under the commercial name of "Pará") and in the State of Bahia (the product being known as "Bahia").

In Pará cocoa has been cultivated for a very long time, but in Bahia it was only begun in the nineteenth century (see Chapter I.).

The importance and increase of the industry also dates only from the last half of the nineteenth century, and Brazil must therefore be classed among the younger cocoa-growing countries. The annual export of "Pará" remains nearly stationary, but that of Bahia has been very rapidly increasing, as the following figures show:—

[1] *Gordian*, February 1910, xv. p. 3229.

[Table

	"Bahia."	"Pará."	Total for Brazil.
	Kilog.	Kilog.	Kilog.
1830	...	...	26,000
1850	...	...	282,000
1870	...	...	1,216,000
1883	...	...	6,280,000
1894	6,555,000	3,594,000	10,149,000
1896	7,233,000	3,321,000	10,554,000
1898	10,283,000	2,660,000	12,943,000
1900	13,836,000	3,080,000	16,916,000
1901	15,457,000	2,867,000	18,324,000
1902	16,190,000	4,452,000	20,642,000
1903	15,775,000	5,125,000	20,900,000
1904	17,865,000	5,195,000	23,060,000
1905	16,727,000	4,263,000	20,990,000
1906	23,030,000	2,105,000	25,135,000
1907	21,027,000	3,501,000	24,528,000
1908	29,678,000	3,278,000	32,956,000
1909	28,899,000	4,831,000	33,730,000
1910	24,539,000	3,691,000	29,158,000
1911	...	...	34,997,000
1912	...	...	30,500,000

The increase in the export of "Bahia" is, however, not the result of systematic and persistent efforts on the part of planters who have had to surmount great difficulties. It is more the consequence of a combination of remarkably favourable circumstances, which in this much-favoured country make cocoa-growing possible and even successful in spite of the absence of any great care. Indeed, the natural conditions in those parts of Brazil[1] where cocoa is cultivated are perhaps more favourable than those of Ecuador, and accordingly the cultivation is still more primitive. These natural conditions would result in a still greater extension of the cocoa industry if the economic conditions were better and if the States in question were governed in a more sympathetic manner.

In Pará the districts of Cameta, d'Obidos, and Tocantins are the most important cocoa-growing centres.

[1] Jumelle, *Le Cacaoyer ; Gordian* (1910 and 1911) ; *Le Brésil, ses richesses naturelles, ses industries* (publié par le Centre industriel du Brésil).

Cocoa is grown only in the southern part of the State of Bahia, the principal centres being:—

(1) The *municipio* of Belmonte. The plantations are situated along the borders of the Rio Jequitinhonha, principally along the northern bank. The export from here at present amounts to 4,200,000 kilograms.

(2) The *municipio* of Canavieiras, situated on both sides of the Rio Pardo. The export is about 3,600,000 kilograms.

(3) The *municipio* of Ilheos, where the cocoa is cultivated more in the interior, the coast region apparently being unsuitable.

(4) The *municipio* of Itabuna, formerly combined with Ilheos. These two *municipios* export together about 1,500,000 kilograms.

(5) The *municipios* of Una (situated between Canavieiras and Ilheos) and of Rio de Contas, north from Ilheos.

The majority of the planters are small proprietors, and the plantations are mostly far from large. In Bahia there is an export duty of 17 per cent *ad valorem.*

As has been mentioned, the methods of cultivation adopted in Brazil are very simple. Shade trees are not planted. Formerly a certain number of forest trees were left standing, but this is no longer the custom. When the forest has been cleared, however, and the cocoa seeds have been put into the soil, secondary bush is frequently allowed to grow between the young cocoa, which in this way receives a sort of temporary shade—very often too much of it. In the first few years this secondary bush is occasionally cut down a little, so as to give the cocoa plants room; but this is sometimes omitted, and the plants have to grow up for a year or two among the weeds and shrubs. Generally, however, the bush is partially removed every year, until the branches of the young trees spread and reach each other. This is soon the case, for the trees are planted fairly close together; the planting distance varies from 6 to 12

feet, but is generally between 7 and 9 feet. Three or four plants are usually left growing together on the same spot, whether the seeds are sown out or the plants reared in nurseries; in the latter case they stand in groups of three or four close together, and the whole group is kept together in transplanting. The primitive methods of cultivating the young plants, and the growing of the older plants without shade would in most other countries result in the death of the trees, but here it meets with success owing to the extremely favourable natural conditions.

As regards climate, there is no real dry season to speak of. Rain falls every month, though not to the same amount; the wettest months are May to August, the driest December to February. Exact meteorological figures are not to be had, however, as up to the present none of the planters use any instrument to measure the rainfall.

The curing seems to be done with a certain amount of care in the regions along the Rio Pardo and the Rio Jequitinhonha, but in the *municipios* of Ilheos and Itabuna it is performed in a very slipshod manner. The crop comes in in two main harvests, one in December and January, the other in May and June.

No pruning is done, but the dead wood is sometimes removed when the fruits are being picked. Water-shoots or suckers are generally removed.

Though, as has been said, the methods of cultivation usually adopted in Brazil are very primitive and rough, there are a few exceptions. In the neighbourhood of Belmonte and Canavieiras a few planters have adopted more modern methods, and a few plantations under Swiss management may even be called first rate.

It is a very common practice for small proprietors to plant a certain area with cocoa, and then sell it later on to planters with more capital. Such buying and selling does not take place according to the area of the fields, but according to the number and age of the trees.

The average yield cannot be stated with any certainty, as the number of reliable figures is too small, but in Dr. Zehntner's opinion it is not higher than 1 kilogram per tree. On a plantation where the planting distance was 12 × 12 feet (4 × 4 metres) the average yield per tree was 1½ kilogram. These figures would certainly point to a high average yield of about 450 kilograms per acre; but it is more than possible that the average is not so high and that these figures are based on the yields of exceptionally productive fields. When further and more reliable statistics become available, it will probably turn out that in Brazil, as in most other countries, the average yield varies between 200 and 300 kilograms per acre.

At present there are no data as to the area under cocoa cultivation. Dr. Zehntner estimated in 1911 that in the State of Bahia from twenty to twenty-five million trees were in full bearing, while he put the number of young trees at about ten to twelve millions. At any rate the number of trees is rapidly increasing.

Diseases and insect-pests do occur, but up to the present none of them has done either great or general damage.

III. San Thomé and Principe[1]

Geography.—San Thomé, an island with an area of only 1000 square kilometres (360 square miles), is situated in the Atlantic Ocean just north of the equator, about 160 miles east of the mouth of the Gaboon River. With the much smaller island of Principe, situated a little to the north-east, it forms a province of Portugal. About half the island of San Thomé is cultivated and covered with cocoa trees;

[1] The principal work on the cultivation of cocoa in this country is the interesting and circumstantial work by Aug. Chevalier, *Le Cacaoyer dans l'Ouest africain* (fasc. ii. of *Les Végétaux utiles de l'Afrique tropicale française*. Paris, Aug. Chalamel). Special subjects have been treated in the following works: Francis Mantero, *Manual Labour in San Thomé and Principe* (Lisbon, 1910); J. A. Wyllie, *The Boa Entrada Plantations* (Edinburgh and London, 1907); José de Almeida and A. Cannas Mendes, *Les Plus Graves Maladies du cacaoyer à San Thomé* (Lisbon, 1910).

of the remaining part one-half is still suitable for the cultivation of cocoa, while only one-quarter of the whole island is considered unfit for agriculture.

Climate.—This comparatively small island contains three regions with very different climates. The northern and north-eastern part possesses a climate with a small rainfall—about 1000 mm. (40 in.)—and a strongly marked dry season during the months of June, July, August, and September; in the south and south-west there is much more rain, probably not less than 3000 mm. (120 in.), except near Miguel, where it is a little drier; and, lastly, the centre of the island, which culminates in the peak of Santa Anna (7000 ft.), is a region of a rather high rainfall and a very damp atmosphere.

Cocoa is cultivated in all three regions, but never above about 2000 ft. In the dry northern and north-eastern part of the island irrigation is necessary, but even then the cocoa often suffers a good deal from drought and has to be densely shaded. On the other hand, this district has the advantage that the product can always be dried in the sun.

In the south the amount of rainfall suits cocoa much better, but here artificial curing has to be used.

The Soil.—San Thomé is of volcanic origin. The rocks contain a little lime and considerable quantities of phosphoric acid and potash, and their slow decomposition produces very fertile soils. In many valleys red or yellow clay is found, but where cocoa is cultivated it is nearly everywhere to a considerable extent mixed with sand. In many places the soil contains humus, sometimes to a depth of one metre (3½ feet). These soils lie principally along protected slopes. In many parts of the island the soil contains numerous large stones; in these regions cocoa cannot be cultivated, as the stones would first have to be removed, which would be too expensive.

Sandy soils are rare; they lie chiefly in the north of the island near the sea and around the town. Cocoa

grows well here provided the layer of vegetable earth is of sufficient depth.

Near the shore and the river-mouths salt soils occur. If the salt water remains standing, the young cocoa dies; yet Chevalier saw near San Miguel a fine plantation where the trees were often flooded by high tide. This agrees with the experience, gained in Surinam, that cocoa can stand a good deal of salt in the soil if it has grown accustomed to it when young.

As serious damage is done by sea winds the cocoa trees have to be protected against them by thick shelter belts of trees.

The chemical composition of the soil in San Thomé is very variable. The analyses given by Chevalier yield the following general figures :—

	Per cent.
Nitrogen	0·07 to 0·2
Potash	0·1 to 0·2
Phosphoric acid	0·07 to 0·5
Lime	0·3
Organic constituents	1 to 2 (in one case 7).

The physical structure is to some extent shown by the following figures :—

	Per cent.
Stones	15
Gravel	16
Fine Earth	68 to 90

The following figures are also interesting :—

	Per cent.
Water	9 to 22
Humus	1½ to 3
Sand	40 to 50
Clay	30 to 50

History.—The first cocoa plants were introduced into San Thomé in 1822 from the island of Principe, which had probably obtained them from the Spaniards in Fernando Po. For a long time, however, the cultivation of cocoa made so little progress that as late as 1869 no more than 50 tons were annually exported, but in the last quarter of the nineteenth century the

export increased rapidly. While in 1869 there were only 64 owners of "roças" or "fazendas" (estates), this number amounted to 153 in 1872, and to 495 in 1898.[1]

Some plantations are very large, and employ as many as 1500 labourers.

The following figures[2] show the growth of the export of cocoa from San Thomé and Principe from 1870:—

Year	Kilog.	Year	Kilog.
1870	92,800	1904	20,496,000
1895	7,022,900	1905	25,669,300
1896	7,509,500	1906	24,619,600
1897	8,599,800	1907	24,194,600
1898	9,945,300	1908	28,560,300
1899	13,932,900	1909	30,261,000
1900	13,935,000	1910	36,664,800
1901	16,982,600	1911	35,000,000
1902	17,619,000	1912	35,500,000
1903	22,050,900		

The abolition of slavery in 1875 tended to retard for a time the development of agriculture.

A trial was first made with free labourers from the Cape Verde islands, but this was soon abandoned. Then Chinese from Macao and Timor were tried, but it was found that the mortality amongst them was very great and that they showed little aptitude for agriculture. Finally, people from the coast of Angola were taken into service under contract.

The arrangement of the estates.—There are three classes of plantations:—

(1) The first are those belonging to free natives; they are generally smaller than five hectares (about 12 acres). The owner lives on his plantation, working it himself with his family, and little care is bestowed on the cultivation.

Several cocoa seeds are sown in one hole, the distance of one group of trees from another being often less than 1·50 m. ($4\frac{3}{4}$ feet). Pruning and manuring are wholly neglected, but the shells of the cocoa-pods

[1] Ferreira Ribeiri, *A provincia San Thomé e Principe.* Lisbon, 1877.

[2] *Gordian,* 1911–13.

are placed round the foot of the trees. The trees die earlier and produce less than in the plantations which are worked more carefully. When a tree dies seeds are sown close to the vacant place, after the soil has been tilled to a depth of 6 or 7 inches. Notwithstanding this careless treatment, the yield is fairly high, which must be regarded as a proof of the excellent quality of the soil.

Fermenting and curing are carried out in as primitive a way as by the negroes on the Gold Coast, and the produce is mostly sold to native merchants.

(2) The second class of plantations vary in size from 10 to 100 hectares (25 to 250 acres). A few belong to natives or Creoles, but most of them to Portuguese, who manage them themselves or have a European manager. Some of these estates are very carefully cultivated. The owner is generally assisted by two or three European labourers, and requires about one native per hectare ($2\frac{1}{2}$ acres).

As the transport and the treatment of the cocoa are not so well arranged as on the large estates, comparatively more labourers are required. Therefore the profits gained on these plantations are small. Chevalier thinks that newly established plantations of this kind would scarcely give any profit at all within the first ten years.

(3) The third class of plantations comprise the large European estates or "roças." Some belong to private persons, others to agricultural companies, and most of them represent a capital of several millions of francs. Nearly all belong to Portuguese and are worked with Portuguese capital. The establishment of a large estate is very expensive, and after it is established it requires a large European staff and about one labourer for every 2 hectares (about 5 acres), exclusive of those required for the enlargement of the plantation and for the treatment of the produce.

Chevalier describes one of these estates—the manager's house and the neighbouring buildings, amongst which

are the fermenting and drying houses, the hospital, the houses where the native labourers live, the stables, etc. Considerable care is given to the roads on the plantation (Fig. 104). On some estates the small carts for transport are drawn by mules or men, on others steam-power is used. Very large "roças" have branch establishments, named "dependencias." These are managed by a European director, have accommodation

By permission of Mr. Monteiro de Mendonça.

FIG. 104.—Repairing a road on the estate "Boa Entrada," San Thomé.

for fermenting and curing, and generally employ from 100 to 200 labourers.

Labour conditions.—The owners of the large "roças" of San Thomé mostly live in Portugal, but from time to time they visit the island to control the state of affairs on their possessions. Every estate is directed by a manager, who is left entirely free in his management and is held responsible.

The population of San Thomé itself being negligible, the labour for the cocoa plantations is obtained from other Portuguese colonies, especially Angola. The

recruiting of natives for this purpose is performed by agents under the direct supervision of the Government and has been made the subject of elaborate regulations. Whatever abuses there may be in the methods of these recruiting agents, there does not seem to be much doubt that on the whole the natives are well treated once they have reached the plantations. They are well fed, and are generally housed in a long

By permission of Mr. Monteiro de Mendonça.

FIG. 105.—Labourers' dwellings and tank for washing cattle on the plantation "Boa Entrada," San Thomé.

building (Fig. 105), divided into a row of rooms, each of which is occupied either by a family or by two single labourers. Every plantation of any size also has its own hospital (Fig. 106), but in spite of all precautions the mortality among the imported natives is high.

De Almada Negreiras estimates that the cost for every "serviçal" amounts to 1·50 franc a day (1s. 3d.); wherein are included the contract costs, the wages, food, clothing and the loss by the large mortality among the newly arrived.

Chevalier estimates the costs for one "serviçal" at about 40 francs a month (32s.), divided as follows:—

Contract costs and loss by heavy mortality .	16 fr. (12s. 10d.)
Monthly wages	12 „ (9s. 7d.)
Food and dress	12 „ (9s. 7d.)

Comparing San Thomé with Trinidad and Surinam, Chevalier concludes that labour is very cheap at San

By permission of Mr. Monteiro de Mendonça.

FIG. 106.—Hospital on the plantation "Boa Entrada," San Thomé.

Thomé. In this he is, however, mistaken, for in Surinam the cost for one contracted labourer amounts to about 33 frs. (about 26s. 6d.) per month, viz. 16s. wages and 10s. 6d. indirect expenses (immigration expenses, as, for instance, passage on the steamer, hospital, houses, etc.).

The San Thomé labour-system, especially the way of contracting, has been in England the subject of much criticism.

Three of the most important cocoa manufacturers in

England sent a Commission to San Thomé and Principe to gain information about the way in which the "serviçals" were engaged and about the treatment on the estates. This Commission considered that much improvement was necessary as regards contracting; and in 1908 and 1909 the cocoa manufacturer, William A. Cadbury, made a journey through San Thomé and Principe to investigate the labour question.

He considered that the state of affairs was unsatisfactory, especially the details of contracting and the opportunities for repatriation after expiration of the contract. According to Mr. Cadbury, the Government did not look carefully enough after the fulfilment of the regulations.

After many deliberations, which had no satisfactory results, Mr. Cadbury, together with a group of other important cocoa importers, formed the resolution to boycott the cocoa of San Thomé, expecting in this way to induce the planters and the Government to improve the methods of contracting and the conditions of repatriation.

It cannot be said that this action of the English philanthropists has had much success. The San Thomé planters have not been inconvenienced by this boycott, as their cocoa has simply gone to other markets, especially to New York and Hamburg.

The cultivation.—At the present time new cocoa plantations are nearly always established on virgin land, so that the first work to be done is clearing the forest. As lianes or bush ropes are absent, this is not such a hard work as in many other countries. The shrubs are first cut down, and then the trees at about 0·80 m. (about 2½ feet) above the earth. Stumps are never dug out, as they moulder away in two or three years when the suckers are cut off twice or three times a year. The useful wood is sawn into boards, the worthless is used as fire-wood, or left to moulder in the field. Formerly, big forest trees were left as shade trees, but latterly this practice has been abandoned, and even

in old plantations they are cut down at the risk that the falling stems will destroy the cocoa trees.

When the land has been cleared, plant-holes are dug at 3·50 or 4 m. (10 or 12 feet) distance, as much as possible in straight rows; between them, rows of plant-holes are dug for the bananas, which have to give the first shade to the young cocoa trees, and must be planted at least six months before. In very good loose soil the plant-holes are made about 70 to 80 cm. (2·5 feet) deep, and at the surface 40 to 50 cm. (1 to 2 feet) in diameter; but if the soil is very stiff or contains big stones they are made as deep as 2 m. (6·5 feet). In this case a labourer cannot dig more than six holes a day; on an average a labourer during a year can do no more than dig holes for one hectare. The bottom of the holes must not consist of an impenetrable layer; to control this the holes are sometimes dug several months before the cocoa is planted; if the rain-water remains standing in them they must be made deeper.

While the clearing of the forest in San Thomé takes less work than in most other countries, the digging of the plant-holes is much more elaborate.

When digging a hole if a large boulder is met, the hole is not used for planting a cocoa tree; but a banana is planted there, because this plant does not need to penetrate deep into the soil with its roots, and the cocoa is planted a little farther on. For this reason even young plantations are hardly ever regular.

First, all sort of vegetable refuse is brought into the hole: fallen leaves, cocoa-shells, etc.; then follows a layer of good earth, which sometimes is fetched from a distance, and at the top pen-manure.

On soils which are always wet, or where the water remains standing a long time when the grounds have been flooded by rivers, draining is necessary. As draining is rather expensive, swampy grounds are often not planted. Irrigation is only practised in the north of the island and round the town of San Thomé.

Manuring.—It has already been mentioned that

the plant-holes are partly filled with manure. This is done on all estates in San Thomé, and is considered indispensable. In such a plant-hole the young cocoa plant grows quickly: in the third year it flowers, and in the sixth it gives a good crop, sometimes even earlier.

As manure for the plant-holes are used:

First. The refuse of fruit and vegetables from the kitchens of the plantation, weeds, and what remains after the sorting of the cocoa and coffee. This is all collected in a definite place on the estate and forms a good compost.

Second. Pen-manure, which is chiefly collected from oxen and mules, but it is often badly protected from the rains, and much of the fertilising substances are lost.

Third. Humus. When the soil is not fertile, at least one cubic metre of earth is removed from the plant-hole and replaced by the humus, which is taken from the surface of the soil, or sometimes brought a great distance from the banks of the river.

Fourth. Ashes from wood, which is burnt in large quantities in the drying houses.

Fifth. Cocoa husks. These are never thrown away, not even on the native plantations. They are brought near the foot of the trees or put into the plant-holes. The husks are sometimes burnt before being buried, as when buried in the green state they often attract the troublesome white ants.

While the plant-holes are dug in the dry season the sowing is done at the beginning of the wet season, in October or November. Some care is spent on the selection of the seed. At the estate of Monte Rosa the pods are taken from full-grown, healthy, and very productive trees; only the best seeds are used from the middle of the pod. These seeds are at once sown in rich soil in a nursery, or in the newly filled plant-holes if they are planted at stake, which is generally done in San Thomé.

Some planters sow but three seeds in one plant-hole

at a distance of 10 to 15 cm. (or ½ foot), but generally more seeds are placed all over the plant-hole.

Until the little plants are about 1 foot high they require much care: weeds must be removed as they appear, and white ants must be kept away.

Planting distance.—The natives generally plant very closely, and often put five or six plants on a surface of about 1 m. (9 feet square). The trees also often stand in groups of two or three, and each group at 1 m. (3 feet) distance. These trees make spindling stems, and branch as high as 8 or 11 feet. The produce is small, and when they are fifteen or twenty years old they must be replaced by others.

In old European plantations the trees also stand at small distances, but on very rich soil the yield, nevertheless, is good; on ordinary soil, however, no more than 400 or 500 kilograms per hectare are obtained. In the new plantations of Boa Entrada the trees stand at a distance of 3·50 to 4 m. (12 to 13 feet).

Chevalier believes—and he mentions Preuss as being of the same opinion—that with a planting distance of 3 to 4 m. (10 to 13 feet) two trees may be left in a plant-hole,[1] so that there would be 1200 to 1500 trees per hectare. At present most European planters leave two or three plants so near each other that their stems seem to be branches of the same stem.

Nurseries.—Nurseries are established in shaded places on rich soil, almost always in the neighbourhood of the buildings. The seeds are laid out at a distance of 20 to 30 cm. (8 to 12 inches apart).

According to Chevalier the number of young plants which die or do not develop is 30 per cent in the first year, 15 per cent of the rest in the second, 6 per cent of the rest in the third, and 2 per cent in the fourth. These figures show that in the soil of San Thomé the young plant has considerable difficulty in forming its roots,

[1] I think Chevalier is mistaken herein. As stated in Chapter VI. I cannot see any advantage in planting two cocoa trees at the same spot, and I am unaware that Preuss ever recommended this method.

which explains why so much care should be spent on preparing the plant-holes.

Shade.—In San Thomé cocoa is always cultivated under shade, and Chevalier believes it to be indispensable for West Africa.

For the purpose of shading the plants during the first few years bananas are everywhere used, the *prota* (banana) as well as the *pâo* (plantain). They are planted six months before the cocoa. Sometimes they are put in rows, one banana to two cocoa trees, but mostly irregularly. Until the fourth year these are considered as absolutely necessary, after that time the cocoa trees grow larger and the shade trees give the only protection.

A great many different trees are used. Sometimes the original trees are spared when clearing the forest. Chevalier mentions many of them, among which the *Elaeis* (the oil-palm) is regarded by him as very suitable. Where these trees are planted at about 10 m. (33 feet distance) they seem to afford an excellent shade. Fruit trees are also used, and among them the advocade (*Persea gratissima*) is much appreciated. Erythrinas on the contrary are not used at all.

It is remarkable that in San Thomé so many different trees are used for shade. It shows that the planters are not over-particular in this respect. Many trees are mentioned of which it is hardly to be believed that they are suitable for the purpose; the oil-palm, like many other palms, demands too much space for its roots to allow the cocoa tree to thrive vigorously next to it. In other countries one or two trees have been found to be most fit as shade trees, and, without going further into the question, we may say that a tree must have very special characters to be in all respects fit as a shade tree (see Chapter VI.); there is no doubt that trees belonging to the order of Leguminosae possess these qualities.

It is very likely that as regards experiments with shade trees, much remains to be done in San Thomé; and before trying to keep up the quality of the soil by

manuring it should, in my opinion, be settled what shade trees are best suited for the purpose.

Windbelts are especially necessary along the coast.

Altitude.—Generally cocoa is not grown in San Thomé on an altitude higher than 650 m.; on more elevated grounds the seeds are small, and they therefore lessen the commercial value of the cocoa with which they are mixed.

Pruning is much practised in San Thomé except in the native plantations. Pruned trees give a larger crop than unpruned ones. In this island the branch system is often formed at a height of less than 60 cm. above the soil, which is too low. Therefore often a watershoot is left growing in order to form a more elevated foliage system. After two or three years, when the higher foliage system begins to bear, the lower one is removed.

Suckers are regularly removed. Old trees are cut down just above the soil, after which the wound is tarred. Watershoots are formed after some time; the strongest is allowed to grow up to form a new tree.

Weeding.—In very wet parts weeding is done three times a year—twice in the rainy season, once in the dry season. In places where it is less wet, it is only done twice a year.

Produce.—The cocoa tree begins to bear in the fourth year, and is in full bearing from the twelfth to the twentieth year. An estate which gives twenty to thirty pods per tree (1 to 1·5 kilograms of cocoa) is considered to give a good yield. Chevalier believes that the estimate of one ton per hectare as average yield is too high, and thinks that 600 to 700 kilograms per hectare is more likely to be the average.

Harvest.—The principal crop comes in in October and November, a smaller one in March and April.

The most skilful labourers are charged with the picking of the pods. The fallen pods are laid in small heaps; afterwards these are collected into bigger heaps along the nearest road (Fig. 107). The seeds are put

in little baskets or boxes, and these are emptied into small waggons, which are taken to the "seda," the buildings where the fermentation and drying take place.

Fermentation.—The cocoa seeds are put into wooden boxes to ferment; on some estates they remain there for five or six days until the fermentation is finished, and are not turned over at all. On other estates one

By permission of Mr. Monteiro de Mendonça.

FIG. 107.—Piling up the cocoa pods for shelling—plantation "Boa Entrada," San Thomé.

box remains empty; after three days the cocoa is turned over thoroughly and then transferred to another box.

When the fermentation is finished the seeds must be dried. In the more elevated parts of the island and in the south, where rain falls during the greater part of the year, artificial drying is necessary. In the north, however, the cocoa can be dried in the sun.

On the estate of Boa Entrada the wet seeds are first spread out in thin layers on stone floors, for a couple of hours. When the drying has well set in, they are put

on drying platforms. These can be moved along rails, and are run every night into the drying house and taken out early every morning.

On the estate "Monte Café" the cocoa is dried artificially in a large hall. The tables, on which it is spread out, are arranged one above the other and are in contact with hot-air pipes. During the first hours the temperature is maintained at 50° or 60° cent. to prevent moulding; after that it is allowed to fall back to 35° cent. Generally the drying is finished within thirty hours.

Sorting.—When the seeds have been dried they must be sorted. This is generally done by hand, on some large plantations by machines; but as these grade by size only, it is necessary to go through again in order to separate the fine seeds from those which are less good. Usually four-fifths of the harvest consists of good seeds. The second quality are those seeds which have been well fermented but are of small size. The third quality contains principally the seeds which have not been fermented but have been found under the trees after an attack by rats, or the black seeds from dry pods which have been overlooked in picking, also the fermented seeds which have become mouldy. They are packed in bags which contain 70 kilograms, and are transported on small waggons to the steamer which every week goes round the island. In the port of San Thomé the cocoa is transferred to the Portuguese packet-boats which take it to Lisbon.

While years ago the cocoa from San Thomé stood in bad repute, at the present time the produce of some roças can compete with good South American cocoa.

Varieties.—In San Thomé two or three local varieties can be clearly distinguished; all foreign kinds which have been imported years ago after one or two generations assume the habit of this type, Chevalier thinks by adaptation, not by hybridisation; but this remains still to be elucidated. The imported trees themselves as they grow older give pods which are more

and more unlike the original type and approach to the native variety. Especially trees which are left to themselves are said to take the characters of the general type more rapidly than well-cared-for trees.

The common variety in San Thomé as well as in Principe and in all West Africa is named "Creoulo" by the Portuguese (not to be confounded with the Creollo of Venezuela and Java) (see Fig. 31). According to De Almada Negreiros it originates from Bahia in Brazil. In 1822 the first seeds were received. Chevalier believes that this type has been grown for a long time in the Spanish colonies in West Africa and has spread from these. When ripe, the pods are lemon-yellow, 15 to 18 cm. (6 to 7 inches) long, egg-shaped, mostly a little constricted towards the basis, and with a blunt apex. They have indistinct furrows and are smooth or a little rough. The fruit-wall is rather thin, the seeds are numerous; they are very flat, about 21 mm. long, 11 to 13 mm. broad, and 7 to 8 mm. thick.

This type has generally yellow pods and is then called "Creoulo amarillo," while the "Creoulo colorado" with red pods is less frequent.

The second variety is the variety which Chevalier calls *Theobroma sphaerocarpa*. The Portuguese call it "Cacao caranja" or "Carupano" or "Cacao amarillo redondo." This fruit is distinguished by small yellow pods; though ribs are present it is on the whole globular. It is said to be a native of Venezuela, and not infrequently met with twenty-five years ago. Yet it never takes up more than one-tenth of the plantations and is said to fail in the roças of the South. There are different opinions about the value of this variety. Some are afraid that the San Thomé cocoa would deteriorate when this species would be grown in large numbers because the beans are small and bitter. Others, however, say that the product is not inferior to the Creoulo if the trees have a good soil: moreover, they give a larger yield.

Several varieties of Forastero occur also, and prob-

ably they have been spread from the roça "Monte Café," which imported them in 1882 in Wardian cases.

Enemies and diseases. — The principal animal enemies of the cocoa are the *rats*, which cause a great deal of damage. De Almade Negreiros estimates it at one-fifth of the crop. They feed on the pulp which surrounds the seeds and then drop the seeds; these are collected, dried, and exported to Europe as the most inferior quality ("Cacao dos rabos"). Besides, white ants cause considerable damage.

One borer has been studied by Granier; it is the caterpillar of some *Zeuzera*, perhaps *Zeuzera coffeae.* The caterpillar finds its way into the branches, bores a passage which may be 12 mm. in diameter and 50 cm. long. The attacked branches die; the leaves get dry and remain on the branches.

The best way of fighting this insect is the cutting and burning of the infected branches, so that the caterpillar and chrysalides are destroyed.

There are other borers in the cocoa plantations, but not in large numbers, and the caterpillars principally attack unhealthy trees.

In the south of the island it sometimes occurs that several trees die suddenly. In some cases it appeared that the roots had not been able to penetrate into the stony or clayey layer; in others the roots had been attacked by a fungus. The fructification of this fungus has not yet been found.

A pod disease occurs, which makes a sort of brown rot: it generally begins with the fruit-wall; the tissue gets soft, and soon the infection spreads all over the pod. Chevalier sent some pods to the "Laboratoire de Cryptogamie du Museum" in Paris. They were examined by Hariot and Patouillard, who on nearly all of them found a *Botryodiplodia.* It is, however, probable that this organism is not the cause and was preceded by *Phytophthora.*

Export duty.—An export duty is raised, amounting to 5s. 8d. per 100 kilograms when the cocoa goes in

Portuguese ships to a Portuguese harbour; 11s. 5d. when it goes in foreign ships to a Portuguese harbour; and 18s. when it goes in foreign ships to a foreign harbour.

IV. Trinidad and the Lesser Antilles

Trinidad.[1]—The island of Trinidad, which is situated

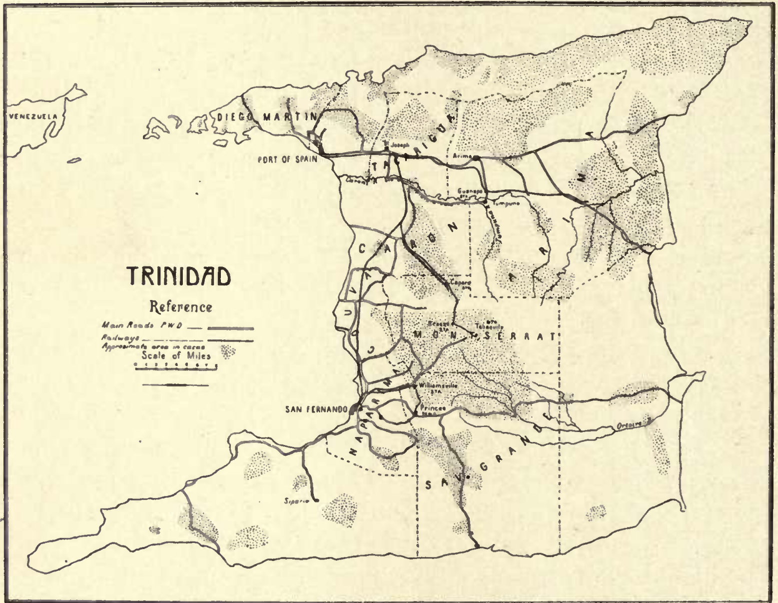

Fig. 108.—Map of Trinidad, showing the cocoa-growing areas.

at 10 N. and 61 to 62 W., near the coast of Venezuela, has an area of 1750 square miles (see map, Fig. 108).

Of the Lesser Antilles Trinidad is the most beautiful, and its capital, Port of Spain, though not large, is one of the most modern tropical towns. Everything in

[1] Olivieri, *A Treatise on Cacao* (Trinidad, 1903); J. H. Hart, *Cacao* (Trinidad, 1900, and London, 1911); Preuss, *Expedition* (1901). *Proceedings of the Agricultural Society of Trinidad and Tobago. Bulletin of Miscellaneous Information*, edited by the Botanical Department. *Bulletin*, edited by the Department of Agriculture; *West Indian Bulletin*, the Journal of the Imperial Agricultural Department, West Indies. *Trinidad Year-Book.*

this town, the neat houses, some of which are indeed luxurious buildings, the well-managed gardens, the macadamised streets,—everything shows the thriving condition of its inhabitants, and also in the interior of the island the good roads as well as the well-managed railway give an impression of wealth. This is almost all the result of the successful cocoa culture: cocoa being by far the most important of the export products.

As regards the climate, the description which Olivieri gives may be quoted here :

> The year only comprises two seasons, the dry and the wet or rainy season. The dry season commences with the month of January and ends in May; while the rainy season extends from June to the middle of December. The driest months are February, March, and April, and the wettest days are generally experienced during the months of July and August, with an interruption of very fine days from September to the end of October, known as the Michaelmas summer. The change from the dry to the wet season is generally characterised by a calm and close atmosphere, with occasional showers of rain from the middle of May to the middle of June, while during the rainy season rain falls in torrents for hours without relaxation, often accompanied by flashes of lightning and peals of deafening thunder.

The rainfall near Port of Spain is as follows :—[1]

Rainfall in Millimetres.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
St. Clair .	73	39	48	50	98	207	228	245	183	167	173	121	1632
St. Anns .	70	30	30	50	140	190	220	270	190	190	170	150	1700

These figures show that the rainfall in Trinidad is not very heavy for cocoa cultivation, and it could not be much less without being insufficient. In the dry months (January, February, March, and April) the cocoa suffers sometimes very much, and in years with

[1] *Report Botanical Department*, 1905 ; and Preuss, *Expedition*, p. 184.

heavy drought many trees and sometimes whole areas die, especially where the shade is scarce. From these facts the planters regard a rather dense shade as necessary.

On the plantation La Réunion the rainfall seems to be greater, being in 1896, 1897, and 1898 : 2730, 2580, and 2390 mm.

The temperature ranges between 20° and 30° C.

From January to June the prevailing winds are

Photo. Jacobson.

Fig. 109.—A six-years-old cocoa field on a Trinidad plantation.

from the east, while from June to October the winds are more variable, and, when southerly, generally are followed by or accompanied with rain.

Cocoa is not grown to any great extent on the alluvial flat lands. These are used for the cultivation of sugar, corn, coconut-palms, or as pastures for cattle. On the hills and mountains we find the cocoa plantations (Figs. 109, 110), and it is a curious and beautiful sight, when the shade trees or "immortelles" are flowering, to

see the slopes of the mountains covered as if with red tapestry.

The soil is here all decomposed rock. Sometimes, how-

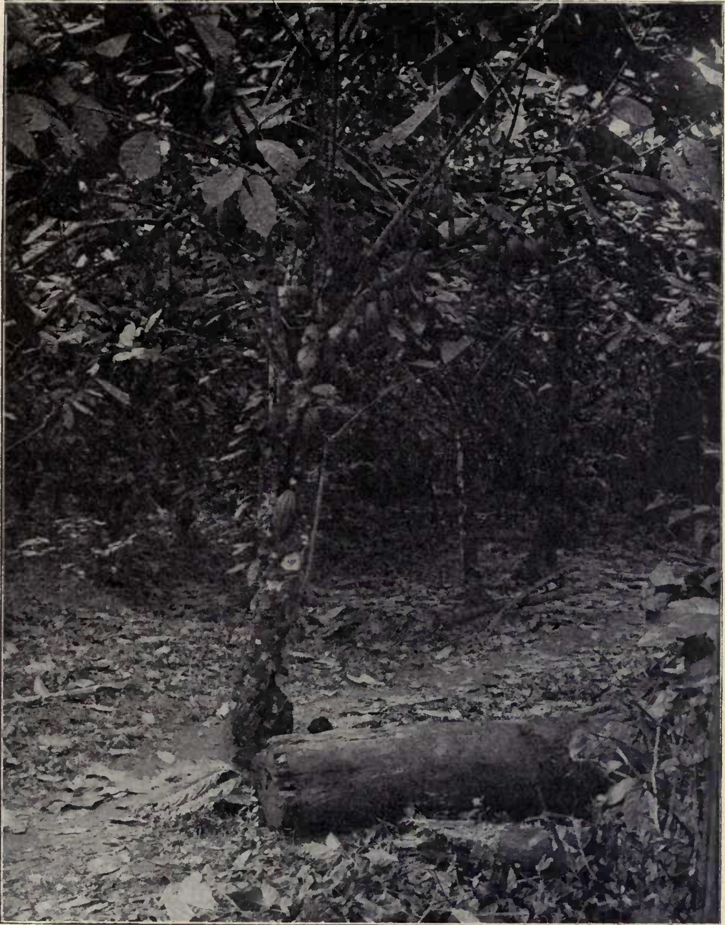

Photo. Jacobson.

Fig. 110.—Part of an old cocoa field in Trinidad.

ever, on the banks of a stream or river, there may be a considerable depth of alluvial deposit. Though the chemical composition of the soil is not of great interest from a practical point of view, an analysis of

a good cocoa soil may be given here. I select one of the several soils analysed by Professor Carmody, the Government Analyst, now Director of Agriculture.

Composition of the dry soil (the hundred and thousand decimal parts have been neglected):

Loss on ignition (mostly organic substances)	7·0	Potash K_2O	0·3
Iron Oxide Fe_2O_3	2·1	Soda Na_2O	0·1
Alumina Al_2O_3	5·7	Phosphoric Acid P_2O_5	0·1
Lime CaO	0·1	Sulphuric Acid SO_3	0·1
Magnesia MgO	0·4	Chlorine Cl	0·1
		Insoluble Silicates	84·0

Of the part lost on ignition, the nitrogen amounted to 0·13 per cent.

But these figures are not so very important, for it is well known that the chemical composition of the soil gives no reliable data as to its agricultural value. In Trinidad, as in all other countries, the planters know how to distinguish the different soils and approximately estimate their value as cocoa soils. The wild plants may assist to frame such an estimate. Olivieri mentions the following trees as indicating that the soil is good and fertile: the wild fig tree (*Ficus sp.* ?), the mountain-cabbage (*Oreodoxa sp.*?), the cedar (*Cedrela odorata*), the wild plum tree or moubin (*Spondias lutea*), the sand-box tree (*Hura crepitans*), the trumpet tree (*Cecropia peltata*), the bois lézard-fidèle (*Vitex capitata*), etc.

It is remarkable that several of these trees, which are regarded as indicators of a fertile soil, grow in Surinam by preference on light soils, generally too poor for successful cocoa cultivation. As regards the undergrowth in Trinidad, the balisier (*Heliconia*), the wild tanias (*Caladium*), the black roseau (*Bactris*), and other plants are supposed to grow on soils fit for cocoa culture.

One of the most appreciated soils is the so-called "chocolate soil," which has the brown colour of chocolate; it is considered to be very productive.

The soil must be deep; the rocky underground not too near the surface. In several plantations the soil is very stony, but this is not considered to be in any way detrimental.

The preparation of the land, the planting and the care of trees in the first two or three years, is either done by the owner himself or by a contractor under the so-called contract system. This system is the consequence of scarcity of labourers. It may be briefly described as follows :—

The planter makes a contract with a peasant or contractor who has a certain number of labourers at his disposition; the contractor is bound to plant the land with cocoa trees, and receives for his labour the use of the land for the purpose of growing annual crops of provisions, *plus* a fixed price per tree to be paid out to him at the end of five or six years, when the cocoa trees commence to bear, and the land becomes useless for gardening purposes. In 1889 an Ordinance was passed controlling such contracts, and now each contract has to be signed before the magistrate of the district.

As an example of such a contract the following may be quoted : —

TRINIDAD

IN THE MATTER OF THE AGRICULTURAL CONTRACT ORDINANCE, 1889

Statutory Contract made this day of 190 . Between of (hereinafter called the Owner), and of (hereinafter called the Contractor), for extending the cultivation of the Estate in the Ward of in the Island of Trinidad.

Whereas the Contractor was on or about the day of 190 let into possession of of land or thereabouts bounded on the North by lands of
on the South by lands of
on the East by lands of

on the West by lands of
Being part of the said Estate, on agreement with the Owner to plant the same in Cocoa trees in a regular and husbandlike manner, but the said agreement was not at the time reduced into writing; And whereas the Owner and Contractor are desirous of bringing the said existing Contract within the provisions of the Agricultural Contract Ordinance of 1889

It is now agreed as follows:

1st. The Contractor shall continue from the date hereof to plant such part of the said land as is not yet planted in Cocoa trees in a regular and husbandlike manner, and complete planting the whole within days; such Cocoa trees to be planted at (14) feet by (14) feet, and Immortelle trees to be planted at (42) feet by (42) feet in the centre of the Cocoa rows, and shall keep the whole of the trees heretofore and henceforth to be planted in a good and husbandlike manner.

2nd. The Contractor shall not plant any Rice nor more than one crop of Corn on the said land unless the consent of the Owner in writing is first obtained.

3rd. The Contractor shall not remove any plants, timber, or grass, or burn charcoal unless the consent of the Owner in writing is first obtained.

4th. The Contractor shall destroy all ants' nests that are and may come upon the land granted under this agreement.

5th. The Contractor shall plant and keep a nursery of Cocoa and Immortelle trees planted from seed, and such plants are to be used only for supplying the said lands when necessary.

6th. The Contractor shall weed or cutlass his contract four times a year in February, May, August, and November, and supply the missing trees at each cleaning, or the Owner may, if he thinks fit, do so and charge the Contractor with the costs.

7th. The Contractor shall dig all small drains (12) inches by (12) inches at the distance of feet from each other, and spread the earth dug therefrom at his own cost, or the Owner may, if he thinks fit, have them dug and the earth spread and charge the cost to the Contractor. Owner to show the Contractor how the drains are to be dug.

8th. The Contractor shall not trim his Cocoa trees or Immortelle trees unless the consent of the Owner in writing is first obtained, or under his direction.

9th. The Contractor shall not pick his Cocoa without notifying the Owner at least twenty-four hours before picking.

10th. The Contractor shall not allow any foreign trees to grow on his contract, such as Bois Lorme, Corkwood, Hog Plum, Trumpet Wood, or any Stumps; if he does the Owner may, if he

thinks fit, cut down such trees or stumps, and charge the Contractor with the cost.

11th. The Contractor shall have the full benefit of all provisions growing on the said land until the termination or cancellation of the Contract.

12th. The Owner or any person authorised by him shall have power at any time to inspect the said Contract.

13th. The Owner or any person authorised by him shall have power to order out of the land and out of the Contractor's house any objectionable person not being the Contractor's married wife.

14th. The Owner shall dig all main drains at his own cost. The Contractor shall spread the earth dug therefrom and keep the said drains clean.

15th. The Owner shall at the termination of this contract pay to the Contractor for each bearing Cocoa tree the sum of (twenty-four cents), for each young tree in flower which shall not be less than three years old the sum of (twelve cents), for supplies or trees not less than two years old the sum of (six cents).

16th. The Contractor shall pay the Owner the sum of (twenty-four cents) for each missing Cocoa tree, and the sum of   for each missing Immortelle tree. It shall be lawful for the Owner to deduct from the monies coming to the Contractor, all monies (if any) due or owing by him to the Owner.

17th. Should the Contractor be convicted of any kind of larceny; or for conveying or being in possession of cocoa suspected to have been stolen, such conviction shall operate as a termination of the Contract, but the Owner shall within one month of such conviction have the Contract valued and pay to the Contractor the amount found due on or before the next regular pay day after the Contractor shall have claimed the same.

18th. At the expiration of the Contract the Contractor shall deliver up all drains of proper depth and width, all Cocoa and Immortelle trees trimmed, and the contract clean and free from grass or weed.

19th. This contract shall continue for the term of (five) years from the date that the Contractor was let into possession, provided that it shall be lawful for the Owner to defer the taking over of the contract until the whole of the contract shall be bearing.

20th. It is hereby lastly agreed that it shall be lawful for the Owner at any time, and from time to time after the expiration of (five) years from the date on which the Contractor was let into possession of the said contract, to take over the whole or part or parts of the contract as to such Owner shall seem fit. On the taking over of the said contract or such part or parts as

aforesaid, the Owner shall pay to the Contractor at the rate specified in clause fifteen with such deductions as mentioned in clause sixteen.

In Witness Whereof the said Owner and Contractor have hereunto set their hands in the presence of

Contractor.

Stipendiary Justice of the Peace.

Owner.

The sum paid per tree varies according to the situation and the supply of labour, but generally ranges from 15 cents to 25 cents (7½d. to 1s.) per tree.

The contractor lives during the time the contract lasts as a farmer on the land. He builds a very primitive little house, clears the forest, and plants the crops which he considers most useful for his purpose, as plantains, bananas, cassava, cow-peas, tanias, sometimes also beans and ground-nuts or vegetables, and between them the cocoa and its shade trees.

When, in accordance with the contract, the time has come—usually after four years—the owner inspects the land with the contractor, the number of bearing trees and the number of those not yet bearing are figured out, and the owner pays out to the contractor what he owes him.

This system of planting by contract has its advantages and its disadvantages. It is certainly a cheap and easy way to get a certain area planted with cocoa, but the difficulty is, of course, to have it planted carefully. And while with an honest contractor the planter has a good chance of getting a well-planted area with healthy trees, he may be badly betrayed by a dishonest one: inferior types of cocoa may be planted; the young plants may be treated carelessly, either being hindered in their growth by too closely planted intercrops or by insufficient weeding, or by not being regularly freed from insects as borers; several plants may grow so slowly that one or more years are lost; or it may even happen that the contractor takes the land, grows one or two catch crops and disappears without planting cocoa.

And the worst is, that in such cases the owner can do very little against the contractor, as he is generally without a penny, and any attempt to recover damages would be useless.

Therefore many a proprietor prefers to have his cocoa planted by "day labour" under his own supervision, if he cannot get a reliable contractor, of whose honesty he is sure.

Sometimes an intermediate plan is followed, and the owner supplies the contractor with seed and with some men chosen among his own labourers.

The upkeep of regular plantations is performed by the planter with a certain number of labourers who are living on the plantation. They are partly negroes, partly East-Indian immigrants.

All labour is done as far as possible by task-work. For instance, for the cleaning of 100 cocoa trees planted at 14 feet distance about 37 cents is paid, making the cost of weeding one acre about 75 cents, the picking of 110 lbs. cocoa 70 cents (1 cent = one halfpenny).

This comparatively cheap labour and the easy way in which cocoa can be cultivated in Trinidad—no drainage being necessary and no very noxious diseases being prevalent — make the cost of production low and cocoa-growing very remunerative. According to Mr. Edgar Tripp the cost of production, apart from capital charges, is on the best estates about $7 per "fanega" (110 lbs.), rising to $10 per "fanega" on less fertile or less well-managed properties ($1 = 4s. 2d.), included putting on the market at Port of Spain.

For clearing the forest the dry season—February, March, April—is preferred, to permit a thorough burning. No forest trees are left for shade; the shade trees are all planted. In former times forest trees were sometimes left, and in old cultivations the large sand-box trees (*Hura crepitans*) standing in the cocoa fields are often troublesome. The reason for leaving this tree may be found in the fact that the bark is very poisonous and dangerous to the skin and eyes. In

cutting sand-box trees many a labourer has been badly injured or has even lost his eyes by the sharp milky juice. It may be mentioned here that the juice of the sugar-cane is a good remedy against it, and in Surinam the labourers, when they go cutting forest which contains sand-box trees, never omit to take a piece of sugar-cane with them.

Quite different from Ecuador, where through the whole country the type of cocoa is so very uniform, the Trinidad plantations show a *mixtum compositum* of all sorts of varieties, but all Forastero types, Criollo not being grown in Trinidad.

To save confusion I refer to what was said about the Criollo variety in Chapter V. It would be very confusing to call "Criollo" in every country the variety which is considered to be there the indigenous one. In doing so the name "Criollo" could no longer represent a definite variety or a well-defined class of types. We had better keep the names "Criollo" and "Forastero" over the whole world for the same varieties, calling "Criollo" the variety with soft-skinned, deeply-furrowed, warty fruits and white round sweet beans, and "Forastero" the variety which has less warty or even smooth fruits with a hard, woody skin, with not such deep furrows and flatter beans, this latter variety comprising all the sub-varieties running from the "Angoleta," which is much alike the Criollo, through the "Cundeamor" and "Amelonado" to the "Calabacillo," with very hard-skinned fruits with almost a smooth surface and very flat bitter beans.

If we accept the terms "Criollo" and "Forastero" in this sense we can say that no "Criollo" is grown in Trinidad, but of "Forastero" all sorts of types may be found.

It has, however, not always been so.

Dr. de Verteuil[1] tells us in his work on Trinidad that from its first settlement Trinidad exported cocoa, and *that* cocoa soon gained a reputation on account of

[1] Dr. de Verteuil as quoted by Hart (*Cacao*, 2nd edition, 1900, p. 56).

its delicious aroma. According to Gumella it was superior to that of Caracas and other places; so much so that the crops were bought and paid for beforehand.

In the year 1727, however, a terrible "blast"—either a hurricane or a blight—spread through the cocoa plantations and complete ruin followed.

Blast 172

Thirty years later, some Aragonese Capuchin Fathers were successful in their attempt to revive cocoa growing in the island. They imported from the mainland a new kind of cocoa which, though giving a produce of inferior quality, was nevertheless promptly propagated as being hardier. That is the Forastero cocoa at present cultivated in the island.

Though only two varieties are described—the one giving a produce of superior quality but not resistant against diseases, and the other more resistant but giving a produce of inferior quality, it is clear that the varieties are Criollo and Forastero. It is interesting to note that Trinidad imported its Forastero from Venezuela, and doubtless from that part of Venezuela where other districts obtained the Forastero variety, namely, the basin of the Orinoco.

Whatever the historical facts may be, at the present time no other varieties are cultivated in Trinidad than Forastero varieties, but these are present in a great diversity of forms; and in the plantations we find all types of Angoleta (called "Forastero" by Hart, Fig. 29), of Cundeamor (Hart's "Trinidad Criollo"), and of Amelonado (Fig. 111) mixed.

Still, the Angoleta and the Cundeamor are prevalent.

It is often the case in Trinidad, that after being cleared the land is allowed to lie fallow and is planted next year. Generally the distance adopted now is 12 to 15 feet (Olivieri recommends 12 to 13 feet on ridges and elevations and 14 feet on flat lands and gentle slopes). Generally speaking, 12 feet will be good on poorer soil, 15 feet on rich soil. In older plantations we find the trees generally closely planted at a distance of

10 feet or even less, but this system is followed no longer. Care is taken that no water remains standing in the fields, and, when necessary, narrow trenches are made; but as cocoa is grown on hill-slopes, and not on flat lands as in Surinam, while the rainfall is not

Photo. Jacobson.

Fig. 111.—An Amelonado type grown in Trinidad.

so extraordinarily heavy—as, for instance, in some parts of Java and British India—the damage done by the rain-water, either by keeping the soil too wet or by washing away the earth, is not so much to be feared in Trinidad. Still, in some plantations, where the land

is flat and the soil stiff, a regular system of open drains is considered necessary.

Planting at stake and from nurseries are both practised; as in Surinam, many planters also in Trinidad are in favour of using nursery plants, and well-managed nurseries are to be found here with the plants standing at distances of 1 or 1½ feet, well covered with a roof of banana leaves. But, as Hart remarks, the method of stake has also advantages, and as explained in Chapter VI. the combination of both systems may be found the best for Trinidad also.

The coating of the seeds with lime or ash before planting to avoid the attack of insects is generally done.

In Trinidad the choice of temporary shade plants does not appear to be of great consequence. The *banana*, the *tania*, and the *cassava* may be mentioned as mostly used, but also *pigeon peas* (*Cajanus indicus*), castor-oil plants (*Ricinus*), and corn (*Zea Mays*) are often to be found in the young cocoa plantations.

When planted by a contractor these temporary shade plants are planted in very different ways and a uniformly adopted system does not exist: the choice of plants and the way of planting may be very different. When the planter does the planting himself there is generally more system in planting.

The rows of bananas are usually placed between the cocoa rows and at half the distance of the cocoa, the distance being 7½ feet if the cocoa is planted at 15 feet. In this system sometimes tanias are planted in the cocoa rows. Another system is to plant in the cocoa rows a banana between every two cocoa plants, while a banana is sometimes planted also between the cocoa rows in the centre of every square formed by four cocoa plants. Tanias, pigeon peas, and cassavas are planted between the bananas and the cocoa, and the more drought is to be feared on the land planted, the closer the shade plants are put together. The banana usually used as shade is the "Jamaica" or "Gros Michel," the variety so largely cultivated in

Jamaica, Costa Rica, Colombia, Panama, and Surinam for export to America and Europe; of the plantains the so-called "Jumbi plantain" is preferred.

Of the tania different varieties are used, of which Olivieri[1] gives a review. The "giant" or "plantain tania" is one of the most common. Of this variety the tubers become developed and good for reaping at the end of ten to twelve months after planting; some seven tubers are then produced measuring 3 to 7 inches in length.

By exposing, however, and breaking off the tubers without rooting or digging out the plant, which process is called "castrating," two or three crops yearly can be reaped during the second and third years after planting, each plant giving an average yield of thirty pounds of tubers, provided after each digging the parent rhizome is moulded up and covered with the removed and surrounding earth to a height nearing the last internode below the leaf-stalk.[2]

In Trinidad the cocoa plants and the permanent shade trees are planted at the same time. For this purpose no other trees are used than two Erythrinas ("immortelles"), namely, for the low lands the "Bocare" or "Bocare Piñon" (*Erythrina velutina*), and for the higher lands the "Anauca" or "Nauclero" (*Erythrina umbrosa*).

The "Bocare" is closely related to the "Koffiemama" of Surinam (*Erythrina glauca*). Both have the same appearance, and form a large and rather dense foliage system. The leaf is composed of three leaflets, which are not very large, about 10 to 12 cm. long and 6 to 8 cm. broad. But the leaflets of the "Bocare" (*E. velutina*) are slightly hairy on the under surface, while those of *E. glauca* are glabrous. The bark of the "Bocare" is rather smooth and provided with pointed nipple-like thorns (*piñones*), more or less scattered along the trunk and the lower portions of the branches. It is an easy grower, succeeding in all sorts of soil, also in stiff clay and in soils where the drainage

[1] Olivieri, *Treatise*, p. 44. [2] *l.c.* p. 45.

is not very good. The legume or pod of the "Bocare" is about 9 to 12 cm. long and contains two to five seeds.

The "Anauca" or "Nauclero" (*Erythrina umbrosa*) is only grown on the high lands, where the soil is of good quality; in low lands and poor soils it does not succeed. Wherever it grows well, the "Anauca" attains a much greater height than the "Bocare" and does not afford so dense a shade; it is planted at wider distances apart, generally at 40 to 45 feet. The bark of this shade tree is coarser than in the "Bocare," while the thorny nipples are more profuse and sharper, but less prominent. The legume or pod of the "Anauca" measures about 15 to 30 cm. in length and contains from five to eleven seeds.

These two Erythrinas are in general use in Trinidad. They suit the purpose extremely well, giving the right amount of shade to the plant and to the soil, and giving a rich humus, dropping all their leaves in the dry season —a very useful character, which has already been discussed in Chapter VI.

Another useful character of the "immortelles" is the luxuriant profusion of their annual harvest of flowers. Carmody analysed these flowers and found that they were rich in nitrogen; fifty immortelles (the number standing on 1 acre) yielding 500 lbs. of dry flowers containing not less than 24 lbs. of nitrogen.

It has been suggested that the "Saman" (*Pitheco-lobium Saman*) would advantageously replace the immortelles as a shade tree for cocoa. But the general opinion is not in favour of this view. The shade of this big tree with its enormous foliage system is considered too dense, and it does not drop its leaves in the dry season, leaving this character to the advantage of the immortelles. Besides, the wood is brittle. *Terminalia bellerica*, which produces the "myrabolan" of commerce, has also been suggested. I cannot recommend this tree.

In the low lands where the "Bocare" is used, this shade tree is planted rather closely—one shade tree to

every three cocoa trees; sometimes when the cocoa is planted at a rather wide distance, there is a shade tree to every two cocoa trees. Generally the distance of the "Bocare" is 30 to 35 feet.

The "Anauca," on the higher lands, is planted wider; the shade afforded here is therefore less. One "Anauca" is planted to every three or four cocoa trees, and the distance of the shade trees is generally 35 to 40 feet.

These distances of the shade trees are rather close, and it may seem at first sight that they could be planted wider, but the general opinion in Trinidad is that a close planting of the shade trees is necessary to avoid suffering of the cocoa from drought.

Weeding is more or less carefully done. Generally the established plantation is weeded only twice a year.

Pruning is done in Trinidad in very different ways, and, as in some other countries, views about this part of the culture are widely different. On several plantations the pruning-knife or *machete* is used very indiscriminately, and not only a great number of young branches but also thick and old ones are cut away without any necessity, and after pruning the ground is covered with a thick layer of branches and twigs. It is to be understood that, seeing the results of this method, some Trinidad planters have become enemies of pruning; they call themselves "anti-pruners" and their object is to remove only the watershoots (suckers).

It must be said that the appearance of the trees on plantations where this method is followed is much better than on those where branches are cut away incessantly and indiscriminately, while the production is doubtless higher. But still a sensible and not too heavy removal of the too numerous twigs in the centre of the tree is useful in Trinidad as elsewhere.

Trinidad as well as other countries has cocoa diseases, but none up till now is of such importance as to be regarded as a calamity for the country.

The most important are the following:—

The ordinary "blackening of pods" (caused by

Phytophthora) is well known on all plantations. Possibly it may have been the disease which destroyed the Criollo crops about the year 1727, which led to the introduction of the Forastero about 1757.

The canker is also well known and occasionally causes loss of trees. This is also the case with the "die-back" or Diplodia-disease (*Diplodia cacaoicola*), which at present may perhaps be regarded as the most serious disease.

Mr. Barrett[1] especially pointed out that in many cases the death of cocoa trees had to be attributed to Diplodia or "die-back" disease, and he recommended a careful removing of all diseased or dead wood and the burying of pods or covering them with lime.

Besides, "thread-blight" and "horse-hair blight" are sometimes met with. Neither of these diseases is so prevalent that regular measures have to be taken against them.

Among the insect pests the cocoa-beetle (*Steirastoma depressum*) is by far the most important, but the parasol-ant (*Oecodoma cephalotes*) is also sometimes very troublesome.

The trees are flowering during the whole year but most abundantly from June to September. Accordingly the main crop is gathered during November, December, January, and February, but during the whole year cocoa is picked in a greater or smaller quantity.

The picking is done by means of a light cutlass or *machete* as used in pruning, and for the fruits which hang high in the tree a "cocoa-pruner" is used. This cocoa-pruner (see Fig. 63, *b*) is attached to a long wooden rod or bamboo, and consists of a blade, about 4 inches long, which is provided with a bent-down narrow knife. With this instrument either a push upward can be made (with the straight part), or a pull downward (with the curved part).

The pickers are chosen amongst the most skilful workmen.

[1] Papers of the Agricultural Society of Trinidad and Tobago, 1907.

As to the further gathering (Fig. 112), what Olivieri[1] says about it may be quoted here:—

The gathering of the picked pods is generally performed by women and boys, who follow the pickers and gather the pods in small disseminated heaps, either along the roads or in other accessible spots, where the sudden swelling of rivers and ravines will not carry them away. Often these small heaps are collected into larger and less disseminated ones; but in all cases, so as to

Photo. Jacobson.

Fig. 112.—Piling up and shelling pods in Trinidad.

obtain good results of fermentation, the breaking of the pods ought never to be retarded beyond the week during which their picking has been started. The pods are broken and opened with a short, heavy and rather blunt cutlass, a work which is performed with great dexterity by holding the pod with the left hand and cutting part of the rind through a semi-crosswise manner. The chop is accompanied by a twisted jerk of the cutlass which wholly or partly opens the pod. In this way the pod is put before the shellers, who either with the fingers or a small wooden pallete,

[1] Olivieri, *Treatise*, pp. 85-86.

scoop out the cacao seeds on an improvised tapis of green banana leaves. Here the seeds or beans are cleaned by removing all coarse pulpy strings and other débris, and then conveyed either in panniers or sacks, to the fermenting house or chamber, where they are measured with a standard flour barrel or its equivalent before being finally put into their respective fermenting compartments. All black and blighted pods, if mature and sound internally, are shelled separately, and their beans, which are also fermented before being put to dry, serve to produce an inferior article known as "black cacao" which is generally sold locally. An ordinary cacao "breaker" is able to cut and open for his day's work a sufficient number of pods to produce from five to seven barrels of cacao beans and to keep during the operation two women busily engaged in scooping out the beans.

On flat cacao plantations, and where proper roads have been established, the transportation of the cacao-beans is done with donkey or mule carts, but on hilly estates crooking mules or donkeys are used, and often when animal traffic is difficult and impracticable, men and women have to be resorted to.

A good picker is expected to pick per day sufficient pods to produce two or three barrels of beans, each barrel giving 110 lbs. net of ready cacao.

What Olivieri says about the method sometimes followed to pay the pickers per weight delivered is also worthy of being mentioned :—

Some plantations establish regular picking gangs, where each gang undertakes the picking and reaping of a certain number of fields throughout the twelve months of the year at the rate of one dollar to one dollar twenty cents (4s. 2d. to 5s.) per barrel of cacao delivered in the fermenting house, without the estate furnishing or providing animals for its transportation. In such cases, however, the pickers demand a strict and constant supervision, as during meagre pickings they skip many trees and pick only those where ripe pods are plentiful and of easy access. Barring these naturally tricky tendencies, which must not be overlooked, the system can only be considered advantageous and satisfactory in those plantations where great difficulties are experienced in the formation of suitable crooking or bridle roads, and where pasture and grazing grounds often prove inadequate for the economical and proper upkeep of the required number of heads of crooking or pack-stock.

In fermentation there is in Trinidad not much

uniformity. The structure of the sweating boxes as well as the length of the fermenting process differ on the different plantations.

Generally the sweating boxes are simply built, in the same way as those used in Surinam. The flooring is, of course, double; the upper is lathed one-eighth of an inch apart, so as to allow the juice to flow away. Each compartment is 3 to 5 feet high, 3 to 5 feet deep, and 5 to 7 feet long. In these boxes the cocoa is placed to a height of 3 feet. As in Surinam, a close covering of the boxes is avoided, and generally the fermenting cocoa is only covered with fresh banana leaves. When necessary, the cocoa is transferred during the fermentation from one box to the next, so as to obtain an equal fermentation through the whole heap.

As to the details, planters work differently, as well as regards the moment in which the cocoa has to be transferred to the next box, as in the length of time required for the whole fermentation.

Mr. Edgar Tripp, the Secretary of the Agricultural Society, gave me the following information :—

> Regarding the time of fermentation, planters disagree, many arguing that what may be gained in quality is lost in weight by long fermentation, and, from a market point of view is therefore not advantageous. But all the best-known and highest-priced brands have been subjected to the longer process. Mr. Hart, a leading authority, says: "Cocoa put to ferment on Saturday should be turned on the following Tuesday and Friday, and taken to the drying floor on Monday, thus giving a clear nine days' fermentation," and so far as my experience goes, I believe from eight to nine days is the average time on the best estates.

The temperature in the heaps ranges between 40° and 45° C., and care is taken that the temperature does not rise too high, at any rate not higher than 50° C.

The moment the external pulpy mass of the cocoa-beans has attained a thick greyish state of a dough-like consistency, their removal to the drying or curing trays becomes at once necessary.[1]

[1] Olivieri, *l.c.* p. 90.

Washing the cocoa after fermenting is not usual in Trinidad; planters are of opinion that the trouble and the loss in weight are not compensated by a higher price.

Drying is generally done in Trinidad by exposure to the sun, though artificial drying is also done on some of the larger estates.

The drying in the sun is simply done "on large

FIG. 113.—Drying floors with movable roofs, Trinidad.

From Fauchère, *Culture pratique*.

wooden floors or trays which can be rapidly covered when rain is about to fall, either by running-in the trays under a fixed roof or having a movable roof over a fixed floor (Figs. 75, 113). The latter is by far the most common form of a drying house used in Trinidad, though both systems are in use, separate or combined."

Hart gives the following description of the drying houses:—

The houses are erected of wood, the floor being made large or small according to the size of the estate.

The general run of floor is about 40 to 50 feet long by 18 to 20 feet wide. The sliding roofs are made extremely light, placed on wheels, and are covered with either plain or corrugated galvanised iron. The roof is divided in the centre, and when the floor is exposed each half is received by the frame-work contrived at each end of the house. The central portion under the flooring may be used for two sets of trays, one on each side, which are made to run on wheels or light iron rails, and so arranged as to be run out on frame-work at right angles to the main frame-work of the building.

In these trays the cocoa is exposed to the sun after being sufficiently fermented; but in the middle of the day it is the custom, if very clear, to close the house for an hour or two, to prevent the excess of heat from blistering the cocoa. The layer of beans is spread about 3 or 4 inches thick over the floor and is turned frequently during the time it is exposed to the sun.

Though often the use of artificial dryers has been recommended to avoid the loss by "mildewed cocoa" (slightly moulded cocoa) in rainy seasons, a good number of planters are of opinion that the produce obtained by artificial drying is never so good as when dried in the sun, and they prefer to run the risk of obtaining now and then "mildewed" cocoa than to deteriorate the produce by artificial drying, but others are convinced that such a deterioration is only imaginary.

As regards the dimensions of the drying floor in the ordinary system, an area of 100 square feet is considered ample drying space for the proper curing of 330 lbs. (150 kilograms) of cocoa at a time. Besides, it is generally accepted that there must be accommodation for drying one-fourth to one-fifth of the whole year's crop. A plantation producing 600 to 1000 barrels (300 to 500 bags of 100 kilograms) must have an accommodation for drying some 200 to 225 barrels (10,000 to 11,250 kilograms), viz. a drying floor of 6500 to 7500 square feet, or about 700 to 800 square metres.

The curing of cocoa, after fermentation is finished, is effected in two ways in Trinidad—either the beans are simply dried, as in most other countries, or they are treated in a special way by means of red clay. Of this "claying" process Olivieri gives a good description, which may be quoted here:[1]—

Claying consists in the addition of dry red earth of a ferruginous character and free from organic matter. The addition of dry red earth promotes uniformity of colour among the cacao-beans besides preserving their aroma; while, on account of its siccative nature, it also absorbs moisture and prevents mouldiness. It is used in a finely pulverised state, which is obtained by pounding the lumps or granules in a mortar at the rate of half to quarter pound of coarse red earth for every barrel of cacao. During the first day of exposure, or soon after the transfer to the drying house the cacao-beans are cleaned and freed of any remaining débris and pulpy strings; while at the close of the same day, if the weather has proved dry, or the following evening, if otherwise, they are heaped up longitudinally along the centre of the tray. The morning after, and while the roof is kept closed so as to prevent the powdered earth from being blown off by wind or breeze, the earth is sifted over and along the heap of the cacao-beans thus made either by means of a fine sieve, or through a split oats bag. This operation is repeated till the whole quantity of allotted earth has been applied, while after or during the progress of each operation the heap of beans is upturned and stirred with the usual wooden cacao shovel without spreading out to an undue extent its longitudinal and original formation. The earth becomes gradually absorbed by the viscous mucilage then covering the cacao beans, which are opened out along both sides of the tray after scraping and cleaning the viscous substance adhering to the flooring. The scraping is also carried on along the centre of the tray before the beans are spread out in uniform thickness, ranging from 2½ to 3 inches, through its whole breadth.

The beans are then left under the care of a woman or boy, who keeps walking through them to and fro in a close and parallel manner to the side of the tray from which the walking started. This movement is changed at intervals into a cross or opposite but identical manner, and any pulpy threads or foreign substances which may be brought out during the stirring are also picked up and removed; while all adhering or lumpy beans

[1] Olivieri, *Treatise*, p. 94.

are detached and spread. The long but light wooden rake for stirring purposes becomes handier and more useful from the time the cacao beans have obtained their slack or faded stage. Stirring becomes then less frequent, and the person engaged can start the gradual sifting and more minute cleaning of the beans so as to have them cleaned throughout and in the best manner possible before their dancing or trampling, and which must only take place two or three days before the required state of complete drying is attained.

The beans are then formed into heaps, averaging six to eight barrels each, and while they are being heaped up they are gradually sprinkled over with clear and clean water at the rate of about nine gallons to every six barrels or heap, till the whole heap has become slippery in itself and clammy.

The trampling with the naked feet is started at this stage, beginning at the top centre of the heap with two or three persons till the gang can be increased to six or seven persons—women, boys, and men—who must be kept within the centre of the ring formed by the gradual sinking and spreading of the cacao heap. The object of this restrained trampling is to add and promote both rubbing and friction amongst the cacao beans without allowing their mass to become disconnected, and thus avoid all material cracking or breaking of the beans. This compactness can be easily maintained with the aid of an ordinary bass broom, while the wooden cacao shovel must only be used when the time has arrived for the gradual upturning and shovelling in under the feet of the tramplers the external self-formed cacao ring. This stage can be easily detected as soon as the central mass becomes of a glossy appearance, which is followed by a gradual cracking-like noise from the beans while being trampled. The thorough and proper dancing of a cacao heap of the bulk and sizes here stated will occupy from fifty to sixty minutes and seldom less. Its attainment of perfection is indicated by an even gloss and polish throughout the whole mass; and, thanks also to the elasticity then acquired, it will be found that the beans have become rounder in shape, besides proving slippery and recalcitrant to a second compact gathering or heaping up of their mass.

The beans are then spread over the dry portion of the tray, while the damp trampled area is being scraped and air- or sun-dried. The trampling proves more effective and less wasteful in water, etc., if done under cover or with the roof closed.

Soon after spreading or after a few hours of exposure the last and final sifting is proceeded with by the one person left in charge of the tray after dancing, and when the beans are

only stirred or raked at intervals. The sifting and cleaning is proceeded with gradually without heaping up the beans by pushing in front those to be cleaned, an operation which generally ends with their proper and complete curing. This is recognized when the beans crackle like dried walnuts and break easily under the pressure of the hand or fingers, a test which must always take place either soon in the morning or while the weather is damp and cold. . . . The beans must never be bagged or heaped up while still warm, and several hours ought to elapse before bagging after the final closing of the roof. It is always safe, therefore, to perform this work early in the morning, when the beans are cool and not apt to sweat while in the bags. The same objectionable reason to the water-flushing of the fermenting compartments applies also to the tray of a drying cacao house, which ought only to be scraped dry and cleaned before claying and soon after dancing.

We have discussed in Chapter VII. the significance of claying and the use of it to prevent moulding of cocoa, and we pointed out that this method is practicable and indispensable when dealing with cocoa which is only slightly fermented, and the pulp of which is accordingly not wholly destroyed. For Venezuela Criollo, and other fine Criollos which cannot stand a long fermentation without deteriorating in quality, claying is desirable in order to make the remaining parts of the pulp dry and not subject to moulding.

Whether claying is necessary, or even useful, in Trinidad cocoa, produced from Forastero varieties, which are fermented during four to nine days, seems to me questionable. At any rate, cocoa of very good and even superior quality comes unclayed from Trinidad, dried in the ordinary way.

Besides, we know that claying is sometimes exaggerated, and that the cocoa merchants in Trinidad have sometimes complained about abusive claying, much cocoa being offered for sale "coated with clay."

But still the Trinidad cocoa has on the market a very good reputation, and fetches good prices.

The exports were as follows[1]:—

[1] Figures from 1821 till 1891 quoted from Jumelle, *Le Cacaoyer*; figures from 1895 to 1912 from *Gordian*.

	Kilog.		Kilog.
1821	546,300	1903	13,821,700
1831	850,000	1904	21,017,800
1841	1,122,000	1905	22,017,800
1851	2,498,600	1906	12,983,500
1861	2,938,900	1907	18,611,400
1871	8,889,900	1908	21,737,100
1886	8,060,900	1909	23,390,100
1895	10,480,400	1910	26,231,000
1901	11,942,700	1911	21,220,000
1902	17,612,700	1912	18,900,000

No accurate account has been kept of the area planted, but it has been a constantly increasing one for many years. According to official returns it amounted in

1890	to about 190,000 acres, increasing gradually till
1905–6	to 207,900 acres ;
1906–7	„ 214,973 „
1907–8	„ 226,880 „
1908–9	„ 245,706 „
1909–10	„ 245,706 „
1910–11	„ 290,200 „
1911–12	„ 322,508 „
1912–13	„ 325,503 „

An export duty amounting to about 9d. per 100 kilograms is raised for agricultural services.

Grenada[1]

The little island of Grenada, not larger than 430 square kilometres (168 square miles), may be considered one of the important cocoa-growing countries. Its export is steadily increasing, and reached in 1912 5,948,100 kilograms.

But it is not principally the quantity exported that deserves our interest, it is the curious way of successfully growing cocoa *without shade trees* (Fig. 114).

This method of cultivation is remarkable because it is not followed in any of the other Antilles. In Trinidad the general belief, which is supported by Mr. Hart, is that growing cocoa without shade is impossible —though it must be said that some planters no longer

[1] Preuss, *Expedition*, pp. 35-38 and pp. 185-187 ; *West Indian Bulletin*, i. p. 415 ; *Bulletin No. 7 of the Inspectie van den Landbouw in West-Indië* (Surinam, 1906).

agree with this view. But it is at any rate not done to any extent in Trinidad or any of the other Antilles.

In Chapter VI. we have discussed the question why cocoa can be grown in Grenada without shade trees and why planters there prefer that method, while in hardly any other country is this the case—except in Brazil and San Domingo.

As explained in that chapter, I do not consider the conditions of climate of Grenada exceptional in any

Fig. 114.—Cocoa field without shade, Grenada.

way. The rainfall is not heavier than in the majority of other countries, amounting to about 2000 mm. per annum; and we have no reason to suppose that the sunlight is there less intense.

In my opinion, however, the use of shade trees is not in the first place the affording of shade to the trees, but the improving of the soil, by shading it, giving it humus by the fallen leaves and flowers, by adding nitrogen to the soil—in fact, influencing the soil in the same way as green dressing does. These views have been fully explained in Chapter VI.

In accordance with this view is the fact that the planter in Grenada, having no shade trees, does himself what the shade tree does in other countries. He must keep the soil in good condition, and has to till and manure the soil in order to keep it loose, giving humus and plant-food to the soil in the form of pen-manure or other organic substance. In the meantime he has to take care that the soil is as much shaded as possible by the cocoa trees themselves, by planting them closer than would be useful if shade trees were planted.

The principal difference between the cultivation of cocoa without shade trees in Grenada and the ordinary cultivation, is therefore the care which is given to the soil in order to keep it in good condition in spite of the lack of shade trees. This makes the cocoa cultivation in Grenada a more careful orchard cultivation than is to be found in the other countries; and I believe *this care for the soil is the secret of cocoa-growing without shade.*

But not every soil can be handled in this way with the same success; and we may readily assume that success will only be met with when dealing with soils which are loose and have a good constitution from the first.

The first cocoa plantations in Grenada were established on the mountains at a higher level than the sugar estates. After the decline of the sugar industry, cocoa was more and more planted in the low lands.

Therefore the soil of the cocoa plantations varies from alluvial clay to more or less decomposed rock. The best soil for cocoa is often considered the clayey soil which still contains parts of the rocks by the decomposition of which it was formed.

A special study of the Grenada soil has not yet been made, as far as I know. Some samples have been analysed, but we do not obtain in this way information about its physical structure, and it would be interesting to have such information in order to compare the soil in Grenada, where cocoa can be grown without the soil-

improving shade trees, with the soils in other countries, where those soil-improvers seem almost to be indispensable.

One analysis may be given here:

Organic matters and combined water	9·688
Phosphoric anhydride	0·058
Sulphuric anhydride	0·027
Chlorine	traces
Iron peroxide	12·033
Aluminium	12·710
Manganese oxide	0·249
Calcium oxide	1·183
Calcium carbonate	0·099
Magnesium oxide	0·680
Potassium oxide	0·428
Sodium oxide	1·102
Insoluble silica and silicates	61·743
	100·000
Containing nitrogen	0·224

As to the climate of Grenada, the following figures are average-figures of the rainfall during five years at two stations:—

RAINFALL IN MILLIMETRES

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Springburn St. Patrick	180	90	50	60	140	200	230	270	190	200	170	260	2040
Dunfermline	170	70	50	60	120	140	280	280	180	150	180	220	1830

The dry season lasts from February to April, whilst the months of July and August are the wettest.

Averages of 2040 and 1830 mm. may certainly not be considered as indicating a very heavy rainfall, and there is therefore no reason to consider the heavy rainfall as the circumstance which makes cocoa-growing without shade possible in Grenada.

The actual circumstances are: (1) a soil of fine quality, (2) conditions which make the keeping of a

sufficient number of cattle or sheep, or both, possible and not expensive; and (3) the absence of heavy winds. Where these conditions are prevalent, the growing of cocoa without shade trees must, as far as I can see, always be possible.

All the Grenada cocoa plantations have a good number of animals to provide for pen-manure. In fact, as in Ecuador, where they are needed for transport purposes, so in Grenada, where they are needed for manuring purposes, the stock is regarded as an indispensable part of the working capital. The stock needs food, and so of each plantation one-fifth part is kept in pasture lands and fields of fodder plants, while four-fifths are planted with cocoa.

In order to avoid as much as possible loss of manure, the animals are kept in a pen, in which they stay nearly all the time that they are not in use. In this way the excrement is easily collected.

A practical method was long ago adopted by the owner of plantation Good Hope, who regularly covered the ground of the pen with cut bush and litter and spread at intervals a layer of mould over it and recovered it with litter. He obtained in this way after a few months a thick layer of excellent manure.

When young, the trees need shade in Grenada as well as everywhere else. For this purpose bananas are mostly used, which are left standing during three or four years, after which they are removed. However, cassavas, yams, tanias, and other crops, even canes, are often also planted between the young cocoa trees, especially in the first and second years.

As mentioned, the planting distance is close in Grenada—not wider than 9 to 12 feet. In this way the soil is rather well shaded by the cocoa trees themselves when the temporary shade is removed after some three or four years.

The importance of this close planting must not be overlooked. It must be considered as one of the necessary measures for successfully growing cocoa with-

out shade, and several attempts to grow cocoa without shade may have failed because the trees were planted at the same distance as when cultivated under shade.

From the beginning care is taken in Grenada to keep the soil in good physical condition, not only by applying pen-manure, but also by tillage. The method of tillage is, however, different on different plantations. Some planters claim to have obtained the best results from a system of deep forking and liberal root-pruning; others maintain that they prefer a light turning over or loosening of the soil, with as little disturbance of the roots as possible—applying deep forking only to trees which are in poor condition.

Manure is applied in the beginning of the rainy season—May and June—but more or less the whole year through, except when the soil is very wet.

About pruning, opinions vary in Grenada as in all other cocoa-growing countries: one planter removes every year a good number of twigs, while others only remove the dead twigs and the suckers.

But great care is always exercised to keep the bark clean from moss, a trouble which seems to be of more importance in Grenada than in many other countries.

As explained, the cultivation without shade trees compels the planter to spend more care on tillage and manuring, but it gives him several advantages:—

First. The absence of shade trees saves the expensive work of pruning and cleaning the trees, and losses so often caused by the falling of branches and heavy epiphytes do not occur.

Secondly. The cocoa trees come much earlier into bearing, and a full crop is usually obtained in the fifth or sixth year.

Thirdly. It is generally accepted that the cocoa without shade gives a higher yield. An average production of 350 kilograms per acre is assumed on well-managed plantations at Grenada. However, not enough figures about different plantations are published to establish this point satisfactorily.

From the little plantation of Good Hope it is known that very high yields were obtained. But this must be an exception. It is mentioned that Good Hope obtained an average of 650 kilograms to an acre.

A disadvantage of the system is, that the cocoa trees do not last so long as when planted under shade trees.

The system of growing cocoa without shade dates only from the last fifteen to twenty years. Formerly cocoa was grown under the same shade trees as in Trinidad, and in exactly the same way. About twenty years ago some planters observed that cocoa did well without shade, and from that time the system has been gradually more generally adopted.

The intensive way of tilling and manuring, together with the necessity of keeping stock and not less than one-fifth of the whole area devoted to pasture-lands and fodder crops, is more suitable for small cultivations than for large ones; nearly all the cocoa plantations in Grenada are small. Only a few are larger than 20 to 50 acres, and the majority are even smaller.

The exports of Grenada during the last eighteen years were as follows:[1]—

	Kilog.		Kilog.
1895	3,514,900	1904	6,009,800
1896	4,581,800	1905	5,796,600
1897	3,345,100	1906	4,931,500
1898	4,544,300	1907	4,612,100
1899	4,037,200	1908	5,108,200
1900	4,793,900	1909	5,441,400
1901	4,767,900	1910	5,846,400
1902	5,191,900	1911	5,948,000
1903	4,827,600	1912	5,500,000

Grenada cocoa does not obtain as good a price as the Trinidad article. The bean is smaller, but the flavour is good.

The following figures of the prices of Grenada cocoa

[1] The figures of the years 1895–1902 are quoted from *West Indian Bulletin*. The figures of the following years are quoted from the *Gordian*.

and Trinidad on the London market illustrate the difference in prices :—

	Grenada.	Trinidad.
	Price per cwt.	Price per cwt.
1900	70s. to 73s. 6d.	68s. to 75s.
1901	67s. to 69s.	65s. to 70s.
1902	57s. to 64s.	58s. to 67s.
1903	51s. to 62s.	
1904	52s. to 64s. 6d.	58s. to 76s. 6d.

The export duty amounts to about 10d. per 100 kilograms.

Dominica

Dominica lies just between Martinique and Guadeloupe, both also cocoa-growing islands.

The island is very mountainous; the rainfall ranges from 1500 to 1750 mm. on the Leeward coast to over 5000 mm. in the interior. The roads are poor, and communication is difficult and tedious.[1]

Cocoa and lime are the two important industries.

The exports of cocoa amounted to:[2]

Year	Kilog.	Year	Kilog.
1904	493,300	1909	984,600
1905	589,400	1910	573,000
1906	572,900	1911	576,000
1907	584,100	1912	600,000
1908	487,800		

Until the last quarter of a century the exports of cocoa from Dominica were very small, as it was produced only by peasant proprietors. When, however, the crisis overtook the sugar industry, many of the sugar planters, feeling the effects of hard times, planted portions of their estates in cocoa and limes, and from that time the exports of cocoa began to increase.[3]

[1] M. H. A. Tempany, *Agricultural Labour Conditions on the Leeward Islands* (1910, edited by the Assoc. Internat. d'Agriculture Tropicale).
[2] *Gordian.*
[3] Dr. Nicholls (Agricultural Conference in Trinidad, 1905).

The practice in Dominica is not to use shade trees in the ordinary way, but to plant the trees so as to make them serve as wind-breaks. Experiments with the planting of the Erythrina in the way it is done in Trinidad has not been a success.

Dominica is situated in the hurricane belt, and the trees are sometimes badly damaged by hurricanes and strong winds. This was the case, for instance, in 1903.

Interesting manurial experiments carried on at Dominica have been mentioned in Chapter VI.

As regards the labour conditions, men's wages range from 10d. to 1s. 4d., women's from 7d. to 10d. The supply seems on the whole to be fairly adequate, though at times there may be something of a shortage.

An export duty of 2s. 5d. is raised for every 100 kilograms exported.

St. Lucia

The cocoa industry of St. Lucia has not shown much progress during the last ten years. The methods of cultivating are much the same as in Trinidad. Good results have been reported from manuring with basic slag and sulphate of potash.

The exports have been as follows :—

	Kilog.		Kilog.
1895	369,000	1906	703,300
1900	659,000	1907	779,600
1901	765,000	1908	614,500
1902	765,000	1909	552,900
1903	785,000	1910	743,000
1904	800,000	1911	940,000
1905	858,800	1912	900,000

St. Vincent and Montserrat

Both these islands export small quantities of cocoa. The industry is, however, of little importance, cotton cultivation being the main industry.

V. Guadeloupe, Martinique, and the other French Colonies

The total amount of cocoa exported by the French Colonies was as follows :—

	Kilog.		Kilog.
1906 . . .	1,262,000	1910 . . .	1,575,000
1907 . . .	1,387,000	1911 . . .	1,364,000
1908 . . .	1,421,000	1912 . . .	1,500,000
1909 . . .	1,372,000		

Guadeloupe [1]

From Martinique the cocoa plant was brought to Guadeloupe.

Up to the middle of last century a small area was cultivated with cocoa in the north-eastern part of the island (Grande Terre); the exports amounted at that time to about 30,000 kilograms. At the present time, however, no cocoa is cultivated at Grande Terre; but the decline of the industry in that part of the island has been accompanied by a rise of cocoa culture in the south-western part, called Basse Terre or Guadeloupe in the strict sense. This industry has gradually increased; the exports amounted in 1874 to 85,000 kilograms, in 1891 to 331,300, in 1897 to 400,900, in 1907 to 781,500, which amount has not yet been surpassed. In the years 1906 to 1910 the exports were as follows : [2]—

	Kilog.		Kilog.
1906 . . .	675,300	1909 . . .	594,300
1907 . . .	781,500	1910 . . .	778,900
1908 . . .	744,000		

It is not to be expected that the industry will show a much greater development, as the area suitable for cocoa-growing seems not to be very large, the soil of many parts being unsuitable for this crop.

The types of cocoa cultivated belong mostly to the Amelonado variety; the most common one is called "Cacao Creole." All the other types are designated by

[1] Guerin, *Culture du cacaoyer* (1896). [2] *Gordian.*

the name "Cacao Cayenne," a designation which does not seem appropriate in any way.

In the plain, with its alluvial soil, irrigation is considered indispensable, and during the dry season the young plants must be watered every week. For this purpose trenches are made at distances of 20 or 25 feet. From these trenches the young trees are watered by hand, the irrigation by imbibition not being sufficient. When the trees get older they may be watered less frequently, for instance about once every month when they are seven or eight years old.

In the second or third year the drainage is laid out and the trenches are dug at distances varying from 25 to 50 feet, according to the character of the soil and the humidity of the place.

For manuring, the best results have been obtained with pen-manure; cotton-seed cake has also been applied with success. Artificial manures containing phosphoric acid and potassium had no appreciable effect; the application of lime, however, seemed to be useful.

Of the enemies the borer (probably *Steirastoma depressum*) and the rats are the worst. The introduction of the mongoose, which has resulted in other islands in a great failure, has met in Guadeloupe with success, according to Guerin (1896).

Martinique

In the seventeenth century the cocoa-tree was imported into Martinique. It is told that in 1661 the first plants were brought from the continent by Benjamin Dacosta.

By the end of the eighteenth century the cocoa industry had become important. The area in cocoa contained about 1½ million trees; and at that time Martinique, together with San Domingo, produced almost the whole of the cocoa consumed in France.

After that time, however, there was a decline, a great part of the area being replanted with sugar cane.

The exports in 1906–10 were as follows :—

	Kilog.		Kilog.
1906 . . .	472,900	1909 . . .	592,900
1907 . . .	502,800	1910 . . .	592,800
1908 . . .	529,900		

French Congo[1]

Cocoa is only cultivated to a small extent in the French Congo. Since 1889 attempts have been made, with more or less success, to establish cocoa plantations. At the present time there are thirty-eight of them, mostly situated along the borders of the Gaboon and its affluents.

The first exports were made in 1896, and since they have increased regularly, but slowly. In 1909, 103,358 kilograms were exported, in 1910 about 120,000 kilograms.

Madagascar[2]

Cocoa is cultivated in Madagascar to a very small extent, and in a primitive way. It is worth mentioning that the variety cultivated is a pure Criollo, *Madagascar Criollo* (see Chapter V.). The exports amounted in 1909 to 22,967 kilograms, in 1910 to 28,000 kilograms.

French Guiana, Mayotte, Ivory Coast, Dahomey, Réunion, New Caledonia

These colonies possess very little importance as cocoa producers. The several amounts exported in the years 1909 and 1910 were as follows :—

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[1] Chalot and Luc, *Le Cacaoyer au Congo français* (1906); Chevalier, *Le Cacaoyer dans l'Ouest africain* (1908), p. 213.

[2] Fauchère, *Culture pratique*, etc., p. 159.

[TABLE.

	1909	1910
	Kilog.	Kilog.
French Guiana . . .	22,814	18,327
Mayotte (Comoro Islands) .	21,826	25,727
Ivory Coast . . .	5,136	7,589
Dahomey	4,264	1,934
Réunion	3,603	1,557
New Caledonia . . .	1,024	

VI. Venezuela [1]

A century ago Venezuela was the most important cocoa-growing country. It exported three times more than Ecuador. Half a century ago, however, its cocoa export was already surpassed by Ecuador, but by no other country. But since then its place among the cocoa-growing countries has become less prominent, and Trinidad, as well as much younger cocoa countries such as Brazil and San Thomé, have become more important, so that Venezuela now occupies only a fifth place, or sometimes even a sixth place, being in many years also surpassed by San Domingo.

As regards quality of the produce, however, Venezuela keeps a premier place, as its Criollo produce is unsurpassed, and its Forastero yields also produce of high quality. From this point of view as well as from a historical one we may call Venezuela the classical home of cocoa, and especially of Criollo cocoa.

Jumelle [2] gives some interesting facts about the history of cocoa enterprise in this country.

In 1634 Dutchmen, established in Curaçao, induced the Venezuelans to export cocoa to Europe. Though Spain prohibited cocoa export to any other country, still the Venezuelans went on selling cocoa to Dutch and English merchants in a clandestine way, and this to

[1] Very little was known about cocoa culture in Venezuela before Preuss gave us his excellent work (*Expedition*, etc.). I have to thank Mr. Sgobel in Caracas for much valuable information about cocoa in Venezuela.

[2] Jumelle, *Cacaoyer* (1900), p. 145.

such an extent that Amsterdam got almost all the Venezuela cocoa. From 1706 to 1722, it seems, not a single Spanish ship came to Spain, and that country was obliged to buy from other countries the cocoa of its own colony at high prices.

In 1728 Philip V. granted the exclusive licence for the cocoa commerce with Venezuela to a company of noblemen of Biscay, and this company was able to get back all the advantages which Spain had previously lost. This state of affairs lasted till 1780, when the licence expired, and the cocoa plantations mostly came into the hands of rich Catalonians.

Only after the war of 1830, which resulted in the emancipation of the country, did the trade really obtain its independence.

In that year the export amounted to 3,600,000 kilograms, a very important quantity in regard to the world-production of that time. Since then the production of Venezuela has increased, but not appreciably until recent years:—

Cocoa Export of Venezuela

	Kilog.		Kilog.
1830–1831	3,600,000	1903	12,550,000
1841–1842	4,800,000	1904	13,048,800
1851–1852	5,400,000	1905	12,700,600
1872–1873	3,442,500	1906	12,864,600
1886–1887	6,975,400	1907	13,471,100
1894	6,924,000	1908	16,303,200
1896	9,562,000	1909	16,847,700
1900	11,900,000	1910	17,250,600
1901	7,860,000	1911	17,381,000
1902	9,925,000	1912	12,500,000

If Venezuela had not been disturbed by so many revolutions and civil wars, and if it had not suffered so many years under the despotic reign of President Cipriano Castro, doubtlessly the whole economic situation would have been much better than it is now, and the extension of the cocoa culture would have made more progress.

It is, however, to be expected that under the reign of President Gomez, Venezuela and its cocoa industry will make greater progress.

President Gomez has shown himself not only a soldier of uncommon bravery, but also, as Governor of the Federated Districts, a statesman of great capacity and strict reliability.

As regards cocoa, a great thing has already been done by this President, viz. the abolition of the heavy export duties.

The cocoa plantations are almost wholly confined to the coast, being situated in the littoral region from the sea up to an elevation of about 1500 feet. In the interior no cocoa is grown except along the banks of the Orinoco river.

A rough sketch of the cocoa-growing regions of Venezuela is given in Fig. 115.

As the most famous area may be regarded the region between La Guayra and Puerto Cabello. Here is grown the pure Criollo, the "Criollo legitimo," as the Venezuelans call it; and the places situated here—as Chichiriviche, Cepe, Chuao, Choroni, Ocumare, Turiamo, and Patonemo—are well known for their very superior produce, which may be considered the finest in the world.

Also west from Puerto Cabello, round San Felipe, and along the Rio Yaracuy, cocoa is cultivated which yields very fine qualities. This is also the case south of the Lake of Valencia, near Guigue.

East from La Guayra, Rio Chico forms an important centre; the cocoa grown here—along the Rio Tuy and along the coast between the mouth of this river and the place Piritu—is no longer Criollo, but a fine Forastero; or, as they call them in Venezuela, "Trinitario" varieties, namely, Cundeamor and Angoleta types. The produce is very fine, though not so superior as that of the Criollo of the parts above mentioned and situated more eastward.

The produce of the whole western part of Venezuela

is known on the market as "Caracas" cocoa, and fetches the highest market prices.

It is mainly shipped from La Guayra and Puerto Cabello, and in small part from Maracaibo. Often the cocoa shipped from the last-mentioned ports is called "Puerto Cabello" and "Maracaibo."

The cocoa grown in the eastern part of Venezuela, on the peninsula of Paria—round Cariaco, Carupano,

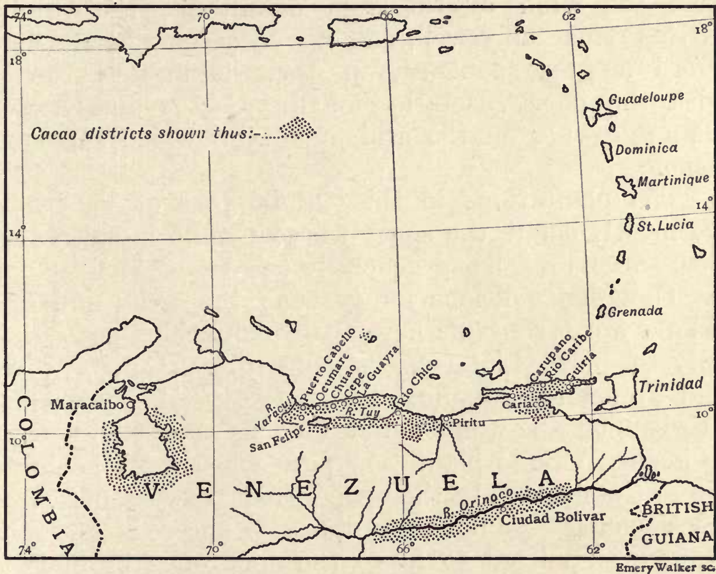


FIG. 115.—Map showing cocoa-growing areas in Venezuela.

Rio Caribe, Aragua, Maturin, etc.—and along the Orinoco, of which district Ciudad Bolivar forms the centre, is of much inferior quality. This cocoa is generally called "Carupano," and is the produce of the coarser Trinitario (Forastero) varieties. It is mainly shipped from Carupano.

As a rule, cocoa in Venezuela is not grown at a higher altitude than about 1000 feet, but there are exceptions, as, for instance, in the country round Guigue, where cocoa plantations are situated at an altitude of

about 1400 feet, and here and there cocoa is even grown at about 3000 feet.

But the most famous Criollo is principally cultivated between Puerto Cabello and La Guayra, in the valleys near the coast. These valleys, generally narrow, and bounded by high mountains, are very fertile, the soil being composed of fine particles of the rocks, washed down by the rains from the mountains, together with a large amount of humus. On this fertile soil, sheltered from the wind by the high mountains, the Criollo thrives remarkably well, and the cocoa plantations here afford a great contrast, in their luxuriant growth, with the poor vegetation of the Cactus and Agave plants growing on the arid mountains which surround them.

The plantations in this Criollo part of Venezuela are mostly small, the spots where Criollo is cultivated with success not being generally large.

Though conditions for growing the weak and fine Criollo are favourable here, still plantations consisting only of pure Criollo are getting rare. Generally we find Forastero trees mixed with the Criollo trees; and this is not to be wondered at, for it is almost impossible to keep a Criollo plantation pure when trees begin to die in the fields. In the open spaces between old cocoa trees young Criollo trees do not succeed, and the planter is obliged to leave the spot open or plant a Forastero tree. Generally he chooses the latter; and the consequence is that many Criollo plantations get more and more mixed with Forastero (Trinitario) trees, while their produce gradually diminishes in quality. This is the case in nearly all the Caracas cocoa districts.

Besides, it is not only for supplying the open places in Criollo fields that planters use the Trinitario varieties, but the advantages of this variety are so important that many planters prefer it to Criollo to plant new fields, even in the plantations situated in the true Criollo country, between La Guayra and Puerto Cabello. They choose for this purpose the very best types of Angoleta

or Cundeamor, with large round seeds, light coloured and sweet, yielding a produce of fine quality, but not so high priced as the superior Criollo produce. Nevertheless, the planters prefer the Trinitario, because of the little care the trees require in comparison to the Criollo, its larger yield, early bearing, resistance to disease, and the easier preparation of the produce.

Besides, Criollo suffers soon when the season is dry, and trees die from drought, while Forastero is only little damaged; further, the hot wind which comes from the interior—a sort of sirocco—damages the Criollo much more than the Forastero.

This preference for the Trinitario, and the diminishing of the quality of the produce which is a consequence of it, has often been a cause of complaint by the manufacturers.

Preuss mentions the opinion of a well-known chocolate manufacturer, who wrote to him:[1]

> The Caracas cacao goes backward in quality since about ten years. We buy always the really first-rate qualities which are offered for sale, but we have more and more difficulty in obtaining the quantity we need, though we pay 150 to 170 marks, and even more. The really fine aroma and the nice taste, with a little false taste of Swiss cheese, are hardly any more to be obtained. It is with cacao as with other products; the ordinary quality, produced in large quantities, has improved (it is true that the price has also got much higher), and the very fine quality is going backward, because it does not pay.

I must confess that I never detected a taste of Swiss cheese in cocoa, whether rough or prepared, but nevertheless the opinion of the manufacturer about the decline in quality is clear.

The different Venezuelan varieties have been mentioned already in Chapter V. A few particulars may be added here.

The Venezuelan Criollo has the irregular and very warty appearance of all the true Criollos, with deep furrows. The colour is mostly red, the number of

[1] Preuss, *Expedition*, p. 226.

Criollo trees with yellow fruits is small. According to the colour the Venezuelans distinguish "Criollo legitimo" with dark red, "Criollo amarillo" with yellow, and "Criollo mestizo" (which means "half-caste") with yellow-and-red fruits.

The Trinitario of Venezuela contains all the sub-varieties, from the finest Angoleta and Cundeamor, which are in most respects much like the Criollo, to the Amelonado, called here *Sambito*, and the coarse Calabacillo, called here *Cojon de Toro.*

The finer Trinitario varieties, especially Angoleta and Cundeamor, are to be found in the west of Venezuela, where Criollo also thrives; the coarser ones ("Carupano")[1] more in the eastern provinces.

It is very remarkable that, according to all the Venezuelan planters, the Trinitario varieties, when planted in the western parts of Venezuela (the Criollo home), improve in quality. This is certainly a remarkable fact. It is confirmed by Preuss's observation, who noticed that even the types which do not belong to the finer Forastero varieties, for instance Amelonado types (Sambito), have in some respects high qualities which they do not show in other countries. So we can find in the district between Puerto Cabello and La Guayra Sambito fruits which contain such beautiful round beans that they are much like Criollo beans.

This improvement of Forastero varieties planted in a Criollo field must be ascribed to cross-fertilisation with pollen of the Criollo trees. It is interesting to know that planters are very positive in affirming that it is not only the offspring which shows these improved characteristics, but even the imported tree itself. The

[1] The name "Carupano" is confusing. Sometimes it is the name for the whole Forastero group, and thus identical with "Trinitario"; sometimes it indicates the more ordinary and coarse varieties; but it is also used to indicate a special group of Forastero types, each of which is again indicated with a special name, as: Carupano legitimo, Carupano grande, Carupano mestizo, Carupano parche, Carupano taparito, etc.

Further, "Carupano" is also the commercial name for all the cocoa produced in the eastern part of Venezuela (especially the Orinoco delta), and mostly shipped from the port of Carupano.

improvement in the beans of the mother tree may easily be explained by the fact that the bean is a product of the fertilisation with pollen of the Criollo father, and it is therefore not astonishing that Criollo characters are to be found not only in the offspring, but also in the bean of the interplanted Forastero tree.

On the other hand, the Venezuelan planters have observed that the presence of the Forastero tree has no effect on the offspring of the Criollo. Even when surrounded by Forastero trees, the Criollo gives always an offspring consisting of pure Criollo trees.

It may be remembered here that exactly the same facts have been observed in Java, and the present author is able to confirm the observations made by the Java planters: Forastero hybridises and improves in following generations when Criollo trees are in the neighbourhood; Criollo, however, does not hybridise, and remains in following generations pure Criollo in spite of the neighbourhood of Forastero trees.

The methods of cultivation in Venezuela are rather simple, but not so primitive as in Ecuador, and by far not so rough as in Brazil.

The forest is wholly cleared; no trees are left; and at once the temporary shade plants are planted, such as bananas; also corn and other crops.

The seeds are planted directly on the spot ("at stake"), usually at distances of from 9 to 12 feet; but generally the planter has also a nursery for supplying the places where the seedlings failed.

Together with the cocoa the shade trees are planted. The same two Erythrina species are used as in Trinidad, namely the *Erythrina velutina*, called here "Bucare pionio," for the low lands, and the *Erythrina umbrosa*, called here "Bucare anauca," for the higher lands. But also different sorts of Guamo (Inga) are much planted, and sometimes the Saman (*Pithecolobium Saman*) or the Mijagua (*Anacardium rhinocarpus*). According to Preuss, opinions widely differ about the value of the two last-mentioned trees—some planters are very enthusiastic

about the Saman, while others consider it as not at all suitable for the purpose, and so also with Mijagua. The Guamos are used on the mountains, but more as shade for coffee.

The following particulars especially concern the western parts, where the Criollo and the fine Trinitario are grown.

The Criollo requires when young much more care than the Forastero (Trinitario), especially as regards weeding, shading, and irrigation. For without irrigation the growing of cocoa, especially of Criollo, would be impossible, and there hardly exists one plantation in Venezuela where cocoa is grown without irrigation. This is no wonder in this country, where the rainfall is small (as already told, we find on the adjacent mountain a typical xerophytic or dry-land vegetation of Cactus, Agave, etc.), while Criollo is very sensitive to drought.

Figures about rainfall in the cocoa districts seem not to be available, but Preuss estimates the rainfall in the cocoa districts near Guigue as amounting to no more than 1200 to 1500 mm.

Generally the irrigation is of a primitive sort: the water in the river and the brooks is retained a little by walls of stone, and from here the water is conducted into the plantations by means of open trenches.

Little is done in pruning; only dead twigs and watershoots are occasionally removed.

Diseases have not been very serious up till now. The blackening of pods is well known; and, when the weather is propitious for the disease, losses are sometimes sustained.

Picking is done with the ordinary cocoa-hook, which is also in use in Trinidad and Surinam, while the pods are opened with the cutlass, also in the same way as in the countries mentioned.

The Criollo comes into bearing later than the Trinitario or Forastero. When five or six years old it gives its first fruit, and only when seven or eight years old the crop begins to get important, and at ten years

old the tree is in full bearing. The Trinitario yields fruit when three or four years old, and may be considered to be in full bearing when eight years old.

Fermenting is done in a way rather different from that in other countries, and the cause of this difference is no other than the fact that there are very fine varieties grown which yield a sweet produce and which are only allowed a very slight and short fermentation.

The method of fermenting is as follows:[1]—

When a sufficient quantity of fresh seeds has been gathered, they are spread out in the sun for a day. For this purpose a quantity of a few hundred kilograms is sufficient, because, for the slight fermentation which follows, no large quantities are required. The drying is performed on large floors, made of burned-clay or brick, sometimes covered with a coating of lime or cement.

While the cocoa is still hot it is gathered together in a heap and covered with banana leaves, or it is put into special sweating boxes.

The cocoa is only allowed to ferment one day. After that time it is at once removed and stained.

This "staining" is done in the following way:— Clay

Some cocoa is put on a sheet, and two persons, by lifting up the corners and moving them alternately up and down, cause the beans to rub against each other. Then some dry red earth is poured on them, and again the same manipulation is done with the sheet, till the earth is equally spread over the beans.

Then again the cocoa is spread out on the drying floor, and left there till it is completely dry.

The earth used for staining is found in many places on the slopes of the mountains, but not everywhere; and the planters of the plateau of Valencia, near Guigue, are obliged to fetch it from the coast near Choroni. Sometimes the earth is pulverised in special machines. And it is always carefully dried and sifted.

This method of "staining" is almost the same as the method of "claying" in Trinidad; and, indeed, the

[1] Preuss, *Expedition*, p. 231.

meaning of it is the same. As explained in Chapter VII., the coating with earth has no other use than to prevent the moulding of the cocoa, the pulp of which has not wholly been removed by the short fermentation. It is applicable only for the sweet and fine varieties of cocoa, which can only stand short fermentation, during which the pulp is only partially destroyed. The remaining particles of the pulp could, indeed, easily give rise to mouldiness of the cocoa in the sacks, being hygroscopic (attracting water from the air), and a good nutrient medium for fungi. The coating with dry earth makes these remaining parts harmless, and prevents the growth of fungi.

As it seems, the Venezuelans, however, do not understand exactly the use of this common method. They consider it as an old custom, through which the produce acquires a nice appearance; some consider it also as an easy method to increase the weight. I think, however, that these advantages are of minor importance in comparison with preventing mouldiness.

For this purpose the coating with earth is in every way suitable; and I do not agree with authors who consider it a method to be abandoned, and replaced by a thorough cleaning of the beans. Without doubt also a thorough washing, which removes all the remains of pulp, would render the beans no longer subject to mouldiness; but we may be sure that in the meantime the fine aroma would be more or less damaged—the quality of these fine cocoa species being already damaged by exposing them a little longer to the sun than is necessary.

The question, what is the cause of the superiority in the quality of the Venezuelan produce is not easily answered. But certainly this superiority is not due alone to the varieties cultivated, as exactly the same varieties are grown in other countries without yielding such a fine cocoa. The Java Criollo and the Old Red Ceylon are as varieties identical with Venezuela Criollo, and by far not so fine. It may therefore safely be accepted that the local conditions of soil and climate

are of no less influence, and contribute to the superiority of the Venezuelan cocoa.

This superiority is very prominent, and even persons wholly ignorant of cocoa commerce and not cocoa experts will notice at once the sweet aroma, in which a slight chocolate taste is already to be recognised, and which is so very different from the sour smell of the ordinary produces, as Carupano and Surinam cocoa.

Perhaps it is not superfluous to state that the information about using nutmegs in Venezuela to give a special aroma to the produce is quite erroneous. This spice is never used for this purpose.

The very finest brands of Venezuelan Criollo are sold directly to the well-known French and Swiss chocolate manufacturers. They take a distinct place in commerce, and the very high prices paid for them are not subject to fluctuations of the market as those of other Venezuelan cocoas ("Caracas" and "Carupano").

VII. San Domingo[1]

The republic of San Domingo, though a part of the same island (Haiti) as the republic of Haiti, exhibits quite another development of its cocoa culture.

Though also in this republic the economic conditions are not as they could and should be, the influence of the United States, who control the money market, makes the economic conditions in this republic more stable. A regular and rapid extension of the culture and increase of the exports are noticeable.

While the republic of Haiti is one of the oldest cocoa-growing countries, San Domingo has only become important in the last half of the nineteenth century, but during the last twenty years it has rapidly outgrown its sister republic, as is shown by the following figures of the exports :—

[1] It is as difficult to get particulars about San Domingo as about Haiti. Through the kind help of Mr. A. A. Boom, Assistant Superintendent of the Royal Dutch West India Mail, I am able to give a few particulars about San Domingo.

	Haiti.	San Domingo.
	Kilog.	Kilog.
1890	1,500,000	1,400,000
1900	2,112,000	5,963,000
1905	2,162,000	12,604,000
1908	2,709,000	19,005,000
1909	2,122,000	14,818,000
1910	1,851,000	16,623,000
1911	1,485,000	19,828,000
1912	2,000,000	20,900,000

The Government does its best to help the cocoa industry, and a good thing has been the reduction of the export duty, which amounted until 1910 to 8s. 5d. per 100 kilograms, but has now been reduced to one-half. Besides, great efforts are made to improve the roads. Also, for drainage and irrigation important works have been undertaken.

As to the technical side of agriculture, however, much remains to be done, and an agricultural department, with an experiment station and garden, and able men to advise the planters, would find in this country a large field for useful work.

Cocoa is grown especially in the northern part of the island. The rainfall is greater there than in the south. The following districts are the most important as regards cocoa culture: Puerto Plata, Sanchez, Moca, San Francisco de Macoris, Salcedo, La Vega, Cotuy, Samaná, Sabana la Mar, Higuey, Seybo, Monte Plata, San Cristobal, and a part of San Carlos. The best quality of cocoa comes from Seybo, Higuey, Sabana la Mar, and the southern part of Samaná.[1]

Generally, planting in the open field ("at stake") is practised. Three seeds are put into the soil at a distance of 6 inches; when the plants have reached a height of about 1 foot, the strongest one is left and the two others are removed.

[1] The greatest amount comes at present from the country between San Francisco de Macoris and Moca. The transport is here facilitated by the railway to Puerto Plata and Sanchez.

The distance of the trees is generally 3 Castilian yards (= 2·52 metres; 1 Castilian yard is 84 cm.). This distance, equivalent to about 8 feet, is certainly too small, and the more intelligent planters understand that they have to plant wider; a distance of 4 to 5 Castilian yards, or 11 to 14 feet, is now adopted by several of them; some prefer 6 Castilian yards = about 17 feet.

As temporary shade for the young cocoa the plantain is generally used. The plantains are removed when the cocoa has reached a height of 5 feet; on some plantations, however, every other row of plantains is left standing, till the cocoa has reached its full size (after about six years). Instead of the plantain ("platanos") the banana ("guineos") is sometimes used, sometimes also the "yuca" or cassava.

As shade tree sometimes a wild forest tree is left standing, the "guarima,"[1] a small tree; but often the whole forest is cleared. In this case between the plantains or bananas a special shade tree is generally planted, the "amapola," which is probably identical with the "bocare" of Trinidad (*Erythrina velutina*), the "bucare pionio" of Venezuela. In some districts, however, no shade trees are used at all, a remarkable fact, which shows again that this method of cultivating cocoa is not so rare as is generally believed. We have already seen that not only in Grenada, but also in Brazil, this method is very general; in Trinidad it is becoming more and more popular; and here we meet it again in San Domingo.

On many plantations there is a natural drainage and no special drainage-canals are dug, but it is believed that on several plantations a drainage-system would greatly benefit the trees and increase the yield.

Once or twice a year the full-grown fields are weeded; young fields, however, are often not treated carefully enough as regards weeding.

It is an interesting fact that budding of cocoa has already been tried in this country by several planters.

[1] I am unable to give the scientific name of this tree.

The results, however, are not considered to be encouraging. Hurricanes frequently occur in this country, and the budded trees seem to be less resistant against wind than trees grown from seed. Besides, it is considered that the difficulties and the expense are not counterbalanced by the advantages.

As regards the varieties, the most common type is still a rather smooth Amelonado (wrongly called "Calabacillo" by the San Domingo planters), brought originally from Trinidad; the yellow variety is more common than the red one. Gradually, however, this type is being supplanted by other finer varieties, because planters know that the original Amelonado, with its bitter taste, gives a produce of very ordinary quality. From Venezuela the finer Forastero types, especially of the Cundeamor variety, have been imported, and seeds from Ecuador have also been imported. But at present the old Amelonado is mostly to be found on the plantations.

Among the enemies a sort of plant-louse (*Aphis*) has been mentioned as being exceptionally noxious. No general measures are taken against this pest. Spraying with kerosene emulsion, however, has been proved to be effective.

The normal yield per tree is estimated to be 1 lb., when about 200 trees are planted to the acre. This yield of 200 lbs. per acre is not a high one. My correspondent, Mr. Boom, however, informed me that, when the plantation is well cared for, an annual yield of 750 to 800 kilograms per hectare (300 to 320 kilograms per acre) can be obtained.

The crop comes in through the whole year, but the main crop is picked from March to June; a second main crop, though less important, is picked from October to December.

As regards fermenting, planters seem to act differently. Generally, wooden sweating boxes are used, and the cocoa is often left fermenting only for three days. Some planters, however, ferment the old Amelonado

much longer, up to seven or eight days; while the finer, newly-imported varieties are left fermenting only during from two to four days. After fermentation the cocoa is run on hand-barrows into the open air and is dried in the sun.

The small labourers, however, often do not ferment at all. They simply spread out the cocoa on the soil or on cow-hides and let it dry for some time. It will be clear that the beans, treated in this way, are still surrounded by the whole pulp, which, though greatly dried, is still hygroscopic, absorbing water easily and making the cocoa liable to "mildew" or mould. The local merchants, who buy the cocoa from the small labourers, are therefore obliged to dry it again; but this is only incompletely done in the warehouses, and the cocoa often comes on the European market in an inferior condition, mildewed or even rotten. The consequence is that the Samaná cocoa (this is the commercial name) has a rather bad reputation on the European market.

Locally, the merchants pay at the present time (1911) about $7 to $9 per quintal (50 kilograms), or 7d. to 9d. per kilogram, which is certainly a low price, and indicates an inferior quality.

The wages in the various districts are slightly different; in some districts 30 to 40 Am. cents (1s. 3d. to 1s. 8d.), in others 50 to 60 Am. cents (2s. 1d. to 2s. 6d.) is paid, or 30 cents (1s. 3d.) with food.

The plantations in San Domingo are mostly of small size. The yearly yield is generally no more than 300 to 500 quintals (= 150 to 200 bags of 220 lbs.). The number of those which produce 1000 quintals (500 bags) or more is very small.

The great progress of the cocoa culture in the last twenty years may be seen in the following export figures:—

	Kilog.		Kilog.
1890	1,400,000	1900	5,963,000
1894	1,975,000	1901	6,850,000
1896	2,250,000	1902	8,975,000
1898	3,993,000	1903	7,825,000

	Kilog.		Kilog.
1904 . . .	13,558,000	1909 . . .	14,818,000
1905 . . .	12,604,000	1910 . . .	16,623,000
1906 . . .	14,313,000	1911 . . .	19,828,000
1907 . . .	10,151,000	1912 . . .	20,900,000
1908 . . .	19,005,000		

The prices paid for Samaná cocoa on the European market differ according to the way in which it has been prepared. The plantation cocoa is much better paid than the produce of the small labourer. Taken as a whole, the Samaná cocoa belongs to the ordinary sorts. It is a little superior to Accra cocoa (Gold Coast), and about of the same quality or a little inferior to San Thomé.

Formerly Germany was the most important consumer, but lately the United States of America have become still more important.

VIII. The Gold Coast[1] and Lagos

The Gold Coast (see map, Fig. 116) occupies a special place among cocoa-growing countries, for the remarkable growth of the industry, though mainly in the hands of native small proprietors, finds no parallel elsewhere. The first cocoa was exported in 1891, a quantity of 80 kilograms being shipped to England; in 1911 the export amounted to more than 40 million kilograms (40,000 tons of 2200 lbs.).

At the present time cocoa is grown in all the districts of this Colony, and is also rapidly extending to the adjoining Protectorate of Ashanti. It is only the sandy and stony coast-region which is unfit for this cultivation.

If the Government persists in its endeavours to improve the cultivation, to find methods to fight the prevalent diseases and pests, and to make the natives adopt these methods, it may be expected that the

[1] See the *Annual Reports of the Agricultural Department of the Gold Coast*, and also Chevalier, *Le Cacaoyer dans l'ouest africain* (*Les Végétaux utiles de l'Afrique tropicale française*, fasc. iv., 1908, pp. 185-200).

industry will make still greater progress in the near future.

The rainfall is rather low for cocoa-growing. In the Botanical Gardens at Aburi (1500 feet above sea-level) the average of ten years (1899–1908) was 46·12 inches (1153 mm.); at the Boonso Station the average of three years was 75·9 inches (1897 mm.); and at the Kumassi

Fig. 116.—Map of the Gold Coast.

Station the average of three years was 62·8 inches (1570 mm.).

The following figures show how the rainfall at Aburi and Tarkwa varies in the different months:—

[Table

RAINFALL IN MILLIMETRES

	Aburi Botanical Gardens (average of 10 years 1899–1908).	Tarkwa Agricultural Station (average of 5 years 1904–1908).
January . .	23	41
February . .	60	52
March . .	128	174
April . . .	138	183
May . . .	125	245
June . . .	166	327
July . . .	92	126
August . .	44	21
September . .	80	120
October . .	134	204
November . .	117	175
December . .	46	76
Total .	1153	1744

The comparatively small rainfall may be counterbalanced to a certain extent by the great humidity of the atmosphere, which is shown by the mists, which, at any rate at Aburi, cover the hill throughout the whole year during the night and the early morning. Nevertheless the cocoa trees sometimes suffer from drought, especially when they stand under too light a shade.

The first small cultivations arose from seeds which were imported from Kamerun (or Fernando Po ?) to Manpong by a native. Sir William Brandford Griffith, who was Governor of the Gold Coast from 1880 to 1895, greatly encouraged the young industry, especially by the distribution of cocoa seeds either free or at a low price, and also by buying the first product from the natives. He was well supported in this work by the missionaries of the "Basel Mission."

In 1892 he established a Botanic Station at Aburi, which has since contributed to a great extent to the development of the cocoa culture. Some 5 acres were planted with cocoa, and treated very carefully, so as to be an example to the small growers.

The latter settled by preference in the neighbourhood of the Botanic Station, which became in time a centre of cocoa culture.

At first cocoa-growing was chiefly confined to the province of Aquapim, but later it has been developed in the other provinces such as Krobo and in such districts as Akim, Kwahu and Fanti, and more recently also in the districts north from Winnebah and Saltpond.

In the meantime the English Government has continued in helping and encouraging the industry. More Botanic Stations have been established, and more officers have been appointed to instruct the small growers.

Thus the cocoa culture has grown in this colony more rapidly than in any other country—a consequence of special conditions, of which the most important is certainly the favourable soil, which permits successful cultivation in spite of little care. The easy way in which cocoa grows at the Gold Coast made it a culture very suitable for the natives. But still the success would never have been so striking if the population had not been a diligent one and if it had not been warmly supported by the Government.

The following figures of the exports will illustrate the rapid growth of the industry :—

Cocoa Export from the Gold Coast

	Lbs.	Tons of 1000 kg.	Value £.
1890	0	0	0
1891	80	0·036	4
1892	240	0·108	4
1893	3,460	1·5	94
1894	20,312	9	547
1895	28,906	13	471
1896	86,754	39	2,276
1897	156,672	71½	3,196
1898	414,201	186	9,616
1899	714,929	322	16,064
1900	1,200,794	540	27,280
1901	2,195,571	988	42,837
1902	5,367,405	2,415	94,944
1903	5,104,761	2,297	86,250
1904	11,451,458	5,153	200,025
1905	11,407,608	5,133	186,809
1906	20,104,504	9,047	336,269
1907	20,956,400	9,430	515,089
1908	28,545,910	12,846	540,821
1909	45,277,606	20,533	755,347
1911	88,987,324	39,726	1,613,468
1912	86,568,481	38,624	1,642,733

As mentioned, the cocoa culture is carried on entirely by small growers; the areas are hardly ever larger than 10 acres, and generally even much smaller.

The variety, everywhere planted, is a Forastero-Amelonado, yellow when mature, and of the same type as the common San Thomé variety, which is known under the local name "San Thomé Creoulo." The average length is 15 cm., the average diameter 7½ cm. The seeds are flat.

Planting at stake and planting from nursery beds are both done. With the first method, the natives after clearing, and rather incompletely burning the forest, make small holes with a primitive hoe, and put several seeds in each hole. The planting is generally rather irregularly done, and the distances between the holes vary between 6 and 10 feet. In planting from

nursery beds the nursery is generally made in a suitable corner near the house, and when the plants have attained a height of 30 to 50 cm. they are re-planted at the definite place. For this purpose the natives pull the plants out of the nursery beds and scrape with the hoe a small hole, which can just contain the roots, and put in the plant. No manure of any kind is added.

In cutting the forest a certain number of trees are left standing, and these furnish a light shade. Mostly useful trees are chosen, as, for instance, the oil-palm (*Elaeis guineensis*), the Cola nut (*Cola acuminata*), and the native rubber (*Kickxia elastica*), but also the Rokko (*Chlorophora excelsa*), *Cola cordifolia*, *Piptadenia africana* and different species of *Albizzia*.

No care is spent on these trees, and, according to Chevalier, the oil-palms get sometimes troublesome by the great many epiphytes on the old, dry stalks of the fallen leaves.

As a catch-crop, more than for temporary shade, plantains are planted between the young cocoa plants, also cassava and tanias.

Generally speaking, cocoa-growing on the Gold Coast may be called in every sense a haphazard one. The weeds are left growing too long between the trees; pruning is very rarely done, and even the suckers are generally left. Only in the neighbourhood of the Aburi Station is the good example given by the Station followed, and a little more care given to the cultivation.

It is not to be wondered at that trees treated in this way have only a short life and, as is reported, they often begin to die at the age of twelve years. By cutting the whole tree back, leaving only a stump of the stem, a new growth can be obtained and the life of the tree may be lengthened.

The fact that the cultivations are suffering from different insects and fungi pests may partly also be attributed to the careless way of cultivating. Much damage is done throughout the Colony and Protectorate

by the following insects: (1) borers; (2) an Hemipterous insect of unknown species, which attacks the young branches; (3) an insect which attacks the pods (perhaps a *Helopeltis* species, according to the Director of Agriculture of Gold Coast), and by fungous diseases as follows: (1) die-back (perhaps caused by Diplodia); (2) white thread (*Marasmius scandens?*); (3) horse-hair blight; (4) canker; (5) root fungus; (6) crown-rot.

Of all these plagues the borers and the Hemipterous insect, which attacks the young branches, are doing most damage, especially the borers. They bore holes in the stem and in the branches, and, according to the descriptions, the damage done is still greater than that of the West Indian borer (*Steirastoma*). It is probable that the Gold Coast borer is the larva of another beetle.

To fight the borer a small piece of jagged wire is pushed into the hole of the stem or the branch, and after it has been worked up and down for some time, the wire is pulled out and the hole filled up with clay; but in the majority of cases the branch is simply cut off.

The Agricultural Department is busy in drawing the attention of the natives to the Hemipterous insect, which attacks the young branches, and is giving instructions to fight the enemy. A notice issued by the Department, and printed both in English and in the native language may be quoted here:—

NOTICE TO COCOA-FARMERS

An insect pest has been discovered to be doing great damage to the cocoa trees and, if allowed to spread, it may destroy the whole industry. Every chief and farmer must do his utmost to prevent the spread of this pest and so save the crops from the danger which threatens them.

DESCRIPTION OF THE INSECT DOING THE DAMAGE

The insect when young resembles a tick or spider and is reddish in colour; when old it is brown or black, and, though it generally has wings, it cannot fly more than short distances. The insect, young or old, has a trunk which, when not feeding, is folded back.

TO PREVENT ATTACKS OF THE INSECT

(*a*) Plant the trees from 12 to 15 feet apart to keep them strong and healthy.

(*b*) Keep the plantations clear of weeds, dead wood, and empty cocoa-pods, which should be buried.

(*c*) Avoid too much shade.

TO RESIST ATTACKS

(*a*) If the trees are attacked and appear to be dying, cut them off 18 inches from the ground, tar the stumps, and burn all the branches and decaying wood about the plantation, and turn the soil over completely; or

(*b*) Spray the trees with kerosene emulsion in the early morning when the insects are feeding. Kerosene emulsion is made as follows: Take one lb. of soap and four gallons of kerosene, cut up the soap and boil it in two gallons of water; when the soap has dissolved, remove from the fire and add four gallons of kerosene and mix thoroughly. To one bottle of this mixture add nine bottles of water before spraying.

Sprayers and syringes for use with emulsion can be obtained from the Agricultural Department on application.

(Sgd.) W. S. D. TUDHOPE,
Director of Agriculture.

In spite of the great damage done by these enemies, a general system is not yet followed for combating either insect or fungi pests, and every year great loss follows, which could be avoided to a great extent if the natives made more effort to combat the pests.

The main crop is picked in November and December. After breaking the pods, the seeds are put in ordinary boxes, not deeper than 25 cm. Often the natives use simply empty boxes, in which merchandise has been imported into the Colony; by preference small gin-cases are used.

The bottom of the boxes is covered with banana leaves, then they are filled with the cocoa seeds, which are again covered with banana leaves. On the top small boards are laid, and the whole is pressed with heavy stones. The beans are allowed to ferment for 4 to 6 days.

This method is, however, not generally followed, and the way of fermenting adopted by the majority of the natives is still more primitive. They simply put the fresh beans into little heaps in a more or less sheltered place. Now and then these heaps are turned over, but neither fermenting nor drying is done with any care. It will easily be understood that the fermentation obtained in this way is very poor, and the cocoa is very subject to moulding when lying in heaps, and also later when ready for sale. This is not to be wondered at, for the juicy pulp which surrounds the seeds is only incompletely removed, in consequence of the insufficient fermentation.

Still, when a little care is given, the cocoa is easily dried in this country where the rainfall is not so great, the sun-heat is always sufficient, and artificial drying is not necessary.

The result of the imperfect curing is a product of inferior quality. Insufficiently fermented, not washed, more or less slightly moulded, and insufficiently selected, the product of the Gold Coast, known on the market as "Accra Cocoa," fetches, speaking generally, only low prices.

The cocoa is sold by the natives in small quantities of 4 to 5 kilograms to the agencies of the commercial houses. Here the cocoa is dried a second time and packed in barrels, which contain about 1000 kilograms. These are rolled to Accra and shipped to Europe. Almost the whole of the product is shipped from Accra; only small quantities are shipped from the ports of Winneba, Saltpond, and Cape Coast.

As mentioned, the Government made a beginning, under Sir William Brandford Griffith, and with the view of encouraging agriculture the Botanic Station of Aburi was established.

Afterwards the Gold Coast Department of Agriculture was established, which has under its control four agricultural stations, viz.:

(1) The Aburi Botanic and Agricultural Station

(the headquarters of the Department), situated in the Eastern Province, established in 1892.

(2) The Tarkwa Agricultural Station in the Western Province.

(3) The Assuantsi Agricultural Station in the Central Province.

(4) The Kumassi Agricultural Station in Ashanti, recently started at the request of the Chief of Ashanti.

These stations distribute seeds and plants at a low price to the small growers, and give demonstrations in their gardens how to grow cocoa and other crops. At the Aburi Station some 5 acres have been planted with cocoa, and a much larger area has been devoted to this culture at the Tarkwa Station. In these gardens all the care they need is given to the plants. The seeds are sown in nurseries under the artificial shade of palm leaves lying on frames of bamboo or other wood. In planting out, sufficient distance (14 to 20 feet) is left between the trees, and instead of leaving certain forest trees as shade, the whole forest is cleared and shade trees of a special kind (*Erythrina umbrosa*, or *Pithecolobium Saman*) are planted. The weeds are carefully removed and diseases are combated.

It is not to be wondered at that the conditions of these trees are quite different from those of the trees of the small growers, and that they give a heavier yield, viz. about double.

Trials have been made with a few plants of three imported varieties, but according to the report of 1908 the results so far obtained have not been such as would recommend their more extensive cultivation to the exclusion of those at present grown.

The fermentation and drying of beans is at present also receiving much attention, but among a primitive people progress is naturally slow.

The work of the Department, however, is not confined to the stations. One European and five trained native instructors are touring throughout the Colony and Protectorate visiting the native farms and demonstrating

how to prune the trees, clear the land, make drains, how to fight fungi and insect pests, etc.

From information kindly forwarded by the Director of Agriculture it is evident that the Government is satisfied with the results obtained. The Director adds: "The fact that the natives receive these men (viz. the travelling instructors) and are glad to welcome them, shows that the money expended by the Government is not being wasted, and within the next few years any one writing on the Gold Coast cocoa industry will have quite a different tale to tell."

Lagos[1]

In this country the cocoa industry has developed in the same way as in the Gold Coast, though not to the same extent.

With the help and the encouragement of the Government the natives have established an industry which is increasing in importance every year.

Often the oil-palm (*Elaeis*) and cocoa are interplanted. It is considered that the best-managed fields are those situated near the village Okenla (district Egba).

From the Botanical Station of Oloke Meji and the garden at Ebutte Metta a great number of cocoa plants have been distributed by the Government.

The exports are as follows:[2]—

	Kilog.		Kilog.
1890 . . .	6,000	1908 . . .	1,388,000
1895 . . .	22,000	1909 . . .	2,276,300
1900 . . .	114,000	1910 . . .	2,978,000
1905 . . .	454,400	1911 . . .	4,471,000
1906 . . .	734,700	1912 . . .	3,500,000
1907 . . .	947,500		

IX. Kamerun and the other German Colonies

Though these colonies are not yet very important as cocoa producers, it is not impossible that in the

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain* (1908), p. 202.
[2] Chevalier, *l.c.*, and *Gordian*.

future the cocoa industry, more especially in Kamerun, will become important.

The exports of these colonies amounted to:[1]

	Kilog.		Kilog.
1895 . . .	120,000	1906 . . .	1,368,000
1900 . . .	261,000	1907 . . .	1,966,300
1901 . . .	528,000	1908 . . .	2,737,500
1902 . . .	658,000	1909 . . .	3,823,300
1903 . . .	918,400	1910 . . .	4,072,700
1904 . . .	1,109,200	1911 . . .	4,404,000
1905 . . .	1,454,200	1912 . . .	5,400,000

Kamerun has by far the most important cocoa industry. The area planted with cocoa was estimated in 1909 to amount to 8000 hectares (20,000 acres); *Samoa* comes second with an area of about 2000 hectares (5000 acres); while *Togo* comes third with an area of no more than 200 hectares. Cocoa is also grown to a very small extent in German East Africa, German New Guinea, the Bismarck Archipelago, and Kaiser Wilhelmsland.

The labour question[2] has caused some difficulties, as the natives of the coast-region, where the plantations are situated, dislike regular and continued plantation work. Therefore the estates are obliged to recruit by means of the contract system labourers from inland; especially from the Yaunde district, also from Ossidinge, Joh-Albrechtshöhe, Bali, and Banyo.

In 1910 about 10,000 contract labourers were employed on the estates.

The contracts are made by sanction of the Government. The labourers are contracted for six, twelve, or eighteen months; the travelling expenses to the plantation and, after expiration of the contract, home to the native village are paid by the estate. In the contract it is stipulated in what way the labourer will be paid: the payment is partly in food, partly in cash; when the labourer gets his food free from

[1] *Gordian.*

[2] *Die Arbeiterfrage in Deutsch-Ostafrica und Kamerun* (published by the Association Internationale d'Agronomie Tropicale, 1910).

the estate the payment in cash varies generally between eight and twelve shillings per month, according to the training of the labourer.

The industry is chiefly in the hands of European Companies. The attempts of the natives to grow cocoa have not yet been a success.

The young cocoa culture in Kamerun is already much troubled by diseases and enemies.[1] Of fungoid diseases the black rot of pods causes great loss, as is not to be wondered at in a country with so much rain.

The yearly rainfall amounts to about 4000 mm., divided over the different months as follows:—

Jan.	Feb.	March.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
40	80	200	230	340	550	730	750	500	430	150	80	4070

A root disease, caused by an unknown root-fungus, is also the cause of damage. Of less importance is the Kamerun witch-broom disease (not to be confounded with the Surinam witch-broom disease) (see Chapter VIII.).

Of the insects the rind-bug (*Sahlbergella singularis*) is the worst pest[2] (see Chapter VIII.). Of less importance is the borer, *Monohammus ruspator.*

Of the rodents the Kamerun hamster (*Cricetomys gambianus*) is noxious in the fields by eating the seeds of the ripe fruits, and in the nurseries by devouring the seeds before germinating.

The Kamerun cocoa belongs to the ordinary sorts. The best plantation cocoa, known as "Kamerun," fetches about the same prices as ordinary "Bahia" or fair "San Thomé"; while the inferior Kamerun cocoa, called "Victoria" by the merchants, does not get higher prices than ordinary "Accra."

It has been suggested that the quality could be much improved by cultivating finer varieties and

[1] Von Faber, *Die Krankheiten und Parasiten*, etc.
[2] Busse (*Tropenpflanzer*, 1905; and *Beihefte*, October 1906).

especially by fermenting more carefully. It may, however, be considered questionable whether finer varieties (Criollo or Criollo-like Forastero) would thrive in this rainy country. A good fermentation will probably bring the "Victoria" up to the height of "Kamerun," but obtaining a still higher quality is not to be expected.

Kamerun exported :

	Kilog.		Kilog.
1907 . . .	1,797,600	1909 . . .	3,322,800
1908 . . .	2,447,200	1910 . . .	3,431,000

Togo cocoa, as yet, is unimportant. The cultivation is almost entirely confined to the Misahöhe district and in the hands of the natives. Only one small plantation is a European undertaking. It exported in 1910, 137,045 kilograms.

Samoa.[1]—In Samoa the cocoa industry is only to a small extent in the hands of European Companies. Except five or six plantations of an area of some 300 to 500 acres each, the fields belong to small proprietors, who are in possession of small areas of 10 to 100 acres.

The export amounted in 1904 to 19,500 kilograms, in 1905 to 27,500 kilograms, in 1906 to 92,200, in 1907 to 116,500, in 1908 to 204,500, in 1909 to 386,800, in 1910 to 504,600.

The variety mostly cultivated is Criollo; the type is identical with the Java Criollo and the Ceylon Old Red. The produce has much resemblance to Java and Ceylon produce.

Also Forastero varieties are planted. The Forastero was introduced some twelve years ago from Ceylon.

The labour question in Samoa is a difficult one; the Samoa native is not fit for steady labour. In 1908, 1000 Chinese coolies were imported for plantation work.

[1] Preuss, *Über Cacaobau und andere Plantagenculturen auf Samoa* (*Beihefte Tropenpflanzer*, 7. März 1907).

X. Ceylon[1]

The cocoa plant was introduced into Ceylon by the Dutch in the early nineteenth century.[2] But the main of the cocoa, cultivated at the present time, is probably the offspring of plants obtained from Trinidad by Sir R. Horton in 1834–35 and the varieties imported in 1880 and 1881 from the same place.[3]

The decline of the coffee culture, between 1870 and 1880, in consequence of the combined attacks of leaf-disease and green bug, induced the planters to start another culture, and from that time cocoa was cultivated with much success.

The first export, in 1878, amounted to 500 kilograms; in 1885, 343,300 kilograms were exported; in 1890 about 1,000,000 kilograms; in 1895 about 1,500,000 kilograms. From that time the following amounts were exported:[4]—

Year	Kilog.	Year	Kilog.
1896	1,837,100	1905	3,224,900
1897	2,221,700	1906	2,509,600
1898	2,434,100	1907	4,699,600
1899	2,379,100	1908	2,836,200
1900	1,890,400	1909	3,570,000
1901	2,697,000	1910	4,069,000
1902	2,673,100	1911	3,064,000
1903	3,075,300	1912	3,500,000
1904	3,254,800		

The most important crops in Ceylon are tea and Para rubber, then follows cocoa. The number of estates in 1909 was 2091 with a total area of 957,709 acres, of which 30,016 acres were planted with cocoa. In 1910 the area in cocoa amounted to about 27,000 acres. This acreage is apart from 5800 acres (approximately)

[1] Literature about cocoa in Ceylon:—Herbert Wright, *Cocoa*; *Circulars and Agricultural Journal of the Royal Botanical Gardens, Ceylon* (especially vol. vi. No. 6, "Cacao Cultivation in Ceylon," by R. H. Lock); *The Tropical Agriculturist* (Colombo, Ferguson).

[2] Jumelle, *Le Cacaoyer*, p. 183.

[3] Herbert Wright, *Cocoa*, p. 6.

[4] *Gordian*.

in native gardens. The total area in cocoa thus amounted in 1909 to about 36,000 acres, in 1910 to about 33,000 acres.

The following particulars are mainly taken from Wright's and Lock's publications.

The combination of rainfall, temperature, and elevation required for the profitable cultivation of cocoa, eliminates many parts of the island for this product. The large tracts of land in the hilly districts cannot be included in the cocoa zone on account of low temperatures or unfavourable moisture-conditions.

The amount of land suited for cocoa cultivation in Ceylon is therefore limited, and the range of suitable elevation is especially small, when compared with the toleration displayed by tea and even rubber in this respect. Thus cocoa is not expected to be really successful in Ceylon below 500 feet or above 2000 feet elevation. A rainfall of at least 60 inches (1500 mm.) is considered to be necessary as well as a good protection from strong winds.

Of the total area the districts around Kandy and Matale account for some 27,000 acres, and the cultivation extends towards Teldeniya on the east and Kurunegala on the west. A line drawn through Peradeniya, Rambukhana, Nalanda, and Teldeniya will enclose the greater part of this area. Practically the whole of the cocoa in Ceylon therefore grows in quite a small district.

The rainfall varies between 2000 and 4000 mm. (80 to 160 inches).

The following are the details of a few cocoa-growing districts :—

	Annual Rainfall.	Elevation.
	mm.	feet.
Heneratgoda . .	2653	33
Kandy . . .	2038	1654
Matale . . .	2110	1208

In the Kandy district the south-west rains are heavy during April and June, while in October and November those from the north-east are still heavier. There is a warm dry period in February and March, a hotter but moister one during April and May, followed by seven to eight months of rainy weather, when the temperature is slightly lower and the humidity high.

The Criollo variety, called here "Old Red Ceylon," has been in the beginning the only one cultivated, but since ravages of diseases have become prominent, there has been a tendency to replace this variety with the more prolific varieties of Forastero, in the belief that the latter was not so liable to these ravages.

The Forastero, however, has not answered in every respect to expectations. The *Helopeltis* and the canker appeared to attack the Forastero as well as the Criollo, and this experience has induced some of the planters to plant again the "Old Red" (Criollo).

May, June, and July is the time of full-blossoming, and the main crop is obtained in the months of October, November, December, and January.

As regards distance of planting, the opinions in Ceylon agree with those of the Java planters: 15 × 15 feet is considered close enough for a good Forastero under ordinary conditions, and it is the opinion of Mr. Lock that this interval may be increased to as much as 20 × 20 in cases where soil and shelter are especially favourable.

It seems that the banana is not used for preliminary shade. In this respect cocoa culture in Ceylon and in Java appear to correspond. In both countries the dadap (*Erythrina lithosperma*) is considered the best plant as well for temporary as for permanent shade—at any rate when it is not subject to the attack of many insect-enemies, as is the case in most parts of Java.

The way in which the dadap is used in Ceylon is described by Lock[1] in the following way:—

[1] Lock, "Cacao Cultivation in Ceylon" (vol. vi. No. 6 of the *Circulars of the Royal Botanical Gardens, Ceylon*, February 1912, p. 95).

The best of all shade trees for Ceylon is almost certainly the dadap, which has the great advantage of growing well from large cuttings—indeed, the cutting can hardly be too large—so that a fair-sized tree can be established by this method in a year or two. At the outset as many dadaps as cacao trees will be required, and these may be planted in the same lines as the cacao plants and alternately with them, so as to admit of a free view down the lines of cacao. As the dadaps grow they should be pruned in such a manner that their branches are kept a few feet above the tops of the cacao plants, and the leaves and twigs removed during this process should be mulched close round the young cacao. As soon as the branches of the dadaps have met above the cacao so as to afford a tolerably close shade, the question of thinning them out must be considered, and at the beginning of the next wet season one in three of the dadaps may be cut down, the leaves being again used for mulching. The process of thinning should be continued year after year, until ultimately the dadaps stand 45 by 45 feet in each direction—a condition which may be reached five years after the time of original planting, when the cacao will be just coming into bearing. A young dadap cutting may now be planted in the centre of each square of old dadaps to take the place of the latter when they have outgrown their condition of greatest usefulness in two or three years more. The old trees are then gradually cut down, and the store of organic matter which they represent returned to the soil. In addition to all this, the branches of the dadaps should be lopped periodically at the onset of wet weather if the shade appears to be too heavy.

All this planting and cutting out of shade trees may appear unduly complicated, but there is no doubt that the proper treatment of shade is the first essential of success in cultivating cacao in Ceylon. The use of the dadap ensures a sufficient supply of nitrogen derived from the prunings and loppings constantly returned to the soil, and no further supply of this expensive and necessary constituent will be required on good land if the recommendations here given are carried out.

In the beginning, however, plantations were not very particular about shade and contained several species of trees, and while they are now by preference using dadap (*Erythrina lithosperma*), the mixed cultivation with *Hevea* also has become very popular. Of the Erythrinas, *E. lithosperma* is preferred to *E. umbrosa* on account of its more rapid growth, more luxuriant

foliage, absence of thorns, and the way in which it stands regular lopping once or twice a year.

Some other shade trees, however, are also met with on the cocoa estates, especially *Albizzia moluccana* and *Albizzia stipulata*, and the rubber species *Castilloa elastica* and *Manihot Glaziovii.*

At the present time the planting of cocoa and Hevea as a mixed cultivation is much in favour, and it is extending, especially in the Matale, Dumbara, Kurunegala, Polgahawela, and Kandy districts.

This interplanting has often been quite successful, but care must be taken to plant the trees wider apart than is the case when they are planted separately. Wright[1] recommends to plant Hevea as well as cocoa 20 feet apart, so as to obtain approximately 100 rubber and 100 cocoa trees per acre. As regards the yield, this same author mentions that Ceylon estates, with Para rubber trees eight to eleven years old planted through slightly older cocoa, are now obtaining a yield of about 200 lbs. of rubber and the same of cocoa per acre per year.

But few planters are interplanting with Manihot and Castilloa.

Weeding is done on most estates by contract; the contract coolies are paid 7 to 12 rupees (9s. to 16s.) per acre per year. Some estates apply green manuring in the young cocoa fields, in order to keep the weeds in check and to improve the soil. For this purpose the following plants have been recommended for Ceylon: different Crotallaria species (*C. striata*, *C. laburnifolia*, *C. incana*), *Cajanus indicus*, species of Indigofera (*I. anil*, *I. tinctoria*, *I. hirsuta*), etc.

A fair amount of artificial manure is used on the estates; but, so far, systematic experiments have only been carried on at Peradeniya in the Botanical Gardens. From these experiments it may be concluded that good results were obtained from nitrogenous manures; it is a fact worth mentioning that the best results were

[1] *Cocoa*, p. 84.

obtained by green manuring with Crotallaria and an application of lime to the amount of 2 tons per acre; the second-best results were obtained with nitrate of sodium (800 lbs. per acre); followed by cattle manure (10 tons per acre).

For particulars reference may be made to the figures given in the Annual Reports of the Botanical Garden, Peradeniya.

Systematic pruning of cocoa trees is an operation which is hardly known or very rarely practised in Ceylon. Cleaning the trees, however, is generally done, often only after crop-time, during the dry months from January to April; in this case the work is done together with the treatment of the stems against canker.

The regular removal of all the suckers is generally practised, and it has been recognised that the cultivation of suckers at the right time is often the means of saving a plant which is attacked by canker disease.

The shelling or breaking is done either by means of a knife or small cutlass, or by pressing the fruit against a steel cutting surface lodged in a piece of wood. The seeds are collected in baskets, and the shells are generally buried in pits.

The cocoa plant is attacked in Ceylon by a few troublesome enemies. The most serious insect pest is the *Helopeltis*, while of the fungoid diseases the *canker* and the *black rot of pods* are often the cause of considerable loss.

The canker disease began to get troublesome at the end of the last century. At present the method of cutting and burning all the diseased parts is generally adopted, and it is supposed that in this way the disease is kept in check. It has been recommended to watch the disease the whole year round, and not to wait for the measures mentioned, but to inspect the trees every month. The judicious thinning out of too dense shade has also helped in fighting the disease. In some cases good results were reported from a treatment of the

Diseas

cankered areas with strong reagents, especially strong sulphuric acid.

Against the black rot of pods spraying was tried at the Peradeniya Gardens, with good result.

Helopeltis was first noticed on cocoa in Ceylon in 1880. Every year the damage is a serious one, and planters are as yet nearly helpless against this enemy. The use of suitable shade trees is recommended, and shade is considered to be the most important palliative.

A common pest in store-rooms is the larva of a Pyralid moth (*Ephestia*).

For fermenting, the seeds are treated in Ceylon about in the same way as is done in Java, which method will be described later in detail. On the fermenting floors the seeds are heaped up in heaps of four or more bushels. Every day or every twelve hours the heaps are turned over. About the time necessary to obtain the right produce opinions are different. Some planters ferment only during 1½ days, while others consider it better to ferment during 2½ days or 3 days, or even longer.

In most estates washing is carried out, and this seems necessary when the beans have been subjected to a comparatively short fermentation, because it is otherwise difficult to obtain a satisfactory drying.

Lock[1] gives the following description of fermenting and washing in Ceylon :—

> The beans and wet pulp are piled in cement tanks and covered with plantain leaves and jute hessian, and are allowed to remain for twenty-four hours. They are then uncovered and partly washed by stirring with water, which is allowed to drain away from the bottom of the tank. After a further twenty-four hours the same process is again repeated, and is followed by a final fermentation period of twenty-four hours, the total period of fermentation being thus three days. The beans are then finally washed and are ready for the final process of drying. The washing should not be done too thoroughly, as it is found that the beans dry a better colour if a certain amount of pulp is left adhering to the surface.

[1] *l.c.* p. 99.

When the weather is favourable, the curing is done by exposure to the sun. This method is preferred in Ceylon on account of its cheapness and the better quality of the produce. The most usual method is to spread the seeds over large floors. Sometimes drying waggons are used, as in Surinam, or movable roofs, as in Trinidad.

When, however, the weather is rainy, the seeds are cured in the curing house. Numerous types of such houses are in use. According to Wright[1] most of the curing houses in Ceylon consist essentially of two chambers, the lower one being spacious and specially adapted to receiving the hot air, and the upper one the fermented seeds. The coir matting on the floor of the upper chamber is covered with the freshly fermented seeds, the hot air passed through this mass from below upwards, and the moist air is drawn off by means of a fan. In most cases the heat is drawn through the chamber by means of a fan driven by hand or power, and placed at the opposite end of the chamber, away from the heating apparatus; in some cases, however, the hot air is driven through the lower chamber and allowed to escape at the end of the building opposite the fan. The air-space beneath is usually very spacious, and by means of a series of brick baffle-plates the air may be made to travel throughout its length before commencing to ascend.

After curing, the beans are sorted and shipped. The Ceylon produce has much resemblance to Java cocoa. Both kinds are in good demand, principally on account of the light colour and the comparatively sweet taste. Accordingly, high prices are paid for well-prepared, first-quality Ceylon. There is, however, little uniformity, and also much inferior Ceylon is brought to the market.

As regards profit and cost of production, Lock gives an estimate.

When the total area planted and the exports are

[1] Wright, *Cocoa*, pp. 136, 137.

compared, it turns out that the average crop is rather less than 3 cwt. (150 kilograms) per acre. In well-cared-for estates, however, the yield is higher, though it may be regarded as questionable whether the estimate of 5 cwt. (250 kilograms), which Lock regards as a mean estimate for estates, is not a little high. An amount of 5 cwt. represents a return per acre of about 200 rupees (about £13 : 7s.).

Of the expenses the most considerable item is labour. The average rate of daily pay in the cocoa districts is about 40 cents (about 6d.). A permanent force of more than sixty coolies per 100 acres is never employed. Supervision will cost about 15 rupees per acre, and other expenses, including manure, perhaps 30 rupees more. According to Mr. Lock, it will probably be safe to take the cost of production as 75 rupees per acre for the lowest estimate and 120 rupees for the highest (1 rupee = 1s. 4d.).

XI. Java and the other Islands of the Indian Archipelago

Long ago the cocoa plant was imported into the Malayan Archipelago. It is said that about 1560 the first plants were brought to Celebes by the Spaniards.

In the northern part of this island (Minahassa) it was cultivated, but only on a very small scale, in the end of the eighteenth century; the product was consumed locally. About 1820, however, the culture was extended in Minahassa; this was in consequence of increased demand in Manila for Minahassa produce.

The export from the port of Menado began about 1825, and increased a little up to 1838, when it amounted to 91,740 kilograms. From that time a disease, the nature of which can no longer be traced, began to damage the cocoa fields in Minahassa. The cocoa culture went backward, and the exports from Menado diminished. At present the cocoa exports from Menado

are no longer of importance; in 1909 only 30,050 kilograms were exported.[1]

In Java the decay of the coffee culture was the direct cause of the starting of cocoa-growing. When, about 1880, the coffee plantations began to decline, in consequence of the ravages of the leaf-disease (*Hemileia vastatrix*), the first trials were made in Middle Java, near Salatiga, to plant cocoa in the old coffee fields. This seemed to be a success, and since that time cocoa has been planted in fields of Coffea arabica and of Coffea liberica in several plantations in Middle and East Java.

At present cocoa plantations are to be found principally in the regencies of Semarang, Solo, Pekalongan, Kediri, Pasoeroean (in the southern part), and Besoeki. They are scattered over these regions, and are mostly situated on the slopes of mountains at an altitude of 500 to 1800 feet; a few are situated on a lower altitude, near the sea-coast.

The conditions of soil, temperature, and rainfall are widely different in the several districts of Middle and East Java, and this accounts for the fact that the methods of cultivation show little uniformity.

As regards rainfall, an east monsoon—the dry season, and a west monsoon—the wet season, can be distinguished. The east monsoon lasts from May to October; especially in the months of July, August, and September droughts of several weeks are expected, but the cocoa stands such droughts quite well.

The following figures of the rainfall on two estates may be given as example:—

[1] See Kamerling en Zehntner, "Voorloopig overzicht, etc." (*De Indische Natuur*, 1901, p. 43).

[Table

RAINFALL IN MILLIMETRES

	"Widodaren" (Besoeki, East Java).	"Getas" (Salatiga, Middle Java).
January . .	510	414
February . .	473	322
March . .	490	397
April . . .	332	247
May . . .	213	189
June . . .	150	152
July . . .	77	100
August . .	72	92
September . .	92	108
October . .	243	196
November . .	464	332
December . .	484	386
Total .	3610	2935

The figures at Widodaren are the average figures for the years 1886 to 1909; those of Getas are the average figures for the years 1900 to 1909.

Cocoa would, doubtless, have become a culture of more importance for Java if the two enemies, the cocoa moth (*Zaratha cramerella*) and *Helopeltis*, had not become so very destructive some fifteen years ago. The moth especially reduced the crop to a great extent. The natural consequence was a tendency among cocoa planters to make the expenses as low as possible, and to combine cocoa with other crops so as to get a larger revenue from the plantation without making the expenses much higher.

In this way cocoa cultivation has not grown in Java on uniform lines and on principles acquired by experience of several generations. Every planter tries to make the best of it, and has his own way of interplanting with other crops.

A great advantage in Java is the cheapness of labour. It makes cocoa culture pay in spite of its enemies. In most parts of Java a day-task of a man is paid 25 to 40

cents (5d. to 8d.), while a woman is paid 15 to 25 cents (3d. to 5d.) per day. In Middle Java and a great part of East Java as many labourers are obtainable as are necessary.

The cost of production varies because the conditions are so different in different parts of Java. For Middle Java the following estimate may give an idea :—

	Per bouw (0·7 hectare).	Per pikul[1] (60 kilograms).
	Guilders.	Guilders.
Field work (except manuring and picking)	20	4
Manuring	25	5
Picking	12·50	2·50
Fermenting and drying	5	1
Management and general expenses	12·50	2·50
Taxes	5	1
	80	16

[1] It is admitted in this estimate that 1 bouw produces as an average 5 pikul.

In this way the cost of production would be 16 guilders or £1 : 6 : 8 per pikul (60 kilograms), or about 25 cents (5d.) per kilogram.

When cocoa is planted in old coffee fields (Fig. 117), where the shade has been left, temporary shade is not used; and the cocoa is grown under quite other conditions than those in the more classic cocoa countries, where a preliminary and comparatively dense shade, such as bananas, is considered necessary to the young cocoa plants.

The habit of cocoa plants planted in these old coffee fields is, accordingly, not normal. The tree ramifies at a rather low height (Fig. 118 and Fig. 35). This may account for the system often followed of letting a sucker grow up, in order to form a second branch system above the first one.

When new fields are established in Middle Java, the cocoa is often combined with randoe or "kapok"

(*Eriodendron anfractuosum*) or with the Central American rubber tree (*Castilloa elastica*). For temporary shade the dadap (*Erythrina lithosperma* Miq. = *Erythrina hypaphorus* Boerl.) is often used; at present, however, other plants are sometimes preferred, being less liable to insect pests; the "lamtoro" (*Leucaena glauca*) is just now very popular; here and there the "toeri" (*Sesbania grandiflora*) is used, or the "Sengon

Fig. 117.—Cocoa planted in an old coffee field (plantation "Getas").

The shade trees are *Albizzia moluccana*. On the right of the photograph is to be seen a Liberian coffee tree, in the centre a young cocoa tree, behind the cocoa tree a nutmeg tree.

laut" (*Albizzia moluccana*), and sometimes, but rarely, taro species (*Xanthosoma* sp.) (Fig. 119).

As regards the height at which cocoa is grown, in the plains along the sea-coast the results are on the whole the best. The attacks of the moth are not so terrible here, in comparison with cocoa grown at some 1000 or 2000 feet above sea-level; the growth is quicker and the yields are higher. But the number of cocoa estates in the plains is small, most of the available land in this region being already occupied by sugar estates.

Above 1800 or 2000 feet the growth is still satisfactory, but the yields are small, and the prolonged growth makes conditions favourable to the moth. The cultivation of cocoa is therefore considered not advisable on lands above 1800 or 2000 feet.

In most cases the nursery system is followed. Often pots are used for the purpose. Baskets are generally considered unsuitable, because, when planted

FIG. 118.—Cocoa planted in an old coffee field (plantation "Getas").

Shade is afforded by *Albizzia* and "kapok" trees, some of the latter being used as supports for pepper.

out into the field, the baskets attract white ants, which begin to devour the baskets, and sometimes afterwards attack and destroy the young plants. Bamboo pots are considered more practical; these are used either in the ordinary way (see Chapter VI. pp. 133-134) and removed before planting by splitting them into two parts, or they are split before, and the parts fastened together by means of fibre. By this method all injury to the young plants in splitting the bamboo is avoided (Fig. 46).

A system, as far as I know only used in Java, is the use of pots made of cow-dung and soil. In different proportions the ingredients are mixed on the plantations. One of the most convenient mixtures seems to be:

10 tins of cow-dung.
2 „ black-mould or clayish earth.
2 „ sand.
$1\frac{1}{2}$ „ fibre of the areng palm.

FIG. 119.—Young cocoa tree planted in an older cocoa field under the light shade of "kapok" and temporary shade of taro (plantation "Siloewok Sawangan").

When these ingredients have been well mixed together with the addition of water, the mixture is put into a mould made of wood into which is pressed a block to form the pot. Fig. 120 may give an idea of the instrument.

The pots freshly made are dried and hardened in the sun. When dry they are fit for use.

When these "dung-pots" are used in the nursery, they must be kept under a roof, so as not to be wetted by rain, and when the plants are watered this must be done carefully, otherwise the pots break down.

When the plants are old enough to be planted into the field, they are left in the "dung-pots" and put together with these into the plant-hole. When the rains come and pots and soil are thoroughly wetted, the pots break down, and the roots of the cocoa plant have no difficulty in penetrating the pots. Besides, in decomposing the pots give food to the young plants.

The only drawback to this system is that the pots sometimes get too hard because the mixture has been made with too much clay, or because they have been dried too much in the sun.

The plant-holes are generally well prepared and mixed with pen-manure. It is done so at least in

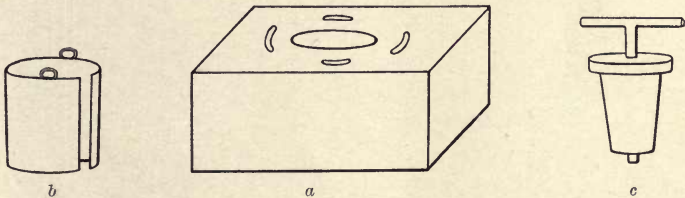


FIG. 120.—Implements used in making "dung-pots."

The tin-plate *b* is fitted into the hole in *a*, which is then filled with the mixture. The instrument *c* is then put into the hole and turned round, giving the shape. The tin-plate *b* helps to remove the "dung-pot" easily from *a*.

Middle Java. In this region the soil is not very rich, perhaps in consequence of the coffee culture, which has been practised for a hundred years or longer on these soils. In East Java the soil is more fertile; sometimes virgin land is used here, and then the planters simply loosen the soil a little before the cocoa is planted.

As already mentioned, cocoa culture was started about 1880. About that time a few plantations in Middle Java began to plant cocoa on a large scale in the old cocoa fields; the plantations "Tlogo," "Getas," "Djati Roenggo," all situated near Salatiga, were among the first.

They all planted with red Criollo cocoa (Fig. 121), this being the only variety abundant in Java, the yellow variety being rare. A small cocoa field at the planta-

tion "Medono" supplied almost all the seed for the new plantations.

One of the planters of Middle Java, Mr. Henri MacGillavry, however, was, for different reasons, not satisfied with this variety, and judging from what he learnt about the splendid quality and great productivity of the Venezuelan Caracas cocoa, he expected that this variety would be better for planting than the "Red Java cocoa" (Java Criollo). He tried to get this Caracas cocoa, and imported in 1888 from Venezuela a

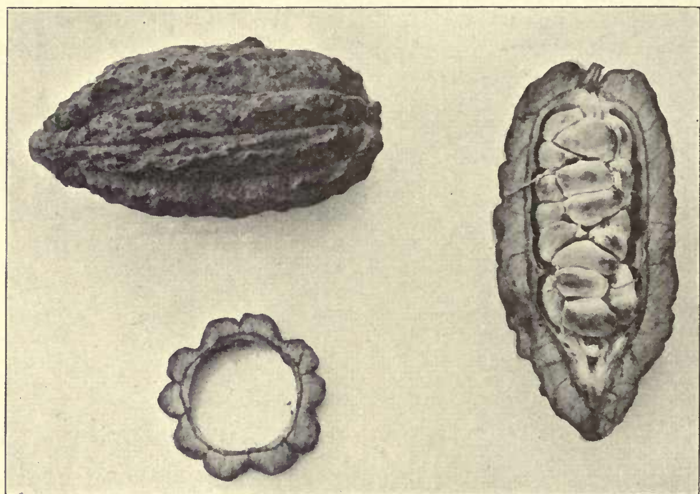


Fig. 121.—Java Criollo.

case with cocoa plants, which he got under the name "Caracas cocoa." Only two plants arrived alive, and one of these died soon. The only surviving plant was planted out on the plantation "Djati Roenggo." It turned out to be a Forastero variety of an inferior type.

Java may be deemed happy for this mistake of the Venezuelan correspondent of Mr. MacGillavry. For if, indeed, plants had been sent of the famous real "Caracas" variety ("Venezuela Criollo"), this would have been no acquisition of any value, this variety being identical, or nearly identical, with Java Criollo.

It may be that the Venezuelan correspondent did not want to send the valuable type of his country; at any rate, the single tree which remained out of the case from Venezuela proved to be an inferior Forastero, a Cundeamor type, with small yellow fruits, and flat beans of a dark violet colour (Fig. 122).[1]

If the progeny had been of the same quality as this first Forastero tree, it would have been of little value for the cocoa culture in Java. This, however, was not the case. The trees, grown from seeds of the imported tree, were very different among each other, but all possessed distinct Criollo characteristics, together with Forastero characteristics of the mother-tree.

FIG. 122.—A fruit of the original Forastero tree imported into Java from Venezuela (after Zehntuer).

The hybridisation was so apparent that Mr. MacGillavry called the progeniture "Djati Roenggo *hybrid* cocoa," a collective name for all the descendants of the imported Forastero tree of the plantation "Djati Roenggo."

Like all the hybrids, the "Djati Roenggo" hybrid is very inconstant, and shows a great variety (Figs. 123, 124). Among the different individuals, all sorts of combinations of Forastero and Criollo characteristics are to be found. Some trees (Figs. 124, 125) have fruits which are hardly to be distinguished from true Criollo fruits; others have a clear Cundeamor type (with a constriction near the stalk); some have large, round beans, others have small, flat beans, etc.

[1] Particulars about this introduction are to be found in *Archief voor den Landbouw in Insulinde*, i. (1901), pp. 23 and 52.

Generally the planters prefer this Forastero hybrid. New fields are only in rare cases planted with Criollo; and also for supplying in old fields the "Djati Roenggo" hybrid is preferred. The growth of Criollo in old fields is too slow. But the main drawback is its little resistance against attacks of moth and Helopeltis. When attacked by Helopeltis, the "Djati Roenggo" hybrid does not suffer so much, because the dead twigs are quickly replaced by new ones.

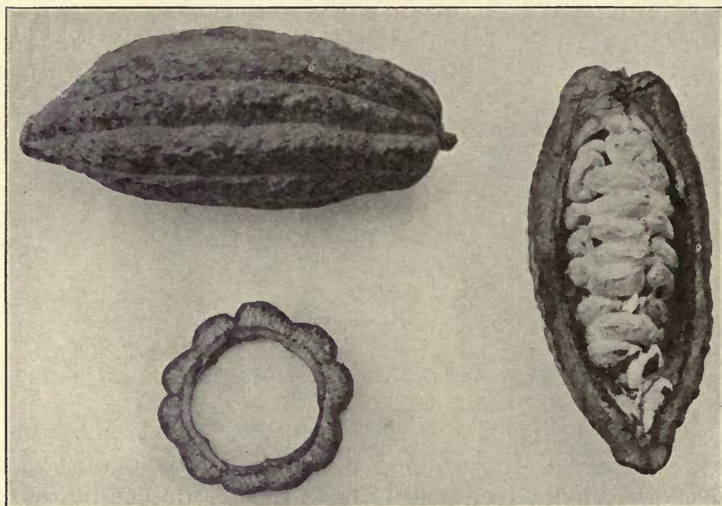


Fig. 123.—A common type of the "Djati Roenggo" hybrid.

The Criollo characteristics, especially the large round bean, are apparent when compared with Fig. 122.

Opinions are divided about the yield of both varieties, but it is generally believed that the "Red Java cocoa" ("Java Criollo") gives under favourable conditions not a smaller, possibly a higher yield than the "Djati Roenggo" hybrid.

This corresponds with the growth of both varieties. Under favourable conditions, as, for instance, on rich, virgin soil in East Java, the Criollo makes large strong trees, which are in no respect weaker or smaller than

the Forastero trees, but on poorer soils the Forastero shows its greater strength and vitality.

The pure, fine Criollo produce always fetches a price a little higher than the Forastero, but the

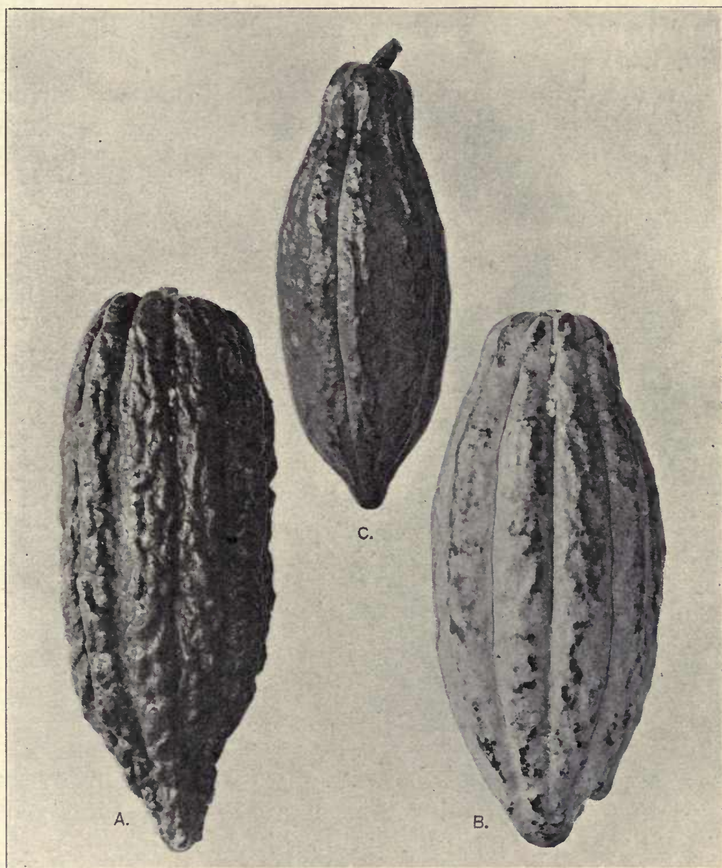


FIG. 124.—Different types of "Djati Roenggo" hybrid.

A. An Angoleta type. B. and C. Cundeamor types.

difference in the case of produce of good Forastero types is unimportant.

In addition to the group of "Djati Roenggo" hybrids and the Java Criollo, a few trees of other

imported varieties are found. The most remarkable is a type standing just between a typical Angoleta and a typical Amelonado, with a thick red fruit-wall and large round beautiful beans, to be found at the plantation "Assinan," and originally imported by the Department of Agriculture, probably from Nicaragua (Fig. 125).

In the old coffee fields the "dadap" (the Erythrina species above mentioned) was formerly used everywhere

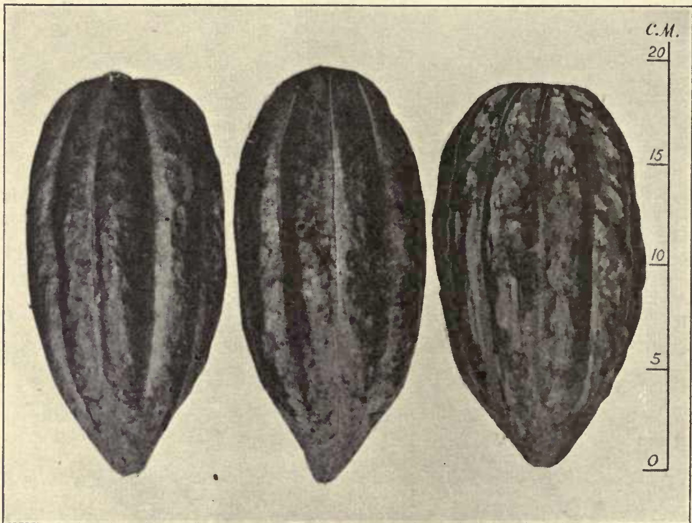


Fig. 125.—The Angoleta type of the plantation "Assinan."

as a shade tree, and it was quite suitable in every respect. Generally it was planted at distances of 18 × 24 or 24 × 24 feet. But different insect pests attacked this tree many years ago, and the pests have increased to such an extent that at present the "dadap" is only used for temporary shade. These enemies are principally the dadap-bug or dadap-fly (*Typhlocybe erythrinae*), which attacks the leaves and causes them to drop as thrips does, and the dadap-borer, a beetle (*Batocera Hector*).

This decay of the dadap has often caused damage

when it was not quickly replaced by another shade tree. It is, however, difficult to find a really suitable tree, and it may be said that at present no shade tree has been found which in every respect is suitable, like the dadap before it was ruined by its enemies.

The most popular shade tree at the present time is perhaps the "derris" (*Deguelia microphylla*), which forms high trees with a light shade. In many estates the results are satisfactory, but in some places the "derris" seems to have a bad influence on the growth of the coffee and cocoa. This is not the case with the "lamtoro" (*Leucaena glauca*), which is very suitable in many respects, as well for green manuring as for permanent shade. In some places, however, this tree does not grow well.

The quickly-growing "sengon laut" (*Albizzia moluccana*) would have great advantages, if it were not so liable to attacks of borers, while the allied "sengon djawa" (*Albizzia stipulata*) is a very slow grower. The "sengon djawa" has also the drawback of being attacked by scale insects and lice, the excrements of which cause the cocoa trees to be covered with a black mildew.

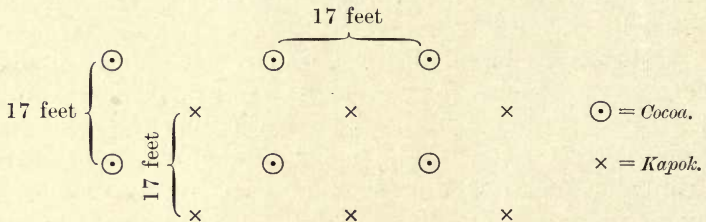
Other trees have also been used with more or less success, for instance *Caesalpinia dasyrrhachis* and *Adenanthera pavonina.* The Saman (*Pithecolobium Saman*) has been tried, but is generally considered unsuitable, getting too large and giving too dense a shade.

On the whole the "lamtoro" (*Leucaena*) seems to be in most cases the most recommendable. When planted first at a distance of about 12 × 12 feet, it may be thinned out later on, remaining finally 24 × 24.

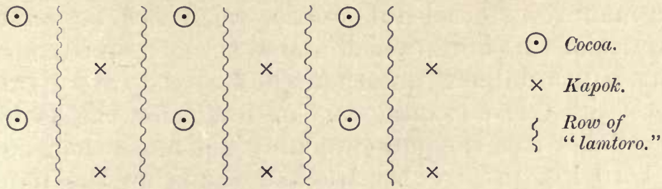
All these shade trees afford a light shade, and it is obvious that in Java the shade is much lighter than on most estates in the American cocoa lands. The Java planters all agree, however, that a more dense shade is not recommendable, and would result in small yields.

As to the best planting distances opinions differ. Often we find the Criollo planted at 12 × 12 feet, which is generally a consequence of the gradual replacing of Liberia coffee, which was planted at that distance. But this is doubtless too close; a distance of 15 × 15 feet is for Criollo more recommendable. For the Forastero ("Djati Roenggo" hybrid) distances varying between 12 × 12 and 18 × 18 have been adopted. When the soil is not exceptionally fertile and the trees do not grow very large, as is the case in Middle Java, 15 × 15 feet seems to me the best average distance.

When cocoa is not planted in old coffee fields in Middle Java, it is often interplanted with kapok; this crop grows well on moderate altitudes, where the rainfall is not too heavy. It gives a very light shade. This, together with the fact that the kapok is not a leguminous plant and a soil-improver, makes it necessary to take measures in order to renovate the soil. This is often forgotten by the cocoa planters. Usually the cocoa and the kapok are planted at distances of 17 × 17 in the following manner:—



The consequence of the interplanting with kapok is that the soil gets poor, while the growth of the cocoa is checked. This drawback can easily be avoided by the use of green manures in the proper way. The "lamtoro" (*Leucaena glauca*) is very suitable for this purpose; it is planted rather densely in rows between the cocoa and the kapok, as shown below:—



The great advantage of the "lamtoro" is its remarkable vegetative power; it may be pruned every two or three months, and each time a great amount of leaves are obtained, which can be used as a green manuring for the cocoa and the kapok.

Another plan is to plant the cocoa closely and to thin out later on. A good system is to plant the cocoa 12 × 12 feet, and to thin out afterwards, leaving the cocoa 12 × 24 (the kapok 24 × 24) (Fig. 43, p. 118). But even when this system is used, the interplanting of a leguminous plant is advisable.

On some plantations cocoa is successfully planted with the Central American rubber tree (*Castilloa elastica*) (Fig. 45, p. 121). This tree grows remarkably well in Middle Java, and it must be admitted that the cocoa is not checked in its growth or damaged by the presence of the *Castilloa.* Still, it seems that the cocoa does not give as high yields as when grown under the shade of a leguminous tree. Besides, the shade given by the Castilloa is rather dense, and a regular pruning is necessary to prevent the foliage system getting too dense. It must also not be forgotten that the Castilloa, like the kapok, is not a leguminous tree, and misses all the advantages of a real shade tree, like the Erythrina, the Inga, etc.; it does not add nitrogen to the soil, it does not loosen the soil by its roots, and the leaves are not so useful in affording humus. This makes it necessary to manure the fields thoroughly by a humus-forming manure. The dense shade of the Castilloa does not allow the growth of a leguminous undercrop, except in the first few years, when cocoa and Castilloa are young, and it is therefore necessary to use

pen-manure, ground-nut refuse, rice-straw or another manure of this kind, which makes the system expensive. It is still a dubious question whether the interplanting of Castilloa is advantageous or not; for the yield of this rubber tree is small (probably not more than 50 gr. or 1/10 lbs. per tree). Much depends on the market price of rubber.

The planting distance is different on some estates. In many cases a good system is 24 × 24 feet for Castilloa and 12 × 18 for cocoa.

Another plant which is often seen in the cocoa fields, sometimes only in one or two rows along the roads, is the nutmeg (Fig. 117).

The kapok tree is often used as a support for the pepper plant (Fig. 118).

In this way the cocoa fields have often become a sort of "mixtum compositum" of different crops. We may find combined numerous crops such as cocoa, coffee, kapok, nutmeg, and pepper, and sometimes Castilloa, and in such a case the Java planter is not quite wrong when he calls his plantation "a grocer's shop." On one of the estates the fields are all surrounded by kola trees as wind-breaks. This tree is quite suitable for the purpose, and the nuts pay well, but it has the drawback of being attacked by the cocoa-moth.

Manuring is sometimes omitted on rich soils. But on most plantations the soils have been cultivated with coffee during many years, and it is no longer possible to obtain a satisfactory growth without manuring. Where pen-manure is available, this is always used. It is generally an inferior sort, bought from the people. If enough can be had, two kerosene tins are given every year to each cocoa tree (one tin contains about 30 kilograms of manure).

Most of the estates use only pen-manure, some others pen-manure and ash, others again use ground-nut cake or kapok cake, or both together.

On one estate the manager has solved the difficulty of obtaining a good humus-affording manure by culti-

vating indigo on separate fields, and using the plants as manure for the cocoa. This may demonstrate how badly the necessity of manuring is felt in Java.

Also as regards soil management opinions differ. This is not to be wondered at, on account of the great differences existing between the various kinds of soil in Java. On some estates, especially where the soil is clayish, it is considered good to give, if possible, every year a hoeing, but often, especially on stony soils, this is not considered necessary, while some planters are even of opinion that cocoa cannot stand a thorough root pruning.

Not long ago it was a generally adopted system to allow one sucker under the ramification (Fig. 61, page 185). It may be considered probable that this system was in consequence of the low height of the branching of cocoa trees which had grown up in the old coffee fields under the light shade of dadap or Albizzia, without the more dense temporary shade of bananas.

Though the adaptation of this system may have had some advantages there is no reason to regard it as a necessity. Two branch- and leaf-systems are thus formed, the lower one by the ordinary ramification of the stem, and the upper one by the ramification of one of the suckers, and in consequence an irregular form of tree is formed which makes pruning, cleaning, and treatment against diseases and pests difficult.

The system has therefore been gradually abandoned. In the younger cocoa fields the ordinary method has been followed, leaving no root-suckers, so that the crown of the tree is only formed by the main ramification of the stem.

As in all countries, pruning is done in different ways; on some estates it is not considered necessary, while on others much care is spent to give a regular form to the trees and keep the branch system open in centre.

On one estate the old Ecuador system is followed, and all the suckers which sprout out at the foot of the stem are left growing. In this way each tree

has three, four, or five stems (Fig. 60). I cannot, however, see any advantage in this method, and it has certainly not been proved that the yield of trees, treated in this way, is higher.

Flowering goes on on most estates more or less through the whole year, and the time of the main blossoming is different on different estates, and shows also some variability in the following years. Also the time necessary for the ripening process is not the same everywhere. Generally speaking, it is shorter in the plains, where the temperature is high. It takes about four months and a half there. Up in the mountains, where the climate is cooler, the ripening takes longer, about 5 to 5½ months, in some fields even six months.

These circumstances result in that the season of the main crop is different.

These different conditions are also the cause of the lack of uniformity in "rampassing" on the different estates, as we shall show below.

As already mentioned, the cocoa in Java is, probably more than in any other country, subject to insect pests.

The two worst enemies are the cocoa-moth and the Helopeltis; but in some parts of Middle Java the borers are terrible enemies, especially the *Glenea* beetle. In some plantations the canker does much damage.

These diseases and insect pests have already been described in Chapter VIII., and we need not again go into details here. A few words are desirable as to their influence upon the crops.

The moth began only to be important about 1895. Before that time cocoa culture was very remunerative and high yields were obtained; yields of 10 pikul (600 kilograms) per bouw (0·7 hectare) (about 750 lbs. per acre) were no exception. But since the appearance of the moth an average yield of five pikul is seldom obtained (about 400 lbs. per acre). Not only the yield but also the quality is much affected by the moth. It is difficult to estimate what is the total loss caused by the moth, but

it is estimated to be on an average yearly about fl.150 per bouw (about £7 to £8 per acre).

The moth is to be found in every cocoa field, and every tree has more or less fruit damaged by this insect, but in the plains, where the climate is hot, the loss is not so great as up in the mountains. In the plains the Helopeltis is the worst enemy.

These two pests dominate the whole system of cultivation, and their presence must always be taken into consideration with every cultural measure.

The moth makes it necessary to "rampas" every year. As shown in Chapter VIII., this means that at the right time all the fruits hanging on the trees are removed and destroyed. The right time of rampassing is difficult to fix, and is a subject of continual deliberation and discussion. The time of blossoming and the time of picking depend, again, on the time of rampassing.

The combating of the Helopeltis also requires much consideration (see Chapter VIII.).

The borers are present over the whole of Java. On several estates they are not of much importance, but in Middle Java near Kendal the damage on some estates is very important. In this same district rats are now and then very noxious, while more towards the west, near Pekalongan, the "badjing," a comparatively large rodent (*Sciurus notatus*), is so numerous that a steady fight is necessary.

The rats are more or less successfully killed by means of poison; by preference dead crabs treated with arsenic are used—the smell of the crabs seems to attract the rats.

In East Java, principally in fields situated at a short distance from the forest, pigs and a small species of deer, called "kidang" (*Cervulus muntjak*), are sometimes troublesome; in rare cases also a larger species of deer (*Cervus russa*).

When the fruit is healthy, not attacked by moth, 2500 to 3000 fruits are necessary to obtain 1 pikul

(60 kilog.) of marketable cocoa, or 40 to 50 fruits for 1 kilogram. Criollo and Forastero of fine type seem to behave about the same in this respect.

The Criollo is generally fermented during 1½ days, 2 days, or 2½ days; every day the cocoa is turned over once or twice.

The Forastero cocoa is generally fermented a little longer; but here also the methods are not always the same.

The washing also is done in different ways.

On one of the Criollo growing estates which makes a produce of a very fine quality the following method is used:—

First day: the cocoa is put in the fermentation box at about three o'clock in the afternoon. Second day: early in the morning it is turned over into the second box, in the evening it is turned over into the third box. Third day: the beans are washed in the morning, and in the evening they are put in fresh water and left there until the following morning, when they are washed again and dried.

Leaving the cocoa during a whole night in the water is necessary, in order to wash off the rest of the pulp which is still adhering in consequence of the short fermentation (1½ days).

When the Criollo is fermented one day longer, washing once is sufficient; but the longer fermentation gives a darker colour and often a less equable colour of the produce.

The following is the method more generally adopted: The cocoa is turned over either once or twice a day. Thus the cocoa placed in the afternoon of the first day in the first box, is turned over in the morning of the second day into the second box, the next morning into the third box, and is removed in the morning of the fourth day. It is well washed in running water, and dried.

The Criollo is always fermented in large open boxes in low heaps or layers. The temperature is not allowed to rise above 50° or 55° C.

The Forastero is often covered with bags during fermentation, which lasts $2\frac{1}{2}$ to $3\frac{1}{2}$ days, and is turned over once, or sometimes twice, a day.

Drying is done as far as possible in the sun (Fig. 126), and in drying houses, as described in Chapter VII. The temperature is on some estates kept at 55° to 60°, on others at 60° to 70°.

Sorting is always done carefully.

The Java cocoa has a feeble aroma, but some estates

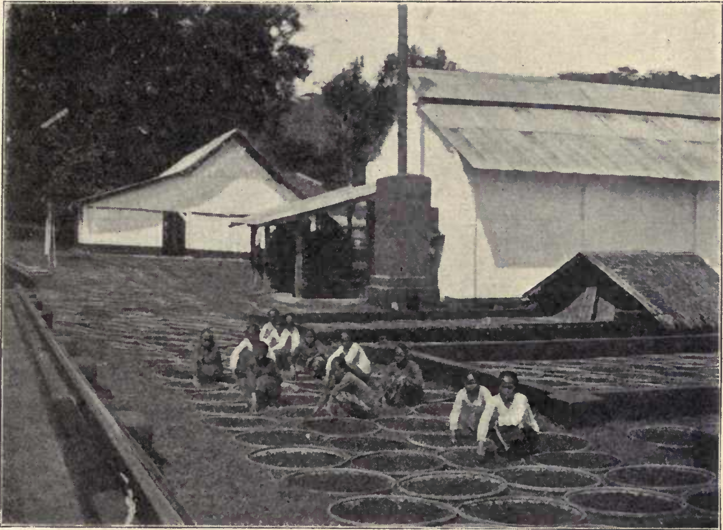


Photo. Roepke.

Fig. 126.—Drying cocoa on bamboo trays.

make a produce of rather a nice flavour. The bitter principle is little developed. Its main good quality, however, is its light colour. This makes it much in demand for mixing with other kinds of cocoa in order to obtain a light-coloured chocolate. For this purpose it is an advantage that its aroma and taste are feeble.

For the first quality high prices are paid (see Chapter X.), but much inferior cocoa is produced from the pods which have been attacked by moths.

All the Java cocoa is shipped to Amsterdam, and

sold on public auction by the brokers for each plantation separately.

The exports (in kilograms) amounted to :

Exports from Java

	Kilog.		Kilog.
1884	12,100	1905	1,030,100
1887	23,300	1906	1,815,800
1890	150,000	1907	1,750,200
1895	920,400	1908	2,278,200
1900	1,266,100	1909	2,367,300
1901	1,200,600	1910	2,478,900
1902	827,800	1911	2,360,300
1903	1,380,400	1912	2,033,400
1904	977,400		

From the other islands of the Archipelago the exports in the last twelve years were as follows :—

	Celebes.		Ternate.	Amboina.	Sumatra.		Bali.	Total.
	Makassar.	Menado.			West.	East.		
1900	9,300	58,407	2,285	6,190	...	...	...	76,200
1901	19,132	39,008	896	7,000	...	...	...	66,100
1902	3,500	51,783	444	6,355	95	...	...	62,200
1903	6,665	76,026	1,736	4,500	278	50	...	89,300
1904	5,351	27,684	292	6,078	200	135	850	40,600
1905	5,766	31,866	...	10,016	445	141	5,267	53,500
1906	493	24,976	124	8,088	360	...	...	34,000
1907	102	57,547	106	7,745	295	...	...	65,800
1908	...	70,890	75	295	1,588	...	...	80,500
1909	357	30,050	...	...	1,600	...	...	41,000
1910	580	39,032	...	...	2,650	...	250	48,400
1911	8,375	16,431	...	9,398	4,460	...	...	38,664
1912	14,012	34,604	...	10,248	5,030	...	...	63,894

XII. Jamaica

Cocoa was already cultivated in Jamaica at the time the English conquered the island from the Spaniards (1655). The industry experienced many ups and downs, and did not acquire a great importance.

The present situation of the cocoa industry has been obtained in the course of the last forty years; from

1875 up to the present time a gradual increase and extension has taken place, and the exports, amounting to about 20,000 kilograms in 1875, have steadily increased till 1912, in which year 3,400,000 kilograms were exported.

The exports were as follows :—

Year	Kilog.	Year	Kilog.
1894	650,000	1906	2,505,600
1898	1,000,000	1907	2,218,700
1900	1,200,000	1908	2,694,400
1901	1,350,000	1909	3,214,100
1902	1,525,000	1910	1,743,100
1903	1,696,700	1911	2,783,000
1904	1,650,000	1912	3,400,000
1905	1,357,600		

Though these figures indicate that the cocoa industry is not unimportant in Jamaica, the increase must be considered as slow. The position of the cocoa culture in this Colony was well described by Mr. Wm. Fawcett at the Agricultural Conference in Trinidad in 1905. Mr. Fawcett said :

The cacao industry in Jamaica is of considerable importance, although rather overshadowed by the banana industry. Therefore we do not look upon it as you do in Trinidad and Grenada, as one of our great industries ; it is rather a subsidiary industry in Jamaica : but I hope it will become in time one of our great industries. The reason why it has not advanced quicker is that the banana has been so very important. But now the planters, seeing the bad effects of hurricanes, are gradually beginning to plant their estates with cacao, and some have converted their banana estates altogether into cacao estates.

The increase in the cultivation of cocoa has been simultaneous with the extension of the banana industry. This industry is the most important of all in Jamaica, and the island owes to the banana the revival of its agriculture after the decline of the sugar industry.

In fields where the bananas have been cultivated for many years in succession, and do no longer yield a paying crop, interplanting with cocoa has often been successful. The bananas give a temporary shade to the

young cocoa, and are removed after some three years when the shade trees have grown up.

It must, however, not be forgotten that bananas, when planted for exporting the bunches, must be grown in a different way than when planted as temporary shade. In this last-mentioned case care must be taken that the shade is not too dense, and when the cocoa and the permanent shade trees get older, the bananas must be removed gradually. It seems that this has not always been done in Jamaica.

The planting, in time, of trees for permanent shade is another matter which has not always been practised in the right way. The absence of shade trees, at the time they are needed, is in Jamaica more prejudicial to the cocoa than in other countries, because strong winds are not rare, and even hurricanes occur now and then. Only in suitable and sheltered places can cocoa be grown in Jamaica, as in other countries, without shade, as on the north side of the island here and there.

The hurricanes make the question of shelter-belts of great importance.

The types of cocoa grown belong to the Forastero variety, as in all the other Antilles. Of the enemies, the borer is to be considered the worst; damage is also experienced from the black rot of pods and the canker disease.

In Jamaica the aversion of the negro and mulatto population to field work on plantations is the same as in Trinidad and in Guiana. The descendants of slaves who were imported in former centuries prefer to work hard during a few days of the week and rest the other days, rather than devote themselves to daily, regular plantation work. Though labourers are present in sufficient numbers, Jamaica has been obliged, like Trinidad and Guiana, to introduce British East Indians. The opportunity offered by the Panama Canal to earn high wages makes many of the natives emigrate. So we find in Jamaica, side by side, emigration of the black population and immigration of British East Indians.

Agricultural labour, however, is not everywhere deficient.[1] In the districts devoted to cattle-raising, and where land is very largely partitioned among small settlers, labour is at least equal to the demand. In areas where large sugar factories exist, and where fruit cultivation (especially banana cultivation) is carried on on a large scale, the deficiency in labour must be made up by immigration.

XIII. Cuba

From the beginning of the nineteenth century cocoa has been cultivated. The local consumption is important, and not until 1850 was cocoa exported. In 1857 the export amounted to about 491,000 kilograms.

Civil war hindered for a long time the development of the industry, which made again a fresh start about 1880. Since that time a slow and irregular increase has been noticeable; the highest amount was exported in 1906 (3,272,000 kilograms).

The fact that the sugar-cane cultivation occupies the chief interest of the planters may be a cause of hindrance to the development of the cocoa industry, but greater influences are certainly the irregularity of the seasons and the long periods of drought. The years 1907 and 1908 were in this respect very unfavourable, and the consequence was a decrease of the exports to 1,713,800 kilograms in 1907 and to 862,600 kilograms in 1908.

Cocoa is especially cultivated in the east and in the central parts of the island. The province Oriente is the most important cocoa district; next to it come the provinces Santa Clara and Camaguez.

The exports amounted to:

	Kilog.		Kilog.
1895	1,345,000	1902	1,875,000
1900	1,671,200	1903	2,540,100
1901	1,750,000	1904	2,697,000

[1] *Agricultural Labour Conditions in Jamaica*, by M. A. H. Miles, Collector-General (edited by the Association Internat. d'Agric. Tropicale) (1910).

	Kilog.		Kilog.
1905	1,767,700	1909	1,940,000
1906	3,272,000	1910	1,412,000
1907	1,713,800	1911	1,251,000
1908	827,000	1912	2,000,000

XIV. Haiti

Cocoa culture has been practised in Haiti for a long time. With Trinidad it is the oldest cocoa country of the Antilles. The Spaniards began to plant cocoa on this island in the sixteenth century.

But it would seem that Haiti was predestined to be visited by wars and revolutions.

It was the disturbed condition of the country after the war with France in 1664 that caused the first decline in cocoa cultivation; but later, on the exceptionally fertile soil, it was started again.

In the beginning of the eighteenth century—in 1716—a hurricane devastated the cocoa fields, as well as the houses; but gradually the culture was re-established, and at the end of the eighteenth century the export amounted to about 300,000 kilograms.

From that time the industry continued more or less successfully. Periods of gradual extension were followed by wars or revolutions, which devastated in a short time what had been built up by several years' work.

So in 1789 the export was reduced to 75,000 kilograms; gradually it increased till, in 1801, it amounted to 270,000 kilograms; in 1819 it was again reduced to 100,000 kilograms; but in 1824 the figure of 250,000 kilograms was reached. In 1828 it was reduced again to 37,000 kilograms. From this time a more regular increase began, as is shown by the following figures:—

	Kilog.		Kilog.
1836	225,000	1896	1,682,000
1843	350,000	1898	1,621,000
1858	728,000	1900	2,112,000
1862	871,000	1901	1,950,000
1880	1,365,000	1902	1,990,000
1894	1,000,000	1903	2,175,000

	Kilog.		Kilog.
1904 . . .	2,531,000	1909 . . .	2,122,000
1905 . . .	2,162,000	1910 . . .	1,851,000
1906 . . .	1,820,000	1911 . . .	1,485,000
1907 . . .	2,226,000	1912 . . .	2,000,000
1908 . . .	2,709,000		

The principal ports from which cocoa is shipped are Jeremie, Cape Haytien, Gonaives, and Port-au-Prince.

A few large plantations are in the hands of German planters, but most of them are small and belong to the negroes, who form the mass of the population.

The island could certainly be of much more importance from the cocoa point of view. It is considered to be very fertile, and all the natural conditions seem to favour the culture; but the incapable administration and the repeated revolutions have long since proved that the people cannot govern themselves. The export figures show that, though there has not been an important reduction of the crop during the last ten years, still a material increase has not been made.

As regards quality, the Haiti cocoa belongs to the inferior kinds.

XV. Fernando Po[1]

The introduction of the cocoa plant into Fernando Po—a Spanish possession—dates from the sixteenth or seventeenth century, but only towards the end of the nineteenth century did the cocoa industry begin to be of importance.

Cocoa is chiefly cultivated in the coast districts. In the interior no regular plantations are to be found, and the virgin forest is inhabited by the natives, who cultivate in a primitive way bananas and the oil-palm.

No large roças are to be found here as in San Thomé; the comparatively small plantations are mostly in the hands of Spaniards, Portuguese, German, and English planters.

[1] Chevalier, *Le Cacaoyer dans l'Ouest africain*, p. 209.

As in San Thomé the labour question is a difficult one. Formerly the natives of the Gold Coast and Lagos came in sufficient numbers to Fernando Po and made a contract for two years. But the Governments of the countries mentioned have checked this exodus, judging it better to have these labourers growing cocoa in their own country. At the present time the Portuguese and Spaniards employ principally people from Liberia and from the island of Bubis.

The methods of cultivation are about the same as in San Thomé.

The produce is almost entirely exported to the mother-country Spain.

The amounts exported were as follows:[1]—

	Kilog.		Kilog.
1902	1,198,600	1908	2,267,200
1903	1,499,000	1909	2,669,000
1904	2,010,800	1910	2,349,000
1905	1,862,900	1911	3,000,000
1906	1,557,900	1912	2,300,000
1907	2,438,900		

XVI. Surinam

Surinam is one of the old cocoa countries.

It is said that in 1684 Chevalier de Chatillon brought the first plants from the Orinoco Valley to Surinam, and in the beginning of the eighteenth century the first plantations were started.

The first exports were made in 1725. Gradually the exports increased and amounted to 180,000 kilograms in the middle of the eighteenth century, and to about 230,000 kilograms in 1790.

The first part of the nineteenth century was an unfortunate time for this colony, and, like other industries, the cocoa industry went backward. In the middle of the century, however, the cocoa culture became more important—partly in consequence of a large demand

[1] *Gordian*, February 18, 1910, and September 19, 1912.

from America, partly because of the decline of the sugar industry, causing several sugar plantations to be turned into cocoa.

From this time the area devoted to cocoa was gradually extended and the exports increased again, reaching in 1870 the amount of 500,000 kilograms, in 1880 about one million kilograms, and in 1895 about 4½ million kilograms (4,456,300 kilograms).

At that time the disease known as "witch-broom" ("krulloten ziekte") began to attract attention, and year after year the damage experienced was greater. The exports decreased, and in 1904 not more than 854,000 kilograms were exported. This was the most critical year; since then there has been an increase, the exports reaching in 1910, 2,042,500 kilograms. The exceptional drought in 1911 caused again a decline in 1911 and 1912.

The exact export figures are as follows:—

	Produced by the plantations.	Produced by the small proprietors.	Total amount of export.
	Kilog.	Kilog.	Kilog.
1893	2,788,000	701,000	3,489,000
1894	2,645,600	603,500	3,249,100
1895	3,166,100	1,290,200	4,456,300
1896	2,440,500	862,000	3,302,500
1897	2,829,200	753,000	3,582,200
1898	2,218,700	611,700	2,830,400
1899	3,395,800	464,100	3,859,900
1900	1,863,900	1,063,300	2,927,200
1901	2,384,000	779,400	3,163,400
1902	1,683,300	671,800	2,355,100
1903	1,353,500	861,100	2,214,600
1904	487,500	366,500	854,000
1905	916,400	765,400	1,681,800
1906	792,500	678,000	1,470,500
1907	912,000	713,200	1,625,200
1908	932,000	767,200	1,699,200
1909	1,143,200	754,300	1,897,500
1910	?	?	2,042,500
1911	?	?	1,565,000
1912	?	?	1,000,000

We may expect that the production will rise again, since a remedy has been found for the witch-broom disease. The conditions of soil and climate are suitable for cocoa culture, and before the witch-broom disease reduced the yield per acre to 30 kilograms or even less, cocoa-growing was a very paying business in Surinam.

In some respects, however, the conditions make the work in this colony more difficult than in other cocoa-growing countries.

Every one who visits Surinam for the first time is surprised to see plantations established on alluvial soil, near the sea and on sea-level, each plantation surrounded by a strong embankment, to protect it from being flooded, and provided with a wide system of draining canals.

Preuss wrote in his book:[1]

> In opening this country, the Dutch have accomplished an extraordinarily difficult and a splendid work. Perhaps no other people would have had the courage as well as the ability to drain the whole country by an extensive system of canals, and to protect it by means of strong embankments, with sluices, from being flooded by the sea or by flood-waters.

Indeed, this circumstance makes agriculture in Surinam a difficulty unknown in other countries.

All the plantations, with the exception of two or three, are situated along the rivers (Fig. 127): the greatest number is to be found along the Commewijne River; a good number are situated along the Surinam River, and a few along the Saramacca, the Cottica, the Nickerie and the Para Rivers.

These rivers are all broad and slow-flowing streams and subject to the tide-movement of the sea. The difference in height between high-tide and low-tide measures about 4 feet when neap-tide, 8 feet when spring-tide. With high-tide the level of the river is above the level of the plantations; with low-tide it is under this level.

It is therefore clear that every plantation must be

[1] Preuss, *Expedition*, p. 13.

surrounded by a strong embankment to prevent the water of the river flooding the cocoa fields at high-tide: an accident which would have very serious results, because the river-water is brackish near the sea, where the plantations are situated, and in time of drought even salt. The front embankment has to keep away the river-water, while it is the task of the back embankment (or "back-dam" as it is sometimes called) to keep away the bush-water or swamp-water behind the plantation, which rises in the rainy season to a

FIG. 127.—Plantation in Surinam (plantation "Vredenburg").

considerable height. When the rainfall is exceptionally heavy, a break in the back-dam sometimes occurs; this is always a serious thing, which needs immediate repair to avoid the loss of the low-lying fields.

The planter must therefore never forget to keep his embankments in good order. But a matter of still greater care, and which needs constant attention, is the drainage.

In these low-lying lands there is no natural drainage as in those countries where cocoa fields are situated on the slopes of the mountains, and the planter in

Surinam must get rid of the superfluous water by means of an elaborate system of canals (Fig. 128) which communicate with the river by means of a sluice (Fig. 129). The sluice is closed at high-tide; at ebb-tide, when the water is sufficiently low, the sluice is opened and the water flows from the plantation through the main canal into the river.

The soil is a very heavy clay soil of a compact

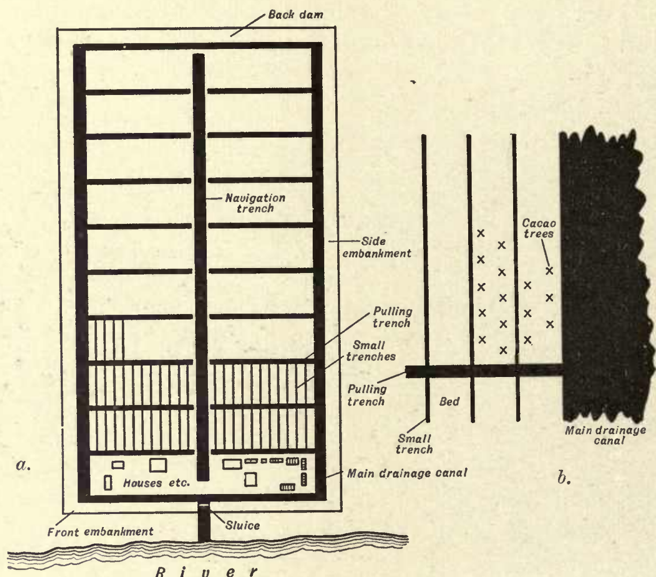


Fig. 128.—Scheme of a Surinam plantation, with its drainage system.

a. Scheme of the whole plantation.
b. Details of the drainage.

consistency. It slowly gives away the rain-water it has absorbed, and consequently the number of draining canals must be great. Generally the distance between two canals is not more than about 30 feet (10 metres); when the distance is greater, the centre of the bed between the canals is insufficiently drained.

Thus the whole plantation is divided into beds, about 30 feet broad, and separated by small drains about 3 feet wide and 2 feet deep, called "small

trenches" (Fig. 130). The small trenches are not allowed to be longer than about 150 metres; they end into a common canal (draining canal of the second order), generally 4 to 5 feet deep and about 5 feet broad, called "trekker," which means "puller"—this canal pulling the water from the small trenches into the main trench.

Generally the arrangement is as indicated in Fig. 128,

Fig. 129.—Sluice of the main drainage canal (plantation "Vredenburg").

The sluice is opened (drawn up) and the water is running under the sluice-gate to the river.

with a main trench running on each side of the plantation; the two main trenches meet behind the front embankment and run together into the canal in which the sluice is built.

As mentioned, the sluice is opened in the rainy season at every low-tide, therefore twice a day. When the rains are no longer heavy it is only opened when it seems necessary, and in the dry season the sluice remains closed all the time, and is even calked in order to prevent the inflow of river-water, which is very brackish at this

time of the year.[1] Often for the same purpose a dam is made behind the sluice in the main trench, which dam is removed when the rain comes.

Sometimes a large trap-door sluice is used, which opens only towards the river: when the river sinks, the water in the main trench thrusts open the door of the trap-door sluice and runs out; when the river rises again, it closes the door. Though these trap-door sluices do not need constant watching to be opened at

Fig. 130.—A small trench separating two beds (plantation "Susannasdaal").

low-tide and closed at high-tide, they cannot be wholly left alone, and special care must be taken that no drift-wood or waterweeds come between the sluice-door and the sluice, which would allow the brackish water at high-tide to run into the main trench.

It will be clear that the building of the embankment and the sluice, but still more the digging of the drainage system, means an enormous expense. For a plantation

[1] In *Bulletin No. 13 of the Department of Agriculture in Surinam* the Government analyst, Dr. Sack, gives figures of the amount of salt contained in the river-water of different rivers at high-tide and low-tide in the different months.

like the one in Fig. 128, this expense under present labour conditions may be estimated to be about f.36,000 (£3000), while the building of the sluice involves an expense of about f.12,000 to f.18,000 (£1000 to £1500).[1]

In the old time of slavery a great amount of work of this sort was done by the slaves, and the establishment of the plantations dates from that time. It is questionable if it would pay at the present time—even when we eliminate the influence of the witch-broom disease — to establish a cocoa plantation where the whole drainage system has to be laid out. But this is seldom necessary. The number of plantations, abandoned after the abolition of slavery, was comparatively large, and when one desires to start a new plantation it would be possible to obtain an abandoned one, which would have more or less useful portions of old embankments and drainage works.

Not only the establishment of the drainage system is expensive, the upkeep also requires annually a large sum, which has not to be spent in other countries where there is a natural drainage. For a plantation of some 300 acres this yearly expense is at least f.1200 (£100), including repair of sluices.

Against this drawback Surinam has compensations. There is a rich soil, which gives very fair returns and — a great advantage — easy means of communication along the rivers of the plantations with the port of shipment at Paramaribo.

All transport takes place along the river, and the tide-movement is of great use. Without any special

[1] For the reader who takes an interest in drainage works the following specification of labour expenses may be given here :—

DIGGING OF EMBANKMENTS AND TRENCHES FOR A PLANTATION OF 300 ACRES.

Front embankment (600 metres)	f.1,800
Side embankments (4000 metres)	8,000
Back embankment (600 metres)	1,200
Digging of the main trench (5200 metres long)	10,800
Digging of the navigation trench (2000 metres)	4,000
Digging of the pulling trenches	2,700
Digging of the small trenches	6,000
Total cost of digging work	f.34,500, or about £3000.

moving power, boats and even open punts can go to and fro to town, making use of the tide-movement of the river, going down the river with the ebb-tide and up the river with the flood-tide.

This makes the transport of the crop to Paramaribo, as well as the conveyance of implements and other goods from the town, very cheap and easy, and the cocoa-planter is in this respect in a much better position here than in other countries, where all the goods have to be carried by mule-carts to and from the plantation, often across mountains.

All the plantations are situated along the coast zone on the heavy clay, which is brought there by the sea. The origin of this clay is to be found in Brazil: the Amazon throws constantly an enormous amount of mud into the ocean, and the current which runs along that part of the coast of South America carries it to the coast of Surinam.

This sea-clay, which constitutes the soil of almost all the plantations—here and there a sand-ridge runs through the clay—is a heavy but a rich soil. In the rainy season it is very slippery, while it is very hard and cracks deeply in the dry season.

Of the many analyses one may be mentioned, made by Professor Harrison in Demerara. This soil can be regarded as being of an average constitution :—

Organic matters and combined water	15·452
Phosphoric anhydride	0·139
Sulphuric anhydride	0·047
Chlorine	trace
Iron peroxide	5·952
Alumina	16·076
Manganese oxide	nil
Calcium oxide	0·495
Calcium carbonate	nil
Magnesium oxide	1·071
Potassium oxide	1·072
Sodium oxide	0·258
Insoluble silicate and silicates	59·438
	100·000
Containing nitrogen	0·306

The chemical composition is remarkable for its very high amount of potassium oxide (about 1 per cent) and for the total absence of calcium carbonate (carbonate of lime). Also the high percentage of iron is remarkable. As regards the absence of carbonate of lime, attention has often been drawn to this fact, and it has been supposed that it may be the cause of various undesirable facts, as, for instance, the extraordinary stiffness of the soil, or the unsatisfactory growth of some crops, or the presence of diseases in the cocoa. But the addition of carbonate of lime or lime oxide has never had the effect expected. For the cocoa tree such an addition has always turned out to be quite useless. The cocoa tree seems to find in the soil enough lime in another form.

However this may be, the soil is certainly very suitable for cocoa-growing. For years and years cocoa may be cultivated on it without any manuring and without showing any decline in yield.

Moreover, manuring with chemical manures such as basic slag, superphosphate, gypsum, guano, has always had as little success as manuring with lime.

The stiffness of the soil and its little porosity allows the air to penetrate only to a rather low depth, and only the surface, to a depth of 2 feet or 2½ feet, is sufficiently aerated to be suitable for the growth of the roots of the cocoa tree.

Thus the cocoa tree has developed into a "surface feeder." The opinion expressed in so many handbooks that the cocoa tree needs a deep soil to develop its tap-root, is therefore not strictly correct. In rich soils the cocoa tree grows successfully with only a superficially developed root system. In Surinam a tap-root is only present in young trees.

Another thing which can be seen in Surinam is the remarkable amount of salt in the soil which a cocoa tree can stand.

Several small proprietors who have their grounds near the river are only partially protected against the

brackish water of the river: through the primitive sluices or through holes in the front embankment, often this water comes constantly into their cultivations. But nevertheless the cocoa grows well.

It must, however, be pointed out that in these places the cocoa is accustomed to grow in a brackish soil from its early infancy. When, however, in a regular, well-drained plantation, well protected against the river-water, brackish water enters accidentally into the cultivation, the cocoa tree, accustomed to grow in a soil with very little salt, begins at once to suffer.

The rainfall in Surinam amounts to about 2100 to 2300 mm. per annum. The average rainfall in the different months for eleven years (1899–1909) was as follows (in millimetres):—

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
220	182	221	240	316	293	219	142	70	66	122	220	2311

The months of May and June are always very wet, and in April and July sometimes the rainfall is also heavy; in August the rainy season gradually ends with a few heavy showers, generally accompanied by thunderstorms and heavy winds, while September and October are dry; in November rains begin to fall again, and in December the whole vegetation looks fresh, with new leaves as in spring-time. January till April is a very unreliable season. This is the coolest time of the year: the night temperature is sometimes as low as 20° C. (68° F.), and the climate in these months is delicious. In the dry season, however, it is generally very hot, the thermometer sometimes indicating 35° C. (95° F.) in the shade.

In the dry season the shade trees (the so-called "Koffiemama" or *Erythrina glauca*) drop their leaves —a useful habit, resulting in a very little evaporation of these trees and an inconsiderable absorption of water from the soil by their roots. Another good result is the

abundant flowering of the cocoa tree. From this time flowering goes on till the heavy rains come in May and June. The cocoa tree needs in Surinam about four months and a half to ripen its fruit; accordingly, the trees begin to bear about January or February, while the main crop generally comes in the months of April, May, June, July, while in the end of the year again a little is picked. But there are exceptions to this rule: on some plantations, for instance, the crop is always late, and the main crop is not reaped before June and July.

The following figures may give an idea of the amounts reaped in the different months. They indicate the quantities (in kilograms) sold to the local merchants:—

	1909.	1910.
January	12,100	12,400
February	24,900	15,600
March	61,400	36,800
April	126,400	295,800
May	624,900	336,000
June	568,300	500,900
July	229,000	354,300
August	95,300	165,400
September	59,200	76,000
October	36,600	82,700
November	32,500	89,100
December	23,600	77,400
Total	1,897,200	2,042,500

The number of the original inhabitants—the Indians—is so small that these people are of no significance from an economical point of view, and in old times an important slave-trade was necessary to import every year the number of slaves required for the plantations.

After the emancipation of slaves in 1863 the plantations had to look for other people to get the work done; for the negroes, now free, refused to work any longer in the fields.

An attempt to employ Barbadians and Chinese was not a success, and it was proposed to make a trial with British East Indians, who had already shown in Trinidad and Demerara to be good workmen. For this purpose the Dutch Government made a contract with the English Government, and an immigration law was established.

This immigration of East Indians—begun in 1873—has been in many respects successful; these people, good labourers, are diligent and very thrifty. The only drawback is that they are rather suspicious and easily upset. Murders are not rare occurrences among them, and more than one planter has been killed by his East Indian people, sometimes for trifling grievances.

In 1896 the Government began also to introduce Javanese labourers. These are in many respects superior to the East Indians. They have a natural instinct for garden work, and on the plantations they are splendid for all work which requires special care and skill, as, for instance, pruning, and collecting noxious insects. But also for clearing the forest the Javanese are very useful labourers. It is true that money is not such an important matter to the Javanese, and money cannot induce him, like the East Indian, to work day and night in case the manager thinks it desirable. It is, however, a great advantage to the planter to work with people not only quiet and easily satisfied, but also steady and skilled workmen. This is the reason why at present the Javanese immigrant is generally preferred to the East Indian.

The Government settled what is to be considered as a day's task, as well in digging work, forking of the soil, and weeding, as in all other work to be done on the plantation, and while the planter binds himself to pay to the immigrant or "contract labourer" for the day's task 60 cents (1 sh.), to give him a house, and medical help in case of illness, the contract labourer is bound to perform each day at least a day's task.

The control of the immigration, the treatment of

the immigrants on the plantations, the hospitals, and the houses, gives the Government in Surinam a lot of trouble, and is entrusted to a special Department of Immigration. In this way an absolute guarantee is obtained as well by the planter as by the immigrant.

This system has made agriculture possible after the emancipation of the slaves. It is true that the labour obtained in this way is not cheap, the building and upkeep of hospitals and houses and the nursing of the sick people require much money, but we must not forget that in many countries of South and Central America labour is still more expensive, and high wages have to be paid up to a dollar a day.

Some idea of the wages may be gathered from the following examples: for digging work about f.1 is paid per 3000 cubic feet, forking about f.15 per acre, weeding about f.4, hoeing about f.6, clearing the bush about f.16, clearing the virgin forest about f.32 per acre (f.1 = 1s. 8d.).

In one respect the East Indian is much superior to the Javanese: he is more successful as an independent labourer. After the expiration of the contract the Government gives many facilities to the men who want to remain in Surinam to settle as small proprietors. Many an East Indian has settled in this way and is now a successful small proprietor. The Javanese, however, have in this respect not the same skill and assiduity as the British Indians. But still a certain number of Javanese have latterly settled as small proprietors.

In bringing new land into cultivation, land is chosen by preference on which in old times coffee or sugar has been cultivated and which is covered with secondary bush ("kapoewirie"). Much of the old drainage system is still present in such fields, and this makes the digging work less expensive than when virgin land has to be cleared and all the small trenches and "pullers" and part of the main trench have to be dug.

The clay-soil, already described, is rather uniform, but nevertheless it is in some places more productive

than in others, and it is not everywhere of the same compactness. The presence of wild-growing plants belonging to the *Musa* family (family of bananas, etc.) is generally regarded as a proof of fertility, also the occurrence of certain palm species, as the "palisade palm" (*Euterpe oleracea*) and the royal palm (*Oreodoxa regia*), while other plants are regarded as indicating a less suitable soil.

When the forest has been cleared, the wood is arranged into rows running longitudinally in the middle of the beds, leaving at each side place to plant one or two rows of bananas or plantains, which are the temporary shade plants commonly used (Figs. 131, 132, and Fig. 36). Generally, the rows of wood are slightly burned; a too heavy fire is undesirable and spoils the soil.

Sometimes, however, one crop of corn (maize) is grown immediately after clearing the forest. Among small proprietors this is a general practice.

Formerly the plantain[1] was cultivated during a few years before the cocoa was planted. This was a very paying crop, because the plantain together with salt fish was *the* food of the people; the negroes cannot do without it, and not less than about f.1 (1s. 8d.) was paid for one bunch.

In those days the planter sometimes got, in the first years after clearing, a return from his plantains as remunerative as later from his cocoa.

The plantains were generally planted at a distance of 8 to 10 feet. But plantains cannot be cultivated during many years; after a few crops, generally after two or three years, the bunches begin to get very small. Before that time, cocoa and shade trees were

[1] As to the difference between the *plantain* and the *banana* there is sometimes some misunderstanding. It may therefore be pointed out here, that the plantain is the variety which is never eaten raw, but always boiled or baked in ripe or unripe condition; in several parts of South America the plantain is much appreciated by the people and always higher prices are paid for it than for the banana, which is eaten raw, more as a fruit than as a food. It is rather confusing that in Surinam the name for the plantain is "banaan" or "banan," while the name for the banana is "bacove."

planted between them, and, where it seemed necessary, the easily growing apple-banana or fig-banana was planted as temporary shade.

Plantain-growing, however, is no longer so paying as it was some years ago. The number of small proprietors has increased, and the plantains are no longer so scarce. Besides, the people are gradually using more rice for their food. Now not more than 15 cents (3d.) is paid for a bunch of plantains.

Fig. 131.—Young cocoa under temporary shade of plantains.

The field belongs to a small proprietor; the shade is rather dense; fruit trees have been interplanted.

At the present time the banana is more used for temporary shade than before. Since 1906 the "Gros Michel" or "Jamaica variety" has been grown for export of the fruits. This makes banana-growing more paying than it was formerly when the fruits had practically very little value, being only saleable on the local market (Fig. 132).[1]

[1] Since this chapter was written the banana industry has met with much difficulty in Surinam, in consequence of the so-called "Panama disease." At present (January 1914) there is no export of bananas of any importance.

Bananas are in one respect more suitable for temporary shade because they are easier grown than the plantains; they grow for many years without showing a decline in growth on the same field, while plantains begin to get weak, sometimes after having given only one or two crops.

This is especially the case when they have not been cultivated carefully, as often happens on the grounds of small owners; and here the drawback mentioned has

Fig. 132.—Cocoa just planted out between "Gros Michel" bananas.

often been badly felt. Often the plantain begins to decline rather suddenly before the shade trees have grown large enough to give sufficient shade. Sometimes also the small proprietor is careless, and waits too long before planting the shade trees (Fig. 133 and Fig. 37).

The consequence is that the young cocoa is left suddenly without shade; and this has often been the cause of the death of many young cocoa trees.

This fault is easily avoided when not only plantains are planted but also bananas; and it has been the object

of the Department of Agriculture to induce the small proprietors to plant not only plantains, but alternately a row of plantains and a row of bananas. When the former begin to decline, sometimes suddenly, and the shade trees are not yet big enough, the bananas are still there to protect the young cocoa.

For this purpose the banana already mentioned, namely, the "Gros Michel" or "Jamaica banana," is the most suitable on sandy soils; the easiest grower

Fig. 133.—A cocoa field belonging to a small proprietor.

The cocoa stands without sufficient shade.

on clay soils, however, is the so-called "apple banana" (called "fig banana" in the West Indian Islands).

The planters do not use any other plants for temporary shade than the plantain and the banana, the small labourer, however, using not only these two, but also cassava and tanias. This, combined with the fact that these people often plant the bananas and plantains too closely, results not seldom in a too dense shade which makes the cocoa grow up in spindling form.

Together with the cocoa the cuttings of the shade trees, the "koffiemama" or *Erythrina glauca*, are planted; large cuttings 3 or 4 feet in length are generally and successfully used for the purpose, and after three years the shade afforded by these trees is sufficient to replace the plantains or bananas.

Formerly the custom was to plant the cocoa closely, at 12 feet or sometimes less. But later 15 feet was adopted; afterwards 18 feet was considered a good distance, and there has recently been a tendency to make the distance still greater.

In this respect, however, there has been a reaction, and, without adopting the idea of the negroes, "more trees more cocoa," planters have seen that, though trees planted at distances of 18 to 24 feet may develop beautifully, the increase of production per tree under such conditions is not enough to give a higher return per acre. It is now estimated that the best results are obtained when the cocoa trees are planted at a distance of about 15 × 18 feet, or 18 × 18 feet, or 15 × 24 feet, while the shade trees are planted at a distance of 50 to 80 feet in the row, the rows being at a distance of 30 feet (one row of shade trees on each bed of 30 feet).

Sometimes plant-holes are made, but not always; and it seems not absolutely necessary. As previously stated, the cocoa plant in Surinam is a surface-feeder, and it must be so, because in the rainy season the water always stands at a high level in the soil. The roots cannot live in the deep layers, and therefore a deep loosening of the soil would be useless. But a superficial loosening is useful, and the covering of the soil round the newly-planted tree with fallen leaves and refuse of weeding improves the growth.

A system of regularly covering the soil round the young tree with banana leaves, as is done on the plantation "Susannasdaal," has very good results. It prevents the soil getting dry in times of drought, as well as getting stiff by heavy rains.

Planting at stake is generally done, but in most

cases the planter is prudent enough to keep a nursery in addition. When by unfavourable circumstances, for instance exceptional drought or an attack of mole-crickets, a number of young plants in the field do not succeed, the plants in the nursery are still there to fill the vacant places.

As shade one kind of tree is used, namely, the *Erythrina glauca*, which resembles the "bocare" of Trinidad (*Erythrina velutina*). The "bocare" is occasionally also to be found as shade tree in Surinam.

Erythrina glauca has been used for centuries as shade tree, formerly for the coffee, now for the cocoa; the name "koffiemama" (mother of the coffee) dates from olden times.

This tree is in many respects very suitable for the purpose. It grows easily in the compact clay soil and gives a splendid shade; it is not attacked by diseases or insect pests, which weaken it or render it sick or make it die. The big caterpillars which cover the tree almost every year, mostly in the months of January and February, cannot be regarded as troublesome; the result is only that the tree is leafless for some time, but very soon new leaves are put forth, while in the meantime the caterpillars have disappeared. At such times the soil is covered with the excrements of the caterpillars; and in this respect they certainly give a manure to the soil which is not without value.

The only trouble which the "koffiemama" gives, is the care which has to be taken to make the foliage system not too low and to keep it high. When the trees are young, the lower branches have to be removed, and the trees have to be systematically trimmed. When once full-grown, the branches which develop again on the stem or on the lower branches have to be removed regularly. This work requires skilful labourers, in order not to damage the cocoa trees by the falling branches, and for this work the best Javanese coolies are employed. It must be said that these people are remarkably handy at this work; they cut the

branches and make them fall so carefully that hardly ever any damage is done to the cocoa trees.

The "koffiemama" has also to be cleaned from epiphytes, especially so-called "wild pine-apples" (plants belonging to the *Bromelia* family). When this work is not regularly done, it not only gets difficult and expensive to have it done, but also the risk is run that the branches will break under the heavy weight of the epiphytes and damage the cocoa trees.

The arrangement of the beds 30 feet broad, separated by small trenches, and all planted with two regular rows of well-formed cocoa trees, gives the cocoa plantations in Surinam a regular and orderly appearance; besides, never more than one tree is allowed to grow in the same place, and watershoots are always removed; the trees make, therefore, an impression of being well cared for.

People who know how disorderly the appearance of cocoa plantations is in other countries, are always impressed by the regularity and cleanliness of the Surinam plantations. Preuss says,[1] speaking about Trinidad: "When the cocoa plantations in Surinam, which I saw, are compared with well-attended gardens, those in Trinidad may be really called 'plantations.'"

In Trinidad one finds here and there a forest tree, for instance sand-box trees (*Hura crepitans*), left standing in the cocoa fields. In Surinam, however, this is never the case; only the "koffiemama" trees, planted in one row on each bed, are allowed to shade the cocoa here.

Once the plantation is established, the field work consists in weeding, keeping the trenches clean and in good order, pruning, picking, and fighting the diseases and enemies.

Tillage of the soil is rarely done. Sometimes, however, when a field has suffered and the trees are in weak condition, the field is forked, leaving round the tree a circle of some 6 feet diameter unforked, and

[1] Preuss, *Expedition*, p. 180.

this manipulation is generally very successful, the trees appearing to appreciate the loosening of the stiff clay soil; sometimes the planter only forks the weak trees in his different fields. It would be too expensive to fork the whole plantation. Generally no tillage at all is done.

Weeding is done two to four times a year—according to the amount of shade. When the cocoa trees are full-grown and not planted too widely, the soil is so shaded that weeding twice a year is sufficient. In rainy months, especially in May and June, the weeds grow very quickly; in the dry season, however—September, October, November—the fields may be left unweeded for longer time.

In the most critical years of the witch-broom disease (1904–1905), planters had to be as economical as possible, the receipts being very small. In those years weeding as well as the other labour was reduced as much as possible, and the fields remained often half a year and longer in high weeds. When these weeds were of the "soft" or "harmless" sort—and these weeds are always prevalent on good soil under sufficient shade—the harm done was indeed much less than would be expected, and it was apparent how hardy a plant cocoa is and with what little care it will grow when soil and climate are suitable. On soils, however, where "hard" or "noxious" weeds (grasses, etc.) were prevalent—for instance on places with little shade—the bad effect of too little weeding was very apparent.

The heavy rains wash away earth and fallen leaves from the beds into the small trenches; every year a certain number of them have to be cleaned and deepened. Also the main trench has to be cleaned from water-weeds, which prevent the free flowing of the water when the sluice is open for drainage, and which make also the navigation with boats and little open punts difficult.

Pruning is considered by some planters to be absolutely necessary; many, however, do not remove

any twig or branch but the dead ones and the suckers (Fig. 134). So, as in most other countries, the

FIG. 134.—A cocoa tree about five years old, normally developed, unpruned.

opinions about pruning of cocoa are divided. Never, however, are suckers purposely left; and a second foliage system above the first one, as is found in Java,

is here never allowed to develop. Only when the tree is weakened or in bad condition—for instance, being damaged by worms or otherwise—one sucker at the foot of the tree is allowed to grow up in order to renew the tree. My opinion is that for many trees in Surinam a light pruning is useful. It improves its bearing power to keep the foliage system not too dense in the middle of the tree. It must not be forgotten that every tree must be considered individually and a single rule cannot be given, but in many trees in Surinam the natural growth tends to make the foliage system very dense and the removal of a part of the twigs in the centre of the tree seems to be useful (Fig. 135).

Picking is performed by means of the ordinary cutlass, and, for the fruits hanging at the higher branches, by means of a cocoa-hook of the form indicated in Fig. 63 *b*.

The variety most generally planted is the Amelonado, though here and there other Forastero types are to be found. Criollo, however, is nowhere present.

It may be that this fine variety, which is in many respects less strong than Forastero, would not be suitable for being planted on a large scale; most probably the stiff clay soil would not suit its requirements. In the Experimental Garden of the Department of Agriculture a few Criollo types were planted on a sandy soil; some strong trees were obtained, but the majority were weak ones.

Of the Forastero variety, however, many types are present. Most of them, however, belong to the Amelonado group. The most common type (Fig. 136, and Fig. 32, p. 92) is rather smooth and broad.

The types vary a little on different plantations. On some plantations a short Amelonado, a little pointed towards the apex (Fig. 137), is the most prevalent one; on other plantations the most common type has rather deep furrows, and resembles the Ecuador Amelonado (Fig. 138), or it is rather broad or rather smooth,

approaching the Calabacillo. Often the fruits are more or less "bottle-necked" (Fig. 139).

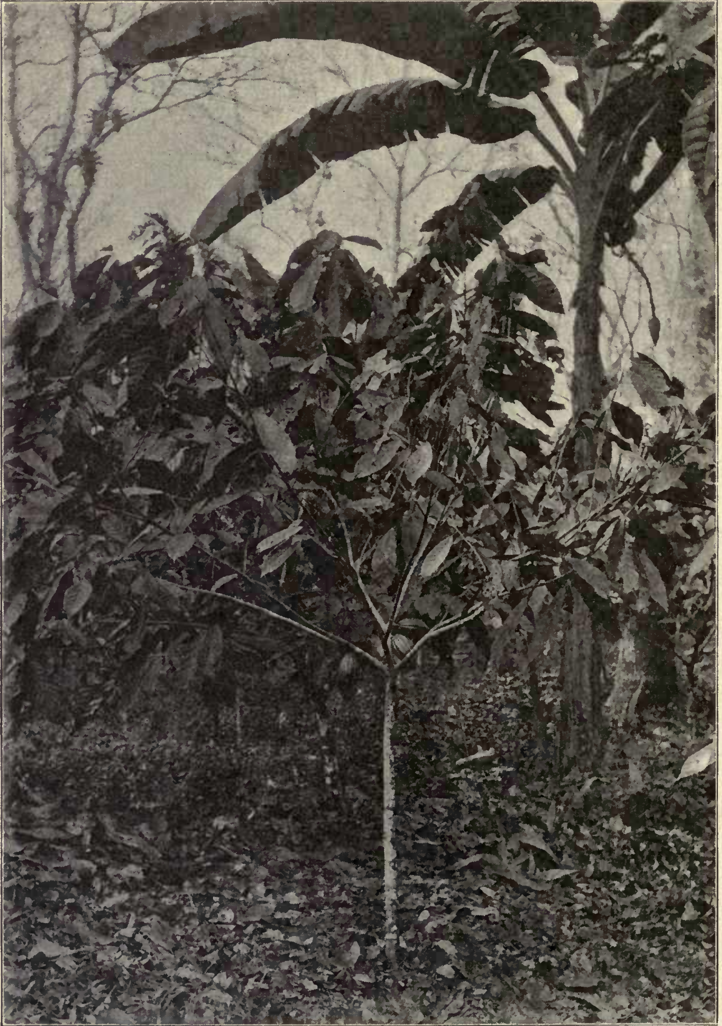


FIG. 135.—Cocoa tree three years old, pruned.

The average size of the type of fruits illustrated in Figs. 32 and 136 were as follows: length, 16 cm.;

diameter, 8½ cm.; weight, 559 gr.; weight of the seeds, 128 gr.; number of seeds, 41; weight of one seed, 3·1 gr.

Fig. 136.—The common Surinam Amelonado type (see also Fig. 32).

The seeds are dark violet and of a bitter taste, rather flat, as in most Amelonado types.

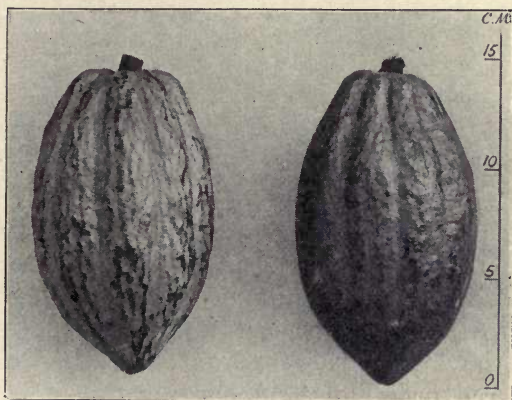


Fig. 137.—Another type of Surinam Amelonado.

Red as well as yellow types are present; neither is prevalent.

Besides, there are to be found other Forastero varieties, but they are not so general as the ordinary

Surinam Amelonado, and occur only occasionally here and there. Two may be mentioned; they are known by the local names "Caracas" and "Alligator," names which are both equally confusing.

The "Caracas" variety is an intermediate form between the Amelonado and the Angoleta type. The fruits are short, but longer than those of the Surinam Amelonado; the furrows are deeper, the surface is a little more warty. The colour is red. The name is very confusing, because this variety, with its flat beans, has nothing to do with the Venezuela Criollo which

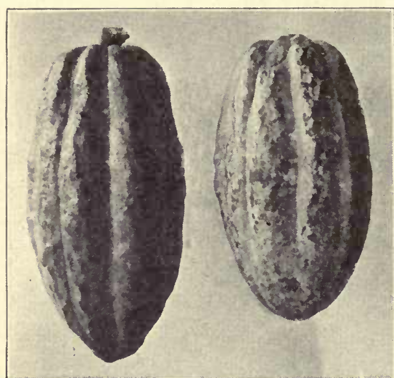


FIG. 138.—A Surinam Amelonado with comparatively deep furrows, resembling the Ecuador Amelonado.

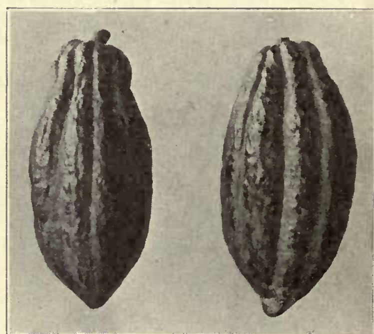


FIG. 139.—Two "bottle-necked" types of Surinam fruits.

gives the produce known on the market as "Caracas," and stands far away from the finer Forastero varieties cultivated in the coast region of Venezuela near Caracas.

The "Alligator" variety is more elongate, pointed towards the apex; the furrows are rather deep; the colour is red or yellow. According to the form of the fruit it is a Cundeamor type. The name of this type also is not appropriate, because the name "Alligator cocoa" is generally given to the *Theobroma pentagona*.

Up till recently no figures were given by the plantations to show the average production. Generally the yield per acre was considered to be very high, and

it was commonly assumed that 3 bags (300 kilograms) or more could be considered as an average. Recently, however,[1] figures were obtained of the total acreage of the plantations and the production.

These figures show that, in the time that the witch-broom disease had not reduced the yield as it has done lately, the yield per acre was a little more than 200 kilograms.

The figures are given below. It must be understood that they refer only to the plantations, and not to the grounds of the small labourers.

	Total surface of the plantations in acres.	Total production of the plantations in kilograms.	Yield per acre in kilograms.
1893	12,700	2,788,000	219
1894	13,302	2,645,600	199
1895	13,632	3,166,100	232
1896	13,675	2,440,500	178
1897	14,435	2,829,200	196
1898	15,041	2,218,700	147
1899	15,370	3,395,800	221
1900	15,230	1,863,900	122
1901	15,598	2,384,000	153
1902	15,750	1,683,300	106
1903	15,828	1,353,500	85
1904	14,677	487,500	33
1905	14,091	916,400	65
1906	13,874	792,500	57
1907	13,781	912,000	66
1908	13,481	932,000	69
1909	about 13,200	1,143,200	about 87

From 1899 the decline of the yield per acre, caused by the witch-broom disease, was very marked, but in the years 1896–1899 the production was also influenced by the disease. In 1904 it was reduced to the very low yield of 33 kilograms per acre! But all the figures from 1896 up till now must be considered as exceptionally low, and the normal average

[1] Van Hall en Drost, *De krullotenziekte der cacaoboomen* (*Bulletin No. 16 of the Department of Agriculture, Surinam*), pp. 39, 41; and *Proceedings of the Agricultural Society of Trinidad and Tobago*, December 1909, pp. 46, 49.

may be regarded as amounting to a little more than 200 kilograms per acre.

To the regular field work of the plantation belongs also the fight against pests and diseases (see Chapter VIII.).

One pest has to be combated on all plantations, namely, the larvae of the cocoa beetle (*Steirastoma depressum*). These occur during the whole year, boring channels through the branches and the stem. They have to be cut out with a knife. For this purpose a regular gang of trained grub-collectors ("wurmenzoekers") is employed, and after the close of the day's work these labourers have to show what they have collected. Sometimes they are paid simply by day-task, but sometimes they are paid per piece, or per weight of grubs collected.

As pointed out in Chapter VIII., not only the larvae but also the beetles are harmful, and to eradicate the pest not only the larvae, hidden in the wooden parts of the trees, but also the beetles have to be caught. These are flying from tree to tree, well protected by their greyish colour, resting here and there, gnawing at the bark of the young twigs, and the females depositing their eggs in crevices or holes of the bark.

In order to catch these beetles, the Javanese immigrants found out a handy method. They noticed that the bark of the wild "cotton tree," or, as the negroes call it, "cancantree" (*Bombax ceiba*), had a special attraction for the beetles, and on pieces of this bark attached to the branches of cocoa trees soon a certain number of beetles were to be found, apparently attracted by the odour of the bark. In this way a great number of beetles were easily caught.

There are different species of cocoa beetles, but by far the most common is *Steirastoma depressum* (Fig. 87), the larvae of which construct their channels rather superficially, at any rate not deep in the trunk of the trees.

In neglected fields this beetle causes an enormous damage, and its presence is at once visible by the great

number of dead branches, for it chooses by preference the place of insertion of small or large branches and, boring in several directions in the young wood and the bark of the branch, it practically rings the branch and kills it.

Especially in places where the cocoa has suffered from wind, from drought or otherwise, or where the growth has been rather weak, the trees are affected by another enemy, the *thrips.* Sometimes the trees attacked by these insects are to be found scattered here and there in the fields; often, however, rather large areas are attacked at the same time. The leaves get yellowish and fall off, and for some time the trees stand almost leafless. New leaves are made again; but when the thrips again attacks the new leaves, often the tree is much weakened and dies. This pest must have been present for some time in Surinam; before the cause of the disease was known planters called it "leaf-disease." The "leaf-disease" is nothing else but the "thrips disease," the same which damages the cocoa trees in several West Indian islands (Grenada, St. Vincent, etc.).

When the cocoa tree makes new leaves, the young leaves are often attacked by caterpillars belonging to a small moth of the family of Geometridae. Sometimes very little of the leaves, only the nerves, are left; but, though such an attack weakens the tree, the results are not serious.

The "parasol ant" exists in Surinam, as it does in all other tropical lands and islands of South America; but the damage done to the cocoa in Surinam is unimportant—unlike Trinidad, where the parasol ant is regarded as one of the worst cocoa enemies. In Surinam the nests found in the plantation are carefully destroyed by means of carbon bisulphide. The coffee trees, and especially the orange trees, also the mango trees, are preferred by the parasol ant to the cocoa tree; and while of the former sometimes a great number of trees are defoliated in one night, this is very seldom the case with the cocoa trees.

It must not be overlooked that the cocoa fields on the plantations in Surinam are shut off from the surrounding forests by the main drainage trenches which surround the plantation, and only by means of the few bridges or timbers access is obtained to the fields. When the planter therefore takes care to have no nests in his own fields, he is seldom troubled by parasol ants.

Young plants just unfolding the first few leaves above the cotyledons are often badly damaged by mole-crickets (*Scapteriscus*). These insects cut the young stem just above the soil; and it happens sometimes that of a whole field not a single plant is left standing. These insects (called "coti-coti" in negro English, which means "cut-cut") are very common, and their presence makes it always necessary to keep a nursery. For it is easier to keep them away from the nursery than from the fields, and when the plants have once attained a certain height they can be transplanted into the field without fear, for large plants are no longer attacked by the "coti-coti."

Of larger animals only the deer may be mentioned. These are sometimes troublesome, damaging the bark of old trees with their horns.

Among the fungus diseases may be mentioned the witch-broom disease (Figs. 84-86), the canker (Fig. 80), the die-back disease (Fig. 81), and the blackening of pods. These diseases have already been described in Chapter VIII., but a few words may be added here.

Towards the end of the last century the cocoa culture was gradually becoming more important in Surinam. Every year the acreage extended and the export increased. In 1895 the export reached a total of 4,456,300 kilograms, but in that same year the plantations in the Saramacca district began to suffer from a new disease, the witch-broom disease, which caused every following year greater losses, and in the years 1895 to 1900 the production of this

district decreased from 267,000 kilograms to 84,500 kilograms.

Gradually all the districts of the colony became infected. Along the lower course of the Commewijne and Surinam River, where most of the plantations are situated, the maximum production was obtained in 1899—2,292,000 kilograms; but in the following years a rapid and disastrous decrease was experienced, and in 1904 only 173,700 kilograms were obtained. This will give an idea of the calamity the witch-broom disease brought to the colony. Also the exports figures given on p. 433 show the rapid decline from 4½ million kilograms in 1895 and a little less than 4 million in 1899 to 854,000 kilograms in 1904.

The uncertainty whether it would be possible or not to combat the disease induced the Government to make a trial to establish a new culture. In 1906 about thirty plantations began to cultivate bananas with money advanced by the Government.

Though up till now this culture has not been a financial success, it has helped to save several plantations from being abandoned. The bananas were sold to the United Fruit Company, and every week the bananas were exported by special fruit ships to New York.[1] In the early years the "Gros Michel" variety was planted, but the serious disease (the so-called "Panama disease") which attacked this variety led to the planting of a more disease-resisting variety, the so-called "Congo" banana.

It is not impossible that the culture of the "Congo" bananas will be a success. If this could be obtained it would help to extend the area planted with cocoa, making the first few years during which the cocoa may be cultivated under shade of the Congo banana remunerative.

As explained in Chapter VIII., a method has been

[1] Since this chapter was written the United Fruit Company has discontinued the buying and export of bananas. At the present time (January 1914) there is no export of bananas from Surinam. Planters are busy with negotiations with other companies for selling their bananas.

found to fight the witch-broom disease. It has been shown that it can be combated by "cutting back" the branches, followed by spraying with copper-sulphate. This means that the future of cocoa-growing in Surinam may be regarded with more confidence.

The witch-broom disease is often accompanied with the "die-back" disease, caused by *Diplodia cacaoicola*, and in the last ten years the effects of this disease have been in a sense still worse. For, while the witch-broom disease caused a great loss of fruits and a great decrease of the yield, the result of the die-back was a loss of trees. And this amounted to such a high percentage in many fields that several had to be abandoned.

The table on p. 459 shows how the acreage on the plantations gradually decreased from 15,828 acres in 1903 to 13,481 acres in 1908. This is all the direct effect of the die-back disease and an indirect consequence of the witch-broom disease, for the loss caused by thrips is only very small in comparison with the loss caused by the die-back.

Of less importance is the "canker" disease. It appears only here and there in the fields, and seems to get disastrous only in times of heavy rainfall on plantations where the drainage or the embankments are not in order. In the rainy year, 1907, it was evident that the canker appeared as a serious disease only on some plantations along the Saramacca River, where the trees had been standing in the water for several days.

"Blackening of pods" occurs often when rain falls continuously with very little sun, as sometimes happens in April, May, or June. Against this disease, as well as against the die-back disease, the burying of fruit-shells after breaking would be a very useful thing, for both the *Phytophthora* and the *Diplodia* live on the shells. But this method is very seldom followed, and generally the heaps of shells remain unburied in the fields.

The pods are thrown into heaps by the pickers, and generally women perform the work of breaking or shelling, which is done by means of the ordinary cutlass. The beans are put into baskets, which are conveyed by boats along the main drainage trench or along the transport trench to the fermenting house.

First, however, the amount is measured in boxes, specially made for this purpose, 65 cm. long, 45 cm. broad, and 50 cm. high. Every inch in depth indicates an amount of fresh seeds of about 8 kilograms (yielding about 2½ kilograms marketable cocoa).

The beans are subjected in Surinam to a long fermentation, lasting from five to eight days. When the beans are subjected to a shorter and less thorough fermentation they remain leathery and tough instead of getting brittle, the seed-coat remains adhering to the cotyledons instead of being brittle and easily removed, while the colour of the seeds is brownish violet instead of brown.

For fermenting usually a special house is built provided with six or eight sweating boxes. The house is about 10 to 15 m. long and 3 to 4 m. high. Each box is about 5 to 6 feet broad, 6 to 7 feet deep, and 5 to 6 feet high, and is wholly made of timber; also the walls of the house are made of timber by preference of the "bolletree" (*Mimusops balata*), (Fig. 67).

The boxes are separated by double boards, which can easily be removed; the loose planks, forming the front of the boxes, can be drawn out, thus making it easy to clean the boxes when necessary.

The bottom of the boxes, which contains holes to let the fermenting fluid flow away, is, for this same purpose, inclined forwards; this is also the case with the part of the cemented floor of the house which lies about 10 to 20 cm. under the bottom of the boxes. In this way the fermenting fluid flows into an open gutter, made in the cemented floor of the house, along which it flows away.

The fresh cocoa-beans are put into box No. 1, and covered with fresh banana leaves. Generally the beans

are heaped up not higher than 3 feet. The next day, in the morning, the cocoa is turned over into box No. 2, and box No. 1 is cleaned, and thus made ready to receive the fresh beans from fruit picked that day.

So the cocoa is turned over every day into the adjoining box and picking can go on every day, when a sufficient number of boxes is present. The fermentation is considered to be complete on the morning of the fifth, the sixth, the seventh, or the eighth day. As fermenting never lasts longer than seven days and eight nights, not more than eight boxes are needed.

Generally, however, the fermentation is finished after four days and five nights, but under unfavourable circumstances it may last as long as seven days and eight nights. This is, for instance, the case when only a small quantity of pods have been picked (as happens in the beginning and at the end of the harvest), and also when the weather is dry. It will be clear that in small heaps the temperature does not rise so quickly and so high as in large heaps; but it is not well understood why in dry weather fermenting is slower in Surinam.

Drying was in old times only done by means of sun-heat, and for this purpose each plantation had large floors made of stone with cement. On these floors the cocoa was spread out in the morning and heaped up into large heaps at sunset till it was completely dry.

But as the main crop is reaped in the rainy part of the year (May to July), often much difficulty was experienced to get the cocoa dry, and in times of little sun and much rain it could hardly be avoided that much of the cocoa was lost by mildew.

An improvement was the establishment of large wooden trays (Fig. 72), moved on rails, which could be rapidly pushed under the cocoa-shanty or cocoa-house ("cacao-loods") when rain came. As soon as the rain ceased they were again pushed outside the house.

But this arrangement was sometimes unsatisfactory; though the cocoa was not wetted by rain there was sometimes so little sun that drying was too slow and

moulding occurred. Therefore artificial drying was started, and now almost all the large plantations are in possession of a drying apparatus. Most of them use a "Guardiola," and this apparatus has proved to work quite satisfactorily in Surinam; the drawback experienced in other countries, namely, the breaking and crushing of beans, when it contains an excessive weight of beans, is not felt in Surinam. It is admitted that

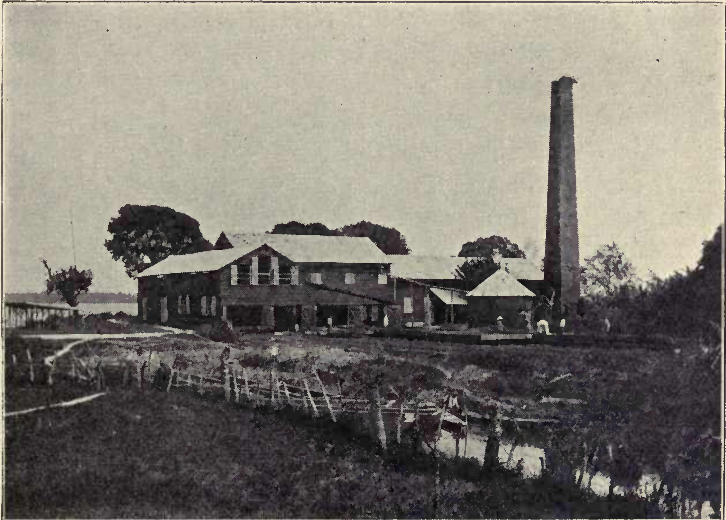


Fig. 140.—Building used for storing the drying waggons and the cocoa after curing (plantation "Susannasdaal").

The drying waggons may be seen outside the building. The tall chimney dates from the time when sugar was cultivated on the estate.

the produce dried in the "Guardiola" is of the best quality. Another apparatus, the "Huizer apparatus," is used on some estates. It dries quickly and perfectly, but it does not work so cheaply as the "Guardiola."

The arrangement of the curing establishment on the Surinam plantation is generally so that a house or shanty is always present (called the "cacao-loods"), which is generally a large building (Fig. 140) with a ground-floor and often a second floor; it contains on the ground-floor the trays on rails, and here is also room

for putting the cocoa into bags; it is generally used as store-house for implements, and sometimes a part of it is used as sweating room. Sometimes a special sweating room is present, separate from the cocoa-shanty.

On those plantations where no trays are used, always the large, old-fashioned drying floor is still present, adjoining the curing establishment.

Though several plantations are in possession of an apparatus for artificial drying, they use as much as possible the sun-drying, be it on the drying floor or on the trays. It is cheaper, and the produce is to be preferred when dried in the sun. But in very rainy weather the drying apparatus must be used.

In large rowing-boats the bags, containing 100 kilograms each, are brought from the plantation by the river to Paramaribo, and generally sold there to the merchant who ships the cocoa to New York.

It may be interesting to give here an estimate of the cost of production of cocoa in Surinam on a plantation of average size (300 acres), and producing the average of old times (630 bags of 100 kilograms or 210 kilograms per acre).

Such a plantation, when once established, will have yearly the following expenses:—

Field Work—

1. Weeding (f.5 per acre)	f.1,500
2. Pruning, destroying noxious insects, and fighting diseases (f.10 per acre)	3,000
3. Upkeep of the drainage system	900
4. Picking, fermenting, drying, making the cocoa ready for the market	2,400
5. Care of shade trees	300
6. Headmen and watchmen	1,200

Immigration Expenses—

7. Hospital expenses	900
8. Contract expenses (the repairing of the houses of the immigrants is included sub 11)	2,184
Carried forward	f.12,384

General Expenses—	Brought forward . .	f.12,384
9. Wages of manager and overseers		4500
10. Taxes		100
11. Repairing of houses, boats, sluices, implements . .		1500
12. Depreciation on buildings, etc.		2000
13. Diversa		616
	Total .	f.22,000

(f.1 = 1s. 8d.).

The produce being estimated at 60,000 kilograms, the cost of production of 1 kilogram may be estimated at about 37 cents. With a local market price of 60 cents this estate would make f.37,800 (£3000), leaving a net profit of f.16,000.

Of course the expenses vary on different estates; the above-mentioned expenses are rather low—the cost price on other estates may rise to 40 or even 45 cents.

The cocoa is generally sold to merchants in Paramaribo, who ship it mostly to New York; only a small portion is sent to Europe and sold in Amsterdam.

The prices paid by the merchants to the planter in the last few years were as follows:—

Prices paid locally (Paramaribo) for Plantation Cocoa
(in cents per kilogram; 5 cents = 1d.)[1]

Year.	January.	April.	July.	October.	Average of the whole year.
1901	74	75	75	72½	74
1902	72½	70	68	68	69
1903	67½	62½	60	64	65
1904	63	63	63	63	63
1905	63	61	60½	57	60
1906	55½	54½	55	72½	56
1907	90	87	93½	115	89
1908	92	80	65	60	72
1909	60	60	60	60	60
1910	54	54	54	54	54

The averages are made up for the whole lot of

[1] Taken from the local newspaper, *De West*, of February 10, 1911.

plantation cocoa bought by the merchants in the different years. For the cocoa of the small labourers a few cents less is paid per kilogram.

XVII. Belgian Congo

Belgian Congo is not yet an important cocoa country, but it may be regarded as promising.

The climatic conditions are considered to be quite suitable, and the Congo negro is well fitted for agricultural work.

Up till now, however, cocoa has not become a culture of the small proprietors. The negroes are working more in the forest at present, especially in collecting native rubber, a work to which they have been compelled by the Government. But it may be trusted that the Government will start another policy, and encourage the small proprietors to take up different cultures, especially cocoa, and to do it well.[1]

The exports have been :—

Year	Kilog.	Year	Kilog.
1901	4,000	1907	549,000
1902	16,000	1908	612,000
1903	89,000	1909	769,400
1904	231,000	1910	901,900
1905	195,000	1911	681,000
1906	402,000	1912	800,000

XVIII. Central America and Colombia

Central America is not only the country where the cocoa has been cultivated for centuries, but several sorts of *Theobroma* are found there growing wild.

This is the case with the "Cacao lagarto" (*Theobroma pentagona*), the "Pataste" (*Theobroma bicolor*), the *Theobroma angustifolium*, while also the ordinary cocoa tree (*Theobroma cacao*) grows wild in many places, though probably not spontaneously, it being probable that in olden times the Indians imported it from South America.

[1] Since this chapter was written, the Government has started this work.

Though these facts would seem to indicate that in Central America conditions were favourable for cocoa-growing, still in none of these countries has it become an important business, and only from Costa Rica a small amount is yearly exported.

On the other hand, though the export is very small and Central America does not play a rôle of any importance from a commercial point of view, the production for home consumption is not unimportant, the inhabitants of Mexico, Guatemala, Honduras, Nicaragua, and Costa Rica being large cocoa drinkers.

The demand for cocoa is therefore considerable in those countries, and especially for the home-grown produce.

The Central American people do not like the cocoa from abroad. The Ecuadorian cocoa, which is imported to satisfy the large demand, is regarded as decidedly inferior to the home-grown cocoa, while the fine chocolate- and cocoa-brands from Europe are not at all appreciated.

The people want the Central American cocoa, and by preference the produce of their own country. The Nicaraguan considers the Nicaraguan cocoa as being the best; the man in Mexico the Mexican cocoa.

High prices are paid for it on the local market—much higher than the produce ever could fetch on the European market.

Preuss[1] gives the following interesting figures of prices paid in 1900 on the local retail market in Managua (Nicaragua) for different Central American kinds:—

	s.	d.
1 lb. Nicaragua	1	8
1 „ Salvador	1	7
1 „ Soconusco (Guatemala and Mexico) . .	1	7
1 „ Cauca (Columbia)	1	5

These prices are certainly very high, but the Central American pays them, anxious to drink real cocoa. What we are consuming under that name would not

[1] Preuss, *Expedition*, p. 270.

be accepted as such by him. Only very little sugar is added to the mild Central American cocoas, while the European manufacturer is obliged to add a large amount of sugar to the comparatively bitter produce of Ecuador, Bahia, or San Thomé. In this way we get a produce in which the true cocoa aroma is concealed by the sugar; and Preuss may be right in saying that the Central American as regards cocoa is more discriminate than we Europeans are. Very little has been published about cocoa culture in these republics. The most valuable information is that contributed by Preuss in his well-known book.[1]

Mexico

The country where Europeans saw the cocoa tree for the first time, and from where the first cocoa was shipped to Europe, has not become an important cocoa country from a commercial point of view. Cocoa must be imported to supply home consumption.

The following are the important cocoa-growing states: Chiapas, producing about 1½ million kilograms; Tabasco, producing about 1 million kilograms; and the states of Vera Cruz, Guerrero, Michoacan, Oaxaca, Tepic, and Chihuahua, producing together about half a million kilograms. Besides 50,000 to 100,000 kilograms are yearly imported from Ecuador.

In Mexico it is considered that the best quality of produce is obtained in the state of Tabasco. According to Preuss, the variety which yields this produce is characteristic by its very large and heavy fruits, which have a green colour and get yellowish when ripe; the fruit-wall is very thick, the furrows are deep, the surface is warty. The seeds of this variety are not large, medium-sized, or even small, but quite round—not flat. The taste and the appearance of the marketable produce are good, but the aroma is not strong.

Consignments have now and then been sent to

[1] Preuss, *Expedition*, pp. 255-275.

Europe, and at first the merchants were very enthusiastic about its beautiful appearance; but the German manufacturers did not like it, and considered it to be of inferior quality on account of its lack of aroma and its grassy taste.

A cocoa well known in Europe, the Soconusco, has long been regarded as the produce of Mexico; it has the reputation of being very fine. It is, however, only for a small part—or perhaps not at all—a Mexican produce. In the district of Soconusco (in the state Chiapas) little cocoa is grown, and the cocoa of that name seems to come mostly from Guatemala.

Guatemala

Especially in the south-western part of Guatemala cocoa is cultivated. The natural conditions seem favourable, the rainfall is larger than in Nicaragua and San Salvador, and the soil very fertile.

Not only the different varieties of the ordinary cocoa tree, but also *Theobroma pentagona* grows into big, healthy trees.

The varieties of Guatemala, observed by Preuss, were all Forasteros, of different types—Cundeamor as well as Amelonado and even Calabacillo types, but all with round whitish beans.

It is generally fermented for one or two days, and afterwards washed.

The sweet taste and the light colour are in favour of the produce, but, like the Mexican Tabasco, the aroma is feeble. The opinion of European manufacturers about this cocoa was unfavourable; the insufficient fermenting and the feeble aroma made it unacceptable to European taste.

Preuss had the opportunity of seeing the culture in Trapiche grande and San Isidro. As shade trees all sorts of forest trees are left standing, among which the "Pataste" (*Theobroma bicolor*) is the most interesting. But also some trees are planted for shade, for instance,

the rubber tree (*Castilloa elastica*), and *Myroxylon Pereirae* (which yields the balsam of Peru). The *Castilloa*, however, is regarded with some distrust, because it is said to have a bad influence on the cocoa trees.

The best plantation, which Preuss saw, was the plantation of Aguná. As contrasted with other so-called plantations in Guatemala, the trees are planted here at regular distances (4 varas = about 3·3 m. or 11 feet apart); they are well cared for and are regularly pruned. Forest trees are left standing for shade. One tree, the so-called "Molinillo," was considered there to be very suitable; to Preuss, however, it seems to be a little doubtful whether this opinion is right or not; the growth of this tree is pyramid-shaped, and the branches are arranged in table form, as in the "tropical almond" tree (*Terminalia Catappa*).

In this plantation different varieties are grown, of which may be mentioned the red and the yellow Alligator cocoa, "Lagarto colorado" and "Lagarto amarillo" (*Theobroma pentagona*), and a variety which is much like the Nicaragua Criollo.

The fresh beans are put into a wooden box and are left here fermenting for one day. Next day they are spread out into the sun for a few hours, after which they are put again into the box and left fermenting for the rest of the day; the third day the same operation is done again. Finally, the cocoa is dried in the sun.

The cocoa is not washed at Aguná, as is otherwise the custom in Guatemala. This may be the reason why the aroma of the Aguná cocoa is stronger than that of other Guatemalan cocoa.

The production of Guatemala is estimated to be about 200,000 to 300,000 kilograms. About 50,000 kilograms are yearly imported from Ecuador.

Honduras and San Salvador

These two countries are of little importance as regards cocoa-growing.

In Honduras the cocoa from Gualan near Omoa is considered the best.

In San Salvador the culture has been wholly abandoned, but has been taken up again some twenty years ago.

The produce is treated as in the other parts of Central America; after one or two days' fermenting it is washed.

As in the Mexican and Guatemalan cocoa the taste of the San Salvador produce is sweet and the colour fine, but the aroma is very feeble.

Preuss[1] gives a description of a plantation near Sonsonate. He obtained the impression that cocoa could grow very well here and the cultivation would be a success. It had, however, been neglected for a long time. The varieties cultivated were again "Lagarto" (*Theobroma pentagona*) and another variety, much like Criollo. The beans are round but small, white or slightly violet. As shade trees were used: Chico Zapote (*Achras Sapota*), Zapota Mamey (*Lucuma mammosa*), Breadfruit (*Artocarpus incisa*), Mamey (*Mammea americana*), three kinds of *Inga*, etc.

No cocoa of any importance is exported; about 50,000 kilograms are imported yearly from Guayaquil (Ecuador).

Nicaragua

Nicaragua is the most important cocoa country of the Central American republics.

It is not only famous for its well-known Criollo, the Nicaragua Criollo, which gives the largest beans of all the cocoa varieties (see Chapter V.), but the methods of cultivation are more careful here than in the neighbouring republics.

A few comparatively small plantations are situated near the little town of Grenada (Nicaragua Lake), but the best-managed are near Nandaime (Pacific coast). The plantations "Valle Menier" and "Las Mercedes"

[1] Preuss, *Expedition*, p. 266.

may be mentioned especially. The first plantation belongs to the well-known French manufacturer, Menier, the last-mentioned one to a Hamburg firm.

When one arrives in this country in the dry season it gives an impression of being so dry and windy that it can hardly be understood how cocoa can be grown here.

From the north or north-east the strong, dry wind is blowing. This disagreeable wind is prevalent during the dry season in the whole of Central America. Even during the night it does not give way. The roads are dusty. The thick layer of dust on the leaves shows that rain has not fallen for a long time, and the atmosphere does not give the impression that rain may be expected soon. The whole vegetation, with the many thorny acacias and the hedges made of gigantic representatives of the cactus family, shows that the yearly amount of rain must be very small.[1]

The dry season lasts from November till May. The whole amount of rain is estimated to be no more than 1800 mm. (45 inches).

Cultivation is only possible here by means of irrigation. In order to keep off the wind, the plantations are wholly surrounded by rows of closely-planted mango trees, and also along the roads in the plantations mango trees have been planted.

Shade trees as well as cocoa trees are kept low; this gives a dwarfed appearance to the fields. The number of shade trees used is large: sometimes one shade tree is planted to every cocoa tree.

On the Atlantic coast, however, the region is not so arid and the rainfall is greater. This part of Nicaragua seems therefore to have a more suitable climate.

The following kinds of trees are used in Nicaragua as shade trees: "Madre de cacao" or "Madera negra" (*Gliricidia sepium*); "Quelite" (a kind of *Jatropha*), which gets not higher than 4 metres; "Elekeme" (*Caesalpinia exostemma*) and two kinds of Erythrina, one of which, called "Pito," is a small tree much like

[1] Preuss, *l.c.* p. 261.

Erythrina corallodendron,[1] while the other seems to be identical with the "Anauca" of Trinidad (*Erythrina umbrosa*). Also the "Pataste" (*Theobroma bicolor*) is used as a shade tree.

Chiefly planted are the "Lagarto" (*Theobroma pentagona*) and the "cacao del pais" or Nicaragua Criollo, both cultivated here since memory of man. Besides, the "cauca," a Forastero variety from Columbia, and other Forastero varieties from Trinidad have been imported; they have been planted out at the plantation "Las Mercedes."

The advantages and the disadvantages of the two first-mentioned ones and of the imported varieties ("cacao estrangero" = cocoa from abroad) are the same as the advantages and disadvantages of Criollo and Trinitario (or Forastero) in Venezuela.

The quality of the "cacao del pais" (which name includes often "lagarto" and "Nicaragua Criollo") is superior to the quality of the "cacao estrangero," but the growth of the imported Forastero varieties is so much quicker, the bearing power and the resistance against diseases is so much greater, that in many cases the "cacao estrangero" will have the preference. This is especially the case when old fields of "cacao del pais" have to be supplied.

In the plantation the two groups are always kept separately, as well during fermenting and drying as for selling.

In Chapter V. the Nicaragua Criollo has been described. This type is doubtlessly a Criollo, and belongs to the same Criollo group as the Venezuela Criollo, but it takes a place apart. Very characteristic of this type are the large seeds—larger not only than in Venezuela Criollo, but even larger than in any other variety.

The produce of this "cacao del pais" is considered in Central America to be the finest of the world, and

[1] Preuss mentions that the buds are eaten as salad and have a strong narcotic effect.

as much as 1s. 8d. per lb. is paid for it on the local market. The European manufacturers, however, would not pay so much, considering again the aroma and the taste as being too feeble.

In some respects the culture cannot be said to be backward, and the irrigation is especially worth consideration. The water is conducted into small canals made of cement, which bring it to the different parts of the plantation. From these canals the water is allowed, when necessary, to run into the shallow irrigation trenches, of which one is present for each row of cocoa trees.

The pruning is also done with care, but the picking is effected in a very primitive way, the fruits being simply twisted off by means of a fork-shaped instrument fixed on a pole of wood.

The "cacao del pais" is generally fermented during two days, the "cacao estrangero" at "Valle Menier" during four to five days. Washing is not done.

About 30,000 to 50,000 kilograms cocoa is yearly imported into Nicaragua from Guayaquil (Ecuador).

Costa Rica

Though the cocoa tree seems to grow well in Costa Rica, along the Atlantic as well as along the Pacific coast, the culture has no great importance.

Most cocoa is cultivated along the Atlantic coast, where the climate seems to be the more appropriate, on account of its larger rainfall.

A good class of produce is obtained from Matina, near Port Limon.

The Government of Costa Rica is anxious to encourage the culture of cocoa by affording premiums, but apparently without great success.

Still, a small quantity has been exported during the last decennium; the exports in 1906–1912 amounted to :

	Kilog.		Kilog.
1906 . . .	176,000	1910 . . .	184,000
1907 . . .	278,000	1911 . . .	343,000
1908 . . .	340,000	1912 . . .	400,000
1909 . . .	235,000		

Colombia

In Colombia cocoa culture is on a moderate scale; but it is of no importance from a commercial point of view, as almost all the cocoa is consumed locally and very little is exported.

It has been estimated that about 12,000,000 lbs. are used for home consumption, the number of inhabitants being 4,000,000, and the consumption per head 3 lbs.[1]

As an example how popular cocoa is, it may be mentioned that the servants are paid not only in wages but also in a fixed ration of cocoa per day.

In several districts cocoa is cultivated, for the greater part in small fields not larger than a few acres. These are to be found over the whole country, especially along the Magdalena River, above Honda; in the whole Cauca Valley, in the Sinú Valley, and in the neighbourhood of Santa Marta, where the bananas are the main culture.

The produce is mostly made into chocolate by the inhabitants themselves, not in large factories. A few factories exist in Carthagena and Bogotá.

The produce of the Cauca Valley is well known also on the European market, though only small lots arrive here now and then. The great drawback, however, of this part of Colombia is its situation so far away from the port (Buenaventura), and the cost of transport to the port is so high that it hinders the extension of the cocoa culture in the Cauca Valley.

Along the Atlantic coast conditions are better; especially near Rio Frio an extension of the cocoa culture may be expected.

[1] Jumelle, *Le Cacaoyer*, p. 144.

Cocoa is also cultivated in the provinces Bolivar, Magdalena, near Santander, and in the Tolima district.

In this last-mentioned district the rainfall is small and irrigation is applied. The produce obtained here is of the finest quality. It is wholly consumed in the country itself.

The export is insignificant. Exact figures are not available, but it may be estimated that no more than 300,000 to 400,000 kilograms are exported yearly, mostly to France.

XIX. Peru and Bolivia [1]

Cocoa is cultivated in Peru and in Bolivia, but to a very small extent. Exports of any importance are not recorded.

In Peru cocoa is cultivated principally in the zone, called "La Montana," situated between the chain of the Andes and Bolivia. The "cacao de Cuzco," obtained in this district in the valleys of the Urubamba and the Paucartambo, is said to be of high quality. This cocoa, however, does never come to Europe, the means of communication with the coast being too difficult.

Sometimes a small amount is exported of the product, obtained near the coast in the north-western part, near Piura and Lambayeque.

In Bolivia the cocoa plant is found in the forests and is used by the natives.

[1] Jumelle, *Le Cacaoyer*, p. 154.

CHAPTER X

COMMERCE

Some Characteristics of the Marketable Bean

The chemical constitution of the marketable bean has already been discussed in Chapter III.

A few words may now be said about the general and microscopical texture.

In the marketable bean the seed-coat and the kernel or embryo are easily recognisable. When well prepared (fermented and dried) the seed-coat is quite free from the kernel; it surrounds it as a thin, very brittle, free cover.

In some kinds of cocoa, especially the varieties grown in Western Venezuela ("Caracas," "Porto Cabello," "Maracaibo") and sometimes also in the Trinidad cocoa, the seed-coat is covered with a very thin layer of red earth. In other kinds of cocoa the seed has a very clean appearance, as in well-washed Java cocoa and in good quality Ceylon. Of many sorts, however, and among them the fine, high-priced Ecuador cocoa, the appearance is not good, the colour is uneven, and shows that little care has been taken in fermenting and curing.

The kernel in a well-prepared bean is always very brittle. The colour is light brown in some of the finer sorts, as in the cocoas of Western Venezuela, Ceylon, and Java; in most sorts, however, it is dark brown or reddish brown, sometimes with a slight violet tinge.

Generally the dark sorts have a bitter taste, while the lighter coloured are generally sweeter.

Not only in appearance, but also in fragrance and aroma, each sort has its own character.

The finest sorts, as "Caracas" and "Porto Cabello" (Venezuela) and "Arriba" (Ecuador), have a distinct and pleasant chocolate-aroma, but in most other sorts, and especially in the more ordinary ones, this aroma is wholly, or almost wholly, concealed by the acid odour of fermentation, or, more correctly, of acetic acid.

In this book there is no space for the description of the microscopical characters. It will be sufficient to refer to special books, in which this subject is treated.[1] Only one well-known microscopical character may be mentioned here, the so-called "corpuscules of Mitscherlich."

The outer cell-layer, the so-called epidermis, of the seed-lobes shows under the microscope little multicellular outgrowths or trichomes, which are more or less club-shaped, while the contents of its cells are dark coloured. These "corpuscules of Mitscherlich" are so characteristic for the cocoa-seed, not occurring in any other vegetable produce, that they are of great use in detecting whether or not a certain material contains cocoa.

The most important Commercial Cocoa-Sorts

In Chapter IX. the several cocoa countries were dealt with, and a few observations were made about the produce of each one.

Here the different commercial kinds of cocoa may be treated a little more in detail.

Ecuador

This country produces the three important commercial sorts: "Arriba," "Balao," and "Machala," and the less important "Manabi." "Arriba" is by far the

[1] Zipperer, *Die Schokoladen-fabrikation*, p. 11; Schimper, *Anleitung zur mikroskopischen Untersuchung der Nahrungs- und Genussmittel* (Jena, 1886).

most important, as annually 20 to 27 million kilograms come to the market; of "Balao" and "Machala" about 5 to 6 and 2 to 3 million kilograms; of "Manabi" about 1 to 2 million kilograms.

Finally, a fifth sort, called "Esmeraldas," comes also from Ecuador. This is good, if sound, which it seldom is; but the quantity is small.

Of the other more important market sorts, "Arriba" is the finest in quality. It is produced all through the year, but the regular crop is from March to June, when the cocoa attains its finest quality and is quoted in the European markets as "prime red summer Arriba." It is principally sent to Europe. A little goes to England, but the largest part is shipped to "Havre for option," and of this the greater part goes to Germany and Holland.

"Balao" comes in principally from May to October, but mostly in September and October. It is considerably inferior to "Arriba." This cocoa is principally consumed in Spain.

"Machala" is, like the other two mentioned, to be obtained the whole year round. The price varies according to the quality, but generally it is a little lower than "Balao." The cocoa is in good demand both in Germany and the United States.

The "Esmeraldas" comes from the province of that name.

The appearance of Ecuador cocoa generally is not very good. The beans are flat and irregular in form, and not of equal colour. In section the beans appear to be darker at the outside and more light-coloured in the centre, a consequence of the slight and incomplete fermentation. The skin of "Arriba" is a little lighter coloured than the skin of the other sorts.

The aroma of the "Arriba," especially of "summer Arriba," is fine, and the typical flavour of chocolate is clearly perceptible. In a less degree this is also the case with "Machala" and "Balao."

The taste of "Arriba" is rather sweet. Of the

other marketable sorts the bitter principle is a little more developed.

It must be mentioned, however, that the quality of "Arriba," especially of "summer Arriba," has not been improving in the last few years. It is to-day often claimed that the flavour and taste are no longer what they were formerly. The cause by some is said to be the same as in Venezuela—the planting of inferior varieties.

This opinion is not correct. Some time ago Venezuela seed was tried in Ecuador in the Arriba districts, but the entire production resulting from the trees does not amount to 1000 quintals per annum, and cannot possibly influence the quality of the 590,000 quintals which the crop reaches.

The average measurements of the "Arriba" beans are: 24 mm. long, 15 mm. broad, 6 mm. thick; weight of one seed, 1·75 gr.; of "Machala": 22 mm. long, 13 mm. broad, and 5 mm. thick; weight of one seed, 1·17 gr.[1]

Brazil

"Bahia cacao"[2] is the most important cocoa of Brazil.

The produce has little uniformity, and shows great differences in quality. When well prepared, Bahia cocoa fetches a rather good price, but is always much lower priced than Ecuador cocoa, and also than Trinidad cocoa, which both belong to the "fine" sorts, while Bahia is one of the best "ordinary."

Speaking generally, Bahia cocoa competes with Samaná and San Thomé cocoa, but is generally regarded as slightly superior, and accordingly a little higher priced. Much of the Bahia cocoa goes to Germany, England, and France.

The other important Brazil cocoa is the "Para" or

[1] These figures and those of the other sorts of cocoa are taken from the book of Zipperer, *Die Schokoladen-fabrikation.*

[2] This "Bahia" must not be confounded with the "Bahia-cacao" of Ecuador, which is better called "Manabi," or Bahia de Caraques" or "Caraques," to avoid confusion.

"Para Maranhão," of which yearly 3 to 5 million kilograms come to the market. It is of better quality and higher priced than "Bahia." Most of the "Para" goes to France.

The taste of "Bahia" is bitter. The colour is dark brown, with a violet tinge, at the outside almost black. The beans measure: 23 mm. long, 14 mm. broad, 4 mm. thick; average weight, 1·2 gr.

"Para" has seeds of a dark reddish colour; they are not so flat as those of "Bahia."

San Thomé

This cocoa with "Bahia" is the most important representative of the "ordinary" sorts. The exports have reached about 35 million kilograms.

The market prices vary considerably according to the preparation, which is generally given with good care. The best "San Thomé" fetches generally a price a little lower than the best "Bahia" and little higher than the best "Samaná."

Up till lately a great deal of San Thomé cocoa went to English manufacturers. As mentioned in Chapter IX. a combination of important English cocoa manufacturers decided to boycott the San Thomé cocoa, because they had philanthropic scruples as to the way in which the labourers were contracted for and treated in San Thomé. The object was to induce the San Thomé planters to change their labour system.

The result, however, has been that the cocoa of San Thomé now goes to other markets, principally to Germany and Holland, and also to America.

Trinidad

The Trinidad cocoa is one of the fine sorts. It ranges immediately after the best Ecuador.

Besides, the produce of the plantations is very uniform.

The beans are large, broad, and more or less flat—at any rate not quite round. The colour is dark brown. The average figures are: 25 mm. long, 18 mm. broad, 4 mm. thick. The greater part is "unclayed," or slightly only.

Venezuela

The country produces the commercial sorts known as "Caracas," "Porto Cabello," "Maracaibo," "Carupano," and "La Guayra."

The three first-mentioned are the very finest sorts which come to the market. They are grown in the eastern part of Venezuela, and shipped from La Guayra, Porto Cabello, and Maracaibo. "Porto Cabello" and "Maracaibo" are higher priced than "Caracas," and a small quantity fetches fancy prices.

The very superior brands, however, which are produced in Venezuela, appear on the market in small lots.

The beans are nearly always treated with red earth ("clayed") to avoid moulding. This gives them a light reddish-brown or dark-orange appearance.

The size of the beans is large. They are not flat, but round and large in diameter. The interior colour is light reddish brown, lighter than other sorts with the exception of Javas and Ceylons; the taste sweet (bitter principle very little developed); the aroma strong and pleasant, chocolate-like, and nutty.

The average figures of "Caracas" are: 23 mm. long, 15 mm. broad, 8 mm. thick; weight of one seed, 1·77 gr.; of "Porto Cabello": 24 mm. long, 15 mm. broad, 8 mm. thick; weight of one seed, 1·25 gr.

A great part of "Caracas" and "Porto Cabello" goes to France and Spain.

"Carupano" is the produce of the eastern part of Venezuela, especially of the Orinoco Valley. Its quality is much less fine than of the Venezuelan sorts mentioned above. It has flat beans, of a dark colour and a bitter taste. The size is much smaller than of the beans of

"Caracas" cocoa. They are not clayed, and are more like Trinidad in quality.

The export of the three principal different harbours amounted to:

	La Guayra ("Caracas").	Porto Cabello.	Carupano.
	Kilog.	Kilog.	Kilog.
1908	5,700,500	3,414,700	4,098,000
1909	8,240,100	2,113,500	4,238,800

San Domingo

This cocoa is known under the name "Samaná" or "Samaná Sanchez." The harbours from which it is shipped are Puerto Plata, Sanchez, Samaná, and Santo Domingo. Though the produce bears generally the name of the port Samaná, this is not the most important. At present Sanchez and Santo Domingo (harbour) ship the greatest part.

The produce now belongs to the most ordinary sorts, and is often used by the manufacturers for mixing with better sorts for the manufacture of cheap chocolates.

This cocoa shows very little uniformity, and the prices differ greatly according to the manner of preparation. Taken as a whole it is lower priced than ordinary "Bahia" and ordinary "San Thomé."

Gold Coast

The "Accra" cocoa is as yet one of the most ordinary and lowest priced sorts. Only Haiti is still lower priced. The inferiority is mainly due to the fact that it is wholly obtained from small growers; the fermentation and drying are therefore generally primitive, and there is no uniformity.

But of late a great improvement is perceptible, and with improved communication from the interior to the shipping ports the large amount of "country damage"

is decreasing greatly. For well-fermented lots it now ranks in value along with "Bahia," and on account of the enormous increase of the crop it is much in demand to-day.

Grenada

Grenada cocoa belongs to the fair cocoa sorts.

It remains always slightly lower priced than Trinidad, and may be compared with Surinam and Carupano. The beans are smaller than those of Trinidad, and the taste is rather bitter.

Ceylon

Well-prepared first quality "Ceylon" is a fine sort, which fetches a high market price—higher even than the Ecuadorian "Arriba," and not much less than "Caracas."

But not all the "Ceylon" is first quality. The produce is very different, and much inferior Ceylon cocoa comes into the market.

The aroma is not strong, and in this respect it is much surpassed by the fine American sorts, like "Porto Cabello," "Ecuador," "Trinidad," etc., but the appearance is very pleasant. The bean is rather round (not flat) and light coloured; the skin is smooth and uniform (greatly a consequence of careful washing).

Average figures: 20 mm. long, 12 mm. broad, 7 mm. thick; average weight, 1 gr.

Java

Java cocoa has a close resemblance to "Ceylon." The beans are generally a little larger and rounder; the colour is lighter.

Average figures: 23 mm. long, 12 mm. broad, 9 mm. thick; weight, 0·8 gr.

The first quality Java is high priced; it has large beans of a good appearance and very light colour. Much of the Java cocoa, however, is second-rate, or

even very inferior. This is almost wholly in consequence of the attacks of the "cacao-moth," the enemy which causes every year enormous losses, and makes the pods either totally worthless or spoils the beans. These injured beans are also fermented and cured, but yield a produce of inferior quality.

Jamaica

Jamaica cocoa belongs to the better sorts, but the produce is not very uniform, and the quality is not quite equal to Trinidad, although much like it.

Surinam

The same can be said of the quality of Surinam cocoa. This produce, however, is very uniform. Very little of this sort comes to the market. Almost the whole crop is sold to local merchants who are agents of special American manufacturers.

There are, generally speaking, only two qualities: plantation cocoa and the produce of the small proprietors. The plantation cocoa is very uniform; the bean is flat and dark coloured, well fermented and well dried; the produce of the small proprietors is less uniform, and generally incompletely fermented and dried; the price paid for it, however, is only a little lower.[1]

Haiti

Haiti cocoa belongs, like "Samaná" cocoa of the neighbour republic, San Domingo, to the ordinary sorts, but it is inferior to the Samaná. Very careless preparation, very little uniformity, dirty admixtures, make merchants and manufacturers often afraid to buy this cocoa.

Kamerun

Kamerun cocoa is of ordinary quality, and may be compared with Bahia cocoa. A great part is of very

[1] The information given by some handbooks, that the lowest quality of Surinam cocoa is a produce of wild-growing cocoa, is a mistake.

inferior quality, and is not better than the cocoa from the Gold Coast. The Kamerun cocoa of lower quality bears the commercial name "Victoria."

The taste of the Kamerun cocoa is bitter, and the beans are small and flat, whilst many lots are "smoky" in flavour on account of defective artificial drying, as used to occur with Thomé cocoa.

MARKETS[1]

The commerce takes place partly in the countries of production and partly in Europe and New York.

In the different ports from which cocoa is shipped, cocoa merchants are established, who buy the cocoa from the planters, and ship it to Europe or New York direct to manufacturers or to merchants there. In Java, however, the planter usually ships it direct to the merchant, who sells it for him at auction in Amsterdam.

From San Thomé the cocoa goes direct to Lisbon merchants.

When the local commerce is important, it greatly influences the prices paid on the world market, especially when the local merchants are working in a speculative way.

Large quantities of cocoa are nowadays shipped from the cocoa-growing country direct to the manufacturers in the different countries, but the greatest part is conveyed to one of the ports of arrival, where an important cocoa market exists. Of these ports five of importance are in Europe—Hamburg, Havre, London, Amsterdam, and Lisbon—and one in America — New York. Of minor importance are Bordeaux, Bremen, and Liverpool.

[1] The reader who takes an interest in the commerce of cocoa is strongly recommended to read the interesting little book of Walter Stollwerck, *Der Kakao und die Schokoladenindustrie* (Jena, Fischer, 1907), while the German fortnightly review, *Gordian*, is always well informed as well about production and commerce as about industry and manufacture.

In speaking of the cocoa markets and the customs in trade I have for the most part followed these two sources.

Lisbon derives its importance from the fact that nearly all the cocoa from San Thomé and Principe goes to its market.

In the same way Amsterdam is only of importance as a market for Java cocoa. In 1911, 31,669 bags of cocoa came to the Amsterdam market, of which 31,223 were Java cocoa; in 1910, 26,064 bags, of which 25,834 came from Java. It is customary on the Amsterdam market to sell the cocoa at public auction.

Of far greater importance are Hamburg, Havre, London, and New York.

Some twenty-five years ago London was the most important market. The supply amounted to about 9 million kilograms, while in Havre about 6 million and in Hamburg about 5 million kilograms came to the market.

Since that time, however, conditions have changed, and the supply in London has not grown in accordance with the growth of the world production. In the same way as the importance of London decreased, Hamburg and Havre increased.

About 1891 the arrivals at Havre attained the same figure as those of London (about 13 million kilograms). After that time Havre surpassed London more and more, and in 1905 the supply of Havre was 38 million kilograms, of London only 12·6 million kilograms. Hamburg surpassed London for the first time in 1896; in 1905, however, its supply amounted to more than three times the London supply.

Up till 1908 Hamburg surpassed both Havre and London, but gradually Havre has again gained more importance, and in 1909 it again surpassed Hamburg. In this year the arrivals were:

	Havre.	Hamburg.	London.	New York.
1909	762,701	731,214	270,642	577,304 bags

(1 bag contains about 70 kilograms.)

The arrivals in the four principal ports were in the last four years as follows:—

ARRIVALS, IN BAGS OF ABOUT 70 KILOGRAMS.

	Hamburg.	Havre.	London.	New York.
1909	731,214	762,701	270,642	575,065
1910	803,991	809,242	238,524	569,296
1911	1,134,247	756,397	257,174	674,294
1912	1,007,605	668,152	267,597	762,017

The favourable and cheap conditions *of sale* probably account for the great increase in importance of Hamburg, while the unfavourable or, at any rate, less favourable selling and handling conditions of London must be responsible for the decline of its cocoa market.

The sale on the Hamburg market may have been favoured by the situation of the port in regard to countries on the Continent. Both in Germany itself, and also in Russia and Austria, cocoa manufacture has made great progress. Also the great increase in importance of the German merchant-fleet must have favoured the Hamburg market.

The New York market is only important for the sales in the United States. Nearly all the cocoa brought to the New York market is sold for consumption in North America. Its importance is therefore almost wholly dependent on the consumption within that area.

The purchase of cocoa takes place in various ways.

Either it is bought by the manufacturer on one of the world markets, or directly in the country of production, this latter mode being greatly on the increase.

The cocoa destined for sale on the world's market, for instance at Hamburg or Havre—a manner of buying indicated by the term "loco"—is imported by the merchant and stored in sheds or store-houses, and the manufacturer buys it there from the importer either directly or indirectly.

When the manufacturer purchases the cocoa from the country of production, he can do it either directly

from a merchant in that country or through a cocoa merchant in Europe.

By either of such means the manufacturer in Europe can pay the freight and insurance, and the merchant abroad has simply to deliver his cocoa on board the ship ("f.o.b." = free on board). Or the cost of freight is included in the price, indicated by "c. & f." (which means, cost and freight included), or, not only is the freight included, but also the insurance (indicated with "c.i.f.," viz. cost, insurance, and freight included).

It will be clear that prices differ according to the manner in which the transaction is made, either "loco," f.o.b., c. & f., or c.i.f. In these dealings may also be included the loss in weight of the cocoa during the voyage, in respect of which special mention is made when the transaction is done f.o.b., c. & f., or c. i. f.

Market Prices of Different Sorts of Cocoa

In the beginning of this chapter a short description was given of the most important sorts of cocoa, and it was stated that there were great differences in character and quality according to the country in which the cocoa was grown.

Though in this way each country occupies a special place as regards quality, it is difficult to indicate exactly the right place for each country. The reason lies in the fact, that in some countries the produce is very unequal and comes to the market in very different qualities.

On general lines the most important sorts of market cocoa may be compared as follows.

The highest prices are paid for the cocoa of the western parts of Venezuela, first of all for "Maracaibo" and "Porto Cabello," and secondly for "Caracas"; then follows the Ecuador cocoa, with "Arriba" first, and at a distance "Balao" and "Machala"; close to these follows "Trinidad." From Java and Ceylon, however, the best brands are higher priced than both Ecuador and Trinidad, but, on the other hand, very inferior lots come to the

market from Java and Ceylon. Trinidad is followed by "Grenada"; about of the same value are "Surinam" and "Carupano." Then come the best "Bahia" and the best quality of "Kamerun," while "Samaná" and "Thomé" are again a little lower in price; "Accra," "Victoria," and, finally, "Haiti" close the list, with the most inferior sorts.

Average prices paid for the different sorts on the Hamburg market during the years 1901–1905 are to be found in Stollwerck's book. The average of the five years together may be mentioned here:

AVERAGE PRICES PAID FROM 1901 TO 1905 ON THE HAMBURG MARKET (in marks for 50 kilograms net; 1 mark = 1s.)[1]

Sort	Price
Maracaibo and Porto Cabello	81½–118
Caracas	62 –98
Guayaquil	65 –78
Ceylon and Java	54 –82½
Trinidad	62 –73
Grenada	58 –64
Kamerun	54 –60
Bahia	54 –59
Thomé	49 –58
Samaná	51 –54
Victoria and Accra	50 –53

These figures may give an approximation of the value of the most important commercial sorts during 1901–1905. Since then, however, the qualities of many cocoa-producing countries have greatly improved, so that San Thomé and Accra cocoas are becoming the leading ordinary qualities.

Some market prices of 1909–1911 on the Hamburg market may be added.

[1] From Stollwerck, *l.c.* p. 48.

[TABLE

Average Prices during 1909, 1910, and 1911 on the Hamburg Market

(in marks for 50 kilograms net ; 1 mark = 1s.)

	1909.	1910.	1911.
Summer Arriba . .	66	65	61½
Trinidad . . .	56–58	55–57	57–59
Kamerun . . .	51	50	54
Bahia	51–55	50–53	51–56
Thomé	47–52	46–50	51–54½
Samaná	49	47½	51
Accra	47	47	48–50
Haiti	45	44	45

We should not omit to call attention to the fact, that it is principally the ordinary sorts which have increased in quantity. We may follow the *Gordian* and divide the different sorts of cocoa into two groups—one containing the cocoas of fine and of fair quality, the other containing the ordinary sorts—and classify them as follows :—

Fine sorts : Venezuela, Ecuador, Trinidad, Grenada, Ceylon, Java, Jamaica, Surinam, Lesser Antilles.

Ordinary sorts : Bahia, Kamerun, San Thomé, Samaná, Accra, Haiti.

The figures of production of these two categories (in kilograms) are—

	Fine.	Ordinary.	Fine.	Ordinary.
	Kilog.	Kilog.	Per cent.	Per cent.
1895	60,218,000	15,995,000	79	21
1900	64,823,000	37,253,000	63	37
1905	78,831,000	65,981,000	55	45
1909	94,000,000	111,000,000	46	54
1912	72,042,000	154,577,000	32	68

This shows the much greater increase of the ordinary sorts. In 1895 they amounted to 21 per cent of the

world production (the fine sorts to 79 per cent); in 1912 to 68 per cent (the fine sorts only to 32 per cent).

These figures indicate that the quality of cocoa, taken as a whole, is falling off owing to the prevalence of sorts of lower quality.

In the different industrial countries the extension of the industry was not in the same way influenced by the increasing predominance of the ordinary sorts. The share of the ordinary sorts in the world production and in the consumption of the most important countries in 1903 and 1909 may be estimated from the following review:[1]—

PERCENTAGE OF ORDINARY SORTS USED IN THE INDUSTRY.

	1903.	1909.
	Per cent.	Per cent.
United States, America .	40	54
Germany	62	75
France . . .	41	48
England . . .	43	46

It is apparent from these figures that the ordinary qualities play an important rôle in the German industry, which is also the case in Holland and England to-day. In all the other countries their rôle is less important. In France a large amount is still used of the finer sorts. This may partly be a consequence of the higher quality of the chocolate manufactured in that country; but the fact that the industry of powdered cocoa is so important in Germany and Holland accounts also for its demand of ordinary sorts. Powdered chocolate grows more and more important as a cheap beverage for the people, and cheap cocoa is needed for its manufacture.

As a rule the prices of the different sorts approxi-

[1] *Gordian*, No. 364, June 1910, pp. 3514-3517.

mately follow each other, but their mutual position on the market may be slightly different in different years.

The market prices ruling at Havre for "Trinidad" and "Guayaquil" cocoas for the years 1890 to 1900 will give some idea of the fluctuations in those years (the prices are in shillings per 50 kilograms) :—

	Trinidad.	Guayaquil.		Trinidad.	Guayaquil.
1890	63–64	76–79	1901	67–68	68–72
1891	64–65	67–89	1902	63–64	66–74
1892	65–66	68–88	1903	59–61	64–73
1893	74	72–82	1904	59–60	66–74
1894	61–62	57–67	1905	54–56	66–74
1895	54	48–58	1906	54–84	75–90
1896	46–47	48–57	1907	86–111	92–119
1897	57–59	59–65	1908	60–90	71–115
1898	75–77	75–80	1909	54–62	52–70
1899	70–71	68–74	1910	53–58	54–70
1900	71–73	75–79			

The rise in 1892–1893 was followed by a fall in 1894–1896, which must be regarded partly as a consequence of the enormous increase of the stock. An increase of the consumption of cocoa (a consequence of the low price) and a small crop in 1896 were the natural cause for the rising of the market in 1897–1898.

It must, however, not be forgotten that prices are also influenced from time to time by speculation. As an instance may be quoted the fall of prices in 1904–1906. In 1906 the most important plantations in San Thomé and some bankers in Lisbon combined to fight the speculators ; a capital of £600,000 enabled them to retain large quantities of cocoa and to keep them in stock. This obliged manufacturers to offer higher prices and the consequence was a *hausse.* The price for San Thomé, for instance, which was 48·60 marks in the summer of 1906, rose to 69·50 marks in November ; Trinidad, which was 54·90 marks in the summer, rose to 75·00 marks in November. Here again speculation

played an important rôle, and the conditions remained favourable for the speculators in the first half of 1907 in consequence of the small stock.

Also in consequence of speculation, a gradual rise of the prices which took place in the first months of 1907 was followed by an enormous and quite unusual rise in July 1907. In August, September, and October this unusual situation, for which no natural cause could be found, remained. As much as 102 to 106 marks was current for "Accra" on the Hamburg market, and 107 to 114 marks for "San Thomé." A sudden fall in November was a return to more normal conditions, but it was accelerated by the financial crisis in America, the sellers being afraid to do business with America and preferring to sell at low prices.

In 1908 large crops in several of the principal countries (Ecuador with an increase from 20 to 29 million kilograms, Bahia from 21 to nearly 30 million kilograms, etc.) formed the natural cause of the fall in price in that year.

1909 from a commercial point of view was a very quiet year. Almost the same prices were paid the whole year through. On the Hamburg market, for instance, the prices were all through 57 to 58 for "Arriba," 54 to 55 for "Machala," 50 to 51 for "Bahia," 50 to 52 for "San Thomé," 47 to 47½ for "Accra." This may partly be attributed to the very large production. As mentioned, the stock amounted in the beginning of 1909 to no less than 48 per cent of the world consumption; with such a large stock, enough to meet the demand for almost half a year, there was no room for speculation.

Also in 1910 the cocoa-market was quiet and prices remained low. Only a slight rise took place. On the Hamburg market the prices were in January 47 for "Accra good," 50 for "Bahia fair," in December 48 for Accra, 51 for Bahia (in marks for 50 kilograms).

In 1911 again a slight *hausse* occurred, but in December prices were about the same as in January;

Accra, Samaná, Thomé, and Trinidad a little higher, Ecuador and Bahia a little lower.

In 1912 prices went upwards, and the year closed with 56 for "Accra good" and 58 for "Bahia fair."

World Production and Consumption

The production of cocoa in the different countries in following years has been mentioned in Chapter IX. We may give here a review of the total production in the last five years:[1]—

Production in Tons of 1000 kg.

	1908.	1909.	1910.	1911.	1912.
Gold Coast . . .	12·946	20·534	23·112	40·357	39·500
Ecuador	32·119	31·564	36·305	38·804	35·500
San Thomé . . .	28·728	30·261	36·665	35·000	35·500
Brazil	32·956	33·818	29·158	34·994	30·000
Trinidad	21·370	23·390	26·231	21·220	18·900
San Domingo . . .	19·005	14·818	16·623	19·828	20·900
Venezuela. . . .	16·303	16·848	17·251	17·381	12·500
Grenada	5·159	5·441	5·846	5·948	5·500
Lagos	1·388	2·276	2·978	4·471	3·500
German Colonies . .	2·738	3·823	4·073	4·404	5·400
Ceylon	2·836	3·570	4·069	3·064	3·500
Fernando Po . . .	3·001	2·726	2·349	3·000	2·300
Jamaica	2·694	3·216	1·743	2·783	3·400
Java	2·378	2·460	2·579	2·460	2·000
Surinam	1·699	1·897	2·043	1·565	1·000
Haiti	2·709	2·122	1·851	1·485	2·000
French Colonies . .	1·421	1·372	1·575	1·364	1·500
Cuba	·827	1·940	1·412	1·251	2·000
St. Lucia	·615	·553	·743	·940	·900
Belgian Congo . .	·612	·769	·902	·681	·800
Dominica	·488	·985	·573	·576	·600
Columbia	·621	·730	·297	·400	·400
Costa Rica . . .	·340	·235	·184	·343	·400
Other Countries . .	·800	1·000	1·000	1·500	1·500
Total . .	193·753	206·337	219·562	243·819	230·000

An impression of the world-consumption may be got from the following figures:[2]—

[1] *Gordian*, 1912–13.

[2] *Ibid.*

Consumption in Tons of 1000 kg.

	1908.	1909.	1910.	1911.	1912.
United States . . .	42·615	53·379	50·315	58·965	57·000
Germany	34·352	40·725	43·941	50·855	55·100
France	20·445	23·254	25·068	27·340	26·900
England	21·052	24·264	24·082	25·396	28·100
Holland	15·821	19·387	19·187	23·536	24·900
Switzerland . . .	5·821	6·684	9·089	9·852	10·300
Spain	6·580	5·980	5·517	6·379	5·300
Other Countries . .	18·455	21·165	23·967	27·665	32,400
Total . .	165·141	194·838	201·166	229·988	240·000

CHAPTER XI

NOTES ON COCOA AND CHOCOLATE INDUSTRY[1]

THE simplest way of preparing cocoa for human consumption is well known in every country where cocoa is grown. In Surinam, for instance, every negro cook knows how to prepare chocolate-cakes resembling those which were formerly used in Europe before Van Houten invented his method of preparing "soluble" cocoa-powder.

The simple way of preparing chocolate-cakes is as follows:—The beans are first roasted. When the quantity to be prepared is rather large, this is most conveniently done by the baker. Thereupon the beans are crushed on a clean table by means of a piece of wood, or an empty bottle which is pressed and rolled over the beans; this has no other purpose than separating the cuticles from the kernels. The light cuticles are removed by means of fanning with an ordinary little fan, made of native fibre. The kernels are then ground in a hand-mill; this results in a fatty mass, which melts to a semi-fluid pap when put in the sun, and solidifies again when placed in the shade. A little condiment is added, such as vanilla, cinnamon, and pimento. The chocolate is then cut into little cakes. This sort of chocolate is made with sugar and milk or water to a very nourishing, but rather heavy beverage, owing to the retention of the cocoa-fat.

[1] In this chapter only a few of the most important facts about manufacturing and consumption are mentioned. The reader who takes interest in this subject may be referred to Zipperer's well-known book (*Die Schokoladen-fabrikation*). The statistics about consumption are yearly published and critically reviewed in the *Gordian*.

The above-mentioned simple operations are also the most important in the modern manufacture of chocolate. In the manufacture of cocoa-powder, which is at present mostly used in the preparation of cocoa for drinking purposes, the cocoa undergoes still another important manipulation, namely, the removal of a great part of the cocoa-fat or cocoa-butter.

It was the Dutch manufacturer, Van Houten, who in 1828 took out a patent for this invention, which has proved of the greatest importance for the manufacture and consumption of cocoa, as was already mentioned in Chapter I. The many powdered cocoa-brands, which are turned out to-day by different manufacturers, are all more or less manufactured by means of the method invented by Van Houten.

One of the important tasks of the up-to-date manufacturer is to select his various cocoas and to mix them in order to obtain the desired taste. The proportion in which this is done is the secret of the manufacturer.

The first manipulation in the factory is always the cleaning. This is generally done in a machine, by which the beans are revolved in a cylinder made of wire-netting or some other stuff, through which the impurities but not the beans pass. After this the beans are again sorted.

By the succeeding process, the roasting, the aromatic flavour is more fully developed and the bitter taste reduced, at the same time the cuticles are made more brittle, which makes them easier to be removed. For this purpose large boxes are used which are kept continually and rapidly turning, and are heated by means of hot air or steam. Care must be taken that the right temperature is maintained, and that the beans are left neither too long nor too short in the boxes.

The breaking is done by the breaking-machines, in which also the kernels and cuticles or shells are separated. In order to obtain an accurate separation, a rather complicated construction of these breaking-machines is necessary. By means of a strong current of air the

shells are removed. Special machines separate the embryos again from the rest (the seed-lobes or kernel proper). This is done by means of centrifugal power, which throws the heavier embryos away.

The mixing of the different sorts is the next manipulation.

When soluble *cocoa-powder* is to be made, the cocoa is freed from a great part of its fat, the cocoa-butter, by means of strong hydraulic presses. By the best and strongest machinery about 53 to 60 per cent of the fat is pressed out, the beans containing before treatment about 50 parts of fat against 50 parts of other substances, and after pressing 20 to 23½ parts of fat against 50 parts of other substances.

After the pressing out of the fat, the cocoa is made "soluble." This is done in different ways. That mostly used is the "Dutch method," viz. the treatment of the cocoa with carbonate of magnesia, or with carbonate of potassium, of sodium, or of ammonia. This results not really in the "solubility" of the cocoa in the true sense of the word, but it keeps the powder better suspended in water or milk and not sinking so quickly to the bottom.

The manufacture of *sweet chocolate* is entirely different from that of powdered cocoa. After cleaning, breaking, and roasting, the necessary cocoa-sorts are mixed and roughly ground. Thereupon the cocoa is warmed and mixed with sugar and other substances. This is done by special machines, which divide the mass very minutely. In general terms the proportion of sugar added to the cocoa is about 1 to 1. Finally, the air contained in the chocolate is drawn or pressed out by another machine, and the chocolate is moulded into the form required.

The many different sorts of chocolate are made by special methods, requiring special machinery and special substances to be added (for instance, cocoa-butter or milk), but this need not be described here.

The different products of cocoa manufacture are

therefore powdered cocoa, chocolate, cocoa-butter and, finally, the chaffy shells or cuticles.

The cocoa-fat or *cocoa-butter* is a much-appreciated by-product of cocoa manufacture.

In connection with the fact that the industry of cocoa-powder is so important in Holland, Amsterdam is at present the most important market for cocoa-butter. The price fluctuates from 60 cents (1s.) to about one guilder (1s. 8d.) per ½ kilogram (in 1907 the abnormally high price of 2s. was paid). While being obtained in the manufacture of cocoa-powder, it is again used for the manufacture of chocolate. But it is also of great value for the manufacture of unguents, pomades, and tooth-pastes.

The *cuticles.*—As has been stated in Chapter III. the shells or cuticles contain, generally speaking, the same constituents as the kernels. They are sometimes used as a substitute for cocoa, and are, for instance, used in the manufacture of different sorts of "coffee" (Kneipp Malz Coffee a.o.), and in some countries for making infusions, which are used as a cheap beverage instead of tea. This is done, for instance, in Switzerland and Ireland.

Mixed with straw they form a valuable food for cattle and sheep. They are also sometimes used as manure.

Industry in Different Countries

The enormous increase of the world's production of cocoa shows how the consumption has increased during the last decade (see Chapter IX.). Accordingly the manufacture has made extraordinary advances in the different countries concerned.

The most important industrial countries are: the United States of America, Germany, France, England, Holland, and Switzerland. Of less importance are Spain, Belgium, Austria, Russia, Italy, and Canada.

The amount of cocoa imported for local manufacture by the chief countries is as follows:—

	1885.	1904.	1912.
	Kilog.	Kilog.	Kilog.
United States	4,676,000	32,329,000	57,000,000
Germany	3,300,000	27,101,000	55,100,000
England	6,630,000	20,536,000	28,100,000
France	12,203,000	21,794,000	26,900,000
Holland	1,227,000	12,186,000	24,900,000
Switzerland	1,203,000	6,839,000	10,300,000

In 1885 France was by far the most important cocoa manufacturing country, England came second. Since that time the relative importance of both countries has considerably diminished, while the relative importance of Germany and the United States has increased. At present the United States comes first, Germany second, and England third, as indicated in the list.

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