Cacao Culture

in the West Indies.

CACAO CULTURE

IN THE

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INTRODUCTION

In this booklet we aim to give the planter such information as may help him to solve the numerous practical problems with which he is daily confronted in his plantation. While it is published by the department of the potash propaganda it was written by a man who is intimately familiar with cultural methods in the different islands and we beg to call the reader's attention to the fact that it is not merely advertisement but solid knowledge worthy of a place in any agricultural library.

The large number of articles on cacao that have appeared in tropical publications during the last few years together with the valuable reports of the Agricutlural Departments of the British Islands show the great need of improvement in field methods and also point the way for such improvements to be carried into effect. These articles are scattered however and many of them contain technical descriptions which the average planter has no time to read. The author of this work has consulted a great deal of such recent literature and has correlated the information so that what is here presented is not merely his individual views nor the statements of any one writer but a consensus of opinion of a number of men who have studied the question for years on the plantation or in the laboratory.

GENERAL VIEW—RIVER ESTATE, TRINIDAD

If cacao were a plant very different from other cultivated plants and required radically different treatment it would not be possible to do justice to the subject in such a small book but fortunately the underlying principles of plant culture in general can be applied to cacao in every case. Although cacao has been grown in the West Indies almost since the Islands were discovered and probably before, it has scarcely been cultivated in the sense in which that term is usually applied . But as said before, it responds to cultural treatments like the orange or the apple and it is with the hope that such improvements as have been made in orange culture for instance, will also be made in cacao that we present this pamphlet to the West Indian planters.

VARIETIES

The botanical name of cacao is Theobroma, and two species are cultivated viz. Theobroma cacao and Theobroma pentagona. Practically all the cacao grown in the West Indies belongs to the species Theobroma cacao which has been separated into three classes * viz: Criollo, Forastero and Calabacillo, under each of which several varieties are recognized. It is difficult however, for the practical planter to distinguish these varieties because usually there are so many intermediate strains which have come through the intermixing of two or more varieties that the gradations are not very distinct. Even the three main classes cannot be readily distinguished because they vary in color as well as thickness of pod, and they vary even in shape of pod. For instance, the Forastero with its typical cucumber shaped pod is melon shaped in the variety called Amelonado and in that respect

* Classification of Mr. John Hinchley Hart F. L. S., formerly Director Trinidad Botanical Gardens.

TYPICAL PODS OF FORASTERO

TYPICAL PODS OF CRIOLLO

resembles the Calabacillo type. The chief characteristics are that the **Criollo** has a more or less pointed and often bottle-neck formed pod, finely ribbed with roundish, light colored or white seeds. The tree is rather small, not vigorous and not very prolific except on good soil and under favorable conditions. The quality of the bean is the very best, however, and decided improvements in quality have taken place where the other classes have crossed with this one.

The **Calabacillo** has a roundish, smooth pod with a flat, dark colored seed. The tree is a vigorous grower and usually prolific, but the quality of the bean is inferior.

The **Forastero** stands between the two former types. It has a large, straight, blunt, ribbed or corrugated pod with large medium flat seeds of a purplish color. The tree is vigorous, although less so than the Calabacillo, especially under unfavorable conditions. It is also prolific and the quality is good although inferior to Criollo.

The other species of commercial cacao, Theobroma pentagona, resembles the Theobroma cacao very much and the botanical difference is not very great because one can be budded onto the other and in all probabilities they can be intercrossed. It has a five-ridged pod with a warty surface, resembling the skin of an alligator from which its common name, Alligator cacao, is derived. The pod is soft and breaks open easily when handled. The beans are larger than those of other cacao types which seems to be the greatest point in its favor. The quality has not been thoroughly determined yet, but it seems to be classed about equal to Criollo.

PROPAGATION

Cacao is propagated almost entirely from seed and until a few years ago it was thought that it could be propagated

½ Natural Size. ¼ Natural Size.

TYPICAL PODS OF CALABACILLO AND BICOLOR

in no other way. Sometimes the seeds are collected promiscuously, at other times the best pods from the best trees are selected and the seed taken from the center of such pods. While the last method is certainly much better than the former it is far from being perfect, which will readily be understood when we remember that pods from a tree surrounded by other trees do not contain seeds that are entirely the product of that tree. Pollen is brought from tree to tree and from flower to flower by the wind and by insects and therefore the best looking pods from a Criollo or a Forastero tree may contain seeds that will produce Calabacillo trees and fruit. That is, of course provided that there are any Calabacillo trees in the neighborhood from which the pollen could come. But even if there are no such trees it is very difficult to secure pure seeds on any plantation because of the way in which cacao varieties are mixed These mixtures are not always undesirable, as a matter of fact the ideal cacao variety, if it is ever found, will come through crossing. It may not come through a natural cross but if men like Harrison or Bovell would devote as much time to cacao as they have to sugar cane they would unquestionably produce a variety with the vigor of the Calabacillo, the pod of the Forastero and the bean of the Criollo or Pentagona. That however, is scientific work which the average planter has neither the knowledge, the facilities nor the time to do, and his work is to find the best natural varieties and propagate from them in such a way that none of the desirable characters are lost. This can be done by budding, or inarching, which methods we herewith describe fully with the hope that they will be instructive to those who have not yet taken advantage of the teachings of the various agricultural departments.

It is not probable that the majority of the plantations

in the Islands where cacao has been grown extensively for years will be improved by budding in the immediate future, nor that a large percentage of the new plantations will be planted with trees propagated in that way, because as the saying goes "it is hard to teach an old dog new tricks." Nevertheless it is the only way in which those Islands can retain their prestige in the cacao world. The orange grower with his knowledge of improved methods will some day take hold of cacao and those who will not adjust themselves to the change will simply be left behind.

SELECTION

The main requirements of a cacao tree are that it must be vigorous, disease resistant, prolific and produce beans of good quality. These are sometimes obtained in pure strains of Forastero, and planting seeds from such trees may give good results. In selecting seeds the following precautions should be taken:

(1) The tree or trees from which the seeds are selected should be surrounded by no other cacao trees except they are of the same variety and fill the requirements as set forth above. (2) Selection should as a rule not be made from trees growing under unnatural conditions, such as in back yards or close to barns where the abundance of plant food may be the entire cause of vigor and prolificness. (3) Selection should not be made from trees on the strength of one season's crop, but only after it has been proved that the vigor and prolificness are inherent qualities not caused by external influences.

When selecting trees from which to take bud-wood practically the same requirements should be considered. The tree should be prolific, disease resistant and the beans of

good quality. The vigor is not important because in budding on to a vigorous stock that character will be transmitted to the scion. All the characters can be judged by the eye except quality which cannot be determined before the beans have been cured. Therefore the practical method of selection is to note the trees that are healthy, vigorous and prolific, bearing regularly large well developed pods with large well shaped and uniformly colored beans. Such trees should be labeled and a half dozen pods selected from each, the beans of which should be placed in muslin bags and labeled the same as the trees from which they were gathered. These should then go through the sweating and drying process together with other cacao and tested separately by experts after it is cured. The trees from which the beans do not grade up to standard should of course be rejeced at once as unworthy to propagate from whereas those that are satisfactory should be numbered or named for future reference.

As said above it is uncertain to propagate from seeds even though they are carefully selected, and the only way to establish a uniform plantation is by budding or grafting.

It is well known that the Criollo is a desirable variety but difficult to grow where the conditions are not favorable. It is equally well known that Calabacillo is hardy but of inferior quality. It is therefore readily apparent that by using the Calabacillo for stock and the Criollo for top a great deal would be gained. Even a good variety of Forastero, being both vigorous and prolific, would be improved by budding because it would bear earlier and it would insure uniformity of the plantation which is always impossible when planting from seed.

The Pentagona may prove to be a desirable variety to grow when budded on a strong stock. It is probable however, that it will improve in hardinness by being crossed with

some other desirable variety, and where such crosses occur with a resulting hardier tree and larger bean we should look for varieties to propagate from. There are also species of Theobroma that do not produce marketable beans but which are very vigorous and disease resistant and may therefore profitably be used for budding stock. One of these is the Theobroma bicolor (Tiger cacao) and another the Theobroma angustifolia (Monkey cacao), both of which grow wild in Central and South America. Mr. J. H. Hart of Trinidad introduced these to that Island as long ago as 1893 and specimens distributed by him can now be found in most of the West Indian Islands.

However, this is merely to call attention to the abundance of material that may be used by those who are sufficiently interested in securing the best that can be obtained. For those who are not experimentally inclined it is quite satisfactory to select from the best strains that can be obtained in the neighborhood, regardless of whether they conform to the description of any variety or not. The main points are that the quality must meet the requirements of the best markets, that the quantity must be abundant and that the grade must be uniform.

STOCK FOR INARCHING AND BUDDING

Every one will have observed that certain trees are much more vigorous and disease resistant than others, and most planters know that certain varieties grow better in their locality than others, although the yield and the quality may be inferior. Seeds from such vigorous trees should be selected for budding stock in the following manner: Pick the pods when they are fully ripe. Take out the seeds, discarding the small and deformed ones. Mix the seeds with

INARCHING—SHOWING SMALL TREE YIELDING FOUR INARCHES. The tree was originally inarched from a desirable variety. A few months after, pot-grown seedlings were set up close to it and the union made according to directions given in the text.

dry earth to absorb the mucous liquids after which dry in the shade for a couple of days when they will be ready for planting.

As cacao does not stand transplanting well it is best to plant in pots, and in the West Indies the cheapest pots are made of bamboo. Large bamboo with fairly long joints are selected and sawed off in sections about a half inch below each joint. A hole is made in the closed partition which serves as a bottom in the pot and the section is filled with earth and used in the same way as a regular flower pot.

The seeds may be planted directly in the bamboos or in seed- beds or garden flats, but in all cases they should be covered very shallow with fine loose earth because the young plant is not able to force its way through a layer of hard crust. If the seeds are sown in flats the young plants may be transplanted into the pots as soon as the first permanent leaves have formed.

The best place for a nursery is in a shady place, such as a frame partly overgrown with vines or lightly covered with palm leaves. The bamboo pots may be placed close together and should be watered frequently enough to keeep the soil constantly moist. When the plants have attained the size of a lead pencil they will be ready for inarching.

For budding the seedlings should be at least one half inch to one inch in diameter and the seed well matured. Such large plants cannot well be grown in bamboos unless the joints are extra large, and those who want to propagate that way would have to make wooden boxes three to four inches square and at least twelve inches deep.

INARCHING

This method of propagation is open to all planters as it is so simple that any one can do it. A scaffold is built

2 1 3 4

GRAFTING—Showing Calabacillo seedling in pot which was grafted when it was the ize of a lead pencil and the wood still soft. (See fig. 1) After the union had formed the top of the seedling was cut off (See fig. 2) This is more successful if a short section of bamboo is placed around the plant and filled with sand up to above the union (See fig. 3) Fig. 4 shows inarched plant after severing from the mother plant.

around the trees that have been selected for quality, prolificness, etc., and the bamboo sections with the young plants are placed on these among the branches of the trees. A cut is then made in one side of the seedling with a sharp knife, removing a thin slice of wood with the adhering bark from three to five inches long. A similar cut is made on a branch of the tree of the same size as the seedling and the two cut surfaces placed together so that the bark of one touches the bark of the other, on one side at least, if they are not exactly the same size. They are then tied together with soft twine or raffia and also tied to a stake in such a manner that the wind cannot sway them back and forth and thereby prevent them from growing together. In many cases the scaffold can be dispensed with as the bamboo section can be tied to a limb of the tree and the seedling joined to a small branch in the way described. In all cases however, it is necessary to water the soil in the bamboo pots every day or as often as necessary in order to keep the plant growing. In about six weeks the union will have taken place and the plants should be examined. Those that have grown together can be taken down after cutting off the top of the seedling above the union. Those that have not wholly knitted should be left longer but the cuts above and below the union may be partly made in order to change the sap flow and hasten the union.

The inarched plants should be left in a protected place and carefully watered until the union is complete and no danger of the top blowing off, after which they may be planted out in the usual way.

BUDDING

A cacao tree cannot be budded as readily as an orange tree or a rose bush but many are now obtaining fairly good

No. 1 Spring Graft. No. 2 Shield Bud. No. 3 Side Graft, suitable for young seedlings. No. 4 Patch bud, most suitable method of budding cacao.

success with budding. The seedling may be budded while in pots in the nursery but they should be of good size and the wood well matured. They may also be planted in the field and left until well established and growing vigorously before budding. Or the seeds may be planted in the field in the regular manner and the plants budded when the stem attains the size of one half inch to one inch in diameter.

There are several methods of budding, some of which are here illustrated. The patch bud seems to have been the most successful so far.

The only tool needed is a thin bladed knife, sharp as a razor, with which to cut the bud, and some soft yarn, raffia or tape, with which to wrap the bud after it is inserted. It is especially necessary to be careful in cutting the bud so that it is smooth and straight. A ragged bud torn off or cut with a dull knife will not unite with the stock. A patch bud should be exactly the same size as the piece of bark removed from the stock and fit as snug as a cabinet-maker would fit inlaid work.

In about two weeks the bud should start to grow if the operation has been successful and it should then be forced by removing a ring of bark from the stock a couple of inches above or by cutting the stock half off at that distance above the bud and bending the top down to the ground. When the young shoot from the bud has grown a few inches it should be carefully tied to a stake and all the other shoots should be kept cut off. The bud shoot should be trained straight by tying to a stake until it is about a meter high when the tip should be pinched off in order to induce it to branch.

SOIL

The requirements of the cacao tree are not essentially different from those of other cultivated trees. There are certain soil conditions closely approaching the ideal, but judging from the widely different soil types in which trees are growing and apparently thriving well it is evident that climatic conditions and cultural methods may make up for certain soil defects. It is not so difficult to judge a soil as many people imagine but it requires knowledge to handle different soils so as to obtain the best results. An ideal soil is usually described as a deep alluvial deposit with a pervious clay subsoil and covered with a thick layer of humus formed by decayed vegetable matter. But indeed such a soil would be ideal for any cultivated crop. With such a soil under the management of a competent man the various burning questions, such as small yield, diseases, plant food etc., would be more than half solved, but, although such soil cannot often be obtained, it is certainly well to keep the ideal in view. A soil to be at all suitable must be fairly friable. A stiff clay, deficient in humus, should never be chosen. The soil should also be deep, if there are but a few feet of it underlayed by an impervious subsoil it is unsuitable for cacao. In such locations a tree may grow normally for a few years but after the roots strike such an impenetrable strata and curl up instead of growing downwards the tree will soon show the effect of it. The same is true of water if the normal water level in the soil comes up to within about six feet of the surface the roots will not have sufficient room for healthy growth and diseases of various kinds will gain entrance. Aside from the under-

ground water the surface water must be considered. A soil may be all that could be desired in other respects but if it is flat and low in relation to the surrounding territory it may be unfit because it cannot be drained.

The top soil containing decayed vegetable matter is also of more importance than most planters realize, which will be further discussed under fertilizing, but it may be well to emphasize at this point that most of the so called worn-out soils in the West Indies are simply deficient in humus and available plant food. Such soils may be reclaimed, just as poorly drained soils may be drained and dry soils irrigated, but all of these things cost money and this should be carefully considered when selecting the land.

The majority of cacao plantations are situated in valleys and on mountain sides which is undoubtedly due to the fact that such situations are the natural home of the tree. But along with the choice of the natural situation the old planter also adopted the natural methods of cultivation, or rather he planted in such a way that nature would take care of the cultivation. In such old plantations the soil is in a most deplorable condition today, especially on the mountain sides where all of the humus has been washed away.

Cacao is of course grown on flat land also, and where the conditions are favorable it has many advantages. There has however, been many mistakes made in selecting locations on the plains, and it may be well to call attention to the folly of starting on a worn out cane land or on poor sandy soil or on hard clay soil or on a wind-swept plain where it would be difficult to furnish adequate wind protection. It is true that such land can be improved and made to produce cacao or any other crop but it should certainly not be planted until such improvements have been made.

CLIMATE

Just as there are certain indeal soil conditions so there are certain ideal climatic conditions under which cacao thrives best. When such conditions are not naturally present they must be artificially provided or the best results cannot be expected. The following points are of importance: Temperature, raifall, humidity and wind.

Cacao is at home in moist wind-sheltered valleys with a day temperature of 80° To 100° Fahrenheit and a night temperature of 65° to 75° Fahrenheit. Trees are often found in the mountains where the temperature is much less than this, but the lower altitudes and higher temperature is well known to be most favorable. The amount of rain needed depends on the distribution, the physical condition of the soil and on cultural methods. On flat land with friable soil on which the capillary action is maintained by mulch or cultivation, two inches per month might be quite sufficient, while on a steep hillside not cultivated the trees might suffer from drought with twice or three times that amount.

In most cacao growing countries the rainfall is from 60 to 100 inches per year, but there is usually a dry period with one and one half inches per month or less at which times the trees suffer unless the planter can cultivate or mulch his soil.

The humidity of the air may or may not be an important factor. It is not so much that the cacao tree needs a humid atmosphere but under the natural or artificial conditions most favorable to its growth the air is humid compared to more exposed positions. The humidity in a cacao plantation

usually depends on the amount of wind protection it has and it will be found that the general welfare of the plantation also rests upon that point. In a plantation where the soil is shaded and where the trees are protected from the wind, evaporation and transpiration do not take place as rapidly as where the air is constantly in motion, hence the soil moisture is not depleted so fast and the trees may continue to grow where those not so protected would suffer. Where irrigation is available the cacao tree may bear good crops even though the air is dry, provided the plantation is adequately protected from the wind.

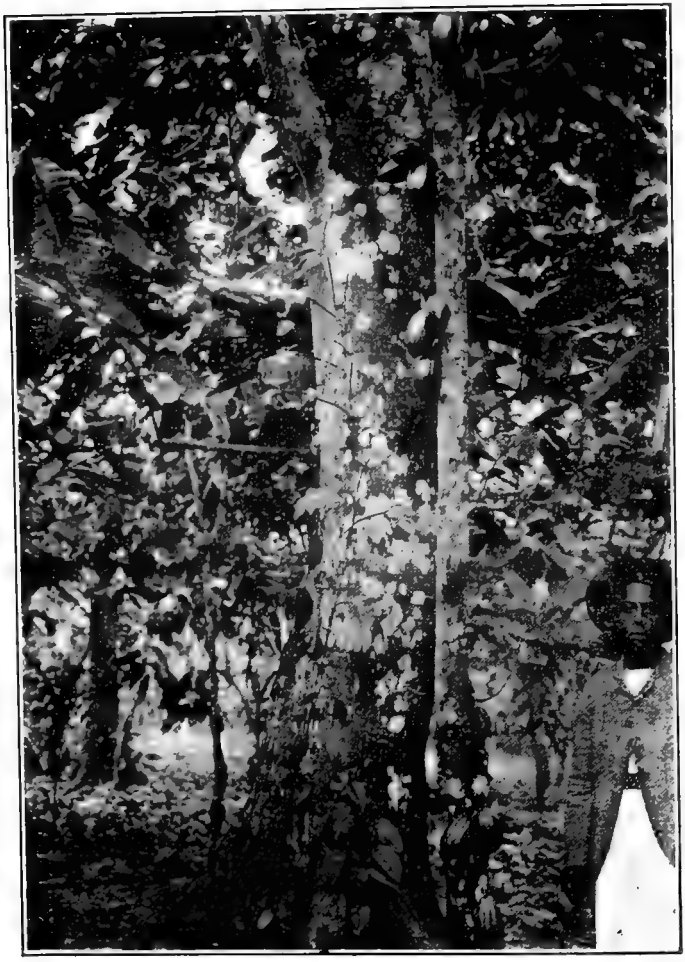
SHADE

There is great diversity of opinion regarding the necessity of shade in cacao plantations. Some maintain that shade is not necessary except for the first three to four years and others say that shade is absolutely necessary in their locality, not alone for young but also for old trees. As these are opinions of men who have local experiences there is of course a foundation for the assertions. Nevertheless it is not probable that a cacao tree needs a radically different treatment in one island from what it does in another, which as a mater of fact is the case. In Central America, where cacao is at home in the natural forest, it does not thrive well in the heaviest shade nor in the open where it is not surrounded by anything but grass, which shows it to be of a habit similar to coffee and citrus trees. This habit was not changed during the many years it has been semicultivated in the West Indies. The old plantations were established and maintained on nature's plan, and it was soon evident that with no more care than what nature bestows it was not wise to deviate from nature's ways.

If a plantation is too heavily shaded the trees naturally

grow tall and irregular in their effort to reach up into the sunlight. They become affected with various diseases both on account of abnormal and unhealthy growth and because the too humid atmosphere and absence of light make the conditions favorable for fungus growth. Still the trees grow because the temperature is even, the moisture plentiful and the soil in good condition for root-formation. The opposite of this is where a plantation has been established without any shade. There the trees are subject to wind and frequenly suffer for the want of moisture because of the soil being exposed. Even though the grass is cut frequently the trees will make but slow growth and almost invariably be in worse condition than those that are overshaded. On the other hand if the plantation is located on the lee side of a mountain or protected from the wind by a forest belt and the soil well shaded by the cacao trees themselves or by some cover crop, the growth is normal and the yield satisfactory. Again, on a flat land for instance, where the plantation is protected by windbreaks, the soil cultivated and kept in good tilth, the growth and yield may be all that could be wished for. This would indicate that the shade is not for the protection of the tree, its leaves or its branches against the sunlight, but more for the protection of the soil against too rapid evaporation and for the maintenence of that equable temperature and humid atmosphere so necessary to a great many tropical plants. This is probably correct unless cacao is very much different from other plants of similar nature. It has been found for instance in shading tobacco that as good results could be obtained from windbreaks of cheese cloth placed close enough together, as from overhead covering.

It seems to be well understood in all the Islands that young plantations need protection, whether it is wind pro-



TREE IN OLD, OVERSHADED PLANTATION—NOTE TALL, SLIM TRUNK CLOSE TO LARGE SHADE TREE

tection, sun protection or both, and probably no one would advocate leaving even an old plantation without some kind of protection. The practical questions therefore are: Which plants will give adequate protection? Will they thrive in this locality and in this soil? Are they of any value for commercial purposes, for food or for manure, or are they fit for protection only? Should they be planted so as to give shade to the cacao tree or in belts a certain distance apart for wind protection?

In older plantations large trees were usually planted among the cacao trees for the purpose of shading these, and trees belonging to the leguminous family were chosen because they were recognized as being of greatest value although the reason for that was not always known. Planters now usually know that such trees are of manurial value because they feed on nitrogen from the air, part of which is given to the cacao tree in the form of dropping leaves and flowers. Among such shade trees the Erythinas seems to take first rank. There are several species but they all go under the name of Madre de Cacao in Spanish countries and Mortel or Immortel in English.

Gliricidia maculata is another tree frequently used and this is also called Madre de Cacao or Mother of Cacao, a name adopted by the Spanish in Central and South America. Pithecolobium saman, the saman or guango as it is commonly called is also frequently used.

It is quite probable however, that in the future very few of these trees will be planted for the purpose of shade, but they will undoubtedly all of them be used for wind belts, for which purpose any reasonably fast growing tree may be used provided it is long-lived, wind resistant and not subject to any disease that is common to the cacao trees.

TREE UNSHADED—TRINIDAD

It will be noticed that these trees are for protection mainly, although they furnish some food for the cacao trees as well.

Of commercial crops for wind protection the Central American rubber, Castilloa elastica, has been suggested, and it may be used for wind belts wherever it grows fast enough. It will not be satisfactory in all places however, and it will probably never be satisfactory if planted alone because it needs wind protection itself the first few years of its growth.

While the cacao trees are small something more than wind breaks are needed and it is common practice to grow food crops such as corn, casava, malanga or tannias, castor oil, bananas etc. These plants thrive nearly everywhere and they are usually planted between the rows of cacao the first three or four years. This has certain advantages and also many disadvantages. It is desirable from an immediate economic standpoint for the reason that the yield is often enough to pay for the upkeep of the plantation. On the other hand it is soil robbery the way it is conducted and the plantation may suffer from the effects of it forever after. It is never good economy to take more out of a soil than what is returned to it immediately, and in growing the economic crops a part of the year leguminous crops should be planted alternately and worked in so as to supply the humus and the nitrogen lost in growing the other crops.

Of mineral plant foods enough may be available in virgin land the first few years but of course in removing crops continually they will finally be exhausted.

Of smaller leguminous plants there are a number which thrive well in most islands but most of them are too small to be of value for shade or wind protection for the cacao.

They are of value mainly as cover crops for the protection and enrichment of the soil. Pidgeon pea (Cajanus indicus and C. catjan) is an exception. It is valuable for wind protection and shade as it grows higher than most cacao trees under four years old. Of smaller leguminous plants the following thrive in most of the Islands: Cow pea (Vigna unguiculata), Sword bean (Canavalia gladiate and ensiformis,) Crotolaria (Crotolaria Sp.) Wolly Pyrol (Phaseolus mungo), Peanut (Arachis hypogea), Beggar weed (Desmodium tortuosum. The last one cannot be depended upon in all places and none of them will grow under heavy shade. That is, after the cacao trees become large enough to shade the ground these plants cannot be grown although Crotolaria, Wolly pyrol and peanut will stand some shade.

PREPARING THE LAND

The initial preparation will of course depend on the condition of the land. A forest land may be cleaned to the extent of cutting down the trees and burning most of the cut-off material around the stumps so as to get rid of it and partly burn the stumps as well. In places it may be possible to sell the timber and it may also be possible to remove the stumps with dynamite and stumppulling machinery. The last is certainly preferable on flat land that can be cultivated with machinery as it will facilitate cultivation and cheapen the upkeep of the plantation in general. Forest land is preferable for several reasons, although it costs more to prepare it than if there were no trees to cut off.

There are two essential things present in forests, viz, humidity and wind protection, and by judicious clearing and after-treatment these can be retained. Tropical forests

usually afford very good protection against wind, and in clearing land, wind-belts should always be left at an interval of 500 to 1,000 feet. The knotty question of shade in cacao plantations would solve itself for planters if they would pay more attention to wind protection.

After the land has been cleared or if it is free from forest to begin with it should be measured off and stakes placed where the trees are to be planted. This is, at the present time at distances varying from 10x10 feet to 15x15 feet, arranged in the square or the quincunx system. 12x12 feet in the square system, which allows 300 trees per acre is very common. 15x15 feet in the square system allows 193 trees per acre, but if planted at that distance in the quincunx system it allows for 288 trees. The distance depends upon the variety planted. As it is the object to have the ground covered as soon as possible it is argued that at least 300 trees should be planted of the smaller and slower growing Criollo, while 200 of the large vigorous Calabacillo will cover the ground in the same time.

After the trees become too crowded the plan is to thin them out but unfortunately that is seldom done and it is quite certain that many plantations are suffering from overcrowding.

Budded trees do not grow as large as seedlings but with improved cultural methods they will grow faster, and in a plantation being established where the soil can be cultivated and the other plants grown among the cacao trees until they fill all the space, 20x20 feet would undoubtedly be close enough. This would leave room for 108 trees per acre. However, we do not recommend such a change except where corresponding changes in cultural methods are made also.

Where the stakes were placed holes should be dug, not

less than two feet square and 18 inches to 2 feet deep. The top soil from the area surrounding the hole should be filled back in and left to settle for two to three weeks before planting.

Whether the ground should be plowed or not will depend on the conditions. Forest land, even if fairly well cleared, will be difficult to plow and of course on hillsides it may be impossible to do so. On level land the soil should be well prepared before planting as it is a great saving later on.

PLANTING

The preparation of the land, including digging holes, is necessary whether seeds are planted or nursery trees. But the subsequent work will differ according to the location. On hilly forest land where the rainfall is fairly regular and where the land is well sheltered by mountains or by wind-belts left when clearing the forest, the cacao can be planted in the holes previously prepared, and any small crop such as corn, casava, pidgeon peas or whatever is selected may be planted between the rows. If however, the land is without wind protection and subject to periodical droughts, the cacao should not be planted until wind-belts have been well established and are far enough advanced to afford protection. Afterwards bananas and pidgeon peas should be planted between the cacao rows and allowed to get a good start before the cacao is planted.

In planting seeds it is customary to plant three close to the stake and afterwards pull up the two weakest plants.

In planting trees from bamboo pots the pot soil should be moistened to prevent it from crumbling and the bamboo should be split open, leaving a cylindrical ball of earth containing the plant. This should be set in a hole previously

prepared without breaking it or in any way exposing the roots. The plant should never be set without removing the bamboo as that does not decay readily, even when imbedded in the soil.

In setting a plant it is essential to take care that it is set high enough so that the crown-roots are partly visible after the soil has settled. The tendency is always to plant too low because the soil is usually water-soaked when planting, and instead of it settling down the plant settles. This is the cause of more root disease in cacao, coffee and citrus than most planters realize and it should be strictly guarded against. A cacao tree that may be expected to bear fruit upwards of a hundred years should certainly not be handicapped from the beginning by the carelessness of some irresponsible workman. This touches upon the question whether cacao should be planted on the contract system, as in some of the British Islands, which cannot be discussed at length. It is unquestionably the cheapest to establish a plantation that way but the man who expects to keep the plantation as a paying investment would do well to start right even thought it costs a little more.

Immediately after planting, whether seed or nursery trees, the surrounding soil should be covered with a thick layer of grass or any weeds, raked up on the ground. This will preserve the moisture and prevent the growth of weeds close to the plant.

It is also good practice to place a couple of palm leaves on the south east side of the plants to protect them from the hot rays of the sun until the surrounding plants become tall enough to give the necessary protection.

CULTIVATION

Cacao is seldom cultivated in the West Indies in the sense in which that term is usually applied. In many plantations the cultivation consists entirely in cutting the weeds with machetes or cutlasses, although the more progressive planters fork the soil occasionally. Such a thing as plowing and cultivating in a cacao plantation is practically unknown. This is of course natural in view of the methods employed. It would be impossible to plow land full of stumps and roots, and by the time these obstructions have disappeared the soil could not be plowed without doing great injury to the roots of the cacao trees. As to forking, it is naturally costly and something that would never be thought of in some of the Islands. It is almost unknown in Porto Rico, Santo Domingo and Cuba. There the hoe is used to some extent but aside from that it is either machine cultivation or no cultivation. That the method of weeding with cutlass and forking occasionally is to a degree successful is evident from the number of plantations that are giving fairly good returns and receiving no other treatment. That it is not successful in all cases is evident from the number of plantations suffering from the lack of real cultivation. Cultivation in which the soil is broken up to some depth and the surface kept pulverized is beneficial because it admits air and liberates plant food, and especially because it conserves the soil moisture. Where the rainfall is abundant or where the ground is thickly covered with vegetable matter the soil may retain its desirable physical character without being cultivated, but soils deficient in humus and subject to periodical droughts are of but little value unless they are

YOUNG PLANTATION, WELL DRAINED, CULTIVATED AND MANURED—TRINIDAD

broken up and stirred occasionally. There is only one substitute for working the soil and that is covering it up. But in order to be successful the layer must be fairly thick and replenished from time to time. A thin layer such as from weeds produced in the plantation itself during the rainy season is not enought. Such weeds may serve as a mulch immediately around young trees but spread broadcast it would be of but little value. Therefore in order to employ the method of mulching as a substitute for cultivation it becomes necessary to have land on which to grow plants for that purpose only. It should be remembered also that the roots form in the surface soil immediately beneath the mulch and whenever this is decayed and not replenished the roots die. For the same reason mulch cannot be left on the ground for a long time and then be forked in as that would destroy the roots. This as a matter of fact, happens in the plantations today where there is some leaf mold present and where the roots grow profusely near the surface during the rainy season. The roots formed there are practically all destroyed by forking and it is questionable whether forking under those conditions is beneficial or not. For loosening the soil it would be better to insert the fork and withdraw it without turning it over.

The question of cultivation is very difficult to discuss in a manner that may be of benefit to the man who has an old plantation because with the system of close planting of cacao and shade trees often on steep hillsides with bare clay soil, nothing in the way of cultivation is thoroughly satisfactory. Humus is the first thing needed, but it is too shaded to grow any smaller plants, and mulch is really the only resort.

In new plantations planted on level land and with the trees about 20 feet apart the conditions are different. There

the soil may be plowed and cultivated as long as the plantation exists and leguminous cover crops may be grown to some extent. In such plantations it is good practice to plant legumes, such as sword beans or cow peas, at the beginning of the rainy season, plow these crops in before the dry season begins and after that keep the soil pulverized and loose on the top by frequent stirring with cultivators, such as Planet Juniors or a small disk harrow, until the rainy season starts again.

FERTILIZING OR MANURING

A fertilizer is any material supplying plant food, but in discussing it in its narrower sense, only the three elements, nitrogen, potasium and phosphorus, are included. These are the only elements of plant food in which ordinary soils are deficient. The analysis of a soil is not a sure guide to its productivity, nor is the analysis of a crop more than an indication of what fertilizers should be used. Herbert Wright in his book on Cacao gives figures from analysis made by Boname showing that each ton of marketable cacao takes from the soil 112 kilograms of mineral matter of which 57 kilograms are potash, 9 kilograms phosphoric acid and 20 kilograms nitrogen. With a crop of 450 pounds per acre this would be about 25 pounds potash, 4½ pounds phosphoric acid and 10 pounds nitrogen. Hart * quotes Harrison from Demerara, Marcana from Venezuela and Boname from Guadeloupe giving four analyses to show the unavoidable loss of plant foods, that is those actually removed in the marketable products. The average from the four are as follows: 8.4 pounds nitrogen, 4.2 pounds phosphoric acid and 4.4 pounds potash. From the same authority we quote

* West Indian Committee Circular Vol. 25 No. 298.

analyses made by the Government Laboratory, British Guiana, in which the average figures from ten cacao soils collected in different islands were as follows: .119% phosphoric acid, .451% potash and .256% nitrogen. These are stated to be good cacao soils. Another series of eight soils, in which the yield is said to be unsatisfactory, the average analysis was phosphoric acid, 054%, potash .063% and nitrogen .127%. Presuming that the samples were taken in the usual manner, viz. from the upper 6-2/3 inches of soil, which weighs over an average two million pounds per acre, the total plant food in the good soils would be 2380 pounds phosphoric acid, 9020 pounds potash and 5120 pounds nitrogen and in the poor soils 1080 pounds phosphoric acid, 1260 pounds potash and 2540 pounds nitrogen.

Comparing the figures of the unavoidable loss and the actual plant food in the soil we find that even the poor soil contains enough nitrogen for 202 crops, enough phosphoric acid for 255 crops and enough potash for 290 crops. This however, is merely a theoretical possibility. Practically, the question is not how much actual plant food does a soil contain but how much plant food is there available or can there be made available during the growing season.

The plant foods removed from the soil by the crops taken off represent but a fraction of the actual loss, especially in the cacao plantations as they are cultivated today.

The principal losses are caused by leaching and washing. The heavy tropical rains wash away large amounts of humus as well as soluble potash and phosphate salts from the underlaying soil. The shade trees take up large amounts of potash and phosphate as well as nitrogen, except the legumes. These elements are again partly returned to the soil in the leaves and flowers dropping, but a great deal of the plant food is lost before it reaches the cacao roots.

These losses can never be wholly prevented but they can be greatly minimized by improved cultural methods.

With the knowledge that an abundance of plant food is present a planter is not willing to supply more and his trees are in about the same position as he would be on top of a heap of uncooked beans without any fire or pot to cook them in. A pot of cooked beans would be real food whereas a ton of raw beans would be next to starvation. The same is true of that locked-up plant food in the soil, the cacao trees may be actually starving in the midst of plenty. Hence the planter's problem is how to supply the food.

The remedies are organic matter, lime and cultivation augmented by artificial manure. Organic matter supplies nitrogen and also organic acids which liberates the mineral salts of potash and phosphorus. Cultivation lets air into the soil and this liberates plant foods. Lime is needed as a plant food but aside from that it is needed in most cacao soils to neutralize acidity. A soil containing free inorganic acids does not yield good crops and especially leguminous plants do not thrive well. Likewise decay of organic material which is caused by bacterial action does not take place in soils that are perceptibly acid. Lime may be applied in the form of marl or chalk or burnt limestone. The former can be applied in large quantities, two tons or double that amount per acre, but burnt lime or caustic lime should be used with caution, not more than 1,000 pounds per acre should be applied or it will "burn-up" the organic matter too fast. Rightly used, most cacao soils would be benefitted by liming each 5 to 6 years or more according to the amount applied.

Most cacao soils that have been under cultivation for some years also need to be manured. This is a fact fairly well recognized by all who have studied the subject, but the

question confronting the planter is what to use and how to use it. Barnyard manure cannot be obtained in the West Indies except in small quantities, and the only way to obtain soluble plant foods is to buy commercial fertilizers. This is strange to most planters when first confronted with it and on first sight it seems peculiar that a hundred pounds of sulphate or muriate of potash for instance, containing but fifty pounds of potash should be able to exert an influence on an acre of land which already contains, according to analysis, several tons of that material. Experience in all countries have clearly demonstrated however, that it is the only remedy, and with cacao as well as with other crops it is short-sightedness to keep the trees in a half-starved condition depending upon the slowly available plant foods in the soil. This is well recognized by the more progressive planters who are conducting experiments on their own plantations and by the Departments of Agriculture in the various Islands, all of which have been conducting experiments for several years.

While such experiments are valuable and really the only sure guide to follow, the results may be misleading where the rule of thumb methods is followed. In an old plantation with trees which are different, one from another in variety, vigor, prolificness etc., and where there are a number of shade trees also more or less unequal, it is almost impossible to obtain reliable results by comparing the yield from one plot to that of another. Furthermore the trees in a plantation having never been cultivated or manured will respond to a different treatment the first year or two to what they ought to have later. The first manurial operations in such a plantation are liming and forking. This will almost invariably give good results. It will not last however, and in six months or a year a fertilizer rich in nitrogen

TREE NOT FERTILIZED—TRINIDAD

should be used. This will also give good results, convincing enough to any planter who will note the luxuriant growth and healthy state of his trees. On the other hand, if he should use a fertilizer containing much potash and but little nitrogen at that time the planter might not obtain that result and he would gain a wrong impression of fertilizers because of having used the wrong material.

Nitrogen is conducive to wood and leaf growth, while potash matures the tissues and is conducive to fruit formation, On old trees usually the first thing is to start new growth, hence the nitrogen to begin with. If however, this is followed up with nitrogen without potash the result may be quite different. The luxuriant growth started by nitrogen will enable the tree to take up some of the insoluble potash in the soil but seldom enough for hardening up the wood and setting a large crop of fruit, therefore the second attempt of fertilizing would not be as satisfactory as the first. Fertilizing is indeed a science and the man who masters it on his plantation will not have to worry over canker and all the various diseases so frequently discussed.

The nitrogen may in old plantations be supplied from Nitrate of Soda, Sulphate of Ammonia, Slaughterhouse Products or lime nitrogen. However, where the plantation is shaded with some leguminous tree, like the Immortel or Madre de Cacao, less nitrogen will be needed. In new plantations where cover crops can be grown, most of the nitrogen can be obtained in this way.

Phosphoric Acid is usually obtained in the West Indies from Acid Phosphate and Basic Slag. Either may be used but the slag is much preferable on land inclined to be acid because of the large amount of lime it contains. The Double Acid Phosphate is a desirable form where transportation is an object as it contains over 40% phosphoric acid.

TREE IN SAME PLANTATION AS THE FORMER—FERTILIZED WITH POTASH, NITROGEN AND PHOSPHORIC ACID

The Potash is all obtained from the Stassfurt Potash salts, especially Sulphate of Potash, Muriate of Potash and Kainit. The sulphate is used almost entirely for cacao at the present time but general experience in the West Indies indicate that muriate is the more effective, especially on the heavier soils, and probably that form will be used more extensively in the future.

All fertilizers contain or should contain these three elements, nitrogen, phosphorous and potasium, in the most suitable form and in the proportions needed by the tree at the time the fertilizer is applied. A young tree or a dormant, neglected tree needs proportionately more nitrogen while a tree in good condition needs proportionately more potash and phosphoric acid. The following formulas are examples of what may be expected to give good results:

No. 1.—For Young Trees or Old Neglected Trees.

Muriate of Potash. . .	40 lbs.	6 %	potash
Basic Slag.	100 „	6 %	phosphoric acid
Nitrate of Soda. . . .	200 „	9.4 %	nitrogen

Apply from one pound per tree on small trees to 10 pounds per tree for large old trees.

No. 2.—For Young Trees Beginning to Bear or Old Trees in Fairly Good Growing Condition.

Muriate of Potash. . .	40 lbs.	7 %	potash
Basic Slag.	100 „	7 %	phosphoric acid
Nitrate of Soda. . . .	150 „	8.3 %	nitrogen

Apply from two to three pounds per young tree, according to size, and about ten pounds per old tree of good size.

No. 3.—For Bearing Trees in a New Plantation or Trees in Old Plantation Having Previously Had Former Applications.

Muriate of Potash. . .	50 lbs.	10 %	potash
Basic Slag.	100 „	8 %	phosphoric acid
Nitrate of Soda. . . .	100 „	6.4 %	nitrogen

Apply five to fifteen pounds, according to condition of trees. *

Fertilizing is not a universal panacea for all cacao troubles. It will not cure canker, drive away insects, supply humus and moisture nor loosen the soil. It will however make the trees resistant to diseases, prevent the excessive dropping of blossoms, and be better able to withstand unfavorable climatic conditions. But fertilizers should never be used except in conjunction with drainage, cultivation, pruning and general sanitary measures. Also whenever the soil is lacking in vegetable matter and is in poor physical condition fertilizers cannot be expected to give good results without cover crops or mulch.

In young plantations fertilizers should be applied 2 to 3 feet from the tree in a circular band 2 to 3 feet broad As the trees grow older the circle must be broadened, and for old trees entirely covering the ground, the fertilizers should be broad-casted over the whole plantation. In new plantations in which the soil is cultivated from the beginning the fertilizers should always be covered at once by whatever tool is used for cultivation. In old plantations, where no machinery has been used and the soil cannot be forked without destroying the roots, all the leaves and vegetable matter may be raked into piles around the trees, the fertilizer then scattered broad-cast and the soil vertically forked, that is, inserting the fork and withdrawing it after twisting so as to enlarge the holes. After which the leaves may again be scattered.

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* Where leguminous crops, such as cowpeas, pidgeon peas etc., are produced in quantities and plowed or forked in, the amount of nitrogen can be cut in half, and after a few crops dispensed with altogether.

What fertilizing does may be seen from the following experiments: *

Plat Number.	MANURE PER YEAR	Average annual yield of cured cacao during 7 years.	Annual value per acre over No manure at 12 cents per pound of cured cacao	Annual cost of manure per acre	Annual gain per acre by manuring.
1	No Manure.	1,144 lbs.			
2	Basic Slag 400 lbs. . . Sul. Potash 150 „ . .	1,386 „	$29.04	$10.86	$18.18
3	Dried Blood 400 „ . .	1,334 „	22.80	8.64	14.16
4	Dried Blood 400 „ . . Basic Slag 400 „ . . Sul. Potash 150 „ . .	1,529 „	46.20	19.50	26.70
	✣ Mulched.				
5	With about 80 lbs. . . per tree of grass, leaves and sweepings.	1,620 „	57.12	14.40	42.75

In the remarks on the general health of the trees in these plats it is stated that the trees in plat No. 1 were so small that it required 178 trees to cover an acre, 155 trees in plat No. 2; 139 trees in plat No. 3; 124 trees in plat

* Dominica Botanical Station Report 1909-1910.

✣ According to the West Indian Bulletin, Vol. 10 No. 2, the grass from one acre of cacao orchard contains 70.8 pounds nitrogen, 21.1 pounds phosphoric acid and 94.8 pounds potash. The mulch used in the experiment was much richer however, because it contained sweepings and Saman pods which are very rich in nitrogen.

No. 4; and 108 trees in plat No. 5. This shows the size of the trees fairly well and it is readily apparent that the last two plats, the one fertilized with nitrogen, potash and phosphoric acid and the one mulched, did not alone yield the most but the trees were also larger and in better condition. In regard to the mulched plat it may be well to remember that the material used was brought in and that the quantity applied probably furnished opwards of 1-¼ pounds of nitrogen, ¾ pounds potash and ¼ pound phosphoric acid per tree, which is more than any of the other plats received. But aside from that it shows the value of mulching as a method of cultivation.

In St. Lucia manuring and cultivation gives good results.* A field yielding 56 pounds only to begin with was brought up to 1,100 pounds in the short space of three years by pruning, forking and manuring with 1,000 pounds Basic Slag, 50 pounds Sulphate of Potash, 100 pounds of Sulphate of Ammonia and 5 cart loads of barnard manure. The cost of cultivation and manuring during the three years was $70.32 and the value of the crop for that time was $218.40. A gain of $148.18.

On another estate, not under the Departament supervision, similar cultural and manurial treatment, on 38 acres of old cacao resulted in a net profit of $864.00 for 9 months over and above the average crop reaped from the plantation before manuring was commenced. The benefit to the general health and bearing capacity of the trees is said to have increased their value by $2400.00.

From Grenada Mr. H. A. Berkely of Mount Hope Estate reported that in 1908 he obtained an increase of almost

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* West Indian Bulletin Vol. 8 No. 2.

100% from an application of 800 pounds of Basic Slag * and 100 pounds Sulphate of Potash per acre.

In this connection we also quote experiments conducted by Prof. Wohltmann in Camaroon, German West Africa. He says that typical soils of that district are very good and cacao makes excellent growth when properly treated. Trees ten to twelve years old show lack of vitality however, and frequently plantations are injured by diseases more than should be expected under such conditions. The yield also diminishes earlier than might be expected from experience in other countries which led to the following experiments:

Analysis of Soil from the Plantation

Where Experiment was Conductod.

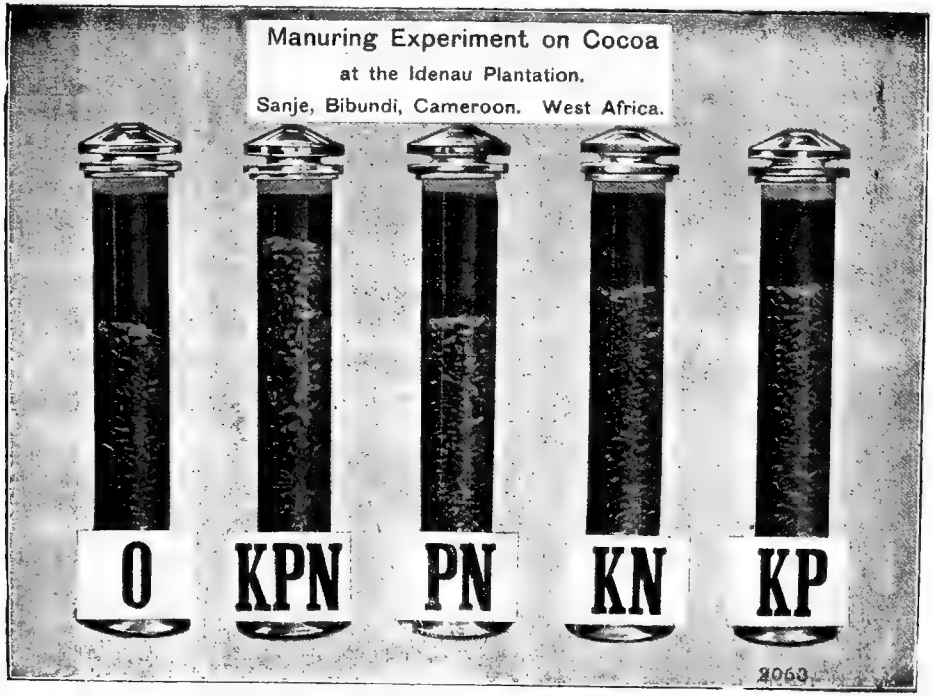
	To a depth of 20 inches.	From 20 inches to 40 inches.
Moisture.	14.49 %	12.27 %
Organic Matter. . . .	11.31 %	10.96 %
Nitrogen.	0.133 %	0.127 %
Iron cpds.	28.391 %	32.305 %
Silica.	0.989 %	0.658 %
Lime.	0.321 %	0.309 %
Magnesia	0.217 %	0.263 %
Phosphate.	0.123 %	0.145 %
Potash.	0.04 %	0.151 %

* Large applications of Basic Slag seems to have given better results than might have been anticipated in many cases, which is no doubt due to the lime it contains.

Fertilizers Applied and Yield per Tree.

Plat No.	Material per Tree	Yield per Tree of Dry Cacao
1	Lime. . . . . 2.2 lbs. Kainit. . . . . 2.2 „ Superphosphate. . . . 1 „ Sulphate of Ammonia. ½ „	3.78 lbs.
2	Same as No. 1 without Lime	5.32 lbs.
3	Same as No. 2 without Nitrogen	4.66 lbs.
4	Same as No. 3 without Phosphate	3.23 lbs.
5	Same as No. 4 without Potash	3.87 lbs.
6	Same as No. 1 without Nitrogen	3.89 lbs.
7	Same as No. 1 without Phosphate.	4.68 lbs.
8	Without Fertilizer	1.45 lbs.

The materials used in this experiment cost, including freight, Kainit $2.74 per sack; Superphosphate $3.12 per sack and Sulphate of Ammonia $6.62 per sack, which makes the fertilizer on plat No. 2 cost 6.5 cents per tree. As there was a difference in yield of 3.87 lbs. per tree between that plat and the unfertilized the profit after



RESULT OF EXPERIMENT IN CAMEROON, WEST AFRICA

deducting the cost of the fertilizer would be 36 cents per tree with cacao selling at 11 cents per pound.

In another experiment with trees 7 years old, plats containing 50 trees each, were fertilized with Muriate of Potash, Basic Slag and Sulphate of Ammonia with the following results:

No. Plat	MATERIAL APPLIED PER TREE	Cost per tree in cents.	Yield per tree in lbs 1907.	Yield per tree in lbs. 1908.	Total.	Gain or Loss compared to Plat No 1.	Value of increase in cents.	Profit per tree in cents after deducting cost of manure.
1	½ lb. Murate of Potash		2.01	2.30	4.31			
2	1-¾ lb. Basic Slag ½ lb. Sulphate of Ammonia	4.82	2.55	2.62	5.17	0.86	9.46	4.64
3	Same as No. 2 but without Potash	3.64	2.07	2.00	4.07	0.24	Loss	6.28 Loss
4	Same as No. 2 but without Phosphate	2.94	2.31	2.36	4.67	0.36	3.96	1.02
5	Same as No. 2 but without Nitrogen	3.06	2.33	2.38	4.71	0.40	4.40	1.34

These returns are not phenomenal but compared to the amount of fertilizer applied the increase in yield is very good. From an experimental standpoint the results are very suggestive, showing the need of Nitrogen, Phosphor-

ous and Potash, especially the latter, as shown in the loss from plat No. 3 where no Potash was applied.

Many results might be quoted but to sum up the matter, fertilizer in conjunction with cultivation pays. A fertilizer should contain all three elements: nitrogen, potash and phosphoric acid. The relative amounts of these elements should be varied according to the tree's need.

PRUNING AND SANITATION

A cacao tree, like an apple tree, or an orange tree, can be pruned to suit the fancy of any planter. For practical reasons the tree should be low and spreading and it should be made to assume that form from the beginning. When three to four feet high the young stem should be checked in its upward growth by pinching off the terminal bud. This will induce it to branch and in a few weeks all shoots should be removed except three to four of the upper ones growing in opposite directions which will then form the main branches of the tree. After that all other shoots springing from the trunk should be removed every few weeks and new growth on the branches that show an inclination to grow too tall or to make the shape of the tree lop-sided should be pinched off. This is the ideal to strive for but it is difficult to reach in a large plantation because the trees grow so fast that they cannot all be attended to at once and when the shoots become too large to pinch off they must be cut off. But as soon as cutting tools are introduced troubles of all sort begin. In the first place improper tools are used and in the second place the average laborer does not know how to prune properly. It is frequently asserted that a machete or cutlass in the hands of an experienced man is a good enough tool for

pruning, but that is only theoretically correct. A cutlass should be strictly prohibited for that purpose. The proper tools are a knife, a saw, a pair of hand shears and a pair of long-handled shears. These tools should all be kept sharp and no laborer should be allowed to prune until he has been taught to do it properly. A branch, whether small or large, should always be cut off so close to the trunk or limb that the scar will heal over without leaving any perceptible mark. The cut should be clean and smooth. If the edges are ragged they should be trimmed off with a sharp knife. If the branch to be removed is large and heavy it should be sawed off a distance from the trunk to relieve the weight and prevent it from splitting after being partly sawed off. The stub can then be sawed off close to the trunk, the edges trimmed with a knife and the scar painted over. For covering scars alomst anything that will stick and seal the cut over can be used. The main thing is to prevent the entrance of fungi until the scar has healed over. If the scar is not too large a coating of carbolinium may be sufficient as that wi'l keep it aseptic, but on large scars some kind of paint or coal tar must be used. When removing small branches no such precaution is needed as such scars will heal over quickly.

Unfortunately trees are usually injured in other ways than by pruning. All old trees show more or less scars caused by the cutlass when cutting weeds in the plantation and by the picking tools when gathering the crop. Such injuries are usually the indirect cause of fungus diseases. Most planters know that canker is caused by fungi but the laborers do not realize that any little rift in the bark caused by sharp instruments immediately becomes a harbor for fungus growth.

Old plantations are very much more difficult to handle than trees which have been properly cared for from the

beginning. Some trees are fairly healthy but tall and sprawly, frequently full of holes caused by rotting stubs of limbs removed years back. Others are sickly and bear no crop although the roots seem healthy because water sproughts come up each growing season. The first mentioned trees may be topped gradually and be made to branch lower and more regular, but first of all the diseased parts should be cut off. Tree surgery is now a profession in northern countries, why should it not be in the tropics also? An inexperienced laborer cannot properly clean out and fill up a cavity in a tree. That can only be done by an experienced man and it should never be left to a man who is not conscientious. In cleaning a cavity it is essential that all the dead and decaying material should be removed, for which operation chisels of various sizes are the best tools. Also the opening of the cavity should be narrower than the interior in order to retain the filling, on the same principle that a dentist fills a tooth. The interior of the cavity should also be made aseptic with carbolinium or a 5% solution of carbolic acid in water. For filling, cement is used successfully in the north, but anything that will prevent water from entering may be used. Mr. Barrett * recommends two parts clay to one part fiber, such as from the silk cotton tree, moistened with water to allow it to be worked together and a little oil added to it to prevent it from cracking and shrinking. Whatever is used it should be packed in firmly to within a quarter of an inch of the outer edge of the cavity. This leaves room for the bark to grow over it, whereas if it were filled topfull the bark would take much longer to heal over and also leave a hump on the tree.

* Society paper 266 Agricultural Society Trinidad.

The precautions in tree surgery are to cut into live tissue and to cover with a material that will not let in air and water. Trees that are sickly and bear but a few pods should be renewed. That is, a water sprout should be allowed to grow up and the old trunk should be cut off. In doing that it is not alone possible to renew the tree in a couple of years but is is also possible to change it into a desirable variety. A water sprout after it attains the size of an inch or so can be budded or it may be inarched by taking a potted plant that has been previously inarched and setting it close to the young sprout, scarify the two plants on one side and tie them together in the usual way.

The old saying "an ounce of prevention is worth a pound of cure", is absolutely true in plantation sanitation. As a matter of fact the ordinary remedies for fungus or bacterial diseases do not cure, they merely prevent spread. A copper solution, such as Bordeaux mixture, does not kill the mycelium or part of the fungi in the tissue, it merely kills the spores on the surface and prevents new ones from germinating as long as there is a particle of copper left. Therefore spraying is not the first resort. All dead and diseased wood, bark and pods must be cut off and burned or buried. After that spraying with Bordeaux mixture may prevent new attacks. However, with proper methods of planting, cultivating and fertilizing, the spray pumps will be less needed and cacao growing will be more profitable.