VEGETATIVE PROPAGATION OF CACAO FROM GREEN-WOOD CUTTINGS AT THE LOWLAND AGRICULTURAL EXPERIMENT STATION, KERAVAT.

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The importance of vegetative propagation by green wood cuttings has been realised by the Officers of the Department for some considerable time although it was not until the latter portion of 1949 that detailed experimentation was undertaken in this particular field. Interest was centred upon applying already proven overseas techniques.

Propagators.

When it was finally decided to undertake propagation trials in earnest, the first thing attempted was the construction of a propagator along the lines of the "I.C.T.A. Solar Propagator (8)".

Limited success was obtained by using the Solar Propagator. However, to simplify procedures it was decided, towards the latter portion of 1950, to attempt methods of propagation that would greatly reduce the costs of installing large cement and glass structures and obviate the necessity of having extensive water reticulation systems. This work was undertaken for several reasons, not the least important being the difficulty of obtaining suitable building materials from local sources and the fact that the average person on plantations would be able to construct the more simple propagators with materials already on hand. Materials such as packing cases and similar wooden structures, together with sheet glass coverings, were selected as the basis for experiments.

Propagators of Simplified Type.

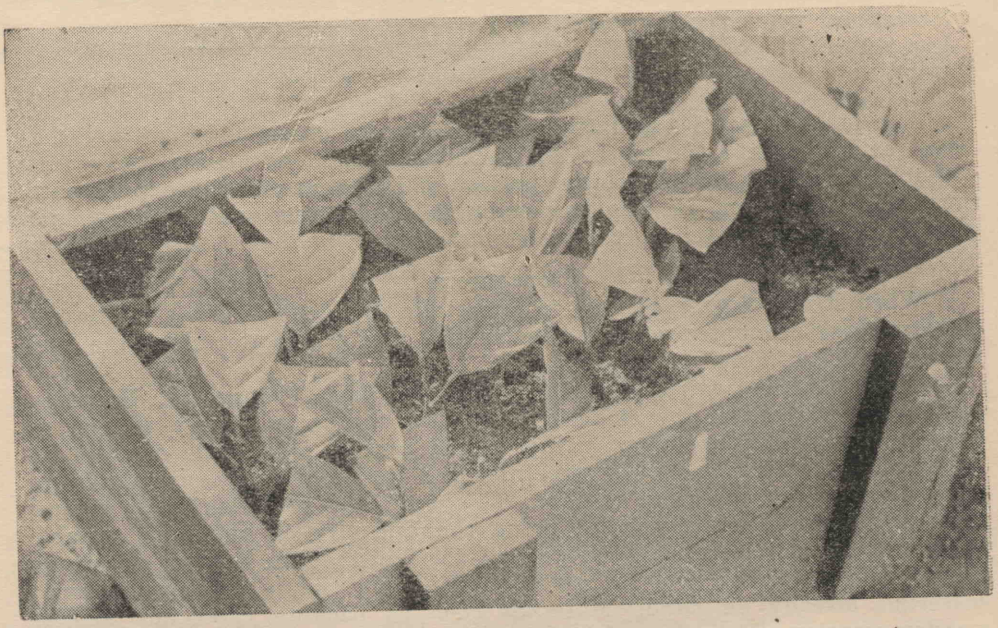
In the first trials ordinary Oregon Pine packing cases 25" x 15" x 14" deep, raised 3" from the ground on pieces of wood were utilised. Drainage was insured by means of holes bored in the base of the case, the base being lined with small stones on top of which was placed well rotted sawdust to a depth of 6-inches. The cacao cuttings were inserted in the prepared soil and the case covered with glass and cheese-cloth. The immediate success obtained in striking the cuttings prompted further experiments along these lines.

All further trials were laid down using home-made cases measuring 20" x 30" x 12" deep and using 6" x 1" timber for construction. It is considered quite practical to have larger cases constructed provided the glass used is of sufficient size to cover them without causing any appreciable drop in the internal humidity. The cases were so made as to be left with small openings between the narrow planks or slats forming their base so as to enable excess water to drain away. These slat type openings in the base were covered with small stones and over these stones well rotted sawdust was placed to a depth of 5". Cheese-cloth coverings were placed over the cases and on top of the cloth was placed sheets of one-eighth inch plate glass.

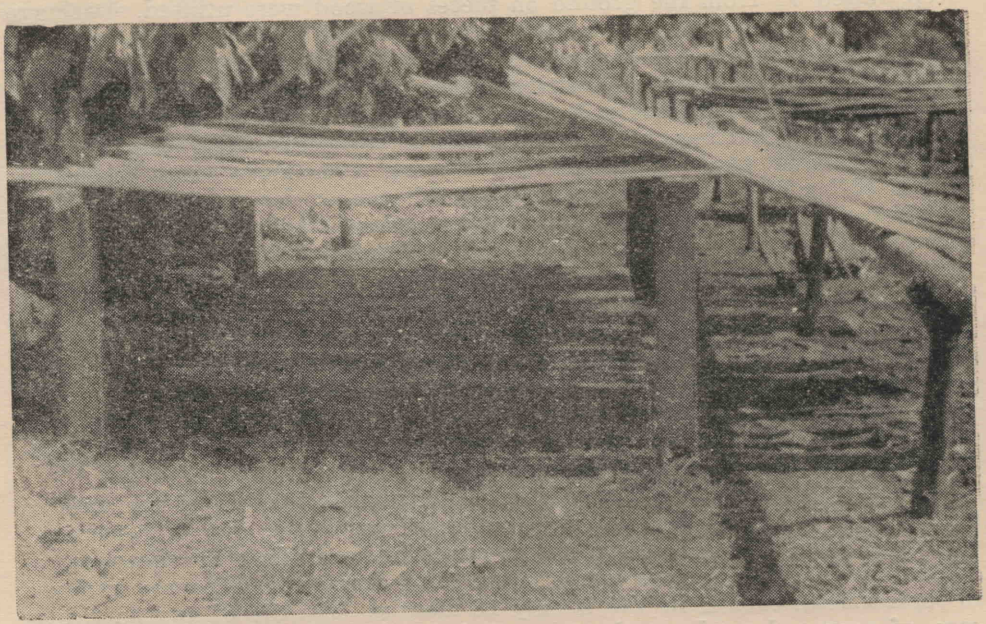
It will be seen that the cases so constructed were by no means elaborat and their assembly calls only for semi-skilled craftsmanship.

The disadvantages resulting from the fact that the life of the case so constructed is limited because it is made of wood and, due to continuous watering, is kept in a constantly wet condition, are offset by cheapness of construction. These factors would more than repay any expenses involved in replacement, even if its life is only 18 months. The life of any particular case, of course, depends on the type of timber used in its construction, e.g., whether hardwood or of softwood. In these experiments the painting of

the inside of the cases, either for preservative or light reflecting purposes, was intentionally avoided in order that costs might be kept to a minimum.



Cacao cuttings in place in the wooden boxes which are used as propagators.



The alternative cement propagator, covered overhead by bamboo slats and by glass and cheese cloth over the cuttings.

Cuttings set in place in the above propagator.

There is nothing against the use of a permanent cement structure for propagation of cacao cuttings; however, ease of portability is a decided advantage. Where it is desired to produce large quantities of cacao cuttings the obvious procedure is the arrangement of a number of boxes in "batteries," particularly as the boxes constructed as described above are light and thus capable of being easily transported to selected sites in the field near where planting is to be done.

Selected Trees and Cuttings.

The cuttings are taken from the terminal green-wood, which has hardened following a "flush" to a stage where the leaves, when gently crushed in the hand, emit a crinkling sound, but do not crack or exhibit signs of damage. In the field the cuttings are generally taken longer than required. This is done to permit a further cutting immediately prior to insertion in the propagator. In this way a freshly cut surface is brought into contact with the rooting medium. It is sound practice not to remove all the green-wood of the parent tree but rather to leave a small proportion so that the natural development of the tree is not excessively hindered. However, the availability of suitable wood governs this factor. Where material permits, the longer and thicker the cutting, the better.

The cutting of material from the tree is usually performed early in the mornings. There have been various opinions expressed as to the best time for collection. Some authorities consider that it is advisable to collect in the late morning, by which time the terminal stem and leaves have had an opportunity to build up and store available carbohydrates. However, there is little to support that any one time in the morning is better than another under New Guinea conditions. Cuttings are generally gathered about 7.30 a.m. and inserted in the propagator by 10.00 a.m.

For general purposes, cuttings are taken with ordinary secateurs, marked

for identification with a metal tag and wrapped in previously wetted hessian type material. This latter provides sufficient protection until it is possible to get the cuttings to the site of the propagators.

Where cuttings are taken from a parent tree in an exposed position, considerable trouble has been experienced in rooting them. Material from trees receiving only 40 per cent. to 50 per cent. of the full light intensity, tends to give better root strike. It is sometimes necessary to collect material in a completely exposed position. In this case, cuttings taken from the branches protected by the tree itself develop roots better than those taken from fully exposed branches.

During the experiments, certain of the numbered selections set roots more easily and quickly than others. This can be partly explained by the above paragraph as the selected parent trees were situated in areas of varying shade intensity. However, there are apparently other factors also governing cutting development. Cuttings taken from certain selections have set root up to three weeks before those of other selections which have been given identical treatment. Such cases are, fortunately, rare and usually these cuttings, if left for a longer period in the propagators, will set roots as well as the earlier developing types. However, death occasionally results where cuttings are left for excessively long periods due to the exhaustion of the available food stored in them. Various techniques have been evolved whereby cuttings can be kept by treating them with carbohydrate, sucrose solutions. These techniques are outside the scope of this paper.

It has been recorded that rooting percentages vary with certain periods of the year. As yet no significant variation has been detected, though it is probable that at Keravat, root development will be uniform, as the rainfall is relatively evenly distributed throughout the year. Where there is any noticeable variation, it will more than likely by connected with rainfall; root development falling off where trees are experiencing dry conditions.

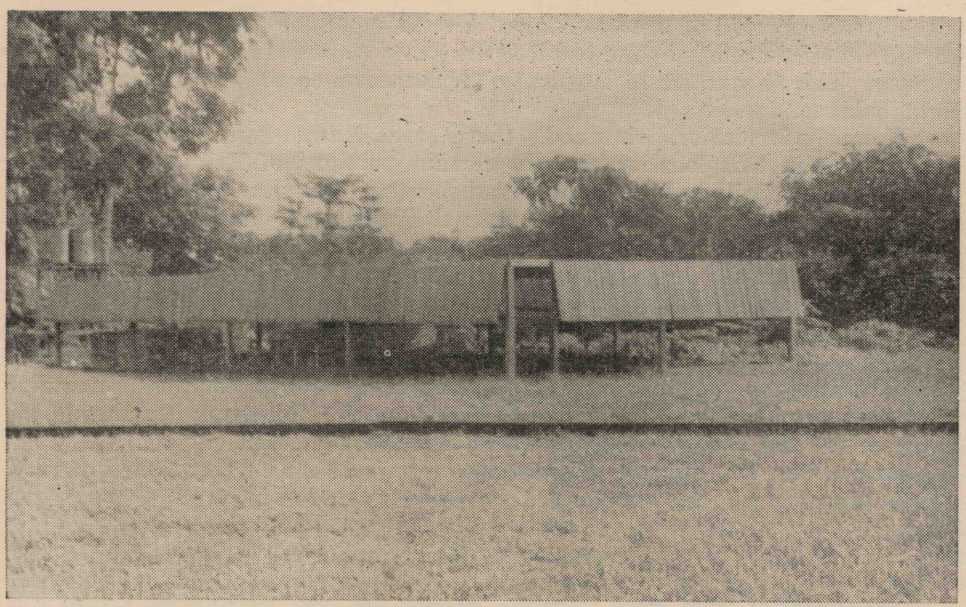
Future Propagating Material.

To ensure future supplies of selected parent material, it is general practice to plant up a specially prepared retaining block. Such a block permits the cutting of propagating material without damaging trees required for production and also permits closer observation and control of the parent material.

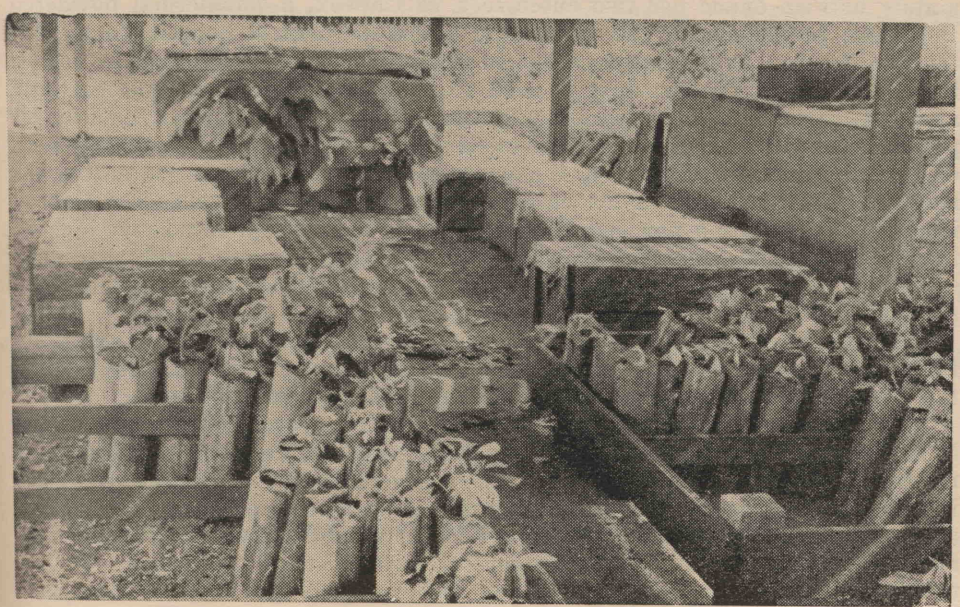
The propagational block at Keravat is interlined with **Leucaena glauca,** which supplies the necessary shade, in rows nine feet apart. Between these rows, provision is made for planting the Cacao in holes four feet apart. Once the cuttings are planted, the shade is adjusted to produce maximum suitable greenwood. In this way, by careful pruning of shade and cacao, an abundance of propagation material is obtained. Shade should be somewhat heavier than for trees planted out in the field for, as stated above, better rooting has resulted from cuttings taken from trees under 40 per cent. of the external light intensity. There is apparently a correlation between shade and the flushing of cacao, and this must also be taken into account if the maximum propagating material is to be obtained.

Site of Propagator.

The cases to be used as propagators are generally mounted in a site where natural shade is to be found, i.e., under a tree. If this is not available, then artificial shade will have to be created, either with calico, hessian, frond or lath constructions.



General view of the lath shelter in use at Keravat for establishing cacao cuttings.



Internal view of shelter showing the cuttings hardening in bamboo containers, the propagation boxes and the cement hardening chambers.

Light, and the rooting medium, together, form the most important factors for successful root formation and the resulting high percentages of root development.

Considerable trouble was experienced in the original work due to the neglect of the light factor and the placing of too much emphasis on temperature and humidity control. The first attempts resulted in complete leaf drop in four to six days. The only time that a noticeable improvement was obtained

was during a period of overcast days. Alteration of the shade, but apparently to the other extreme, again resulted in heavy losses and a low percentage rooting. This is quoted to illustrate the importance of obtaining a correct light balance.

From information obtained, there are many more cloudless days experienced in this locality than in certain portions of Trinidad and other sectors of the British West Indies and Central Americas. This requires an alteration of their recommended external shade controls to suit local conditions. It was not possible to obtain a correct light balance when using calico awnings.

We have found that boxes placed in a light intensity of about 40 to 50 candle-power per square foot have given best results. The light readings were obtained by means of an ordinary photographic exposure meter. The general trend of the reading was towards the 50-foot candles. Whatever the reading, and this is important, it should be the objective to maintain the light, under the shade canopy, as even as possible. Without the aid of an exposure meter, it is difficult to give any guide as to the correct light intensity, and it can only be found through trial and error.

Operation of Propagator.

The medium used with greatest success for the rooting of Cacao was ordinary rotted sawdust, to which had been added a small amount, approximately half an ounce per two cubic feet, of Cuprox, a commercial powdered Bordeaux preparation. The Cuprox is added to control certain fungi that tend to develop in the sawdust but it is not very effective, unless it is in a fresh condition. The sawdust is used to produce three batches of cuttings, and then discarded. It is possible that the sawdust could be used for a longer period before becoming useless, due to either complete breakdown of structure, or fungal infection. However, the nearness of a sawmill has permitted the renewal of the sawdust in the cases at three-monthly intervals. The Cuprox is added every time a new batch of cuttings is to be propagated. By digging to the bottom of large stacks of sawdust, which can be found near most sawmills, it is generally possible to locate material at an ideal stage for propagation purposes.

Coir fibre, well rotted and finely ground, has made a suitable substitute for sawdust. This is considered a second preference, for it tends to hold to the roots and cause damage when removing cuttings from the bins.

Suitable sand has been difficult to obtain from local sources and results have been very poor whenever it has been used. It consists of too great a mixture of fine and coarse grains which pack excessively when watered. Sand is a recognised rooting medium, and there is no reason why it should not be used provided that it is the right type. Coarse sands, given sufficient water, are preferred by some nurserymen for propagation work. However, care has to be exercised when using such sands, for excessive aeration can take place resulting in excessively calloused cuttings with slow root development. This abnormality can sometimes be overcome by more frequent waterings, but on the other hand, it would be far more advantageous to locate a finer particled sand. A suitable medium should be capable of good drainage coupled with the ability to remain in a moist condition until the next application of water.

The case is filled to a depth of five inches with rooting medium. This is just sufficient to permit lengthy roots to develop without becoming twisted and damaged by growing to, and coming in contact with, the bottom of the case. If trouble is experienced in this respect, and this has not yet been the case at Keravat, it is obvious that the case must be made deeper. Seven

to eight inches is generally sufficient space between the glass and the top of the sawdust.

The cuttings having been brought from the field, are immediately prepared for insertion into the propagator. This entails taking as long a cutting as practicable, though space inside the propagation chamber does not permit the selection of cuttings in excess of seven inches overall length. Standard practice now is the normal three-leaf cutting, with about two inches being allowed for insertion into the sawdust. Some material when brought from the field is of such a length that two cuttings can be taken from the one piece of wood. The leaves are cut with a sharp knife or razor blade to about one-third of their natural length and the main stem is severed to expose a freshly cut surface. The actual site or angle of the cut matters very little, for rooting takes place satisfactorily whether cut at nodes or internodes. A sharp cutting instrument is essential to prevent excessive damage to the stem and leaf tissues.

The freshly exposed surface is immediately dipped into a hormone solution and placed into the rooting medium at about three to four-inch intervals on the square. The treated cuttings are then watered, a single layer of wetted cheese-cloth put over the glass lid, or alternatively, the glass lid placed on top of the cloth. The internal bin temperature is generally about 83 degrees F. during the hottest hours of the day, though Cacao is widely tolerant as regards temperatures. The extreme temperature recording with root development still taking place was 98 degrees F. In order to obtain maximum root formation, it should be the objective to keep the temperature as near as possible between 83 to 85 degrees F., for, if exposed to continuous high temperatures, root development is retarded. The humidity was maintained between 94 to 100 per cent. throughout the trials.

Numerous types and concentrations of hormones have been used, with varying degrees of success. It was originally intended that only compounds which could be obtained from a commercial firm in ready-made form would be tested, since laboratory facilities were limited, and it was desirable to keep costs as low as possible for intending small producers. Hormones are expensive, and as very dilute concentrations are used, purchasing costs of concentrated ingredients could become an important factor where it is not intended to plant or establish large numbers of cuttings.

Trials were laid out in the case, as already described under the heading "Propagators," treating each of 12 cuttings with the following:

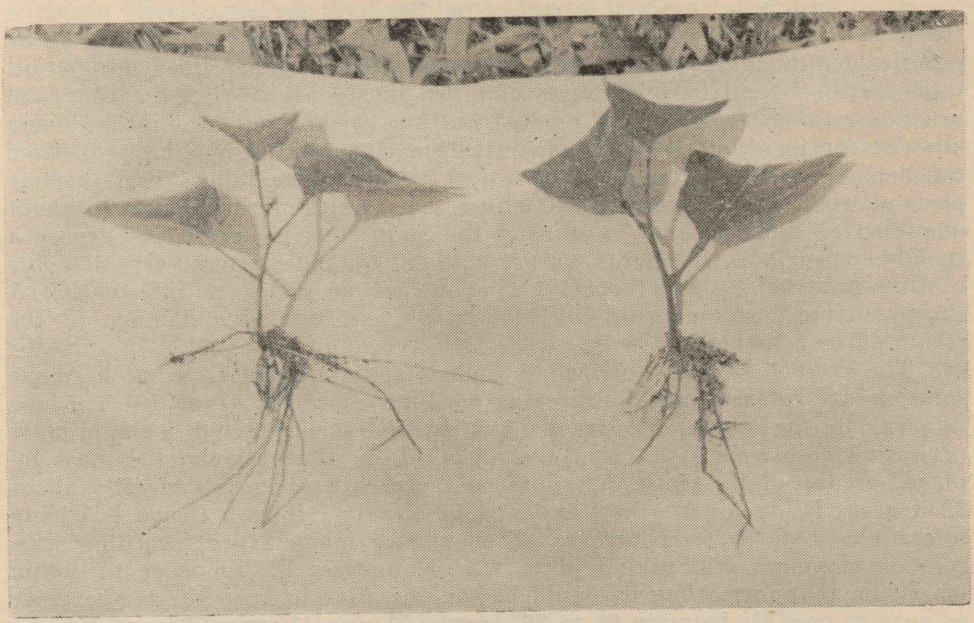
(a) Indole butyric acid—2½mg. per 1 c.c. of 50 per cent. alcohol.
(b) Indole butyric acid/Indole acetic acid powder.
(c) Potassium Indole butyrate/Pot. Napthalene Acetate solution.
(d) Control.

Table of Rooting Percentages at Completion of 28 Days.

Treatment	Average Length of Roots	Number of Roots in Cluster	Percentage Strike
I.B.A./I.A.A. Powder	2—3 ins.	3—5	25
P.I.B./P.N.A. Solution	3½—4 ins.	6—11	100
I.B.A. Solution	2½—3 ins.	3—5	60
Control	—	—	—

A one hundred per cent. strike was obtained from all inserted cuttings; cuttings treated with the Potassium Indole Butyrate/Potassium Napthalene Acetate solution were outstanding. At the end of 28 days, roots in clusters of 6 to 11 measured three and a half to four inches in length. The next in importance was the Indole Butyric Acid solution, though it was necessary to replace forty per cent. of those thus treated for a longer period to obtain

roots of satisfactory development. Although root formation did eventually occur with the others, they were far too slow.



Cacao cuttings removed from sawdust after three and a half weeks.

Utilising the information thus obtained, bulk trials were laid down, and every time, though root percentages were not always one hundred per cent., they never fell below seventy-five per cent. At this point it might be mentioned that trials laid in dull weather, with the weather lasting for any length of time, cause a marked detrimental effect on the rooting percentages. For quick root development, the P.I.B./P.N.A. solution is superior to anything of some fifteen preparations tested to date. The costs of large quantities of this preparation are rather expensive, but when calculated that each cutting tested costs approximately .1 of a penny, it is almost insignificant in comparison with the value of the resultant trees.

The cuttings are watered twice daily, 7 a.m. and 3.30 p.m., with an ordinary watering-can fitted with a very fine rose. A third watering at 11.30 a.m. is sometimes given during very hot weather. Care is taken to see that the cheese-cloth and glass is replaced following every watering. It has been found unnecessary to lift the glass to harden the cuttings, as is so important with certain other types of propagators. This is probably due to the fact that a certain amount of air gains access through the timber joints. The periodic removal of the glass coverings for watering would assist in removing excessive carbon dioxide that might have built up in the chamber.

The cheese-cloth rots rapidly and has to be replaced at three-monthly intervals. The cloth can be placed on top of the glass without any detrimental effects. This increases the life of the cloth. Precautions have to be taken to see that the cloth does not blow off the glass, exposing the cuttings to excessive light. Frosted or painted glass has been used, and has given satisfactory results. It is not recommended except where cloth is unavailable, for having the wetted material near the glass causes the internal bin temperature to be decreased by as much as 2 degrees F.

Within six days, the majority of those cuttings that are going to shed their leaves will have done so, and are removed from the boxes. A cutting without leaves, or portion of a leaf, is taking up valuable space, for replacements can be inserted. Leafless cuttings, though occasionally setting root within the chamber, generally die following potting, where the roots wither and rot. The remaining cuttings are left in place for approximately twenty-two days, by the end of which time they should be ready for removal and potting. Those that have not reached a satisfactory stage of development are left for a further period to permit roots to develop.

Potting.

Under local conditions, it has been necessary to utilise bamboo pots for the potting process. They are not the best type to pot, but they are satisfactory. The pots selected are the largest diameter possible, 4 to 5 inches, and about 10 inches in length. These are split lengthwise into two portions, and then re-fastened with a piece of wire. This reduces damage to the roots when the time comes to plant in the field. The wire is undone, instead of slashing the bamboo with a knife, and the two sections separate easily from the soil.

The potting mixture in use is equal parts of well decayed compost, top soil and well washed river sand. To this is added equal quantities of muriate of potash and sulphate of ammonia, two ounces per two cubic feet of mixture, a day or so prior to the actual potting.

When removing the cuttings, care is taken not to damage the roots whilst putting them into place in the tubes. In most cases a quantity of sawdust adheres to the roots and it is a sound practice to leave it intact. It is worth remembering that Cacao roots are quick of growth, tender, and very easily broken or damaged. Careless handling can result in a rooted cutting being rendered useless for potting.

Hardening.

The cuttings having been tubed are placed in a hardening chamber for approximately fourteen days. The Solar Propagator has been found ideal for the hardening process, for the potted cuttings can be easily placed in the chambers. The lid of the propagator is completely closed for two days. The following three days the cover is lifted to a height of one and a half inches, and then to three inches for the remainder of their time in the hardening chamber. Waterings are given at daily intervals for the first five days, after which time the cuttings are watered only once prior to removal.

Hardening having been completed, the cuttings are stood out under a lath shade, or other suitable shade, with a light reading one-fifth to a quarter of the outside light intensity. They are left for approximately two months before being planted out in the field. To give an exact period for them to be left under this shade is difficult, and can only be gauged following the production of the first few batches. Some authorities consider it advisable to remove to the field as soon as possible, for they consider that plant foods available whilst tubed, are limited, and hinder rapid development. Others advise a lengthy period in the tubes to enable them to stand up to the conditions with which they will be faced when planted in the field. Occasional applications of sulphate of ammonia and muriate of potash benefit the tubed cuttings.

The hardening for plantation purposes should present no difficulties even without the Solar Propagator. It is to be remembered that a loss of up to seven per cent. is sometimes suffered during the hardening process,

with occasional losses being even higher. A hole two feet six inches by five feet can be dug to a depth of one foot in a well shaded site, preferably near the propagators. On top of this hole is built a framework of planking another foot above ground level, thus forming a large chamber. The bottom of the hole is filled with sand to provide material upon which to stand the bamboo pots and affording, at the same time, a certain amount of drainage. The

Cacao cuttings in one of the hardening chambers.

Cuttings hardening off prior to being transplanted out in the field.

Cacao cutting in bamboo pot at four months of age.

structure is completed by the addition of a framework, calico covered, and acting as a lid. The principals for hardening, as already discussed, are used in operating the structure. A commercial product which seems ideally suited is "Windolite," a wire reinforced transparent plastic material obtainable in rolls two feet six inches wide. The product appears to be an ideal substitute for the glass and calico used in covering the hardening chambers, or propagation boxes.

Further Possible Experiments.

The field for further investigation is considerable. Not the least important is the application to local conditions of the single leaf cutting technique perfected by Professor Stahel (2). It is widely used overseas and it is possible that it could be used in conjunction with the propagation boxes described. However, as the entire leaf is left undamaged in this process, the boxes would possibly have to be made deeper to accommodate the extra leaf surface. The benefit to be gained from one bud, one plant, where limited propagational material is available is obvious.

Another rooting medium worthy of trial is exploded mica. This is distributed under the name of " Amicalite," and should it give the results with Cacao that is has with other plants, it will be a most satisfactory rooting medium.

Losses on planting in the field are often high. Mortality might be reduced by further experimenting with better pots, experimenting with potting mixtures, and extending the length of time the plants are left to harden.

The problems with vegetative propagation of Cacao do not terminate with what has been described or discussed in the above. It does, however, seem to have promise for the small planter, who is interested in the benefits to be gained from vegetative propagation and is not prepared to spend a lot of time and expense upon large structures. As many details as possible to assist in answering problems that will and might come to the fore, have

been given. There will be many others that will occur, but once overcome, the financial returns from the crops of resultant trees should more than repay the trouble taken and expenses incurred.

Summary.

i. A method of cheap propagation of Cacao cuttings is described utilising ordinary packing cases, or alternatively, home-made timber boxes measuring 20" x 30" x 12".

ii. Collection of material from the field, benefits in care of selection of parent material, and the planting of selected material in "holding" blocks are discussed.

iii. Site of propagators and the importance of light intensities are stressed.

iv. Sawdust is described as being the most promising of the rooting media, with the hormone treatment being preferably Potassium Indole Butyrate/Potassium Napthalene Acetate solution for use with multiple leafed cuttings.

v. Potting and hardening techniques are discussed using bamboo pots, with the cuttings being hardened in special chambers for two weeks prior to being stood out under a lath structure for further development.

Acknowledgement.

I wish to express my indebtedness to Mr. H. S. Darke, who has been most helpful in making available numerous hormone preparations.

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