

THE VEGETATIVE PROPAGATION OF *COFFEA ARABICA* L.

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INTRODUCTION

THE importance of vegetative propagation in a number of tropic plantation crops is well known. The earliest work on the vegetative propagation of coffee was carried out in Java some sixty years ago, and suitable methods have been established there. However, it is necessary to confirm such results under local conditions and trials of various methods for the vegetative propagation of coffee were commenced at the Highlands Agricultural Experiment Station, Aiyura, in July, 1955. The aim was to develop successful techniques for vegetative propagation as a tool to be used in the breeding and selection programme. Whether the development of a practical method of vegetative propagation will have a direct applicability in plantation practice is at present uncertain.

Methods.

Three methods of vegetative propagation have been tried, namely:—

- (1) Cuttings;
- (2) Grafting;
- (3) Budding.

Considerable success has been obtained with cuttings and grafts, but budding, although carried out successfully in other countries, has so far been unsuccessful at Aiyura.

1.—*Propagation by Means of Cuttings.*—

Experiments have demonstrated that coffee can be propagated at Aiyura by means of cuttings without the use of glass covered propagators, thus obviating the initial costs of cement, sawn timber and glass. Such propagators did, in the few trials conducted with them, lead to a small increase in the rapidity of striking cuttings, but this initial advantage was quickly lost. Excellent results were obtained with the simplest locally available materials, as will be described below.

(1) *Types of Cuttings.*—Cuttings from plagiotropic branches (laterals) give bushes of abnormal form in which the growth is flattened and insufficiently upright. Only cuttings from the orthotropic branches, generally known as suckers or watershoots, will give bushes of normal form, and they have thus been used exclusively in these studies.

Cuttings of various lengths and consisting of two or more internodes were used experimentally, but in these trials the longer cuttings did not give better results than single internodes. Only when the internodes are short (less than 2½ inches) is the use of two internodes advocated. The length of single internode cuttings varies from about 2½ inches to 5 inches. The use of single internodes, of course, permits the maximum increase of the material available which is most important in a plant improvement programme where the availability of material may limit the proper replication of treatments.

Generally speaking, the whole of the length of a watershoot is suitable for making into cuttings, with the exception of the top two internodes plus the terminal bud. Sometimes success will be obtained with this immature terminal growth, but results are variable. Great differences were not found in the rooting capacity between various parts of the watershoot. This is contrary to the findings of Roelofsen and Coolhaas (1) in Java, who found that "cuttings from young parts of a sucker survive and root better than cuttings from older parts, the terminal cuttings always being most successful". Typical results using cuttings of different ages are given in Table I. Hormone treatment was used in some instances, but the pattern of behaviour was unaffected.

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TABLE I.—Influence of Age of Cutting on Root Formation

Cutting Material	No. of Cuttings	Number of rooted cuttings per treatment							
		* Hort. 1/100		Hort. 1/200		Hort. 1/300		Control	
		weeks		weeks		weeks		weeks	
		12	16	12	16	12	16	12	16
Two top internodes and terminal bud (two intern. cutting)	10	0	0	0	0	0	0	0	0
3rd Internode †	10	0	6	3	9	0	5	4	9
4th Internode †	10	6	10	1	10	2	10	3	7
5th Internode †	10	0	10	3	10	1	10	8	9
Single intern. Yellow, turning brown	10	3	6	1	9	2	9	2	9
Single intern. Brown wood	10	0	10	4	6	1	9	2	7

* Hortomone A, a proprietary hormone preparation for inducing root formation.

† Greenwood single Internode Cuttings.

Some of the terminal cuttings did root eventually but they were extremely slow in coming away and did not tolerate unfavourable conditions. The older brown wood cuttings were generally slower to form roots than those taken from the younger wood, but over a longer period the differences almost entirely disappeared. For practical purposes it is considered that any part of the watershoot except the tip is equally valuable for cuttings.

In taking cuttings it was found that results were better when the two leaves of the

cutting were retained complete than when they were reduced. Whether the cut was made just above or below the node, or whether made with a pair of secateurs or a sharp knife was found to be immaterial. Consequently the quickest and most economical method, viz., cutting with secateurs just above the node, was adopted as standard practice. The impression was gained that making the cuts with secateurs and thus slightly damaging the tissues had a stimulating effect upon the root formation, but on the other hand the tissue damage also increased slightly the danger of root rot.

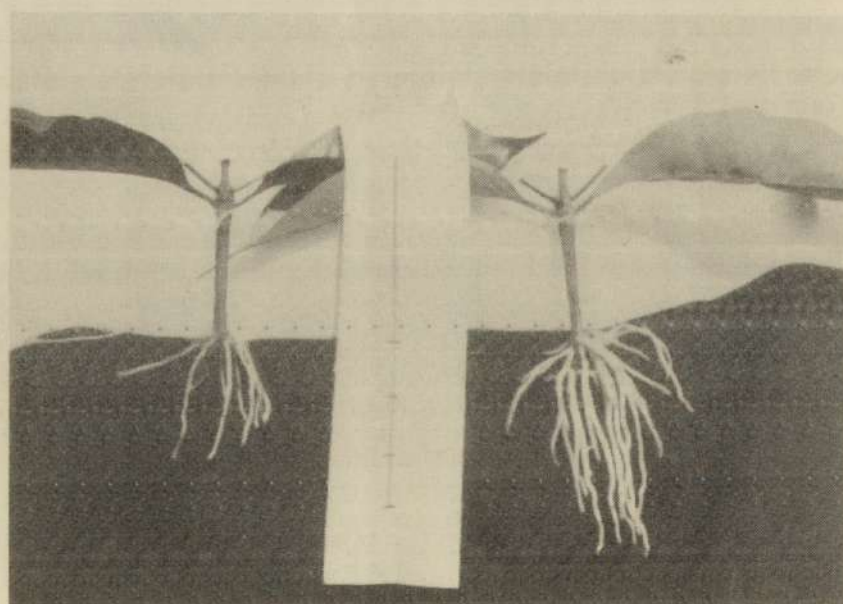


Fig. 1.—Effect of Hortomone A on rooting. Left—control. Right—treated. Age of cuttings—12 weeks.

(2) *The use of hormones*—The proprietary preparation Hortomone A was the only root inducing hormone preparation tried. It was generally found that Hortomone A did encourage early root formation, this being well illustrated by Figure I. However, the initial advantage was lost after a time, and from about the sixteenth week there was no difference between the percentage of success-

ful strikes and vigour of treated and untreated cuttings. Nor was there any significant difference between Hortomone A at a concentration of 1:100 and 1:300. Some results with hormone pretreatment have been given in Table I and further results are presented in Table II. In every instance the cuttings were allowed to stand overnight (about 17 hours) in the hormone solution.

TABLE II.—Effect of Hortomone A Treatment of Coffee Cuttings

Treatment	Date Planted	No. of Cuttings	Alive Not Rooted		Rooted		Dead	
			12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
Hortomone A 1:100	21.12.55	50	33	18	14	29	3	3
Nil	21.12.55	50	36	15	9	30	5	5
Hortomone A 1:100	5.10.55	40	31	9	9	31	0	0
Hortomone A 1:150	5.10.55	40	30	7	9	32	1	1
Hortomone A 1:200	5.10.55	40	34	8	6	30	0	2
Hortomone A 1:250	5.10.55	40	30	8	9	31	1	1
Nil	5.10.55	40	24	7	13	30	3	3

Under Aiyura conditions, therefore, there seems to be no advantage using hormone treatment, except possibly in the case of clones which do not produce roots readily or when very old mature wood is used for cuttings. Other hormone preparations may be more effective than Hortomone A, but they have not been studied as results with no treatment at all were entirely satisfactory.

(3) *Ecological Factors.*—

(a) *Light.*—Light is a most important factor in striking cuttings successfully. The secret of successful propagation is to keep the leaves alive and healthy and root formation will eventually follow. Herbaceous cuttings usually have only small amounts of stored auxin and cannot survive and form roots on their stored reserves only. Their successful propagation thus depends on the continuation of the normal assimilation processes by their leaves in the presence of light. Under tropical conditions however, the ratio between assimilation and respiration is often unfavourable. High night temperatures with consequent increased respiration require increased assimilation, which in turn depends on more sunlight; however if sunlight is increased too much, excessive transpiration and leaf burning follow. To summarize, "the whole question of retaining the leaves

on the cutting depends on whether the cutting assimilates more during the daytime than it respire during the night" (2). It is sometimes necessary to use glass-covered propagators to obtain sufficient control of these factors, but under Highland conditions this has not been necessary.

At Aiyura it has always been necessary to use some shade; when cuttings were exposed to full daylight they quickly lost their leaves and died, even when frequently wetted using a knapsack spray. After considerable trial and error, the best results have been obtained during the dry season with a light intensity of 30 per cent.-40 per cent. of that of normal daylight, ranging up to 80 per cent.-85 per cent. of normal intensity during the wet season. It is a matter of experience under any particular set of conditions as to what amount of shade is required for the best results. The increased humidity and lower temperature of the medium probably affect propagation during the wet season, but it is believed that the reduced number of hours of sunshine per day is the most important variable. The adverse effect of over-heavy shade during the wet season is well illustrated in Table III. All measurements of light intensity were made with an ordinary photographic exposure meter.

TABLE III.—Influence of Light Intensity Upon Root Formation. Planted 21.12.55.

Treatment	Number of Cuttings	Alive Not Rooted		Rooted		Dead	
		12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
Light intensity 30 per cent.-40 per cent. of daylight	100	44	34	2	12	54	54
Light intensity 80 per cent.-85 per cent. of daylight	100	69	33	23	59	8	8

The simplest and cheapest form of shade used was a heavy cover of ferns, little more than 12 inches from the ground, which is illustrated in Figure 2. However, this shade reduced the light to 30 per cent.-40 per cent. of normal intensity, and was satisfactory only during the dry season. During the wet season, bamboo blinds, 3 feet-4 feet above ground-level (illustrated in Figures 3 and 4), have proved to be satisfactory, and they permit up to 80 per cent. to 85 per cent. of the normal light to enter. The use of these bamboo blinds throughout the year is satisfactory as they can be supplemented by additional shade when necessary, but for large scale propagation it would be more economical to carry out the operation during the dry season, using fern shade only.

(b) *Humidity*.—Humidity is most important in the successful propagation of cuttings and the objective has been to maintain as high a humidity as practicable at all times, in order to reduce transpiration.

Excessive transpiration leads to wilting, followed by loss of the leaves and death of the cutting. At the same time, care must be taken that not too much water is applied to the rooting medium or waterlogging and rotting of the cuttings will follow. The technique adopted in these trials was to give a quick wetting with a fine spray, at hourly intervals from 8.00 a.m. to 5.00 p.m. on fine warm days, with decreasing frequency on overcast days. However, at times the application of moisture to the soil was excessive and rotting did occur although this trouble could be avoided by the use of pure sand as a rooting medium. This medium had other disadvantages, as will be shown in a later section.

Under the relatively uncontrolled conditions of experimentation at Aiyura, the correct maintenance of humidity is primarily a matter of experience and the judgment of the propagator.

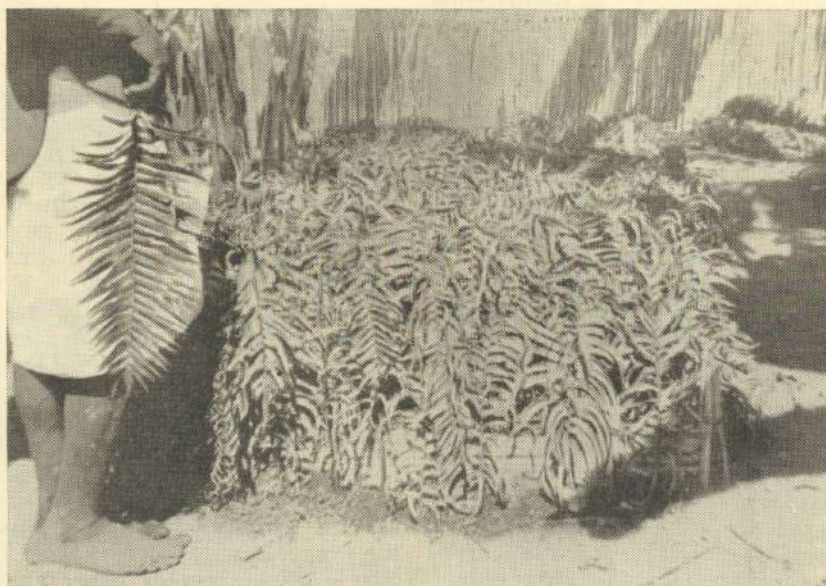


Fig. 2.—Heavy fern cover over propagator.

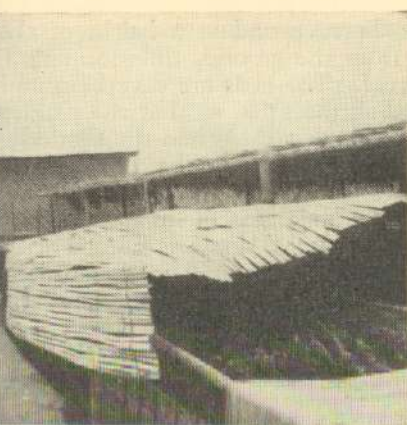


Fig. 3.—Bamboo blind in down position.

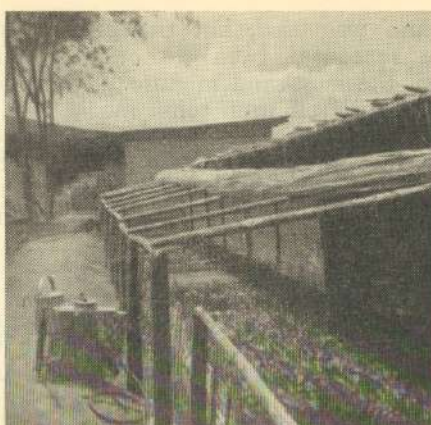


Fig. 4.—Propagator with bamboo blind rolled up.

(c) *Temperature*.—The maximum temperature for coffee propagation is said to be 88° F. (31° C.). Under Highland conditions this is very rarely reached. Although optimum temperature appears to be between 79° F. and 84° F. (26° C. and 29° C.), very good results were obtained at 74° F. with an average day temperature of 72° F. (22° C.) and an average range from 64° F. (12° C.) to 78° F. (25° C.). No temperature control was possible so that a

comparison of results at different temperatures could not be made.

(d) *Media*.—A number of rooting media was tried including coarse sand, fine sand, sawdust, local soil, moss and sand and mixtures of soil and sand and sawdust and sand in various proportions. Fine sand was unsatisfactory as it consolidated unduly after a period, and its use was soon abandoned.

Typical results with a number of media are given in Table IV.

TABLE IV.—Results Using a Range of Rooting Media

Rooting Medium	No. of Cuttings	Planted 9.9.55				Planted 29.12.55			
		Rooted		Dead		Rooted		Dead	
		12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks	12 weeks	16 weeks
soil (sifted)	40	7	20	15	15	5	13	22	22
(coarse)	40	6	32	0	0	0	13	0	0
dust (well rotted)	40	5	15	2	2	1	7	2	2
and coarse sand 1:1	40	21	34	1	1	15	34	1	1
and coarse sand 1:1	40	12	31	3	3	9	30	3	3
dust and coarse sand 1:1	40	12	35	0	0	3	21	2	2

Well-rotted sawdust, although generally regarded as one of the best rooting media, gave disappointing results in these trials. Cuttings transplanted from 100 per cent. sawdust in the propagation beds to 100 per cent. local soil in the nursery beds also suffered more of a set-back than cuttings transplanted from other media.

A medium consisting of coarse sand and local soil in equal proportions gave outstanding results with regard to percentage of rooted

cuttings as well as further growth after transplanting. This medium is not really practical although of experimental interest, but it would seem to indicate the desirability of the addition of humic materials to any medium. A rooting medium consisting of one part of local soil and one part coarse river sand, thoroughly mixed, has been adopted as the standard medium for the practical propagation of cuttings. Not only was the strike obtained very good when this

medium was used, but transplanting was more successful from no other medium except the moss-sand mixture. Transplanting to local soil from some media such as pure sawdust and pure sand caused serious set-backs and heavy losses; at least two transplantings are necessary to graded media so that the change of environment will not be too sudden.

(4) *Season*.—The best time of the year for successful propagation of coffee cuttings under Aiyura conditions seems to be the dry season, and especially the months July-October. It is easier to control light intensity and humidity during these months. The months December-April are least favourable, and many dead cuttings were found during these months; root formation also tended to be slower. At times during the wet season, light intensity is too low and there is too much moisture for good soil aeration. It is assumed that these are the factors mainly responsible for the greater difficulty of striking cuttings during the wet season.

(5) *Technique*.—The propagation beds at Aiyura are 4 feet wide and of various lengths, built up at the sides which are supported with flattened bamboo, and filled with the rooting medium to a depth of 10 inches-12 inches.

Suckers are collected early in the morning and the laterals developing from the leaf axils are reduced to half an inch in length. Cuttings are made as described previously and planted immediately or else allowed to fall into a bucket of water if there will be some time lag before planting out. This process is always carried out under shade. Planting is done by pushing the cuttings into the medium right up to their leaves with spacings of 5 inches between rows and 2 inches within rows. Whether the cuttings are planted vertically or at an angle has not affected the results. If planting be done during dry weather, the beds should be thoroughly moistened and cloudy days are preferred for setting out new beds of cuttings.

After the cuttings are planted, the shade is built above the beds, being either of bush ferns or bamboo blinds as already stated. To make the fern shade, the fronds are placed in lines between the cuttings and bent over, breaking the midrib, all in the

same direction and at a height of about 1 foot from the ground, thus forming a tile-like roof. The beds are covered completely including the sides, so that the cuttings are not visible at all. When the shade is close to the ground as is the case with ferns, evaporation is at a minimum and an even level of humidity is maintained. The ferns dry up and the shade is automatically reduced gradually as time passes. When bamboo blinds are used, a supporting structure must be built from bush timber, at the required height (3 feet-4 feet) from the ground.

If weeding is necessary it should be carried out by partly removing the shade and replacing it as the work proceeds; weeding should be done on cloudy days.

(6) *Observations and Results*.—Root formation seldom takes place in less than 8 weeks and usually commences between the 10th and 16th week. Some cuttings do still take after the 16th week. During the more favourable times of the year an average of 25 per cent. of rooted cuttings can be expected after 12 weeks, 75 per cent. after 16 weeks, and up to 90 per cent. 95 per cent. if the remaining cuttings are left a few weeks longer. During the less favourable times of the year the percentages may be down to 10 per cent. to 15 per cent. and 50 per cent. to 60 per cent. after 12 and 16 weeks respectively.

New growth from the buds in the leaf axils usually commences just after 6 weeks, and will average 4 inches in length after 4 months, 6 inches after 6 months, and 10 inches after 9 months. The average length of roots at the same ages are 2 inches, 5 inches and 8 inches respectively. Compared with seedlings of the same age, cuttings are usually somewhat better developed. (See Figure 5a and 5b).

As shown in Figure 5a, the plants grown from cuttings do not develop a tap-root system like seedlings, nor do their main roots correspond entirely to the lateral roots of seedlings. Cuttings develop several main roots with a mass of fibrous roots which give the impression of a modified tap-root system. The absence of a tap-root does not appear to be a disadvantage, although subsequent growth, yield, etc., will have to be observed over a long period before this contention can be maintained with confidence. The



Fig. 5a.—Cuttings at 8½ months (made 13.7.55).



Fig. 5b.—Seedlings at 8½ months (sown 6.7.55).

absence of a tap-root may even prove to be an advantage where the water table is on the high side.

The initial spacing of 5 inches by 2 inches is not sufficient to permit development of the cutting to the stage where it may be transplanted directly into the field. The practice adopted has been to leave the cuttings in the propagating beds for 4 months and then transplant them to a nursery at a spacing of 6 inches by 6 inches, where they are left for a further 4 months before they are transferred to the field. Alternatively, satisfactory results may be obtained by planting the cuttings originally at 6 inches by 6 inches and leaving them in the original propagation beds for 8 months before transferring them

directly to the field. This latter method, however, is prodigal of the use of the special rooting medium; it is more difficult to control humidity with the wider spacing; and finally, rejection of badly rooted specimens at the time of transplanting cannot be performed.

2.—Propagation by Grafting.—

Although practically all methods of grafting have been attempted in the main coffee growing countries of the world, it is apparent from the work of others that the cleft or wedge graft has proved most successful. At Aiyura, cleft, saddle, whip (or splice) and side grafting were carried out and cleft grafting was most successful. As it is also the simplest of these methods, it has been adopted as the standard technique at Aiyura. Typical cleft grafts are shown in Figures 6, 7 and 8. Experiments have been carried out



Fig. 6.—Cleft graft 10 weeks old.

to determine under what circumstances cleft grafting can be used with maximum success under local conditions. The factors studied, which will be dealt with separately, include type of stock, height of grafting, type of scion wood, type of graft cover, time of

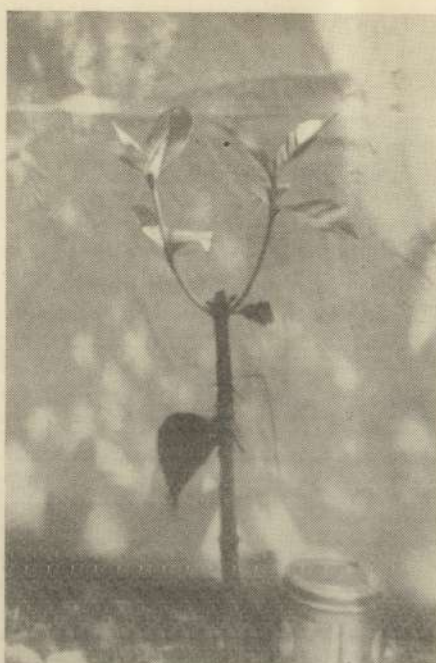


Fig. 7.—Cleft graft 15 weeks old.



Fig. 8.—Cleft graft 8½ months old.

removal of cover and tying material and seasonal influences.

(1) *Type of Stock*.—Most workers agree that the best stocks are seedlings of 1-2 years of age. The only seedlings available at Aiyura at the commencement of these experiments were 18-20 months old, spaced at 15 inches by 15 inches under normal nursery shade. Their stem diameters at ground level varied from 1 cm.-2 cm. Although this stock was considered somewhat too old, the stem diameter at grafting height being rather too great and the bark tissues too rough, all the trials had perforce to be carried out on this stock. The ideal stock has a diameter of 7 mm.-9 mm. (pencil thickness) grafting height and at Aiyura this size is attained at an age of 12-14 months.

(2) *Height of Grafting*.—In the Philippines the stock is cut back to a height of 12 inches from the ground, in Tanganyika to 8 inches, and in Java the height is usually about 6 inches. Presuming that about 8 mm. is the optimum stock diameter at grafting height, the optimum height depends on the age and thickness of the stock. With twelve months old seedlings the optimum thickness

is usually found at 4 inches-6 inches from ground-level. The older the seedling stock, the higher the best grafting height will be. The operator will also regulate the height of grafting according to the thickness of the scion which is ideally of the same diameter as the stock; it may be thinner but should not be thicker as good results will not be obtained if some of the cambial surfaces of the scion are exposed.

As grafts should not be implanted too high on the stock, the use of stock seedlings of the right age is important.

(3) *Type of Scion Wood*.—Orthotropic branches (watershoots or suckers) have always been used for scions, except for a few plagiotropic scions used experimentally, for the same reason as the former have been used exclusively for cuttings—plagiotropic scions will not produce a tree of normal form. A few grafts from plagiotropic branches (laterals) are being grown on to see what the growth and bearing habits will be like.

Hard green wood was grafted more successfully than brown wood and all scions are now selected from the middle sections

of watershoots (preferably of pencil thickness), discarding the soft top portion and the old brown wood. Length of scions is 2 inches-5 inches.

It was found that scions with leaves reduced to $1/3$ to $1/4$ of their length gave better results than those on which the leaves were left complete. Scions with all leaves completely removed also gave excellent results. There was some indication that it might be better merely to reduce the leaves thus in the wet season, but to remove them entirely when grafting during the dry season.

(4) *Type of Graft Cover.*—To prevent the graft from drying out some kind of graft cover has usually been found necessary as coffee scions seem to be particularly susceptible to dry conditions.

As binding material only raffia has been used and it is entirely satisfactory. As graft covers the following were tried:—

- (a) Grafting wax;
- (b) Moist sphagnum moss tied around the graft;
- (c) A cylindrical cover of a length of banana leaf sheath around the graft;
- (d) "Colgraft"—a proprietary grafting compound;
- (e) Waxed paper bags covering the graft.

Colgraft proved to be the most effective and has the additional advantage of ease of application as it can readily be painted with a brush over the tying material and exposed cut surfaces.

(5) *Removal of Cover and Tying Material.*—The period elapsing between grafting and the removal of the cover and tying material varies from 3-4 weeks to 2 or 3 months in different countries. It was found at Aiyura that the removal of the cover and tying material after 3 and 6 weeks respectively, or even after 6 and 9 weeks, often spoiled an apparently successful graft. When the tying material was removed at less than 9 weeks the scion often came away from the stock unless a firm union had already taken place, which of course led to the death of the scion. According to observations at Aiyura, a union seldom takes place in less than 12 weeks and the binding which holds the scion in intimate contact with the stock should not be removed before that time. When Colgraft is used as the cover

material, it is removed at the same time as the raffia as they cannot be removed separately. In any case it is not necessary to remove the Colgraft apart from that which comes away with the raffia. It is now the standard practice at Aiyura not to remove the cover and tying material until it is evident that a union has taken place. This varies as a rule from 12 to 16 weeks after the grafting operation. The binding material can be left even longer than this, but as it causes constriction when the point of union starts to swell, it must then be removed, or damage will ensue.

(6) *Seasonal Influences.*—The right time of the year for the most successful grafting of coffee is a problem which can be solved only by trial and error over a prolonged period. It has been stated by overseas workers (6) that "the difference between 100 per cent. take and complete failure may be brought about by only two months difference in the time of grafting". In general, unduly wet conditions or hot dry conditions are less favourable than warm, moist weather, and according to the literature, grafting should be carried out for preference when the tree begins active growth after rest, but before the sap flow becomes too free.

There are as yet insufficient data to be able to state the best time of the year for grafting at Aiyura, but results so far indicate that, under local conditions, grafting can be carried out at any season. The average result obtained has been a final take of 60 per cent. The best result was a 75 per cent. take with grafts made in the second half of November, which confirms the conclusion of other workers that grafting should preferably be carried out when the tree begins active growth after a period of rest, but before the sap flow becomes too free. However, seasonal influences are by no means the only factors influencing success and a final strike of over 90 per cent. or under 50 per cent. at any time of the year is not surprising in coffee grafting.

(7) *Other Factors.*—It is, of course, obvious that grafting should always be carried out under shade and never in direct sunlight. There is little exact knowledge about the physiological factors affecting grafting but the condition of the stock and scion wood are likely to affect the results. Little

is known of the interactions which may occur between stocks and scions or of the compatibility of Arabica varieties.

(8) *Grafting of Cuttings*.—The possibility of grafting newly made cuttings has also been investigated. Such a technique, if successfully developed, could be used to save time and hasten progress in the study of clonal stocks.

During September and October, 1955, several attempts to graft freshly taken cut-

tings were made with varying success. Final takes of 10 per cent. and 20 per cent. were obtained in two trials. The technique could probably be improved, but it is the opinion of the writer that a final take of about 50 per cent. is the best that could be expected. The successfully grafted cuttings developed new shoots and grew normally, although their growth was considerably slower than that of scions grafted on one year old seedling stock (See Figure 9 and cf. Figures 6, 7, 8).



Fig. 9.—Successfully grafted cuttings at the age of 6 months.

Summary and Conclusions.

Investigations carried out at Aiyura in 1955 have led to the development of two successful methods of vegetative propagation of Arabica coffee, which is an important step in the testing of the mother trees which form the basis of the coffee improvement programme. Only the simplest and most readily available materials have been used. The successful technique may be summarized as follows :—

1.—Cuttings.—

- (1) *Cutting Wood*.—Single internode cuttings with the cut made just above the node from any portion of a watershoot except the top two internodes and the growing tip. Leaves left entire.
- (2) *Hormones*.—Hortomone A had no permanently advantageous effect.
- (3) *Rooting Medium*.—A mixture of equal parts of local top soil and coarse sand.

- (4) *Shade*.—Light intensity under shade should vary from 30 per cent. to 40 per cent. of normal in the dry season to 80 per cent. to 85 per cent. in the wet season.

- (5) *Humidity*.—Spray hourly with a fine mist in dry weather and less often during wet weather.

- (6) *Season*.—Best results in the dry season.

2.—Cleft Grafts.—

- (1) *Stock*.—1-2 year old seedlings. Stem diameter at grafting height preferably 7 mm.-9 mm.
- (2) *Scions*.—Middle section of watershoots (hard green wood), preferably of same thickness as stock, but may be thinner, length of scion 2 inches-5 inches, length of actual wedge $1\frac{1}{2}$ inches-2 inches, scion leaves entirely removed or cut back to $\frac{1}{4}$ of their length.

- (3) *Grafting Height*.—Preferably about 6 inches from ground-level but should be regulated according to thickness of stock and scion.
- (4) *Tying Material*.—Raffia.
- (5) *Graft Cover*.—"Colgraft".
- (6) *Removal of Covering and Tying Material*.—12 weeks after grafting or later if no evidence of union at 12 weeks.

Bibliography.

- (1) Roelofsen, P. A. and Coolhaas, C. (1939), Over het stekken van koffie. Arch. Koffie cult. Ned. Indie. 13, No. 2.
- (2) van Emden, J. H. (1955), personal correspondence.

(3) Sundaram, S. (1953). Factors favouring rooting of coffee sucker cuttings. Indian Coffee 17, No. 2.

(4) van Emden, J. H. (1941) Mededelingen inzake het stekken van thee II. (The propagation of tea by cutting II.) Arch. Thee Cult. 1, 33-45.

(5) Lods, G. (1954). Cacao propagation in the New Hebrides. Quart. Bull. S.P.C., 4, No. 4.

(6) Anon (1940). Technical Communication No. 13. Imp. Bur. Hort. Plant. Crops.

(7) Kehl, F. H. (1950). Vegetative propagation of tea by nodal cuttings. Tea Quart. (Ceylon) 21, part 1.