GOUGH'S PRACTICAL BUDGRAFTING AND SEED SELECTION OF HEVEA BRASILIENSIS

Revised and Rewritten

BY

JENKINS & CHITTENDEN.

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PRACTICAL BUDGRAFTING AND SEED SELECTION OF HEVEA BRASILIENSIS

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INTRODUCTION TO 1st EDITION.

In Malaya there is very little literature on the subject of budgrafting and seed selection of *Hevea Brasiliensis*,* nor is there any Research Station to which a planter can turn for advice and instruction. Hence this attempt to fill a gap until in course of time something can be published and taught by our newly formed Research Institute.

I have no scientific training of any sort. The knowledge which I endeavour to impart has no pretence to be anything excepting some of the more essential parts of what I have learned during visits to Sumatra, coupled with my own experience gained while working at the subject for the past six years. During these years I have seen my many mistakes, and now my ultimate success. I have been responsible for every detail of the budgrafting of about 1,500 acres of rubber, continually seeing the results of the work at all stages, and have therefore been able to gather some experience.

If this book proves to be of use to the general planting community it will have attained its object.

I am glad to have this opportunity of expressing my very great gratitude to the American, Dutch, and English companies in Sumatra for their long continued kindness and generosity in allowing me to gather knowledge from their conversations and writings, and

* Two useful and practical papers were contributed so long ago as 1921 and 1922 in the Agricultural Bulletin by Mr. J. N. Milsum.

from the inspection of their practical and experimental work. I am most deeply indebted to Mr. J. Grantham, Director of the H. A. P. M. Research Department in Sumatra, and also I am very grateful to Dr. de Jong, Director of the A. V. R. O. S. Research Station and to Dr. Heusser of the same institute. I owe many thanks to other gentlemen in Sumatra who also showed me kindness from time to time.

I would like to mention that it was Mr. R. M. Richards who, nearly six years ago, first told me of the possibilities of budgrafting Hevea, and Mr. J. N. Milsum of the Department of Agriculture, F.M.S. and S.S. who, an equally long period ago, showed me that method of carrying out the actual operation of budgrafting which I employ to this day, and who has now kindly drawn the illustrations in this book for me. I thank Mr. R. C. M. Kindersley for affording me facilities for carrying on my work, and for his constant encouragement and optimism for the period of years during which it was difficult to hear of anyone in this country or in England who believed that budgrafted rubber trees could ever be a practical success.

H. Gough.

Kajang,

December, 1926.

INTRODUCTION TO THE REVISED EDITION.

The selection of planting material, whether bud-wood or seed, with a view to obtaining higher yields of rubber, demands expert knowledge, and to make the most effective use of such material calls for a high degree of skill. Both knowledge and skill are continually growing.

In 1926 I published a short handbook on the subject, largely based on my experience in planting up Prang Besar Estate, I take it as a great compliment that such first-rate authorities as Mr. R. O. Jenkins, the present Manager, and Dr. Chittenden, the Scientific Officer of that Estate should have cared to expand my little book into the present informative and up-to-date work. Their revision of my handbook has developed really into a second and more advanced volume; and their treatment of the subject will be found to be as practical as it is scientifically sound.

H. Gough.

Raford, Co., Galway,

August, 1929.

PREFACE TO THE REVISED EDITION.

Major Gough has now been home three years and in that time many advances have been made in Bud-grafting and Seed Selection. We have therefore been requested by him to revise and where necessary re-write this book,—a task we have undertaken with much pleasure hoping our effort will meet with the same approval as that accorded to the first Edition.

We have to thank many friends in Sumatra, Malaya and Java for facilities for seeing and discussing their results and material. For help more particularly connected with this book we must thank those able artists Messrs. Milsum and Amcotts. Our thanks are due to our colleague Mr. Allin for his painstaking reading of the manuscripts and proofs, and to Mr. K. N. Pillay for general assistance in preparing the book for the printers.

R. O. JENKINS.

R. J. CHITTENDEN.

Prang Besar Estate,
September 2nd, 1929.

NOTE.

Since this book went to the printers Dr. Heusser has published a very interesting paper in the Archief voor de Rubber Cultuur September 1929 giving the yields both of the Avros Clones and his hand pollinated seedlings. The yields of the seedlings compare very well with those of the Avros Clones, which, as Heusser himself says, are in 1928 somewhat disappointing. Dr. Heusser states that "the full possibilities with regard to Clonal Selection have not yet been reached." We must therefore look forward in the future to even better Avros Clones propagated from the best of these experimental seedlings.

R. O. J.

R. J. C.

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DEFINITIONS.

CLONE.—The *vegetative* offspring of one tree.

BUDGRAFTING.—The operation by means of which a bud patch is grafted from one tree on to another.

SCION.—The growth obtained from a bud patch grafted on to another tree.

STOCK.—The tree on which the budpatch is grafted.

MOTHER TREE.—The mother tree of a clone is the tree from which wood was originally taken to provide the buds by means of which the clone was propagated. We prefer the use of the term Bud Parent rather than Mother Tree as indicating more clearly the vegetative rather than the sexual nature of the process by which clones are propagated.

PROVED TREES.—A tree can only be regarded as a proved high yielder when the clone made from it is also high yielding. Individual trees whose yields have been recorded over a long period might be named Tested Trees but should *not* be called Proved Trees.

PROVED CLONES.—No clone can be regarded as completely proved until we have experience of its behaviour when tapped over a complete life cycle. For practical purposes however a clone is regarded as "proved" and is recommended for planting when good results have been obtained on one or two years tapping. The longer the experience of the behaviour of the clone under tapping and the larger the number of trees under observation the greater the degree of proof.

NATURAL OR OPEN POLLINATED SEED.—Seed of which only one parent is known—the mother; the father being any one of the other trees in the neighbourhood. This seed has been popularly termed illegitimate, a term already in use in genetics in a different sense, i.e. for crosses between varieties of *Primula* or *Oxalis* etc. with the same style length.

SELFED OR CROSSED SEED.—Seed of which the parents are known and which result either from the self pollination of a clone or the cross fertilisation of two clones. This type of seed has also been popularly termed legitimate, a word already in use in genetics to describe crosses between varieties of *Primula* or *Oxalis* etc. with different style lengths.

HETEROZYGOUS.—The expression of every character of a plant or animal is usually governed by at least one pair of genetic factors. When a plant or animal has received a dissimilar contribution from its father and mother in respect of a character, and consequently will not breed true with regard to that character, it is known as heterozygous or impure with regard to that character.

HOMOZYGOUS.—The reverse of heterozygous, i.e. when a plant is "pure" for any particular character.

HETEROZYGOSIS.—The state of being heterozygous.

HETEROZYGOTE.—A heterozygous plant.

HETEROSIS (Hybrid Vigour).—Increased vigour which frequently accompanies wide crossing where the heterozygote is hetrozygous in many respects.

CHAPTER I.

The Case for Budgrafting.

Since the first edition of this book appeared the position of budgrafting as a means of propagating and multiplying high yielding types has been established and it is unnecessary to recapitulate here the reasons which led to its adoption.

As a defence of its use it is sufficient perhaps to quote the figures of Grantham (Paris Conference) in which it was shown that only 0.73% of 4,500,000 seed trees inspected were equal in yield to what is classed as a good clone.

Most of the objections to budded trees have now been answered by the behaviour of clones in tapping :—

1. Yield has been well maintained.
2. Bark renewal, and tapping on renewed bark, have been satisfactory.
3. Clones have shown an intensive increase in yield up to at least ten years of age.

Further it must not be forgotten that clones are selected not only with regard to yield but in respect of :—disease resistance, resistance to wind, bark renewal, wound recovery, and other desirable characters.

Budgrafting has certain obvious advantages and certain possible disadvantages and limitations.

Advantages.—1. It provides a method for ascertaining whether any particular tree is genetically a high yielder.

2. It is a ready, quick, and easy means of propagating indefinitely any desirable type.

Possible Disadvantages.—1. The technique of budding is a source of trouble when unskilled coolies are employed.

2. Until clones are more completely proved, material cannot be guaranteed against defects which may appear later in the life of the clone being proved.

Limitations.—Yields can be vastly increased by using proved clones but we cannot hope by *vegetative* reproduction to achieve a real advance in the provision of new planting types. Budgrafting is merely a means of propagating and disseminating good material which already exists. Any ultimate improvement in the types available must result from continued selection from seedlings obtained by generative propagation.

Sexual Reproduction versus vegetative Reproduction as a means of obtaining a strain of high yielders.— No strains of seed are as yet known,* or are likely to be known for some time, in which the average yield of the seedlings would compare with that of a good clone.

The difficulties of obtaining a strain of seed of this quality will be at once realised when we consider that the type of tree sufficiently good to provide a good clone is extremely rare, (on Grantham's figures about 0.73% of seedlings—or less, since all may not be genetic high yielders—reach this standard). Thus

* A.V. 36 × 35—The seedlings of this cross certainly compared well in yield with Avros clones of the same age. Nevertheless Avros clones at this age when compared with others appear to be rather low yielding.

clones are made from trees selected from among thousands, or even millions of others, and even then only a small percentage of this first rigorous selection are good clones.

The good clone once obtained, though itself a good genetic type, cannot be expected to breed true to this standard; it may be heterozygous for some, or many, of the high yield factors (i.e. though the character itself is fully present, the genetic factors governing its expression may be present as a half "dose" only). Its seedling offspring will consequently show segregation in respect of these characters. The chance of finding two good clones complementary in all or most respects is also somewhat remote. Thus there appears to be no means of evading a long period of experimental crossing and selfing of good clones before anything approaching a good strain of seed can be put on the market.

That very high yielding seedlings will be found amongst the progeny of good clones, whether resulting from cross or self fertilisation, no one doubts. It is not probable however that they will occur in a sufficient proportion to render the planting of such seed profitable, when their average yield is compared with that obtained from proved buddings. Further if the seedlings are not sufficiently uniform, uniform thinning out without sacrificing high yielders may be difficult in some cases.

Even after a long period of selection it is doubtful whether seedlings will ever be able to compete with buddings, for as the standard of yield amongst seedlings is raised by careful crossing or selfing of good clones, so also will the standard of the clones rise, since they will be selected from the best of the new seedlings.

No one will deny that other things being equal a seedling is probably a better tree than a budding. On the other hand it is possible by vegetative means to propagate indefinitely types which cannot be propagated with any degree of uniformity by seed, for instance types which owe the very fact that they are good to their hybridity (i.e. the fact that they cannot be bred true—their vigour being due to heterosis or hybrid vigour). Should such types occur in rubber the advantages of vegetative over generative propagation are obvious. In any case, for the present, till good strains of seed showing comparative high yield and uniformity are available, the use of good clones (which are proved for other characters as well as yield) appears to be preferable to the planting of seedlings.

CHAPTER II.

UNPROVED CLONES.

It has been assumed that the planting of unproved material will not be practised to-day except with the object of finding new clones.

Budgrafting from unproved material was in the past a profitable policy. The yield from an area of mixed unproved buddings compared favourably with that obtained from seedlings (the only other planting material available) and had the additional advantage that good clones might be discovered. Now that proved material is available it is no longer profitable, from a rubber producing point of view, to plant unproved clones. The planting of unproved budgrafts has now but one advantage, i.e., the possibility of discovering new good clones.

Since only a small proportion of unproved clones are high yielders it will be necessary to plant as many unproved clones as possible in order to obtain a reasonable selection. The ideal would be to have 100 to 300 members of each unproved clone under observation. Commercial Estates will probably be reluctant to devote such a large area to each unproved clone, when they consider the loss of possible yield (i.e., that which could be obtained from the same area planted with proved material).

It is suggested that only 30 to 40 members of each unproved clone be planted. Thirty or forty trees are in our opinion quite sufficient, now that we have some general knowledge of the behaviour of the buddings, for comparative tapping and selection; though it is realised that this small number cannot be widely distributed over a clearing and consequently disturbances due to environment may affect results. Desirable clones which showed promise in earlier tapping could be multiplied and planted on a larger scale in future clearings.

Methods of Planting Unproved Clones.

1. Mixing unproved buddings and seedlings.

Formerly the seedlings were planted as an insurance against the failure of some or many of the unproved clones. Now that proved clones are available, this policy cannot be recommended. If a mixed planting policy be adopted it is better to interplant proved and unproved buddings.

Estates which consider the planting of at least some seedlings absolutely necessary as an insurance against the failure of the buddings should only plant the best grade of seed available (see Chap. XI, page 79).

2. Mixing proved and unproved buddings in a clearing.

The proportion of the two types may be varied. One quite usually adopted is 50% each of proved and unproved. All, or nearly all, the unproved must be maintained in tapping till after their 7th—8th year.*

* After that any clones not having attained high yield may be cut out as, even if they develop into high yielders later, they are probably not economic.

GOUGH'S METHOD OF MIXED PLANTING.

4	3	2	1	6	5	4	3	2	1
3	2	1	6	5	4	3	3	2	1
2	1	6	5	4	3	2	1	6	5
1	6	5	4	3	2	1	6	5	4
6	5	4	3	2	1	6	5	4	3
5	4	3	2	1	6	5	4	3	2
4	3	2	1	6	5	4	3	2	1
3	2	1	6	5	4	3	2	1	6

On the other hand one does not desire to thin out too many of the proved clones, which should form the bulk of one's ultimate stand per acre. Too high a stand per acre is therefore undesirable and a stand of 150 to 200 is recommended.

System of Planting.—a. Proved and unproved buddings alternating along the row or contours :—

Planting, supplying, checking and recording call for a great deal of careful supervision. The clearing, however is even, and not subject, upon thinning out, to large gaps caused by possible failures of unproved clones.

b. Alternate rows of proved and unproved buddings.

Planting, supplying, checking and recording are simplified. There is a possibility of unfortunate gaps in the clearing owing to the failure of unproved clones : but the simplification of test-tapping and recording is probably sufficient to outweigh this drawback.

3. Planting Unproved Buddings only.

In such planting it is necessary to maintain sufficient members of all, or most, clones for test-tapping till the 7th to 8th year. On the other hand it is desirable to have as large a stand per acre as this necessity will permit, to allow a good selection in thinning out.

A stand of 150 to 200 per acre is advised, thinning out being always heavier on the unpromising than on the promising clones.

Methods of planting are :—

(*a*) Mixed planting along the row or contour.
(*b*) Row or Contour planting—one clone to one row or contour.
(*c*) Block planting.

Method (*a*) renders planting and recording more difficult than methods (*b*) and (*c*) but provides for even thinning out and gives a wider distribution to members of the clone, thus helping to counteract disturbances due to environment.

In methods (b) and (c) ugly gaps may occur in the clearing after thinning out.

Selection of Bud Parents to form New Clones.

Too much care and trouble cannot be taken in the selection of trees which are the possible bud parents of new clones. High yield is, and presumably always will be, the acid test, but, apart from this character, many others should engage the attention of the selectionist.

Yield.—This should of course be high and also demonstrably good over many different tapping heights showing an even and regular distribution of the latex vessels. The flow should be rapid and the yield quickly accomplished. There should be a high D.R.C. and an absence of lump and of such objectionable characters as coagulation on the cut.

Habit & Growth.—Growth should be vigorous and straight, and the trunk of the tree evenly rounded. The branching habit should be of a type resistant to wind damage. Bark should be thick, and if possible soft, with few stone cells—renewal and wound recovery good.

Disease Resistance.—The incidence of disease if any should be noted.

Latex System.—If possible, readings of the number of latex vessels at various heights should be made. Types with a large bore, many layers, and an even distribution are more desirable providing that they pass the yield test.

Age.—The selectionist should endeavour to be certain that the trees have been uniformly high yielding from an early age, since the behaviour of a tree in this respect may be repeated in its vegetative offspring.*

Final Selection.—When considering which bud-parents should be selected from among those under observation on an estate it is important to consider not only actual yield but also comparative yield, i.e., the yield of the tree in relation to that of the other trees in the division in which it is growing.

Trees near coolie lines or enjoying other favourable conditions should either be ignored or their yield suitably discounted.

* Environmental causes have been considered responsible for the small proportion of good clones obtained from high yielding bud-parents. Since many clones were made from trees about which the only information was that they gave a high yield at 15—20 years old it is quite possible that many of the clones, in being poor in the early years of tapping, are but repeating the behaviour of their bud-parents.

CHAPTER III.

PROVED CLONES.

Theoretically no material can be regarded as unquestionably proved till tapped over a complete life cycle. Providing, however, that sufficient trees are under observation, clones may probably be regarded as 75% proved after the first 2—3 years tapping. After a complete cycle of tapping on virgin bark and some experience of yields on renewed bark a clone may for all practical purposes be regarded as fully proved.

The planting policy to be adopted depends therefore on the degree of confidence felt in the present so-called proved material. Those feeling confidence in the future of the clones they select will adopt a policy of planting clones in blocks, those who are still doubtful will prefer mixed planting.

MIXED PLANTING.

The main factors to be considered when selecting a mixed planting policy are :—

(1) Ease of supervision when planting or budding, supplying, and recording yield and behaviour.

(2) An even distribution of the clones used for planting so that thinning out is simplified and an even clearing results.

These two factors are to a certain extent opposed. Supervision would be easier if the different clones used for planting were grouped but there is a risk that one of them may fail and the clearing be uneven.

On the other hand the greater the degree of mixing the more even the clearing, but the harder will be the supervision of its planting.

(1) The Mixing of Proved & Unproved Material.

The unproved material may consist of seedlings, of unproved buddings, or, of both. From a rubber producing point of view this policy will almost certainly result in failure to obtain the highest possible yield, which could only be obtained if the area consisted entirely of proved high yielding clones. Further the seed produced by the area is not of the same grade as if proved clones only had been used. The main reason for this mixing of proved and unproved material is the fear of the later development of some defect in one or several of proved clones planted. This argument may have been justified when budgrafting was new and less was known of the behaviour of budgrafts.

Most of the objections to budgrafts have now been shown, in the light of experience, to be groundless: it seems unreasonable therefore not to aim at obtaining the highest possible yield from an area by planting proved high yielding clones only. This of course does not apply to estates experimenting with a view to obtaining new clones or better strains of seed.

Systems of Planting.—A discussion of the methods used in the mixed planting of proved and unproved material will be found in Chap. II. For the interplanting of proved buddings and seedlings similar methods of planting may be employed : in this case however no large gaps, due to the failure of the unproved material, are likely to occur in the clearing.

A stand per acre of 150 to 200 is sufficient in all cases where proved buddings form 50% of the total number of trees in the clearing.

(2) Mixing of Various Proved Clones.

This method of planting is now widely used both in Sumatra and Malaya and has much to recommend it. It provides to a certain extent against the later development of defects in one or even more of the clones selected.

Since the wintering period of all the clones selected will probably not be coincident it spreads the loss of yield due to wintering. The advantages of a mixed planting policy are enjoyed, and, since only proved clones are used, there is no loss of the highest possible yield from the area which would occur if a proportion of unproved material were used.

The number of clones used in one clearing varies on different estates. Obviously the smaller the number of clones used the less effective is the insurance against one of them failing and having to be removed. The number of clones usually recommended for planting in any one clearing is 6. If more than 6 clones are planted the difficulties of supervision are greatly increased.

When proved clones only are employed, whether planted in a clearing of mixed proved clones or in separate blocks of one clone, an original stand per acre of 150 is sufficient. Since there is a correlation between yield and length of tapping cut it is possible to thin out within the clone on girth alone.

Systems of Planting.—Various methods have been adopted; the better known are discussed below. Any of them may be adapted to suit plantings in which all clones do not occur in the same proportion.

(1) Planting the clones in sequence along the row or contour. Various refinements of this exist (such as that practised on the H.V.R. Estate, Pulau Tiga) whereby no two members of the same clone are ever in juxtaposition.

Planting out and supplying require most careful planning and supervision if this method be followed. The difficulties of checking and supervision would be even greater if budding be done in the field. It will also be harder to make records of the yield and behaviour of the clones. This system has many advantages however :—

(*a*) It gives a most even mixing of the clones used and hence ensures even thinning out and even yield over the area.

(*b*) Should one clone have to be cut out, or otherwise fail, no large gaps will occur.

(2) Devoting one row or contour to each clone, this sequence of rows or contours being repeated as many times as is necessary.

Planting out (or budding in the field) supplying, checking and recording yields and behaviour will be simplified. The resultant clearing is however somewhat uneven. Thinning out will be more difficult than in method 1 and should one clone have to be cut out large gaps will occur in the clearing.

Note on Systems of Mixed Planting—Unmethodical Mixing.

This method is never to be recommended. Difficulty will probably be experienced :—

(1) In re-identifying later—tickets are liable to be lost or transposed.

(2) In checking budgrafters* and recording errors.

(3) In recording yields from the clones or from unproved material or seedlings used for interplanting.

Block Planting.

With increasing knowledge of the clones available this method of planting now has its adherents. It has many advantages though should one clone fail for some reason the effects would be somewhat severe. If it be practised it is better to plant in large blocks of 50 to 100 acres, since by planting in small blocks or groups many of the advantages are lost.

If large blocks be planted with one clone :—

(*a*) Planting (or budding in the field), supplying, supervision, checking, and recording of yield and behaviour are much simplified.

* A budgrafter given a limited amount of wood and paid by the number of successful buddings obtained is quite capable of taking buds from the top of the stock and budgrafting them on to it below.

(*b*) There are no difficulties in thinning out.

(*c*) Bark thickness will be more or less uniform throughout and better tapping should result.

(*d*) Different systems of tapping specially adapted to the various clones planted may be used in the different blocks. If the blocks be large enough specially suitable systems of manufacture may be accorded to the latex from each clone.

(*e*) Should one of the clones fail and have to be cut out the area can be replanted. Where mixed planting is used the failure of one clone might result in gaps in the clearing which would be difficult to replant.

(*f*) Seed selection may be done by unskilled coolies, and if it be gathered from the centre of each block would probably be selfed seed of the clone used in that block. It is doubtful however if this seed is to be preferred to that obtained from the centre of a large clearing planted with mixed proved clones

If clones be planted in small blocks only (say 25 acres or less) the advantages are not so pronounced; the smaller the block the fewer the advantages :—

(1) Different systems of tapping for small blocks only would be impracticable.

(2) If one of the clones fails and has to be removed the area would be more difficult to replant successfully owing to interference by neighbouring mature trees in other blocks. This

would only apply when the block used was very small.

(3) If very small blocks are used one would lose all hope that seed from the centre of the block was selfed.

Discussion.

As will be observed all methods have their advantages and disadvantages. Definite recommendations can only be given when the particular circumstances affecting the present and future planting policy of the estate concerned are known.

CHAPTER IV.

Budgrafting in the Field

Versus

Budgrafting in the Nursery.

Since the first edition of this book appeared further experience has been obtained in the budding of rubber in all parts of Malaya. It is in the light of this experience that the following rather controversial views are put forward. Budding in the field has never been popular in Sumatra, and it is possible that the success of nursery budding there may have influenced earlier workers to advocate nursery budding in Malaya.

The advantages claimed for nursery budding are well known and are as follows :—

(1) The plants are closer together than in the field ; thus budgrafting costs are lower since a coolie can bud more plants per day.

(2) The work of budgrafting is more easily and efficiently supervised.

(3) More successes are obtained in the nursery because the plants offer each other a certain amount of protection.

(4) Stocks may be selected from the point of view of vigour and state of growth.

(5) When the time comes to plant out, a selection of buds from the point of view of vigour or activity is possible.

(6) The stocks are generally more vigorous as it is easy to maintain a nursery in a high state of cultivation by draining, forking and manuring.

(7) A more even clearing is obtained, for in field budding, unsuccessfully budded plants have to be rebudded and at least one month must elapse before this can be done.

(8) Budding in the nursery results in 100% successes in the field, provided a margin of reserves for supplying is allowed for.

(9) In field budding a year must elapse between planting and budding whereas with nursery budding there is no such delay.

There are possibly other advantages, but the above are sufficient to show that the writers have given full consideration to the practice of nursery budding. Each of the points in favour of nursery budding given above are dealt with hereunder :—

No. 1. Nursery Budding Cheaper than Field Budding.—This is admitted. A coolie can budgraft 150 plants in the nursery and 100 in the field. The difference in costs is about ½ cent per plant. The cost of transplanting from nursery to field would more than outweigh this.

No. 2. Better Control.—This is a question of supervision. As a rule in nursery budding it is impossible to see more than about two coolies at one time.

No. 3. Better Results.—This is partly true. As a rule however, field budding is just as successful as nursery budding. It is not uncommon to obtain 80% successes in field budding and 70% successes can be considered a conservative average.

No. 4. Selection of Stocks.—This is also possible in field budding if 3 plants one foot apart are grown at each point.

No. 5. Selection of Buddings.—This is admitted, but in a clearing where three plants are growing at each point an opportunity of selection is possible.

No. 6. Better Growth owing to Better Cultural Conditions.—This is so, but the vigorous growth has been brought about by artificial means, whereas the ultimate vigour of the stock will depend largely on its own self (i.e. on its inherent vigour) and on its soil conditions in the field.

If planting out is to be completed before mid-October, a nursery planted in September must be ready for budgrafting the following July. Thus in nursery budding it is often necessary to employ artificial measures (such as manuring) to promote growth so that the plants may be sufficiently large for budgrafting at least six weeks before planting out is done. In other words because a stock is vigorous under nursery conditions it does not necessarily follow that it will be vigorous in the field.

With budding in the field there is no such race against time or weather conditions, and the growth of the stock, although possibly not so advanced as that of the artificially fed nursery plant of the same age, is steady and sure according to its environment and natural vigour.

No. 7. Even Clearing.—There is so much supplying to be done with nursery budding (if weather conditions are unfavourable) that an even clearing is rarely obtained.

No. 8. 100% Successes.—This is of course obvious but it is suggested that the margin of reserves has to be a very liberal one.

No. 9. Earlier Results.—This a sound and unassailable point in favour of nursery budding.

BUDDING IN THE FIELD.

Field budding in Malaya is just as successful as nursery budding and if once the bud has shot it rarely dies back. The stock having remained in situ with its root system undisturbed it necessarily follows that the earlier development of the scion is rapid and vigorous.

Budding in the field can be done at any time of the year (except of course during a drought or very wet weather), since field buddings (when compared with budded stumps) are not to the same extent subject to arrested growth owing to adverse conditions.

Some authorities in Malaya maintain that stumped plants when transplanted do not develop such good tap roots as those plants whose root systems have remained undisturbed. This, if true, is a further argument against budding in the nursery. It is sometimes stated that budding in the field does not produce such good unions as nursery budding. Observations during early growth may appear to confirm this but on mature trees no such difference can be detected.

In Sumatra, where conditions are somewhat different to those obtaining in Malaya, nursery budding will remain popular because :—

1. Budding in the field is generally attended with very poor results. This is sometimes put down to the effects of a hot dry wind known as the "Bohorak".

2. The soil conditions in Sumatra are ideal for early growth and the loss in planting out is never great.

3. The development of a good tap root is not of much importance where the water table is high. In the low lying areas of Sumatra E.C., where much of the planting is done, there would probably be little difference in the development of tap-root between trees planted as budded stumps and those budded in the field.

4. Should watering be necessary it is neither difficult nor costly on low lying lands.

Disadvantages of Nursery Budding.—There is in our opinion one objection which outweighs all the advantages accruing from nursery budding, viz. that no one, however careful, can entirely guard against the risk of unsuitable weather during or after planting. Should adverse weather conditions be experienced, and watering be impracticable, disastrous results may ensue.

In the case of budded stumps, while root development is as yet poor drought resistance is miserably weak, and the budding is liable to die back. Even when the scion has grown 6 to 8 inches long, dying back has been known to occur. Conditions on the hill land of Malaya are not so conducive to good first growth as the light soils of low lying lands, and unless the planter is exceptionally lucky with regard to weather the planting out of budded stumps is both costly and disappointing. Further, the slow development of the budded stump renders it susceptible to periods of drought at any time during the first year of growth. For this reason it is recommended that budded stumps should be planted as early as possible in the planting season, so that they may be fairly well established by January, February, or March, when periods of dry hot weather are sometimes experienced.

Conclusions.—Budding in the nursery can be recommended :—

(*a*) If the areas to be planted possess good light soil giving satisfactory early growth.

(*b*) If watering is practicable.

Budding in the field should be done—

(*a*) On all hilly land.

(*b*) On all heavy soils such as clay or laterite.*

(*c*) On all poor soils.*

(*d*) On any area where watering is for all practical purposes impossible.

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* These are not conducive to good early growth.

CHAPTER V.

Nurseries and Multiplication Beds.

Nurseries should whenever possible be laid out near the clearing to be planted. The advantages of this will be fully realised when transplanting from the nursery to the field.

In making nurseries or multiplication beds three things should be considered—site, soil and drainage.

The best sites are generally those at the bottom of slopes of hills, and in valleys or ravines that are drainable and above normal flood level. The site should also be an open one, for a too heavily overshadowed site is sunless, resulting in spindly grown plants.

Nurseries or multiplication beds should have good soil. This is of the utmost importance. The land should be deeply dug and all wood heaped and burnt, and the surface soil on which the seed is to be sown should be made as fine as possible. The drainage of nurseries and multiplication beds is too often neglected : this should be attended to as early as possible.

On undulating sites a system of small catchments 6″ wide and 9″ deep, with the earth therefrom forming bunds, has been used to advantage.

It matters not whether the seeds be of good germinating power, or be selected from high yielders or vigorous growers : for if the nurseries or multiplication beds are badly sited, of poor soil and inefficiently drained, poor results will be obtained.

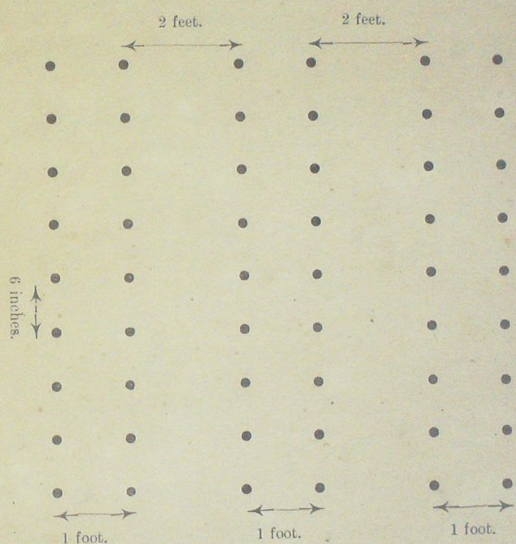
A suitably prepared nursery will give the seed a good start, which generally results in healthy well grown plants.

The Laying out of Nurseries.—The old type of nursery, considered good enough for ordinary stump planting, is not suitable for modern needs. In order to obtain good growth the close planting common to the old type must be replaced by wide spaced planting. This wide spacing is also necessary to allow the budgrafter to do his work. The following method is suggested.

The nursery is planted with a space of 2 feet between every two rows which in turn are a foot apart. The seeds are planted 6 inches apart down the length of the rows (see sketch). This type of nursery has been found to offer the following advantages :—

1. Easy division and identification of the beds.
2. Possibilities of variation in the size of the beds.
3. Drains can be introduced as frequently as desired without interfering with the planting.
4. Budgrafters can do their work without injury to the plants and inconvenience to themselves.
5. Makes for ease of inspection and checking the work of budgrafting.
6. Provides an early canopy to the soil round the roots of seedlings.
7. Offers an opportunity for the thinning out of weakling plants.
8. Makes for ease of carrying out cultural operations such as manuring, forking or spraying.

METHOD OF PLANTING NURSERIES.



Multiplication Beds.—It is suggested that multiplication beds be planted on the same lines as the nurseries excepting that the seeds are planted at 1′ x 1′ with (as in the case of nurseries) a space of 2 feet between every two rows. This method offers an opportunity of heavy thinning out so that the ultimate stand is reduced to 2′ x 2′.

When an area is to be planted for the dual purpose of nurseries and multiplication beds it is recommended that the planting out should be done as described under laying out of nurseries, i.e., 1′ x 6″ with 2 feet spacing between every two rows. Plants could be used for field planting until the stand is reduced to 2′ x 2′.

The Planting out of the Seed.—Germinated seeds are of course planted : the seed may be said to have germinated when the radicle (or rootlet) makes an appearance. It can be planted out at this stage, but it has been our experience that its growth is to some extent arrested if it is planted out so soon. It is thought that better and quicker nursery growth is obtained by allowing the seedling to develop further, and transplanting it when in the growth stage shown in the sketch—viz. when the plumule (stem) has appeared.

Germinated seeds with stems 6 inches long can be successfully planted out. These would of course need extra care and the planting could only be carried out on dull days or in the evenings.

The transport of germinated seed from the germinating shed to the nursery can be done in ordinary baskets, and provided that proper care is exercised, first when up-rooting from the germinating beds, secondly in placing the seed gently in a basket, thirdly in carrying the basket of seed without undue roughness, few if any of the rootlets will be damaged.

To avoid twisted roots in seedlings the seed should be planted out in the same manner as when planting in germinating beds. See chapter IX. The soil should be well worked by hand, the rootlets carefully packed and the seed partially covered with the (hooked) stem showing above the surface of the ground. Watering should be done every evening until the plants have established themselves. (This is not necessary on rainy days).

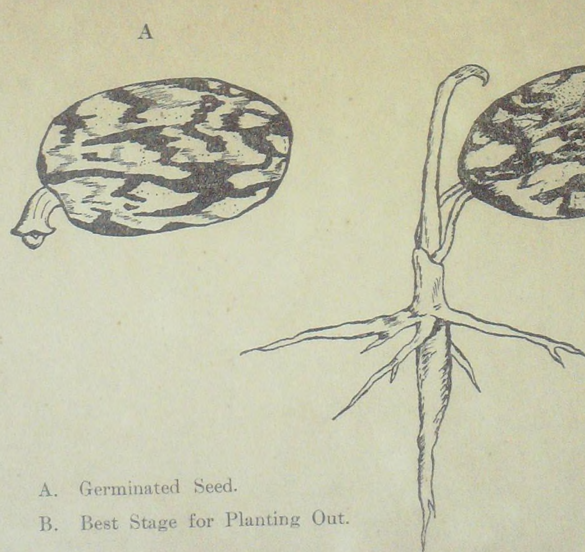
After Care of Nurseries.—Nurseries should be clean weeded by hand. Changkol weeding causes much damage to the stems of the young seedlings. All drains should be properly upkept and the earth from them spread over the surface of the beds.

The plants should be periodically inspected for double stem growths, and where this occurs the weaker growing shoot should be removed.

After Care of Multiplication Beds.—Multiplication beds must be inspected frequently for lateral shoots, which should be pruned off. When the buddings are about 7 to 8 months old the "snags" can be sawn away. The best growth is obtained,

1. by keeping the soil clean of weeds and cover crops,

2. by upkeeping all drains efficiently,



A. Germinated Seed.

B. Best Stage for Planting Out.

3. by frequent forking (which keeps the soil well aerated) taking due precaution to prevent soil wash by means of bunds or ridges.

For intensive cultivation of this nature manuring is necessary. Where a supply of cattle manure is available this should be used. It is the practice in Sumatra to apply cattle manure and quick-acting fertilisers alternately every six months: if cattle manure cannot be obtained a complete fertiliser such as a mixture of equal parts of Nitrate of Soda and Nitrophoska* is recommended.

The budwood can be cut when the plants are between 10 and 18 months old. Each plant should give from two to three yards of budwood and from each yard an average of 15 buds can be used. When cutting budwood care should be taken to leave at least two buds on the remaining stem. The exposed top of the stem should be waxed. In the second year of growth all poor growing plants should be removed and two shoots allowed to grow from each of the plants remaining. In the third year the stocks should be sufficiently vigorous to grow three shoots and in the fourth year four shoots. After the fourth year a rigorous policy of thinning is recommended thus allowing for the remainder of the plants to "bush."

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* Nitrate of Soda and Nitrophoska have been used on Prang Besar on the advice of Dr. Haines of the Soils Department R.R.I.

CHAPTER VI.

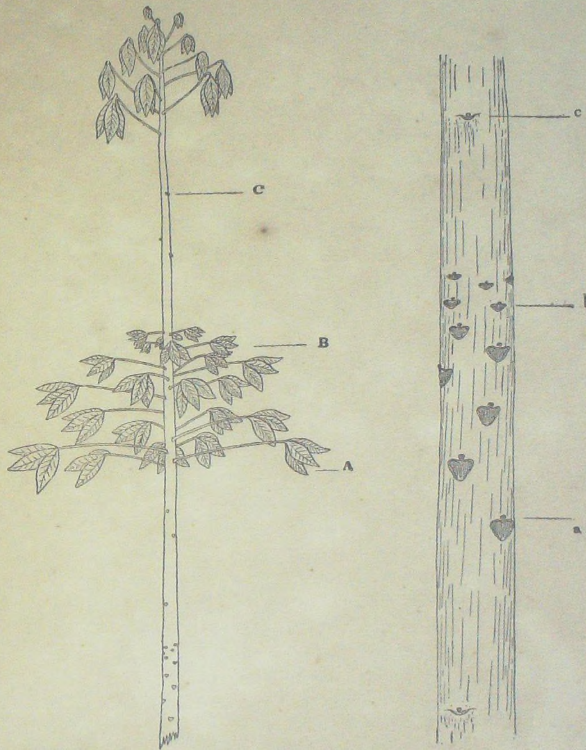
THE OPERATION OF BUDGRAFTING.

Size of Plants for Budding—Plants of ½ inch to 1 inch diameter or 1½ inches to 3 inches circumference at the budding point are generally the most suitable for budgrafting. Well grown nurseries at 10 months old contain a good percentage of plants ready for budding. Bad unions (Elephant Foot) are sometimes the result of budding on large stocks: a bad union is not in any way a defect but it is objectionable because (*a*) it looks ugly and (*b*) the tapping cut is higher from the ground than in the case of a tree with a good union, for it is usual to tap the scion of a budding and not the stock.

The Budding Season—There is no budding season, for the operation has been carried out successfully in every month of the year. Budding in the field may therefore be looked upon as an operation which can be carried out at any time. During periods of exceptionally hot weather field budding should be suspended, or carried out in the early morning or late afternoon, and every care taken to provide shade to the region of the bud-patch.

Nursery budding with a view to planting out the buddings in a new clearing should be carried out during or immediately prior to the planting season, when good planting out weather prevails.

Condition of the Plants for Budding—Budgrafting is more successful when the plant to be budded is in a state of active growth with the topmost whorl of



A. Large Leaf.
B. Small Leaf.
C. Rudimentary Leaf.

a. Bud formed in the axil of a large leaf.
b. Bud formed in the axil of a small leaf.
c. Bud formed in the axil of a rudimentary leaf.

leaf well developed. When the terminal bud has "shot" and a new whorl of leaves is beginning to grow much of the energy of the plant must be given to this new leaf development. Nearer the base of the plant where budding takes place there is less activity at this time, and if budded the chances of success are lessened owing to the conditions of the plant during budding. Experienced budgrafting coolies can generally pick out the plants with which they are fairly certain of success.

Material Required—

(1) *Knives.*—Two knives are generally used viz. a budding knife fitted with a bone spatula and a kitchen knife about 12 inches long. The budding knife is used for the actual budding operation, the bone spatula being used for levering the "flap". Experienced coolies frequently use cheap pocket knives. The kitchen knife is used for cutting up the budwood prior to the actual stripping of the bud. A thick bandage of waxed calico at the point end gives this knife a double handle.

(2) *A Work Box.*—This is made of the cheapest papan, and is about 13 inches long, 8 inches wide and 6 inches deep. One half of the top is covered over and serves as a table on which the coolie can if necessary shape the bud-patch before inserting it inside the "flap". In the box the coolie keeps his materials such as bandages, knife etc. This work-box has many advantages and the Chinese budding coolie looks upon it as a necessity.

(3) *Waxed Calico.*—(*a*) *The wax.* "Entwas," which costs about $35.00 per picul and is sold by the

Asiatic Petroleum Company, has given satisfaction for a number of years and is therefore recommended. Other kinds of wax are available and may give good results.

(*b*) *Calico.*—Two types of cloth can be used—a cheap material that can serve once and a more expensive type that can be used two or more times. A cheap cloth that can be recommended is " Grey Supers " No. 22 costing about $340.00 per bale of 100 pieces and obtainable from the Borneo Company. This material can also be bought by the piece which is 26 yards long and 30 inches wide. A cheaper cloth is likely to break when bandaging tightly. A more expensive cloth should be scraped clean and re-waxed after each time of using.

(*c*) *To Prepare the Bandages.*—There is more than one way of waxing calico. The following is a quick method :—

Cut a piece of Grey Supers 22 lengthways down the centre; make each half into a firm roll and tie with string, making a loop for the purpose of hanging to drip. Place a tin cylinder about 18 inches deep and 8 inches diameter containing a quantity of wax inside a kerosene tin of water which must be kept boiling. When the wax in the cylinder is melted, immerse in it three or four rolls of calico. Bubbles will be seen to rise to the surface. When all the bubbling has ceased (i.e. after about 20 minutes) take out the rolls of calico and hang up to drip over a latex pan. When cool they will be clean hard rolls and can then be cut into strips ready for use. The length of the bandages will vary according to the size of the plants to be budded, and it is therefore recommended that bandages of two sizes should be cut;

Large size—about 24 inches long and 1½ inches wide,

Small size—about 18 inches long and 1¼ inches wide.

A good method of cutting the bandages ready for use is as follows:—

Example for bandages 24″ x 1½″.—Open out the roll of waxed cloth and cut away a piece 24 inches long. Re-roll this 24-inch piece closely and evenly, flatten out with the hand and cut with a sharp knife 10 pieces, each 1½ inches wide. These pieces when unrolled measure 24″ x 1½″. A piece of Grey Supers 22 will provide 780 bandages at 24″ x 1½″ and 1248 bandages at 18″ x 1¼″.

The cost of cloth (not including the waxing) in the case of the former is 0.43 cents per bandage and the latter 0.27 cents per bandage.

Four catties of Entwas costing $1.40 is required to wax 1 piece of 26 yards x 30 inches of "Grey Supers 22" cloth. So that the cost of bandages measuring 24″ x 1½″ including wax (but not including labour) is 0.62 cents and that of the smaller size is 0.39 cents per bandage. The cost of labour (Chinese) for preparing waxed cloth is from 18 to 24 cents per piece or approximately 0.02 cents per bandage. The total cost of waxed cloth therefore works out at about 0.64 cents for the larger size and 0.41 cents for the smaller size bandage.

Selection of the Budwood.—Budwood can be used from a tree or from budwood nurseries known as multiplication beds. When cutting from a tree in the field, the following points should be noted :—

(1) Select branches at the top-most part of the tree, of not more than 2 inches diameter at their base. Low lying and horizontally growing branches are generally not strippable.

(2) Before cutting a branch test it for stripping.

(3) After cutting the branch, lower it very carefully to the ground.

(4) Remove the leaflets at their base by squeezing them together between thumb and forefinger or snick them off with scissors or sharp knife. Great care should be taken (at this stage) not to remove the leaf stalk at its juncture with the branch as this would cause excessive bleeding.

(5) The branch must be carried carefully. In estate practice it will be found an economical procedure to cut the budwood (particularly if cut from field trees) the evening before it is to be used. It should be cut into convenient lengths, placed vertically in an inch of water in a kerosene tin, and kept in a cool place. Budwood kept over night in this manner will give just as good results as if it had been cut immediately before using.

Pollarding large secondary branches of a tree in order to obtain a good supply of sappy budwood a year later is not considered good practice. Such trees have been known to suffer permanent injury. No clearing need be planted with more than 50 buddings of one unproved bud-parent, however desirable and high yielding it may be. Assuming that a yard of budwood will give 10 successful buds, then not more than 5 yards need be cut from any unproved tree, and to obtain this quantity there is no necessity to pollard large branches a year in advance.

Budwood in Multiplication Beds—can be used when 10-18 months old. It should be cut at about one foot from the union. Multiplications of this age generally yield from 2 to 3 yards of budwood per plant. Multiplication budwood is leafy but if the leaflets are pruned off about a week before using the budwood the leaf stalks will die away leaving the wood clean.

A few Suggestions before Commencing Budding Operations—Budwood purchased from Prang Besar, F.M.S., A.V.R.O.S. Sumatra, or from Proefstation Voor Rubber Java, is usually cut into yard or metre lengths, with both ends waxed over to prevent desiccation. When budwood arrives from any of the above Experimental Stations the following points should be noted :—

(1) To prevent a consignment being thrown ou on the platform, or left in the sun, or taken beyond its destination, it should be met at the station by a reliable person and the station master informed of its expected arrival.

(2) On arrival at the estate the budwood should be carefully unpacked, half an inch of the lower ends sawn off, and the remainder

placed vertically in about an inch of water, the sawn end lowermost. This should be repeated each day, i.e. a new piece sawn off and the water changed daily.

(3) Use the green wood first as this will deteriorate more quickly than the brown wood.

(4) When the budwood arrives on the estate its clone number will be found on one or both ends of each stick; but it is advisable to give each clone a colour, and to paint that colour or some other identification mark (which can be understood by a cooly) on one end of the stick before it leaves the office.

Before commencing operations, in the field, identification boards should be placed at both ends of each row of trees to be budded. (When budding in the nursery, if it is divided into beds each bed should be numbered and identified by boards). Since the average Chinese budgrafter is unable to follow a defined course, i.e. to follow a row of trees that are in line in rectangular planting, or along the contour in contour planting, it is necessary to smear a little paint (of the same colour as that put on the budwood) on each plant to be budded. If the budgrafter is using Clone X, and the colour given to Clone X is red, the coolie must be placed at the end of a row whose identification board is marked Clone X and told to confine himself to the plants painted red.

Identification boards should be sufficiently well made to last four years. They can then be renewed, or the necessary marks can be painted on the trees.

In addition to having the buddings identified by means of boards a plan of the area is considered necessary, particularly when unproved buddings have been used. In Sumatra cemented brick blocks with the numbering imprinted on the cement are favoured. While these are permanent they have the disadvantages of being :—

(*a*) rather expensive.

(*b*) very heavy to carry to the field.

(*c*) liable to get buried or hidden by cover crop unless of a large size.

Selecting the Bud.—Buds are usually formed in the axil of the leaf. Every node of leaves consists of large, medium and small leaves. The large are found at the bottom and the small at the top of a node with the medium leaf intermediate between these two. The buds growing in the axils of all these leaves are potentially good buds. Buds formed in the axils of the large leaves will probably show a little more vigour immediately after budding. Small rudimentary leaves grow at intervals between the nodes : buds formed in the axils of these undeveloped leaves are good buds. Briefly, all the buds on a piece of budwood should be used, excepting

(1) Those that have "shot"

(2) Those that have been damaged.

(3) Inflorescence buds. These would rarely be found on multiplication budwood, but may occur on budwood cut from field trees. They are just flower buds and can be easily detected by their oval cuplike appearance.

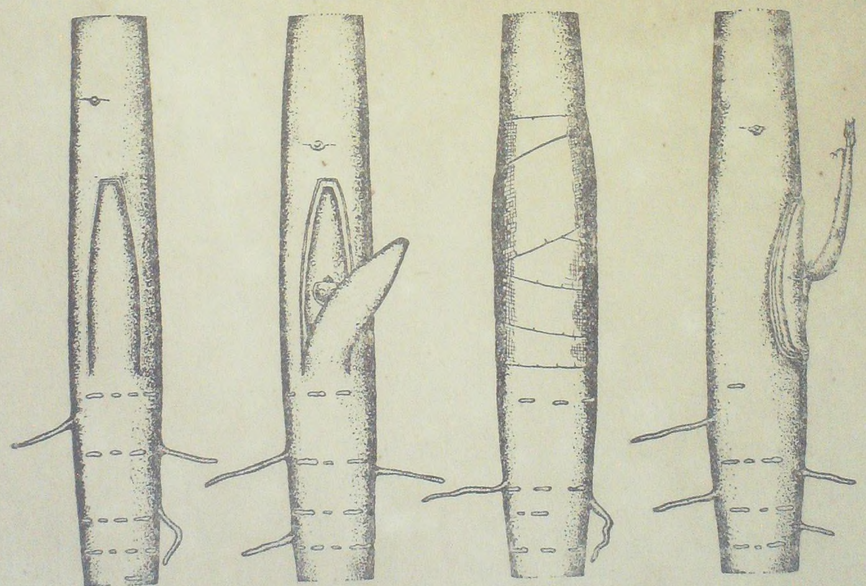
Before commencing to remove the buds, leaf stalks (should there be any) should be pruned to one-tenth of an inch from the bark.

The Budding.—Preparation of the Stock—Having selected the plant to be budded, make, close to the ground, two vertical cuts 2½-3 inches long and ¾ inch apart at the lower end, converging towards the top and there joined by a third horizontal cut (see diagram). These cuts are made to the wood and latex flows out. With the bone end of the budding knife the bark flap is levered away from the stock (this is a much more simple operation than when a rectangular plan is made) and slightly drawn down. The thumb and fore-fingers of both hands are drawn lightly over the edges of the flap to remove the clotted latex.

It is advisable to make the three cuts described above on 10 or 20 plants before drawing down any flaps so that by the time this is done the latex will have coagulated along the edges. Should latex spread over the cambium there is little chance of the budding being successful.

Removing the Bud.—With the kitchen knife described above, a strip (about 2″ to 3″ long, ½ inch wide, and ¼ inch* thick) of the budwood is removed. This small chip of budwood is then placed in the left hand, wood uppermost, and gripped by the lower joint and ball of the thumb on the one side and the tips of the four fingers on the other so that an even pressure is given along both sides (when gripping with the tip of the thumb only on the one side and the

* According to the thickness of the wood.



A. Panel. B. Insertion of Bud. C. Binding.

fore-finger on the other the bud-patch is frequently split just as the wood is removed). The bark is loosened slightly at the top end and the blade or spatula of the knife inserted between the wood and the bark. The wood is gripped between the blade or spatula and the thumb of the right hand. By gradually lifting the wood (with the right hand) while retaining hold of the bark (in the left hand) the bud is "*stripped*". The wood is thrown away, leaving what is known as the bud-patch, in or about the centre of which should be the bud. The bud-patch is then placed on the table of the work-box (cambium uppermost) and its edges trimmed. It must be noted here that an exact fit is not considered necessary, in fact a small space all round has been found to give the best results.

When using green buds which generally have a large projection of leaf stalk it seems expedient to trim the lower half of the bud-patch to within about half an inch of the bud. When binding, the projection of leaf stalk is immediately under the pressure of the bandage and the bud-patch is kept in position. If this is not done it is difficult to bandage over the projecting leaf stalk without forcing it upwards, thus chafing the whole bud-patch.

Green buds should, if possible, be used on small or young stocks. If only large stocks are available it is advisable to trim to a more triangular shape (the bud being fairly near the base of the triangle). This will avoid splitting of the bud-patch, which generally takes place when the bud-patch of a small stem is applied to the less curved surface of a larger stem.

Inserting the Bud and Binding.—The bud-patch is placed inside the flap, cambium to cambium, (care should be taken that the bud-patch is the right way up i.e. the leaf scar below the bud). In binding, the first hold is taken beneath the plan and the bandage carried thence spirally to ½ an inch above the top of the plan. Each time the bandage is passed over the flap, care is taken to keep the bud-patch in position (to prevent rubbing of the cambiums) by pressing the flap near the top of the panel with the left thumb. The binding is secured by rubbing the folds together either with the hand or the back of a budding knife, care being taken not to cause injury to the bud. In the field it is necessary to shade after budding. This is done by taking a few leaves from the budded plant and tying on at about six inches above the bandage.

Some Common Faults in Budding.

(1) Blunt knives.

(2) Lack of cleanliness, e.g. dirty hands, knives and stocks.

(3) Faulty stripping. Splitting the bud-patch by holding it between the thumb and fore-finger during stripping.

(4) Faulty bandaging.

(*a*) Rubbing the two cambiums together.

(*b*) Too much pressure in the case of protruding buds.

(*c*) Too little pressure in bandaging so that the two cambiums cannot unite.

(*d*) Insecure binding — becoming loose at the top thus allowing the entry of air and water, which bring about disease.

(*e*) Injury caused when smoothing over the bandage (This is done to induce cohesion, but the area of the bud-patch must be avoided).

(5) Exposure of the bud-patch to the sun, air, or water. (Special care should be taken to avoid damage by water when budding in the Nursery in the early morning).

(6) Damage to the cambium of the bud-patch when removing specks of dirt. (Tamil coolies have been seen to lick a whole bud-patch in doing this).

Opening Up.—Opening up is done from 14 to 20 days after budding. Factors that are to be considered when determining the period between budding and opening are :—

(*a*) Weather conditions. It would be unwise to keep on the bandages for the maximum period of 20 days during wet weather. The bandages, though waxed, are not weather proof for a long period.

(*b*) The condition of the plants budded. The more vigorous the budded plant and the more active its state of growth, the more rapid will be the adhesion of the two cambiums, and the healing over of the exposed cambium which is not covered by the bud-patch. In healthy vigorous plants, it is not uncommon to see a white skin-like callus growth completely covering the bud-patch. (This must be removed very carefully without injuring the bud-patch).

The very vigorous plants can therefore be safely opened up after a 14-day period. In all cases it is advisable, 2 or 3 days before it is thought the opening up should be done, to open a few (say 10) average looking plants in different parts of the nursery or field and ascertain to what extent they have already healed over.

It is thought that the longer the budding can be *safely* left unopened the fewer the casualties that will occur after the removal of the bandages. The opening up is carried out as follows:—

(1) Remove the bandage.

(2) Raise the flap of bark and break or cut it off at its base. This must be done without injuring the bud-patch.

(3) Scratch minutely with a knife above and below the bud. If these cuts expose green tissues the budding has so far been successful.

In field budding, the shade is not removed but supplemented with a few more leaves if it is thought necessary. When unsuccessful the shade is cut away and a knot tied on the bandage of the unsuccessfully budded plant.

At the end of each row of plants in the field, or of each bed in a nursery, the number of knotted and unknotted bandages are noted. The percentage of successes on opening is thus obtained.

A few casualties will occur after opening the bandages and these are noted on the second inspection a week later. These casualties or failures can be again budded when the plant has recovered from the shock of the first operation, i.e. about one month later.

Labour.—Chinese coolies learn budgrafting quickly and soon become expert.

Javanese coolies obtain good results in Sumatra.

Tamil coolies require much training even when they are specially picked men.

A Chinese budgrafter is generally paid $1.20 per day of 6 hours. In some districts the pay is $1.50. A good coolie can budgraft per day about 150 plants in a nursery and 100 plants in the field, and the percentage of successes is about 75 (this is a somewhat conservative figure). It is advisable to keep a record of each coolie's individual successes, and this can be done by giving to one coolie one bed (in the nursery) or one row or contour (in the field).

Chinese Contractors can be engaged to undertake budgrafting work. Most of these men received their training either on Prang Besar or Kajang Estate and although expensive they generally give satisfaction.

CHAPTER VII.

Planting Out and After-Treatment.

The importance of planting out early in the planting season is well recognised. It is even more important with budgrafts than with ordinary stumps.

A budded stump is sensitive to a period of drought, unless it is well established, and planting out should be done if possible before the end of October (in Selangor). To complete an early planting out programme, it may in some instances be necessary to commence budgrafting in July, and nurseries planted with the previous August to October seed crop should be given proper attention in order to obtain the necessary growth. Manuring should be resorted to if necessary. Whatever the condition of the nursery, it has been found that manuring with a quick acting nitrogenous fertiliser some time previous to budding generally promotes the active growth conditions so desirable if one is to obtain the best results.

There are three ways of planting out from the nursery to the field.

(1) Transplanting immediately after the bud has shot.

(2) Transplanting before the bud has shot.

(3) Transplanting nursery grown buddings of ten to fifteen months old.

Method (1).—Ten *days after opening bandages the plants are re-examined. The successes are cut down to three inches above the bud-patch sloping to two inches on the opposite side. The pollarded stocks are then waxed or tarred. Wax is to be preferred to tar because there is always a danger that the particular tar used may have an injurious effect and delay healing. About ten days later buds will begin to appear.

Transplanting should be done when the buds are $\frac{1}{4}$ of an inch to $1\frac{1}{2}$ inches long. Points in favour of this method are :—

(*a*) The buds are induced to shoot as soon as possible after budding. A few weeks or a month may mean little to the age of a tree at 10 years old but early vigorous growth of the budding in its first stage is very desirable.

(*b*) By reducing to a minimum the period between budding and cutting back there is little chance of the bud becoming too inactive.

(*c*) A selection can be made of the buddings, and if only those whose buds appear strong and vigorous are used and providing that planting out is successful an even clearing will be obtained.

* It is not imperative that cutting back should be done ten days after removing bandages. Ten days is given as a "safe" period between opening and cutting back, 7 days being the minimum. Cutting back can be postponed indefinitely in the event of unpromising weather conditions or a delay in field preparations e.g. holing etc. After cutting back the buddings must be transplanted before the bud grows too large.

The two main points against this method are :—

(*a*) That the buddings must be transplanted when the buds are between $\frac{1}{4}$ of an inch and $1\frac{1}{2}$ inches long regardless of weather conditions : this frequently involves heavy watering costs. On hilly land watering is practically impossible.

(*b*) The transport of buddings whose buds have shot will always be difficult, for the utmost care and supervision is necessary to prevent damage to the young shoots.

Method (2).—In this method (i.e. transplanting before forcing out the buds) the budding is treated as an ordinary stump. Ten days after the bandages are removed re-examine for successes, cut back the latter at about $2\frac{1}{2}$ feet from the ground and wax or tar the top of the stumps. After a further 10 days or more (according to weather conditions) transplant the stumps to the field. Cutting back at $2\frac{1}{2}$ feet does not induce "shooting" of many of the buds but about the tenth day ordinary buds near the top of the stump will begin to swell out. The stump having been transplanted with as much care as possible, the ordinary buds near the top will in due course begin to grow, as in the case of an ordinary stump. The appearance of the ordinary shoots is a promising sign of activity. When these "shoots" have been growing for at least one month (on no account should they be pruned away) the stump is cut back to within 3 inches of the bud-patch sloping to 2 inches on the opposite side. After this operation, which, if it is to be successful, must be performed without disturbing the roots, the bud should begin to shoot. Points in favour of this method are :—

(a) Planting out need only be done during favourable weather.

(b) The transport difficulty is not serious.

Points against this method are :—

(a) Since the plants are taken from the nursery while the buds are still inactive no selection of plants with respect to their buds is possible.

(b) The period between opening bandages and cutting back in the field is about 50 days, and if the bud has been inactive throughout this period there is the possibility of it having become so dormant, that, even after the cutting back in the field, some weeks may elapse before the bud appears. This delay is very unsatisfactory and if a period of dry weather is experienced in January, February or March will have a noticeable effect on the clearing.

Both the methods described above have been used on a large scale. In the writers' opinion however, the first method is the better in spite of the risk of unfavourable weather.

Method (3).—Having budded in the nursery and cut back 10 days after removing the bandages (as described above) the buddings are allowed to grow in situ for 10-12 months. They are then stumped in the nursery by cutting back to about 3 feet from the ground. The tops of the stumps are waxed, and the stumps transplanted about 10 days later when the buds (near the top) are showing signs of life.

The period between budding in the nursery and planting out is about a year. It is not suggested that clearings should be planted with stumped buddings, but it is advisable to leave growing in a budded nursery a small number of buddings of each clone. Should supplying be necessary these could be stumped and planted as described above. Stumped buddings are not dependent on one bud as is the case with budded stumps and few losses if any should be incurred when planting this material. Further they are ideal for "supplying" because their stocks and scion (up to about 30") respectively are of the same age as those of the other plants in the clearing, so that the age of the tapped bark (if tapping is below 30") will be the same throughout.

Suggestions for Planting Out.—The rows or places (in the field) where each clone or budding is to be planted should be defined by means of identification boards or coloured pegs.

Each budded stump should be painted with its clone colour corresponding to one already used in the field. A plan of the planting should be made and if natural landmarks are not available by which the plan can be orientated an artificial landmark or landmarks should be provided.

Budded stumps should be uprooted from the nursery with the aid of forks. All roots should be lightly pruned and the tip of the tap root dipped in melted budding wax.

When the buddings are treated according to Method 1 empty kerosene tins have been found useful for transport purposes. The budded stumps are placed upright, roots lowermost in the tins, and so arranged that the buds cannot be injured.

When the distance between nursery and field is many miles, planting out should be done according to method 2. In any planting programme, next to having vigorous young trees the greatest asset for quick results in the growth of the trees is in preparation of the ground. This has been fully realized in Sumatra, where the authors have seen in one instance four tractors ploughing a large clearing, and in another a 100 acre clearing, formerly very heavy jungle, which was not only clean cleared but thoroughly forked to a depth of 3 feet. This form of cultivation may not appeal to some on account of the cost and would not be favoured by others because of the danger of soil wash. If holing be the only preparation, then it is suggested that the holes be made as large as possible say 3′ x 3′ x 3′ or at least 3′ x3′ x 2′. The holes should be filled with good top soil, for this will give the young plants that congenial rooting medium so much needed by the fine delicate rootlets. Care should be taken that the young lateral rootlets of the stump are placed as naturally as possible when filling. Pushing a stump into a filled hole causes the young lateral roots to be turned upwards with disastrous results.

In order to plant the budded stump with the bud-patch at the proper level, it is advisable to place a piece of wood across the holes. Filling is then done with the lower end of the bud-patch in line with this piece of wood. When planting the importance of filling and packing the soil tightly in the hole cannot be sufficiently emphasised. The bud-patch should be kept free from silt. Should watering be necessary, cover the wet earth with rubber leaves or cover crop to prevent evaporation and cracking of the soil. Should cracking occur thé top earth should be broken up to form a fine tilth.

After Care.—The formation of the union* of stock with scion is of necessity a gradual process. Until this union is complete it is easily broken and the budding must be carefully looked after.

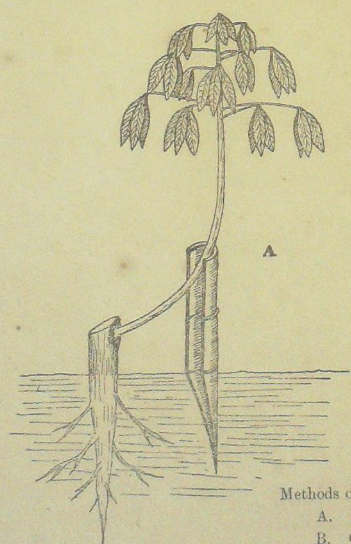
Weeding around a budded plant should be done by hand and weeding coolies should be warned against brushing the shoots with their legs or changkols. Should cover crop grow near to or over the budding it must be removed with the utmost care.

Field budded plants, owing to the roots of the stocks not having been disturbed, usually grow vigorously, developing a heavy head of foliage. Until the union with the stock is fairly advanced, such young buddings are liable to damage by wind and therefore need protection. There are several ways of preventing wind damage. Diagrams of two methods are given here.

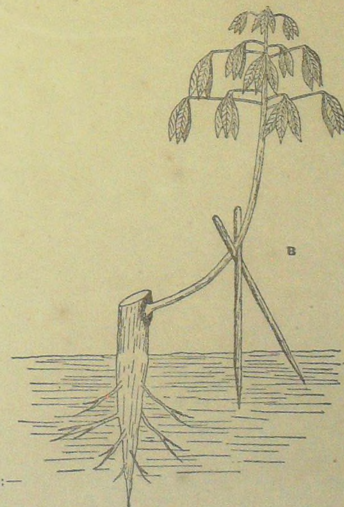
(1) Two sticks, crossed, are pushed into the ground, and the young shoot is placed resting in the cleft.

(2) A split bamboo pointed at the lower end is pushed into the ground in front of and about 6 inches away from the bud. The shoot

* Once the union is complete breaking at the union is very rare; in fact no such break has been observed by the authors.



A.



B.

Methods of Protection :—

A. Bamboo.

B. Cross Sticks.

grows up the concave of the bamboo and is thus not only assisted in keeping to the vertical but also gets some protection from the sun's rays during its earliest growth.
When the budding is about 4 months old there is not much danger of wind damage and the crossed sticks or bamboos should be removed.

Pruning.—Suckers growing out of the stock should be cut away and one shoot only allowed to grow from the bud-patch. (Occasionally two or three buds are seen on one bud-patch). Budded shoots are a bright green colour,* while those growing out of the stock are usually a dark colour. When the scion is three or four months old it may begin to throw out lateral shoots. These should be regularly pruned off until the budding is at least 8 feet tall.

That part of the stock which remains above the region of the union of stock and scion is sometimes known as the "snag." In the course of time this will fall off of its own accord leaving a small crater on the top of the stock which disappears with the growth of the plant. It is recommended however, as a disease preventive measure that when the scion is sufficiently grown to show 12 inches of brown bark the snag should be removed. The cut by which this is effected should commence flush with the union and sloping away at an angle of about 45°. The exposed wood should then be tarred or waxed and the snags collected and burnt.

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* Clones showing a pigmentation in the bud-shoot are very exceptional.

CHAPTER VIII.

EXPERIMENTAL TAPPING.

This chapter falls under two headings :—

(a) Experimental tapping of all clones on the same system to determine the comparative yields of clones when tapped on that system, and

(b) Experimental tapping of the same clone on different systems to determine the best tapping system for that particular clone.

(a) EXPERIMENTAL TAPPING TO DETERMINE COMPARATIVE YIELDS.

The ideal method should satisfy the following conditions :—

(1) Continuous tapping on some well known system.

(2) A large number of trees in tapping. (If for some reason only a small number (*) can be experimentally tapped, these should be, representative trees and as many other trees as possible of the clone should be kept under observation).

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* The figures for Avros clones are in some cases based on 4 or 5 trees only: on Prang Besar a ten tree unit has been adopted. If care be taken in selecting average trees (or more accurately speaking in excluding exceptional trees), it is our opinion that over a year's tapping the figures obtained will not show a variation of more than 1 or 2% from those obtained by tapping a large number of trees. Where trees of one clone are not so widely scattered as on Prang Besar, but are conveniently planted in blocks, more trees per clone may be tapped without incurring undue trouble or expense.

(3) Actual yields per tree per year, and not estimated yields, should be given.

(4) The tapper, and the order in which the clones are tapped, should be varied regularly.

(5) Latex and dry rubber records should be kept, and, if possible, yields should be divided into Number 1 rubber and lower grades.

(6) The rubber should be properly dry before weighing: this condition should be obtained by one of the recognised systems of manufacture i.e., smoking or creping.

(7) Trees should be growing under commercial conditions.

Such a system is, for a variety of reasons, not always possible, and discontinuous test tapping is often practised.

Systems of Experimental Tapping carried out over short periods only.

The objects of this type of test tapping are usually as follows :—

(1) To obtain some information as to the value of clones of very young trees.

(2) Periodic recording for comparative purposes of the yields of older trees.

1. To obtain information as to the value of the clones of very young trees :—

Several systems are in use—the better known are given below :—

(*a*) Gough's system :—1 month's tapping of the young trees—records taken after the first ten days of tapping.

(*b*) H. A. P. M. System :—Tapping the young trees to the wood for 2 weeks.

(*c*) Tapping regularly but with a long interval, say 5 days, between tapping.

All these systems (*a*), (*b*) and (*c*), have their advantages and disadvantages. Early tapping does not necessarily disclose the best yielding clones; but only those that are earliest to mature. On the other hand, if sufficient clones are selected and multiplied, some at least should remain in the first rank. If however, the yields from this early tapping be taken as a guide for thinning out the results may be unfortunate—many somewhat slow maturing but good clones being sacrificed.

Method (*c*) has the advantage that it is less strain on the young tree than the other methods. On the other hand trees slow to regenerate latex after tapping would probably make as good a showing on this system as normal trees, whereas if tapping were carried out on a daily or alternate daily system they would almost certainly occupy a very different position in the table of comparative yield.

2. Periodic Recording, for comparative purposes, of the yields of older trees :—

(*a*) At regular and frequent periods.

(*b*) Once a year.

(*c*) Over a period of a definite number of good tapping days.

All these systems have disadvantages. For instance, some of the clones may be periodic yielders and show up well or badly according to the period chosen—this might be particularly marked if method (*b*) be practised. Method (*c*) has certain advantages when used for selecting, from among a group of clones, those good enough to be put into continuous test tapping.

Faults which may occur in any method of test tapping are the following :—

(1) Test tapping or recording yields on good tapping days only (i.e. when tapping was not interfered with by weather conditions). If the average yield per tree per tapping be based on these records and then multiplied by 160 (the estimated number of tapping days in the year) the result may be most misleading.

(2) Not tapping trees continuously but bringing them into test-tapping after periods of rest.

(3) Not bringing the trees into continuous tapping till they have reached an advanced age.

(4) Not using trees and clones comparable in age,* or in previous cultural treatment.

(5) Not using average yielding trees.

(6) Giving too small a task to the test tappers. They should finish at approximately the same time as the commercial tappers on the estate.

* The age of a budgraft, whether budded in the Field or Nursery, should be reckoned from the time of budding, as this will give the exact age of the bark to be tapped.

The faults mentioned here are those which tend to exaggerate the yield of a clone. Methods which underestimate yield, unless they do so grossly, are not so pernicious, and have not been detailed, as it is believed that their practice is not widespread.

Experimental Tapping to determine the best tapping system for any particular clone.

It is probable that some clones will give better results on some tapping systems than on others. Various systems might be tried involving :—

(*a*) A different period of rest between tappings.

(*b*) A difference in the tapping cut or cuts, whether in height, number, or shape.

It is imperative that all tests should be begun simultaneously and carried out over a similar period of time. The trees used should be of the same age and be as closely comparable as possible in other respects.

CHAPTER IX.

THE TRANSPORT AND PACKING OF BUDWOOD, BUDDED STUMPS AND SEED.

An important communication on this subject by Maas appeared in the Archief voor de Rubber Culture for September 1926. Maas found that if budwood be used within one week after cutting.

(1) Green wood is as good as brown.

(2) Waxing the ends (at least of brown wood) is not necessary.

(3) Banana leaf sheaths are quite a suitable and easy packing material.

(4) It is desirable to use the wood as quickly as possible.

(5) The placing of the branches with the lower ends in water, which should be changed daily during the time between arrival and use is to be recommended.

If more than a week must elapse between cutting the budwood and actual use Maas writes .

(1) Brown wood only should be used.

(2) The ends of the wood should be waxed.

(3) The small bundles should be wrapped e.g. in Jute bags (better than banana leaf sheaths, which rot during transport).

(4) The wrapped up wood should be packed in closed chests.

(5) The intervening spaces between the bundles of branches should be filled with moist charcoal.

(6) On arrival on the estate a small piece of the lower-end of the sticks should be immediately removed and the budwood placed in water, which should be changed daily.

The object is of course to pack the budwood, whether for short or long journeys, in such a way that on its arrival it has retained as much as possible of its moisture content in addition to being free of wounds and bruises. It is obvious that cut budwood exposed to either air or sun must deteriorate very quickly.

(1) *Short Distance Packing.*—We agree with Maas that green wood is as good as brown, but it is recommended that the young or green wood should always be used first.

It has been found that waxing the ends of the sticks of budwood is not necessary for short distance packing (maximum 3 days) e.g. within Malaya. In spite of this, waxing is practised because it offers a simple method of affixing or writing the clone number on each piece of budwood.

Slightly moist coconut fibre has been found to give better results than banana sheaths. Besides being considered the better packing material it is usually cheaper and much easier to obtain in large quantities than banana leaf sheaths.

(2) *Long Distance Packing.*—For long distance packing it is necessary to use a packing material which not only prevents desiccation (for which a wet packing seems almost essential) but also to preserve the budwood from becoming diseased. Materials such as

dry saw-dust and dry coconut fibre, though not so likely to induce disease, do not conserve the moisture content of the budwood.

Wet packing materials e.g. wet saw-dust, generally ferment, causing the budwood to become mouldy. Since the fermentation is no doubt set up by the activity of micro-organisms, it occurred to certain authorities in Sumatra to experiment with sterilized packing material and with different methods of sterilization.

Sterilized wet packing material is now being adopted by several estates in Sumatra. Sterilized wet sawdust has since been tried on Prang Besar with excellent results.

The following is a report on a shipment of budwood from Prang Besar Estate to Balangriri N. V. Celebes Landbouw Maatschappij, Celebes Island :—

Date of Cutting.	Date of Budding.	Name of Budwood.	No. of Yards.	No. of buddings made.	No. of successes.	Percentage.	No. of successes per yard.
2/1/29	22/1/29	P.B. 24 in saw-dust*	10	264	191	72	19.1
2/1/29	24/1/29	P.B. 24 in fibre*†	10	241	99	41	9.9

Similar results have been obtained with other long distance shipments when using sterilized sawdust.

* Sterilized sawdust.
† Unsterilized fibre.

A double case (i.e. one case let into a larger one allowing an air space at the bottom and both sides) is used for overseas shipments.

PACKING OF BUDDED STUMPS.

Since there *is* a method of planting budded stumps before the buds have appeared (see Chapter VII) it is thought that any contrivance for long distance packing of budded stumps, whose buds have begun to grow out should be considered obsolete. In any case it is thought that a young green bud shoot of $\frac{1}{4}$ to $\frac{1}{2}$ inch in size could not be kept alive for a period of more than say 7 days except by employing the most elaborate and costly methods of packing.

The packing of budded stumps whose buds have not shot in the nursery is a simple matter. An experimental shipment of budded stumps was sent to B. N. Borneo. 150 buddings were cut down to $2\frac{1}{2}$ feet from the ground 10 days after removing the bandages. The tops of the stumps were waxed, and after a further 10 days they were uprooted, (the rootlets pruned and the tap root dipped in wax) and packed in 3 boxes of 50 plants each as follows :—

50 stumps were packed with their roots in wet powdered charcoal.

50 stumps with their roots in wet coconut fibre and 50 stumps with their roots in dry coconut fibre.

In each case the budpatches were carefully wrapped with fine coconut fibre.

The time that elapsed between uprooting and planting out was 10 days.

A report on this shipment received from Messrs. Harrisons & Crosfield, Sandakan, was to the effect that no particular method of packing appeared in any way better than another; that 132 out of the 150 buds had grown and that the remaining 18 buds were alive and showing signs of swelling out.

Local consignments (anywhere in Malaya) are packed in bags instead of boxes, with a little wet fibre round the roots (the bud-patches of course carefully wrapped as above).

SEED.

Seeds picked from the ground cannot as a rule be guaranteed to be fresh. It is therefore advisable to pluck the fruit when it is semi-brown in colour. Plucking should be done on dry days and the fruit cracked open to release the seed. All fresh seeds are damp and if heaped they are very liable to become hot. Heated seed is useless.

The first considerations therefore before packing seed for despatch are :—

(1) That only fresh seed is handled.

(2) That this fresh seed is placed in separate layers in a dry cool room to prevent heating.

For short distances it is recommended to pack in boxes as follows :—

On the bottom of the box place a layer about ½ inch thick of moist powdered charcoal or coconut fibre and cover over with cardboard. On the cardboard place a layer of seed and cover over with a second cardboard. On the second cardboard place a layer of seed, and so on to the top of the box. The topmost piece of cardboard is covered over with a layer ½ an inch thick of charcoal or coconut fibre.

By this method free circulation of air is obtained, the cardboard acts as a cushion, and the charcoal or fibre is to some extent a protection against external drying influences.

For longer distances the following method has been found satisfactory :—

On the bottom of the box place a layer of moist powdered charcoal and cover with cardboard or thick paper. On this another layer of moist powdered charcoal on top of which is a layer of seed. Cover with cardboard or thick paper and place another layer of moist charcoal on the second piece of cardboard or paper. On the second layer of charcoal is the second layer of seed, and so on to the top of the box.

Should seed remain packed in this manner for a period of 10 days or over it is quite possible that some will germinate before arrival. Unpacking should therefore be carried out with much care. The writers have not had very much experience of packing seed for journeys of over 10 days. It is thought however that, should seed germinate in transit there is a possibility of the young radicle or rootlet being attacked by mould. It may therefore be advisable when packing seeds for journeys of over 10 days to use a sterilized packing material.

Treatment of Seed on Arrival.

Ungerminated seed should not as a rule be planted out in the nursery or field.

Seeds should always be germinated in specially prepared germinating beds.

Germinating should be done under cover from rain and sun, and if an old shed is not available a new one should be built on or near the new clearing or nursery to be planted.

The germinating beds must be carefully prepared, the top soil worked into a fine tilth by hand. Fine sand has been found to be better than soil. If a small supply of sand is available it should be mixed with the top soil.

The beds can be divided off by means of planks and so laid out to be convenient for watering, inspection and collection. The name or number and quantity of seed together with date of planting (in the germinating bed) should be ticketed on each bed.

The seed should be planted horizontally,* the dorsal side uppermost, with the micropylar end (where the shoot appears) slightly depressed (see sketch No. 3). The spacing between each seed should be about $\frac{1}{4}$ of an inch. Germinating seed should not be entirely covered over with soil or sand, but the planting done so that the upper surface of the seed is just visible.

* The practice of covering germinated seed with wet sacks is not recommended because the close moist conditions so induced encourage disease.

The seeds should be evenly and lightly sprinkled with water morning and evening. Too much water, resulting in a waterlogged state of the beds, is undesirable.

It is probably better never to move seed in the process of germination until it is in a suitable condition for planting out.

Delayed germination may occur even in freshly plucked seed, and only seed showing signs of mould or other disease should be discarded.

Husking.—Husking is not recommended, because the husked seed is subject to insect and mould attacks.

CHAPTER X.

INTERPLANTING.

Policies of interplanting buddings with seedlings have mainly been used as an insurance against the possible failure of the buddings. Our increasing knowledge and experience of budgrafts renders this possibility more and more remote. Though the original reason for interplanting no longer exists with sufficient force to render the planting of seedlings essential, yet certain policies of interplanting have their advantages. Companies who still desire to interplant with seedlings should only use seed of the higher grades (see Chapter XI).

Proved buddings may now be used as an insurance, and these interplanted with more speculative material such as unproved buddings or seedlings. Thus one has the advantage of proved material in a clearing which is also being used for the proving out of new clones or of new strains of seed.

If interplanting with seedlings is practised and if

(1) *budding be done in the field,*

(*a*) The seedlings used for interplanting may be planted as basket seedlings just after budding.

(*b*) The interplanted seedlings, if planted at the same time as the stock for budding, should be pollarded when the stocks are pollarded, and to a similar height. When pollarding, allowance may be made for lack of vigour;

for instance a poorly grown seedling need not be pollarded so heavily as one showing normal growth.

The seedlings, when pollarded down to 2—3 inches in this manner, will probably recommence growth from the buds in the axils of the cotyledons. These buds are, or should be, below soil level and consequently no bad union is likely to occur on the tapping panel. Even if adventitious buds develop higher up the stump the pollarding has been sufficiently severe to prevent undue interference with tapping.

(2) *budding be done in the Nursery,*

Basket seedlings may be planted out after the planting of the budded stumps.

If some such procedure as that detailed above be not followed, considerable over-shading of buddings by seedlings may occur and the former be poorly developed in consequence.

Methods of Planting.

These have already been described in Chapters II & III. The most suitable, when proved clones are being interplanted with unproved material such as seedlings, are :—

(*a*) alternate rows of proved and unproved material

or (*b*) proved and unproved material alternating along the row or contour.

Stand per acre.—This depends on :—

(1) whether proved material is to be used in the clearing.

(2) if proved material is to be used what proportions of proved and unproved material are to be planted.

The usual policy is to plant with 50% of proved buddings and 50% of unproved material such as seedlings. Should these proportions be adopted a stand of 150—200 per acre is sufficient.

Thinning out.—This can be done within the clone on girth alone. When thinning out, proved material should never be sacrificed to unproved unless the latter is wanted for experimental purposes.

CHAPTER XI.

Seed Selection.

Plant breeding and budgrafting are to a certain extent interdependent. By means of budgrafting, existent high yielding material is propagated, multiplied and distributed. The further budgrafting is developed, and the larger the number of clones made available, the stronger will be the position of the geneticist, since there will be a greater variety of proved material available for breeding purposes. On the other hand, the geneticist, by carefully selecting types used for crossing, may hope to produce better types of bud parents, and thus raise the standard of the clones available.

Though no strains of seed are yet known,* or are likely to be known for some time, in which the average yield of the seedlings would compare with that of a good clone, yet, since there are no clones which can at present be regarded as fully proved, many people prefer to interplant buddings with seedlings. In order to maintain as far as possible the high yielding nature of the clearing it is desirable that the best grade of seed available be used for interplanting. For the production of seed of this type we must rely on the plant breeder.

Aims of the Seed Selectionist.

The ideal of every plant breeder would be to establish a pure line of high yielding material. The

* Av. 36 x 35.—The yield of seedlings from this cross certainly compares well with that of good Avros clones, such as 49, at the same age, i.e., 5—6 years. The Avros clones at this age appear to be somewhat low yielding when compared with Malayan clones

difficulties likely to be met with in achieving this are not generally realised. The quickest means of establishing a pure (or comparatively pure) line would almost certainly be by Inbreeding; i.e., in *Hevea* by the continued self-fertilisation of a selected individual, or individuals, in each generation. The chances are that the greater the degree of variation shown by a plant (and hence the greater its capacity for heterozygosis) the larger the number of generations of selection that will intervene before the plant can be regarded as breeding true, or comparatively true, with respect to any particular character, or characters. Further, in some plants and animals, inbreeding has resulted in a loss of vigour and constitution.

Considering these hypotheses in relation to *Hevea*, it will be observed that :—

(*a*) *Hevea* is a plant showing a remarkable degree of variation in such characters as those affecting seed and bark appearance. It is little if at all less variable in yield behaviour, probably therefore it will take very many generations* of selection to obtain a strain comparatively pure for high yield. The process will probably be lengthened by the fact that not only should the desired strain of seed breed true with regard to high yield but it should also do so with regard to other good characters such as :—disease resistance, wind resistance, good bark renewal, etc.

* Allowing for the proving of the individuals of each generation for high yield, a generation in this sense should be reckoned as at least 8 years.

(b) *Hevea* may degenerate on being inbred and a costly experiment thus collapse.

(c) *Hevea Brasiliensis* is probably of a somewhat complicated hybrid interspecific origin. It is possible therefore that several disturbing factors, such as irregular chromosome distribution may place further obstacles in the path of a plant breeder desirous of obtaining a pure, or comparatively pure, strain.

The endeavour to establish pure strains of *Hevea* is probably best left to a pure research station to which time, money, and possible lack of return are not such immediate objects of concern as they are to an estate run on commercial lines. The ordinary estate might set itself a lower standard whereby seed of good quality could be obtained, in which, after some time, a definite proportion of high and medium yielders might be guaranteed.

Such strains of seeds might possibly be obtained fairly quickly by two means :—

(a) *Self-fertilisation.*—A large selfing programme would be carried out on many clones in the hope of finding one giving a high proporportion of desirable types in its progeny. This clone would then be planted in an isolation plot and its seed gathered and used for planting.

(b) *Cross-fertilisation.*—A large number of crosses would be obtained from a variety of clones with the object of finding two clones whose genetic constitution was more or less complementary with regard to desirable characters, that is, clones that when crossed would give a high proportion of good offspring. It is desirable that these crosses should be carried out on a diallel system.*[1]

Once a good combination were found it would also be necessary to ensure that the progeny, arising from self-fertilisation of each of the clones used, was reasonably good. The two clones A. & B. could then be planted in an isolation plot, the seed gathered and :—

Clone A seed sold as seed of clone A selfed or crossed with B and clone B seed sold as seed of clone B selfed or crossed with A.

Both methods, cross and self-fertilisation, should if possible be employed in the hope of obtaining a good strain. The following considerations may indicate the method on which it is better to concentrate.

Self-fertilisation.—This has the following disadvantages.

(1) *Hevea* is usually more self than cross sterile, and, may possibly, in view of its hybrid origin be found, in some cases, to be completely self sterile.*[2]

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*[1] Diallel System.—i.e., many males used on one female or the reverse. In this way one parent is common to many different families, and it may reasonably be assumed that any characters common to all these families were contributed by the common parent. A genetic analysis is thus possible on much slighter material than if any other system were adopted.

*[2] Before planting up a clone in an isolation plot it is always safer though perhaps not strictly necessary to test experimentally its degree of self fertility.

Proved Clones, Unproved Clones, Seedlings (selected and unselected) from proved or unproved Clones.

Planting With Proved Clones.

Planting with one or two clones only.—Our present incomplete knowledge with regard to the behaviour, genetic and otherwise, of all clones renders a policy of planting with one or two clones inadvisable.* The possibilities of disaster are too great. For instance :—

(*a*) No clones can yet be regarded as fully proved. Owing to the possible later development of a defect in one of the selected clones it might be necessary to cut out this clone from the plot. Such an occurrence would have a somewhat overwhelming effect on a plot where only one or two clones had been planted, and would be a serious loss to the company concerned.

(*b*) As we have little knowledge of the genetic behaviour of our clones, we have no guarantee, however carefully we may select them :—

1. that there will be a sufficiently large proportion of high yielders in the progeny to render the planting of such seed an economic proposition.

2. that bad characters, latent in the parent, may not appear in the progeny.

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* Certain Avros clones might reasonably, in view of the work of Heusser, be planted by themselves, or in company with one other clone.

It may be the policy of the geneticist to follow a programme of self and cross fertilisation with the object of finding one or two clones of a sufficiently good genetic type to plant in an isolation plot. It would however, be hasty and ill advised for a company desiring to use the seed commercially to plant only one or two clones until their genetic behaviour has been proved by experiment.

Planting with several Clones.—Though the same arguments may be used against this method as against planting with one or two clones it is hardly likely that all the possible parental combinations will be bad. Should one of the clones develop undesirably and have to be cut out, the effect on the plot would not be so overwhelming as in cases where only one or two clones are planted. The more clones one can plant, without lowering the average yield, the more likely one is to get all possible good characters represented in the plot.

Planting with unproved Buddings.

As everyone knows, not every high yielder can be regarded as a genetic high yielder i.e., capable of giving a clone of high yielding buddings. Consequently planting with unproved material almost certainly lowers the standard by introducing genetic low yielders into the plot, the very result which an isolation policy is calculated to avoid. And, if it be true that the poorest yielders are often the highest seeders, the progeny may be poor indeed.

(2) To make any attempt at a genetic analysis or even to draw any useful conclusions a large number of seedlings would be required.

(3) Only a low proportion of high yielders may occur in the progeny of the clone selected, since this clone may be heterozygous for most of the genetic factors advantageously influencing yield.

(4) The selected type may be heterozygous for bad characters either directly concerned with yield, or for others economically disadvantageous, such as empty or imperfect seeds and white or yellow seedlings.

Cross fertilisation :—

(1) Since *Hevea* is usually more cross than self fertile it is easier by this method for the plant breeder to obtain in any one year more material on which to base his conclusions.

(2) If a series of diallel crosses is made, genetic conclusions can be drawn from smaller families, and hence a large number of combinations can be attempted in one year.

(3) By careful selection of the parent types much may be done to ensure that, in at least some respects, they are complementary, and the number of desirable types in the progeny is thus appreciably raised.

(4) It is unlikely that the clones selected for crossing will be heterozygous for all the same bad characters. Thus there will be an elimi-

nation of some out of all the possible bad types from the progeny.

We cannot determine (in our present state of knowledge) by observation alone whether a clone is likely to be heterozygous for many or few of the factors affecting high yield. A selfing programme is therefore always a gamble in which one endeavours to reduce the risks by attempting to self a great variety of clones. We can however by observation select clones which are complementary in at least some respects, and, if these clones are crossed, the possibility of disappointing results is somewhat reduced. If this careful selection of parents be practised the desired result—a good strain of seed—should be arrived at more quickly.

A policy of cross fertilisation is therefore more promising, and where shortage of money or land exercises too strong a limiting influence it is better to concentrate on this alone.

Present Policy.—While awaiting the results from hand pollination, isolation plots and seed gardens might be planted, to provide for present needs, with material the behaviour of whose progeny is unknown. The material itself should in this event be carefully selected.

The Planting of Isolation Plots.

The planting material* at present used or suggested by various authorities includes the following :—

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* It is perhaps unnecessary to mention that some at least of the material planted should show a fair degree of fertility.

Seedlings.

Seed from Proved Buddings.*—A retrograde step —segregation will have occurred, and part, at least, of the material will be genetically low yielding.

Even if selection is practised in the plot, and the poorer yielders are cut out, there is no assurance that the high yielders left can be regarded as proved genetic high yielders in the same sense as members of a proved clone.

Discussion of Methods of Planting and Recommendations.

Except for experimental purposes the planting up of seedlings or unproved buddings in an isolation plot is definitely not recommended. The planting of one or two clones unsupported by evidence based on the results of previous crosses (by hand pollination) is a mere shot in the dark. It may be successful, or it may not, and the plot have to be cut out and replanted or rebudded. If the combination selected is unsuccessful it will be some time before this is discovered, and time and money will be lost. Until experimental evidence is available, the best method seems to be to play for safety, and without lowering the average yield, to plant up as many clones as possible in an isolation plot, proceeding meanwhile with hand pollination work to discover the best single clone, or combination of clones, for planting.

* The same arguments apply to seed obtained from unproved buddings, except that in this case the seedlings may be of lower quality.

The advantages of this method are as follows :—

1. It may be some years before a good single clone or combination of clones is discovered. Meanwhile the plot is profitably occupied.
2. By planting many clones it is possible that the clone or clones finally selected on the basis of results from hand pollination will be already represented in the plot, and of seed bearing age. Clones not desired being pollarded, and their stumps rebudded if possible, the plot will never be completely out of commission as far as seed production goes—a saving of $2\frac{1}{2}$ to 4 years.
3. The eventual planting of the isolation plot depends not on guess-work but is based on experimental evidence.

For estates not intending to undertake hand pollination the planting of several clones is recommended. A large number is preferred, as the presence of many clones in the plot lends a certain plasticity to the material. By pollarding one, two or more clones in different years, and observing the yield of the seedlings produced, experiments may be made with a view to discovering the best parental combinations available in the material originally planted.

Isolation Distance.

Hevea is almost certainly insect pollinated. In Malaysia the insects noted as visiting the flowers of *Hevea* include the following :—

Syntoriets	Thelephorus
Nitidulidae	Flies

Seedlings.

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Nitidulidae	Flies

Phlacridae	Ants
Curculiondae	Small Bees
Mordellidae	Male Mosquitos

Isolation distance depends on the flighting distance and habits of the insects responsible for pollination. On this subject entomologists can at present give very little information. We have assumed that 2 to 3 miles is an adequate isolation distance. Since isolation is not necessarily a matter of distance alone, but depends also on other factors, such as the nature of the intervening barrier, and the direction of the prevailing winds, if any ; we have assumed that, if heavy jungle provides the isolation belt, shorter distances are probably effective.

The isolation distances suggested here are probably sufficient for accurate scientific purposes. Shorter isolation distances, though not providing that degree of certainty necessary to the scientist, are probably no less effective commercially. Probably many are familiar with the very small isolation distances accorded to their crops by some seedsmen in England. Only a very small proportion of rogues result from the use of these short distances, though, of course, for scientific accuracy; this isolation is not nearly sufficient.

It is still a moot point as to what is the economic isolation distance* for Rubber, as it is unknown how rapidly the percentage of rogues increases with a decrease in the isolation distance. We believe however,

* i.e. not necessarily the distance which ensures complete isolation but that which ensures that rogues, if present, are but a small percentage of the whole.

that the increase would be slight and that, even if the garden were adjacent to an ordinary rubber estate, 90-95% of the seed collected from its centre would, provided the garden were of sufficient size, be of the desired type.

A Discussion of the Grades of Seed Now Available.

An endeavour has been made to grade this seed in order of merit. The classification is based on the probability of both or even only one parent being a genetic high yielder. It is not claimed that the classification is accurate and that seedlings from grade 6 will necessarily be worse than those of grade 1, it is merely claimed that the odds are in favour of the higher grades being better than the lower. That is, over a large number of purchases, seed of the higher grades should be more uniform and probably of a higher average yield than that of grade 6. This grading is not intended to be detailed: it would of course be possible to subdivide the grades many times.

Class A. Seed from Proved Clones in isolation plot.

Grade 1. Seed from a plot containing one, two, or even more clones, the seedlings from which have been proved to be good.

Grade 2. Seed from a plot containing a high yielding clone or clones the behaviour of whose seedlings is unknown.

Class B. Seed from Proved high yielding Clones (or trees*) not isolated.

Grade 3. Seed from a high yielding clone in an area where there are no genetic low yielders (i.e. all are proved good clones.)

Grade 4. Seed from a high yielding clone in a high yielding area.

Grade 5. Seed from a high yielding clone. (yield of area unspecified).

Class C. Seed from Unproved Trees or Clones.

Grade 6.

(*a*) Seed from a high yielder in an area where there are no low yielders.

(*b*) Seed from a high yielder in a high yielding area.

(*c*) Seed from a high yielder.

(*d*) Seed from a high yielding area.

NOTES ON THE GRADES.

Grade 1. If proved good combinations of clones have been used it should also be known :—

a. that the clones are self sterile or nearly so

or *b*. that the progeny raised by self fertilising them is reasonably good.

* Proved Trees i.e. the bud parents of proved good clones. Seed from such trees is as good as that from the proved clone to which they gave rise providing they are growing in an equally good area.

Grade 2. Seed from plots where several clones are planted is probably the safer investment.

Grade 3. Should the area be sufficiently large, and the seed from the centre only be collected for use, this grade is probably as good as grade 2. A protective belt of say a chain in width should be left uncollected. This protective or isolating belt might be composed of sterile or nearly sterile high yielders.

Seedling Selection by Vegetative Means.

Endeavours to select the better types by observations made on the young seedling (of about 1 year old), whatever may be their degree of accuracy (or lack of it), are probably impracticable on the large scale required in practical planting.

They either assume that plants that are poor yielders when only one year old will remain so, or that that very complex character, yield, is correlated with one vegetative character only. Further their practice would usually be very expensive.

A variety of them are, or have been, in use experimentally and will be briefly described. The majority may be grouped as follows :—

1. Those depending on pricking or making incisions in the young tree and an estimation of the latex or rubber produced.

(*a*) depending on one or more series of cuts only, such as that evolved, we are informed, by Dr. Cramer.

(*b*) The Prang Besar Test—An endeavour to estimate both the reservoir capacity and the ability of the young plant to regenerate latex. The young plant is ringed by a sharp knife in 3 places (the cuts being say $1\frac{1}{2}''$—$2''$ apart and the amount of rubber exuded estimated. In the spaces between these cuts, further cuts are made at regular intervals to estimate the extent of regeneration of latex in the isolated strips of bark.

2. Those depending on the inspection of some anatomical character: Take as an example Mr. Ashplant's Nursery Test (which it is claimed is the most reliable of all). Mr. Ashplant claims that

(1) Latex tube bore is the most important character affecting yield, (though the number of latex rings is also important).

(2) that physiological characters affecting yield are unimportant.

The question of (1) attaching so much importance to one or two anatomical characters only, as the determinants of so complex a thing as yield (2) declining to attach any importance to physiological characters such as the activity of the protoplasm in regenerating latex is open to argument, (the second claim is in fact very debatable).

All these nursery tests suffer from disadvantages viz:—

1. If they rely on the yield of rubber from the young seedling :—

   a. This seems to be affected by the vegetative condition of the young plant.

   b. A good yielder at 10 months old, though not perhaps a poor yielder at 4-6 years old, is not necessarily in the first class.

2. If they rely on anatomical characters they generally rely on one only and ignore others equally likely to affect yield.

Nursery Tests, however, usually fail on the question of cost alone. For instance, a set of comparative costs for budding with proved clones, and planting seedlings Nursery-selected by the Ashplant method are given below, the cost of budgrafting set off against the cost of making the Nursery Test.

Costs.—The relative costs, if we adopt Mr. Ashplant's figure of 180 trees per acre for his seedlings, and for proved buddings the figure of 150 trees per acre, recommended by Sumatran experimental stations, would appear to be as follows.

BUDGRAFTING.

100 acre clearing to plant with proved buddings at 150 to the acre :—

Seeds required :—30,000 (to allow for failures and poor growth)

Size of Nursery 2′ x 1′ planting, 1½ acres.

Seeds at $5/- per 1000	$150.00
Budwood at 10 successful buds per yd. to give 15,000 plants. 1,500 yds. at $2/- per yd.	$3,000.00

or if the budwood is used for multiplication when a 20-fold increase is obtained :—75 yds. at $2/- per yd. $150.00

Thus the cost varies from $3/- per acre to $31.50 per acre depending upon whether the budwood is multiplied or not. The value of the wood available in future years from the multiplication bed more than offsets the cost of making and upkeeping the bed.

Mr. Ashplant's Method.

100 acre clearing to plant with seedlings selected by the Nursery Test at 180 per acre, 18,000 plants required.

The number of seeds required will vary according to the rigour of the selection,* and according to the quality of seeds used :—

Number of Seedlings selected.	Seeds required.	Price of Seed.		
		$5 per 1000	$10 per 1000	$15 per 1000
1%	1,800,000	$9,000	$18,000	$27,000
2%	900,000	$4,500	$ 9,000	$13,500
5%	360,000	$1,800	$ 3,600	$ 5,400
10%	180,000	$ 900	$ 1,800	$ 2,700
15%	120,000	$ 600	$ 1,200	$ 1,800

* Grantham for instance (in a large test over 4,500,000 seed trees, which had already been subjected to thinning out on the basis of yield) showed that only 0.73% of seedlings were equal in yield to a good clone.

The size of the Nursery required (planting 1′ x 1′) will vary from 43 acres to 3 acres according to the severity of the selection to be practised.

Considering these figures we find that buddings can be planted for $3/- per acre, for which one gets material which is as far as possible proved with regard to disease and wind resistance, growth, and bark renewal, as well as yield. If the material were selected by means of Ashplant's nursery test the clearing would cost at least $6/- per acre to plant (on the basis of the Table given on p. 84) and, if we are to aim at getting material comparable with buddings, would cost $90/- per acre. For this one obtains material selected for yield on the basis of one character, and unproved with regard to wind and disease resistance, growth and bark renewal.

CHAPTER XII.

Selection of Stock.

In other crops, such as apples, the effect of stock on scion has been amply demonstrated. By means of vegetative propagation several good uniform types of stock with dissimilar attributes have been established. For instance East Malling Stock 9 has a dwarfing effect and causes early fruiting. East Malling Stock 15 induces vigorous growth and late fruiting.

Little definite experimental evidence as to the effect of stock on scion is available in *Hevea*, nor has much work been done with the object of obtaining uniform stocks. The probable effects of stock on scion in *Hevea* may be grouped under the following heads :—

1. *Yield.*—Apart from a falling off in yield near the union of stock and scion, first recorded by Grantham and common to most but not all clones, little direct effect of the stock on the yield of the scion is suggested by observation up to the present. Provided trees of similar size only are considered, clones may be observed in which the yield is comparatively uniform, though the individuals comprising the clone are budded on a multitude of different stocks.

2. *Vigour.*—There is no conclusive evidence that the stock affects the vigour and growth of the scion in *Hevea*. Field observations and analogy with other crops however suggest that such is the case, and it is now generally believed to be so. If this belief be accepted as correct, vigour is obviously the most important factor in the stock. A vigorous stock implies

a large active root system, that is good anchorage, a good feeding mechanism and hence probably increased growth and length of tapping cut, and therefore increased yield in the scion.

3. *Resistance to Root Diseases.*—If a stock resistant to or immune from root diseases can be obtained the reduction of the stand per acre of good buddings by loss from *Fomes* or similar causes can be greatly decreased.

4. *Incompatibility of Stock and Scion.*—Cases of this have occured in other crops such as pears, plums and peaches. The young pear, plum or cherry tree grafted on to an incompatible stock lives for two or three years and then fails. In *Hevea* there is in our opinion little suggestion of such incompatibility. There are, it is true, rare cases of exaggerated and abnormal elephant foot. Further there are on Prang Besar two clones which, though making fine vigorous growth, yield little if any latex—the majority of the individuals of these two clones being in fact quite dry. Presumably the wood from which these trees were budded was taken from a high yielder. They have however not yet been re-identified with their mother trees and their origin is too uncertain to draw any conclusions.

Propagation of Stock.—With the development of budgrafting, the selection of good uniform stocks becomes increasingly important. There are two methods by means of which such good uniform stock can be obtained :—

1. *Vegetative Propagation of suitable types.*—This method has been very successful in the case of

other crops such as apples. Unfortunately attempts to propagate *Hevea* by means of marcotting, layerings, or cuttings, have not given very promising results. It will be of interest, however, to consider the various attempts to propagate stocks vegetatively, since even small scale experiments on vegetatively propagated uniform stock would provide most interesting data and material on which future stock selection experiments could be based :—

Methods of Inducing Rooting.

(a) *Buddings.*—If Clones could be easily rooted they would provide ideal material for experiment since their vegetative behaviour is known and proved. Clones, even young multiplication wood, are very difficult to root. A variety of methods have been tried :—

Marcotting of various types—This has been unsuccessful on Prang Besar. Experiments in Sumatra however resulted in a few successes. There is some evidence to show that clones vary in rooting power.

Cuttings.—This proved completely unsuccessful on Prang Besar over a large trial with several clones.

(b) *Seedlings.*—Attempts to root clones having been unsuccessful, recourse was had to seedlings. The main stem of a young seedling may be easily induced to root (there is apparently some difficulty in inducing branches to root). The seedling stem may be induced to root as a cutting or as a marcot. The actual method resorted to on Prang Besar to produce a small number of uniform stocks is as follows :—

Several young seedlings differing in vigour were selected in the Nursery. The selected seedlings were marcotted about 6 inches above the ground level. When roots had been produced the marcot and its parent stump were transplanted. Later the marcot when established was remarcotted and the process continued. Thus by repeated marcotting a limited supply of uniform stock may be obtained.

Seed Selection for Stocks.—Vegetative propagation of stocks provides interesting information for future experiments. It is improbable however that the vegetative propagation of stocks will ever become practicable in *Hevea* :—

(*a*) Owing to the length of time required to produce a sufficient number of stocks.

(*b*) Because the root system so produced may be inadequate.

The production of good stocks in *Hevea* will probably devolve ultimately on the plant breeder, who will be required to select strains of seed comparatively uniform in characters such as vigour and resistance to or immunity from root disease.

Present Policy.—For the moment the best that can be done is to bud the most vigorous plants in the nursery. If budding be done in the field it is advisable to plant three plants to a hole and bud the most vigorous only. In the event of two vigorous plants occurring in one hole both could be budded and one used as a supply if supplying be necessary.

Future Policy.—It is suggested that in future estates might themselves experiment with a view to selecting the most generally suitable stock for their soils, or that most suitable to any particular clone they intend to plant.

The type of experiment proposed would be on the following lines. Clones notable for their vigour, or better still clones whose seedlings are uniformly vigorous, and, if possible, resistant to root disease, would be selected. Where a variety of clones suitable to provide seed for stock exists, it might be safer to give preference to the higher yielders. The use of clone seed rather than that from single trees is suggested for the following reasons :—

(*a*) A large supply of the seed is, and probably always will be, available.

(*b*) The clone is already proved for one of the characters—vigour—which one desires. Its seedlings therefore are more likely to be vigorous than those from a single unproved tree whose vigour may be a mere fluctuation due to environment.

Seedlings from the clones selected are then planted out in the clearing in sufficient numbers to ensure that a hundred or more buddings of each clone used are budded on each batch of clone seedlings. Thus each batch of clone seedlings provides stock for every clone used, and the more generally useful one may be determined and used for future plantings.

As a further experiment it has also been suggested that if a clone be budded on to its own seedlings there will be a larger number of cases of harmony between stock and scion than would otherwise be the case.

APPENDIX I.

The Identification of Clones.

When the clearing has been properly planted it should be unnecessary to have to re-identify the individuals of the clones planted. As errors are likely to creep in, particularly when a somewhat complicated planting programme is adopted, it is as well to consider methods of checking results.

The Nature of Clones.

A clone is obtained by propagating vegetatively from one tree. A clone may therefore be regarded as a somewhat widely distributed single tree. Each of its members, being part of a single tree, will be identical genetically* and as similar vegetatively* as the differing environment of the various members will allow.

The environment does not vary sufficiently under ordinary conditions, to cause marked fluctuations in vegetative characters. All members of the clone will therefore be very similar vegetatively and may be picked out by habit, bark, bud, leaf, latex and seed characters etc.

To be absolutely safe one should check classification of the particular tree concerned by several of the characters mentioned; but for all practical purposes identification by seed characters alone is almost invariably sufficient.

* In the rare eventuality of bud variation or of chimerical growth this statement no longer applies.

APPENDIX II.

THE REJUVENATION OF OLD AREAS.

Many old Estates will now find part of their acreage nearly or quite uneconomic. This state of affairs may be due to a variety of causes :—

1. Poor material being used for the original planting.
2. Heavy tapping systems.
3. Bad cultivation—allowing soil erosion, and retaining too high a stand per acre etc.
4. The incidence of disease.

Owing to the high yields to be expected in future from proved budgrafts it behoves every company to consider the policy of rejuvenation as soon as possible.

Until further experience is available it is suggested that :—

1. The rejuvenation be gradual.
2. The poorest yielding areas be the first to be sacrificed.
3. Only proved good buddings be used for replanting.

The area rejuvenated should then have its standard of yield appreciably raised, and be in a position to compete with others planted on modern lines.

Dr. De Jong in the Archief for February 1928 discusses this subject and mentions two methods of dealing with unsatisfactory old areas :—

1. Complete felling, clearing and replanting—This gives an even clearing, as all the area finally consists of plants of the same or nearly the same age.
2. Thinning out all the poorer trees and replanting in the gaps so caused. Sometimes as few as 9 old trees per acre are left.

This method has its advantages since the yield of the old trees remaining in the thinned out area is vastly increased, as much as 40—60% of the yield formerly obtained from the whole area being harvested. This yield helps to pay for the work of replanting; while, if very few old trees, say 8—12 only, are retained, the newly planted young trees are not greatly inhibited in growth by overshadowing.

Whichever method of rejuvenation is practised, proved buddings (the best yielding material now available) should be used to replant the area. Where the the method 2 is practised, enquiry at the estate or Research Station selling budwood will probably elicit the information that specially suitable shade-bearing clones are available.*

It must be emphasised that any replanting programme involves expensive cultivation. All roots of felled trees should be removed: to ensure that this is done as thoroughly as possible the soil should be changkolled to a depth of 3 ft. It will probably be necessary to manure the area to be replanted: where

* P.B. 25 is for instance a better shade bearer than the other good Prang Besar Clones, preserving its usual erect habit even under somewhat dense shade.

available, cattle-dung should be used. If dung is not available, advice as to the manure to be used should be sought from soil experts.

The young trees supplied in replanting should not be planted on a site previously occupied by an old tree. It is advisable to enclose an area 16 feet square round the young tree by a trench about 2 feet deep—this has advantages both from the point of view of disease prevention and in preventing a certain amount of root competition from adjacent old trees.

APPENDIX III.

Showing Liquid Yields in Terms of Dry Rubber (Approx.)

100 C.Cs. of Latex gives Approximately 33 Grammes Dry Rubber

C.Cs.	Liquid ozs.	Grammes of Rubber.	Oz. Avoirdupois.	Lbs. per year @ 160 Tappings.
50	1.76	17	.60	6
60	2.11	20	.70	7
70	2.5	23	.81	8
80	2.8	27	.95	9½
90	3.2	30	1.06	10½
100	3.5	33	1.16	11½
110	3.9	37	1.3	13
120	4.2	40	1.4	14
130	4.6	43	1.5	15
140	4.9	47	1.66	16½
150	5.3	50	1.76	17½
200	7.0	67	2.36	23½
300	10.56	100	3.5	35
400	14.08	133	4.691	47
500	17.6	167	5.89	59
600	21.12	200	7.05	70½