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**A GUIDE TO THE BUD-GRAFTING OF RUBBER IN
PAPUA AND NEW GUINEA**

A. HIMSON *

THE production of high yielding strains of plants or animals is usually brought about by selection with or without preliminary cross-breeding. The importance of natural rubber from the rubber tree *Hevea brasiliensis* is very great in spite of its relatively late appearance in the world as a major economic crop, and a great deal of investigation and experimental work have been carried out with this crop. The results have been most encouraging. It is an established fact that trees from clonal seed or bud-grafts can yield several times as much rubber as unselected seedlings.

Early investigators proved that relatively few rubber trees were responsible for the bulk of production in seedling stands. The property of high yield is most easily fixed by asexual or vegetative propagation which permits the production of an unlimited number of individuals with exactly the same characteristics as the parent plant. Vegetative propagation can be carried out by means of cuttings, layers, runners, buddings, and other means. With rubber, budding has proved to be the most satisfactory method of propagation. Had the earliest clonal selections been entirely satisfactory, no further investigation would have been necessary and the planter would need only to propagate vegetatively from such selections indefinitely. Such a situation has occurred with many varieties of fruit trees which are still as much in demand as the first buddings made centuries ago. However, geneticists assumed that by permitting crosses to occur freely between high yielding trees or by hand pollination of high yielding clones (a clone is the vegetative progeny of one parent plant), still better material might be obtained. This has proved to be the case with rubber, and some new clones pro-

duced by selective hand pollination have given early yields in small scale trials up to about 2,000 lb. of dry rubber per acre. The average annual yield of mature rubber in the Territory is just under 400 lb. per acre. All trees have originated from unselected seed or at least from seed from uncertain sources.

This article has been compiled as a guide to the bud-grafting of rubber. There can be no doubt that the planting of budded stumps entails a certain amount of extra work and care when compared with the use of either unselected or clonal seed. These facts must be faced and balanced against the ultimate benefit to be derived from bud-grafting before a planter can estimate whether it is worth his while to overcome the obstacles to planting say 100 or more acres of bud-grafts per year. Planting on a much larger scale than this has been carried out in all major rubber producing countries since the war, and more recently in West Africa. Bud-grafting has been adopted not only by some of the biggest estates, but also by small holders. The theory that bud-grafting is not practical in this Territory cannot be supported as it

* Officer-in-Charge, Rubber Section, Department of Agriculture, Stock and Fisheries, Bisianumu.

would infer not only ineptitude on the part of the indigenous population to learn the necessary techniques, but also of the management to handle the problems associated with the use of bud-grafts.

This article is a summary of experience gained at Bisianumu over a period of three years and should be of assistance to planters, although no guide can make up for experience. Little that is written here deals with original techniques and much is owed to the experience of workers overseas.

The Principles of Bud-Grafting.

A small patch of bark with a dormant bud in the centre is removed from a tree with high yield and other desirable characteristics. At the same time a vigorous seedling between one and two years of age is prepared by peeling off a patch of bark similar in size to the bud patch. The bud patch is then inserted on the seedling stock in such a way as to secure a permanent living union. Quick and careful manipulation is essential to minimize damage to the active cells on the exposed part of the bud patch and stock. If much damage is done to these cells, the operation will be a failure and the bud patch will die, but when successful, the unharmed cells divide and form a perfect union. After the bud has taken it is necessary to ensure that no other bud from the stock is allowed to develop. In this way the new tree has all the characteristics of, and is genetically identical with, the one from which the bud patch was chosen. A detailed description of the preparations for budding, each step of the budding process and the necessary after care will now follow.

1. Preparation of Seed Beds.—

Budding may take place either in nurseries or in the field. Budding in the nursery will be dealt with first, although much of what is said will apply equally to budding at stake in the field.

The first step for nursery budding is the preparation of seed beds at least twelve months before budding is to commence. A level site is desirable and a small alluvial flat which is handy to water but not liable to flooding or waterlogging is most suitable. Seed beds are dug to the usual depth of 2½ feet to 3 feet. Shade should be provided at a height of about 3 feet and the usual type of shade is a rough wooden framework

covered with kunai grass. Seeds should be planted about 12 inches apart in rows 2 feet apart. It is advisable to plant two or three seeds at each point and rogue later to the most vigorous seedling. Roguing is best carried out just after the removal of the shade. When the shade is removed it is very desirable that the kunai grass be spread as a mulch between the seedlings, a practice which is indubitably beneficial to their growth. A rather wide spacing when compared with spacing in ordinary seed beds is necessary to allow the operator to work efficiently when bud-grafting is performed, and it also makes for more vigorous and healthy stock from which the bark will peel more readily.

The width and length of beds is a matter of convenience, although it is probably desirable to have not more than four rows in one bed for ease of working. The total area of beds, of course, depends on the area of bud-grafts which it is intended to plant in the field. The nursery should contain at least twice as many seedlings as it is intended to plant out as bud-grafts into the field, and when the bud-grafters are relatively inexperienced it is probably wise to grow three seedlings for every bud-graft which will eventually be required. It is not necessary to use any special or clonal seed for nursery stock as investigations have indicated the complete suitability of unselected seedlings for this purpose. At about twelve months to fifteen months vigorous stock suitable for budding should be ready provided the beds have been well prepared and the usual rubber nursery practices such as adequate watering and weeding are not neglected. Good stock ready for bud-grafting should be somewhat over 1 inch in diameter at ground-level with a straight unbranched stem, a straight unbranched taproot, about 7 feet or more in height, and in a state of active growth so that the bark will peel easily when it is lifted with the knife.

2. Tools and Materials.—

It is advisable to order tools when seed beds are prepared as most are not available locally, and there is thus some lag before delivery. It is, of course, wise to order more than actual requirements so that losses and breakages will not interfere with progress. For bud-grafting rubber, all that is required is a budding knife and a set of templates.



Fig. 1.—A nursery of seedling stocks ready for budding. [Photo G. Warr.]

One of the templates recommended cuts a standard sized piece of bark from the scion with the bud in the centre, and the other makes a double incision in the bark of the stock which matches exactly the size of the bud piece removed from the scion. Both budding knives and templates may be obtained from Hunter & Co., P.O. Box 214, Colombo, Ceylon. Budding knife 1131 costs approximately £1, and the pair of templates approximately 10s. per set. Other tools which may be required are sharp kitchen or pocket knives, pruning saws, labels, tree sealing compounds and a pair of secateurs. Bagging twine is a satisfactory tying material and is available in hanks at about 4s. each. At least six dozen hanks should be ordered if serious budding on any scale is intended.

Calico strips specially prepared by dipping in a mixture of molten paraffin wax, resin and tallow were previously used almost universally as a tying medium. This tying medium is not only tedious to prepare and expensive, but has been found to be less successful than the cheap and simple method using coconut fronds which will be described later. Coconut fronds are available almost everywhere in the Territory where rubber is grown, and a fresh frond will be required every day or two when budding on any scale is attempted although a frond remains

fresh enough for use for about one week after cutting. 1 inch masking tape used in conjunction with coconut fronds has boosted the percentage of takes somewhat, but the expense is probably justified only when using expensive imported budwood.

3. Budwood.—

Budwood should be obtained when the seedling stocks are ready. The sources of suitable budwood are restricted and the type should be carefully chosen. The taking of budwood from a local tree which seems to be high yielding is unsound. The slight possibility of selecting a superior clone cannot be denied, but it is most unlikely that a chance selection would be the equal of the commercial clones evolved by major rubber producing countries over a considerable number of years. The major rubber producing countries have rubber research institutes with highly trained staff with long experience, and there are also very large private firms in Malaya and elsewhere which are engaged in the production of superior clones. There are at present more than a dozen clones which are recommended for planting out on a moderate or large scale. The distribution of some clones is likely to be restricted, a kind of patent being held on these clones by their producers. There are,

however, a few free clones available which are worth establishing on plantations as well as certain restricted clones. A few good clones were introduced into the Territory before the Department began work at Bisianumu, but in some cases the subsequent history of these clones is uncertain and their identity doubtful. Accordingly the Department has in recent years reintroduced all the older clones and a wide range of new material. Budwood may be purchased from overseas, but the Department of Agriculture, Stock and Fisheries is now in a position to supply limited quantities of budwood from Bisianumu. Twenty yards of budwood should make a good nucleus for working up a multiplication area from which budwood can be cut in due course for large scale budding. With some of the most expensive new clones just one or two yards is sufficient to establish the clone and multiply it in the plantation nurseries.

Good budwood should be not less than 1 inch and not more than 2 inches in diameter. It should have at least fifteen well spaced buds per yard and should be of a rusty brown colour. The bark should strip easily. It is essential that the budwood be sufficiently mature to have developed a brown or greyish colour if it is not to be used immediately. If cut from the multiplication nursery on a plantation for immediate local use, it can be cut two days in advance without fear of deterioration. Green budwood can be satisfactory if it is cut and worked the same day. If budwood is to be despatched for any distance the ends should be dipped in paraffin wax to prevent deterioration or decay. Budwood which is to be sent away is best packed in some insulating material like sawdust, coconut fibre, or hessian, the packing material being slightly moistened. Budwood received from overseas is usually dusted heavily with sulphur to prevent transmission of fungal diseases and it is wise to wipe imported budwood sticks with a moist cloth before use. Care should be taken to wipe in the direction of growth, that is from the thick to the thin end, so as not to injure the buds. Budwood is always sold in sticks one yard long which should be straight and it is the usual practice to enclose an extra yard or two if the budwood does not come up to the specifications mentioned above.

4. Multiplication Beds.—

The best budwood is obtained from multiplication beds or budwood nurseries. It is remarkable how small a quantity of good budwood can be obtained from mature trees and the establishment of a budwood nursery is essential if large scale budding is contemplated. The establishment of multiplication nurseries is also a good way for a beginner to get experience in handling budwood. Another advantage of the establishment of multiplication nurseries is that it is possible to increase the supply of expensive budwood greatly in these nurseries before commencing budding on a large scale for the establishment of a clone in the field.

The site for a permanent budwood nursery should be chosen in the same way as the site for the temporary nursery beds. For permanent budwood nurseries a spacing of 4 feet by 4 feet is recommended with only two rows per bed. Successful buddings can be transplanted from temporary nurseries or alternatively stocks can be budded at stake. Another simple way of establishing the permanent nursery is to leave the right number of buddings in a temporary nursery after the rest have been removed and planted into the field. If more than one clone is being established in a multiplication plot it is desirable to miss a row of trees or make a very distinct mark in some way to prevent possible confusion. Labelling can be carried out but should not be relied upon entirely as tags come off and labels become indecipherable over a period of time. The only certain way to exercise satisfactory control with regard to the nomenclature of clones, date of budding, etc., is to make a careful diagram of the area and keep the records up to date. This is equally important with nurseries, multiplication plots and field plantings.

Good budwood should be available from permanent nurseries about fifteen months after budding, when one or two yards per tree can be expected. If left for eighteen months the quantity should be increased to 2 to 4 yards per tree. The budwood nursery should be regularly inspected and side shoots cut out in order to produce straight sticks of high quality budwood. When cutting budwood from a multiplication tree, the stick should be cut off about 1 foot above the union or what is known



Fig. 2.—A permanent budwood nursery.

[Photo G. Warr.]



Fig. 3.—Cutting a stick of budwood from the permanent budwood nursery.

[Photo G. Warr.]



Fig. 4.—Two new shoots have come away after cutting a stick of budwood from the nursery.

[Photo G. Warr.]

as the "elephants foot". This permits dormant buds to develop on the scion and two or three leaders can be permitted to take the place of the original one. Further care of the tree consists of cutting back from time to time and not allowing more than three shoots of no more than $2\frac{1}{2}$ inches diameter to develop. As from this nursery all budded trees will originate, extra attention should be given to weeding and pest and disease control, and an occasional application of fertiliser is recommended. It should be remembered that the drain of the nursery on nutrients is high because the trees are constantly being cut back.

5. When to Bud-Graft.—

A skilled operator will obtain reasonable success at any time. However, success is naturally greater under good weather conditions. Budding cannot be done successfully in the rain or when the stem of the stock is wet or water is dripping from the leaves. The best time to bud is on an overcast day when the tree is in full sap, the wintering period being best avoided. If a few dry days follow the budding operation and good showers then set in, it is certain that if successes are not as high as expected the weather has not been to blame. In the Sogeri district it has been found that September to February are the best months. The advantage of budding during this period is that the weather will usually be suitable for transplanting the successful buddings. Similar times will apply to most of the rubber areas of the Territory, although local variations may occur. Budding should commence early in the morning, as soon as most of the dew has disappeared. In the nurseries, budding can be continued throughout the day, but field budding should be discontinued in the middle of the day when there is hot sunshine. Naturally when using imported budwood or budwood which has already been cut for several days, work should proceed immediately even if conditions are not entirely suitable.

6. Final Preparations for Budding.—

Before starting to bud the operator should be equipped with a suitable small box in which his equipment is carried. He will need a budding knife, templates, as many coconut frond slips as he is likely to use during the day, and two hanks of bagging

twine. The coconut fronds should be cut into slips about 4 inches long, and a good frond will produce 400 to 500 slips. A budder should also take as much budwood as he is likely to need, and leave it in a convenient shady spot or cover it with branches. Budwood should be carried carefully as it is easily bruised.

7. Making the Incision in the Stock.—

The incision should be made as low on the panel as possible, but not so low that it will be affected by rain and mud splashing from the ground. The best height is usually about 2 to 4 inches from ground-level. In order to mark stock uniformly the appropriate template should be used, especially by beginners. After some experience has been gained, it will be found that the use of the template can be dispensed with, thus speeding up operations slightly. In this case two parallel incisions are made with the budding knife $2\frac{1}{2}$ inches long and about $\frac{1}{4}$ inches to $\frac{3}{8}$ inches apart. A horizontal incision along the top joins the cuts. This process is repeated on as many stocks as can be worked up in about twenty minutes. A beginner is advised to mark no more than four or five stocks in advance. The advantage of



Fig. 5.—The stock prepared for insertion of the bud. [Photo G. Warr.]

marking stocks some distance in advance is that the latex has time to exude and coagulate and is less likely to contaminate the tissues underlying the bark. A speedy operator is not hampered by the flow of latex and can carry out the operation so quickly that the latex has no time to flow or coagulate. After the horizontal cut is made, and the bud patch has been cut, the bone end of the budding knife is inserted and just sufficient leverage is given to free the flap from the stock without breaking it off at the bottom.

8. Choice of the Bud Patch.—

When taking buds from a stick of budwood it is desirable to acquire the habit of working from the upper or thinner end downwards. In this way the younger and softer budwood which will deteriorate more quickly is used first and it is in any case better to work systematically from one end rather than taking buds at random as fewer buds are then lost. The loss of some buds is unavoidable as they are sometimes very closely spaced and an attempt to save all the buds by cutting them out with very small pieces of bark will prove unprofitable. A further advantage of starting from the top end and working down with Native operators is that it helps them to know which is the right way up to insert the bud.

A good bud should be dormant and should therefore not protrude too much when the bud stick is inspected. With expensive or scarce budwood all buds will be used, but if the budwood is plentiful the buds right at the end of the stock, which may be somewhat dried out, can be left. On many sticks of budwood a compact ring of fine horizontal leaf scars will be observed. These are produced when the shoot goes through a resting period or a period of slow growth between flushes. Bud patches taken from this region are quite satisfactory and it often happens that they produce two or three shoots. Sometimes when taking buds it is observed that what appears to be a bud is shown on closer inspection to be only the scar left by a bud which has shot and then dried back; this is quite useless. When the bud patch is removed the inner side should be inspected for bruises which show up much better than on the bark. If bruised, the bud should be discarded. If the bud is broken

off internally, one will find a small pit or hole on the underside of the patch and a point left on the budwood stock. Such a bud is useless. Budwood which has been cut for a lengthy period without being used shows thin dark lines usually commencing from both ends. These are easily observed when the bud patch is lifted out. Little if any success can be anticipated when budwood has reached this stage.

9. Lifting and Inserting the Bud Patch.—

To cut and lift the bud patch the second template of the set is used. It is a rectangular frame with sharp cutting edges and a handle to apply leverage. The tool is applied to the budwood with the bud in the centre of the rectangular frame, the long axis of the frame running along the budwood. Slight pressure is exerted to cut through the bark, and a gentle twisting movement lifts the bud patch. The bud



Fig. 6.—Removal of the bud from the scion with the budding template.

[Photo G. Warr.]

patch is then removed from the template without touching the exposed tissue. The flap on the stock is gently pulled away and the bud inserted without touching the exposed tissue of the stock. Scraping or



Fig. 7.—Inserting the bud patch.
[Photo G. Warr.]



Fig. 8.—Tying. Note slip of coconut frond covering the bud-graft.
[Photo G. Warr.]

touching of the exposed surfaces of either stock or bud will result in certain loss. The same is true if any foreign matter is allowed to contact these surfaces. The flap is then pressed back on to the stock so that it exerts pressure to bring the cambium layer of the bud patch into close contact with the cambium layer of the seedling stock. Again it must be emphasized that the bud must not be allowed to move after it is pressed firmly against the stock. Any movement after this operation will damage the delicate tissues and cause certain loss.

10. Binding and Shading.—

Whilst the flap is held pressed against the stock, three short lengths of 1 inch masking tape can be stuck over the wound. It is advisable to start just over the horizontal cut so that everything is fixed firmly in position and then attach the other two strips slightly overlapping each other and coming half-way around the girth of the stock. The use of masking tape is not essential but at Bisianumu it has always boosted takes by a few per cent. If stock and budwood are in abundant supply, tape will be dispensed with as extra speed and lower cost



Fig. 9.—Shading the finished bud-graft with leaves.
[Photo G. Warr.]

will compensate for a small reduction in takes. The next step or the first step if masking tape is not used, is to press a coconut frond strip over the wound, the central vein of the frond facing outwards and running vertically up and down the stock. A length of twine is then wound around it as tightly as possible. The best method is to start from the top holding one end of the twine behind the stock, make a loop round the stock to fix the end firmly, run a few coils down to the lower end of the coconut slip, then run a few loops back to the top and tie firmly to ensure that water dripping down the stem cannot enter. Two or three rubber leaves tied on with string so attached as to shade the bud patch complete the operation.

11. Opening up and Inspection.—

After budding is completed plants are left undisturbed for seventeen to twenty-one days. If the weather during this period is dry it is best to wait the full twenty-one days, but if more than 2 inches of rain have fallen since budding was carried out, it is better to open up a few days earlier. The binding material is removed and the bone end of the budding knife inserted between the flap and the bud patch and the flap prised away and broken off so as to expose the complete bud patch. At this stage all writers on the subject recommend that the bud patch be scratched to find out whether it is still green. Although it is certainly true that patches which are already dead can be written off, not all bud patches which are still green can be counted as successful takes. Under favourable climatic conditions many of the bud patches will appear to be in good condition to any but the experienced observer, only to die off later. There thus seems to be no real advantage in this initial scratching and inspection and there are some disadvantages. It is recommended that the bud-grafters be trained when opening up to use the spatula of the budding knife with great care, inserting it gently and to the minimum extent which is necessary to open up properly, in order to prevent any damage to the bud patch. They can then go round ten days later to make the final inspection, which is necessary in any case whether the first inspection is made or not. Ten days is the minimum period which must elapse before the final inspection and a few

extra days make no difference. It is most advisable that the final inspection be carried out by the person in charge of operations and not by the men bud-grafting, especially if it is intended to give bonuses for successful takes. Thousands of grafts can be inspected within a few hours if budding has been carried out in a nursery, and it is obviously worthwhile to undertake the small amount of work involved in order to minimize the risk of planting failures into the field or alternatively overlooking takes. The inspection is carried out by making two slight scratches with the point of the budding knife, one above and one below the bud. If they are clearly green all is well. If the bud has not taken, it may be very obvious when for instance the bud has fallen off, but sometimes the brownish discoloration of the bud patch when scratched is the only indication of failure. Even at this stage there may be doubtful cases. The scratch at the top may be perfectly green whilst the bottom is decayed or vice versa. Fortunately the portion of the bud patch surrounding the bud is always slightly thicker than the rest of the patch and is thus held in firmer contact with the stock and is therefore more liable to take. In cases where there is only partial discoloration of the patch it should be scratched carefully near the bud which will frequently be found to be alive.

12. Re-budding.—

After about two months, during which time successfully budded stumps should be removed and transplanted, failures and those seedlings which were not quite ready during the first round of budding can be done again. In the case of failures the incision should now be made on the opposite side either just above or just below the old wound. It is not worthwhile re-budding again any stock which has had two failures, as the trees have then reached the stage where they are likely to lose vigour or become infected with rotting organisms because of the damage. Such trees should be thrown away.

Stock, of course, becomes progressively larger when re-budding and a few remarks about larger stock are thus worthwhile. Larger stock very often gives just as many successful takes as stock of the optimum size. It may even get away more quickly

when properly transplanted as it has more reserves to draw upon, but the real drawback with large stock is the additional work involved in pulling and planting out.

13. The After Care of Bud-grafts.—

Sooner or later the stock must be cut back to a stump. When budding is done in the field or stumped buddings are to be produced in the nursery, it is practicable to have one man doing the stumping at the same time as the final inspection is carried out. Cutting back should not be delayed more than two months after budding as the continuous physiological changes in the stock over a longer period gradually impair the effectiveness of the bud. The cut should be started 4 inches to 6 inches above the graft and sloping downwards to the side of the stock away from the graft so that rain or latex do not run on to the bud graft. A pruning saw is recommended for this purpose and a dressing to prevent the entrance of wood rotting fungi may be applied. After cutting back, the bud should begin to shoot, although some buds remain dormant for a lengthy period. A monthly patrol to cut off unwanted shoots developing from dormant buds on the stock is essential. This work can be left to budding operators who should by this time understand the object of the operation. The stems developing from buds usually show a slightly greater tendency than seedling stock to develop branches. The side branches should be cut off in the green stage. As mentioned previously, some bud patches contain more than one bud and when several shoots emerge, the most vigorous should be chosen and the remainder carefully removed while still young.

After a year of two, the snags, that is the dry dead stumps above the union, will fall or break off. Sometimes it takes longer and for the sake of appearance the operator may, if he desires, cut off remaining snags with a pruning saw immediately above the union, the cut being made on the same slope as when cutting back to stump the previous year.

14. Transplanting.—

Transplanting of budded material can be done either as budded stumps or stumped buddings. The obvious confusion

which can occur on account of this nomenclature is unfortunate, but the terms are thoroughly established in the literature. A budded stump is a budded stock on which the bud-graft is still dormant and which is planted out within a relatively short time after inspection. A stumped budding is a budded stock which has been cut back in the nursery and there has undergone the necessary after care and is ready for transplanting about a year later. The advantages of planting stumped buddings are that they do not require much after care and can generally be treated like any rather advanced transplanted seedling. The disadvantage is the added difficulty and expense of handling stumped buddings when compared with budded stumps as the former have developed a strong root system, they are harder to pull, and planting holes must be larger. Before planting out, stumped buddings are treated in the same way as seedlings, that is all but a few inches of the green part of the plant is entirely removed. It is a good practice to keep a few buddings in the nursery to plant up any misses in a field planted with budded stumps. The supplies are then of the same age as the initial plantings and do not suffer the same set-back as would new budded stumps.

Budded stumps can be planted out in two ways, but only the second method which will be described in really recommended. The first method is to cut the stock back above the bud, in the way described in the paragraph on after care of bud-grafts, immediately after inspection and plant out within ten days. With careful transplanting this method undoubtedly works and when budded stumps are to be sent to plantations some distance away, they should be despatched in this manner because of the saving in freight. The second method which is generally recommended is to prepare the budded stumps when weather conditions are favourable in the same way as seedling stumps; that is cut them back close to the woody part of the stock at a height which will usually vary between 4 feet and 7 feet above the ground and endeavour to plant them out within ten days. When the stock begins to sprout it is apparent that transplanting has been successful. The stock may then be cut back to stump in the field and after care is the same as previously described. This second

method of planting out has advantages when compared with the first, namely:—

- (a) Should unfavourable weather conditions or other circumstances prevent immediate planting, no great harm is done as stock can be trimmed back again after commencing to shoot. If the first method is adopted the stump must either be planted immediately or left for another year to develop into a stumped budding.
- (b) Handling when planting out is easier.
- (c) Losses on transplanting can be detected at a glance which is not the case with short stumps.

When a surplus of budded stumps exists after the intended acreage is planted, they should be cut to stump in the nursery and left to grow into stumped buddings, when they will come in handy for replanting misses.

When transplanting from the nursery into the field, no notice should be taken of the height of the bud-graft or the union. It is of no importance at all that height should be entirely uniform, and trees must be planted at the same level as they stood in the nursery with the whorl of lateral roots just below ground-level.

When pulling stumped buddings, the tap roots will often be rather large. Any severe pruning is harmful and it is a sound rule never to prune more severely than a single cut with a sharp penknife will permit. Generally speaking no great trouble will occur with transplanting buddings as long as the best practices for planting seedling stumps are followed, but additional care is worthwhile because of the value of the material.

Budding in the Field Versus Nursery Budding.

Most of the previous notes refer specifically to budding in the nursery with a view to transplanting the budded stumps into the field. Budding in the field is not very difficult, but a few points should be observed. About four seeds are planted at stake at each point. When the best developed seedling reaches an optimum stage for budding, this one and the next best seedling should be left and the others removed. Choose dull days for budding and if the

weather is consistently fine, bud only in the early morning and in the late afternoon, and place the buds on the side of the stock facing south. After opening up, the shade should be placed in position again to prevent sudden drying out of the bud patch, exposure to dry air and sun being more severe than in a nursery. Shades can be removed at the final inspection and cutting to stump can be done at the same time. The after care is the same as in the nursery. When the bud has come away successfully the second seedling at each point can be discarded. In the second round of budding to make up for failures, the second seedling is budded. Should failure occur again, the first seedling can be budded a second time, and so on. Thus if only 25 per cent. takes are obtained, a full stand of clonal trees can still be achieved. The pros and cons of budding in the field or the nursery depend partly on local conditions. Provided the budders are reasonably efficient and an area of 20 acres or more is to be planted with only one or a very few clones, budding in the field is to be preferred. The chief advantage of budding in the field is the fact that transplanting is avoided. Not only are transplanting losses more serious with budded material than seedling stumps because of their high value, but transplanting, however carefully done, inevitably checks the growth of the tree. As every tree is checked to a different degree, the times of the bursting of the buds is often a good indication as to the care with which the stumps were transplanted. Over a few years, of course, the differences in development are smoothed out. From the viewpoint of economy, budding in the field avoids both nursery and transplanting costs. Drawbacks of budding in the field is the greater difficulty in supervising operators and the lower number of buddings performed in a given time. Budding in the nursery is easier although not necessarily more successful. If a variety of clones is handled the chances of confusion are less in the nursery than in the field.

Spacing.

With bud-grafted trees the initial field spacing should be such as to give a stand of 180 to 200 trees per acre. If avenue planting is adopted the distance between trees should not be less than 8 feet. Spacings such as 20 feet by 11 feet or 20 feet

by 12 feet are generally useful on flat or slightly undulating country, while 30 feet by 8 feet on the contour is recommended for hilly country. Extreme avenue planting, such as 50 feet by 5 feet or 60 feet by 4 feet, is not recommended and 30 feet is about the maximum distance between rows if yield is not to be sacrificed. As the trees grow they are progressively thinned over six or seven years to a final stand of about 120 to 130 per acre. As all trees of a clone have equal genetical yield potential, thinning may be carried out satisfactorily on the basis of girth and vigour. Since up to about one-third of the initial stand will finally be thinned, it is not essential after transplanting to fill in every miss, provided two or more misses do not occur together.

Costs of Budding.

Nursery budding requires three times as many seed beds as does the use of clonal seed and the additional costs can best be worked out by the individual planter. Budwood is also an expensive item and varies according to the clone. Conditions of sale and the prices of most of the valuable clones are fixed by the companies which introduced them and cannot be varied by the Department. Other expenses are estimated at about $\frac{1}{2}$ d. per bud-graft for materials and tools and $2\frac{1}{2}$ d. for labour costs. Variations occur, depending mainly on the efficiency of the bud-grafter and the scale of the operations.

Variations in Bud-Grafting Techniques.

Over the years many minor variations in the bud-grafting of rubber have been suggested. Amongst such variations are different methods of making the incision, for instance a cut shaped like a Gothic church window, opening up from below, using kitchen knives instead of budding knives, removing the bud from the bud stick with a sliver of wood attached, the wood being peeled off before incision, tying with specially prepared bandages and other materials, shading with pieces of bamboo stuck in the ground, and so on. Most of these procedures are more or less interchangeable. Many of them have been tried at Bisianumu but the method described in detail has been found satisfactory in continuous prac-

tice. It is the method which the Department will demonstrate to interested persons and in which Papuans are trained at Bisianumu.

The Training of Papuans as Bud-Grafters.

Although only Papuans in the restricted sense of the word have so far been instructed, there is no reason to believe that selected New Guinea Natives would not also be suitable for instruction. The reason for the choice of Papuans is self-evident. The rubber industry is concentrated in Papua and as training is not a matter of a few days only, it is natural to select men who are likely to stay on the plantation or station for a lengthy period. Family men living on the property are likely to be most suitable. Any basic education or aptitude for a trade or skill is a good guide for selecting suitable trainees. A very good tapper is likely also to possess the manual dexterity required for a bud-grafter. Trainees must also be clean, with an aptitude for neat and quick work. These qualities can be taught to some degree and the operators trained by the Department of Agriculture, Stock and Fisheries were merely casual workers who came to the Station seeking work. A plantation is likely to have men on the pay-roll with suitable aptitudes for selection.

It takes at least one month to get an indication of how a trainee is shaping. If after one month the trainee is getting less than 10 per cent. of takes, he should be considered unsuitable for training. If after a further two months he is achieving one success in three attempts he is usually worth employing as a bud-grafter and should improve further. At this stage at Bisianumu suitable trainees are graded as nurserymen and recorded as skilled employees. Procedures on private plantations, of course, are at the discretion of the employers and bonuses for percentage of successes might be considered. An 85 per cent. take or about 100 successes per day is considered very good at Bisianumu, and a man who can achieve this level is a skilled workman.

If more than one man is trained, the specialization of labour should not be allowed. To permit one man to make the incision and another to do the binding is not a satisfactory procedure. The extra

handling and delay because of different rates of work do not improve the chances of success. In addition, every part of the manipulation is equally important and unless one man carries out the whole process it is impossible to trace who is working unsatisfactorily if successes are low. However, if two skilled men are engaged in budding, an unskilled labourer or a potential trainee can profitably be used to cut up coconut strips and string to the required length, to clean the stock before budding, and to affix the shade leaves after budding. The first step with trainees is to cut some ordinary seedling material for budwood and let each man work on a few seedling stocks on which he may make as many buddings as he likes. Trained men must watch and correct every step. Any European training Papuans should, of course, be himself well acquainted with the technique before embarking on instruction. Stock even for training should be well grown and in good condition. Old or deformed seedling stock left in an old nursery should not be used for training. It is often bark bound and peels badly, and because of the difficulties encountered in its use the trainees become discouraged. The following points are important in influencing success or failure in bud-grafting:—

- (a) The manual dexterity of the operator. Speed is essential. To fuss is usually fatal.
- (b) Cleanliness (hands, tools and materials) and tidiness, which includes keeping tools sharp at all times and materials handy and ready for use.
- (c) Secure tying to prevent the entrance of water.

- (d) Power of observation so that useless patches are not used, nor are bud patches inserted upside down.
- (e) Well grown stock and good budwood are an advantage.
- (f) Unfavourable weather conditions will lower success.
- (g) During the wintering period of the rubber tree successes are less.
- (h) Some clones are more difficult to bud than others.
- (i) Opening up at the wrong time will destroy many otherwise sound buddings.

Bud-Grafting Versus Clonal Seed.

Although there are other points to consider, the most important question in comparing bud-grafted material with clonal seed is the comparative yield of the two. If budwood of the newest clones is used there can be no doubt that the potential yield is considerably higher than will be obtained from good clonal seedlings. When bud-grafts are used the planter may also produce his own clonal seed if he so desires provided due consideration is given to the selection of clones so that all are good parents and in the right combination. A third point with bud-grafted clonal stands is that when clones are selected the secondary characteristics as well as yield are always taken into consideration. Special adaptability to poor soils, good bark renewal, good latex properties, resistance to wind damage, and other characteristics are always considered. A block of clonal seedlings will not possess good secondary characteristics as uniformly as a block of budded trees.

Summary and Conclusions.

The following table summarizes the procedures involved in bud-grafting:—

Task	Optimum Time	Period of Usefulness
Budding nursery beds	12-15 months after sowing	1-2½ years after sowing.
Budding seedlings at stake	12-15 months after sowing	1-2½ years after sowing.
Opening up buddings	17-21 days after budding	Not more than one day either way.
Inspection of buddings	10 days after opening up	Up to 1 month after opening.
Cutting to stump	Up to 2 months after inspection	No longer than 6 months after inspection.
Planting out budded stumps after cutting to stump	Up to 10 days after cutting to stump	Up to 10 days after cutting to stump.
Planting out budded stumps without cutting to stump	Up to 2 months after inspection	Up to 6 months after inspection.
Planting out stumped buddings	12-18 months after cutting to stump	Anytime after 12 months until too unwieldy to transplant.

In conclusion, anyone connected with the rubber industry is invited to visit Bisianumu to inspect the work going on there and to seek information on doubtful points. It is intended at a later date that demonstrations of budding technique will be given at central points in the main rubber growing areas if there is sufficient demand for this service.

The Department of Agriculture, Stock and Fisheries can undertake the training of a limited number of Native bud-grafters at Bisianumu and any planter wishing to avail himself of this service should contact the Chief, Division of Plant Industry, Department of Agriculture, Stock and Fisheries, Port Moresby. Any planter with practical experience in bud-grafting which adds to or diverges from the information on techniques in this article is requested to forward the information to the Director, Department of Agriculture, Stock and Fisheries, Port Moresby.

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