Rubber Planting Techniques—Part III—Transplanting and Maintenance.

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INTRODUCTION.

In Part I and II of this series *Rubber Planting Techniques* the handling of rubber seed and nursery practices respectively have been discussed. The final part deals briefly with land preparation, and more extensively with transplanting operations and field maintenance until the tapping stage is reached. Mulching, Manuring and Cover Crops, which are part of rubber plantation establishment are also discussed.

FIELD PREPARATIONS.

Before transplanting operations can commence the area to be planted must be prepared. After clearing of the land, planting lines and planting points are to be marked out, plant holes are to be dug and cover crops have to be planted.

In clearing the land the aim should be to clear no more than is necessary for accessibility and ease of working conditions. Burning should be limited to a minimum. Complete clearing and heavy burning destroys the humus constituent of the soil erosion. In felling operations, the trees should be dropped along the contours to assist in erosion control and they may also be used to advantage in terracing work.

TERRACING.

On hilly terrain terracing is strongly recommended. In terracing operations a contour line is pegged out with the aid of a dumpy level, an "A" frame or by another suitable method. Terraces follow contour lines. Digging of the terrace is commenced by starting at about four feet upwards from the previously pegged-out contour line. Soil thus removed is shoveled down this slope to about four feet on the opposite side of the contour line. The result will be a terrace of approximately 6-8 feet width.

Terraces must be sloped inwards into the hill so that water running down the hill is caught on the terraces. The object thereof is prevention of soil erosion. A slope giving a difference of 9-12 inches between outer and inner perimeter is usually sufficient. To check the flow of rain water along the terraces it is normal practice to construct stops at regular intervals. A stop is an uncut part in the contour line of some 2-3 feet in width. For instance, with a spacing of ten feet between trees on the terrace a stop could be constructed at 30 feet intervals, in between every third and fourth planting point. Planting points are measured at about two and a half feet outward from the inside perimeter of the terrace. This allows for sufficient room to walk along the outside of the terrace in future tapping operations.

Individual terraces, i.e., a platform of some 4-6 feet in diameter around the tree, are sufficient on the more gentle slopes, but in general the "continuous" type of terrace is recommended.

SPACING.

The spacing of the trees depends on the type of terrain to be planted. On hilly land the distance between planting rows is usually wider than on flat land. An "avenue" of spacing, i.e., a wide distance between rows and a relatively close spacing between trees in the rows, will simplify future tapping operations and latex collection. It will also reduce terracing and weeding costs.

Spacing depends on whether a high yield per acre or a high yield per tapper is required. With high labour costs and relatively low rubber prices it would be more economical to concentrate on yield *per tapper*. In that case the stand per acre should be less than when yield per acre is aimed at. Another point to remember is that seedling trees have a greater variation in yield than budgrafted trees and that they therefore require more rigorous culling. This is the reason why the initial stand per acre is usually more for seedling trees than for budgrafted trees. To achieve the optimum number of trees per acre when they reach maturity, the initial stand should be 20-30 per cent. more than the desired final stand. Stand per acre is of course directly related to spacing. A popular spacing on flat land in Malaya is 15 x 14 feet for seedling stumps, giving 207 trees per

acre and 17 x 16 feet for budded stumps, with 160 trees per acre. On hilly terrain the more popular spacings are 24 x 10 feet (182 trees/acre) and 27 x 9 feet (197 trees/acre). Some years ago a spacing of 30 x 8 feet (182 trees/acre) was not unusual but lately a wider spacing of trees in the row is recommended.

Whatever spacing is decided upon it should be remembered that the "avenue" type spacing is more economical in establishment, maintenance and latex collection costs.

For these reasons, a spacing of 24 x 10 feet, with an initial stand of 182 trees per acre could generally be recommended for rubber plantings in this Territory .

HOLING.

Planting holes are usually made about one month prior to planting operations. For normal size planting material, i.e., stumps of approximately one year of age a hole of two feet in diameter and tapering to one foot at a depth of two feet is quite satisfactory. For smaller planting material, like pencil stumps, a hole of 12 x 12 x 15 inches will be adequate. Leaving the hole open for some weeks will allow weathering of the soil. The holes are filled in to half of their depth a few days before planting. Any water in the holes is removed prior to filling. Subsoil is placed in the hole before the top-soil.

DRAINAGE.

Drainage of wet areas is another preparation required before planting. Surplus rainwater must be able to drain off effectively. A water-table at a minimum depth of three feet is normally essential to healthy growth of the trees. Although the rubber tree likes an abundant water supply it will not grow in a water-logged soil.

COVER CROPS.

The disastrous effects rain and sun can have on exposed soils under tropical conditions is well known.

In practically all plantation crops, the soil is protected against the adverse effects of weather and erosion by the planting of ground covers or cover crops. In rubber cultivation it is preferable to have these ground covers established before the rubber is planted. Ground covers may either consist of natural vegetation or may be planted crops. The latter type of cover is usually a leguminous creeper or shrub. The advantage of a leguminous type of cover crop over non-leguminous natural covers is that the legumes mobilise, through bacterial action in their root nodules, considerable amounts of nitrogen which become available to the rubber tree. Disadvantages of leguminous covers are the relatively high costs of establishment and maintenance as compared to natural covers. Legumes are often difficult to establish.

Natural, as well as leguminous covers improve soil structure by their decaying vegetable material and thus enrich the soil with organic plant food. On the other hand, both types of covers may become competitive to the rubber trees in nutrients and water intake.

The question of which is best—leguminous or natural cover is a matter of opinion which should be based on the economics of the two systems and which vary with location. Generally speaking, in Malaya the establishment of leguminous ground covers is common plantation practice. Cover crops in Malaya are meticulously weeded and fertilized as well.

In the Territory of Papua and New Guinea the natural covers are much more common and only a few plantations have seriously attempted to establish leguminous cover crops. The reason for this lack of interest in legumes among Territory rubber planters is probably due to insufficient labour being available for regular weeding rounds as well as the relatively high costs of establishment and maintenance of legumes.

There seems to be no doubt that legumes generally have an advantage over natural covers, provided the maintenance work, in particular weeding, is strictly under control. Neglect in legume maintenance could result in complete failure of the cover crop and will certainly make legumes compare most unfavourably with natural covers—as well as proving un-economic.

The Department of Agriculture, Stock and Fisheries, at their Bisianumu Rubber Centre, has adopted natural covers as a general policy in their clonal yield trials. Promising legumes, such as *Calopogonium caeruleum* and *Flemingia congesta* have been established in observation plots. In both systems at Bisianumu the rubber

planting lines are strip-weeded and mulched. Finally some notes on the establishment of ground covers :

Leguminous Covers.

Among the better known leguminous creepers in rubber cultivation are : *Pueraria phaseoloides, Calopogonium mucunoides* and *Centrosema pubescens.* Leguminous shrubs are not as widely used as the creepers ; among the better known shrubs are—*Crotalaria anagyroides* and *Tephrosia candida,* while *Flemingia congesta* has become more popular in recent years. The creepers are usually sown in drills about five feet apart and not closer than six feet from the rubber lines. Calopogonium, Centrosema and Pueraria are mostly planted as a mixture (5 : 4 : 1 by weight) at the rate of 4-5 lb. per acre. Centrosema grows rather slowly but is more persistent. Pueraria and Calopogonium both grow fast but *Calopogonium mucunoides* dies back during drought and is found difficult to re-establish, while Pueraria is more susceptible to insect pests. One of the newer species of leguminous creepers is *Calopogonium caeruleum.* It has proved to be the most vigorous legume introduced at Bisianumu. When properly established it suppresses all grass and weed growth. *Calopogonium caeruleum* does not die back during drought and appears to be shade tolerant. It may prove, however, to be rather competitive to rubber. *Calopogonium caeruleum* does not produce seed under Territory conditions (as is also the case in Malaya). Malaya imports the seed from the Philippine Islands. At Bisianumu *Calopogorium caeruleum* is propagated from cuttings with 80-90 per cent. successful establishment under favourable conditions.

Of the leguminous shrubs, both *Crotalaria anagyroides* and *Tephrosia candida* proved susceptible to pink disease at the Bisianumu Rubber Centre. Both had to be eradicated as they were a source of infection to the rubber trees. *Flemingia congesta* appears to be promising. Flemingia seedlings are raised in nurseries, sown in rows four inches apart. The young seedlings are transplanted to the field when 2-3 inches high at a spacing of 4 x 4 feet and not closer than eight feet from the rubber lines. Flemingia is a slow starter, is shade tolerant and produces great quantities of leaf mulch when regularly slashed, at 2-3 feet from the ground. It tolerates slashing well. Seed production, if required, is abundant within 6-10 months from slashing or planting.

Like most of the legume cover crop seeds Flemingia seed has a very hard seed coat and is therefore extremely slow in germination if not specially treated. Untreated seed showed approximately 60 per cent. germination after nine weeks, against 80 per cent. germination in ten days with treated seed. Seed treatment is quite simple and most effective. It consists of placing the seed in a dish or a bucket and pouring hot water over the seed while stirring. The seeds are left in the water for 6-8 hours, floating seeds and debris are scooped off and discarded. Seeds are sun dried for 5-10 minutes and are then ready for planting. Successful establishment of leguminous cover crops depends for a great deal on favourable weather conditions after sowing or planting in the field. Another important factor is to keep the plants free of weeds. Under Territory conditions weeding of cover crops may prove rather costly and in such instances it appears to be more practical to have a natural cover established.

Natural Covers.

In newly cleared areas natural grasses and shrubs quickly establish themselves. By removing the harmful weeds and those with undesirable characteristics a natural cover of harmless grasses, weeds and shrubs is obtained in short time and at minimum cost. Maintenance of natural covers consists of periodic removal of undesired growth. In the areas under natural cover at the Bisianumu Rubber Centre unwanted growth is removed during the regular rubber-row weeding rounds. All growth between the rows is slashed to a few inches above ground level once or twice a year during the period of immaturity of the rubber trees.

When the trees reach maturity, most grasses and shrubs die out and only the shade-tolerant species remain. This applies also to leguminous cover crops.

PLANTING MATERIAL.

The various types of planting material discussed in this article are :

(*a*) Seedling stumps ;
(*b*) Budgrafted stumps ; and
(*c*) Germinated seed.

Besides the above-mentioned, there is another type of planting material which is becoming increasingly popular in Malaya, namely young seedlings and budded stumps propagated in polythene bags.

Although a few Territory plantations, including the Bisianumu Rubber Centre, are experimenting with this type of planting material there is at present insufficient information available to enable recommendation to be made on general usage. Planters interested in polythene bag planting techniques are referred to No. 63 of the *Planters' Bulletin* of the R.R.I.M.

For the Territory of Papua and New Guinea, we are at present mainly interested in the planting material as mentioned above under (*a*) ; (*b*) ; and (*c*).

(*a*) *Seedling Stumps.*

This is the more commonly used planting material in the Territory, probably on account of the ease of propagation and handling during transplanting operations. A stump of 10-12 months of age, with a diameter of approximately one inch at ground level, seems to be the adopted standard size of seedling stump in this Territory. This kind of stump is hardy and can stand packing and transport over several days quite well. If temporary storage is required they may successfully be kept in damp packing materials, such as hessian, or alternatively they could be kept in a shady spot while their roots are covered with loose, damp soil.

The smaller type of seeding, the so-called pencil stumps of $\frac{3}{8}$ in. to $\frac{3}{4}$ in. in diameter, and usually 6-9 months of age, are not popular in the Territory. Although propagation and transport costs will be less than for the standard type seedling they are not as hardy as the latter. Adverse weather conditions after transplanting will affect them more severely.

Stumps of a bigger size than the above mentioned standard type also make good planting material, but will be more costly in propagation and transplanting. Seedlings stumps within the meaning of this article are high yielding clonal seedlings, but the above naturally applies to common seedlings as well. The latter are, however, not used as planting material anymore except as seedling-stock for future budgrafting.

(*b*) *Budgrafted Stumps.*

With budgrafted planting material we must differentiate between budded stumps and stumped buddings as is explained in Part II of this series. The recommended type of budgrafted planting material for this territory is the budded stump. Budgrafting of the seedling-stock is usually done in the nursery when the seedling is approximately one year old, but budding at the age of 8-9 months is not at all unusual under good growing conditions. At one month from the date of budgrafting the tree is ready for transplanting into the field. The grafted tree is stumped at about 3-4 feet height and becomes a budded stump. They are transplanted with the grafted bud in a dormant condition.

Stumped buddings are not generally recommended for the Territory. They require considerable nursery space, canot be pulled but have to be dug out, are bulky in transport, need bigger planting holes and most careful attention in transplanting. Timing the planting is even more important than with budded stumps as losses can be more severe than in budded stumps when unfavourable weather prevails after planting. However, the advantage of stumped buddings is the reduction in time between planting and maturity. It is claimed that up to two years can be saved on the immaturity period in the field with stumped budding plantings as compared to seedling stumps.

(*c*) *Germinated Seed.*

This type of planting material is seldom used in field plantings. Clonal seed is normally propagated in the nursery and transplanted to the field as a seedling stump. Planting of germinated clonal seed directly from germination bed into the field is not advisable for obvious reasons. The only practical use of germinated seed plantings in the field is for the growing of seedling-stock. The normal size planting hole, as described earlier, is made and filled-in completely a few days before planting the seed. Germinated common seeds are then planted three to four seeds per point and some 6-8 inches apart. Approximately 12-15 months afterwards the more vigorous trees are budgrafted. The advantage is that no transplanting has to be done resulting in an unchecked growth of the budshoot after stumping. The disadvantage is that the field has to be prepared and maintained for at least one year before budgrafting takes place.

On the other hand, budgrafting in the field reduces the time between budgrafting and tapping by some six months at least compared with budded stump plantings.

The planting of seed at stake, i.e., planting of ungerminated seed directly into the field, is not encouraged. Losses due to unfavourable weather, animal damage, etc. make this practice an entirely uneconomic proposition for the Territory.

PLANTING SEASON.

Transplanting is preferably done at the commencement of the rainy season, so that the young trees are properly established before the dry season sets in. If planting is left until late in the wet season and a dry period follows upon completion of planting operations it may cause a serious set-back to the young trees and could result in severe losses. It is most important for a successful establishment in the field and for continuous healthy growth of the transplanted material that planting operations are well timed for a period of reasonable certainity that there will not be a prolonged dry spell.

TRANSPLANTING.

Planting material in the nursery is prepared for the transplanting operation as follows :

The seedlings are cut back with a sharp knife or secateurs to a few inches below the limit of the brown bark. Cutting back into green bark is not advisable as this green bark may deplete the water supply of the stump through excess transpiration and could result in complete die-back of the stump. The height of stumping depends on the size of the trees, but 18 inches of brown bark is generally considered the minimum. Well developed trees of one year old usually have three feet or more of brown bark.

After stumping, the trees are left in the nursery for 5-7 days. At the end of this period, most of the buds at the top of the stump are beginning to swell ; this is the time to transplant. If the weather is not quite suitable, the stumps may be kept in the nursery for another week or two. In case circumstances prevent planting for several weeks after stumping, the green shoots at the top of the stumps are merely removed and the stumps may either be transplanted immediately or left at the nursery until other buds begin to swell.

Removal of the stumps from the nursery is done by pulling straight upwards ; not by turning and twisting as is frequently done by inexperienced planting gangs when stumps prove difficult to pull. Twisting and turning the stumps results in serious damage to the taproot. Stumps which cannot be pulled up are dug out. Digging on one side is sufficient to pull the stump out. In case the soil in the nurseries is rather dry and hard it is good practice to water the beds thoroughly prior to lifting the stumps. This facilitates pulling and will give less breakage of lateral roots. Taproot and lateral roots are cut back. The length of taproot left after pruning depends on the size of the stumps. In well-grown 12 months old seedlings it is usually 18-24 inches, but if in doubt it is safe to prune at a point where the taproot is about the thickness of a thumb. In pencil stumps at least 12 inches of taproot is left. Laterals are pruned to some 6-9 inches depending on size. Roots of the stumps awaiting planting must be protected from drying out and should never be exposed to direct sunlight. It is advisable not to pull more stumps than can be handled in the next two hours. It is better to come back to the nursery several times a day than to pull up a day's planting all at once. In case pulled-up stumps have to be left overnight it is best to place them with the roots in water. It needs no emphasis that only strong and healthy trees are transplanted ; weak plants in the nursery will not become vigorous trees in the field and they are not worth transplanting.

Preparations for transplanting budded stumps and stumped buddings are the same as described above for seedlings.

Transplanting is best carried out on overcast days. Hot sunny days should be avoided. Every care in transplanting the stumps must be taken and the operation should always be supervised by experienced staff. Planting must never become a " rush job ". The future life and health of the plantation depends for a good deal on the planting operation, which is carried out as follows :

A crobar or pointed stick is used to make a cavity in the partly filled hole to suit the stump. The stump is placed in the cavity and the soil around the end of the taproot is firmed. This is the most important part of the planting opera-

tion. It is essential to the survival and growth of the stump that there be no air gap at the end of the taproot, it must be in firm contact with the soil. This is done by firming the soil towards the end of the root with a stick. The soil is then further firmed at the base of the hole ; filling and firming continues to about three-quarters of the depth of the hole. In the second part of the planting operation the lateral roots are laid out in a natural position and the hole filled in. When the laterals are covered the soil is firmed again ; this is best done with the feet but without tamping down. A properly transplanted stump is planted at the same depth as it was in the nursery. It may be slightly deeper, but should never be higher than its original nursery level.

Budded stumps are often planted deeper than their nursery level, to about one inch from the budpatch. This is done to have the so called " elephant's foot " which develops at the point of union between stock and graft as low as possible on the trunk in order to tap more of the high yielding bark. Budded stumps are planted with the bud facing either North or South to avoid as much as possible direct sunlight on the budpatch. Immediately after planting the budded stump is cut back to about 2-3 inches above the bud patch. This is best done with a pruning saw and at an angle of 45 degrees upwards from the bud patch. The soil around the stump is then firmed once more. Sealing the cut surface by " Areoseal " or similar preparations is not necessary. If desired, sealing may be done quite effectively by spreading the latex, which appears after sawing, over the cut surface of the stump with the finger. To prevent excess transpiration through the bark a wax emulsion known as " Ceremul M " is sometimes used when circumstances force planting under less favourable weather conditions. This wax emulsion is diluted in water (1 : 1) and applied to the above-ground part of the stumps either by immersion before planting or by brush application after planting. Although the beneficial effect of this treatment could not be proven, there were indications that it helped to reduce transpiration and probably prevented serious losses during a dry spell immediately after planting.

The final part of the planting operation is :

MULCHING.

A layer of grasses, up to four inches in thickness and some 1-2 feet width, is spread around the newly planted tree. This will complete the planting. Care should be taken not to place the mulch in direct contact with the base of the tree as this could cause collar rot and may result in death of the budpatch in the case of budded stumps. The mulch will prevent drying out of the surface soil surrounding the lateral roots. Kunai grass (*Imperata cylindrica*) is most suitable for this purpose.

If enough mulching matter is available it is a good practice to mulch the entire length of the planting lines ; so called strip mulching. This however is only practicable in the avenue type of plantings with a relatively short distance between the trees in the line. In other cases the mulch can be gradually extended as the trees grow bigger.

A good mulch, besides preserving soil moisture will reduce weeding costs, helps to control soil erosion and improves soil structure. Decaying mulch makes organic matter available to the rubber roots, thus stimulating tree growth. Mulching in tropical agriculture generally, and of rubber in particular, is considered a throughly recommendable practice. Rubber roots thrive under a mulch. Improve soil structure and the numerous lateral feeding rootlets appearing within a matter of months are convincing evidence of the beneficial effects of mulching in rubber cultivation.

MANURING.

The manuring of the planting hole prior to, or at the same time as, planting the stump is not common in this Territory. As stated in Part II of this series Territory rubber soils are generally of better natural fertility than most of the Malayan soils where fertilizing is common practice throughout the life of the rubber tree. It has also been said that the need for fertilizing depends entirely on the natural fertility of the soil. In view of the above it is believed that rubber in this Territory, when properly planted, at the right time and supplied with a good mulch, will grow unchecked and does not need any fertilizer in the first year after planting. If the trees are showing lack of growth and general

vigour it may be advisable to supply additional plant food in the form of fertilizers or animal manure. However, it should be understood that the reason for the lack in vigour is not always attributable to nutrient deficiencies of the soil. The water relationship of the soil, for instance, is a factor of great influence on the growth of the rubber. Changes in the water content of the soil have an influence on the root system and consequently on growth and appearance of the trees. Competition for water from weed growth and cover crops could result in a general backwardness of the rubber trees and must not be confused with nutrient deficiencies of the soil. Soil and leaf analysis, a service carried out by the Department of Agriculture, Stock and Fisheries will be helpful in determining whether fertilizing is required. Unless the lack of a known element is indicated it will be best to fertilize with a compound fertilizer containing the main elements nitrogen, phosphorous and potassium (N. P. and K.), during the early years of growth of the rubber. When the trees become older the phosphorous and potassium requirements decrease and nitrogen fertilizer, such as sulphate of ammonia or urea, may have to replace the compound fertilizer.

When applying fertilizers in mulched plantings the mulch is removed first, fertilizer applied and lightly worked into the soil, after which the mulch is replaced. It is better to give small quantities of fertilizer at regular intervals of say four months than to apply the recommended yearly amount all in the one application. General fertilizer recommendations are presently based on overseas experience. The following application rates may serve for general guidance during the period of immaturity.

The use of a compound fertilizer with a N.P.K. ratio of 21 : 14 : 14 is assumed.

1st year : 4 oz. per tree, divided over two applications at respectively 6 and 12 months after planting.

2nd year : 6 oz. per tree over three applications at 16, 20 and 24 months.

3rd year : 9 oz. per tree over three applications at 28, 32 and 36 months.

4th year : 12 oz. per tree over three applications at 40, 44 and 48 months.

5th year : 16 oz. per tree over three applications at 52, 56 and 60 months.

It must be emphasised that these rates are for general guidance only and are not a standard recommendation on the fertilizing of rubber trees in the Territory. Before starting on a full scale fertilization programme it is suggested to find out which fertilizers and application rates are the most effective for the plantation. This is best done by soil analysis and a small scale fertilizer trial.

FIELD MAINTENANCE.

Field maintenance work includes :

(*a*) Weeding ; (*b*) Replanting ; (*c*) Pruning ; (*d*) Thinning ; and (*e*) Disease and Pest Control.

(*a*) *Weeding.*

A strip of about three feet on each side of the rubber lines is kept free from grasses, creepers and shrubs which compete for soil moisture and nutrients. Strip-weeding is practised in the avenue type of planting system, including terraces. In other planting systems, circle weeding, whereby a circle around the tree is kept free of weeds, will be more economical. Kunai grass, which is most detrimental to the growth of the young rubber tree, is forked out completely or is controlled by weedicide spray. Weeding rounds are naturally more frequent in the early years of establishment, and become less frequent as the trees grow bigger and crown development is shading out many grass species.

As discussed earlier, mulching will reduce weeding costs. Natural covers between the lines are periodically slashed ; leguminous covers have to be regularly weeded.

(*b*) *Replanting.*

The replanting of trees which die after transplanting to the field is carried out as early as possible. If planted well and at the right time, losses will be very few (0.5-2 per cent. is normal) and it is often considered not worthwhile to replant these few misses. Where losses occur in a group of two or more together it is advisable to replant. Replanting is done with material of the same age and type as the original plantings, a supply of which is normally kept in reserve in the nurseries. Replanting must be carried out within two years. Thereafter it is impracticable and uneconomical to replace misses as these

late replants cannot successfuly compete with the earlier established trees and are unlikely to develop into useful trees.

(c) Pruning.

The first pruning is usually done within three months from the planting date and is aimed at selection of the strongest and healthiest of the emerging shoots to form the main stem. Unwanted shoots are removed with secateurs or pruning knife. Sometimes it is difficult to select a suitable leader and two or more shoots are kept until a definite, straight growing leader can be selected. Pruning of side shoots to a height of 7-8 feet is done to obtain a tapping panel without interference from side branches. A word of caution on the pruning of young trees seems advisable because pruning is often overdone in the early growing years. It must be understood that every tree will endeavour to produce the maximum amount of foliage necessary for manufacture of essential plant food. Pruning deprives the tree partly of its ability to produce food from the leaves (by photosyntheses), and must result in slower growth. Severe pruning will seriously retard growth. It also results in the production of numerous branches as a natural reaction of tree regeneration, thereby depleting food reserves even more.

Pruning in the first two years should be restricted to a minimum, necessary for correct and continuous growth. A limited number of side branches could be allowed to grow until the tree is vigorous enough to regenerate new growth before branch pruning to a height of eight feet is done. Pruning must never be left to untrained labourers but should be done by experienced workers who are familiar with rubber propagation and who understand the principles of pruning.

Pruning wounds not bigger than an inch or two are left untreated. Bigger wounds may be treated with " tree seal " or other wound dressings. In cases of wind damage, the break is sawn to form a smooth surface and the wound is treated.

Budded stumps require more pruning attention than seedling stumps. Shoots which emerge from the seedling stock of budded stumps are cut away in monthly inspection rounds. Some clones produce numerous side branches at a low level ; these should be nipped off by hand in the early stages to stimulate the upward growth of the main stem. The snag of wood from the seedling-stock above the bud-patch is sawn off within a year from planting. The cut is made at an angle of 45 degrees with the top of the cut coming out at the top of the junction between bud-shoot and stock. To leave this stock snag decay and fall off is not recommended as this often leads to infection by wood-rotting fungi and may encourage termite attack. Some clones, as well as individual seedling trees, have a tendency to an uninterrupted upright growth resulting in a tall slender stem without branches. RRIM 600 is a typical example of such growth. Pollarding is sometimes practised in such cases whereby the tree is stumped at a height of approximately eight feet. Pollarding, however, is not recommended as it causes a considerable set-back in growth resulting in a longer period of immaturity. To induce branching of these tall growing types it would be better to pinch out the growing point at a height of 10-12 feet after which attention must be given to select two or three strong and well spaced branches to form the frame work of the canopy. This is particularly important ; failure to do so will result in a weak branching system susceptible to wind damage.

A final pruning is given on some plantations around the time when the trees are reaching the tapping stage. The more or less horizontally-growing branches, up to a height of 12-15 feet, are sawn off. It is said that this final pruning will help the tapping panel to dry out more quickly. It is considered that this pruning system has its merits in the really wet districts but that it is of little value in the drier areas. In most instances these lower side branches die off naturally as the crown develops.

(d) Thinning.

The aim of thinning out is to obtain an optimum stand of tappable trees per acre. Removal of poorly growing trees gives the remaining ones a better chance to develop. Better growing conditions for the remaining trees results in improved yield per tree and consequently a higher yield per tapper with lower taping costs. After the weak, and badly damaged trees are taken out, any further culling must be based on girth of the trees. Thinning commences in the third year ; it should be uniform

over the whole area and trees to be removed must therefore be selected by size as well as by position.

With an initial stand of 180-200 trees per acre it is normal practice to thin out to about 160 trees by the time the trees are brought into tapping. Any further thinning must be based on yield. Reducing the stand to 140-120 trees per acre by removal of the low yielders during the first 3-4 tapping years seems justified only when it leads to cheaper production costs. It would be impossible to state the optimum number of trees per acre as this depends on many factors, such as growth rate, planting material, labour situation and a number of other factors, in direct relation to effective plantation management.

(*e*) *Pest and Disease Control.*

Although this Territory is rather free of the serious diseases which occur in other rubber growing countries, a few of the more common ones to the Territory will be discussed. Besides the pests and diseases mentioned in Part II of this series, all of which may occur in the field as well as in the nurseries, the following are more prevalent in field plantings.

Pink Disease caused by the fungus *Corticium Salmonicolor* is often a serious problem in the wetter districts of the Territory. The fungus attacks the branches, penetrates into the wood and the branch dies off. When several branches are affected the whole crown may be lost. The disease is easily recognized by the pink coloured fungal incrustation on the surface of infected branches. The disease seldom occurs in very young rubber ; trees from three to seven years of age appear to be most vulnerable. At Bisianumu, clones RRIM 501 and RRIM 614 have proved particulary susceptible. Spores of the fungus are carried by wind and spread the disease. Control should be aimed at preventing the spread of the disease by removing and destroying infected branches in the early stage.

Gloeosporium Dieback.

The Gloeosporium leaf disease is common in young seedlings in the nurseries. In the field it is usually of less importance except in cases of a particularly susceptible clone, such as RRIM 526, where it may cause dieback of the terminal growth as a result of fungal infection of the stem. In severe cases, the whole tree may die back. Affected shoots are cut off below the infection and burnt.

Root Diseases.

Decaying roots of jungle trees infected by fungal parasites are the cause of rubber root diseases. Loss of mature trees through root diseases appears to be less common in the Territory than in other rubber producing countries. Whether the loss of trees is not recognised as possibly due to root disease is not known, but there are practically no cases of rubber root disease reported in the Territory. At Bisianumu there were a few cases of suspected red root disease in the loss of some 5-7 year old trees, but this could not be proven.

The three major diseases of rubber trees in Malaya are : White Root Disease (*Fomes lignosus*), Red Root Disease (*Ganoderma pseudoferreum*) and Brown Root Disease (*Fomes noxius*). The last one is less common in Malaya.

These root diseases spread among rubber trees when the expanding root system comes into contact with diseased material. The fungus grows along the infected root to the tree collar and the tree will eventually die when tap-root and main laterals are infected.

Unfortunately, root diseases cannot be recognised until the above ground parts of the tree show the symptoms of disease. Regular and careful inspection of the foliage is necessary for early detection of root diseases. When leaves are discoloured, drooping and falling off, the tree is suspect. The top of the taproot is then inspected and lateral roots are exposed and examined. Where infected material is found the root system is opened further until the source of infection is found. Infected material is removed and burned. Where a root-diseased tree is found, it is advisable to inspect the collar and lateral roots of nearby trees as well.

Lightning Strike.

Although injury caused by lightning is not a disease, it is often mistaken for one. The symptoms are : Splitting of the trunk, torn-off bark, discolouration of bark tissue, latex may exude and green leaves may fall off with stalk attached.

Sometimes the symptoms are less clear and may resemble a die-back disease or a bark cancer. Lightning strikes usually affect rubber trees in groups and occur more often than is generally thought. At Bisianumu in 1960 a group of 25 trees in a 4 year old planting were affected by lightning—two trees were a complete loss and 20 trees needed to be stumped. As recently as November, 1964, lightning killed three trees and affected nearby trees in a five year old clonal yield trial.

Treatment consists of removal of dead and dying trees and the cutting back of damage trees to healthy tissues.

Pests.

In addition to the earlier mentioned nursery pests *Amblypelta* and *Idiopsis,* the only other more serious treat to rubber in the field is the attack by termites or white ants. Although no serious infestation has been reported so far, a close watch should be kept as termites of the species *Coptotermes elisae* (Desneux) have been found to attack healthy taproots of rubber trees in the Territory. Invasion of white ants is however more likely when roots are diseased. The recommended treatment is a dieldrin solution, one part of dieldrin 15 per cent. concentrate in 600 parts of water, poured around the base of the tree. One to four pints of this solution is used depending on the size of the tree.

Disease inspection and control rounds are carried out at 2-3 months intervals.

Finaly it must be emphasised that proper field maintenance is of the greatest importance and influences the future health and growth of the plantation. Without constant care even the best planting material will be disappointing. Proper maintenance reduces the period of unproductivity. Under favourable conditions the rubber tree may be expected to reach tappable size in its fifth year after planting into the field. Negligence in maintenance could extend this period of un-productivity to eight years and more. The degree of supervision and maintenance is the key to successful plantation management.

CONCLUSION.

In this series *Rubber Planting Techniques* the handling of seed, nursery practices, transplanting and maintenance of rubber cultivation have been discussed with particular reference to the Territory of Papua and New Guinea.

These articles do not pretend to be a complete manual on rubber propagation, but are intended as a guide to Agricultural Field Officers and prospective rubber planters on small-holdings as well as on plantations.

The articles are based upon practical experience and knowledge gained at the Bisianumu Rubber Centre of the Department of Agriculture, Stock and Fisheries, as well as from visits to rubber plantations in the Territory and overseas.

Further details on all aspects of rubber cultivation in this Territory may be obtained from The Director, Department of Agriculture, Stock and Fisheries, Konedobu, Territory of Papua and New Guinea.

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