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RECENT DEVELOPMENTS

in the

RUBBER PLANTING INDUSTRY

with special reference to

BUDDING,

BROWN BAST TREATMENT, MANURING OF RUBBER, Etc.

by

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FOREWORD.

This report is the outcome of a recent visit to Ceylon, Malaya, Sumatra and Java, undertaken mainly with the object of getting first-hand information on the new Keuchenius Treatment for Brown Bast, and the more recent progress in Budding and Hevea Seed Selection. On the latter question, many conflicting rumours and so much irresponsible talk had been current, that it seemed desirable to learn the actual facts.

As the Ceylon experience of Manuring is the subject of frequent discussion in this country, I have added a chapter to the section on the Manuring of Rubber, dealing with the results of Manuring in Ceylon, so far as I have been able to ascertain these.

Of all the rubber areas visited none produced so much useful information as the Plantations of the General Rubber Company in Sumatra (H.A.P.M.) Kisaran, the headquarters of these Plantations, has become the Mecca of all planters who wish to keep abreast of recent rubber research. It is astonishing to find how many of the familiar problems of rubber planting have been satisfactorily settled during the last few years by the researches of the H.A.P.M. Scientific Staff.

I should like to acknowledge here my very great indebtedness to the H.A.P.M. authorities for the opportunity of revisiting their estates and for all the information they have ungrudgingly given. To Mr. W. J. Gallagher and Mr. J. Grantham especially are my thanks due for their generous hospitality and kind assistance in regard to the matters discussed in this report. Finally, a word of thanks is due to Mr. H. C. Pinching and the other Scientific Officers of the R.G.A., at Kuala Lumpur, whose ready assistance greatly facilitated my enquiries and lightened my path in the F.M.S.

H. A.

MUNDAKAYAM,
S. India, September, 1924.

GENERAL IMPRESSIONS.

DECADENT RUBBER.

One of the things which have most impressed me in re-visiting Malaya and the Dutch East Indies, after five years' absence, is the deterioration of much of the Rubber. Estates which, in 1918,were vigorous and full of promise, have visibly gone back in rate of growth, bark renewal, and general appearance. Altogether I must have seen in the countries mentioned two or three hundred thousand acres of rubber which can only be classed as decadent.

The falling off noted, is not due, primarily, at any rate, to over-tapping, or soil wash, though these factors have obviously contributed, but to unsuitable soil. The remarkable adaptability of Hevea, as displayed in its ability to grow in almost every type of soil, has led to an under-estimation of the importance of the soil factor, and land of any kind has, in the past, been considered good enough for rubber. Up to the eighth or tenth year, most of the land planted certainly had every appearance of being good enough. Time, however, is gradually revealing the inherent poverty of some of these soils, and it is becoming increasingly evident from the decline in vigour and general appearance of the trees that large areas now under rubber are not permanent rubber soils.

Lest this statement be misconstrued, I ought, perhaps, to say that there is no likelihood of this rubber suddenly going out. It has, in all probability, years of life before it, but it has passed its prime, and only by resort to expensive manuring will the trees be retained in heart, and yields kept up.

GOOD YIELDERS REMAIN GOOD.

POOR YIELDERS REMAIN POOR.

Although for some years past, it has been evident from general observations that good or bad milking qualities are a permanent endowment of a Hevea tree, no regular quantitative records of individual tree yields over a long period of years have been available, and statistical confirmation of the permanence of yield capacity has, up to recently, been lacking.

Data on this question are now forthcoming from two sources. On the H.A.P.M. Plantations, accurate yield measurements of individual tree yields from 1,500 trees have been regularly made daily since 1917. The records obtained show that, disease apart, trees which were high yielders in 1917 are, in 1924, still high yielders. Similarly, poor or moderate yielders have remained poor or moderate yielders.

The other observations on individual tree yield mentioned, were made at Peradeniya, Ceylon, by Messrs. Bryce and Gadd, and form the subject of a recent bulletin. The Ceylon investigations are less valuable than those of the H.A.P.M., in that the behaviour of the trees has been followed for two years only. Whilst during this period the position of the individual trees was not always rigidly maintained, to the extent that No. 1 tree persistently ranked as No. 1, it was found that as a class, the good yielders remained good, and the low yielders remained low. What is more interesting, is the fact to which reference is made under another head, viz., that the high yielding trees show a greater percentage yield increase with age than low yielders. Whereas the best class of trees increased their yield in one year by 30 per cent., the group classed as "low yielding" by previous measurements only showed an increase of 9 per cent.

The fact that trees with initially low yielding capacity do not appear to improve in yield with age to the same relative extent as do trees which are good yielders from the start, emphasises the importance of Hevea selection, and any planter who has been led by seasonal fluctuations in tree yield to look upon relative yield capacity as a variable thing, susceptible to considerable change with age or under manurial stimulus, should now realize that the permanence of yield characters has been established beyond all doubt.

I shall return to the question of manuring and rubber yield presently. I will only note here, that, on the basis of their experiments, Messrs. Gadd and Bryce agree with the conclusions of other writers that yield is an inherent character. Their view is that "a tree is in general born a good yielder or a bad yielder, and will always remain such."

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HEVEA SELECTION.

Investigations carried out during the last few years have brought home to us the widely differing yield capacities of our rubber trees. We now know that the yield capacity of a tree is a relatively fixed character of composite origin, but dependant mainly upon intrinsic anatomical or constitutional peculiarities. The observations already quoted in this report show that over a period of seven years, which is long enough to permit of a safe judgement, good yielders have been found to remain good yielders and bad yielders to remain bad yielders. This is true under all manner of soil conditions, and though it is possible by appropriate cultural methods to stimulate within narrow limits the yields of trees, the art of rubber cultivation knows of no alchemy which will enable us to transform a bad yielder into a good yielder.

In the propagation of high yielding Hevea stock, two methods are open to us, *e.g.*, Seed Selection and Budding. Budding, since it seems to offer a quicker path to our goal, has, so far, been the method most favoured, and progress with this is well advanced. Seed selection is a slower business. It is, moreover, a method which calls for special facilities, and a knowledge of heredity and science not usually possessed by the planter. Hence outside the experimental stations and one or two estates, which are really only beginning the work, nothing has been done.

With regard to the progress made with budding, conflicting rumours have got about, and it was, as already stated, one of the main objects of the writer's recent tour to ascertain the true facts. As he has visited most of the budded areas in Sumatra and Java and F.M.S. and has had an opportunity of looking into the actual yields, etc., he is, perhaps, able to speak with some knowledge on the question.

BUDDING.

When the subject of budding Hevea first attracted the attention of planters, the enchanting possibilities of yield enhance-

ment proved too much for the uncritical lay mind. All kinds of extravagant expectations were encouraged, and it was readily believed that we had only to bud from our best yielders in order to obtain straightway, in the first generation, plants capable of yielding 2,000 to 3,000 lbs. and upwards per acre.

It was all too easy and decidedly too good to be true !

Actual results obtained from the budded areas which have since come into bearing have, as might have been expected, not borne out the predictions so widely diffused, and the brief spasm of optimism has given place in many quarters to equally unjustified pessimism. Budding, we are now told by the erstwhile enthusiasts, is a " wash-out."

In view of the present over-production of rubber, it is perhaps, fortunate, that this wave of disappointments in regard to budding has supervened. One of the perturbing features of ordinary rubber planting, perturbing because it may mean its destruction as a European-run industry, is that it is too easy. Had it been possible to bud from high yielders with a certainty of raising equally high yielding trees, nothing could have averted an over-production of rubber which would have robbed the industry of all reasonable profit for a generation.

However, while welcoming the reaction, which will have the effect of stopping any frenzied planting up of new areas for a few years, a critical survey of the results achieved by budding will discover some distinctly encouraging features. Budding is by no means the " wash-out " it has been declared to be. On the contrary, for those planters who can look ahead, and are willing to devote the necessary study and labour to the essential preliminaries, it promises to be a highly successful means of improving the yield value of rubber lands.

It is difficult to set forth the true position in a short report, but the attempt has to be made.

Beginning with the errors, the expectation formerly entertained was that one had merely to bud from a high yielding mother tree, and high yielding offspring would certainly result.

This was disproved by the first tapping results on Pasir Waringen, which showed the yields from two or three of the clones* derived from high yielding parents to be moderate or low. The Pasir Waringen experiments, so far as they went, seem to indicate that for the transmission of high yielding qualities the possession of

* All the budded offspring of a single mother tree are referred to collectively as a " clone."

an unusually well developed laticiferous system, *e.g.*, of a high number of latex rings, by the mother tree is indispensable. A distinction between hereditary high yielding capacity and acquired high yielding capacity was foreshadowed. Certain trees are, presumedly, high yielders in virtue of better soil facilities or superior root growth. As these are accidental characters, such trees cannot be relied upon to transmit their high yielding qualities to their budded offspring. Only high yielders possessing also a high number of latex rings were thought to be capable of doing this.

While the possession of high number of latex rings must still be regarded as an important character in a bud mother, it is now clear from the more extensive experiments of the H.A.P.M. that this anatomical feature is no infallible guide to mother tree selection. Many high yielding mother trees well-endowed with the character mentioned have been found to give rise to moderate yielding offspring.

Yields from Budding.

Rubber production figures, derived from large numbers of buddings, though in the possession of certain estates, are not available for publication. Those published by the A.V.R.O.S. Experimental Station relate to a few months tapping only, while as to the Pasir Waringen figures, these are, for some reasons, suspect. Of the buddings in tapping from which production data for a whole year, obtained by a uniform system of tapping are available, only those of " Bodjong Datar Estate " (Java) have been published.

In the following table, the average annual yields of a number of different buddings on Bodjong Datar have been calculated from the average monthly yields throughout the year. These are compared with the average annual yields of a collection of seed grown trees illegitimately derived from the same maternal parents as the buddings, and grown on the adjoining plot.

As some thinning out took place in the selected seed garden, actual comparative yield figures from these are to be had for nine months only, and the annual yield given below is calculated from these.

Following the Bodjong Datar results are given the average yields from two budded clones on Madjau Estate, also calculated from nine months' results. All the yields quoted were obtained by tapping alternate daily on half circumference, the tapping being started at 27 inches from ground in January, 1923, when the trees were four years and ten months old.

Yields of Buddings on Bodjong Datar.

Number of Trees tapped in each Clone.	Distinguishing No. of Clone.	Average Annual Yield of Dry Rubber per Tree.	Average Girth Measurement of Trees.
32	P.W. 94	4.25 lbs.	19.0 inches.
192	P.W. 60	4.5 ,,	18.6 ,,
46	P.W. 172	3.5 ,,	19.8 ,,
27	K.H. 54	4.0 ,,	18.1 ,,
207	P.E. 24	3.1 ,,	17.6 ,,
372	P.E. 147	3.0 ,,	17.4 ,,
54	K.H. 3	3.37 ,,	20.6 ,,
95	P.W. 43	2.63 ,,	19.0 ,,
101	P.W. 28	2.47 ,,	19.5 ,,
267	K.H. 8	2.3 ,,	17.5 ,,
Yields of Trees grown from Selected Seed (Bodjong Datar)			
242	Group T. 52	4.0 lbs.	21.2 inches.
253	,, T. 48	2.83 ,,	20.7 ,,
277	,, T. 45	2.16 ,,	19.7 ,,
Yields of Buddings on Madjau Estate.			
	K.H. 79	4.4 lbs.	
	K.H. 86	4.1 ,,	

NOTE.—Illegitimate Seed = Seed of which the male parent is not known.

The chief point to note in the above table is the different yield values of the twelve clones. The four first clones on Bodjong Datar and the two Madjau clones may be classed as first rank producers. Next come three good yielding clones, and finally three (for buddings), moderate or low yielding clones. With regard to the selected seed-grown trees, these embrace, it will be observed, one group of first rank yielders. The other two groups are only of moderate yielding capacity.

Attention should be directed to the girth measurements, which in the selected Seed plots are slightly higher than in most of the Budding plots.

The Bodjong Datar experiment is exceptional in that it is the first instance in which the yields of buddings and those of Selected Seed-grown Trees of the same maternal parents, and of similar age have been compared. By some people, the result of the experiment is held to show the preferability of illegitimate selected seed over buddings, it being contended that if the selected seeds are closely planted, and the poor trees afterwards thinned out, the average yield per acre will be equal to that obtained from buddings.

The question of Budding *versus* Selected Seed will be discussed later. I will only say here that in my view, this conclusion, arrived at by considering the yields of the first group only, is not warranted when the results from the three groups of selected seed grown trees are taken as a whole. Through budding, there is good reason to think, races of trees, all high yielders can be obtained. Areas planted from seed, the maternal parent of which only is known to be a high yielder, will always contain a mixture of high, moderate and low yielders.

All trial tappings carried out on buddings to date give similarly mixed results to those of Bodjong Datar. Owing to the non-transmission of the parental capacity for yield in numbers of cases, a block of mixed buddings does not show the great superiority expected over a similar area planted in the old way. A 10 per cent. to 50 per cent. increase in productivity is all that can be looked for from the budded areas now in being. These results are responsible for the present pessimism.

So much for those aspects of the earlier budding results which have been interpreted as unpromising. Attention may now be directed to some features common to all results, early and late, which tend to confirm one's faith in the future of Budding.

Results from Buddings Interpreted as Promising.

While the results from budded areas in tapping have shown that some high yielders do not give rise to good yielding offspring, they have shown equally clearly that other high yielders do transmit their capacity for yield. In the Pasir Waringen, the A.V.R.O.S., and the much more extensive budded areas of the H.A.P.M. Plantations, certain mother trees have been found to give buddings which are uniformly high yielding. On the H.A.P.M. the average yield of the five-year old buddings in several distinct clones has worked out at 4½ to 5 lbs. per tree, or 500 lbs. per acre annually. The tapping system used was a single third cut daily, cuts being commenced at 40 inches. Other clones on the same estate similarly tapped have produced an average of 4 lbs. and 3 lbs. per tree at this age, the highest yield recorded being 6 lbs. per tree. These quantities, it should be remembered, are all average yields, in each case, from a group of trees (from 50 to 125) derived from one parent. The yields of individual members in one of these superior clones have been as much as 9 lbs.

Uniform Yields of Buddings.

The outstanding feature shown by the tappings of all buddings is the uniformity of the yields of the members of any one clone. All are good yielders, moderate yielders, or indifferent yielders. They

do not display the enormous variation in yield shown by trees derived from seed taken from the same tree, and which, as will be seen presently, is also shown by the seed grown progeny of selected high yielders.

Now what do these results mean? If this uniformity in yield exhibited by Buddings on divers stock, with every variety of root system, shows anything at all, it shows that yield has a strongly hereditary aspect. The results quoted demonstrate beyond all doubt the existence of high yielding Hevea trees, which owe their high yield to heredity, and not to the accidental circumstances of environment. *In the fact that there are high yielding trees which, when budded from, give rise to offspring which are also uniformly high yielding under all sorts of conditions, we have a guarantee that the Selection and Vegetative Propagation of Hevea will make possible the establishment of Hevea plantations of considerably higher productivity than our present areas.*

Age and Yield.

A word is, perhaps, called for on the subject of Age and Yield. The results quoted are all from first year tappings. Yields from seed-grown trees, it is scarcely necessary to mention, increase their yields year by year, attaining eventually a production of two or three times that given by first year tappings.

There is no reason to doubt that the yields of buddings will increase with age, at least, in the same degree. The Ceylon observations show, indeed, that one may expect the output from these high yielding clones to increase to a much greater extent than the output of ordinary plantings, so that, although one has admittedly no warrant at present for prophesying yields of 2,000 and 3,000 pounds per acre, which may be dismissed as a dream as far as the budded areas in being are concerned, 750 to 1,500 lbs. may confidently be looked for when the hereditary behaviour of our high yielders is known, and one is able to bud from proven stock.

Such a forecast is no dream except for estates which possess no reserve land. For these, budding naturally presents no attractions. It is to the large concerns in Malaya and the Dutch East Indies with undeveloped land that the possibilities of budding will appeal. Whatever the price of rubber, estates which are able to reach a production of from 750 to 1,500 lbs. per acre will always be able to secure a profitable return.

Influence of Height of Cut upon Yields of Buddings.

In another portion of this report, the manner in which the yields of seed-grown trees vary with the height of cut is discussed. Owing to the termination of the scion latex tubes at the fusion zone just

above ground level, it was expected, and the very earliest yield results confirmed these expectations, that yields from budded trees generally would not increase as the cut neared ground level. The data available do not, at present, enable one to give any sort of value to the height factor. Indeed, it is doubtful whether any very definite relation will be established, for in this respect, each budded tree, much more than is the case with seed-grown trees, is a law unto itself. On the H.A.P.M., I understand, some of the buddings give less at ground level than at 40 inches ; others give about the same, while others again give higher yields at ground level than at 40 inches. I have no actual figures of the yields at the different heights from this source, but a few are available from the Buitenzorg Experimental Station. Taking the average yield at 40 inches as 100, Dr. Cramer found the average yield at 12 inches from ground to be 137, 105 and 146 in three small groups of buddings derived from three distinct parents. The average yield of seed-grown trees at 12 inches was, it may be recalled, about 175 when that at 40 inches was taken as 100.

When the cut was made lower down, in these cases at 1 inch from junction, Dr. Cramer noted, instead of a rise, as would occur in seed-grown trees, a very pronounced fall in yield. While an exceptional tree or so produced as much, or more, at 1 inch from the junction as at 40 inches, the majority of the buddings produced less. The ratio of the yield obtained at 1 inch as compared with that at 40 inches was as 80 to 100.

These figures must not be taken as expressing the true ratio for all buddings, since they were obtained only from a trifling number of trees. They serve but to show that near ground level a point will be reached at which tappings fail to give the yields obtained when the sector was commenced. Present indications lead one to think that this will happen in the majority of buddings. In the case of a small minority, in which the stock as well as the scion will be first-class, some evidence to be adduced presently suggests that this decline in productivity at low levels may not be shown except in the zone of union.

On this question of the lower productivity of buddings near ground level, it seems advisable to point out that we have as yet productive data only from quite young trees in which the dislocation of the laticiferous and conductive tracts at the zone of fusion of scion and stock can scarcely be held to have been fully restored. It is possible that when the buddings are ten years of age or more, a greater co-ordination in the tissue arrangements at this centre will have been brought about and the yield curves may not show such falling away at the low level.

Whether this is so or not, it must not be thought that the effect discussed forms a serious objection to buddings. In the first place, there is, where buddings are concerned, no necessity to continue tapping near ground level, since the bark can be productively tapped at greater heights than with seed-grown trees. Secondly, well-chosen buddings, notwithstanding the diminution in yield at low levels give an average yield throughout their bark cycle much greater than that of random selected seed plants. This will be seen from the following table, in which the average yields at 40 inches and at 1 inch of three first-class buddings are compared with the average yields of a small number of seed-grown plants at the same heights over the same period. The figures are the average yields per tapping in ounces dry rubber.

	May-July. (40 inches)	Oct.-Nov. (40 inches)	Dec. (40 inches)	(Excessive Rains) Jan.-Feb. (40 inches)	Feb.-Mar. (1 inch)
Buddings ..	0.55 oz.	0.61 oz.	0.52 oz.	0.33 oz.	0.28 oz.
Seed-Grown Trees ..	0.07 ,,	0.10 ,,	0.11 ,,	0.08 ,,	0.10 ,,

In regard to the above figures, it might be contended that I have, in the case of the buddings, selected the yields of three good trees only for comparison with the yields of what is evidently only a very moderate yielding collection of seed-grown trees. Apart from the fact that it is this superior type of tree which budding enables us to propagate, and is only justified as a practical method in so far as it achieves this, my reason for choosing the good examples is to show how little the falling off in yield at low levels detracts from the very great yield superiority of well-chosen trees throughout most of their tapping cycle. I may also emphasize a point here, which may otherwise be overlooked, and that is that generally speaking, the better the budding, the greater the falling off in its productivity at ground level. In some of the lower calibre buddings, the yields at ground level were actually greater than those at 12 inches and upwards. This is equivalent to saying that the stock tissues were superior to those of the scion.

The falling off in the yields of good buddings when the knife reaches stock tissue, is then, rightly looked at, a useful confirmation of the heritability of yield in buddings. Such phenomena as those discussed have been the incentive of an enquiry into the influence of the stock on scion in Hevea buddings, and we may now look into some evidence which has been obtained on this.

Reciprocal Influence of Stock and Scion.

In most other plants in which budding or grafting is resorted to as a means of propagation, the choice of stock has been found to be a matter of importance. With pears, for instance, when it is desired to get big trees, wild stock are chosen ; for pyramidical shaped trees, stock of the Quince. Similarly for most other fruits—both for the internal and external qualities of the fruit, as well as for vigour, habit, and quantity—out of the varieties of stock available, the one is chosen which experience has shown will give the qualities desired. It may be mentioned in passing, that Java experimenters have found the choice of stock of great importance in grafting coffee.

Very little study of the laticiferous arrangements in Hevea is required to convince one that here also the stock must have a great influence. One might almost say that, for the attainment of the object sought in making the union, *e.g.*, high yield, there is necessary in a Hevea budding a more harmonious agreement in structure and greater physiological co-ordination between scion and stock than is demanded in other buddings. Indeed, so rarely must it happen, that a scion of the highest possibilities is conjoined with a stock of equal yield potentialities, that we are, perhaps, unjustified in ever expecting from a budded plant yields quite equal to those of its scion parent.

On the reciprocal influence of stock and scion on one another in Hevea buddings, Dr. Cramer has, in his Buitenzorg experiments, collected some suggestive figures.

Firstly, as regards growth. The rate of growth of the root stock of the budding is found to be related to the vigour of the scion used. Where the scion is vigorous in development a corresponding vigour is displayed by the foreign stock. In the cases recorded by Dr. Cramer, buddings with vigorous scions were found, some four years after the operation, to measure in the collar region more than seedling grown trees of similar age derived from the same mother tree. Stock under weak scions showed, on the other hand, a smaller circumference in the region mentioned. It was also noticed that the collar girths of seedling grown plants displayed greater variation than that of the collar girths of buddings.

Coming to the more important relation of the yield of stock to that of scion, Dr. Cramer records also a greater uniformity in the yields of the scion portion than in those of their stocks. Taking three examples, the relative yields were :—

	No. 1.	No. 2.	No. 3.	
Yields from scions at 12 inches	0.94 oz.	0.71 oz.	0.56 oz.	dry rubber.
Yields of stocks at ground level ..	0.72 ,,	0.56 ,,	0.25 ,,	,,

Other groups of buddings in which the scion region and stock of each plant were tapped gave figures of a like character to those cited.

A point which will probably strike people, apart from the greater variation in the yields of the stocks, is the good yields produced by the two first stocks of the three examples. They are only from 20 to 25 per cent. less than those of their respective scions. Though this seems to show that, tapped in their most productive region, some of the plants used as stocks would give yields almost equal to those of high yielding scions, a study of the comparative yields of other stocks and their scions leads one to think that the figures given above do not represent the true yields of the stocks, that is to say, their relative yield value if grown alone. Dr. Cramer found that in all cases the respective yield values of the stock and scion show some relation to one another. Stocks which were budded with scions from proven-out high yielders gave also relatively high yields. Stocks, on the other hand, budded from moderate yielding trees gave lower yields.

The number of trees from which Dr. Cramer's results are drawn is unfortunately too small to warrant the observations mentioned being taken as established truths of budding, but Dr. Cramer regards them as very suggestive. He believes that they indicate the existence of a reciprocal influence between scion and stock upon each others' yield. Where a high yielding scion is budded upon a good yielding stock, not only will the superior yielding qualities of the scion be more fully brought out ; the yield of the stock region will also be higher than it would when nourished by its own shoot.

The practical conclusion is, of course, that in order to realise the highest yield possibilities of our buddings, care must be exercised to bud only on to stock grown from the seed of high yielding trees, or on to stock of good quality. This is rather an ideal at present. The chief value of the above work, however, is in directing our attention to the importance of stock, and in disabusing many planters of the idea they now hold regarding budding, viz., that any old thing will do to bud on to, provided the scion is well chosen.

Having discussed the yields, actual and prospective, of buddings, treated of first, because of their importance, it seems desirable, since the object of this paper is to summarise the general progress on the subject, to consider for a few moments some other matters of interest connected with buddings.

External Peculiarities of Buddings.

One of the characteristic features of buddings is the agreement in habit shown by the members of the same clone. In a plantation

of mixed buddings, it is possible in numbers of cases, to pick out the descendants of a particular mother tree by their mode of branching.

A striking instance of the inheritance of these external characters by buddings is to be seen on the H.A.P.M. plantations. Here one of the trees chosen as a bud mother had, instead of the usual smooth surface, a mass of irregular wart-like corky protuberances. This unusual character, suspected at one time to be due to pathological causes, but now, seemingly, a sort of mutation, has appeared in every one of the 200 odd budded offspring. The spectacle of this assemblage of young buddings each with its curious pachydermatus inheritance is impressive.

The uniformity in the characters of buddings, which one has frequently had cause to mention, is manifest in another feature, *e.g.*, contemporaneous seed production. The members of a clone flower and seed at about the same time. The latter trait has, it will be understood, to be borne in mind in comparing yield figures of buddings, since production will, in all the members of the clone, decline simultaneously at the wintering period.

Deserving of mention also in this connection is the relatively earlier attainment of the seed bearing stage by buddings. Many buddings commence to flower in their third year. On some one year old buddings on which the buds had been applied high up on the stock, and which the writer recently saw in Java seeds had already appeared. This premature fruiting is, as will be mentioned later, of value when buddings are utilised for the production of selected seed.

Perhaps the two most characteristic external peculiarities of buddings are the Elephant's Foot Protuberance at the base of the stem where the scion tissue joins the stock, and the Cylindrical Trunk form. The trunk of a seed-grown tree, as is well known, falls off regularly in circumference with height. In a budding, on the other hand, the decrease in circumference with height is so gradual as to be almost unnoticed in a casual inspection. A collection of buddings at Buitenzorg were found to measure only from 12 per cent. to 20 per cent. more at 8 inches than at 40 inches from ground. In the seed-grown trees compared, the circumference at the lower height was at least 30 per cent. greater than at 40 inches.

An internal character, possibly correlated with this, is the smaller extent to which the number of latex rings decreases with height in buddings. While the number of latex rings in seed-grown trees is frequently at 40 inches, 25 per cent. or more below the number at 6 inches, buddings are found to possess at 40 inches nearly as many latex rings as at 6 inches.

Growth of Buddings. While the set-back caused by the operation of budding naturally handicaps a budded plant as against a tree grown directly from seed, the rate of growth of buddings is usually quite satisfactory. In regard to growth, buddings are quite equal to stump derived plants.

It is interesting to observe that, just as with yield, so in rate of growth, greater uniformity is exhibited by the budded offspring of a tree than by the seed-grown offspring of the same tree. Whereas the differences in rates of girth development of a progeny of seed-grown trees were so great as to lead to the best trees reaching the tapping stage three to four years before the slow growers, the trunk growth in the budded clones investigated was of such uniformity that 100 per cent. of the trees were of the standard trunk size within from one to two years from the time the best trees had reached this standard.

This greater uniformity in growth may be of passing value in the early history of a plantation, but one cannot altogether agree with Dr. Cramer, who carried out these measurements, that the point is of much consequence, since in practice, estates would be planted up not with one, but with many clones, and the growth differences amongst the trees of these mixed clones will probably not be much less than those shown by seed-derived trees.

A Few Imagined Defects of Buddings.

It has been left to the F.M.S. Agricultural Department, which has contributed nothing to the advances made in Hevea Selection, to discover a few bogies in the path. Belgrave has pointed out that the point of union in a budding will always be a source of weakness, and that in a storm, the buddings would be liable to fracture across at this region.

This objection, to begin with, is, from the mechanical standpoint, absurd, since the point of union in a mended fracture is when it has been satisfactorily welded, the strongest region. Experience shows that this is no less true of the point of union in Hevea buddings. During a violent storm on the H.A.P.M. Plantations, in which much damage was done to the budded and other trees, not one case was observed in which a budding had broken across at the zone of junction with stock, though many of them were fractured higher up, and here and there, trees had been blown clean out of the ground.

Susceptibility to Disease. In a recent F.M.S. Agricultural Bulletin, Sharples expresses a fear that budded trees may prove more susceptible to disease than seed-grown trees. He mentions a case in which a few buds made on three-year-old stocks got badly attacked by fungi.

In regard to the instance given there is only one remark to make, and that is that anyone who utilises three-year-old stock for budding on to is asking for trouble. It was long ago discovered that the most suitable age of stocks for employment in budding is from nine months to one year. As Hevea plants grow older, they become progressively less capable of being successfully budded, and where three-year-old stocks are employed, the shoots produced by the scions are frequently measly looking, and liable, one would think, to succumb easily to disease.

As to the contention that buddings generally are more susceptible to disease than seed-grown plants, experience on the many thousand acres of budded rubber in Sumatra and elsewhere gives it no support. Buddings which have been properly made, and are growing under decent conditions, display no especial proneness to disease.

Coming to the question of Brown Bast, an affection which, perhaps, might be held to be more easily provoked in buddings owing to their greater productivity, here, again, actual experience tends to allay one's apprehensions. Steinmann reports that on Bodjong Datar Estate, the Brown Bast casualties after a year's tapping were, amongst the budded trees, 3 per cent. ; and, amongst the selected seed-grown trees, 7 per cent. These figures are quoted, not to refute the idea that buddings may be more susceptible to Brown Bast, but to show that at present experience lends it no support.

Sharples, in justification of his cautionary remarks, says : " The admission that in Malaya there has been no opportunity to carry out bud grafting for ourselves does not prevent us from calling attention to the shortcomings in the published records of results from bud grafting elsewhere."

To this one may reply : " Criticise by all means, but don't base your criticisms on the behaviour of a few trees, or entirely on the meagre data which scientific workers in other countries, most of them with fewer opportunities than are at hand in Malaya, have published. Also why use the imagination and give vent to all kinds of idle fears when opportunities for visual observations are almost at your door." Within two days' journey of the F.M.S. there are some 12,000 acres of budded plants in all stages of growth which can be easily viewed.

Will Buddings Degenerate ? Because varieties of potatoes and many other vegetatively produced plants fall off in vigour after having been grown for a number of years in a district, it has been suggested that Hevea trees derived from buddings, may also

deteriorate after a time. If analogies prove anything there is just as much justification for saying that deterioration will not, as that it will, occur, since there are numbers of fruit trees in Europe which show no signs of degeneration though they have been vegetatively propagated for long periods.

A view closely akin to the one just discussed is, that, owing to the derivation of the scion portion of buddings from branch tissue already, in many cases, advanced in years, the duration of life of buddings will be proportionately shorter than that of seed-grown trees. Here, again, when analogies are invoked they prove just as little one way as another, for vegetatively propagated trees are known in Europe which are at least a century and half old, and still going strong. So far as Hevea is concerned, the planter would be well content if the span of life of his high producing buddings only turns out to be a quarter of this period. The vigorous development of buddings up to now justifies much longer expectations of life, and it seems quite unlikely that they will supply a useful illustration of the old saying that the " good die young."

A final argument which lessens the force of any objection as to possible degeneration or poor life prospects, is, that by many people, budding is only looked upon as a half-way-house on the way to seed selection. Eventually it is hoped to dispense with vegetative methods of propagation in Hevea.

Quality of Bark Renewal.

Owing to the fact that scion tissues of buddings are directly descended from branch tissues, there has been much speculation as to the quality of bark renewal after tapping in buddings. Since the oldest buddings have scarcely been two years in tapping, it is too early as yet to venture an opinion on this. According to report, however, the bark renewal on the buddings in tapping shows every promise of being good enough.

Attitude of Scientists and Planters towards Budding.

It is impossible in the limits of these few notes to refer to more than a little of the evidence upon which the optimism regarding budding is based. All the scientific workers who have closely studied the subject at first hand are convinced of its possibilities. The members of the H.A.P.M. staff, who are in charge of the selection work, and who have had more experience of budding than all the rest of the rubber world put together, were, I found, entirely confident of carrying their work through to success. Such pessimism as I encountered during my three months' tour was chiefly amongst

planters, generally too despondent over the slump to seriously give attention to budding or any other scheme which meant "more rubber." True, there are scientific men in the F.M.S. and Java who are lukewarm, and to a certain extent critical of the possibilities of budding, but scarcely one of these has, as far as my knowledge goes, any intimate first-hand acquaintance with the subject and generally they are uninformed of any results except those of Pasir Waringen and of the other small budded areas in Java.

I have referred to the apathy on the subject of Hevea budding, for which the slump is responsible. The attitude of many planters towards the recent work on budding can less be described as apathetic, than as hostile. In certain circles in the F.M.S. and Ceylon, every difficulty thrown up by the researches of "Buddists" is hailed with satisfaction, and the hope that the object sought in budding will not be realised is freely expressed.

The desire of many Ceylon planters that the efforts at stock improvement through budding will not be successful, is, of course, understandable. The practicability of replanting much of the area now under rubber is questionable, and so little fresh land is available in the Island, that Ceylon would, one fears, be left out of the running should budding become a serious factor.

The attitude of Malaya is less reasonable. The badly washed-out estates of Malaya cannot be satisfactorily replanted, but there are, in Malaya, immense areas of virgin land ideally suited to rubber, still available. It is difficult to see that Malaya's position could be permanently worsened by the success of budding, unless, as seems likely, she is, through neglect of scientific research in her leading industry, left behind in the race. Malaya may yet regret that her Agricultural Department has "cried wolf" so often on the subject of budding.

Present Area of Budded Rubber.

A rough estimate of the area of budded Rubber at present in existence gives Sumatra 12,000 acres, Java 2,000, and Malaya 2,500. It is impossible to get the true figure, but at the most, the area of budded Rubber in being (which also includes many interplanted seed-grown trees) would not exceed 20,000 acres. Of this area, 6,000 acres in Sumatra, and 2,000 acres in Malaya belong to the American Rubber Companies, chiefly to the General Rubber Company. Apart from the American buddings, the only area of budded Rubber, deserving of mention, in the F.M.S., is the 1,000 acres estate of Major Gough, near Kajang, which has been planted up with buddings and seed plants intermixed.

Future Competition from Budded Rubber.

Regarding the yield prospects of the budded areas in being, some idea will have been got from the foregoing discussion. From the best of the areas a production, greater than that from areas planted with seed, of from 20 to 50 per cent., may be expected. An increase of this order will, probably, be obtained from the areas budded from carefully chosen mother trees.

Unfortunately for the future materialization of their hopes many of the estates which have gone in for budding, started operations before the capacities of their mother trees had been properly investigated. There is no doubt that readily flowing trees in the incipient stages of Brown Bast were frequently chosen, by casual inspection, as permanent good yielders, and buds taken from these. As a result of this lack of care, it is not expected that the budded rubber on estates generally will prove much superior in yield value to the average random seed-grown rubber. There need, therefore, be no fear of any largely increased production from present budded areas influencing the market.

While the present budded areas may be dismissed as serious factors in production, he can scarcely be described as a visionary who descries, in the less immediate future, a formidable rival in budded rubber. Later on, when estates have undertaken the stock-taking described, and have planted up their reserve lands with proven-out stock, we may expect to begin to feel the competition from this source. Whether the competition will have disastrous consequences or not for the older plantings, depends upon the demand for the product. Possibly by the time the production from budded areas becomes of sufficient importance to influence the market, the world will need all the rubber available. Should this happen the older areas, by then probably sadly deteriorated, will enjoy a final flicker of prosperity.

The evolution of suitable high yielders for use in budding is, one need scarcely point out, going to take time. Five years at least must elapse before the few progressive estates, which are making a scientific study of budding, will be in possession of sufficient data to commence operations on a large scale, while it will be another decade before any appreciable quantity of rubber from budded areas makes its appearance on the market.

For this breathing time we should, I think, be devoutly thankful. In view of the surfeited condition of the rubber market, a simple and rapid method of improving the yield of rubber areas, such as budding was at first claimed to be, would have been a calamity

rather than a blessing. The discovery that yield improvement through budding can, like most other things worth having, only be fully achieved after careful and lengthy study, is a piece of good fortune for British rubber planters, which they will be well advised to make the most of.

It is to be hoped that the modified yield expectations from the areas so far budded will not lead to apathy on the subject, or the results stated will be quite other than fortunate. The prospects of multiplying yields through budding are merely postponed. They are not cancelled. The experiments proceeding on the one or two scientific concerns in the Dutch East Indies give promise of reaching within the next few years a state of knowledge which will make it possible for their owners to create with certainty from budding, new estates which will yield two or three times the yields of present plantations.

For the benefit of planters in South India, who have already budded up small areas, or have made preparations for doing so, I should make it clear that such buddings are not likely to prove failures. Wherever the selection of mother trees has been carefully carried out, the derived buddings may be expected to give an average production of 25 per cent. at least higher than the production of the present areas. Budding, therefore, is decidedly worth doing on such South Indian estates as have young clearings.

This statement will prevent the indulgence of unrealizable hopes. It will be clear from the foregoing that the maximum yields from budded areas can only be obtained when, by previous trial buddings and tappings the hereditary behaviour of the high yielders on an estate is known.

First Steps in Budding.

Although strongly impressed with the possibilities of budding, I trust I have made it clear that the time for general budding on a big scale has not yet arrived. By no recognizable character, is it possible to distinguish the high yielders which will breed true from those in which yield is not hereditary, and any plantings set out to-day from buds, are bound to result in mixed assortment of high, medium, and poor yielders. Before undertaking large extensions, therefore, the hereditary behaviour of all the very best yielders on an estate should be ascertained. This, as pointed out just now, can only be done by making a number of buddings from each of the likely trees, and subsequently carrying out trial tappings. This work, which every estate has obviously to do for itself, is the first step. It means admittedly a long wait for results, but no estate can

avoid this, and all are similarly placed. Short cuts will only end in failure. Once the hereditary behaviour of the mother trees is known, budding can be proceeded with on a large scale with every assurance of success.

No better advice concerning the selection of mother trees can be given here than has been given already. Although the number of latex rings fails occasionally as a diagnostic character of a good mother tree, it is still a valuable index, and trees should be sought out in which this is found conjoined with exceptionally high yield. Freedom from Brown Bast, and, in South India, insusceptibility to secondary Leaf Fall are also important desiderata.

Where experimental budding is undertaken with the object of proving-out the hereditary high yielders on an estate, at least 75 buddings should be made from each selected tree. The number of likely mother trees which it is desirable to bud from will depend upon the needs of the estate. From 20 to 500 trees should be tested out, according as 50-acre or 5,000-acre plantings are in contemplation.

SEED SELECTION.

While I am a believer in Seed Selection, and think that, ultimately, propagation by Selected Seed will displace Budding, I feel that many seed selectionists are entertaining similar illusions regarding seed selection as were a short time back held by enthusiasts for budding. Seed selection, in short, appears to them to be just such an easy business as budding was first considered to be.

Without wishing to be pessimistic, it seems desirable to point out that we know as yet relatively nothing of the heritability of characters in seed-grown Hevea. We can in matters of this sort only draw on our general knowledge, and this tells us pretty consistently that propagation by seed, which are the outcome of a blend between two parents, invariably leads to very erratic results.

In view of the universal experience with other plants, it is most unlikely that the seed-derived offspring of Hevea trees even where both parents are high yielding, will, in their turn, prove to be uniformly high yielders. One may recall here the familiar facts of Mendelian inheritance, in which certain characters make their appearance in only one out of every four offspring. Remembering this and the frequency of " throw backs," one would be well advised not to place great hopes on getting a race of high yielders in the first generation of Hevea grown from selected seed.

Although it is fairly certain that the average yield from selected seed grown trees, will in the first generation exceed that from a

similar area of random-planted trees, it is equally certain, if experience of selection in other plants is anything to go by, that the yields from the first generation of selected trees will fall very short of expectations. Only by continued selection for several generations, and by the ultimate isolation of pure high yielding strains will the aim of the selectionists be realized.

Some facts were brought to my notice whilst in the Dutch East Indies which emphasise the above-mentioned precaution :

An isolated piece of ground, near a Sumatran estate, contained a group of old rubber trees. One of these trees had been an exceptional yielder for years, giving, I believe, something in the neighbourhood of 20 lbs. per annum. It being desired to get pure seed from this particular tree, the remaining trees were cut out. The seed obtained from the high yielding survivor, which were clearly self-pollinated, were planted, and have lately reached the bearing stage.

As yet, tapping results are only available covering a short period, but these exhibit the most surprising differences in individual yield. Out of the hundred odd direct offspring, some yielded 1 gram., others 2 grams., 3 grams., 4 grams., and so on per tapping. The yield of the poorest member of the group was 0.4 gram., and that of the highest 24 grams.—a difference of sixty times ! The range of yield variation, put in more familiar terms, was from $\frac{1}{8}$ lb. per tree per year to 12 lbs. The total yield from the group promises to exceed that obtainable from a similar number of random planted trees, but the great superiority hoped for cannot materialize owing to the existence of so many poor milkers.

In pointing out the pitfalls of seed selection, I have no wish to discourage pioneers of this method. On the contrary, I should like to see seed selection work taken up more vigorously, particularly on the British side. Seed selection and budding are equally important methods of attaining our objects, and in the present state of our knowledge, any controversy regarding the superiority of one method compared with the other should be avoided.

Seed Selection Gardens.

Work on seed selection was, so far as I could discover, being pursued at three or four centres only—the H.A. Plantations and Avros Station, in Sumatra, and on the Anglo-Dutch Plantations of Java. Selection gardens budded exclusively from high yielding mother trees are possessed by each of these concerns. These seed gardens are situated right away in the jungle, five miles or more from the nearest rubber, so as to avoid all chances of cross-pollination from trees of poorer quality.

As experiments on seed selection had nowhere been taken up until quite recently, no data regarding yield prospects, such as exists on budding, are yet available. On neither of the places mentioned have any but a few exceptional trees reached the stage of seed bearing, and it will probably be another five or six years before the tapping qualities of the generation grown from this seed can be tested.

What the Mass Selection of Hevea Seed leads to.

The attitude of many rubber men towards Hevea Selection makes it desirable to say a few final words on the subject in general. Some planters, believing the silly rumour that budding is a "washout," and, under the impression that Seed Selection is little more than a passing stunt of the Scientific Stations, show an inclination to persist in the old practice of Mass Selection of seed for planting purposes. By this is meant the picking up of seed from heaps collected at random from all over an estate.

On the folly of this mass selection, Dr. Heusser, the A.V.R.O.S. Selectionist, recently made some observations which rubber planters will do well to think over. He points out that between the results of mass selection in the case of plants grown for their seed, such as the coconut or the rice plant and the results of similar mass selection in rubber, there can be no comparison. Through long past selection, the very worst types of coconut trees have been eliminated. We may assume that on the average coconut estate the majority of the trees belong to good types. Since the good type of tree is not only in the majority, but is also the largest producer, a heap of coconuts collected indiscriminately from all the trees will contain a high proportion of nuts of good derivation. Random collection of nuts from the heap for planting, therefore, is bound on the Law of Chance to result in the selection of a high proportion of nuts which will grow up into good trees.

Compare this with the mass selection of seed which takes place on the average rubber estate. The Hevea tree has only recently come into cultivation, and, so far, little has been done to eradicate the worst types. The ordinary Hevea plantation, it is now evident, comprises scores of different races of trees both as regards yield possibilities and other characters. Experience shows that only some 25 per cent. can be considered as belonging to good yielding races. This being the case, what is likely to happen when seed for planting purposes is picked from collections gathered indiscriminately from all parts of an estate?

Leaving out of account any question as to whether good yielders produce fewer seed, as is sometimes contended, we shall, obviously,

on the Law of Chance, pick three seeds from poor yielding parents from the heap for every seed from a good parent.

This is retrograde selection to be sure, but the trouble does not end here. We know that Hevea seed, even from good parents, grow up into trees of which only a minority are high yielders. In view of this, the chances of our finding many good yielders amongst the 75 per cent. of the trees grown from the seed of poor origin is very small.

The behaviour of trees grown from seed of mixed origin cannot be forecasted, but one may reasonably expect that if the present method of mass selection is continued, *we shall be fortunate if* 10 *per cent. of the next generation of rubber trees turn out to be passable yielders.*

The suggestion that our Hevea stock has degenerated has been made more than once, and many thoughtful planters have commented on the lower yield capacity of some of the later planted rubber. The considerations above advanced show that the suggestion that deterioration has occurred is something more than a theory. By the methods usually followed on estates, Hevea trees are undoubtedly selected backwards, and deterioration inevitably goes on.

Selection of Illegitimate Seed.

Little has been said in this report regarding illegitimate selection, that is the taking of the seed for planting purposes (which has resulted from pollination by an unknown father) from the best yielding trees. Planters who are unconvinced of the merits of budding, and have no facilities for proper seed selection should take care that the seed used for further plantings, is obtained only from their best trees. A reference to the tapping results from the illegitimately selected seed grown trees of Bodjong Datar cited earlier in this paper, will show that even by this comparatively easy method of selection, blocks of rubber can be obtained of much higher yielding capacity than the present areas.

Final Remarks on Hevea Selection.

That the recognition of the importance of stock in propagating Hevea has synchronized with a prolonged period of depression in the industry is regrettable. Still, no industry can stand still, least of all an industry subject to international competition like rubber planting. British companies with available land should ponder well the possibilities of stock selection. They should arrange in good time the necessary stock-taking, so that, when the better days prophesied arrive, they will be in a position to take advantage of them. Directors need not be afraid of spending a little money on experi-

mental work, for none of it will be lost. The experience of recent years has taught us nothing if we have not realized the folly of indiscriminate planting. The day when any rubber plant was considered good enough has gone by, and selection in one form or another is likely to be the rule in future extensions. A few early failures with buddings are not likely to prevent the ultimate success of the method, but should the unlikely happen, there is still seed selection to be reckoned with, and we may be sure that this will not fail in achieving its object. Slump or no slump, if British planters ignore the allurements of increased production and lower working costs offered by seed selection or vegetative propagation, the American rubber users who are out for cheap rubber, are scarcely likely to do so.

The foregoing review of the results of Hevea selection is an attempt to describe the present position, as I see it. It is necessary to say, in conclusion, that my remarks there anent must not be taken as arising from a desire to whip up a new interest in the subject in South India. I am well aware that the field open locally to Seed Selection or Budding is small and strictly limited by a number of circumstances. So far as South India is concerned, budding is advised only in present young areas which are not too old for supplying. The opening of fresh land is not recommended. The only step in this direction which estates generally might take, with a view to possible future contingencies, is the evaluation of their high yielding trees.

BROWN BAST—AN ENQUIRY INTO THE KEUCHENIUS TREATMENT.

The mycologist of the Holland-America Plantations in Sumatra, Mr. Keuchenius, who has been working on the Brown Bast problem continuously since 1917, issued some time ago the results of his investigations. The original paper was written in German, and has appeared only in a German scientific journal. Owing to this, and to the fact that the one other account—a short summary—was published in Dutch, British rubber planters, with few exceptions, have remained in entire ignorance of work which may be regarded as the latest real contribution to our knowledge of Brown Bast.

Some of the results of the above-mentioned investigations appeared to me to be of such importance that I lost no time in bringing them to the notice of South Indian rubber planters. A few estates took up the new treatment straightway, and on others preparations were made for doing so. Disappointment with the results of past Brown Bast work had, however, made planters generally somewhat sceptical of the value of any measures against Brown Bast, and it

was felt by certain planters who were keen enough to begin, that before committing themselves to further expense, it would be a good thing to get some first-hand information as to the effectiveness of the Keuchenius treatment. It was one of the objects of the writer's recent tour to obtain this fuller information.

Thanks to the courtesy of the H.A.P.M. Authorities, who gave me every facility, I was able to spend several days on their properties looking into the results of the Keuchenius Treatment. During my visit I was fortunate in meeting Mr. Keuchenius himself, and in being shown by him over the treated area. Mr. Keuchenius demonstrated the method of applying the Isolation Treatment under different conditions, and cleared up certain difficulties. Together with him, I inspected treated trees, new and old, and witnessed the Brown Bast gangs in operation.

As it is difficult to give my impressions of the results of the Isolation Treatment without reference to the details of treatment, I have thought it advisable to repeat here the summary of Mr. Keuchenius's views of Brown Bast, and method of treatment previously circularised to South Indian planters. Comments on the treatment are made in the course of the description, and further comments follow at the end.

The Keuchenius Theory of Brown Bast.

Dealing first with the nature and behaviour of the disease (which Keuchenius still holds is of bacterial origin) briefly, the investigations referred to show :—

(1) That Brown Bast is essentially an affection of the latex tubes, and is propagated from point to point in the tree solely along the latex tubes.

(2) In its original incidence, the affection is exceedingly local, and is limited to a very small area.

(3) The subsequent spread of Brown Bast,until it assumes the dimensions usually met with, is due to continued tapping on or in the vicinity of the diseased area. (This transference of the affection from diseased to healthy regions is termed by botanists " metastasis.").

(4) The extension of the disease can be prevented entirely by the isolation of the affected zone by means of a deep channel to the cambium.

(5) Provided the isolation is efficiently carried out, tapping can be proceeded with anywhere outside the isolated zone, without any danger of the Brown Bast spreading thereto from the old patch.

mental work, for none of it will be lost. The experience of recent years has taught us nothing if we have not realized the folly of indiscriminate planting. The day when any rubber plant was considered good enough has gone by, and selection in one form or another is likely to be the rule in future extensions. A few early failures with buddings are not likely to prevent the ultimate success of the method, but should the unlikely happen, there is still seed selection to be reckoned with, and we may be sure that this will not fail in achieving its object. Slump or no slump, if British planters ignore the allurements of increased production and lower working costs offered by seed selection or vegetative propagation, the American rubber users who are out for cheap rubber, are scarcely likely to do so.

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(3) The subsequent spread of Brown Bast,until it assumes the dimensions usually met with, is due to continued tapping on or in the vicinity of the diseased area. (This transference of the affection from diseased to healthy regions is termed by botanists " metastasis.").

(4) The extension of the disease can be prevented entirely by the isolation of the affected zone by means of a deep channel to the cambium.

(5) Provided the isolation is efficiently carried out, tapping can be proceeded with anywhere outside the isolated zone, without any danger of the Brown Bast spreading thereto from the old patch.

That the continued tapping of a diseased tree would be likely to lead to the extension of the affected area is, of course, really implied in point (1), for if Brown Bast is a disease of the latex tubes, and is propagated solely along these tubes, it is easy to understand that tapping, by causing the movement of contaminated latex from diseased to healthy tubes, will, in all probability, set up the affection in these as well. It follows, also, from the same theory, that the complete severance of all connections between the latex tubes in the Brown Bast affected zone, and those outside, would prevent the disease passing over.

There is, however, one difficulty which will arise in the minds of most people, and this difficulty I will now anticipate. Admitting, in the light of the theory expressed, the impossibility of the disease crossing the isolation gap, what, it may be asked, is going to happen when the gap has, in the course of time, been bridged by the development of new tissue? Once the connections are re-established, will not the danger of Brown Bast spreading be as great as before?

In answer to this question, it may be pointed out that contrary to popular belief, the latex tube connections, sundered by deep channels of this sort, are never re-established. Latex tubes are slowly regenerated in the new tissue behind the wound, but these are not continuous with the old ones on either side of the gap, and are quite unconnected therewith. The wound tissue, termed by botanists, "callus," which fills the gap, is distinguished entirely from the tissue cut away, and, as one would expect from theory and Keuchenius's observations, confirm, this "callus" forms just as effective a barrier to the passage of Brown Bast as an actual gap.

Keuchenius stated in his original paper, that out of the many thousand diseased trees so treated on the five thousand acres embraced in his experiments, not one case has been observed where the Brown Bast has spread from the isolated patch first affected, to the tissue outside. This statement is not wholly correct, for the writer, during his recent visit, found several instances in which the disease reappeared outside the isolated zone. The number of cases in which this had happened was, however, infinitesimal, compared with the scores of thousands of trees on which isolation had effectively checked the spread of the Brown Bast, and when looked into, the apparent failures could nearly always be traced to imperfect isolation in the first instance.

Many of these failures find their explanation, it seems to me, in the procedure followed on the H.A.P.M. The control measures against Brown Bast on the H.A.P.M. are so contrived that the

outbreaks of the disease are spotted in the very earliest stages, and treated before they have involved large areas of cortex. Such stress is laid upon promptitude in treatment that at one time it was the custom to gauge the efficiency of the staff (both European and Native) by the proportion of large-area-infections recorded in the fields under their supervision. Where the supervision is good the majority of cases of Brown Bast are spotted and treated before they have spread beyond an area of a square inch or so. Should many cases be found in which the affection has extended, to say, three square inches in area, faulty supervision is suspected.

It is perhaps to be expected that on estates where the principle of keeping the affection to the smallest possible dimensions is constantly insisted upon, the Brown Bast coolies endeavour to make the isolation channel as near to the limits of the disease as possible. The result of this (since Brown Bast in its incipient stages is scarcely visible to the naked eye) is that, in a small percentage of cases the isolation is imperfect.

I draw attention to this feature of the procedure merely in explanation of the misses. I do not criticise it, because this policy of restricting Brown Bast damage to the narrowest possible limits, though risky, has much to be said for it under the conditions of the estates described. The policy insures that the minimum area of bark is wasted, and as the Brown Bast gang returns every 14 days, any imperfectly isolated examples can be dealt with in the following round before they have spread to a serious extent.

It is necessary to say that the policy of running things fine is only applicable under conditions akin to those on the H.A.P.M., where the isolation gangs return frequently and regularly. .The irregularity of the disease work on most estates and the lack of the efficient control possible on the H.A.P.M. make it desirable to insist on the isolation channel being cut well to the outside of the disease. The first isolation should be the last one.

How Trees are Rid of Brown Bast.

There are three conceivable ways in which a tree may be rid of Brown Bast :—

One is to strip the tree bare to the cambium, thus removing all unhealthy tissues. The stripping operation is drastic, but where it has been successfully performed, the new tissues which arise have been found to be free from disease. The defect of the stripping method is that it involves the entire destruction of all the laticiferous layers. As these are only replaced slowly, the yields obtained from the renewals after stripping are exceedingly poor.

The second method is the familiar scraping treatment. Although, as originally carried out, this was a drastic operation, aiming also at nothing less than the complete removal of all diseased tissues, scraping seldom achieved its aim in practice, and such scraping as has been performed of late has consisted in the removal of the outer diseased layers only. The deeper layers are left for the tree to throw off—a process which has occasionally been assisted by the application of tar and such like medicaments.

The other conceivable method which is really no method at all, is where the tree is left to cure itself by the unaided agency of its own natural healing forces. Left alone, the tree naturally endeavours to throw off the affection. This it does by forming a layer of cork between the healthy and diseased tissue. The formation of this cork layer leads to the drying up of the tissues external thereto, and they tend in the course of time to scale off.

Whether there is such a thing as " self-healing " in the case of a Hevea tree, affected by Brown Bast, has always been seriously doubted. Keuchenius, however, contends that trees do certainly cure themselves, provided " metastasis " is prevented by the isolation of the affected area, and provided also that tapping is limited to the unconnected zone without. Apart from the isolation operation referred to all that is necessary, in his opinion, is the excision of the burrs which occur occasionally as a secondary phase of the disease.

According to this view the curing process may be left to the tree itself. The repeated scaling off of the outer bark, initiated by the formation of wound cork, will, in time, rid the tree of most of the diseased latex tubes. A few will remain for years, but these gradually undergo necrosis, and after a short, though undefined period, become as so much dead harmless tissue. The position of these necrotic latex tubes quite near to the surface, and the fact that they are functionally unconnected with the newer series of latex tubes, prevents the further spread of the disease from the old degenerated layers to the healthy tubes within. The time taken for the complete necrosis of the Brown Bast tubes may be three, or it may be five or six years, but as soon as this has taken place, the tree may be regarded as cured, and tapping can be resumed with safety on the seat of the old affection.

Does the Isolation Treatment Cure the Affection ?

Remembering the miraculously rapid cures, claimed by Harmsen and others, as a result of applying hot tar, etc., many planters will be disposed to be sceptical of alleged Brown Bast cures. The more simple a cure professes to be, the more it is suspect. The fact

that the treatment described is being practised daily on what are not only the largest, but the most scientifically-run estates in the world would, however, be a guarantee of soundness of the Isolation Treatment, even did not the theoretical case advanced for the treatment hang together.

Whether the cures claimed are beyond all doubt complete cures, only prolonged tapping on the treated zones will finally decide. Since treatment was not commenced until about five years ago, general tapping has not yet been resumed on the sites of the old disease on the treated trees. This much can be said, however, that wherever trial tappings have been carried out on zones, isolated, and believed to be cured, the yield of latex has been good, and the Brown Bast has shown no signs of reappearing.

Such a result, which has been repeated over and over again, is justification for thinking that trees on which Brown Bast is immobilized, so to speak, and prevented by means of an isolation channel from spreading to fresh fields, do throw off the disease in from four to six years. The disease seems to work itself out in the circumscribed patch. The appearance of the cortex, after this period supports this view, as also do the tappings which many estates are now carrying out on areas formerly scraped for Brown Bast, and rested for years. Cases have come within the writer's experience in which trees scraped for Brown Bast six years ago, and since rested, are, to-day, yielding latex freely on the zones previously diseased.

These trees, if one may judge from their yield recovery, and the non-recurrence of Brown Bast must be regarded as cured.

What do we Mean by a Brown Bast Cure?

The statement just made raises the question as to exactly what one means by "cure." If asked the question, a few years ago, one would have replied that by a Brown Bast "cure," one meant the complete restoration of the healthy tint to the bark as well as yield recovery.

When the problem is looked at a little more rationally, it is clear that this is rather an impossible demand. Once the tissue elements of a tree have been disorganized or converted into permanent structures (as happens, for instance, in Brown Bast cortex wherein the latex vessels degenerate, and many of the surrounding elements become dead stone cells), by no possible manner of means can a tree restore these altered tissues to their original condition. A tree can only recover by replacing all the altered elements by an entirely fresh set through the activity of its cambium. From this new tissue,

and not from the rejuvenation of the old Brown Bast affected layers, the latex which we get when trees have "recovered from Brown Bast" is drawn.

With regard to the diseased elements, the tree has no blood to absorb them. They can only be got rid of by scaling. A tree, however, is unable to scale off useless layers in the rapid way animals throw off their old skins after cuticular affections. The scaling in trees is brought about by two factors—one physiological, and the other mechanical. Physiologically, a tree's chief reaction to wounds or disease stimulus is the production of cork. By the production of successive cork layers it continually endeavours to insulate its healthy cortex from the injurious influence of the overlying Brown Bast tissue. Since cork is impervious to water, and prevents the passage of foodstuffs, the effect of these corky barriers is to bring about the starvation of the external tissues.

The reaction described ends the direct physiological attempts of the tree to throw off the disease. The actual scaling off of the diseased layers is an indirect result of further growth. As the tree grows, by the addition of new tissues on either side of the cambium, the outer layers are compelled to spread themselves out over an ever-lengthening periphery. Being unable, owing to the presence of so many dead and inelastic elements, to expand in unison with the internal expansion, like healthy tissues, these layers have to give way.

In this way, through the production of cork, the Brown Bast layers are rendered innocuous; and gradually, under the tangential stresses created by the continued growth of the tree, become scaled off. Although the scaling process can be accelerated by bark scraping, which, as has been described, stimulates the production of a fresh cork cambium every time it is applied, the complete removal of tissues, which in bad cases of Brown Bast, may be half-an-inch in thickness, necessarily takes many years.

I have given this description of the healing process because, without some knowledge of what takes place, one's ideas of what constitutes a cure in the case of Brown Bast, must be rather cloudy. It will be evident from the foregoing, that, in demanding as a proof of cure, the complete removal of every trace of diseases from the cortex, we have been demanding the impossible. For five, and possibly ten years (more where growth is slow) after the treatment, the bark will still contain discoloured elements.

The existence of mottled elements in the cortices of trees formerly affected with Brown Bast is then not to be interpreted as evidence of "non-cure." Keuchenius's definition of a cure from

Brown Bast is the absence of metastasis. If, when the tree is again tapped, no further spread of Brown Bast occurs, the tree is held to be cured. His view, that the old Brown Bast layers become, after a number of years, necrotized, and incapable of setting up further infection, has already been fully explained. Experience of the isolation method on H.A.P.M., and the experience elsewhere of the scraping method, indicate the substantial truth of this view.

Since one must still expect to find in the outer cortex of a cured tree the residual traces of the old Brown Bast, the difficult practical point arises as to how one can tell when these discoloured elements have reached the harmless stage, and tapping can be resumed with safety. Though it is possible to get a fair idea of the stage reached towards recovery by inspecting the outer cortex, and noting whether it still retains the moist rotten apple appearance, which is the active condition, or has attained the dry brown mottled stage, indicative of innocence, the only real test of a cure is to tap the tree and see whether the disease spreads. The application of this test is more easily advised than carried out, and in practice, the best plan will, probably, be to fix a definite period like six years before recovery is assumed, and tapping recommenced on the sites of former Brown Bast.

Success of the Isolation Channel in Preventing the Further Spread of Brown Bast.

So much for the curative aspects. With regard to the effect of the isolation channel in limiting the extension of the disease, the wide experience of the H.A. Plantations where the treatment has applied over 20,000 acres or more amply confirms its value: The writer is satisfied from his recent visit and inspection of trees so treated, that the isolation channel, when properly made, entirely arrests the spread of Brown Bast. The great merit of the isolation method, apart from any question of cure, is that it permits of the continued tapping of the tree, whereas, with all other proposed remedies for Brown Bast, trees must be rested indefinitely.

Dangers of Doing Nothing for Brown Bast.

The foregoing general summary of the isolation treatment and its advantages will, it is hoped, be found useful by estates. For those planters who are still unconvinced of its value, or who prefer to do nothing, the following considerations are suggested:

Brown Bast has been proved to occur in much higher percentages on good than on poor soils. Appreciable additions to the number of affected trees are made regularly, even with alternate day tapping. Brown Bast, indeed, seems to be an inseparable concomitant of tapping in any form we know of. It must, therefore,

eventually involve a larger percentage of trees on the best than on the worst estates. Since the disease is propagated throughout the tree by the latex movements induced by tapping ; a policy of *laissez faire* in regard to the trouble will only mean that the Brown Bast, which is increasing every year, will, bye and bye, be spread all over the tapping surfaces of the trees. The treatment proposed is so simple, and so inexpensive, that it would be foolish not to take advantage of the promise which it offers. The percentage of Brown Bast on the average rubber estate is high, higher, probably, than is generally supposed, and whenever the financial situation justifies it, I would seriously urge upon planters the desirability of taking up the systematic treatment of this trouble. Adverse climatic conditions have hitherto been a barrier to Brown Bast treatment, during the greater part of the year, and the stripping method is totally impracticable in countries like South India, but climate, obviously, is no obstacle to the newer method above outlined.

More or less what the treatment involves will have been gathered from the foregoing, but for convenience the procedure is recapitulated below :—

Practical Tips for the Treatment of Brown Bast.

(1) With a scraping instrument, determine the outermost margins of the disease. In order to do this, it is necessary to scrape as deeply as is possible without wounding, for frequently, in Brown Bast trees, traces of the disease are met with quite near the cambium.

(2) Having determined, with very great care, the zone where Brown Bast tissue fades into healthy bark, make with a gouge knife, a deep channel around the diseased patch, almost to the cambium. This done, run a sharp knife—a penknife for preference—along the bottom of the channel, severing tissues right to cambium, and completely isolating the disease. A fine knife is used for finally severing tissues to cambium, since this avoids the bad wounding and bumpy renewal which occurs when the gouge tapping knife alone is employed for the purpose. This isolation channel should, for safety, be made a little outside the area actually found diseased. In fact, where there is any doubt about the exact limits of the disease, it is best to go two inches or more outside. *The importance of complete isolation must be emphasized, for if any diseased tissue is left outside the delimited zone the isolation cut is utterly useless.*

Where a lateral root is effected by Brown Bast, it will suffice to isolate it by making a circular cut on the tap root. Once the disease has been isolated, tapping can be proceeded with on a fresh surface outside.

Old cases in which the disease is confined to one half or one sector of the tree, but continues underground, present difficulties, since the removal of the soil from around the roots in order to make the isolation cut below takes time. The most practicable rule to follow here, is to isolate the diseased area completely (top, bottom and sides) only when this can be done without much digging away of soil. Where the Brown Bast obviously extends far down into the tap root, the most economical solution is (after isolating the tap region and sides of affected area above ground), to continue isolation channel right around base of tree to other side, thus isolating part below ground, and preventing disease being drawn up here. To avoid unduly depressing the yield from the healthy sector, the isolation channel made to keep disease from ascending to this region should be made as near to ground as possible. It should follow the outlines of the large laterals where they emerge from ground.

(3) In very old cases, where the disease is found to have extended almost completely around the tree, isolation can be accomplished by a circular cut, *e.g.*, by ringing the tree above the affected zone. Tapping can afterwards be carried out with safety anywhere above the isolated area, but since the latex tubes have been cut through it will now be necessary to make the cut at least two feet above the isolation channel in order to get a good flow. (See note hereafter.)

(4) Every few months, all treated trees should be inspected for traces of burring, any burrs discovered being removed straightway before they have got too large.

(5) Such portions of the treatment as are indispensable have been described in (1) to (4). Those who so desire, however, can assist the natural tendencies of the tree to self-healing, and bring about a more rapid cure by scraping away all the superficially attacked bark. Although scraping is not absolutely essential, it is always recommended, since recovery will thereby be accelerated. The more of the outer diseased layers the tree can be encouraged to throw off, the better, and " scraping " induces bark scaling.

As to the kind of scraping desirable, deep scraping, aiming at complete elimination of all diseased layers, and which requires skilful trustworthy coolies, is not called for. The rule followed should be to scrape down until slight bleeding shows healthy zone to be reached. Don't worry about the discoloured tissue still remaining. This will scale off in time. Scraping of the kind described can be done by any untrained coolies, and allows of the skilled men being kept wholly on the recognition and isolation work.

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(6) Once the treatment of the accumulated arrears of Brown Bast has been accomplished, it will be easy to keep pace with the new infections. For bringing these to light quickly, before the disease has involved a patch larger than a square inch or so, a fortnightly inspection is recommended, or, instead of this, tappers could be given some encouragement to report all suspected cases immediately.

Cost of Brown Bast Treatment.

On the H.A.P.M. Estates, regular gangs are employed for Brown Bast detection and treatment. These follow the tappers in the mornings and mark the trees diseased, returning in the afternoons and carrying out the isolation work. The skill and speed acquired by coolies after they have been employed a short time at this work are surprising. A gang of ten men with maistry suffice to detect and check in its very earliest stages all the Brown Bast occurring on 1,600 acres. This will give some idea of the modest outlay necessary for controlling Brown Bast, when once the arrears have been attended to. An expenditure of one coolie per 160 acres is surely not much to pay for freedom from such a serious disease, particularly when this immediate treatment keeps every tree in the tapping round.

Will the Systematic Treatment of Brown Bast Involve Loss of Crop.

The fear has been expressed that the adoption by estates with much Brown Bast of the curative measures suggested will lead to a serious drop in output. Where the work is done unintelligently, of course, this will happen, but there is absolutely no reason why crops should fall to any extent if the new cuts are properly placed, since the great advantage of the isolation method of treatment is that it enables every tree to be kept in tapping.

It is difficult to lay down rules for the subsequent tapping of Brown Bast isolated trees, but the principle followed when placing new cuts, should be to place them at such a height as to give an extra area of tappable bark equal to that temporarily out of access through disease. Where, for instance, Brown Bast has involved the remaining twelve inches of tappable bark on one sector, and this has been isolated, the cut should be changed to the opposite sector at a height at least twelve inches above that at which tapping would normally start. Better perhaps open cut 15 inches higher since the 3 inches of bark just above the isolation gap will have little yield value, and is best pared away when reached.

In cases where the whole base of a tree is affected, and has been isolated, a fresh tapping area should be projected above, and the cuts placed at such a height as to permit of eight years' tapping before coming on to the old Brown Bast affected zone.

One may leave out of consideration here trees freshly attacked by Brown Bast, and in which there is plenty of healthy bark below the isolation channel on the sector affected, for it should be clear that in such cases, tapping will be resumed below, after isolation.

From these examples, planters should have no difficulty in placing the new cuts on Brown Bast treated trees in any of the cases which are likely to arise. It may be mentioned that there is no objection to using the vertical isolation groove as the run-off channel for latex in cases where its position will serve that purpose.

If the new cuts are suitably placed on the lines suggested, the amount of crop loss through Brown Bast treatment should be negligible. The high cuts will, of course, yield less than the former low cuts when healthy, but they will in most cases yield as much, or more, than these cuts have done latterly, since becoming diseased. Then, too, must be remembered the fact that many trees which had gone completely dry on their normal cuts, are now, subsequent to isolation, and the opening of new cuts, contributing to the output once more. (*Vide* Appendix).

THE MANURING OF RUBBER.

Although the manuring of rubber has long been a regular practice in Ceylon, where many of its adherents claim to have considerably increase their rubber outputs by manurial treatment, the almost universal failure of scientifically controlled manuring experiments in rubber to demonstrate a measure of improvement which exceeds the experimental error, unavoidable in all such tests, has made planters elsewhere sceptical of the value of manuring rubber. The results of manuring generally have, indeed, been so unimpressive as to lead to the view that the laticiferous mechanism of Hevea is unaffected directly by manurial stimulus, and that immediate crop improvement cannot be obtained by manuring. That manuring has a beneficial influence upon the foliage and growth, and bark renewal has, of course, been proved over and over again. These results, while no sufficient recompense for the heavy expense of manuring are, at any rate, an earnest of better future crops. For the better crops themselves the planter, repeatedly disappointed at the absence of immediate benefit, is more and more inclined to wait patiently until the improved growth and bark renewal of the trees has had time to influence production.

H. A. P. M. Experiments of Manuring.

Some important results have recently become available from the Holland-America Plantations Company (H.A.P.M.), a subsidising company of the United States Rubber Company, which will clearly necessitate a modification in the attitude just described. During the past five years the H.A.P.M. Scientific Staff have been testing the effects of manures on the rubber on their various properties. A number of different soil types were embraced in the experiments, the type calling for special mention being a whitish clay cement like soil common in the flat coast districts of the country. On this soil, the growth of the rubber was at first satisfactory. Soon after the commencement of tapping, however, deterioration set in, becoming more pronounced year by year.

It is essential to know something of the type of soil and to appreciate the condition of the trees described, since it is on such soil, and on trees of such condition that the striking success with manuring, to be recorded was obtained.

Space does not permit of fully describing the precautions taken against error in the H.A.P.M. experiments, but I should emphasize here, since so much uncontrolled manuring passes as "scientific," that these experiments are in a class by themselves. Every manure was tested out in ten or more plots, interspersed with an equal number of controls. The results quoted are the average results from all plots in the respective series after all likely errors have been allowed for. No such thorough manuring experiments have previously been carried out in rubber.

Of the manures tried, positively favourable results were given only by those containing Nitrogen, *e.g.*, Sodium Nitrate, Ammonium Sulphate, Calcium Nitrate, etc. Applications of Potash to the different soils were found to scarcely effect the crop to a measurable extent.

The response to Super-Phosphates on the white clay soil was astonishing. Far from improving the trees in any respects, Super-Phosphates had, instead, a noticeably detrimental effect on their growth and general appearance, and for some time after the manuring, the trees bore unmistakable signs of a set-back.

With regard to the Ammonium Sulphate and inorganic Nitrate manures mentioned, within two or three months of their application, the foliage showed distinct signs of betterment. No effect on yield was noticeable for about eight months, but from then onwards, increases were recorded and maintained, or more than maintained throughout the duration of the experiment. The actual amount of improvement in yield is so striking as to be incredible to those of us

who have been accustomed to look for manure-induced increases with a microscope, and then—generally unsuccessfully. The results are set out below in two series, one of which refers to plots in which the manures were applied yearly, and the other, to plots which received manures once every two years.

Yearly Applications of Manure.

	Amount of crop improvement.
First Year	15 per cent.
Second Year	27 do.
Third Year	96 do.
Fourth Year	79 do.
Fifth Year	146 do.

Manures Applied Every Two Years.

	Amount of crop improvement.
First Year (Manure)	14 per cent.
Second Year (No manure)	57 do.
Third Year (Manure)	56 do.
Fourth Year (No manure)	102 do.

The above results were, it should be emphasized, obtained on the poor white clay soils described. On the other soil types, on the H.A.P.M. similar manures produced *no crop improvement at all*, or a debatable increase of from 5 per cent. to 7 per cent. only.

Costs of Manuring.—The quantity of manure applied in the serial plots was 5 lbs. Sodium Nitrate per tree, or the equivalent of this in Calcium Nitrate, or Ammonium Sulphate. At first the cost of the manuring worked out at Rs. 50 per acre, but by selecting the cheapest form of Nitrate and buying in large quantities, costs have since been reduced to about Rs. 38.

Method of Application.—All the manures were scattered on the surface of the soil in fine powder form, whence they were speedily washed down in the vicinity of the roots by the light rains of February, which, in Sumatra, was found to be the most suitable period for application. This method, which was the method utilised by the writer in the manuring experiments carried out in South India against Secondary Leaf Fall, was found quite satisfactory, and can be employed in every case where soluble chemical manures are prescribed. It involves none of the root damage which is inevitable in digging or forking in manures, and which frequently offsets much of the benefit from the manures. Manures can be broadcasted in this way for a few annas per acre, that is, for a mere fraction of the cost of digging them in.

Most suitable time for Manuring.—A noteworthy feature of the successful inorganic Nitrate manuring was that the maximum crop improvement was obtained when the manures were applied immediately the trees had commenced to lose their leaves in normal wintering, and before the new foliage had appeared.* Manures applied later than this did not give the same degree of improvement.

Some light is thrown upon this result by analyses made of the relative nitrogen content of the leaves from the trees in the manured and unmanured sections. Analysis of the leaves, soon after the appearance of the new foliage, showed the leaves of the manured trees to contain 50 per cent. more nitrogen than leaves of the adjoining unmanured trees.

The fact just mentioned is not without significance in connection with the writer's manuring experiments, against Secondary Leaf Fall in South India. These showed, it may be recalled, that the only manures which had a beneficial effect against the disease were nitrogenous manures. Although the original scheme of these experiments, designed with some such effect as that since recorded in the H.A.P.M. analyses in mind as a possibility, was to apply the manures in two doses, one just before wintering, so that it could be incorporated into the new foliage, and the second dose, just before attacks of leaf fall disease were expected, to assist resistance, the total absence of rain at this period in South India, coupled with late arrival of the manures, led to a change of plan, and actually no manures were got in until February, by which time the trees had already assumed their new foliage.

In view of the importance of the time factor so clearly illustrated in the H.A.P.M. experiments, it would be worth while to make some further trials of manuring against Secondary Leaf Fall Disease, this time applying the manures earlier. A slight difficulty arises here as to the most suitable time of application, for in South India the rains have entirely ceased before the onset of leaf fall, and it is doubtful whether the night dews would suffice to dissolve the manures and carry them down within reach of the root system with sufficient rapidity. In the circumstances, the best plan would probably be to scatter the manures on the soil a week or so before Christmas, in time for the light rains of mid-December to wash them into the soil ready for immediate absorption by the trees.

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* It is most important that the Nitrates be applied at time of wintering. It appears, however, that Ammonium Sulphate can be applied just as effectively a short time before wintering.

Stimulating Effect of Manuring upon Production of Laticiferous Tissue.—Returning to the H.A.P.M. experiments, attention has been drawn to the improvement in growth and bark renewal. Evidence has been gathered, showing that the manuring carried out had a favourable influence also on the rate of production of laticiferous tissue. The increase in the number of latex rings, following upon manuring, was, as will be seen below, considerable, and runs parallel almost to the increases in yield. Below are recorded the results in the differently manured plots :—

Series.	Manure.	Date of application.	Number of latex rings in renewed bark, May, 1922.	Percentage relation between number of latex rings after treatment (number of rings in unmanured control plot taken as 100).
I.	Control, None	—	10.5	100
II.	1 cwt. Sodium Nitrate per acre ..	Feb., 1919	11.1	105.7
	5 ,, Super-Phosphate ,, ..	April, 1920		
	5 ,, Calcium Nitrate ,, ..	Mar., 1921		
III.	5 cwt. Ammonium Sulphate per acre	Mar., 1920	12.5	119.0
	5 ,, Ammonium Sulphate per acre	Mar., 1922		
IV.	5 cwt. Sodium Nitrate, per acre ..	Feb., 1919	12.9	122.9
V.	5 cwt. Sodium Nitrate, per acre ..	Feb., 1919	13.6	129.5
	5 ,, Do. ,, ..	Feb., 1920		
	5 ,, Do. ,, ..	Mar., 1921		
	5 ,, Do. ,, ..	Feb., 1922		

Note.—Counts of latex rings about the time of the first application of manures showed no significant difference between the five series of plots, all being practically equal.

It will be noted from the above table, that the number of latex vessels bears a direct relation to the intensity of the manuring. In every case, the manurial application was beneficial in stimulating greater production of laticiferous tissue, and gave also an increased yield, except in series II—the Super-Phosphate plots. This manure, as was mentioned just now, had a pronounced depressing effect both on yield and growth, from which in Series II, the subsequent Calcium Nitrate application only partially relieved it. For this series, it should be observed, the least increase in the number of latex rings over the control was found.

Prejudicial Influence of Undergrowth.—One other point of importance, brought out in the course of the successful manuring

experiments described, should be mentioned here, and that is the antagonistic influence of undergrowth, such as green manures or weeds. Where the nitrogenous manures were applied to plots bedecked with leguminous plants, in this case, Vigna and Centrosema, these plants appropriated the manure to such an extent that the Hevea trees showed considerably less benefit than that recorded for those on the cover-crop-free areas. This poaching was apparently so serious that it was afterwards deemed advisable to scrape back all cover crops from the zones to be manured prior to the application of the manures.

Limited Utility of Manures.—As reports of the highly favourable outcome of manuring experiments in Sumatra have already reached other countries, and may do harm if accepted without qualification or knowledge of the real facts, it may be as well to lay stress once more upon the special conditions under which the results above described were achieved. The successful results were all obtained, be it noted, on one type of soil, and this a whitish clay soil which is peculiar to Sumatra. The nitrogen content of this soil has been described as sub-normal, but the trouble is, perhaps, less attributable to a dearth of Nitrogen than to the absence of bacteria. There is no doubt whatsoever from the soil and leaf analyses as well as from the effects produced by Nitrogen administration that it is the lack of this element which is holding up the growth, etc., of the trees, or, in other words, that the limiting factor in this special case is Nitrogen. To applications of manures containing Potash—an element in which the soil is apparently not deficient—the trees were practically indifferent, while they reacted to super-phosphates almost as to poisons.

It is suspected that the bad consequences of the super-phosphate manuring are connected with the acid reaction of this manure, but the reasons thereof need not concern us here. These unlooked for effects, are, however, worthy of the attention of those planters who believe that the indiscriminate application to all soils of every sort or mixture of manure necessarily does good.

Such was the experience on a single type of soil. On other types, particularly on the adjacent reddish-clay soils (soils which were not demonstrably lacking in any element), applications of manure, whether Potash, Phosphate or Nitrogen-containing, were very nearly without effect on yield. Compared with the 15 per cent. rising to 120 per cent. increases on the poor white clay, equally carefully controlled manuring experiments with the same manures on the reddish clay were only followed by small increases of 5 per

cent. to 7 per cent.—amounts which are of the same order as the experimental error, and may well be attributed to other causes than the manuring.

Manuring of Rubber in Ceylon.

The tenacious faith of the Ceylon Rubber planters in manuring is well known. Manuring has, in Ceylon, come to be looked upon as an indispensable estate practice, and most estates are regularly manured every one or two years. That this heavy expense is justified, both the local management and directorate have no doubt, and to sceptics from elsewhere, the relatively high and well maintained yields of Ceylon estates as compared with those in Malaya, and particularly with those of the nearer South Indian estates, are quoted as proof of their claims.

Yields in Ceylon are certainly good. They are somewhat better than the local soils, which, to all appearances, are inferior to those of other rubber countries, would seem to be capable of producing unaided. As the yields of the Ceylon rubber rather baffle explanation unless manurial benefit is assumed, it seemed to the writer desirable, during his recent visit to the country, to try and discover some reliable evidence of yield increase through manuring. In view of the H.A.P.M. results, it is possible that there are also in Ceylon special circumstances which would make manuring a success.

With regard to evidence, one could find, unfortunately, nothing of an irreproachably sound nature, no scientifically controlled large scale experiments having ever been carried out. The evidence generally appealed to as proof of manurial benefit on yield consists of nothing more than the ordinary estate crop records, and these, to any one acquainted with the fickle behaviour of rubber yields, prove nothing.

A case in point, mentioned here since it is frequently cited, is that of an estate in the Kalutura district, from all accounts, formerly in a bad way. Under new control, this estate, which was treated to heavy and recurring doses of manure, improved out of recognition, and to-day, and for some years past, has been giving crops of 500 to 600 lbs. per acre.

The fact of improvement is beyond quibble. Only the part played by the manure is in doubt, and must now always remain in doubt. For, granting that the condition of the property has been improved by the manuring, it is an open question as to how much of the yield improvement should be attributed to this, and how much to the increasing age of the trees and the better execution and supervision of the tapping, etc.

Other instances, just as devoid of most of the relevant facts which are essential for forming an opinion, are brought up in discussions. Some particulars were given me of a district in which there exists a short distance from several manured estates, one estate, notorious from the fact that it has never received any manure. Yields on the manured properties are reported to be from 450 to 550 lbs. per acre, as against 375 lbs. on the unmanured exception.

It is impossible to verify these reports, and such figures, or, rather their implications, should be accepted *cum grano salis*. Manuring is, in Ceylon, so much a part of the rubber planter's creed that if an estate is not manured, there is likely to be good reason for the default. It may be that the yields from the estate have from the start, generally been too low to provide the funds necessary for yearly manuring, or that the management is less efficient. Generally speaking, planters who manure their estates, show thereby their zeal in the good management and upkeep of the trees. A little extra zeal in the supervision of an estate, like " elbow-grease " applied to the domestic furniture can scarcely fail (since the influence of the personal factor in tapping is so great), to reflect itself in better yields. The manurial additions to the soil have, doubtless, contributed to the results, but the " elbow-grease " factor is rarely without effect, and frequently in itself provides sufficient explanation of the superiority of one estate's yields over those of another. These points are raised, not to dispute the occurrence of yield improvement through manuring, but merely to illustrate the difficulty of finding sure ground on this question.

The writer enjoyed one opportunity whilst in Ceylon of seeing an estate on which a serious attempt had been made to get useful evidence as to the value of manuring. When the manuring programme on this estate was inaugurated ten years ago, a plot was marked off, and purposely left out of the scheme. Thanks to the fact that this plot has received no manure throughout the ten years, whilst the rest of the estate has been heavily manured yearly, it is now very useful in comparing manurial benefits.

Actual yield figures cannot be given here, but yield in the unmanured-controlled plot has, I gather, shown little falling away during the lengthy period of observation. The yield from the adjoining manured blocks is to-day only about 10 per cent. greater than that of the control*—a surprisingly small difference considering their favourable treatment. With regard to the condition of the

* One has no idea in this case of the amount of the experimental error, but for the present purpose 10 per cent. is assumed as the real increase. It was probably much less.

unmanured trees, bark renewal is not quite so good, whilst in amount and colour of foliage, they are to be distinguished from the manured trees. In this and other respects, however, the inferiority is not striking. The condition of the unmanured trees is still good, and the field has not in any way " gone to hell," as the planter would express it, through not being manured.

The effect of the manure and the general health and vigour of trees may be discussed later. I wish here to lay stress on the difference between the yield improvement actually recorded, and that one had been led to expect, since the special reason of my visit to the last estate mentioned was that the Directors in England, who are also interested in South Indian Companies, consider it to be an outstanding example of what can be done by manuring. The handsome yield on the estate—rather more than 600 lbs. per acre all over—was in this, as in the case of other Ceylon estates, held to be largely the outcome of manuring, and was contrasted with the much lower yields of South Indian estates, held, just as erroneously, I have always believed, to be low through neglect of manuring. We have, it is frequently suggested, only to regularly manure South Indian rubber on Ceylon lines, and yields will eventually attain the levels of that country.

The above-mentioned test, conducted as it was on one estate, without repetitions, contributes only a little of the essential data one would like to have before forming a judgment as to the value of manuring in Ceylon. Still, it is the only example of estate manuring backed by controls which I could hear of, and small, though it is, a fact of this sort is worth more than all the other so-called evidence from the rest of the Island put together. A 10 per cent. increase in yield, that is, an addition of 60 lbs. per acre, at a cost of Rs. 70, is not much to write home about. Still less is it worth writing out about. If this is all that ten years of manuring and an expenditure of Rs. 700 can add to the earning powers of the trees, South Indian planters have no cause to regret their past inattention to manuring.

Economic Objections to Manuring in South India.—The economic limitations of local estates are generally forgotten by persistent advocates of manuring in South India. Space does not permit of discussing this aspect fully here, but it may be pointed out that, with the present output and prices, and assuming that applications of manure on an estate have, as in the instance quoted, produced an increase of 10 per cent. only, more than Rs. 50 per acre would have been thrown away without result. Rubber would have to be at least Rs. 4 per pound before manuring, productive of a 10 per cent. increase in yield, would show a small profit.

" Hope springs eternal in the human breast," where the manuring of rubber is concerned, and it will be contended, probably, that the crops of South India are so much below the ordinary capacity of Hevea trees that much larger increases can be expected from manuring. Experience lends small support to such optimism unfortunately. In years gone by, quite a number of South Indian estates were manured, some of them regularly. If there was any considerable improvement as a result of the manuring, a study of the estate records does not reveal it, and an increase of 10 per cent. is the utmost that can ever have been attained at the period of maximum effect. Crop records to-day show no residual traces of all the manuring, while as for the areas manured, one scrutinizes the trees in vain for signs of benefit. Should there be any optimists who, in spite of all past evidence, look for a yield improvement from manuring which will be commensurate with the cost, they may be reminded that, with tenpenny rubber, an additional crop of 120 lbs. per acre will be required to return even the bare outlay on the manures. So far as one can see, manuring except as a restorant after Phytophthora debilitation, or a possible preventative of this, would not be justified in South India with rubber under 1/9.

Convinced as they are that manuring in Ceylon pays, every Ceylon planter, with whom I discussed the question, agreed with me that the manuring of rubber in South India is not a commercial proposition. Could the costs of manuring be brought down by using smaller quantities, or by less frequent applications, manuring for a special purpose, *e.g.*, against Secondary Leaf Fall Disease, might, were it effective, be occasionally feasible. The experiments of the writer show, however, that the beneficial effect of manures against Secondary Leaf Fall is so slight as scarcely to justify their application from this point of view. It is true that Ceylon planters are inclined to attribute the lesser prevalence of Secondary Leaf Fall Disease in Ceylon to the manuring which has gone on, and though there are other reasons, this is probably one. I should clear up here, however, a difference in the connotation of the term " manuring," as understood in Ceylon, and as used in other countries. In South India and elsewhere, the manuring of rubber has rarely been more than an occasional measure, to be undertaken in a special exigency, or when rubber prices are good. In this kind of manuring, the Ceylon planter has little faith. His notion of manuring is to apply heavy doses, and to apply them frequently, yearly if possible, but, at any rate, in every two years. Light manuring, or sporadic manuring at long intervals without connected plan are, in Ceylon, considered to be ineffective. I mention this point because it is

important that people who credit, without inquiry, the good yields and relatively smaller damage done by Secondary Leaf Fall Disease in Ceylon to manure, and are continually insisting on similar manuring in South India, should seriously ask themselves whether they can afford to pay Ceylon's price. It is no use starting unless they can see their way to go on with it.

Unscientific Manuring. In any discussion of the results of the manuring in Ceylon, one is practically in the position of having to make bricks without straw, owing to the complete non-existence of any valid experimental data. The local planters may be satisfied with results, but, all the same, it is rather surprising that the value of a measure which has attained the importance to which manuring has attained in Ceylon should not by this time have received experimental confirmation.

Not merely has the degree of benefit from the general manuring which has taken place not been ascertained ; little is known also of the real manurial needs of Ceylon soils. Ceylon, in the matter of manuring, is a veritable " Tono-bungay." Certain manuring experts on purely empirical considerations, or certain prominent planters on the basis of results not interpretable, have prescribed and boomed their special yield improvement mixtures. In blind faith in these authorities, or because others are doing likewise, the planter buys Smith's or Brown's " special mixture," and goes on buying them, as we have seen, until he has expended sums far exceeding the capital cost of the estate on manures. There is, no doubt, that these " Tono-bungay " prescriptions do good. They are constituted in such a way (containing, as they do, something of everything), that they cannot fail to " touch the spot " somewhere.

Whether such expensive mixtures are really necessary ; whether in fact an application of some simple manure containing only one of the essential elements would not produce equally good results are points which would handsomely repay inquiry. Although it is not known that Ceylon soils are sub-normal in regard to the content of any element, and there is no evidence as yet that the rubber generally is specially responsive to applications of Nitrogen, as in the case of the Sumatran soils, the H.A.P.M. results quoted provide good ground for suspecting that much of the money spent on manure is thrown away.

I have shown in South India that manures other than nitrates do not perceptibly improve the resistant powers of trees to Secondary Leaf Fall Disease or benefit the foliage. Possibly to the nitrates alone out of the various ingredients of their mixtures, the better conditions of the Ceylon trees are due.

It is worth noting here a piece of evidence which came to my notice which lends support to this view, and illustrates as well a phenomenon brought out by the H.A.P.M. experiments, viz., the greater responsiveness of partially sterile soils to manures. The evidence mentioned relates to an estate, some areas of which had lately received an application of Sodium Nitrate. At the time of my visit it was possible to discern only in one small portion of the manured area, signs of any special treatment. In this area, which had evidently suffered badly from soil wash, the soil being barren-looking, the foliage of the manured trees stood out in marked contrast to that of the unmanured trees in the vicinity. As one passed further along on to the better soil, little or no benefit from the manuring could be observed.

General Impressions of Manured Rubber in Ceylon.—So far I have considered mainly the effect of manuring on Ceylon yields. Little has been said of the effect on the growth and stamina of the trees.

The usual experience of manuring rubber is that, while crop improvement is either non-existent or long delayed, the foliage, both in quality and general vigour, speedily registers improvement. One of the most surprising things about Ceylon rubber is that the trees show so few signs of the rich manuring in their external appearance. Neither in the quality or amount of foliage carried, nor, so far as one can see, in their growth, do the trees bear any impress of their generous treatment. As in the case of their yields, few comparisons with unmanured rubber are possible, and one cannot say what the condition of the trees would be to-day had they not been manured, but it can scarcely be claimed that the trees have that extra robustness which usually follows from manuring. The rubber in Ceylon, taken as a whole, is inferior in appearance to average rubber in Malaya and the Dutch East Indies, which has never been manured. Much of the rubber in Ceylon, indeed, would be rated by the visitor from these countries as second-rate—and he would wonder, and, in fact, does wonder where all the rubber comes from. It is interesting to observe that a Ceylon V.A., who recently visited the F.M.S., has returned with just such an impression. Going there with a strong belief that manuring is indispensable to the production of good rubber, he confesses himself astonished at the wonderful growth and vigour of the Malayan trees, grown in natural unmanured soils, and he has, I gather, modified his views as to the necessity of manuring.

Ceylon Conditions contrasted with those of other Countries.—While there is no evidence that the benefits obtained by Ceylon estates are anything like an adequate return for the enormous outlay

on manures, the special conditions with which rubber cultivation in the Island is beset may well be held to justify, and in places, to necessitate these measures of soil improvement.

Unlike estates created from virgin soils in Malaya, which have a goodly heritage of fertility, Ceylon estates have come into the possession of their present owners, shorn to a large extent of their heritage. Previous to their occupation by rubber, the Ceylon estates were, in many cases, the sites of other crops. Never abounding in fertility, their laterite soils had been denuded by the wasteful methods of past cultivators of most of their stores of plant food before Hevea Braziliensis came on the scene. Land being strictly limited, the Ceylon planter had to make the best of the stuff available. Here and there it might almost be said that he was given a rocky, laterite matrix only, and was faced with the problem of making a soil of this by impregnating it with soluble plant food.

These facts must be remembered in any discussion on manuring in Ceylon.

It is, perhaps, this early need of manure, undeniably existent in certain areas, which has dictated subsequent policy. Believing that their soils can be made fertile by manures, Ceylon planters have done little to conserve such fertility as the soils naturally possessed. On the contrary, they have done their best by their unwise adherence to the policy of clean weeding, not only to dissipate the inherited residues, but much of the added fertility as well. The spectacle of Ceylon planters industriously filling their soil reservoirs with expensive fertilisers, while leaving all the sluices wide open prompts comparison with the strange sights recorded by the immortal Gulliver. However, the problem of soil erosion, now apparently being vigorously taken up in Ceylon, is outside the scope of this enquiry.

From the foregoing remarks, it will be evident that rubber estate upkeep in Ceylon presents special problems which other rubber countries can, or could be, free from. With few exceptions, estates in South India, Malaya, and elsewhere, have endowments of fertility far exceeding in value anything which it would be practicable to add in the shape of manures. All that they have to do is to take care of these endowments. The case of Ceylon is different. Here the past spoilation of the soils has frequently to be contended against. Whether there are local conditions which would make manuring a success in Ceylon generally, the available evidence is too scanty to permit of an opinion, but there is no doubt that the present wasteful policy referred to is gradually creating conditions which will make manuring desirable, if not inevitable everywhere.

To sum up these very incomplete observations, my conviction is that the Ceylon policy of manuring has not led to results of so demonstrably profitable a character as to make imitation worth while by other countries. The good yields of Ceylon estates are only in exceptional cases directly attributable to manuring. On estates, generally, there is reason to think that yields nearly as good would have been attained without manuring. The utmost that could be said of these is that the regular manuring has helped to maintain yield by building up resistance to Secondary Leaf Fall Disease, and promoting growth and bark renewal. The regular manuring has certainly prevented yields from falling away.

Present Attitude of the Scientific Department in Ceylon Towards Manuring.—The foregoing represents an attempt by an impartial outsider to get at the truth concerning the results of manuring in Ceylon. I will conclude by quoting an inside opinion on the subject. A reference was made earlier on to the recent work of Messrs. Bryce & Gadd on Growth and Yield. Their observations have been confined to too few trees and are of too limited a duration to warrant, in the writer's opinion, all their conclusions. Still, their views have some relevance here. After noting with regard to the trees in their experiments, that their observations show :

(*a*) That though the initially low yielding trees improve in *girth* during the year to nearly the same extent as the initially high yielding trees, they only increase in *yield* by 9 per cent., as against 30 per cent. in the latter group ;

(*b*) That in general the trees with the lowest initial measurements of girth showed the highest percentage increase in this character, whereas trees with the highest initial yield showed the highest percentage of increase in yield ;

and (*c*) That those trees which during the course of the investigations made the greatest percentage increase in girth were not in general the trees which gave the greatest percentage increases in yield,

these authors go on to say :

" These facts have an important bearing on the question of cultivation and manuring, since they indicate that manuring or other measures known to promote increased girth will not necessarily result in increased yield. Of the many manuring experiments carried out on rubber, not one experiment has indubitably proved that the application of manures has increased the yield of rubber. That applications of manure increase the girth and general vigour of the trees is undoubted

. . . . . but there is no evidence that it increases the yield. Our observations lead to the conclusion that yield is independent of vegetative vigour. Yield is an inherent character. A tree is in general born a good yielder or bad yielder, and no cultivation or treatment will convert a poor yielder into a good yielder."

This conclusion is quoted in full as indicating the views now gaining ground in scientific circles in Ceylon in regard to manuring. While the latter conclusions are sound,* and their general attitude to manuring justifiable, Messrs. Bryce & Gadd, like the present writer, and others, will have to slightly modify their views. The experiments of the H.A.P.M., already described, have now indubitably proved that, under certain special conditions, applications of manure *do* increase the yield of rubber.

Lessons to be drawn from the H.A.P.M. and other Experiments in Manuring.—The H.A.P.M. experiments described are, without doubt, the most important contribution to the science of manuring rubber which has yet appeared. They are, in fact, the only extensive and wholly reliable scientific experiments which have yet been carried out on the manuring of rubber. They provide, for the first time, convincing evidence of direct crop stimulus by manuring.

I have dealt with the claims of Ceylon.

The large yield increases from manuring occasionally claimed by planters in other countries serve only to show that the isolated life of the rubber planter is not so incompatible with the development of the imagination as has been alleged. Wherever an attempt at verification by similar manuring on more scientific lines has been possible on comparable soil, it has usually ended in demonstrating that the yields from the manurial plots are little, if anything, better than those of the unmanured plots.

The fruitless results of manuring on the more normal soils of the H.A.P.M. agree with the common experience of manuring on rubber estate soils generally. By manurial additions, the latex outflow is, so far as one can see, seldom directly stimulated. Symptoms of improvement are confined at first to the leaves and general growth, only becoming expressed in the yield later on as an indirect result of better growth, and an increased production of lacticiferous tissue, and then, seldom to the extent required to make the manuring worth while.

* Except the statement that "Yield is independent of vegetative vigour," this conclusion the H.A.P.M. experiments show to be untrue.

become so impaired that it is unable to make full use of the nutriment already available, it would seem useless to offer more food. More futile is the belief that yields will be stimulated by this extra food. A speeding up of latex production can only take place with the restoration of the lines of communication, so to speak, the said restoration being a long or short business according as the overtapping has been serious or otherwise. If the trees have not been badly overtapped an improvement in yield may be expected after a year or so's rest, whether manures are applied or not. Where the overtapping has been chronic, however, the prolonged dislocation mentioned, with its accompanying impoverishment, will have debilitated the tree to such an extent as to render it incapable of responding within a calculable period to any manurial coaxing.

Discussing again the remarkable response of the H.A.P.M. trees to Nitrates, it is interesting to recall that at one time potash was thrust upon us as the important element in the nutrition of the rubber tree. Wherever growth or yield fell away, or some ailment appeared, shortage of potash was suspected. In Maclaren's "Rubber Tree Book," potash is imagined to be the panacea for most Hevea troubles.

We have now very definite evidence of the importance of the nitrogen factor, both in maintaining yields and foliar activity, and promoting resistance to leaf disease. Of any trouble traceable to a lack of potash in the soil, there is no evidence. Possibly there are other soil types in which the potash or phosphorous content are sub-normal, and to applications of which Hevea would respond by increased yields, but so far as our knowledge goes, the amounts of these substances present in estate soils suffice for the efficient utilisation of the other foods, and to maintain latex production up to the tree's capacity.

With regard to general all-round soil deficiency, examples of this might, perhaps, be more easily found. The cost of relieving this complete embarrassment by supplying artificial manures would, however, outside of Ceylon, be prohibitive. Experience shows also that the yield response is too feeble to justify the expenditure. The only practical ameliorative for totally impoverished soils is green manuring, and this, one need hardly say, will never bring back the virginal flush to the trees.

Conclusion.—The lesson which finally emerges from the H.A.P.M., and other experience with manuring is not, then, that the manuring of Hevea is necessarily, or even generally, a good thing. In nine cases out of ten the money spent on manure is thrown away on a very debatable yield improvement ; for a result, in fact, which

How to account for this thanklessness on the part of Hevea rather puzzles one, and its behaviour will in all probability continue inexplicable until the functions of latex are better understood. In most rubber soils, the rubber tree can find apparently sufficient of the essential nutritive materials for its physiological balance, and for maintaining latex production up to its capacity. Under these circumstances, obviously manures are powerless to promote increased latex synthesis, and their application can be attended with no commensurate improvement in yield. Here and there, however, types of soil are met with which are markedly deficient in certain elements of plant food. Trees growing in these soils do not long maintain their vigour, however well they start. Decadence is early perceptible in the tired-looking lighter foliage. As time goes on, the poor growth becomes accentuated while bark renewal and yield fall away. Cases of this sort are by no means common but in such a case, wherever encountered, applications of the deficient element will, as with the H.A.P.M. rubber, rapidly and markedly stimulate production.

The Hevea tree has few ways of expressing its needs, and it is not unusually possible to distinguish off-hand the deterioration due to soil poverty from that brought on by over tapping. In the latter case, since bad treatment, and not soil deficiencies are responsible, it is scarcely rational to expect that the addition of a little more plant food to the already full supply will bring about any wonderful improvement, and, as far as the yield is concerned, there is generally little response.

In explanation of the different responses in the two cases mentioned, one may imagine that in barren soils, the failure of an essential element upsets the physiological balance of a tree upon which the maintenance of the organs in full activity depends, and latex production, with the other vital processes, are slowed up. Since all the organs are present intact, cellular activity only being at a low ebb, it is quite understandable that the simple addition of the ingredient responsible for the " hold up " will lead to a quickening of the processes all round, including latex synthesis.

Contrast this with the case of overtapped trees. Here the debilitation is accountable mainly to the malnutrition brought on by the too rapid destruction of the conductive tracts. Food may be present in the substratum in abundance, but owing to the badly dislocated tracts it cannot be transported rapidly enough to keep the organs in full function.

This rough picture leaves out many details, but it will, I think, make the difference in the reaction of rubber trees to manures somewhat intelligible. When a tree's digestive arrangements have

is entirely incommensurate with the expenditure of money and labour. It should now be clear that rubber on certain soil types alone will respond by giving increased yields to manurial applications. The study and recognition of such soils is work which demands careful experimental investigation, controlled, where possible, by the staff of the nearest scientific station. Whether or not trees will be benefited by manuring, can only be decided by well-designed experiments extending over two or three years. Neither by casual field inspection, nor by chemical analysis is it possible to determine whether manure can be applied to a soil with advantage or not, and anyone, be he scientist or planter, who attempts in the present state of our knowledge, to dispense, without the enquiry necessary, suitable manures for every manner of rubber soil should be set down as a pretender.

Secondary Leaf Fall in Ceylon.

My visit to Ceylon did not take place during the season of Secondary Leaf Fall, but on the estates visited, the evidence of past Phytophthora attacks could be clearly seen. These were chiefly visible in the dying back of the terminal twigs and small branches. It is impossible for an outsider, unfamiliar with the appearance of the trees year by year, to venture an opinion as to whether this disease is on the increase in Ceylon or not. The effects of the repeated Phytophthora attacks are, I should imagine, becoming more noticeable in the slower growth and bark renewal of the trees, if not yet on the yield. Owing to the annual dying back of the new terminal shoots referred to, the trees have seemingly ceased to make any crown extension, and thinning-out in Ceylon, as in India, is becoming rather an unnecessary, and possibly a, dangerous operation.

Cultivation of Young Rubber Areas.

The present writer published several years ago evidence as to the damaging consequence of cultivation in mature rubber, and he may claim to have been the first to attempt to bring home to the planters the folly of the practice. Within the last two years the soundness of his views has been confirmed by two sources by the A.V.R.O.S. Experimental Station, in Sumatra, and by experiments on the H.A.P.M.

On the question of cultivating young rubber areas, the writer has not held any very definite views. While cultivation, after planting has taken place, appeared needless, and a waste of money, it has not been evident that the practice has had any damaging results.

From an experiment on the H.A.P.M., it seems as if cultivation, even in young rubber, must also be condemned as bad. A block of

one-year-old rubber possessed by the company, was cultivated, and the results compared with an adjoining area of similar-aged rubber, not cultivated. Measurements show that the rate of growth of the cultivated trees declined after the cultivation, the girth increment being 7 per cent. behind that of the uncultivated control. The yields from the trees, which have lately come into tapping, are also less in the cultivated block.

The Replanting of Old Rubber Areas.

This is a subject which has come into prominence in recent years. Replanting, unfortunately, is, so far, an inspiration mainly of profligate estates. Its supporters seem to have such philosophy of the rubber estate as certain credists hold regarding human destiny. After a mis-spent life, the rubber estate is expected to enter upon a new cycle of existence, this time a higher one—(budded, shall we say).

It is not pleasant to have to put a damper on these aspirations, but the writer feels bound to record his utter disbelief in the possibility of the resurrection of such old rubber areas. After the demise of the present rubber, a long ordeal of purgatory passed in the shape of jungle, will be necessary to fit the estate for any new useful phase of existence. Owners of derelict estates seeking conversion, might, for their meditations, take as a suitable text : " What shall it profit an estate with future crops, if, with the present crop, it has gained the whole world and lost its own soil."

These reflections are intended to direct attention to the truth that the practicability of replanting is mainly a question of soil. Where an estate has given up its soil to the drains and rivers, it may as well give up any idea of replanting ; where it has successfully conserved its soil, it may successfully replant.

For the latter class of estates, an experiment in replanting on the H.A.P.M. has special interest. Realising the possibilities of selection, and, with the object of discovering whether present areas could be improved, a small experiment was carried out in which all trees were cut out from a block, except nine of the very best trees per acre. The vacancies were supplied with specially selected seed plants.

I have no information as to the yield from the nine trees prior to the thinning, but during the first year following, the yield from these trees totalled 120 lbs. The present yield is 170 lbs., which is nearly 50 per cent. of the yield formerly given by the whole area of more than 100 trees.

In another block a similar experiment was undertaken, but this time, 17 trees were left per acre. The present yield from the 17 trees is 250 lbs.

The effect of the removal of so many of its neighbours upon the trees remaining was, in both cases, wonderful. They have improved in bark renewal and health, while in trunk size and crown development they make contemporary trees in the areas adjoining seem dwarfish by comparison. As to the supplies, these are growing as well as any new clearings, and they give every promise of developing into fine trees.

The experiment described is one of the most interesting things to be seen on the H.A.P.M., but the lesson thereof, as mentioned in the introduction, is to the select estates which have kept their soil.

TAPPING SYSTEMS.

Periodic Tapping.—Many estates on the East Coast of Sumatra and Java are now being tapped on what is known as the Periodic System. In this the estate is divided and one portion tapped daily for one month or three months, after which it is rested for the period chosen, and the other portion tapped. There is some reason to think that bark renewal is slightly better with a periodic system, but apart from this, and its greater convenience under certain conditions, the advantage usually claimed is that higher yields are thereby obtained than for instance, with Alternate Day Tapping.

Upon what evidence Periodic Tapping is alleged to be more profitable than Alternate Day Tapping, I was unable to discover. In comparative trials on the H.A.P.M., the Alternate Monthly Tapped Plots showed yield superiorities over Alternate Day Plots from 1 per cent. to 7 per cent. The average yields from the whole series of Periodic Tapped Plots was, I believe, 4 per cent. greater than that from the Alternate Day Plots. Since the probable error in these experiments amounted to about 4 per cent., the very slight superiority in yield which one may presume the Periodic System to give, hardly seems worth troubling about, particularly when its greater provocativeness of Brown Bast is taken into account. Both in Sumatra and Java planters have complained of the greater prevalence of Brown Bast with Periodic Tapping.

Periodic tapping is sometimes advocated as the most suitable system for countries like South India and Burma, where the excessive rains make the harvesting of crop impossible for some weeks during the monsoon. As a matter of fact, this method of tapping seems to be much more suited to countries with relatively even climatic conditions.

With regard to the suggestion that tapping in South India be suspended during the two or three wettest monsoon months, and

daily tapping carried out during the better harvesting season, this is impracticable owing to the impossibility of disposing of the estate labour profitably during the "rest months."

Other Tapping Systems.—In view of the attitude of the Dutch towards Rubber Restriction, the following particulars of the Systems of Tapping practised in the three districts of Java, Soerabaia, Pasoeroean, and Kediri may be of interest :

Daily Tapping	1/4 cut	7	Estates.
,, ,, ...	1/3 ,,	14	,,
Alternate Day Tapping	1/4 ,,	4	,,
,, ,, ...	1/3 ,,	9	,,
,, ,, ...	1/2 ,,	25	,,
,, ,, Other length cuts ..		2	,,
Periodic Tapping		18	,,

Though their example is not recommended for imitation in South India, I may mention here that some of the estates in Java, which have gone in for tapping every third day, are getting very satisfactory results.

None of the numerous tapping systems practised in the countries visited struck me as having such advantages over the Alternate Day System now generally followed in South India as would make their adoption worth while.

Evaluation of Factors which Influence Rubber Yield.

On the H.A. Plantations a long series of experiments have been carried out with the object of evaluating the various controllable factors by which the yield of a rubber tree is influenced. The respective influences upon yield of the Tapping System, Height of Cut, Length of Cut, and Thickness of Bark Parings, have all been cleared up by these investigations, and when the influence of the age of bark renewal, which is still being enquired into, is determined, it will be possible from the collective data to predict with fair accuracy the yields of rubber trees when either of these factors are varied.

Some of the values ascertained in the H.A.P.M. experiments were kindly communicated to me by Mr. Grantham, and as they are of very great general interest, I take the liberty of discussing them in this report.

Influence of Height of Cut upon Yield.

Every one connected with rubber is familiar with the fact that the yield of a tree decreases with the height of cut from ground. No reliable experiments, except those to be described, have been made, however, in which the influence of height has been given a quantita-

tive value. It will, perhaps, be recalled that Lock once attempted to settle the question by tapping a single sector by several superimposed cuts—a comparative test which was obviously faulty since the yields from the upper cuts would have been very adversely affected by cuts interposed below.

Carefully controlled experiments on H.A.P.M. estates show the relative yields from sections of bark at different heights to be as follows :

0″–6″	6″–12″	12″–18″	18″–24″	24″–30″	30″–36″	36″–42″	42″–46″
147	138	113	100	99	93	92	76

It will be useful for Directors of rubber companies who are inclined to regard yield as a constant or ascending thing to bear the ratios given in mind, particularly the fact that a cut at about three feet only gives approximately half the yield of a cut near ground level. The yield of a rubber tree is, as has been seen necessarily cyclical, rising and falling with the height of the bark exploited. Steady crops can only be obtained on estates of mixed ages, where the cuts are of varying heights. Failure on the part of home Directors to appreciate this, and irrational calls on the local management for constant or ascending outputs have led to much of the illicit and damaging tapping which has taken place on estates. It would be a good thing if, in addition to noting the system employed, the average heights of the tapping cuts in the different fields were always given in estate books. The possession of this data would be of assistance in checking crop forecasts, and might perhaps tend to keep expectations reasonable.

Relative Yields from Different Length Cuts.

Thanks to the various tapping experiments of the past twelve years, the relative yield values of different length cuts have become fairly accurately known. Nevertheless, the following figures which are the average values obtained from a series of experiments on the H.A. Plantations with quarter, one-third and half cuts will be found useful by estates :—

Yields from Single cut on		$\frac{1}{4}$°	= 80
,,	,,	$\frac{1}{3}$°	= 100
,,	,,	$\frac{1}{2}$°	= 120

Thickness of Bark Parings.

The old rivalry between planters as to whose tappers could make the greatest number of cuts per inch, died some years ago, and it appears that those fastidious planters who insisted on bark parings of forty cuts per inch, or over, have either been eliminated by the slump, or have seen the error of their ways.

An interesting experiment on the H.A. Plantations raises anew this question. In a series of plots, tapping experiments have been carried out, using different thicknesses of bark. Following are the results obtained :—

Bark excised away at rate of			30	cuts per inch.	Yield = 78
Bark	,,	,,	20	,,	,, =100
Bark	,,	,,	15	,,	,, =130
Bark	,,	,,	12	,,	,, =130

A noteworthy feature of the above results is their demonstration of a fact, which, to anyone who has given the question of bark consumption much rational consideration, should always have been, more or less clear, viz., that in order to get the maximum yield, the paring removed must be of sufficient thickness to clear away the coagulated rubber in the tube ends and open every latex tube. If the experiments quoted are to be relied on, this is achieved when the paring approaches 1/15th of an inch, for parings thicker than this give no greater yield, and thinner parings fail to extract a considerable proportion of the available latex from the area under toll.

This experiment does more than merely give the death-blow to superfine tissue-paper tapping. Ordinary fine tapping at the rate of 25 or 30 cuts per inch involves, seemingly, a serious loss of output. Even relatively coarse parings of 20 cuts per inch economise bark at the expense of crop.

Such results as these give one furiously to think, as literary gents say. They cut so directly across our accepted principles of tapping, and are so susceptible of dangerous misinterpretation, that we may well pause and examine them further. I will consider the experiments themselves later. First, we may see what the application of their conclusions would involve in South India.

Practical Objections to Thicker Parings.—The usual rate of bark consumption on the single half cut, now practised in South India, is 5 inches per year of 150 tappings, the number of cuts to the inch being approximately 30. A change from 1/30th of an inch parings to thicker 1/15th of an inch parings, involving a bark consumption of ten inches per annum, would mean that cuts would have to be started at forty inches to give an eight-year renewal, and at fifty inches to give the ten-year renewal period desirable in South India, when the tree has been once circuited. The height at which cuts would have to be placed when longer renewal periods become necessary, as they have in certain cases, is so prohibitive that it need not trouble us here.

Now the practical obstacles to tapping, even up to fifty inches, will be apparent. Ignoring these and assuming tapping at fifty

inches to be feasible, the point most worth studying here is the extent to which the gain on the " swings " of thick parings would be lost on the " roundabouts " of high level tappings.

With the usual South Indian Bark Consumption of 30 cuts per inch, cuts need not be placed higher than 25 inches. The starting of cuts at fifty inches, which would be necessitated by the adoption of thicker 1/15th inch parings would involve tapping for five years of the ten-year cycle on bark of relatively low productivity.

From the experiment quoted just now we can form a rough idea of the degree to which these higher tappings will offset the advantages of thick parings. If a graph is constructed from the data available as to yields at different heights, it will give the probable yield at 25 inches as 98, and that at 50 inches as 54. The ratio of the yields at the two heights put into easier terms will be as 100 to 55. The figure given for the high cut represents, of course, the lowest value, since a relative inferiority of 55 to 100 would be shown for a short period only. As the tapping descends to the 25-inch level, yields would progressively improve. Actually, the yield obtained throughout the five years in question would be about 20 per cent. poorer in consequence of the lower laticiferous value of the bark drawn on.

The calculated loss of 20 per cent. in the five years of high tappings is not much to put against the 66 per cent. advantage to be got from 1/15th inch parings. Another factor may be cited, however, which in practice would operate to the disadvantage of the higher cuts. That is the poor quality of the tapping usually performed on high cuts, due to the difficulty found by tappers of comfortably reaching the height necessary. At times, the falling off in the quality of tapping would in itself almost neutralise all the yield benefits of the thicker parings.

Limited Validity of Bark Paring Results.—While the foregoing considerations somewhat weaken the case for thicker parings and indicate a strong presumption that during five years out of the ten-year cycle, at any rate, a change in the method of tapping might not be very profitable, it would still appear that a policy of thicker parings would, for the remaining five years, offer immense advantages.

If the experiments appealed to are admitted as valid, the case for the adoption of thicker parings cannot be reasoned away. Is there any justification, we may next ask, for challenging these experiments ?

Knowing the high standard of the H.A.P.M. scientific work, I have generally accepted their results, without question. While there are difficulties inherent in a bark paring test which make large