

LATEX TUBE BORE.*

ON Monday, 3rd December, 1928, Mr. H. Ashplant, the rubber specialist, United Planters' Association of Southern India, gave a lecture in the R. G. A. Council Room on his recent discoveries. The lecture, which was followed by a microscopical démonstration, was attended by members of Council and Directors of South Indian Companies, subscribers to the South Indian Rubber Research work. The following is a report of the lecture and discussion:—

Commencing with a discussion of the causes underlying yield variations, Mr. Ashplant stated that all attempts to express yield values in terms of latex ring number had been unsuccessful. Rubber investigators generally had fallen back on physiological explanations. They were encouraged in this by their failure to correlate yields at different heights in the tree with the number of latex rings at these heights.

In 1926 he, the speaker, had cleared up the last-named mystery. Investigations in South India had shown that the reason for apparent lack of agreement between the number of rings and the yields at various levels was the differing proportion of the total number of rings tappable at different levels. When only the rings in tapping were compared, one found that a remarkably close relation existed between yields and the number of rings.

No one seemed to have appreciated the significance of this work, which, in the speaker's view, rendered the assumption of physiological differences unnecessary, for, if the anatomical facts fully explained the yields at different heights in the same tree, it was reasonable to expect that a more detailed knowledge of the latex-producing organs would go a long way to explain the differences in individual tree yields.

LOGICAL BASIS OF THEORY.

Physiological theorists had entirely overlooked one point, and that was the necessity for accommodation. Even granting the laticiferous elements, in some trees to be more active in synthesising latex than those of other trees; the accommodation of the latex still had to be provided for. The latex is produced and stored entirely in the latex tubes and, being a gross substance occupying space, more latex meant more containing capacity, e.g., either more latex rings or larger latex tubes. There was evidence that the ring mesh of the latex tubes varied in density, but this seemed to have a small influence only.

Accommodation being so necessary, it was therefore clear that when the number of latex rings in a tree would not account for its higher or lower yield compared with other trees, one was driven to infer that the latex tubes themselves were of larger or smaller bore. This was only elementary logic.

It would be a long story to relate the investigations in detail, but as long ago as 1923 he had obtained evidence of the existence of tube bore differences. The measurement of latex tubes was then, however, surrounded by immense difficulties, and the results obtained frequently confusing. After several years' work, during which time he carried out a systematic exploration of the latex tubes, studying them and measuring them

* Reprinted from *The Bulletin of the Rubber Growers' Association*, Vol. 10, No. 12 December, 1928.

ring by ring from root-tip to leaf-tip in six trees, the reason for the confusing results was made clear. Owing to the tangential stresses due to secondary growth, the tubes are distorted, with the result that the diameters of the tubes, as seen in tangential sections, become progressively greater with distance from the cambium. This fact renders comparisons between the latex tubes in different trees exceedingly difficult and unreliable. Only comparisons of rings at similar depths are really valid. (Mr. Ashplant here pointed out from diagrams the manner in which distortion was produced.)

Feeling that the measurement of latex tubes in the bark, though possible, would always present so many obstacles as to be too slow for practical utilisation, owing to the distortion effects, he was impelled to try and discover a region of the tree where no secondary growth and no distortion occurred, and where the latex tubes could be studied in their original form. The leaf stalk suggested itself to him as the most likely region, and when the initial difficulties had been overcome, measurement of the latex tubes in the stalk proved quite feasible. Drawings were made to scale of the latex tubes in the leaf stalks of 240 trees which had been under study for years. These drawings, some of which were shown by the speaker, left no doubt as to the existence of significant differences of tube bore. When the final figures for average bore (which in each case represent the average of over 120 measurements) were available, they brought out the fact that these differences were intimately related to yield differences.

No mathematical analyses were necessary for the appreciation of the main facts. One had merely got to set down the tube bore values together with the individual yields.

The correlation tables prepared from the bore values thus measured were exhibited to the meeting by Mr. Ashplant, who drew attention to the very close relation between tube bore and yield. The tables clearly showed latex tube bore to be the chief factor determining yield. The tables did not show, and the speaker did not claim, that the trees with the largest tube bore were necessarily the highest yielders. There was the other important factor of ring number to be taken into account. Given a high number of rings, a tree of just above average tube bore could manifest good yielding capacity, and some of the high-yielders cited were trees of tube bore slightly below the best which had a phenomenally high endowment of latex rings. Mr. Ashplant said that what the table brought out, and what he did claim to have established, was that trees in which the tube bore was below a certain value never developed into good yielders. In the table exhibited nearly 60 per cent. of the trees fell into this class. Conversely, trees with the highest class of tube bore were never poor yielders. Figures were given of the measurements of nearly one hundred of the buddings and high-yielders on the Mundakavam Experimental Station, in confirmation of the latter statement, and it was further mentioned that some buddings grown from imported proven bud wood from Java had all been found to possess latex tubes of large bore.

Two of the tables exhibited are reproduced as plates.

HEREDITARY NATURE OF LATEX TUBE BORE CONFIRMED BY MANURING EXPERIENCE.

Mr. Ashplant briefly referred to the evidence in support of the hereditary character of tube bore already published in the R. G. A. Bulletin. There were, he said, some overlooked but very relevant facts which afforded strong corroborative testimony to the importance and hereditary nature of tube bore. He referred to the experience of manuring in rubber. With rare exceptions, which could all be explained, no noteworthy improve-

ment in the yields of rubber trees had ever been recorded from manuring. It can only be concluded from this that the factor in the tree that chiefly determines latex yields is unaffected by manurial stimulus. Of what nature could this factor be? It could not very well be of a physiological nature, because we know that physiological processes can be considerably heightened by manuring. The production of both leaf and fruit can be markedly increased by manurial applications. Were latex yields determined in a large measure by physiological factors, one might quite reasonably expect yield improvements of 20 to 50 per cent. to follow from manuring.

The non-responsiveness of rubber trees to manures indicated not only that the factor chiefly determinative of latex yield was a structural—that is to say, an anatomical—one but also that it was hereditary. It was part of the foundational framework of the tree.

Now the tube bore factor had been demonstrated by him to be about 75 per cent. responsible for determining yield. Latex tube bore, whether in nursery or mature plants, had been found to be totally unrelated to size of plant. Large bore tubes were just as commonly met with amongst the poorest-grown plants as amongst the well-grown, while in buddings from the same clone of different ages, or growing in soils of varying fertility, no differences in tube bore could be discerned.

Such facts as these provided evidence of the most weighty character in favour of the tube bore theory. The claim that latex tube bore is the hereditary determinant of yield was supported not merely by the close association between this factor and yield; it was supported by the whole body of evidence from every quarter.

We had here an illustration of the manner in which a single important truth brings all sorts of apparently unconnected facts into line. We had at last a satisfactory explanation of the long puzzling failures of manures in rubber. Not the least valuable part of the discovery was the demonstration that the degree of yield improvement possible from manures is rigidly limited. Only by selection could productivity be appreciably and remuneratively raised.

PRACTICABILITY OF TUBE BORE TEST.

After pointing out that the characteristic tube bore could be observed in plants as early as the sixth month, and probably before, Mr. Ashplant dealt with the practicability of a method of selection based on tube bore observations.

One important aspect of selection methods commonly lost sight of was the time factor. To be commercial, a selection test must be capable of being completed in from one to two minutes. At least 200 plants per day must be got through. Although, when he started these investigations, it took him a month to measure the tubes in a single tree, he could now make a rough estimation, good enough for practical purposes, in a few seconds. Experience shows that when properly organised from 200 to 300 plants could be tested per day. The upper and lower classes could be tested in a few seconds. All the trouble was with the middle classes, and here a few mistakes were unavoidable. He estimated that the test could be worked with 80 per cent. efficiency. New plantings selected in this way should have twice the yielding capacity of present areas.

As to the costs of the method of selection proposed, this would be anything from £1 to £5 per acre, according to the kind of staff employed. Even supposing that the cost of planting rubber be raised by £5 per acre, this was a small sum to pay for an enhanced yield of the order 100 per cent. enduring throughout the life of the plantation. Frequently more than £5

was spent on manures which produced, at the most a problematic increase of 10 per cent. and this only for a couple of years.

(At this point Mr. Ashplant exhibited a series of microscopic slides with mounted sections of leaf-stalks. From the images of these thrown upon a screen the differences in the bores of the latex tubes could be easily made out. A set of the original scale drawings of the latex tubes in leaf stalk tangential sections from which the tube diameter measurements utilised in the correlation tables were made was also exhibited to the meeting).

CONCLUDING REMARKS.

You have now had the opportunity of actually seeing for yourselves that recognisable differences in latex tube bore really do exist and cannot be a matter of controversy. In the last few minutes I have shewn you a fact that scientific workers who have been studying rubber trees for the last twenty years have missed. I do not imagine that in the short time at my disposal I have conclusively established to your satisfaction the close connection between tube bore and yield which I claim to have discovered. A little reflection must convince you, however, that these differences in tube bore must necessarily have an important influence on yield.

When I published my first summary of the discovery, it was decried as having been long known. I don't desire to refer again to a recent controversy, but this is an age of publicity, and I ask you gentlemen, whether it is likely that had anyone previously observed these differences and realised their significance they would have kept so entirely dark about it?

Note:—All trees in Table "A" are 9 years old. They vary in girth from 45 c.m. to 100 c.m. Despite this fact and the differences in number of latex rings, the most pronounced correlation of tube bore and yield will be apparent at a glance. This Table also brings out the difficulties of classifying the trees of around average tube bore. It will be noted that in the horizontal classes of from 14 to 15.5 microns, the examples with few rings are poor yielders, while those with many rings are medium to good yielders.

DISCUSSION.

Mr. P. J. Burgess: How do you explain the variation in yield when you come to diseased trees and wound response? When a tree is about to die it yields most vigorously.

Mr. Ashplant: I have frequently found that sick trees have very dilute latex. It appears to be a logical deduction from my theory that by pricking a plant one could determine the yield value by the rate of flow. Taking leaf stalks of equal dimensions, if one severed the leaf stalk the flow ought to give an indication of the yield. I have found that although sometimes the results from pricking are in agreement with the true yield and with the latex tube bore, there is frequently no agreement. The flow from pricking tests, both on leaf stalks and young or old Hevea plants, seems to vary with time of day, and is affected by a number of factors. I could get no uniform results. Fuller study of the question showed that the chief upsetting factor was the very great differences in the density of the latex, which markedly affected the rate and amount of outflow.

Mr. J. G. Wardrop: How do you investigate the plants in the nursery? Is it your proposal that the leaf stalks of these should be subjected to microscopic examination?

Table "B."—Correlation of Diameter of Latex Tubes and Yield per Ring.

Latex tube diameter (in microns)→	Average Yield per ring per tapping→																	Yield per ring 1927-28.									
	(Rings in tapping at 3 ft.)																										
	3.0	3.5	4.0	4.10	4.40	4.70	5.00	5.30	5.60	5.90	6.20	6.50	6.80	7.10	7.40	7.70	8.00	8.30	8.60	8.90	9.20	9.50	9.80	10.10			
10.5			1																						1		
11.0	1		2	2	2	1																				11	
11.5			3	1	2		2																			8	
12.0	1		3	1	2	3	1	3	2																	17	
12.5			2	1	2	3	3	3	1																	27	
13.0			1	1	4	2	4	3	1	4	1															25	
13.5	1		1	2	5	3	6	7	4	5	3	1														39	
14.0			1		1	3	2	6	2	4	4	1														25	
14.5			1		3	2	3	1	2	1	1	3	1	1												19	
15.0					1	1	3	1	5	3	2	1														18	
15.5			1		1	1	1	2	3	1	3	3														15	
16.0							1	1		2	5	2	1	1	1	1										16	
16.5										1	1	2														4	
17.0															1											4	
17.5										1																2	
18.0																										3	
18.5																										2	
19.0																										1	
19.5																											
20.0																										1	
2	2	10	7	14	24	21	17	28	19	19	18	4	10	16	6	5	4	1	1	1	1	2	1	2	1	1	239

Block by Survey Dept. Ceylon.
Each diameter value in above Table represents the average of over 120 measurements.

Mr. Ashplant: I have written something on this already, and if I have not made myself clear here it was because I did not know how much knowledge to assume. You may remember that I reported that the characteristic differences in tube bore have materialised when the plants were six months old. I did not finish my correlation investigations in time to get on to my nursery young enough, and by the time I tackled the nursery it was already six months of age. I found at that stage exactly the same proportion of the small, medium and large bore plants as I did amongst the ten year old trees. In a number of buddings I have examined I find that characteristic bore differences are already clearly made out when they are only two to three months old. We have recently successfully imported some bud-wood from Java. I have had the opportunity of examining their leaf stalks, and you may be interested to learn that they all have tubes of large bore of my A or B class. My assistant, whom I left to deal with the younger 1928 nurseries, reports that the characteristic tube bore has already materialised and that plants can be successfully examined at three months.

Mr. Eric Macfadyen: You said a native writer could do this work. Would you indicate what the routine would be and what apparatus would be required?

Mr. Ashplant: Some writers whom I have had in training lately were able to cut 40 an hour after four days' practice. I do not think they would have difficulty in cutting 50 to 60. You need one man for cutting sections and another to prepare, stain and mount them. A third man—the best man of all—would make the microscopic observations. I do not know yet whether it would be necessary to have a fourth man, but four would be the maximum. Most of the work except the rather trying actual testing can be done by unskilled men. They must be careful men, of course, who are able to read and write.

Major H. Edgington: Four men for one equipment?

Mr. Ashplant: Yes

Mr. F. D. Ascoli: What is the thickness of a section?

Mr. Ashplant: About 1/32 of an inch.

Mr. C. E. Welldon: Will not soil have an effect on yields?

Mr. Ashplant: There is a certain amount of increase in yield possible from differences in the quality of soils, but the possibilities of variation are very limited for the reason that I pointed out just now. Since tube bore is not influenced by manures and since this is the chief factor determining yield, it is beyond our power to raise trees out of their yield class. The discovery of this new factor and of its unalterable hereditary nature provides us at last with the explanation of the disappointing results from manures.

Mr. C. J. Arnold: Your remarks are in relation to leaf stalk only. Is that so? In that event, from your investigations it will enable us to plant out baskets. The plant will not be in the form of a stump—it will be basket or seedling planting, after investigations in the nursery have been carried out.

Mr. Ashplant: It is much more convenient to have nurseries, and I think ways are known of overcoming the set-back to growth in transplanting that the questioner feels. I am not very much in favour of basket planting for reasons of expense. I am not quite clear as to the first part of your question, but it occurs to me that you might have in your mind that since this work has been done on the leaf stalk, one ought first to establish a relation between the tubes in the stalk and those in the bark.

It is quite immaterial to the theory or practice whether or not there is a correlation between the tubes of the stem and the yield. However, although I have worked out this relation entirely on the leaf stalk, I find there is a most pronounced relation between the tubes of the leaf stalk and those of the stem and between the latter and yield. I have abandoned bark for leaf stalk examinations, because these get rid of the distortions due to the secondary growth and enable the end to be attained more quickly. I should mention that transverse sections are unreliable. All observations should be taken on the tangential plane.

Mr. C. J. Arnold: I am afraid I did not perhaps make myself explicit. What I am driving at is this, if we follow out your research so far as you carry us this afternoon and we employ your methods on the leaf of a plant, I think you said three months old, can I take the leaf stalk or leaf stalks from each individual plant, and shall I be safe in taking my readings of the leaf stalks of my nursery and finding the high yielders and planting out from the basket nursery; shall I be safe to plant out in prepared clearings and be certain that I have high yielders?

Mr. Ashplant: That is my whole point. My discovery amounts to this, that merely by examining and making observations of the tubes in the leaf stalk one can eliminate the C class of tube bore, and in so doing eliminate nearly all those trees that under no circumstances can become good yielders. It is not quite true to say that you will eliminate all of them. It will be advisable to allow for a little subsequent thinning since a percentage of the trees of middling tube bore will not develop sufficient latex rings to be capable of high yield. I have endeavoured to discover whether there are any early indications of a tree's potentialities of ring formation, but I regret to say that I have found no indication. Rings are put on for no rhyme or reason whatever. Sometimes five are put on in a year, sometimes one. I have measured their rate of formation and the distance between each, but unfortunately I have obtained no clue at all. The correlation between the ring number at say two years and the number at maturity is so low as to be quite unusable. Frequently a tree begins badly and picks up in the years following. One's first assessments are often entirely upset. That being so, we have to overcome the difficulty of our ignorance of the ring factor by subsequent thinning out. My proposal would be to plant about 180 selected plants per acre. The thinning out of 50 when about four years old would get rid of everything giving less than six lb. per tree; 30 to 40 trees in excess should be left for a few years to provide for losses from Brown Bast.

Mr. H. L. Coghlan: What would be the effect on budgrafting? Assuming in six months time we can tell, what will be the effect on budgrafting? Shall we continue to budgraft?

Mr. Ashplant: I believe that more recent accounts from Sumatra are very favourable to budgrafting. Theoretically there is everything to be said for budgrafting, but we have discovered a number of snags: weak growth, weak renewal, possibly greater susceptibility to disease, undoubtedly greater susceptibility to Brown Bast. Out of 100 bud mothers, it is doubtful if we should get more 10/15 per cent. of a class suitable for propagation. But I do believe there is a future for budgrafting. Once having proven one's mother trees there is everything to be said for propagating from those. I think the future will prefer a mixture of proven-out buddings and selected seed plants that pass the bore test.

Mr. G. H. Masfield: Perhaps you could tell us whether the whole work might be done by natives. Personally, I cannot see how in practice it will be possible to keep check of 50,000 plants. By what system is it possible to avoid mistakes through mixing the plant numbers? That seems to be one of the big difficulties.

Mr. Ashplant: I think you have hit upon one of the snags not only in this but in all other methods of selection. However, fortunately in the leaf stalk we have an organ which can be removed and labelled with comparative ease. I find that it will be very advisable to have nursery beds of a standard size with, say, 4 rows containing about 100 plants per bed. Supposing the nursery beds are geometrical, that is all the rows are in alignment, it would be almost sufficient to number the rows only. It is quite easy to pencil a number on the plant which will last six months. Immediately a section is cut the number is marked on the slide. We are fortunate in India in being able to get large numbers of men who are good at figures and can read and write English. Properly looked after I do not think there would be much danger of mixing—there is a danger certainly. It has been overcome on my experimental station by organisation, and I think it could be overcome on estates. After all whatever selection method we ultimately find best, we shall still be up against the difficulty mentioned, and if the European staffs and the native staffs of rubber estates are incapable of marking plants in a nursery and keeping records of those plants until the final stage of selection, it is surely an admission of incompetence. Labelling and checking of this character is only routine work. It is quite simple work, quite within the capacity of a man with a systematic mind.

Mr. G. H. Masefield: I have very great pleasure in proposing a hearty vote of thanks to Mr. Ashplant for his most interesting lecture. I had the privilege early this year of paying a visit to Mr. Ashplant at Mundakayam and I must say I was greatly impressed with the tremendous amount of work he has put into this subject, working out the relationship between bore and yield. If anybody could see the charts as I have done myself I think you would realise how much we owe to Mr. Ashplant for the work he has done in Southern India. Already by his solution of the secondary leaf fall problem, I think he can say he has saved the Rubber Industry in Southern India. Gentlemen, I ask you to pass this vote of thanks with acclamation.

NOTE ON MR. ASHPLANT'S WORK ON LATEX TUBE BORE.

The use of budded rubber and of selected seed both have for their objective the production of a stand of rubber of uniformly high-yielding powers. The main obstacle in the path of workers has been the time factor. The testing of mother trees for budding purposes is a lengthy process and, unfortunately, high-yielding mother trees have not always given progeny with high-yielding characters. It has therefore been necessary to prove mother trees, so involving a further expenditure of time. Similar difficulties have occurred in the selection of seed. Rubber is normally cross-fertilised, and in consequence all the known high yielders are of mixed parentage and their progeny will be of a mixed nature. Rigid selection from selected clones in isolated seed gardens may result in the production of seed which is approximately pure as regards yield characters. Here again the time factor occurs and twenty five years is a conservative estimate of the time necessary to achieve this most desirable object, although, in successive generations, the seed obtained would probably be better than that from an average source.

Any suggestion, therefore, that promises to eliminate the time factor in selection of high-yielding trees is of importance and must be investigated fully. Mr. Ashplant, in the preceding article, has indicated a method by

which he claims to be able to select plants in the nursery and to ensure (with 80% efficiency) at least the elimination of unprofitable trees.

Mr. Ashplant points out that attempts to correlate yield with the number of latex rows in the cortex have given results of low significance. He states that this is due to the variation in diameter of latex vessels in individual trees. He also points out that a fair measurement of latex tube bore cannot be obtained from sections of the cortex of the stem owing to distortions caused by secondary growth. He has therefore used the leaf-stalk or petiole for his determinations, and has come to conclusions which, if substantiated by full figures, are of considerable importance. He states that tube bore is an hereditary and constant character and gives a frequency array showing the relationship between latex tube bore and yield of 239 nine-year old trees. The correlation co-efficient of this array has been determined and is + .75 which indicates that there is a very significant relationship between the diameter of latex vessels and the yield. In other words the greater the bore, the greater the yield.

It is unfortunate that Mr. Ashplant has not published a detailed account of his experiments and it is to be hoped that he will do so as soon as possible. He has not told us the variation in latex tube diameters encountered in one petiole nor the variation in latex tube diameters of a number of petioles from one tree. Some errors have crept into his frequency arrays, possibly in reproduction. It is to be assumed that Mr. Ashplant has evidence for his statements, but, until full data are published and contributory experiments have been carried out elsewhere, confirmation of his theory must be withheld, particularly in view of the criticism put forward by Malayan workers.

If Mr. Ashplant's work is confirmed, it will be a relatively simple matter to obtain areas of rubber containing only a low percentage of poor yielders. Selection by examination of petioles in the nursery will ensure that no trees but those with wide latex vessels are planted. Subsequent testing of the yields and judicious thinning out will tend to produce a uniform stand of good yielders. It is not to be expected that areas planted in this way will prove equal in yielding capacity to those planted either with buddings from proved mother trees or with pure seed from high-yielding parents. Since, however, neither budding nor seed selection has yet reached a stage when results can be guaranteed, it would appear that, subject to confirmation, Mr. Ashplant's method is likely to prove of great immediate value to the rubber planting community.—M. P.