TAPPING RESULTS & OTHER OBSERVATIONS ON SEEDLING CROSSES OF HEVEA IN SUMATRA.

A long and interesting paper by Dr. C. Heusser in the September number of the Archief voor der Rubber Cultuur (pp. 495 to 530 in Dutch with an English translation, pp. 531—534, which unfortunately contains a few printers' errors in the summary) contains the results of three years' tapping of a large group of seedling crosses with observations on the inheritance of a number of secondary characters, and also throws light on a number of points on the development of seedlings in general.

In the following summary it is possible to quote particulars only of the crosses that best illustrate the main points. Details of the remainder must be sought in the original by those who have a special interest in any individual clone or cross.

The crosses were made in 1920 and the seeds planted in nurseries. From October 1921 to January 1922 the seedlings, roughly one year old, were planted out as stumps at Sungei Pantjoer after most had been marcotted. In addition a few seedlings of 1919 crosses were transplanted, making a total of 1691 stumps belonging to 30 different combinations of 17 mother trees (which gave from 30 to 80 gms. per tapping in 1919 at about 12 years old).

Owing to root disease and partly on account of unsuccessful plants 15 per cent. were lost in the first year. At the end of the second tapping year 1450 plants were left and 1393 or 96 per cent. of these were in tapping.

The plantation when taken over was overgrown with lalang and is reported to have grown tobacco 20 years before.

After cleaning, *Mimosa invisa* was planted between the rows and later the area was silt pitted and *Vigna* and *Centrosema pubescens* planted and ring weeding was carried out.

The crosses were planted in blocks at a distance of 7 metres (23 ft.) square to allow the trees to develop freely.

Tapping was started in Nov. 1925, 4 years after planting out the stumps, on trees with a girth of 40 cm. at one metre. Others were added later as they reached this size and so the comparison of merely the best trees of the family was avoided. The first tapping panel was opened with a 30° left handed cut over half the circumference at 50 cm. (20 ins.), and at the beginning of the 2nd year all trees were changed to a ⅓rd cut at 75 cm. The trees were tapped in alternate months—some rows of trees in the odd months, and the others in the even. With no Sunday tapping there were 150—155 tapping days a year. Bark consumption was limited to 1¾ ins. per tapping period and amounted to about 10 ins. per year.

The latex was coagulated in the cups and the biscuits for the month creped, dried, and weighed, and the average yield per tapping calculated.

As the yield recording gave additional work the tapping task was set at 150—200 trees and the tappers were moved from task to task in regular succession each day.

II. Tapping Results.

The following table (extracted from Heusser's table II) summarises the yields of all the crosses, and gives a rough comparison with normal estate yields for Sumatra.

TABLE I.

Tapping Years.	Crosses.			Normal Estate Seedlings		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.
Yield lbs. per acre -	119	371	439	112	224	313
No. of trees tapped per acre	58	61	65	69	81	93
Yield per tapping gms.	7.8	18.6	20.2	5.7	7.8	9.5

The yields of 28 unselected stumps in the experimental garden were less than one-half those of the crosses.

Thus even allowing for greater care and the wider planting distance " the higher yield per hectare is so great that the beneficial influence of selection cannot be disregarded." [It must be remembered however that both parents were selected. L.E.M.]

The decrease in the monthly yields due to wintering was less pronounced in the first two years than in the third year.

The reduction in yield due to changing to the new tapping panel is estimated at 37 per cent.

Yield of the Various Families.

There are big differences between the yields of the various families.

One striking result is that all the families with tree 157 as one parent, either male or female, are amongst the best: they averaged 28.5 grammes per tapping in the third year. The 145 families are the poorest with a mean yield in the third year of 15.9 grammes.

From a mathematical comparison of yield between groups of families with a common parent the mother trees can be arranged in order of value. Of those on Bandar Klippar 157 is the best; 161, 164, 151 and 165 are almost equal; 166 and 142 are not so good. The best Tjinta Radja tree is 138; 38, 146 and possibly 49 are almost equally good; and 149, 139 and 146 are bad.

Marked differences are shown between the annual percentage increases of yield. For example the yield of 166 × 164 increased by 200 per cent. from the 1st to the 2nd tapping year and then by 49 per cent. from the 2nd to the 3rd, 138 × 146 showed an increase of 154 per cent. and a decrease of 4 per cent. respectively, and 157 × 151 increased by 118 per cent. and then by 10 per cent. These differences probably are due to a different development of yielding power with age, and also to variation in the dependence of yield on the height of the tapping cut. Heusser concludes that "for selection purposes therefore the first tapping year cannot give a true aspect of the quality of the families, and true conclusions must be based upon several years' observations."

As the object of artificial pollination is eventually to get pure strains, the study of variation is important. With Hevea yielding ability probably is determined by a number of hereditary factors and therefore low variation can be taken as an indication of the purity of the family.

The degree of variation varies from family to family, for example the coefficient of variation (i.e. the standard deviation expressed as a percentage of the mean) for the three years' average yields is 34.5 per cent. for family 145 × 138 and only 19.0 per cent. for 138 × 139. All the 157 families are noteworthy for the symmetrical distribution of the individual tree yields about the mean.

It is not possible to make a strict comparison between the relative yields of mother trees and their clones and seedling families but it does appear that the best clones and seedling families do not necessarily come from the same mother trees, owing to the action of environment on the expression of hereditary characters. Dominant characters and environment determine the yield of the mother tree and its buddings, but the recessive (latent or dormant) characters can appear in the hybrid seedlings and give very different results. A mother tree may give bad buddings and good seedlings or *vice versa*, and both may be good or bad.

The monthly tapping figures of the 70 (5 per cent.) best individual seedlings given in Heusser's Table 8 show that considerable changes took place in the relative performance in the three tapping years. In illustration of this the yields of the seedlings that gave the

highest yields in the first, second and third years are set out in Table II below:—

TABLE II.

Best Tree in	No.	Cross.	——	1st yr.	2nd yr.	3rd yr.	Mean.
1st year	274	49 x 26	Yield gms.	24.5	48.8	34.4	35.9
			Order	1	8	145	22
2nd ,,	275	142 x 157	Yield gms.	19.5	58.4	43	40.3
			Order	9	1	59	8
3rd ,, (& all 3)	317	165 x 161	Yield gms.	11.7	50.4	91.9	51.3
			Order	*	7	1	1

* = below best 10 per cent.

Thus for individuals as for families, changes occur from year to year and the saying "good trees remain good" cannot be used in selection work, although it applies for practical thinning out.

III. Secondary Characters.

Although the production of rubber is the principal consideration in judging the trees, the secondary characters such as growth vigour, bark thickness, etc., cannot be ignored. It has been shown that these are largely hereditary but it is necessary to wait for at least a second generation to understand the method of transmission, which characters are dominant and so on.

Girth.

Measurements of girth give a good comparison of growth development of the trees. It appears generally speaking that the more strongly growing families were obtained from the better developed mother trees. The crosses 49 × 26 and 138 × 49 show the thickest trees, and most of the offspring of 164, 166 and 140 are of small girth.

Within the families the correlation between girth and yield is very slight, and even in the uniform family 157 × 164 the co-efficient is only 0.305 ± 0.014. Even so a well grown tree is to be regarded as more desirable than a feeble or thin one.

Bark Thickness.

Bark thickness appears to be hereditary, and the trees with the thickest bark belong principally to the families of 161 and 49, the bark measurements of which were above the average for the mother trees.

There appears to be a fair correlation between bark thickness and yield but it has not been evaluated so far.

Brown Bast.

At the end of the 2nd and 3rd years 4 per cent. of the trees were found to be suffering from brown bast, which is the same proportion as found in actual practice with the same tapping system. Only 6 trees were taken out of tapping owing to heavy attacks.

With one exception the highest yielding families suffered most severely from brown bast. The families with 164 and 161 as one parent were all badly diseased and, in 164 × 161, 21 per cent. of the trees were attacked. In this family considerable wood formation took place in the affected bark.

Other families of 36, 138, 146 also showed the disorder but it cannot be said which parent has the greater tendency. As brown bast did not appear in trees 161, 164 and 36 until 1921 and 1922, that is after pollination was carried out, it can be stated that susceptibility to brown bast is hereditary. Thus though there is a danger of cultivating seedlings or clones with this character there is also the possibility of eliminating it by careful breeding.

Tree Shape and Tendency towards Breaking.

In order to permit free development of their characteristic branching the crosses were widely spaced. Usually the seedlings of a family display striking uniformity of habit, and sometimes the peculiar characters of the parents are recognisable in their offspring. For example, the offspring of 49 in their second year form small crowns with right-angled branches, which later often become as strong or stronger than the main stem and this frequently ceases to grow. Thus the trees develop the typical bowl shaped crown and irregular branching characteristic of the mother tree and clone 49.

The seedlings of 36 are more liable to wind damage than the others owing to the acute-angled branching, the heavy crown and brittle wood. The influence of the strength of the wood apart from the branching habit is shown in the family 145 x 36 by some seedlings that are subject to wind damage in spite of the ideal lamp post branching they have inherited from 145.

Bark Renewal.

Bark renewal is very satisfactory for all the crosses and particularly so with the well developed trees.

Leaf Fall & Flowering.

The families show a striking coincidence in the time of wintering and flowering, and they can be arranged in the following groups:—

1. Early wintering: 157.
2. Average early wintering: 164, 165, 166, 36, 140, 141.
3. Late wintering: 151, 142, 138, 139, 26, 145, 161.
4. Flowering, but no complete wintering so far: 49.

Fertility.

Strong evidence that fertility, subject to external influences, is hereditary is given by the crosses between 164, a prolific seed bearer, and 161, which so far has produced very little seed. Except for the cross 164 x 161 all the other seedlings of 164 are good seed producers. As the number of seeds per tree is comparatively small in Hevea, the fertility character is important in breeding work.

Seed and Leaf Shape.

The leaves and seed of the seedlings are often strikingly similar to those of their parents, some resemble more closely the father and some the mother.

The seeds of some of the trees of 138 x 49 are very difficult to distinguish from those of 49. The seeds of 49 x 26 mainly possess the colour and markings of 49 with the large round shape of 26.

The leaves of most of the seedlings of the family 164 x 161 have the round broad tip of 161, while amongst the offspring of 151 its long pointed shape predominates.

No relationship could be found between yield and the quantity of leaves and seeds.

Backward Trees.

At the end of 1927 20 per cent. of the trees of the family 138 x 146 were backward. The leaves are yellowish green, wintering was premature and the stems mainly are crooked. As the trees are spread through the whole block this cannot be attributed to their situation and can be regarded as a character inherited from 138. The crosses of 145 were also backward to a smaller extent.

Formation of Cork.

The formation of an abnormally thick layer of cork must also be regarded as an hereditary character. It is particularly common in the progeny of 145, 138 and 164. In the family of 145 x 138

82 per cent. of the trees have coarse bark and both the mother trees and their buddings also display this character. Other families from these parents show from 26 to 43 per cent. of cork bark trees, which appear only sporadically in the remaining crosses.

Yellow Foliage.

The family 166 x 161 contains a number of trees with golden yellow to greenish yellow foliage. This character however is not detrimental to yield, and two trees of the family are amongst the best 2 or 3 per cent. of all the crosses.

Germinating Plants with no Green Leaves.

Several germinating seedlings of 145 x 139 and 138 x 139 had white leaves and died off on planting out. This character apparently comes from 139.

Fasciations.

A number of 164 seedlings developed fasciations when about one year old.

Discussion.

Although the results show that higher yielders have been obtained in the first generation the selection problem has not been simplified, and one cannot prophesy the behaviour of the seedlings from the yield of the mother trees.

Further seed selection will be carried on from families that are uniform as well as high yielding. New clones will be started from those families with high individual yields and a high family average, although for this purpose uniformity is secondary it should be considered as well, for the new clones may be valuable for seed as well as yield.

The most promising type for continued selection is 157. Already new crosses have been made to introduce more growing power and resistance to brown bast in addition to increasing the production, both from the old mother trees and from various members of the families of crosses that possess the desired characteristics.

The 161 families are a promising group for clonal selection but their variability is rather great for seed selection.

As one is limited to a small number of trees for seed selection and breeding, it is apparent that an endeavour must be made to increase the number of trees per family, for the results of experiments on a small number of seedlings can be regarded only as preliminary.

V. Conclusion.

On an average the seedlings have not yielded as well as the best clones, but as the yield of an area of seedlings can be increased by selective thinning then seed from crosses of 157 can be regarded as equal in value to buddings. In time when seed from seed gardens becomes available the slogan "buddings versus seedlings" will be changed into "seedlings and buddings."

L.E.M.