RESEARCH WORK ON RUBBER CULTIVATION IN 1929 (CONTINUED)*

Yield.—An extensive enquiry was made by Tengwall on the production of 275 estates in Java and South Sumatra with a total of 64,482 hectares. He figured out the average yield of fields of the same age and got the following figures:

Table X

Planting Year	Age of the fields years	Kilogram rubber per hectare
1923 ...	4-5 ...	71
1922 ...	5-6 ...	223
1921 ...	6-7 ...	271
1920 ...	7-8 ...	291
1919 ...	8-9 ...	321
1918 ...	9-10 ...	352
1917 ...	10-11 ...	372
1916 ...	11-12 ...	417
1915 ...	12-13 ...	392
1914 ...	13-14 ...	393
1913 ...	14-15 ...	436
1912 ...	15-16 ...	467
1911 ...	16-17 ...	441
1910 ...	17-18 ...	435
1909 ...	18-19 ...	434
1908 ...	19-20 ...	398
1907 ...	20-21 ...	432
1906 ...	21-22 ...	375
1905 ...	22-23 ...	394
1900-1904 ...	23-24 ...	449

In representing these figures in a curve, it becomes apparent that the increase-decrease in following years shows several irregularities. It must be taken into consideration, that the average figures have been obtained from rather heterogeneous material from fields of very different productivity. The figures show, that the decrease in production generally sets in not before the 15th-16th year. When we realise, that in the old fields the cultural conditions have often been unfavourable (much soil-wash, no green-manuring, etc.), the tapping system too drastic, the bark renewal poor, it may be expected that the increase in yield with the younger fields will last longer than in the old fields, so that the decrease in yield will set in later than in the fields under consideration.

Selection.—A general review of Hevea selection in Java was given by De Vries, Schweizer and Ostendorf. From this exposition it is apparent that the planting of selected trees, either seedling or budded trees is in Java not yet so general as in Sumatra, but the interest in selection is at present very great and a great number of clones of superior mother trees are grown on different estates: 85 clones at 6 estates are under observation of the Rubber Experiment Station. Three clones of the Estate "Bodjong Datar" (from mother trees of the Estate "Pasir Waringin") have been well tested and could be recommended to the estates; the average production was at the age of 9 years: 6·35 kg., 7·65 kg., and 6·90 kg. rubber (dry) per tree per year.

* From *International Review of Agriculture*, Part I, Year XXI, No. 9, September 1930. Part I of this paper was reproduced in *The Tropical Agriculturist*, Vol. LXXVI, No. 2, 1931.

In 1926 a beginning has been made with the more systematic testing of the different clones. To this purpose different clones have been planted together in one field, each clone in a number of plots (say 3 or 4) of ¼ to ½ ha. each; or the different clones have been planted in rows, each row of no more than 20 trees and alternately a row of the clone to be tested with a row of the so-called "standard clone", i.e., a clone which has already been tested for several years and the production of which is used as a standard. Of each clone two to six rows have been planted. In these experiments the trees have been planted at a rather large distance, viz., at the rate of 240 to 330 trees per ha.

In Ceylon selection as a plantation practice is still rather backward, L. Lord in a lecture delivered in Colombo, gave a general review of the situation in Ceylon and urged the planters to give the policy of rejuvenation a thorough and wide trial, using for all new plantings the best available material and prosecuting energetically research on the production of superior material. He advised strongly to test a great number of estate trees as mother trees and to test foreign clones. If these measures would be taken the lecturer thinks that there would be no reason for pessimistic views regarding the future of the rubber industry in Ceylon.

In selecting the high-yielding mother trees we are still obliged to follow the ordinary way of measuring the yield of the trees during at least one year. We have not a reliable method of estimating the yield by means of correlating characters.

As De Vries showed, it is still uncertain what may be expected from Ashplant's method of measuring the diameter of the latex tube.

As a general tapping system for the trees which must be tested for selection, the alternate-day tapping over 1/3 has been adopted in Java and in comparative experiments three clones (Ct 88, AV 36, and AV 50) are included as "control" or "standard clones." A reliable impression of the productivity of a clone can only be obtained by experimental tapping continued during one year, or, better still, during several years.

A short review is given by De Vries of the Hevea plants imported in Java from Brazil. It appears that practically all the Hevea trees in Java are descendants from the trees grown from seed which Wickham collected in Brazil in 1875.

On different estates a great number of mother trees have been selected and the yield has been recorded during several years. The Besoeki Experiment Station (Djember) and the Rubber Experiment Station (Buitenzorg) kept a number of these trees in regular observation. This collection contains trees which give an average of more than 150 gm. rubber (dry) per tapping, being tapped on alternate days over 1/3; a few trees give more than 300 gm. per tapping.

The simplest method of selecting consists in planting seedlings grown from "illigitime" seeds (seeds obtained by uncontrolled pollination) from selected mother trees. The fields planted with these seeds have shown that in this simple way a remarkable improvement of the production may be obtained. A field of the Estate "Passir Waringin" of 21½ ha. planted in 1916 with such seeds, gave the following yields:

7th	8th	9th	10th	11th	12th	13th year
390	600	666	820	717	703	745 kg. dry rubber per ha.

A field of the Estate Petaroeman, planted in 1916 and 1917 with "illigitime" seeds from selected mother trees of the Estate Kiara-Pajoeng gave the following yields:

	6th	7th	8th	9th	10th	11th year	
Estate Petaroeman	340	497	573	700	745	775 kg. dry rubber per year	per ha
Average production	200	280	360	420	450	470 do	do

Artificial cross-pollinations between trees of high yield and specially between trees of the best clones have been effected in Java in the last few years on a large scale. Records of yield of the seedlings are not yet available.

A few estates have made isolated fields planted with two or more high yielding clones. Of the seeds produced in these fields it is certain that father tree as well as mother tree is a high-yielder. From the fields planted with seeds from these fields records are not available either.

Other Hevea species than *H. brasiliensis* have been imported in Java viz. *Hevea collina*, *H. spruceana*, and *H. guyanensis*, but they have not shown any character which seems especially desirable. They have not been used for hybridisation experiments.

The practice of budding has been the subject of various investigations. In Java De Vries and Vrolyk made an enquiry about the results of the budding practice on the estates; seventy-five estates gave the information asked for.

The average percentage of success is still low in Java: only 60%. This may be partly the consequence of lack of training of the labourers to whom the budding work is entrusted, but there are still other causes. One of these is that budding is sometimes effected under unfavourable circumstances, and the enquiry proved clearly that budding is not equally successful in the different months. De Vries and Vrolyk figured out for each estate the success of budding obtained in each month in comparison with the success obtained in the most successful month. The figures thus obtained are combined into the following list:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Percentage of success (i.e., percentage of the success-percentage, obtained in the best month)	69	72	76	83	76	80	76

These figures show that it is advisable to wait some time after the beginning of the rainy season before starting budding; in October the stock and scion are generally not yet in the best condition for budding.

Vrolyk and Ramaer investigated this question more in detail. They realised that the differences in success obtained by budding in different months is the consequence of the differences in stage of growth of the scion and of the stock. The object of their investigation was to find in what stage of growth scion and stock are most suitable for the budding operation. They proved that the success in budding is greatest when the stock and the scion have just started to make a new sprout and the first leaves of this sprout are still very small and brown in colour. A little later when the new leaves have adopted a green colour and are still weak and hanging the percentage of success is already a little lower but still satisfactory. The older the new sprout of the stock the less suitable it is for budding, and the same is the case with the scion.

The question what seedlings are to be preferred for stock is still a puzzling one; one thing is apparent, viz., that quick-growing seedlings have the advantage of being earlier fit to serve as stock than slow-growing ones. This fact induced Schweizer to investigate whether seedlings of different mother trees show marked difference in quickness of growth. His investigations showed that this is indeed the case, so that "growth-velocity" must be regarded as a hereditary character; quick-growing mother trees seem to give as a rule quick-growing offspring. In using such seedlings some estates were able to perform the budding operation three months earlier: the seeds were collected in March and budding could be done in the beginning of the rainy season (November-December). Schweizer investigated also whether it is advantageous to use large seeds for

growing stock but, though the plants raised from large seeds are in the beginning stronger than plants from average or small seed, the difference is no longer to be seen after a few months. Thus there is no advantage in the use of large seeds for raising seedlings for stock.

As De Vries and Vrolyk mention, a thing which is in Java the cause of much disappointment is the dying off of buds after they have grown together with the stock. This occurs much more in the dry season than in the wet season (22·7% against 4·6%).

Budding in the nursery is in Java more generally applied than budding in the field (87% against 13%) and it has a greater success-percentage, as is to be seen from the following figures:

Table XI—Success-percentage of budding.

	In the nursery	In the field
	%	%
Besoeki (East Java) ...	53	36
Malang (East Java) ...	77	55
West Java ...	52	49

In this connection the investigations of Man in Malaya may be mentioned.

Budding in the field is carried on in Malaya to a great extent (figures are not given), though failures are more numerous than in budding in the nursery. Under nursery conditions it is possible to choose stocks in the best stage of growth for the operation, while under field conditions choice is much restricted. But the advantage is, that in budding in the field the budded plants are not checked in their growth by being transplanted.

Man considers the vigour of growth of stock and scion at the time of the budding operation as the most important factor influencing success, and the unfavourable results obtained with budding under drought conditions, especially on sandy soils, must be attributed to the less vigorous growth.

In order to prevent the dying off of the bud after opening the author advises to protect the bud. This may be done by trying a shade of leaves around the freshly budded stock immediately above the waxed binding. By this measure the newly-formed wound healing cells (callus) are prevented from dying. Another thing, which Man considers as important, is to take care in budding that patch and pannel fit well so that no wide gaps separate the edge of the patch from the cut edges of the bark of the stock. The following figures are given, which illustrate the influence of drought and of shading the bud:

Table XII

Period of budding	Percentage of success immediately after opening the bud	Percentage final success	Loss after opening as a percentage of initial success
Clone 1 Showery (April-May)	98	84	14
Drought (May-June)	99	70	29
Clone 2 Showery (April-May)	88	85	3
Drought (May-June)	80	35	56

Table XIII

Shading		Percentage of success immediately after opening the bud	Percentage final success
Clone 1	Light or none	91	70
	Heavy	99	87
Clone 2	Light or none	57	48
	Heavy	88	84

In Java the most generally applied budding method is the "modified Forkert method"; in East Java, however, some estates apply the "patch budding". The success-percentages obtained by the two methods were as follows:

Table XIV

Estate	Modified Forkert method	Patch budding
Besoeki (East Java)	55%	49%
Malang „ „	76	66

The Forkert method seems thus slightly more successful.

Budding does not succeed equally easily with different clones. In Java for instance clone BD 5 gives the highest success-percentage. Clone AV 152 the lowest. The same experience of different success with bud-wood of different clones has been gathered in Malacca.

About the influence of the stock on the scion we are still entirely ignorant. Dias surprised us with the statement, that "to a certain extent" the growth of the scion is not at all influenced by the stock. He claims that the bud in developing envelope all round the stock, and that the stock "attains a dormant state" and "increases neither in girth, breadth, length or in any other manner."

This statement, which will certainly not be credited by many botanists and planters, was criticised by Taylor. This author lays stress on the fact, that there is a considerable amount of information available on the influence of stock on scion with other plants than Hevea. This information goes to show that while each of the two retains its general characteristics there is a decided interaction between the two. Taylor considers that research work on bud-grafting in Hevea should keep in mind the possibility of such influence. He says that there seems to be an indication that plants budded on their own stocks grow better. In Java the Rubber Experiment Station takes the same stand and an investigation has been started on the influence of the stock on the scion.

The use of cutting off the "snag" flush with the top of the bud was emphasised by Weir. If this is done in the proper way, the cut sloping downward away from the bud, and at the proper time, say when the bud has grown 4-8 ft. and shows considerable brown bark, the amount of decayed wood remaining on the stock may be very little or may be entirely absent. In many cases however, especially if the snag is cut square across or cut too high, the decay may advance so far below the point where the cut is

usually made that an appreciable amount of decayed wood may be sealed in by callus tissues. The decayed wood next to the bud side of the stock may, before the callus is complete, cause the young tree to be overthrown by the wind. Also the shoot may be broken off by the wind if the cut exposes the decay so close to the bud that the callus does not form rapidly at that point.

The packing of budwood is a practical question of some interest, as the budwood must often be obtained from places more or less remote. Billington recorded the success in budding with budwood packed in different ways. The budwood was transported from Siantar (Sumatra) to Kuala Lumpur. The material was sent from Siantar to Belawan by train, from Belawan to Penang by boat and from Penang to Kuala Lumpur by train, a journey which took three days. Three different methods were used: (1) coconut fibre was put between the layers of budwood sticks, (2) each group of sticks was wrapped in a banana-sheath securely tied with string, the bundles so formed being buried in dry saw-dust, (3) each stick was wrapped in dry sacking and tied with string, and each group of five sticks was rolled in a further piece of dry sacking, and tied and buried in charcoal. All three methods of packing have proved suitable. To differentiate definitely between the methods a longer journey is evidently necessary. In the opinion of Billington it seems, however, that the charcoal and sacking method appears to keep the bark in more pliable and tractable condition.

One common objection advanced against budding is that budded trees may not renew the bark so satisfactorily as seedlings and that they will have to be allowed a longer period for bark renewal.

Billington made measurements on the virgin and on the renewed bark of young budded trees of four clones. Tapping was done daily in alternate months on trees budded in the first half of 1924 and transplanted as stumps at the end of 1924. Records of bark thickness were taken on 23-28 July 1928 of parts tapped February 1, April 1, June 1, and July 20, and again taken on 14-18 January, 1929 of bark tapped at the same dates also on August 1, 1928. Fifty-eight trees from four clones were used in these experiments.

From figures given it may be quoted here that in January 1929 the bark tapped 1st February had a thickness of 5·0 mm. (clones B 50 and B 58), 5·0 (clone A 44) and 6·3 (B 85).

The conclusion is that bark renewal in the budded trees is satisfactory so far and that the bark is adequate for tapping.

Often difficulties have arisen from the fact that budwood of different clones had been confused and that budded trees have been planted out under erroneous names. The need was therefore felt to find characteristics which would enable to distinguish the different clones from each other. It was already well known that the seeds are often very characteristic and they have often been of great help in finding out mistakes. But seeds are not always available when we want to be certain to what clone a certain tree belongs and, besides, the seeds of different clones are sometimes much alike. For this reason the Rubber Experiment Station in Java has made a study to find other characteristics which might enable to distinguish the clone in a more satisfactory way. It was found that the form of the leaves, the shape of the leaf scars on the stem, the shape of the lenticles, the way in which the cork is formed on the stem, the shape of the stem, the shape of the buds, etc., are different in the different clones, and that the clones can

be determined with the help of these characters. For a successful determination some training is necessary. The Rubber Experiment Station in Buitenzorg gives regular courses in which the planters are trained in this determination work.

New figures of the best Sumatra-clones were given by Heusser.

Of the clones which have been in observation for several years the Nos. 49, 50, 71, 152, 163, and 256 may be considered as the best clones. The No. 36 is among the foremost as regards yield, but it has the drawback of being very sensitive to wind.

These excellent clones are closely followed as regards yield by Nos. 27, 35, and 53.

Among the clones which have been in observation only during the short time the Nos. 183, 185, 186, 209, and 214 justify full interest and accurate further observation.

The yields of these excellent clones are given in the following list. Tapping has been done alternate monthly (about 185 tapping days per year).

Table XV

Number of clones	Year of planting	Yield per tapping in grams					
		4th	5th	6th	7th	8th	9th year
49	1919	4·0	2·9	20·6	32·5	35·8	34·5
50	1919	6·1	14·7	30·3	34·0	29·5	31·1
71	1922	7·8	12·4	21 8	–	–	–
152	1922	9·7	17·1	23·6	–	–	–
163	1922	9·8	12·7	20·8	–	–	–
256	1920	?	?	?	?	41·7	–
183	1922	?	14·8	24·0	–	–	–
185	1922	?	21·1	35·1	–	–	–
186	1922	?	14·4	20·5	–	–	–
209	1923	–	13·5	–	–	–	–
214	1923	–	14·5	–	–	–	–

It is interesting to compare with these yields those obtained from seedlings from selected trees by artificial pollination.

Heusser gave an account of the tapping results of such seedlings. Thirty combinations of different father and mother trees were investigated. The number of trees of these combinations were different and varied (from three to eighty-three). They were all tapped with one cut over ½ circumference alternate-monthly. As father trees were used the trees 36, 49, 138, 145, 146, 140, 141, 142, 157, 164, 165, and 166; as mother tree Nos. 26, 35, 36, 49, 138, 139, 140, 142, 146, 151, 157, 161, 164, 165, 166.

Cross-pollination was effected in March-May 1930, the seeds were gathered in August-October of that year and the seedlings were planted into the field in October 1921-January 1922. Tapping was started in November 1925. The yields of a few of the best yielding "families" (as a

"family" are designated the seedling descendants of the same father-and-mother-tree) and the average yield of all the seedlings are given in the following list:

Table XVI

Number of father- and-mother-tree	Yield per tapping in grams			Number of trees tapped
	4th	5th	6th year	
157 × 164	10·19	28·19	34·65	32
165 × 161	7·1	24·53	31·65	4
157 × 151	12·73	27·70	30·43	3
164 × 161	7·98	22·34	29·60	28
166 × 161	7·38	23·44	29·21	4
Average of all the seedlings	7·30	18·63	20·24	724

These figures prove that some combinations of parents give seedling families which are not less productive than the best clones.