J. Rubb. Res. Inst. Malaya, **21(1)**, 56–63 (1969)

Effect of Oidium and Dothidella-resistant Crowns on Growth and Yield of Hevea Brasiliensis

A. J. RADJINO
Research Institute for Estate Crops, Bogor, Indonesia

Since 1954, crown budding has been re-investigated at the Tjiomas Experimental Garden, Bogor, the experiment being initiated due to anxiety over possible outbreak of South American leaf blight caused by Dothidella ulei *P. Henn.*

The aim of the experiment was to look for the best combination of Dothidella-*resistant crowns and the high-yielding panel of LCB 1320. In looking for the best budding height, the budding operation was carried out at 170, 235 and 300 cm.*

Analysis of data for budding success, growth and yields gave the following conclusions:
1. FX 25 crown was the best budding success, while LCB 1320 gave the poorest results. The best results of the budding operations occurred at the height of 300 cm.
2. The effect of crown budding on growth differed significantly during the two growth periods (immaturity and at the time of tapping). In the first period with crown budding, growth was inferior. In the tapping period, however, it was more vigorous than the control group. During immaturity, all treated trees grew poorly.
3. FX 4037 crown gave the most depressing effect on growth during immaturity, while during the tapping years 1960 – 1964, it showed the contrary. Two other crowns, FX 25 and LCB 1320, had a minor retarding effect on growth.
4. The highly significant differences in growth as a result of budding heights were only evident during immaturity, where trees top-budded at the height of 170 cm were most vigorous.
5. All the treated crowns decreased the yield of the tapping panel of LCB 1320. Crowns of LCB 1320 and FX 25 caused the smallest fall in yield, while the LCB 870 crown gave the greatest fall in yield.
6. No significant difference in yield could be seen as a result of different budding heights.

Cramer, pioneer of the crown budding method in rubber cultivation, developed the idea of building the 'ideal three-component rubber tree' (DE VRIES, 1926).

At that time, many crown budding experiments were carried out in Java, to investigate the interaction effects of crowns and tapping panel of the trees. Many of the interactions between scions and stocks had been studied in earlier experiments. The results of advanced trials of crown budding suggested that it was important to investigate the interaction between stock, scion and crowns of the trees (BOBILIOFF, 1931; OSTENDORF *et al.*, 1936; and OSTENDORF, 1948).

Since the evolution of the *Oidium*-resistant clone LCB 870 in 1928, crown budding trials have been carried out for protective purposes. MAAS (1934) suggested top-budding a high-yielding clone with LCB 870, to protect against the *Oidium* attack. In Java, however, this method was not commercially successful. Yield depression caused by LCB 870 crown was greater than that caused by the disease.

In most natural rubber producing countries, the crown budding method is of advantage in commercial practice as a protection against leaf disease. Ceylon and some South American countries are thus the most suitable areas for application of the method.

COMMUNICATION 448

According to YOUNG (1949), indirect control of *Oidium* began in Ceylon in 1940. Top-budding with the *Oidium*-resistant crown, LCB 870, has been recommended there since 1951 (YOUNG, 1952).

LANGFORD (1957) reported that crown budding in South America began in 1940. In commercial practice, top-budded high-yielding eastern clones were used with *Dothidella*-resistant crowns.

HOEDT (1953) suggested international co-operation to protect the natural rubber growing countries against leaf blight outbreaks. He thought that, in the disease-free countries, three steps could be taken:

1. crossing the high-yielding and disease-resistant progenies, and yield-testing of the results;
2. crossing garden plantations for the first purpose; and
3. crown budding for the best combination between the local high-yielding clones and *Dothidella*-resistant crowns.

Resistance-testing of the crossed progenies should be however done in the countries where these diseases break out seriously, *e.g.*, in South America. Java, as a large natural rubber producer, should take preventive measures against the outbreak of this serious disease (HOEDT, 1953; WIDJANARKO, 1964).

For this purpose, Paardekooper re-investigated crown budding in Tjiomas Experimental Garden of the Research Institute for Estate Crops in 1954. In the first programme, he planned to use AVROS crowns assumed to be *Dothidella*-resistant but found alternatives in the *Dothidella*-resistant clones imported from Brazil via Malaya and the *Oidium*-resistant crown, LCB 870.

This experiment was intended to obtain the best combination between a local high-yielding clone (LCB 1320) and crowns of *Dothidella*-resistant clones. *Oidium*-resistant crowns of LCB 870 were also used. The second purpose of the experiment was to look for the best budding height of the crown.

A report by GAROT AND PARDEDE (1960), describes budding success, immaturity growth and latex flow of the prick-test experiment.

MATERIALS AND METHODS

Planting Materials

In this experiment, Tjir 1 illegitimate seedlings were used as stocks, budded with LCB 1320 scions as trunks of trees (recommended planting material for 1953 – 1954 in Java).

Three resistant crowns (and one control) were used:

(a) The *Oidium*-resistant crown of the clone LCB 870, a poor yielder with a heavy crown.

(b) Two *Dothidella*-resistant crowns of FX 25 (the recommended clone in South America) and FX 4037. FX 4037 had a small crown and FX 25 had an intermediate one. The yield data of both clones for Indonesia were unknown.

(c) The leaf disease and wind damage susceptible clone, LCB 1320, was used as the control crown. It had an intermediate crown.

(d) Untreated plants were LCB 1320 trunks, budded on Tjir 1 illegitimate seedlings as stocks.

Experimental Methods

The experiment was established on reddish latosol soil, in a flat small stony area (GAROT AND PARDEDE, 1960).

The budded stumps of LCB 1320 on Tjir 1 illegitimate stocks were planted in December 1954. The planting distance was 8 m × 3 m.

Pre-manuring with 250 grams Cheribon phosphate per tree was carried out just before and after the planting time.

The crowns were budded at heights of 170, 235 and 300 cm above the stock-scion union. The budding operations were carried out at four different times, *e.g.*, 18 – 23 February, 16 – 20 March, 9 – 15 April and at the end of May. At the time of top-budding operations, the trunks were twenty-six to twenty-nine months old, and were over 300 cm in height.

Two buds per tree were grafted in the opposite position in the first budding operation. The second operation was performed after the examination of the first. Trees with one successful budding were budded two new ones, while trees without any successful bud-

COPYRIGHT © MALAYSIAN RUBBER BOARD

TABLE 1. PERCENTAGE BUDDING SUCCESS*

Height of crown-budding (cm)	Crown				Mean
	LCB 870	FX 25	FX 4037	LCB 1320	
170	44	76	60	45	56.2
235	58	77	51	49	58.7
300	51	86	70	59	66.5
Mean of first operation	51.0	79.6	60.3	51.0	60.4
Mean of second operation	34.0	55.0	45.0	48.0	44.0

*GAROT AND PARDEDE (1960), with revised data

ding were rebudded three new ones. The next operation was performed on trees which had one or no successful graft.

All top-budded trees with two or three shoots were ringed 3 cm wide at a height of 5 cm above the top-budded patch, to stimulate the growth of the buds. The growing shoots were tied to the trunk to prevent wind damage.

The cutting-back of the trunk was done at the height of 35 cm above the top-budded patch, from April to 25 June 1957.

RESULTS

Budding Success of Grafted Crowns

Table 1 shows the budding success. FX 25 was more successful than the other crown clones in top working LCB 1320. A budding height of 300 cm proved to be the best for budding success.

Effect of Crowns on Growth

Growth observation was made by girth measurement of the trunk at a height of 150 cm above the first union. Data analysis of the average girth and girth increment are given in *Figures 1, 2* and *3*.

Figure 1 gives an indication of growth during two periods: immaturity (1957 – 1960) and tapping period (1960 – 1964). The girth increment of treated plants was greater in the first period than in the second. All the treated crowns retarded the growth of the trunks in the first period. In the second, they showed contrary effects.

The greatest retardation for the first measurement of growth was caused by the LCB 870 crown in 1958, a year after cutting-back. In the second measurement twenty-two months later, the FX 4037-crowned trees grew very poorly.

There was no significant difference between the depressing effect of both FX 25 and LCB 1320 crowns, which had the least depressing effects of all treatments.

In the immature period (1957 – 1960), the mean growth depressions of all treated trees varied from 9.5% to 25.9%. FX 4037 crown caused the greatest depression (25.9%), so that the trees were two years late in opening

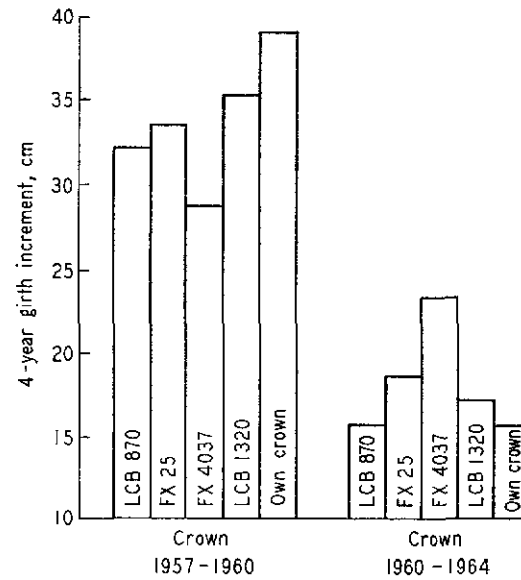

Figure 1. Two periods of trunk growth (girth measurement in cm).

I. Four-year (1957–1960) girth increment before tapping.

II. Four-year (1960–1964) girth increment after tapping had commenced.

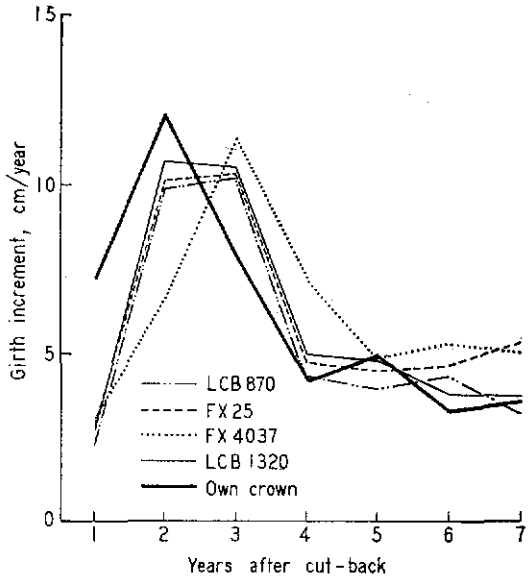

Figure 2. Influence of crown on girth increment.

for tapping. The other treated trees were only two or three months late in opening.

It was obvious that, in the first periods, budding heights caused significant differences in growth. The most vigorous growth was caused by budding and cutting-back at the height of 170 cm *(Figure 3)*. The growth difference, however, did not cause a different time of tap-opening. On tapping period there was no different effect of budding height on growth.

On tapping, all the treated plants grew more vigorously than the untreated ones, except LCB 870 whose growth was similar to the control group. The trees top-budded with FX 4037 grew most vigorously, more than 43.9% of the control rate. The superiority in growth of FX 25 and LCB 1320 was 19.4% and 9.7% respectively over the control group.

Effect of Crown on Yield

Prick-test experiments gave conclusive results, *i.e.*, that top-budded crowns delayed the latex flow of the trunk, and crowns of the poorer yield clones caused a greater depressing effect (GAROT AND PARDEDE 1960). In this, FX 4037 caused the greatest depressing effect, followed by LCB 870. No different effect on latex flow was caused by FX 25 and LCB 1320 crowns, the latter producing the least depressing effects.

Table 2 gives the means of seven half-yearly values of yield in grams of dry rubber per tree per tapping. The effects of crowns on the yield at various budding heights are described in this *Table*. Analysis of variance gives significant differences between crown effects. Budding heights, however, show no differences in yield effect.

Figure 4 shows the average yield for a six-month tapping period spread over three and a half years. Highly significant differences in depressing effect of crowns on yield can be seen for all the treated crowns, the LCB 1320 crown being no exception.

The greatest yield depression (caused by LCB 870 crown), was 40%, as compared to yields of untreated plants. The next crown was FX 4037, which caused yield depression to the extent of some 33.6% of the yield of untreated plants. Crowns of both LCB 870 and FX 4037 had no significant effect on yield.

There were no significant differences in the yield effects of both LCB 1320 and FX 25

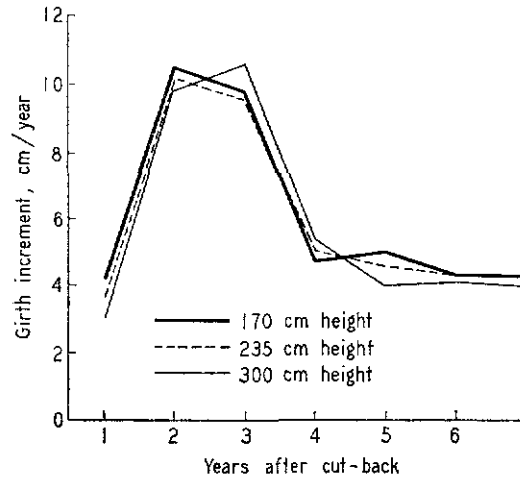

Figure 3. Influence of height on girth increment.

TABLE 2. YIELD IN GRAMS PER TREE PER TAPPING*

Crown	Height of crown budding (cm)	Tapping period 1961 1–6	1961 6–12	1962 1–6	1962 6–12	1963 1–6	1963 6–12	1964 1–6	Mean
LCB 870	170	17.4	15.1	20.3	18.3	20.9	20.3	16.5	18.4
	235	19.2	16.0	18.0	21.0	21.4	21.1	18.9	19.4
	300	18.1	15.1	16.1	17.1	18.1	17.0	17.1	25.2
FX 25	170	26.8	21.7	24.1	28.4	30.3	28.4	23.2	26.1
	235	22.3	19.8	23.8	27.6	29.9	27.8	24.1	25.0
	300	21.5	20.8	23.1	27.9	29.6	28.7	24.5	25.2
FX 4037	170	17.9	16.8	20.4	21.2	24.3	27.0	19.5	21.0
	235	15.2	15.8	17.5	20.0	22.0	25.9	20.9	19.6
	300	15.9	14.2	18.9	21.1	21.2	24.1	20.1	19.4
LCB 1320	170	25.9	21.3	25.5	31.1	32.2	26.0	24.4	26.6
	235	24.3	20.7	25.5	29.3	31.1	23.6	23.8	25.5
	300	25.2	22.0	25.7	30.3	28.2	23.2	23.7	25.5
Own crown LCB 1320	—	31.2	28.0	30.3	34.1	33.2	25.6	24.4	29.1
	—	31.3	27.3	31.2	34.8	34.9	24.9	24.3	29.8
	—	30.4	28.1	30.0	36.5	36.4	26.3	28.7	30.9

Min.sig.diff. (P = 0.01) — 2.5 Min.sig.diff. (P = 0.05) — 1.9 * Tapping system was S/2.d/3.67%

crowns, the decreases being about 14.0% and 15.6% of untreated plants.

In general, all the treated crowns caused yield depressions by about 14 to 40% of the yields of untreated ones. In comparison with treated LCB 1320 crown, there was no depressing effect caused by FX 25 crown (1.9%). LCB 870 and FX 4037 crowns caused serious depressing effects on yield (29.3% and 22.8% respectively).

There was no depressing effect on yield caused by budding heights in the grafting of crowns.

DISCUSSION

The main object of the investigation described here was to look for the best combinations between trunks of the local high-yielding clone LCB 1320 and crowns of *Dothidella*-resistant clones. It was desired that top-budded crowns should give no negative effects on growth and yield of the trunk (tapping panel).

Besides, the best height for budding crowns was also examined in this experiment. The

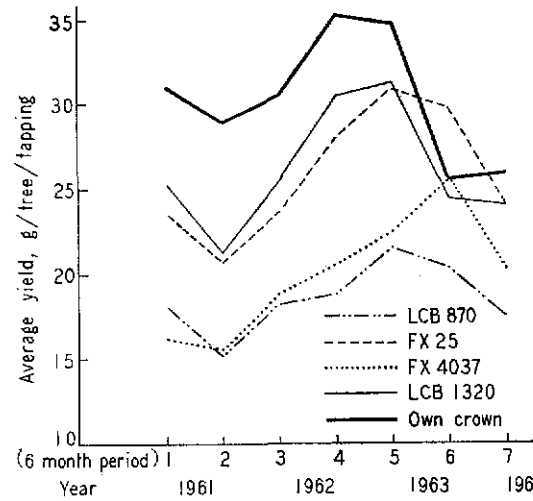

Figure 4. Mean yield of seven tapping periods.

final purpose of the investigations was to determine the recommended plant material and top-budding operational method (especially, the best height), to protect the rubber plantations against leaf blight.

The growth retardation during the immature stage, caused by top-budding and cutting-back, was presumably caused by incomplete re-formation of the crowns. This is obvious from *Figures 1* and *2*, where two different effects of crowns on girth increment in two growth periods are outlined. In the first, when the formation of the crown was not sufficient, growth of all treated plants was retarded significantly. During the tapping period, however, all the crowns were fully re-formed; all treated plants grew vigorously.

The most important factor observed was growth retardation during immaturity. Depressing effect on the growth of FX 4037 crown caused the delay of the tap-opening by about two years. This was the big disadvantage caused by poor growth of trunk, due to the slow formation of the FX 4037 crown.

When the top-budded crowns were fully re-formed, all the treated trunks grew more vigorously than the control group, the FX 4037-crowned trees being the most vigorous. However, this was not useful for commercial practice, because there was no positive correlation between girth and yield in this experiment.

In comparing the three budding heights, there was no varying effect detected on growth during the tapping period. The height of 170 cm gave the best effect on girthing of the trunk during immaturity. It could be presumed that the crown-scion union caused this vigorous growth of the trunk. The interesting factor is, however, the different effect on growth caused by budding heights without any delaying of the tap-opening.

When the best of the budding success was associated with the best height of budding, the best result of budding success at the height of 300 cm was reduced by slow girthing of the trunk. The better girthing effect of budding success of 170 cm was also reduced by the low percentage of the budding success.

In general, the results of the effect of crowns on yield of the tapping panel, were similar to those of previous investigators. Top-budded crowns reduced the yield between 15 and 40% of that of the control group. LANGFORD (1957) reported that depressing effect on yield varied from 10 to 20% of the control group in South America.

The different depressing effects on yield were presumably caused by the different yield capacities of trunk and crown clones: the greater the difference of yield capacity, the greater the depressing effect on yield.

For the confirmation of such conclusions, many more experiments of this type may have to be undertaken.

There is no modifying effect of budding height on the yield of trunk. This means that no answer has been found to the question why Ceylon and South America recommend heights of 8 feet and 6 feet respectively for top-budding operations (YOUNG, 1952; LANGFORD, 1957).

The advantage of success of budding at the height of 300 cm over the success of at 170 cm budding (66.5% vs. 56.2%) was reduced by the retardation of growth at immaturity (33.2 cm vs. 34.7 cm with M.S.D. of 1.4 cm). The choice of height should thus conform with the tapping systems in the whole of the planting programme cycles.

Presumably the height recommended for the growth stimulation could be 170 cm in the scion age of less than twenty-four months.

Two interesting crowns in this experiment are now discussed.

(a) Oidium-*resistant Crown LCB 870*

In the results of LCB 870 crown budding success, the effects on growth and yield were not good. The success of the budding operation itself was very low—51.9% and 34.0% of the whole operation, compared to 80% and 50% for the FX 25 crown. Growth retardation was very high and yield depression was about 40% of the control group.

According to Vollema, the decrease of yield caused by *Oidium* attack was about 25%

in the Java area. Its depressing effect on yield was less than that of top-budded crowns of LCB 870. Therefore, crown budding with LCB 870 cannot be recommended for protection against *Oidium* in Java.

(b) Dothidella-*resistant Crown FX 25*

The effects of FX 25 crown on growth and yield, and especially on the success of the budding operation, were very good.

In comparison with LCB 1320 crown, FX 25 crown gave better results in budding success (80% vs. 50%). It is the best of all treated plants. There were no significant differences between the effects of both crowns on growth and yield *(Figures 1, 2* and *4)*.

Presumably, a good combination between FX 25 crown and LCB 1320 trunk exists, and the physiological disturbance resulting from this union is also very slight. This was the positive result obtained from this experiment.

LANGFORD (1957) has recorded a similar experience in the top-budding experiment in South America. Decrease in yield was found to be very small if the two groups of trees had equal girth and healthy tops.

This experiment obviously shows that similar habits of crowns and girthing of FX 25 and LCB 1320 should cause no significant differences in decreases of yield. For confirmation of such conclusions, many more experiments must necessarily be undertaken. In an emergency, however, where a leaf blight outbreak cannot be avoided, crown budding of FX 25 (crown) on LCB 1320 (trunk) may be recommended in Java.

CONCLUSIONS

From this experiment, the following conclusions have been derived:

1. The FX 25 crown gave the greatest budding success (about 80%), while the crown of LCB 1320 gave about 50% success. The best result (66.5%) was obtained by top-budding at the height of 300 cm.

2. The crown effects on the growth of trunks were as follows:

a. The growth of the treated trunks was retarded by top-budding and cutting-back. Retardation apparently occurred before the re-formation of new crowns. Later, however, growth was more vigorous than that of the control group. The difference in girth increment was highly significant between the two growth periods.

b. At immaturity, the girth increment was retarded by 9.5 – 25.9% as compared to the control group. The greatest depressing effect was caused by FX 4037 crown, so that the tap-opening was two years delayed. The other treated plants, whose retardation in growth was about 9.5 – 17.3% of that of the control group, did not delay the tap-opening.

c. While in tapping, all the treated plants grew more vigorously than the control group, except for the LCB 870 crown. The most interesting crown was FX 4037, which grew most vigorously (43.9% more than growth in the control group). At this period, the average girth increment was less than 50% of that of the previous period. FX 4037 crown, however, gave more than 77.2% girth increment during the immature period.

d. The effect of the budding heights on growth was detected only during immaturity, about 170 cm being the best height for top-budding.

3. Crown buddings caused decrease in yield varying from about 14 to 39.2% of that of the control trees. The greatest depressing effect was caused by LCB 870 crown (39.2%), followed by FX 4037 (33.6%). Both LCB 1320 and FX 25 crowns caused less decreases in yield (about 14.0% and 15.6% respectively of the control).

Different heights of the buddings showed no significant differences in the yield of the trunk.

REFERENCES

BOBILIOFF, W. (1931) Enkele gegevens over hoogeplaatste oculaties. *Bergcultures*, **5(43)**, 1200.

DE JONGE, P. (1967) Data from Chemara crown budding experiments. *Plrs' Bull. Rubb. Res. Inst. Malaya No.92*, 250.

DE VRIES, O. (1926) Superieur plantmateriaal (Zaailingen en oculaties). *Bergcultures*, **1(15)**, 404.

GAROT, A. AND PARDEDE, S.M. (1960) Pengaruh okulasi tadjuk terhadap okulasi biasa. *Menara Perkebunan*, **29(6)**, 103.

HOEDT, TH. G.E. (1953) Remarks on *Hevea*-selection in S.E. Asia and Latin America in connection with the occurrence of *Dothidella ulei*. *Archf Rubbercult.*, **30(1)**, 1.

HOEDT, TH. G.E. (1961) *Dothidella ulei* and the selection and breeding of *Hevea*. *Proc. nat. Rubb. Res. Conf. Kuala Lumpur 1960*, 446.

LANGFORD, M.H. (1945) South American leaf blight of *Hevea* rubber trees. *Tech. Bull. U.S. Dep. Agric. No.882.*

LANGFORD, M.H. (1957) The status of *Hevea* rubber planting material for use in tropical America. *Turrialba*, **7(4)**, 104.

MAAS, J.G.J.A. (1934) De selectie van *Hevea brasiliensis* bij 's lands caoutchoucbedrijf. *Archf Rubbercult. Ned.-Indië*, **18**, 58.

OSTENDORF, F.W. (1948) Twee proeven met meervoudige *Hevea*-oculaties. *Archf Rubbercult.*, **26**, 1.

OSTENDORF, F.W., RAMAER, H. AND VOLLEMA, J.S. (1936) Results of an experiment with high-budded trees of *Hevea* on Klapanoenggal Estate. *Archf Rubbercult. Ned.-Indië*, **20**, 63.

WIDJANARKO, S. (1964) *Dothidella ulei*, tetap merupakan antjaman. *Menara Perkebunan*, **33(12)**, 267.

YOON, P.K. (1967) R.R.I.M. crown budding trials. *Plrs' Bull. Rubb. Res. Inst. Malaya No. 92*, 240.

YOUNG, H.E. (1949) Natural resistance to leaf mildew of *Hevea brasiliensis* by clone LCB 870. *Q. Circ. Ceylon Rubb. Res. Scheme*, **26**, 6.

YOUNG, H.E. (1952) Crown budding for *Oidium* resistance. *Q. Circ. Rubb. Res. Inst. Ceylon*, **27**, 16.

DISCUSSION

Chairman: Prof. D. S. MacLusky

(Paper presented by Mr. W. Partosoedarso)

In answer to the Chairman, Mr. Partosoedarso said that the delay of two years in reaching tappable maturity for crown buddings of FX 4037 was due to many failures, up to four re-buddings being necessary. Mr. P.K. Yoon said this was not unusual in the earlier R.R.I.M. experiments when crown budding onto brown tissues involved cutting off the crown of a two-year-old tree. The estimated delay with the current green budding method was six months if any.

Several explanations of the better girth increment during tapping of trees crown budded with FX 4037, which had the poorest immature growth, were offered. Mr. E.C. Paardekooper thought it was due to the inclusion of a larger proportion of untapped trees in this treatment. Dr. P. de T. Alvim wondered if the FX 4037 crowns were smaller, less mutually shaded and so more efficient, whereas Dr. P.R. Wycherley suggested that they had more scope for expansion. However, Mr. Partosoedarso said the rate of crown growth of FX 4037 did not differ from that of FX 25. Although budding at 170 cm height had given better growth during immaturity than crown budding higher, it had not produced higher yields; Mr. Paardekooper suggested that yield enhancement due to greater girth with the lower budding height might be confounded with yield depression due to the lesser distance between the panel and the low-yielding crown.

Dr. N.W. Simmonds enquired if crown clones resistant to wind damage and to the major leaf diseases in Malaya were available to make it a practicable proposition now. Mr. P.K. Yoon considered GT 1, PR 107 and perhaps RRIM 612 were suitable concerning wind resistance. Dr. R.L. Wastie said several *Gloeosporium* resistant clones were available. Dr. O.S. Peries observed that although LCB 870 was tolerant to *Oidium*, it was very susceptible to *Phytophthora* in Ceylon.

The Chairman enquired the chances of combining high yield and resistance genetically rather than horticulturally. Dr. Simmonds said that in most crop species both high yield and high resistance were rare characters until obtained by intensive selection. The chances of a random combination of these were very low. Dr. Wycherley said extensive collections of wild *Hevea* had been made throughout the Amazon basin by botanists of the United States Department of Agriculture and the Ford and Firestone companies; good yield and resistance were indeed both rare, although a population of *Hevea brasiliensis* from Madre de Dios in Peru was better than average in both respects. Until genetic combination was achieved by breeding, horticultural methods were a useful expedient. In the case of leaf diseases partial resistance in the stock plants and trunk clones is desirable to enable trees to be grown to buddable size at field spacing without artificial protection.