J. Rubb. Res. Inst. Malaya, **21(1)**, 64–72 (1969).

Economics of Controlling Secondary Leaf Fall of Hevea Caused by Oidium Heveae Steinm.

R. L. WASTIE
Rubber Research Institute of Malaya, Kuala Lumpur, Malaysia
B. J. MAINSTONE
Dunlop Research Centre, Batang Melaka, Negri Sembilan, Malaysia

Nine pounds per acre of sulphur dust was applied with a portable duster to the canopy of mature PB 5/51 on an estate in Negri Sembilan, on six occasions at intervals of five to seven days during post-wintering refoliation. Oidium heveae *secondary leaf fall was largely prevented and the foliage was retained throughout the year, in contrast to untreated plots where defoliation was severe and the canopy remained poor. Treatment had no effect on the yield of newly exploited trees, but improved girth increment and the rate of bark renewal. Girth, bark renewal and yield were increased and weeds were suppressed in the case of trees which had been tapped for two years. Although the profit on the eight per cent increase in yield during the nine months after treatment, together with savings on weed control, did not cover the expense of dusting, the cost of treatment would have been recovered if the whole area had been treated with tractor-mounted equipment. The implication of these findings is discussed with reference to the profitability of controlling* Oidium *secondary leaf fall in areas where it is habitually severe.*

Secondary leaf fall of *Hevea* caused by *Oidium heveae* Steinm. was first recorded in Malaya (now West Malaysia) in 1928 (WEIR, 1929). Its importance in neighbouring rubber-growing countries led to extensive studies on its epidemiology (SANDERSON, 1930; BEELEY, 1930, 1932a) and, in 1930, to it being gazetted a notifiable disease. Experiments on the control of *Oidium* leaf fall with sulphur dust were attempted (BEELEY, 1932b, 1933, 1934), but although good control could be achieved, with ensuing improvements in foliage, bark renewal and yield, it could not be shown that treatment was economic, except possibly in the States of Negri Sembilan and Malacca, where the disease was invariably more severe (BEELEY, 1933). Later experiments indicated that dusting was not worthwhile (BEELEY, 1935, 1936, 1938a, 1938b, 1939). This opinion was shared by HILTON (1959); only in seed gardens where protection of the flowers against *O. heveae* is desirable has sulphur dusting been recommended or used (HILTON, 1959; RUBBER RESEARCH INSTITUTE OF MALAYA, 1966).

Among other rubber-growing countries in Southeast Asia, *Oidium* control is widely practised only in Ceylon, where economically beneficial effects of sulphur dusting have been demonstrated (MURRAY, 1931; VAN EMDEN, 1954; YOUNG, 1950, 1954). Early work in Indonesia (quoted by YOUNG, 1952) also indicated the value of dusting, and *Oidium* control was still practised there in 1940 (CRAMER, 1956). Dusting has also been found effective in India (RAMAKRISHNAN AND RADHAKRISHNA PILLAY, 1962); Cambodia and Viet-Nam, like West Malaysia, consider the disease to be of minor importance (PERIES, 1966).

There is a wide variation in clonal susceptibility to the disease (PERIES, 1966). Among the four clones currently recommended for large-scale planting in West Malaysia (RUBBER RESEARCH INSTITUTE OF MALAYA, 1967), PB 5/51 is of above-average susceptibility (PAARDEKOOPER, 1965), and commonly suffers extensive defoliation in areas where *O. heveae* is severe. Repeated defoliation, sometimes followed by dieback of the branch tips, occurs throughout

COMMUNICATION 449

February and March, resulting in a poor canopy for the remainder of the season. Other clones are less affected, but treatment is rarely attempted. This paper reports the results of an experiment to determine the effects of *Oidium* secondary leaf fall on yield, growth and bark renewal of PB 5/51.

METHODS

Two areas of mature PB 5/51 were selected on an estate in Negri Sembilan where the disease is habitually severe; both were situated on a coarse Rengam series soil on gently undulating land. Although the fields had received additional applications of fertiliser to compensate for the poor canopy, the trees were of relatively poor vigour, which could be related to repeated past attacks of *Oidium*. Block A was ten years and Block B eight years old; both were straight-planted and contained approximately 128 trees per acre. The average girth was 59 cm (A) and 54 cm (B). In each area dusting was done over two 5-acre plots, separated by untreated control plots of the same size—3 in Block A and 5 in Block B. Block A, in which refoliation began uniformly at the beginning of March, was dusted on six occasions at 5-day intervals, beginning as the first leaves were expanding. The *Oidium* attack was heavy but no leaf fall had then occurred. At the end of the $3\frac{1}{2}$-week dusting period most of the leaf had hardened and was no longer susceptible to defoliation. Although *Oidium* was still abundant, little leaf fall had occurred in the dusted plots; in contrast, those not treated had suffered severe defoliation.

Block B refoliated more slowly and unevenly; dusting was done five times at weekly intervals and twice at intervals of four days over a period of five weeks, by which time refoliation was largely complete. *O. heveae* was less severe in this area, as was leaf fall in the control plots.

Dusting was carried out at a rate of 9 lb of 95% sulphur dust per acre per round, applied with a 'Kestrel' portable duster driven by a 2.2 hp petrol engine. A team of four workers treated 20 acres in 4 hours, the machine being carried along each interrow. It was, however, insufficiently powerful to cover the entire canopy, hence a moderate amount of leaf was lost from the unprotected top half of the trees.

Girth and bark renewal were measured at 4-monthly intervals throughout the year on fifty trees in the centre of each plot. Girth was measured in cm 6 ft above ground level and the mean squared to give a measure of the cross-sectional area of the trunk. Bark renewal was recorded with a Schlieper gauge at the 9- and 18-month intervals above the tapping cut in Block A; due to the shorter period of tapping in Block B, bark renewal was recorded at the 9-month point only.

Yield was recorded at fortnightly intervals on the same fifty trees under observation for girth and bark renewal by collecting the latex from one tapping and estimating its d.r.c. to calculate the mean yield per tree.

The density of the canopy was estimated at intervals throughout the year by recording (in foot-candles) the amount of light falling on a 'Megatron' photo-electric cell at the base of a black cylinder 4 cm in diameter and 16 cm long, held vertically under the canopy. Seven parallel transects of the experiment were made, passing through each plot in turn each time, eight readings being taken in each plot. An eighth transect was made under open sky. The mean readings in each plot were expressed as a percentage of those in the open, thus indicating the percentage of light passing through the canopy—this being inversely proportional to the canopy density.

The amount of leaf mildew was estimated one week after dusting was finished in Block A and after one month in Block B. In each plot one terminal whorl of leaves was picked at random from the lower half of the canopy of each of thirty trees; the amount of mildew was assessed on each of five leaflets picked at random from each whorl by comparing it with a set of drawings representing disease intensity standards. Scores of 0–6 were given according to the area of leaf covered by the fungus—0, 0.5, 1, 2, 4, 8 or 16 per cent or more respectively. It was not possible to recognise by eye categories of infection above this level. The leaflet scores were added to give a whorl score

TABLE 1. INTENSITY OF *OIDIUM* IN DUSTED AND CONTROL PLOTS. MEAN DISEASE SCORE OF 30 TREES PER PLOT

Block	Treatment	*Oidium* score						
		Plot scores					Mean	% of Control
A	Dusted	5.1	4.2				4.5	27
	Control	18.7	16.4	14.3			16.5	100
B	Dusted	3.4	6.1				4.8	35
	Control	14.1	12.8	14.4	13.8	12.7	13.6	100

(maximum 30) and the intensity of infection expressed as the mean whorl score per plot.

RESULTS

Intensity of Oidium

Table 1 indicates that dusting greatly reduced the intensity of *Oidium* in both blocks, and confirms the visual impression that undusted plots in Block A had the most disease. Presumably it was because of the uneven refoliation that the effects of dusting in Block B were less well marked, and differences between treated and untreated plots were smaller throughout the year than they were in Block A.

Canopy Density

Figure 1 shows that at the first measurement, seven weeks after dusting started, the mean light intensity under the dusted plots of Block A was only 13% of that in the control plots; the disparity narrowed as leaf was lost from the dusted plots throughout the rest of the year—not because of an increase in the canopy of control plots, for this also lightened similarly. The marked fall in the relative amount of light under the treated plots in early October was due to a flush of refoliation after secondary wintering; control plots wintered similarly but did not refoliate.

Block B followed a similar trend, but a gap in the readings in October obscured the post-secondary-wintering increase in canopy density of the dusted plots.

By the end of the year the light intensity in the dusted plots had risen to about 60% of that in the control plots. The striking differences in the density of the canopy can be seen in *Figure 2*. The heavy shading of the ground under the dusted trees is clearly shown, as well as the poor canopy of control plots.

Yield

Dusting had no estimable effect on the yield of Block B, but dramatically improved that of Block A *(Figure 3)*; the first record, taken in May, some ten weeks after dusting had started, showed a 44% increase in yield—a mean of 0.71oz/tree in control plots compared with 1.02oz/tree in dusted plots. This increase gradually fell, and in mid-September the yield of dusted plots dropped temporarily below that of the control plots as a result of secondary wintering. The yield subsequently rose, only to fall again below the control level at the end of the year. Part, at least, of this fall was due to the fact that double tapping was carried out immediately before the yield recording, to compensate for rain in the previous month. The total increase in yield over the thirty-five weeks of recording was 8.1%.

The apparent lack of effect of dusting on the yield of Block B is probably partly associated with the initial poorer vigour of trees in the plots designated for treatment. *Tables 2* and *3* indicate that both bark renewal and girth were initially less in dusted plots, whereas in Block

TABLE 2. EFFECT OF DUSTING ON GIRTH INCREMENT EXPRESSED AS PERCENTAGE INCREASE IN CROSS-SECTIONAL AREA OF TRUNK. MEAN DATA FROM 50 TREES PER PLOT

Block	Treatment	Replicates	Mean of squares of girth (cm^2)			Mean % increments		
			Feb.	June	Oct.	Feb.–June	June–Oct.	Feb.–Oct.
A	Control	3	3530	3644	3721	3.2	2.1	5.4
	Dusted	2	3407	3574	3669	4.9	2.7	7.7
	Difference		123	70	52	1.7*	0.6	2.3*
	Min. sig. diff. (P=0.05)					1.1	1.6	2.3
B	Control	5	3033	3187	3336	5.1	4.7	10.0
	Dusted	2	2875	3059	3242	6.4	6.0	12.8
	Difference		158	128	94	1.3*	1.3	2.8*
	Min. sig. diff. (P=0.05)					1.0	1.5	2.1

TABLE 3. EFFECT OF DUSTING ON BARK RENEWAL 9 AND 18 MONTHS ABOVE TAPPING CUT. MEAN DATA FROM 50 TREES PER PLOT

Block	Treatment	Replicates	Bark renewal (mm)					
			9 months			18 months		
			Mar.	July	Nov.	Mar.†	July	Nov.
A	Control	3	3.90	4.10	3.57	3.84	4.18	4.61
	Dusted	2	3.94	4.53	4.83	3.90	4.62	5.59
	Difference		0.04	0.43	1.26***	0.06	0.44	0.98**
	Min. sig. diff. (P=0.05)		0.47	0.72	0.49	4.62	0.87	0.50
B	Control	5	4.03	4.15	4.02			
	Dusted	2	3.67	4.40	4.46			
	Difference		—0.36	0.25	0.44*			
	Min. sig. diff. (P=0.05)		0.43	0.66	0.44			

†Data from 1 treated and 2 control plots only.

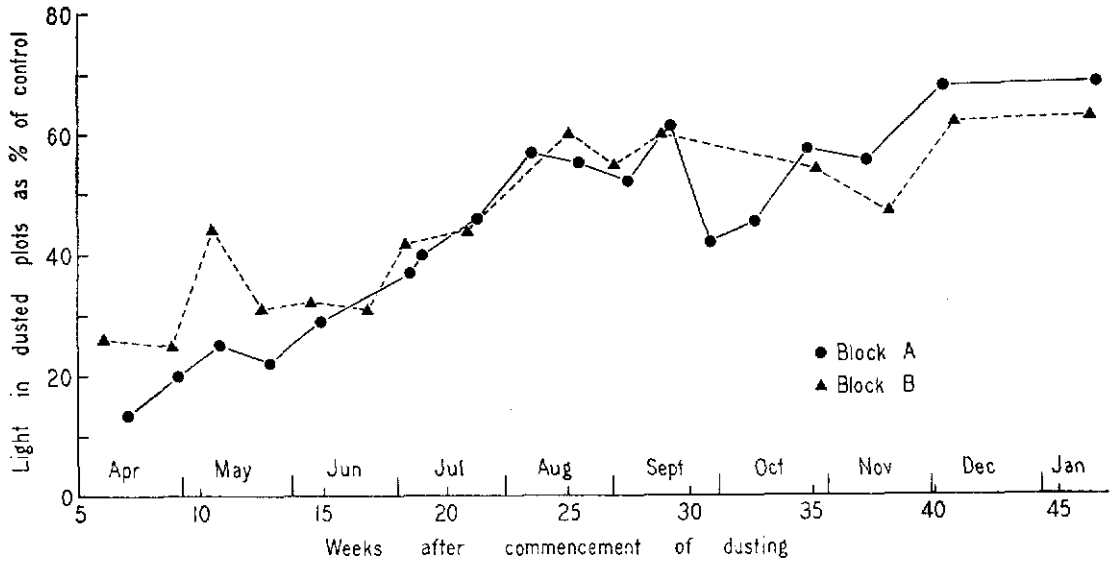

Figure 1. Light intensity in dusted plots as a percentage of that in control plots.

A both series of plots were of similar vigour. Moreover, whereas in Block A the pre-treatment yield of tapping tasks in the experimental area was similar, it is not known if the same was true of Block B; it is therefore possible that the plots designated for dusting were of lower initial yield as well as of poorer vigour.

Growth

Growth rate, as measured by the increase in cross-sectional area of the trunk, was better in the dusted plots of both areas, reflecting the improvement in the canopy *(Table 2)*; over the 8-month period (February–October) the estimated percentage increase in trunk area was 43% greater than that of control plots in Block A, and 28% better in Block B.

Bark Renewal

Progressive improvements in bark renewal were obtained in the dusted plots *(Table 3)*; after eight months the thickness of 9-month-old renewed bark in dusted plots in Block A was 35.3% greater than that of control plots; in Block B the difference was 10.9%. The 18-month renewal in Block A was also much improved.

Weed Control

As a result of the improved canopy in the dusted plots of Block A ground vegetation was strongly suppressed and expenditure on weed control considerably reduced, giving a saving of $6.10 per acre for the eight months April–November *(Table 4)*.

Little weeding was necessary in Block B, but a similar suppression of weeds was noticed. The expenditure on weed control was $1.90 per acre in control plots; no weeding was done in dusted plots.

DISCUSSION

Although it is not possible to predict the future effects of dusting from only one season's results, it is likely that similar benefits would be obtained every year, since *Oidium* is always severe in the area where the experiment was carried out. The cumulative beneficial effects on growth and bark renewal of annual treatments should result in an even greater increase in yield in Block A; for, without dusting, repeated unsuccessful attempts at refoliation led to depletion of starch reserves and twig die-back. By the end of the year the undusted plots

Figure 2. Canopy of a control plot in Block A (left) compared with that of a dusted plot one month after dusting began.

in Block A were almost leafless. It is to be noted, too, that controlling *Oidium* prevented subsequent leaf fall due to *Gloeosporium (Colletotrichum gloeosporioides* Penz.*)* which becomes more serious in the wetter weather usual in April and May. Trees still refoliating at this time are attacked by the latter disease.

The younger and relatively more vigorous trees of Block B, opened to tapping only eleven months before dusting began, benefited from the treatment to a lesser extent than did Block A, which had been in tapping for almost three years. The uneven wintering and subsequent prolonged period of refoliation gave rise to a less satisfactory control of *O. heveae*, even though dusting was done over a longer time. Although yield was not shown to have been improved, bark renewal and the rate of growth benefited from the treatment, so it is to be expected that future yields would be favourably affected as a result.

No significant differences were detected in the nutrient content of leaves from dusted and untreated plots collected on 31 July, but it is nevertheless possible that a saving in fertiliser might accrue in the future since it should no longer be necessary to apply such generous amounts of manure to trees growing with normal vigour as a result of their freedom from mildew.

Economics of Dusting

The only benefits of treatment that can be directly costed are improved yield and reduced

weeding costs. The average overall yield of Block A (of which the dusted portion was only a small proportion) was 1093 lb per acre in 1967; the yield during the nine months after dusting (May 1967–January 1968) was 940 lb. An average improvement in yield in the dusted plots of 8.1% therefore represents an additional 76 lb of rubber during this period, but because the greatest increase in yield was obtained immediately after dusting in months when the yield was relatively low, the actual increase was only 46 lb per acre. The profit on this amount (at 15 cents/lb) was approximately \$7; adding the saving on weed control (\$6 per acre for seven months) gives an improved profitability of approximately \$13 per acre.

The price of dusting sulphur applied at the rate of 9 lb per acre amounted to \$1.39 per acre/round. The cost of applying the dust to a small area was disproportionately high—\$1.82 per acre/round, comprising transport, running expenses of the dusting machine and field workers' wages—thus making an overall expenditure of \$19.26 per acre for the six rounds. However, a more realistic estimate of the cost of sulphur dusting based on that carried out with tractor-mounted equipment to protect seed gardens from *Oidium* flower drop is about \$2.20 per acre/round for slightly more than 9 lb sulphur per acre, of which the cost of application was only \$0.62 per acre/round (McIntosh, 1967). This gives a total cost of approximately \$13 for six rounds.

In Block A the cost of treatment would have been balanced by the benefits of increased yield and reduced weeding costs if overall dusting with tractor-mounted equipment had been carried out. Over the whole year a profit could be expected, and this should be considerably increased in future years for annual dusting would give further improvements in girth and bark renewal which would be reflected in a further increase in yield.

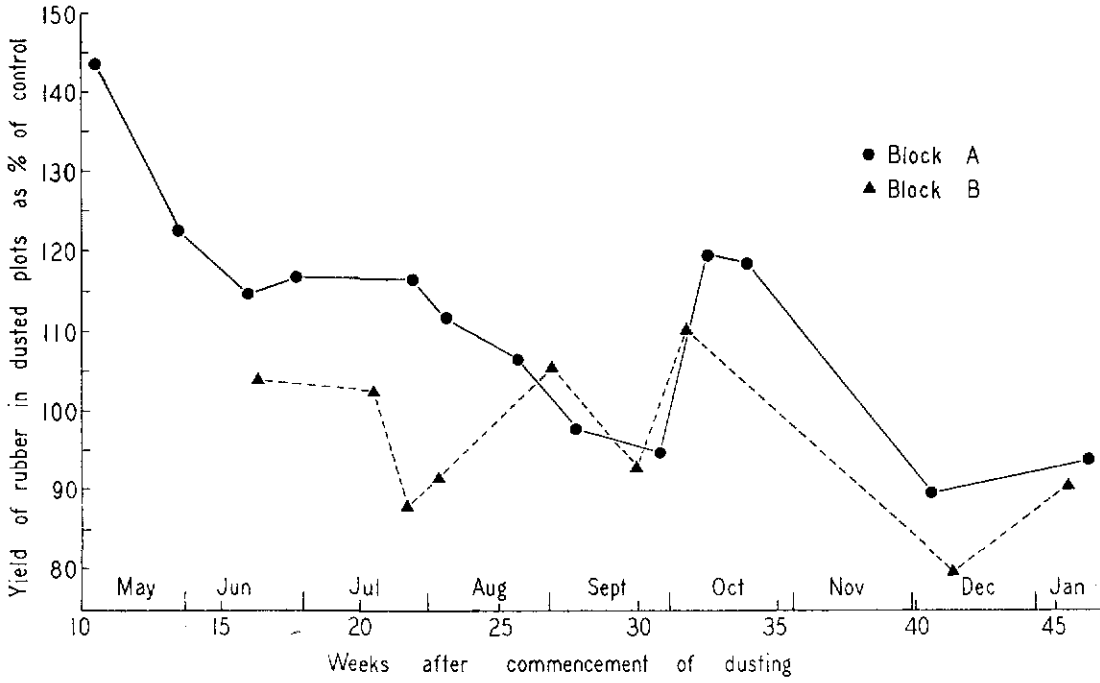

Figure 3. Yield of dusted plots as a percentage of that of control plots.

TABLE 4. MEAN EXPENDITURE ON WEED CONTROL IN BLOCK A

Type of weeding	Month	Mean expenditure ($ per acre)	
		Control plots	Dusted plots
Strip spraying	April	2.50	1.25
	November	2.50	1.25
Eradicating *Mikania cordata*	April	1.50	0.50
	November	1.50	0.50
Eradicating *Imperata cylindrica*	October	0.80	Nil
Eradicating woody perennials	October	0.80	Nil
Total expenditure		9.60	3.50
Reduction in expenditure in dusted plots			6.10

In Block B the only direct benefits of dusting came from a mean saving of $1.90 per acre in weed control. Dusting is still likely to have been of benefit, however, since bark renewal and girth were increased, but this can only be confirmed by future yield recordings.

Clone PB 5/51 was chosen for this investigation because of its high susceptibility to *O. heveae* and because its branching habit is such that an improved canopy could be safely borne without undue danger of damage from wind. Other clones which might be considered for dusting are RRIM 701, RRIM 605, and PBIG seedlings, though the inherent variability in a stand of the latter makes even wintering unlikely, and RRIM 605 is somewhat prone to wind damage. Only RRIM 701, which has suffered severe dieback in the past as a consequence of attacks of leaf disease, is likely to benefit from treatment in certain areas.

Dusting with sulphur is a simple operation, and the fungicide is relatively inexpensive. For flat areas a tractor-mounted duster, locally made at a cost of approximately $1500, is ideal; for hilly terrain an imported portable machine at about the same price is necessary, but the rate of application is somewhat slower. The height to which the dust reaches can be improved by working in the very early morning, but trees of more than about fifteen years of age are too high to be suitable for treatment from the ground. Aerial application may prove to be useful in such situations. Immature trees are in general more vigorous and, with their less pronounced wintering, less prone to heavy leaf fall.

At a selling price of 50 cents per lb of rubber, an average net profit of 15 cents per pound and allowing for a $5 per acre annual saving in weeding costs, an additional yield of 55 lb per acre would pay for six rounds of dusting. This represents only an additional 5.5% yield on a production of 1000 lb per acre, a figure which should easily be exceeded. If wintering is rapid and uniform, five rounds of dusting would be sufficient. In addition, a heavy canopy would obviate some or all of the necessity of nitrogen manuring fields with a poor canopy, thus offering an additional benefit from treatment.

ACKNOWLEDGEMENT

The authors are grateful to Mr. Ng Wing Chuan for much technical assistance, to the manager of Regent Estate for providing the experimental site, and to Dunlop Estates Berhad for permission to publish this paper.

REFERENCES

BEELEY, F. (1930) A recent outbreak of secondary leaf fall due to *Oidium heveae*. *Q. Jl Rubb. Res. Inst. Malaya*, **2(2)**, 61.

BEELEY, F. (1932a) Effect of meteorological factors on the virulence of *Oidium heveae* in Malaya. *J. Rubb. Res. Inst. Malaya*, **4(2)**, 104.

BEELEY, F. (1932b) Report on sulphur dusting experiments. *J. Rubb. Res. Inst. Malaya*, **4(2)**, 115.

BEELEY, F. (1933) *Oidium heveae*. Report on the 1933 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **5(1)**, 5.

BEELEY, F. (1934) *Oidium heveae*. Report on the 1934 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **5(4)**, 342.

BEELEY, F. (1935) *Oidium heveae*. Report on the 1935 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **6(1)**, 49.

BEELEY, F. (1936) *Oidium heveae*. Report on the 1936 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **7(1)**, 20.

BEELEY, F. (1938a) *Oidium heveae*. Report on the 1937 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **8(2)**, 140.

BEELEY, F. (1938b) *Oidium heveae*. Report on the 1938 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **8(3)**, 232.

BEELEY, F. (1939) *Oidium heveae*. Report on the 1939 outbreak of *Hevea* leaf mildew. *J. Rubb. Res. Inst. Malaya*, **9(1)**, 59.

CRAMER, P.J.S. (1956) Half a century of the rubber planting industry in Indonesia. *Archs Rubb. Cult.*, **33(2)**, 345.

HILTON, R.N. (1959) *Maladies of Hevea in Malaya*. Kuala Lumpur: Rubber Research Institute of Malaya.

MCINTOSH, J.B. (1967) Personal communication.

MURRAY, R.K.S. (1931) The influence of *Oidium* and sulphur dusting on yield and bark renewal. *Q. Circ. Ceylon Rubb. Res. Scheme*, **8(3)**, 42.

PAARDEKOOPER, E.C. (1965) Clones of *Hevea brasiliensis* of commercial interest in Malaya. *Plg Man. Rubb. Res. Inst. Malaya No. 11*.

PERIES, O.S. (1966) Present status and methods of control of leaf and panel diseases of *Hevea* in South East Asian and African countries. *Q. Jl Rubb. Res. Inst. Ceylon*, **42(3)**, 35.

RAMAKRISHNAN, T.S. AND RADHAKRISHNA PILLAY, P.N. (1962) Powdery mildew of rubber. *Rubb. Bd Bull.* **5(4)**, 187.

RUBBER RESEARCH INSTITUTE OF MALAYA (1966) *Oidium. Plrs' Bull. Rubb. Res. Inst. Malaya No. 84*, 72.

RUBBER RESEARCH INSTITUTE OF MALAYA (1967) Planting recommendations 1967–1968. *Plrs' Bull. Rubb. Res. Inst. Malaya No. 88*, 7.

SANDERSON, A.R. (1930) Some observations on the mildew leaf disease of *Hevea brasiliensis* due to *Oidium heveae*. *Q. Jl Rubb. Res. Inst. Malaya*, **2(1)**, 16.

VAN EMDEN, J.H. (1954) Notes on the incidence and control of *Oidium heveae* in Ceylon. *Q. Circ. Rubb. Res. Inst. Ceylon*, **30**, 20.

WEIR, J.R. (1929) Report of Pathological Division. *Rep. Rubb. Res. Inst. Malaya* 1928, 61.

YOUNG, H.E. (1950) *Oidium* leaf disease. *Q. Circ. Ceylon Rubb. Res. Scheme*, **26**, 16.

YOUNG, H.E. (1952) Leaf mildew of rubber—a review *Q. Circ. Rubb. Res. Inst. Ceylon*, **27(1–2)**, 3.

YOUNG, H.E. (1954) *Oidium* leaf disease. *Q. Circ. Rubb. Res. Inst. Ceylon*, **30**, 51.

DISCUSSION

Chairman: Dr. A. Newsam

Dr. J.W. Blencowe asked if protection of the trees against *Oidium* with sulphur dust had any effect on the incidence of *Gloeosporium*. Dr. Wastie suggested that protection against *Oidium* enabled the new leaf to harden off before the wet season of April and May and so to escape *Gloeosporium* infection which attacked young leaf at that time. Mr. Mainstone said that other diseases had not been observed on the treated trees, but defoliation by *Oidium* and mites occurred during the subsequent year in areas which were not treated. An increase in yield was obtained from undusted PB 5/51 surrounded by treated areas; this, as well as the absence of *Oidium* in dusted areas a year after treatment, may have been due to locally reduced inoculum.

Oidium infection was reduced by moderate nitrogen shortage (POLINIERE AND VAN BRANDT, 1969)* and Mr. E. Bellis suggested that the economy in fertiliser application following the heavier refoliation obtained after dusting might have produced such nitrogen stress as to maintain adequate resistance to *Oidium*. The increased production potential of the improved canopy might be exploited more fully by a revised fertiliser programme, which was not orientated merely towards economy. Mr. Mainstone believed that marked savings could be made on nitrogen, but increased applications of other nutrients should be considered.

The Chairman drew attention to the amount of extra crop necessary to pay for the treatment, rubber growers could not always afford such control measures. Disease exclusion, as practised against *Dothidella* and projected as regards *Phytophthora*, was preferable.