Jl. Rubb. Res. Inst. Sri Lanka (1976) 53, 31—38

INFLUENCE OF SOME FACTORS ON THE PATTERN OF WINTERING AND ON THE INCIDENCE OF *OIDIUM* LEAF FALL IN CLONE PB 86

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INTRODUCTION

The rubber tree, *Hevea brasiliensis*, is deciduous and the mature trees characteristically shed their leaves during the early months of the year. This natural defoliation of senescent leaves is commonly referred to as wintering. In contrast, several storeys of new leaves are produced on juvenile trees before senescent leaves are shed. This process occurs throughout the year without a marked annual cycle.

The main factor that causes senescence and abscission of *Hevea* leaves is an imbalance between the growth promoter, indol-acetic acid (IAA) and the growth inhibitor, abscisic acid (AA) (Chua, 1970). The inhibition of protein, RNA synthesis and the increase in the hydrolytic activity of certain enzymes with leaf age are also implicated (Chua, 1970).

The exact period of defoliation and its intensity varies between the different clones grown in various rubber growing areas of Sri Lanka, and depends on weather conditions during the wintering period. Although conclusive evidence is lacking, it is generally believed to be favoured by dry and retarded by wet weather.

A short period of dormancy often precedes the stage of bud break. In mature trees the new flush of tender leaves, produced soon after wintering, is susceptible to infection by *Oidium heveae*, which causes secondary leaf fall (SLF). The severity of the disease varies in different years and between localities.

The wintering process can be divided into several components. These can conveniently be considered as (a) the commencement and (b) completion of defoliation (c) the commencement and (d) completion of refoliation (e) defoliation and (f) refoliation phases (g) their overlap and (h) the gap between the onset of defoliation and refoliation. There is no published work on the importance of these factors in the epidemiology of *Oidium* leaf disease. The present investigation was therefore, undertaken to study the influence of host, topographical and environmental factors on the wintering behaviour and their influence on SLF due to *Oidium*, in different rubber growing districts in Sri Lanka.

EXPERIMENTAL

A random sample of 20% of all plantings of clone PB 86 covering a wide range of holdings in relation to size, situation, elevation, age, terrain and aspect, were selected from 43 co-operative sulphur dusting groups. 220 smallholdings (20% sample) that functioned under the state-aided sulphur dusting scheme, in Colombo, Galle, Kalutara, Kegalle, Matale, Matara and Ratnapura Districts were selected for assessments.

The wintering pattern was studied by recording the dates when defoliation and refoliation began and ended on all the holdings surveyed. The intensity of *Oidium* SLF was assessed by counting the leaves that fell on four 6′ × 6′ leaf count beds located in the centre of each selected site. The first two leaf fall assessments were made at 3 and 6 days after the start of sulphur dusting. The next count was taken at the next dusting, followed by assessments at 3 day intervals until dusting again. This procedure was followed after each of the 3 rounds of dusting. The final leaf count was done 3 days after the last round of dusting.

The influence of factors such as age, plant density, terrain and aspect was examined with a homogeneous sub-sample obtained from the sample surveyed.

The figures shown in parentheses in most of the tables are the number of days after 1 January.

RESULTS

When the wintering pattern was considered (Table 1) commencement and completion of defoliation occurred in all areas by 25 January and 8 March, respectively ; the length of defoliation being 41 days. Refoliation commenced around 9 February, after a dormancy period of 14 days. The period of refoliation extended over 42 days and was completed by 19 March. The period of overlap between the defoliation and refoliation phases was 26 days. However, there was wide variability in the timing of each wintering component.

TABLE 1

GENERAL WINTERING PATTERN IN CLONE PB 86

Component of wintering	Range		Mean
Onset of defoliation	6 Jan. — 14 Feb.	(6 — 45)	25 Jan. (25)
Completion of defoliation	6 Feb. — 7 April	(37 — 97)	8 March (67)
Defoliation phase (days)	22 — 60		41
Onset of refoliation	18 Jan. — 3 March	(18 — 62)	9 Feb. (40)
Completion of refoliation	6 Feb. — 29 April	(37 — 119)	19 March (78)
Refoliation phase (days)	19 — 65		42
Overlap of refoliation & defoliation phases (days)	10 — 43		26
Gap between onset of defoliation & onset of refoliation (days)	12 — 17		14

The wintering pattern in each district is shown in Table 2. The onset of defoliation occurred very early in Colombo, Kalutara and Matara Districts and the completion of defoliation was of the same order. The duration of defoliation and refoliation phases and the overlap between them were also short. In these districts, SLF due to *Oidium* was significantly lower than in districts where wintering was delayed. However, in the Galle District defoliation started later than in the other districts in the low country. Consequently, the trees refoliated later and over a longer period. These factors, probably helped in the build-up of inoculum causing significantly greater leaf fall due to *Oidium* in Galle District. In Kegalle, Ratnapura and Matale Districts, which occupied the mid-country areas, the defoliation phase was spread over a considerable number of days. Similarly, the refoliation phase was also protracted and the overlap between the refoliation and defoliation phases was significantly higher than in the low country districts. This probably accounted for the increased severity of the disease in these districts.

TABLE 2

THE WINTERING PATTERN AND THE INCIDENCE OF *Oidium* LEAF FALL IN DIFFERENT DISTRICTS

District	Onset defoliation	Completion defoliation	Defoliation phase (days)	Onset refoliation	Completion refoliation	Refoliation phase (days)	Overlap of refoliation & defoliation phases (days)	Gap between onset of defoliation & refoliation phases (days)	Leaf fall due to *Oidium* per acre
Low country									
Matara	8 Jan. (8)	14 Feb. (45)	37	20 Jan. (20)	12 Feb. (43)	23	25	12	13,915
Kalutara	6 Jan. (6)	6 Feb. (37)	31	18 Jan. (18)	6 Feb. (37)	19	19	12	19,965
Colombo	11 Jan. (11)	16 Feb. (47)	36	24 Jan. (24)	13 Feb. (44)	20	23	13	19,965
Galle	28 Jan. (28)	17 Mar. (76)	48	12 Feb. (43)	20 Mar. (79)	36	33	15	53,542
Mid country									
Ratnapura	21 Jan. (21)	14 Mar. (73)	52	4 Feb. (35)	16 Mar. (75)	40	38	14	33,275
Kegalle	14 Feb. (45)	11 Apr. (101)	56	3 Mar. (62)	13 Apr. (103)	41	39	17	69,575
Matale	6 Feb. (37)	7 Apr. (97)	60	23 Feb. (54)	29 Apr. (119)	65	43	17	1,788,985
$F_{5,141}$	*	*	*	*	*	*	*	*	*

* denotes significance at 0·05 per cent.

Elevation appears to have a marked indirect influence on *Oidium* severity through the influence on the wintering process. (Table 3). At lower elevations defoliation and refoliation commenced significantly earlier than at higher elevations. The length of the defoliation and refoliation phases and their overlap are significantly shorter at lower elevations. The incidence of leaf fall due to *Oidium*, decreases appreciably at elevations below 300 ft.

TABLE 3

THE WINTERING PATTERN AND THE INCIDENCE OF *Oidium* LEAF FALL AT DIFFERENT ELEVATIONS

Elevation (ft)	Onset defoliation	Completion defoliation	Defoliation phase (days)	Onset refoliation	Completion refoliation	Refoliation phase (days)	Overlap of refoliation & defoliation phases (days)	Gap between onset of defoliation & refoliation phases (days)	Leaf fall due to *Oidium* per acre
Less than 100	14 Jan. (14)	12 Feb. (43)	29	26 Jan. (26)	17 Feb. (48)	22	17	12	23,898
100 — 300	11 Jan. (11)	14 Feb. (45)	34	24 Jan. (24)	20 Feb. (51)	27	21	13	17,545
300 — 500	21 Jan. (21)	9 Mar. (68)	47	5 Feb. (36)	23 Mar. (82)	46	32	15	70,482
> 500	2 Feb. (33)	23 Mar. (82)	49	17 Feb. (48)	15 Apr. (105)	57	34	15	114,042
$F_{3,144}$	*	*	*	*	*	*	*	*	*

* denotes significance at 0·05 per cent.

The age of the tree also influence the wintering pattern (Table 4). The beginning and end of defoliation are significantly influenced by age. The defoliation and refoliation phases are of short duration and are accomplished early in younger trees than in older trees, particularly those 16 years or more in age. However, SLF due to *Oidium* appears not to be affected by tree age.

TABLE 4

THE INFLUENCE OF AGE ON THE WINTERING PATTERN AND THE INCIDENCE OF *Oidium* LEAF FALL

Age (years)	Onset defoliation	Completion defoliation	Defoliation phase (days)	Onset refoliation	Completion refoliation	Refoliation phase (days)	Overlap of refoliation & defoliation phases (days)	Gap between onset of defoliation & refoliation phases (days)	Leaf fall due to *Oidium* per acre
Less than 10	21 Jan. (21)	12 Feb. (43)	22	2 Feb. (33)	23 Feb. (54)	21	10	12	26,015
10 — 11	17 Jan. (17)	11 Feb. (42)	25	29 Jan. (29)	25 Feb. (56)	27	13	12	40,232
12 — 13	16 Jan. (16)	13 Feb. (44)	28	28 Jan. (28)	1 Mar. (60)	32	16	12	17,242
14 — 15	11 Jan. (11)	9 Feb. (40)	29	24 Jan. (24)	28 Feb. (59)	35	16	13	22,385
16 and above	8 Jan. (8)	18 Feb. (49)	41	20 Jan. (20)	8 Mar. (67)	47	29	12	22,085
$F_{4,84}$	*	*	*	*	*	*	3·16*	<1·00	1·36

* denotes significance at 0·05 per cent.

Although none of the component of wintering are influenced by the plant density, there is a suggestion that the incidence of *Oidium* increases at higher planting densities (Table 5).

TABLE 5

THE INFLUENCE OF PLANT DENSITY ON THE WINTERING PATTERN AND THE INCIDENCE OF *Oidium* LEAF FALL

Density per acre	Onset defoliation	Completion defoliation	Defoliation phase (days)	Onset refoliation	Completion refoliation	Refoliation phase (days)	Overlap of refoliation & defoliation phases (days)	Gap between onset of defoliation & refoliation phases (days)	Leaf fall due to *Oidium* per acre
Less than 170	19 Jan. (19)	24 Feb. (55)	36	1 Feb. (32)	2 Mar. (61)	29	23	13	9,680
170 — 189	18 Jan. (18)	26 Feb. (57)	39	30 Jan. (30)	25 Feb. (56)	26	27	12	24,200
190 — 209	21 Jan. (21)	21 Feb. (58)	37	4 Feb. (35)	4 Mar. (63)	28	23	14	18,755
210 and over	18 Jan. (18)	27 Feb. (58)	40	1 Feb. (32)	4 Mar. (63)	31	26	14	38,720
$F_{3,80}$	<1·00	<1·00	<1·00	<1·00	<1·00	<1·00	<1·00	<1·00	<1·99

No relationship could be found between the land aspect (facing east and west) with either the wintering behaviour or the incidence of SLF due to *Oidium*.

The wintering pattern and *Oidium* leaf fall are not likely to be influenced by the nature of the terrain, although there was some evidence that defoliation and refoliation occurred earlier on steep hill slopes than in the flat areas.

Correlation coefficients between different aspects of the wintering pattern, and leaf fall due to *Oidium* have been done for each district, in order to ascertain the aspect of wintering that affects leaf fall in each district (Table 6). All aspects of wintering except the gap between the beginning of defoliation and that of refoliation have a significant influence on leaf fall due to *Oidium* in Galle, Kegalle and Ratnapura Districts, but not in Colombo, Kalutara and Matara Districts.

TABLE 6

THE RELATIONSHIP BETWEEN THE WINTERING PATTERN AND THE INCIDENCE OF *Oidium* LEAF FALL

District / Component of wintering	Colombo r (n = 26)	Galle r (n = 20)	Kalutara r (n = 45)	Kegalle r (n = 39)	Matara r (n = 7)	Ratnapura r (n = 19)
Onset of defoliation	+ 0·21	+ 0·53*	+ 0·13	+ 0·59*	+ 0·24	+ 0·50*
Completion of defoliation	+ 0·15	+ 0·59*	+ 0·14	+ 0·61*	+ 0·19	+ 0·52*
Defoliation phase	+ 0·23	+ 0·61*	+ 0·15	+ 0·63*	+ 0·17	+ 0·62*
Onset of refoliation	+ 0·29	+ 0·57*	+ 0·12	+ 0·58*	+ 0·21	+ 0·52*
Completion of refoliation	+ 0·14	+ 0·56*	+ 0·16	+ 0·59*	+ 0·28	+ 0·55*
Refoliation phase	+ 0·17	+ 0·53*	+ 0·09	+ 0·55*	+ 0·19	+ 0·67*
Overlap of refoliation & defoliation phases	+ 0·12	+ 0·54*	+ 0·11	+ 0·56*	+ 0·24	+ 0·56*
Gap between onset of defoliation & refoliation	+ 0·15	+ 0·20	+ 0·11	+ 0·17	+ 0·15	+ 0·12

* denotes significance at 0·05 per cent.

DISCUSSION

Although wintering is a physiological activity of the rubber tree the start of this phenomenon is largely influenced by local weather conditions. In Colombo, Kalutara and Matara Districts wintering occurs early, mainly due to pronounced dry weather conditions at the time of defoliation. The extremely hot sunny weather that was prevalent during the recorded period of refoliation is inimical to the pathogen and resulted in negligible disease throughout all the low country districts except Galle. These observations confirm those of Peries (1965). Acceleration of the defoliation and refoliation processes during dry weather allows disease to be avoided. On the other hand, prolonged wet weather caused the defoliation and refoliation processes to occur late in the Galle District despite being in the low country rubber growing belt. This provides further evidence that dry weather encourages defoliations and wet weather retards them.

Wintering occurred invariably later in the mid-country rubber growing districts such as Kegalle, Ratnapura and Matale, than in the low-country districts. In the mid-country districts defoliation was gradual, irregular and protracted due to the frequent rains from February onwards. Under these conditions, refoliation also proceeded gradually in Kegalle and Matale Districts. Thus, the presence of tender, susceptible leaves for a long period allowed inoculum of *Oidium* to build up and create epidemic levels of diseases which gave severe leaf fall and depleted canopies. These were also favoured by cool, dry weather, mist at night and in the early mornings and intermittent light rain, all conditions known to be conducive for the propagation of the fungus (Peries, 1966). These observations therefore demonstrate that the severity of disease is associated with the wintering process whose variation from year to year depends primarily on weather conditions.

In the low country, persistently dry weather conditions the most years induce early and rapid wintering in PB 86. Consequently, trees refoliate early and their inherent susceptibility is obscured by disease avoidance. However, although wintering occurs early in certain years, conditions favourable for the propagation and dissemination of the fungus could coincide with the refoliation period and severe damage could result.

Rubber grown in the low country districts of Colombo, Kalutara and Matara particularly at elevations below 300 ft. do not appear to suffer from SLF sufficiently severely to warrant large expenditure on sulphur dusting (Liyanage *et al.*, 1970). Here therefore, dusting sulphur as a routine measure may be uneconomical. Liyanage *et al.*, (1970) showed that the incidence of SLF due to *Oidium* increased with elevation. This was possibly due to the virulence of the pathogen and also to favourable conditions for the pathogen. They also demonstrated that the beneficial effects of dusting sulphur to control SLF due to *Oidium* is more significant when the degree of leaf fall due to *Oidium* was high as in Kegalle and Matale Districts. After carrying out long-term experiments, Murray (1935) concluded that there was a sharp decline in yield at high elevations in Matale District. This can probably be attributed to the cumulative effect of repeated defoliation which decreases the vitality of the tree. Under these conditions, sulphur dusting improved the canopy density, bark renewal and yield of rubber. At high elevations, the comparative increase in the yield will adequately compensate for the expenditure incurred for carrying out sulphur dusting.

The age of the trees significantly influenced the pattern of wintering. Older trees defoliated and refoliated much earlier than the younger ones. Rather surprisingly however, the incidence of SLF due to *Oidium* was not affected. It might be expected that older trees would show a higher incidence of the disease than younger trees, due to their defoliation and refoliation patterns. It is likely that this effect was not detected due to the selection of holdings from the low country districts, which escaped much damage from *Oidium*.

A high correlation between most components of wintering and SLF due to *Oidium* was established in Galle, Kegalle and Ratnapura Districts. This suggests that the time when defoliation begins influences all the subsequent defoliation and refoliation processes. If wintering occurs early as in Colombo, Kalutara and Matara Districts, none of the wintering events seem to be of importance to the development of the disease. This situation may well change, however, if wet weather delays wintering.

Young (1951) considered that the manipulation of the time of refoliation to coincide with a period less favourable to disease development appeared to be an efficient means of indirect control of the disease in Sri Lanka. Calcium cyanide used for cotton plant defoliation prior to harvesting was tried in the initial trials. This idea was developed in Malaysia by aerially spraying organo-arsenical dessicants such as cacodylic acids (Rao & Yosuf Azaldin, 1974). This operation was performed to coincide with a relatively dry period, well in advance of the onset of the disease. There are practical limitations to this method since it would not be suitable where a substantial proportion of the total rubber acreage is under smallholdings. Also, protection of flowers from *Oidium* could result in the development of an abundance of rubber pods which would increase the risk of Bark Rot (*Phytophthora* spp.) infection during the South-West monsoon season.

An alternative possibility is to apply quick-acting nitrogenous fertilizers to hasten the leaf production and maturity, as investigated in Sri Lanka by Murray (1936) and in Malaysia by Lim (1974). In this approach also the objective is to enhance leaf maturity before conditions favourable for *Oidium* set in. This is a feasible proposition and should benefit even smallholders. In Malaysia, this method can be employed successfully since rainfall is seasonally well distributed. However, in Sri Lanka, the onset of refoliation coincides with a dry period in most rubber growing areas. Lack of rain will prevent the uptake of the nutrients essential for the plant. This aspect needs careful investigation.

ACKNOWLEDGEMENTS

The author wishes to thank all the Rubber Instructors and Divisional Advisory Officers who participated in the survey (1969/70), for their co-operation and assistance. Thanks are also due to Messrs V. Abeywardena & G. A. J. P. R. Gunasekara for analysis of results and Dr. O. S. Peries for encouragement and helpful advice.

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