

## A CRITICAL STUDY OF THE USE OF WEATHER DATA FOR THE ECONOMIC CONTROL OF *HEVEA* DISEASES

BY

O. S. PERIES

The rubber tree, *Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg. is susceptible to three leaf and one bark disease of economic importance in Sri Lanka. The leaf diseases are caused by the fungi *Oidium heveae* Steinm., *Colletotrichum gloeosporioides* Penz. and a species of *Phytophthora*, which also causes Bark Rot. There has been a dramatic reduction in the cost of controlling these diseases in this country, in recent years. This has been achieved mainly by critical studies on the biology of the causal fungi and applying the findings to field conditions. The Rubber Research Institute has pioneered the studies on the economics of plant disease control in Sri Lanka. The correlation between weather and incidence of *Hevea* diseases is analysed in this paper and the importance of the study of the biology of the fungus in effecting economic disease control is discussed.

Weather is the outcome of the interaction between temperature, atmospheric humidity (including rainfall) sunlight and air movement. These factors cannot be studied individually, as each has an effect on the others. It is the sum total of these factors that determines the level of incidence of leaf diseases, generally, in the field, by its action on the host or the causal agent, or both.

A critical study of the biology of the causal fungi, has provided data on the basis of which the weather conditions conducive to their propagation have been accurately assessed. The purpose of this paper is to illustrate the validity of these data for predicting the incidence of leaf and stem disease of *Hevea*, and how they can be used to economise on disease control costs.

### MATERIALS AND METHODS

Temperature and humidity were recorded on constant recording thermohygrometers placed at various points in rubber estates. Data on ground temperature, number of hours of sunshine per day and windspeeds were taken from the nearest stations, maintained by the Institute. Leaf surface wetness was recorded on a Hirst constant recording instrument.

The time taken by the spores of the three fungi to germinate on the host surface and cause infection was determined by inoculating leaves with dry spores in the case of *Oidium* and spore suspensions in the case of *Gloeosporium* and *Phytophthora*. Sellotape strips of leaf surfaces (Peries, 1961) were taken at regular intervals to follow the course of fungal development.

The number of hours of leaf surface wetness required to cause *Gloeosporium* and *Phytophthora* infection was determined by placing drops of spore suspensions in water, on the host surface, and carefully blotting out the water with clean Whatman filter paper at regular intervals. Black pin-point lesions were clearly visible, when the leaf surface was penetrated.

## RESULTS

*Temperature*

The critical temperatures for the growth of *C. gloeosporioides* were  $\approx 5^{\circ}\text{C}$ ,  $28\text{--}30^{\circ}\text{C}$  and  $35\text{--}40^{\circ}\text{C}$ , confirming the results of Wimalajeewa (1967). For *Oidium* the minimum was again  $5^{\circ}\text{C}$ , the optimum  $28^{\circ}\text{C}$  and the maximum  $\approx 35^{\circ}\text{C}$  and for *P. meadii* the corresponding figures were  $5^{\circ}\text{C}$ ,  $30^{\circ}\text{C}$  and  $36^{\circ}\text{C}$  (Peries & Fernando, 1966). These data are summarised in Fig. 1. It can be seen that there is a remarkable resemblance between the temperature requirements for growth of the three fungi. Temperatures approaching the optimum for these fungi, would favour disease development; because the pathogen can multiply rapidly, producing numerous spores, which increase the possibility of infection.

Temperature has an overriding effect on the development and spread of all three leaf diseases, and our studies have shown that the severity of all of them is low above  $31^{\circ}\text{C}$ . This agrees with the data in Fig. 1, which show that temperatures above  $31^{\circ}\text{C}$  are harmful to all three causal fungi.

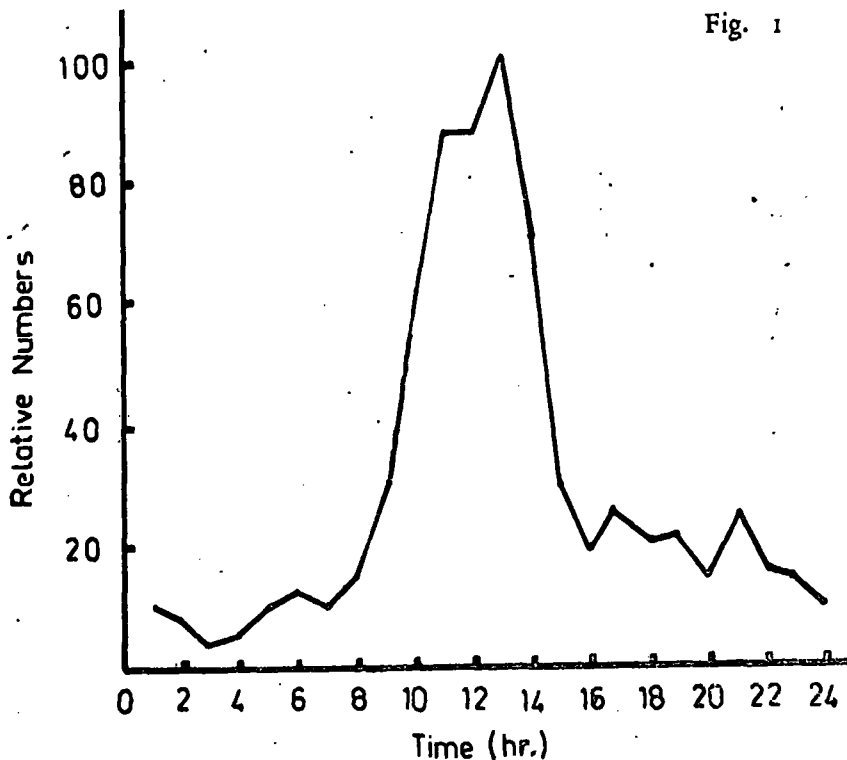


Fig. 1

Mean diurnal periodicity of *Oidium heveae* for 54 days  
(expressed as a percentage)

Laboratory studies on the infection of various parts of the rubber leaf by these fungi have shown that the time taken by them to effect infection is significantly shorter at the optimum for the growth of the respective fungus. The data on infection by *P. meadii* are summarised in Table 1, and confirm this observation. The results of similar studies have been used to assist in the forecasting of *Oidium* leaf disease epidemics in Malaysia (Lim, 1972; Wastie, 1969; 1972).

TABLE I  
 TIME TAKEN (h) BY *P. meadii* TO PRODUCE LESIONS AND PERIOD (h) OF  
 SURFACE WETNESS REQUIRED FOR INFECTION OF *Hevea* LEAF  
 PETIOLES AT VARIOUS TEMPERATURES.

Temp °C	Lesion production		Surface wetness	
	Av. time	Min. time	Av. time	Min. time
20	16—17	16	4—6	4
25	16	14	3—4	2
28	12—16	9	3—4	2
30	16	12	3—4	2
33	16	12	4—5	4
36	16 (very rare)	—	No lesions	

### Humidity

The importance of atmospheric moisture is only second to that of temperature in host-parasite interactions (Dimock, 1967). The relation between humidity and disease incidence has been studied by several workers (Delp, 1954; Longree, 1939; Rogers, 1959 and Yarwood 1939; 1956). High atmospheric humidities are favourable to the propagation of all fungi, including the powdery mildews, which are dry weather fungi in the sense that they do not survive for long periods in free water. However, they too propagate most rapidly under conditions of high humidity. All other fungi require free water for propagation and infection.

The conidia of *O. heveae* can survive for long periods under relatively dry atmospheric conditions. In the laboratory, 50% of the conidia of this fungus retained viability after storage for 48 h over fused calcium chloride. They germinated readily in an atmosphere registering 30-40% relative humidity (RH). It can be seen then that *Oidium* is adapted to growing in dry weather conditions, which accords with the fact that the disease occurs during the driest period of the year, January to April.

*Phytophthora* leaf fall occurs only during the South West monsoon season, as the causal fungus sporulates on rubber pods, and green mature pods are available during this period (Peries, 1965, Satchuthananthavale, 1971). On the other hand, *Gloeosporium* leaf disease can occur during any rainy period of the year; because the causal fungus sporulates profusely on leaves so that it is not dependant on pod set. Therefore, severe defoliation of *Hevea* can occur due to *Gloeosporium* infection during the period of refoiliation, if rainy weather occurs in the immediate post wintering period.

Table 1 shows that a minimum period of surface wetness is essential for *P. meadii* to cause infection of the *Hevea* leaf petiole; similarly surface moisture, but for shorter periods, is essential for infection by *Gloeosporium*. On the other hand, long periods of surface wetness of leaves militate against *Oidium* infection; because free water is injurious to the conidia of this fungus, which are killed by prolonged immersion in water. Conidia can germinate on, but do not infect, wet leaves.

On the basis of these data, epidemics of *Oidium* leaf disease could be expected during generally dry refoliation seasons, when the RH is kept high because of short showers, particularly in the evenings, which result in excess of dew in the nights and early mornings. This agrees with field observations. *Phytophthora* leaf disease would tend to occur during periods of prolonged wet weather, when there are mature green pods on trees. *Phytophthora* epidemics do not occur in this country before pod set or after seed fall, even under optimum weather conditions, because pods are essential for profuse sporulation of the fungus.

*Gloeosporium* leaf disease can be severe, if rainy weather occurs in the immediate post wintering period, because young leaves are extremely susceptible to the disease. The fungus sporulates on the edges of old lesions on mature leaves, but new infections do not occur and the old lesions do not spread so that mature leaf fall is not brought about by *Gloeosporium*.

The incidence of Bark Rot is controlled mainly by the presence of free water for the dispersal of the fungus, which sporulates on pods, and produces a swimming spore. Inoculation experiments (Peries, 1966; Satchuthananthavale, 1971) have shown that *Phytophthora* does not infect the intact bark and that an injury is essential for bark infection. Therefore, tapping rubber trees, when there is surface moisture on them after rain, is liable to cause infection, particularly when there are infected pods on the trees.

#### Sunlight

Plant pathogens are sensitive to intensity and quality of light (Yarwood, 1959). Both visible and ultra violet light can prove lethal to the mycelium or to spores. Sporulation and even the shape of spores can be influenced by irradiation (Foister, 1946). In general, the growth of fungi and bacteria is retarded or they are killed by the direct action of light for relatively short periods.

Comparatively short periods (<1 h) of exposure to either direct sun or UV light is lethal to detached *Oidium* conidia. Detached spores are particularly susceptible, while spores attached to the mycelium on leaves are killed in 2-3 h.

TABLE 2

PERCENTAGE VIABILITY OF *O. beveae* CONIDIA IN DIRECT SUNLIGHT

Period of exposure	Detached Conidia	Conidia attached to mycelium on leaves
Nil (control)	85	85
2 min	75	85
3 "	60	83
5 "	52	80
7 "	40	60
10 "	20	58
1 "	0	47
2 "	0	22
3 "	0	7
4 "	0	0
5 "	0	0
6 "	0	0

Exposure to direct sunlight and UV irradiation for 5 min is lethal to the sporangia and zoospores of *P. meadii* (Peries & Fernando, 1966). The sporangial contents shrivel and disintegrate rapidly on exposure to direct sunlight or sunlight under glass. Zoospores too are rapidly inactivated by exposure to sunlight or UV irradiation. The lethal action of sunlight on *Phytophthora* spores is not entirely due to the effect of UV rays, as it is effective under glass too; therefore, the drying action of sunlight also appears to have an effect.

A period of exposure of 10 min to UV irradiation causes complete inactivation of nearly all *Gloeosporium* spores. The detailed information on this is presented in Table 3 (Wimalajeewa 1965; 1967). These data show the dramatic effect of direct sunlight on this fungus.

TABLE 3

PERCENTAGE VIABILITY OF *Gloeosporium* SPORES AFTER EXPOSURE TO UV LIGHT

Period (min) of exposure	% Viability
0	94.6
2	86.0
3	61.4
5	24.4
7	0
10	0

The incidence of *Oidium* leaf disease is mild when the refoliation period coincides with a spell of bright sunny weather, which also tends to increase the temperature above the critical level (32 °C) for the propagation of the fungus (Peries, 1965). This has been confirmed in Malaysia, where Lim (1972) has recently suggested a method for forecasting *Oidium* leaf disease incidence based on temperature and humidity.

Sunny periods occurring during the South West monsoon season, when *Phytophthora* leaf disease of *Hevea* is prevalent, checks the spread of the disease. This is perhaps due both to the direct lethal action of sunshine on the fungus and also to its drying effect, which checks the activity of the swimming fungal spore. Control measures against the disease can be postponed or dispensed with in relation to the occurrence of sunny periods during the monsoon season (Peries, 1969).

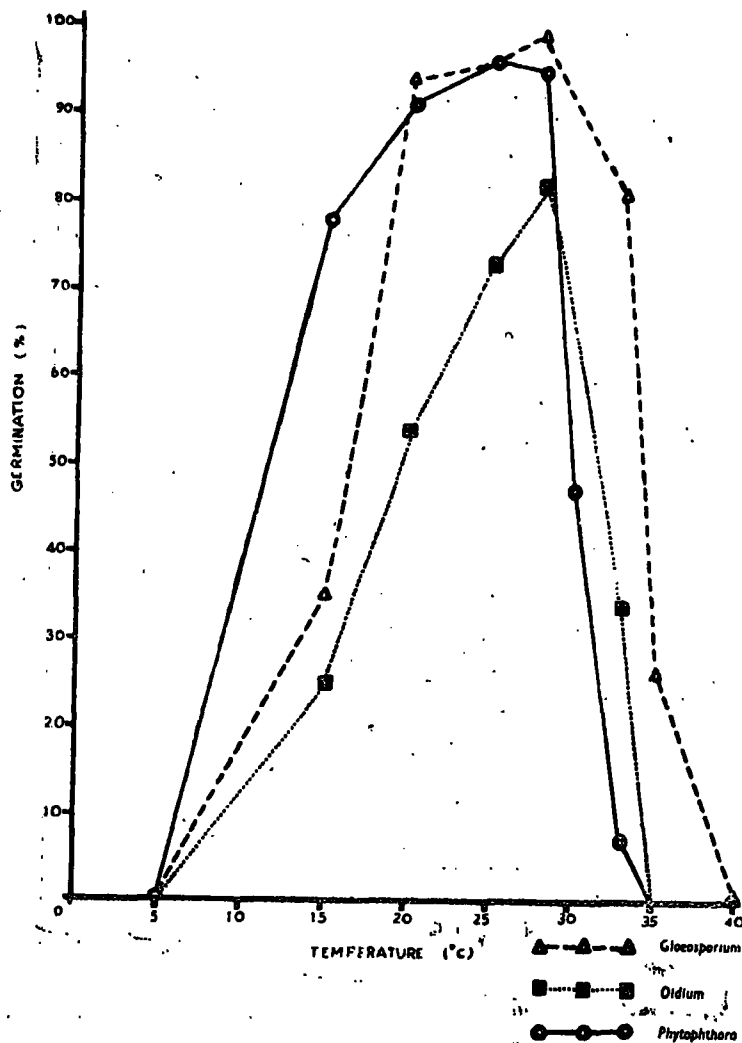
Specific studies on the forecasting of *Gloeosporium* leaf disease have not yet been completed (Peries, 1972). However, the data available now indicate that, like the other two leaf diseases of *Hevea*, there is a negative correlation between the incidence of the disease and the number of hours of sunshine recorded.

#### Wind

Air movement is of direct importance in the transport of certain fungus spores, but there is little evidence to show that wind in itself has any effect on disease development. Air movement affects heat transfer, transpiration, humidity and gas interchange and, to this extent, it can significantly affect host-parasite interactions (Dimock, 1967).

The powdery mildews, like *Oidium*, produce dry spores which are transported over considerable distances by wind. Peries (1956) showed that there is a marked diurnal periodicity in the release of *Oidium* conidia, with a peak in the early afternoon, coinciding with the daily period of maximum wind velocity. These results were confirmed by Fernando (1971). There is a clear relationship between spore release, temperature, atmospheric humidity and wind velocity (Fig. 2). Peak release coincides with high temperatures, low humidities and high wind velocities.

Fig. 2



There is very little relationship between air movement and spread of *Phytophthora* leaf disease. *Phytophthora* spores are dispersed mainly by water droplet splash (Peries, 1965). The spread of leaf fall is rather restricted and is often confined to individual trees bearing a large crop of pods. This is a common field observation in Sri Lanka.

*Gloeosporium* leaf disease is interesting in this respect. It produces a spore that requires free water or extremely high humidities (> 95%) for germination. However, unlike *P. meadii* zoospores, *Gloeosporium* spores can survive for long periods under ordinary atmospheric conditions. Therefore, *Gloeosporium* leaf disease is spread over long distances by wind. Hirst spore trap studies have shown that, like many hydrophyllic fungi, *Gloeosporium* spores are released mainly after sunset and late in the night. Therefore, the spores have the optimum conditions of the day to settle on the host, germinate and effect penetration and infection.

### Forecasting

The relationship between weather and disease enables the incidence of disease epidemics to be forecast accurately. This fact has been used to advantage in Sri Lanka. On the basis of the data presented in this paper, it can be concluded that :

Epidemics of *Oidium* leaf disease are likely to occur during refoliation seasons when the temperature is slightly lower than the normal for that period, the humidity is high, with scattered showers in the evening, leading to heavy mists which persist till late in the morning, and the weather is generally dull and overcast but not wet. On the other hand, high atmospheric temperatures and hot, dry weather with long hours of bright sunshine are likely to militate against disease incidence. Wintering time has an over-riding effect on the incidence of *Oidium* leaf disease. When wintering is early, following a dry December, and refoliation occurs rapidly, the fungus causes only mild damage, as the inoculum cannot build up rapidly. In Sri Lanka, the 1972/1973 season illustrated this admirably. December 1972 was dry, leading to early wintering of most clones. The refoliation season too was hot, dry and sunny and the rubber foliage in 1973 was very good, particularly on clone PB 86, which wintered early. In contrast, in 1970/71, the wet December of 1970 was followed by a delayed and prolonged refoliation season in 1971, when scattered evening showers were recorded frequently. This led to very poor rubber foliage generally in 1971.

Planters are now adept at recognising the weather conditions conducive to *Oidium* infection and dusting only when necessary. It is a pleasure to read VA's reports which state that only half or one third of the estimated amount of sulphur was used for *Oidium* control during the year, but the foliage was excellent. This is a far cry the time that VAs reported, with some pride no doubt, that some superintendent pushed up 10 tons of sulphur dust for *Oidium* control—surely not! It may have been for some experimental study on aerodynamics, but not for *Oidium* control, I assure you.

*Phytophthora* leaf disease control is no longer a problem in this country. However, I should like you to look back over a few years, as it is only a few years since the control of this disease was viewed with any rationality in this country. Epidemics of the disease can be forecast on weather data and the presence of infected pods. We know that one day's good hot sunshine checks the disease more effectively than copper dust. What is so good about sunshine? —now you know, the UV rays are lethal to zoospores of the fungus, sunshine also helps to dry up surface moisture in which the spores swim. Thereby hangs a tale, the secret of Bark Rot control, for which prevention is better than cure. I hope that now we are agreed on the case for not tapping trees until surface moisture dries up. The merest trickle of water on the bark of the tree is like the deep end of the pool for the tiny *Phytophthora* spore, and it will swim happily to the injury, with which you are providing it, to wit the tapping cut. It is surprising that the fungus does not drop you a card, acknowledging your assistance, those of you who permit wet tapping.

*Gloeosporium* leaf disease—is now a problem only occasionally during wet refoliation seasons. Incidentally, there is every chance that leaf fall caused by *Gloeosporium* during refoliation, is mistaken for *Oidium* leaf fall, and that some of you may take up cudgels with me and say that you have had plenty of *Oidium* in wet refoliation seasons. Spare me the venom, gentlemen, it may be a case of mistaken identity.

So there it is, just by keeping our eyes open, we have been able to say good-bye to indiscriminate dusting for *Oidium* control, the unwarranted dusting for *Phytophthora* leaf disease control, the unnecessary application of panel fungicides for Bark Rot control, the futile application of water-proof fungicides for the prevention of Bark Rot—and now we know the reason why.

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