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OIDIUM LEAF DISEASE — THE EFFECT OF ENVIRONMENT AND CONTROL MEASURES ON INCIDENCE OF DISEASE AND ATMOSPHERIC SPORE CONCENTRATION

BY

T. M. FERNANDO

INTRODUCTION

Oidium leaf disease of *Hevea brasiliensis* was first recorded in Ceylon in 1925 on Heatherley and Pantiya Estates, in the Kalutara District (Stoughton - Harris, 1925). Young leaves are particularly susceptible to the disease, mature leaves being immune to infection. Leaf fall caused by this disease is also referred to as "secondary leaf fall", as it leads to a second leaf fall of young leaves at the time of refoliation after wintering — the shedding of the old mature leaves. The severity of the disease increases with increasing elevation, so much so that the Rubber Research Institute of Ceylon does not advocate the planting of the currently popular *Hevea* clones at elevations higher than 800 — 1000 ft above mean sea level.

The disease is caused by the fungus *Oidium heveae* which is a member of the group of fungi known as the powdery mildews (Erysiphaceae). The mycelium of the fungus consists of septate branched hyphae, which form an extensive radiating mat over the surface of the host tissue and obtain their food requirements by sending sucking organs, known as haustoria, into the tissues of the host. Microscopic barrel-shaped spores (conidia) are borne singly at the end of short stalks, called conidiophores. The conidia are produced in great numbers under favourable weather conditions, and are disseminated by wind to colonise other susceptible tissue.

Laboratory studies on the biology of the causal fungus have shown that the elements of weather namely temperature, sunshine, relative humidity and rainfall influence its propagation and subsequent dissemination (Peries, 1966). Sulphur dusting is the recommended method of direct control of the disease on susceptible clones. Some resistant clones are known, but as their yield potential is low, a long-term programme has been initiated by the RRIC to breed clones resistant to *Oidium heveae*. Some clones resistant to the disease at high elevations are now available, and these are being rigidly tested prior to release for commercial planting.

Oidium heveae being a fungus disseminated mainly by an air-borne spore, the production of which is influenced to a great extent by weather conditions, the importance of a study of the atmospheric spore content in a rubber estate, in relation to weather conditions, as an aid to understanding the behaviour of the fungus, was quite apparent. This paper outlines the results of such a study, and discusses the significance of the findings in relation to the incidence of the disease and the outcome of the control measures adopted.

MATERIALS AND METHODS

Spores were trapped with the aid of a "Burkard recording volumetric spore trap", with a flow rate of 10 letre/min, and a drum movement of 2 mm/hr. The apparatus was located in the centre of a six-year old rubber plantation, one acre in extent, on Malaboda Estate, Matugama, situated at an elevation of 150 ft above mean sea level. The experimental area was planted with clone Wagga 6278, a clone fairly susceptible to *Oidium* leaf disease.

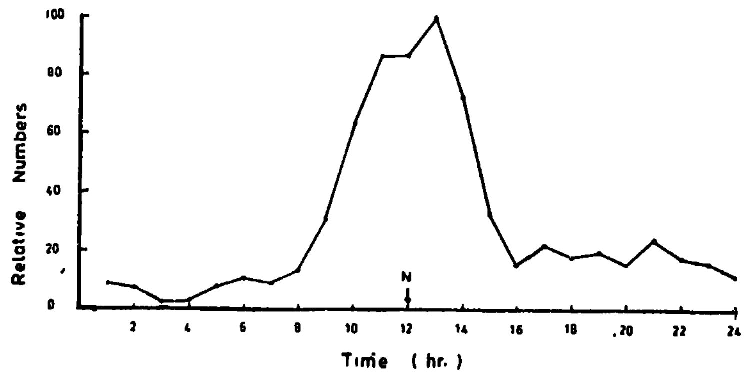

Fig. 1. Mean diurnal periodicity of *Oidium heveae* for 54 days (expressed as a percentage)

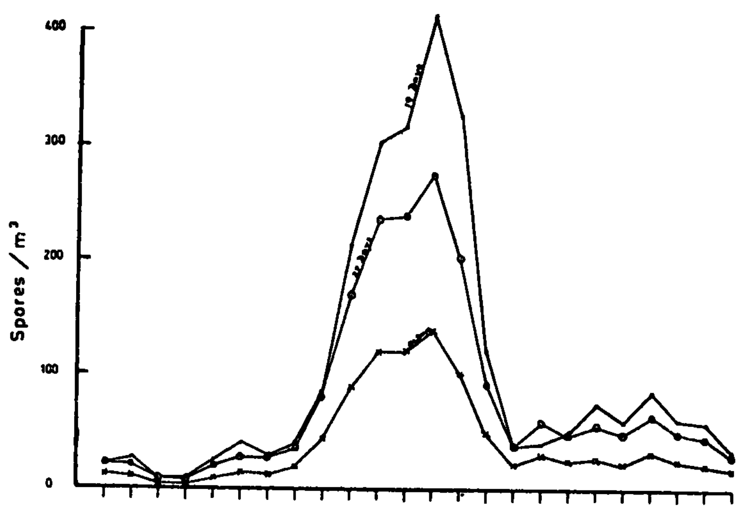

Fig. 2. Mean diurnal periodicity of *Oidium heveae*

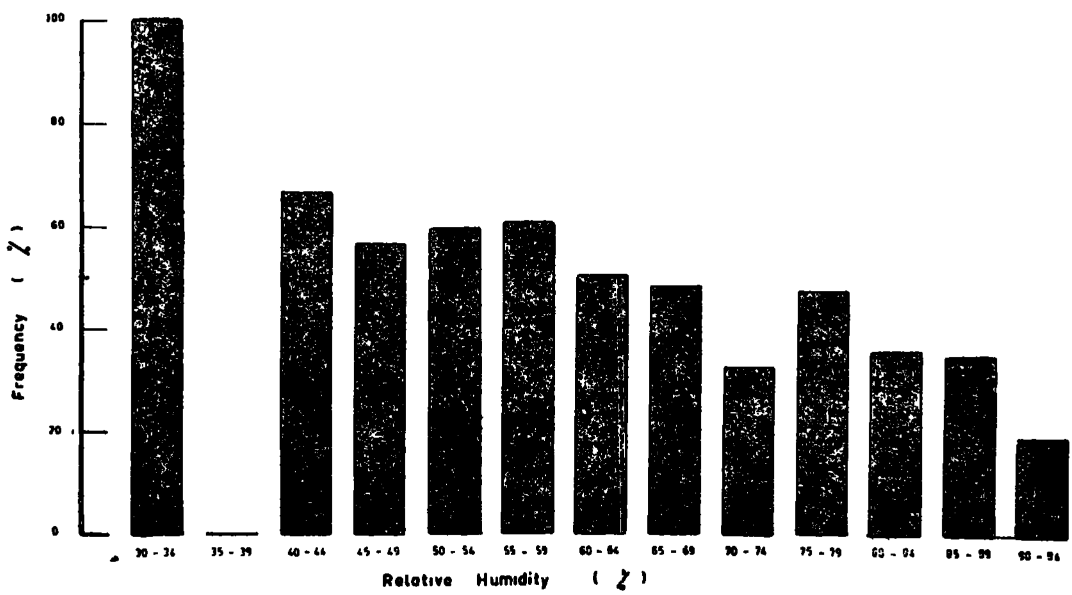

Fig. 3. The frequency with which *Oidium heveae* spores were trapped at different atmospheric relative humidities.

The trap orifice was 16 ft above ground level, at about the height of the first branching points on the main trunks of the rubber trees. The spore trapping surface was changed every seventh day, at 0900 hr, Indian Standard Time (IST). The trap was operated for 57 consecutive days from 1 February to 29 March 1970, and hourly catches of spores were recorded for this full period by examining the trapping surface under the microscope.

Hourly weather records, throughout the above period, were obtained from a Negretti & Zambra thermohygrograph (which was calibrated at regular intervals), a Casella constant recording rain guage, and a MK 3A Hirst & MacDonald leaf wetness recorder. All these instruments were in operation throughout the experiment, to record the temperature and humidity, rainfall and leaf surface wetness, respectively. Observations on sunshine were made daily from sunrise to sunset.

Leaf fall in the experimental area was assessed by counting the number of diseased leaves that fell in ten specially prepared leaf count beds 6 ft × 6 ft in extent, laid down at suitable distances around the spore trap. The field was dusted at 0300 hr on 12 March 1970, with 8 lb sulphur, using a CP 40 mist blower.

RESULTS

Diurnal periodicity: Hourly estimates of *Oidium* spores in the atmosphere, for a period of 54 days, expressed as percentages of the peak mean are plotted against time in Fig. 1. Diurnal periodicity curves derived from the arithmetic means of hourly catches are shown for three periods of 19, 27 and 54 days in Fig. 2.

The build-up of spores commenced from 0800 hr with the highest spore concentration being recorded from 1000 — 1400 hr and a peak at 1300 hr. The spore concentration declines from 1600 hr onwards. The lowest spore counts were recorded in the early morning hours. The highest hourly catch recorded was 1,470 spores/m^3 of air and zero catches were often recorded.

The relationship between atmospheric spore content and environmental factors are given below:—

Relative humidity: Conidia were trapped over a wide range of atmospheric humidities 30—99%. The numbers per m^3 of air trapped at lower humidities were greater than those trapped at higher relative humidities (RH) (Table 1). The frequency with which conidia were trapped for each RH group was also calculated. The hourly recordings of conidia trapped, expressed as a percentage of the total recorded for each RH group, are shown in Fig. 3. The frequency was above 50% at RH values below 65%, and progressively lower at RH values above 65%.

TABLE 1

MEAN NUMBERS OF *OIDIUM HEVEAE* SPORES/M^3 TRAPPED AT DIFFERENT RELATIVE HUMIDITIES

RH (%)	30–43	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–89	90–94	95–99
	214·0	—	191·8	138·5	236·1	210·3	161·0	140·5	111·5	113·5	96·3	66·1	71·0	43·2

Temperature: Conidia were trapped at temperatures between 70°—94°F. The numbers per m^3 of air were highest in the range 90°—94°F, and there was an inverse relationship between temperature and the number of conidia trapped (Table 2). Conidial catches were recorded most frequently in the groups 85°—89°F and 90°—94°F and less frequently in other groups (Fig. 4). A great majority (90%) of the conidia trapped were recorded at temperatures above 75°F, with the maximum in the range 85°—89°F.

TABLE 2

MEAN NUMBERS OF *OIDIUM HEVEAE* SPORES/M³ TRAPPED AT DIFFERENT TEMPERATURE

Temperature (F)	70–74	75–79	80–84	85–89	90–94
	37·8	83·5	104·0	190·2	214·0

Although the number of spores present in the atmosphere and therefore trapped was highest during periods of high temperature and low humidity, the build up of the inoculum was clearly encouraged by low temperatures and high humidities during the preceding period. This is illustrated in Fig. 6, and agrees with the findings of Peries (1966) in his biological studies.

Rainfall and leaf wetness: The atmospheric spore concentration increases just prior to rain and during the first hour of rainfall. This is clearly illustrated by the catches at 2300 hr on 9 March; 1300 hr on 11 March; 1600 hr on 14 March, and 1900 hr and 2100 hr on 16 March 1970, which were periods just prior to rainfall, and high incidence has been recorded during these periods. When rain persists, however, a considerable decrease in the number of conidia trapped is recorded as shown in Fig. 6.

Air turbulence and leaf fall: Air turbulence was coded into four arbitrary groups from observations made, namely (0), still air, to (4), gale force wind. Fig. 5, for a period of 24 hr, and Fig. 6 show that the numbers of spores trapped were directly proportional to the air turbulence at any particular period of time.

Further the leaf fall recorded during these hours had a direct relationship with the spore concentration and air turbulence, as illustrated in Figs. 5 and 6. The leaves that fell were mostly in the copper brown to apple green stages of development and were about two to three weeks old. It is known that leaves are most susceptible to the disease at this stage of development.

Sunshine: Fig. 6 shows that short hours of sunshine, giving rise to gloomy periods from 10 to 16 March, helped in the propagation of the fungus as shown by high catches of spores while bright and long hours of sunshine, from 17 March onwards, were accompanied by poor catches. Therefore these conditions appear to be inimical to the development and spread of the fungus.

Effect of sulphur dusting: On the day of sulphur dusting, there was an increase in leaf fall. This was clearly due to the disturbance caused by the air blast from the dusting machine. Thereafter the leaf fall was reduced considerably (Fig. 6), showing the effect of sulphur on disease incidence. There was no significant difference in the conidia trapped on the days that followed sulphur dusting, though one would have expected a decrease in the numbers.

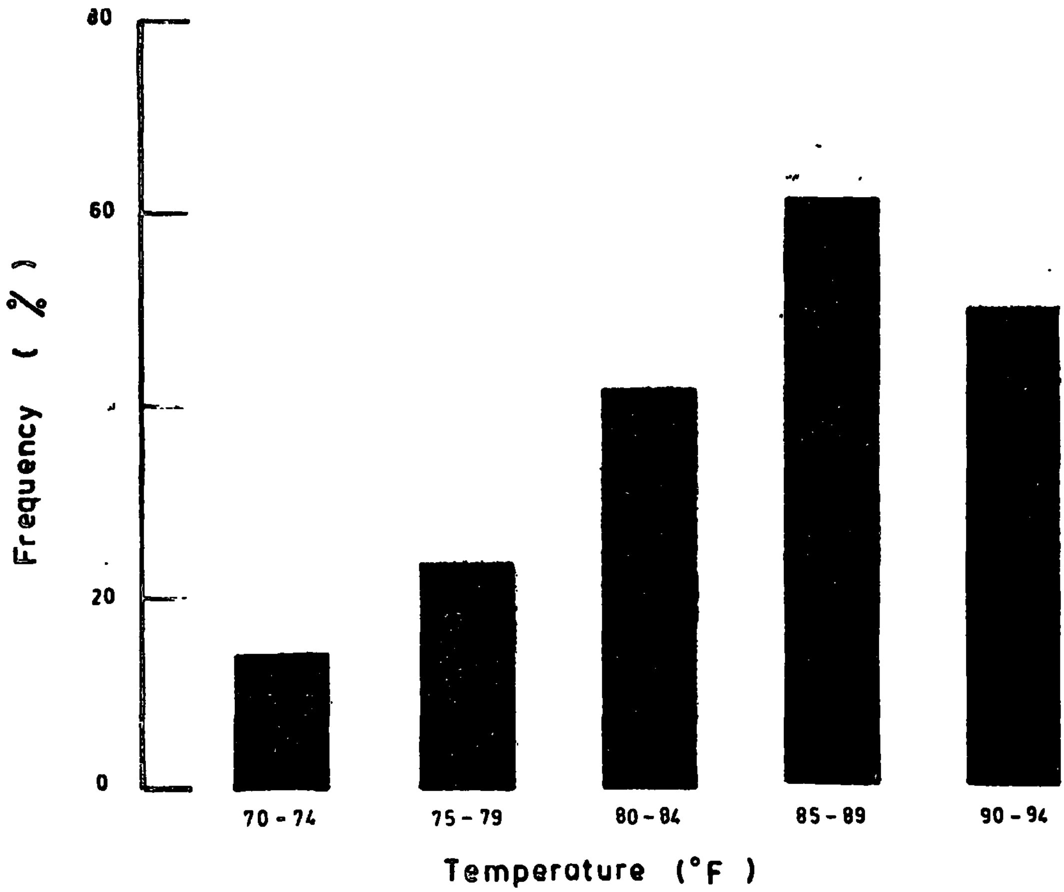

Fig. 4. The frequency with *Oidium heveae* spores were trapped at different air temperatures

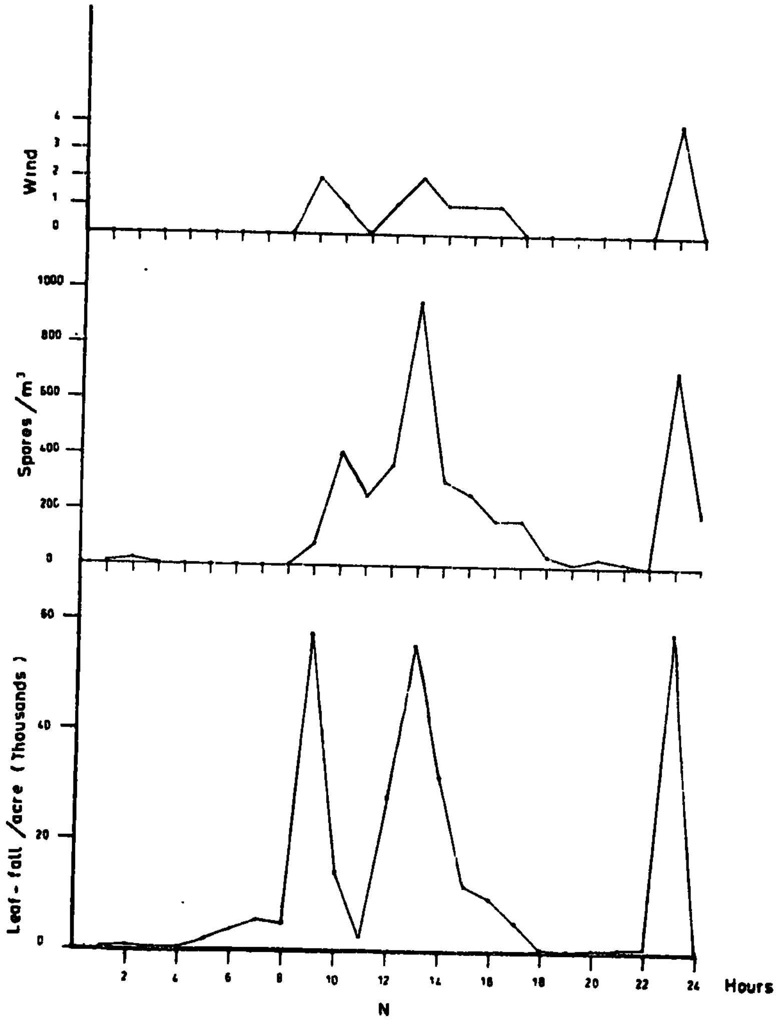

Fig. 5. Spore concentration in relation to leaf fall and air turbulence on 9 March 1970

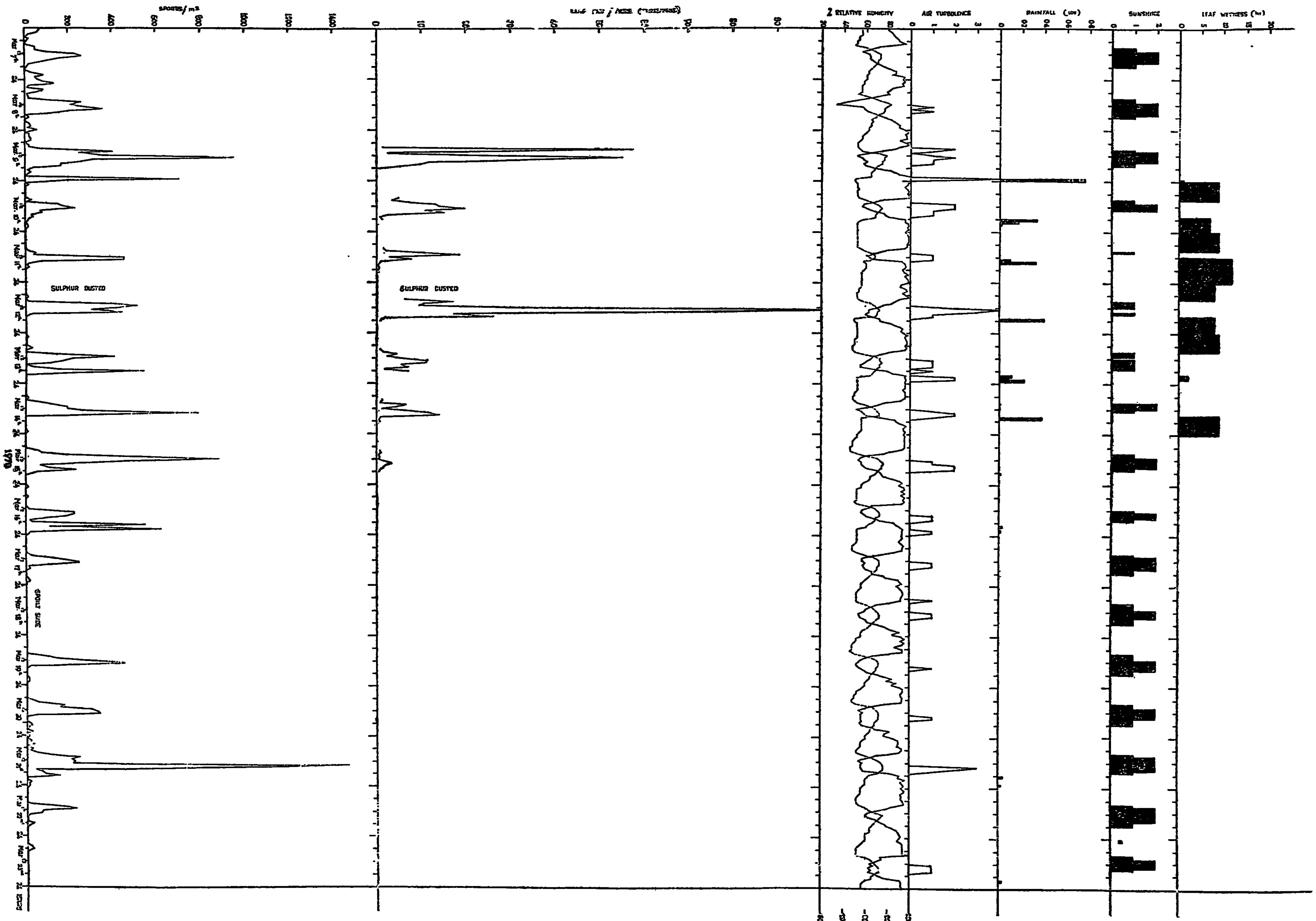

Fig. 6. Hourly variation in spore concentration and its relationship to weather and leaf fall (from 7th March to 23rd March 1970)

DISCUSSION

Gregory (1961) recognizes three main patterns of diurnal periodicity for the release of fungal spores, the nocturnal pattern, the forenoon pattern and the afternoon pattern. *Oidium heveae,* like the fungus *Cladosporium* spp. has a typical afternoon pattern of spore release, reaching a peak at 1300 hr. This set pattern is closely related to the weather conditions, especially to low humidity, high temperature, and high air turbulence, that prevailed during this period.

Hirst (1959) has suggested that changes in humidity are of considerable importance in the liberation of the spores of day spora, where a decrease in RH results in an increase in spore numbers in the air. Some of the conidial fungi are also favoured by dry conditions for their take off (Ingold, 1965). The present results are in agreement with these observations, maximum numbers of spores being trapped when temperatures were above 85°F and at RHs below 60%.

Childs (1939) in his studies on diurnal cycle of spore maturation in certain powdery mildews, reported that in the non-chain forming types, the period of maturation and abstriction of conidia occurred between 10·00 a.m. and 2·00 p.m. one spore being released on the average during a period of 24 hours. *Oidium* on rubber being a non-chain forming type, would follow this pattern. This period coincides with the period when high concentrations of conidia were found in the atmosphere during these studies.

Oidium heveae being a dry-spored fungus, temporary spore increases were observed just before the onset of heavy rain. With continued rain there was a sharp decrease in the spore concentration in the air. The increase was related to the mechanical effects, such as stem vibrations and leaf flutter, brought about by strong winds that occurred just before rain commenced. This would assist spore liberation; further, large rain drops when falling on dry leaves cause sufficient disturbances to liberate conidia formed on these leaves. The rain droplets that wash down the spores, and the wet conditions on leaf surfaces which affect the release of conidia from the fungal mat account for the marked decrease in spore numbers later. These observations agree with those of Ingold (1965) on spore liberation.

Air turbulence was a major factor that was responsible for the dispersal of *O. heveae* spores. When conidia are mature and ready to be released, even low winds helped in their dispersal. Meredith (1967) reported the same phenomenon on *Cercospora* spp. This once again was mainly due to the mechanical effects that were caused on the branches and leaves. Leaf fall too increased due to air turbulence. The infected leaves that fell had crops of conidia, which were probably dislodged while they fell, thus increasing the spore concentration in the atmosphere. Leaf fall was highest during day time and negligible at night once again being closely associated with relatively high wind velocities that accompany the daily thermal turbulence. It was for this reason that it was decided to take hourly leaf fall counts, only during the day time.

The spore concentration in the atmosphere will depend on the propagation of the fungus. Increase in spore production, increases the inoculum in the atmosphere, which in turn will cause fresh infections resulting in further inoculum build-up, depending on the availability of susceptible tender leaves. Temperature, humidity, rainfall, leaf wetness and sunshine were the environmental conditions that had a bearing on the propagation of the fungus, on the basis of atmospheric spore content.

High humidities and low temperatures accompanied by mist during the night helped in the ripening and build-up of conidia that were discharged during the day time, when suitable conditions for dispersal occurred. These conditions for propagation were observed, preceding a good catch of conidia on the trapping surface. This agrees with the findings of Ingold (1965) on fungi-producing conidia and the studies on the biology of *O. heveae* (Peries, 1966).

Heavy showers, as well as leaf wetness for long periods, were inimical to the development of the fungus, as conidia get washed off by heavy rains, and the presence of free water kills the fungus, thus preventing a build-up of inoculum. Overcast, humid conditions with light showers in short spells, provided ideal conditions for the rapid propagation of *Oidium*. These were periods when 0·01—0·04 in. of rain was recorded per day, with a very few hours of sunshine. Bright sunny periods militate against the development of the fungus, and have a lethal effect on detached spores (Peries, 1965). The poor catches on days immediately following bright sunny days, could be attributed to this factor.

Leaf fall was reduced considerably after sulphur dusting, but the spore catch remained almost in the same range as prior to dusting. The conditions for the spread of the disease were ideal during this period, but the reduction in leaf fall suggests that fresh infections have not occurred. Hence the writer is of the opinion that, in the absence of dusting, many more conidia would have been trapped. It is also possible that most of these conidia, that were present in the atmosphere, had lost their viability due to the action of sulphur, thereby rendering them incapable of causing fresh infections and producing fresh inoculum. No distinction can be made between viable and non-viable conidia on the trapping surface. There is also the possibility that sulphur does not kill the fungus on the leaf, but protects the leaf from fresh infection. If this is the case, the fungus present on the leaf would continue to produce conidia, thus maintaining the level of spores in the atmosphere, but fresh infection would be reduced, thus reducing the extent of leaf fall.

CONCLUSIONS

The results of this study have shown that the propagation of the causal fungus (*O. heveae*) is encouraged by high humidities and low temperatures accompanied by mist during the night. These conditions are always followed by high catches of spores in the trap. On the other hand, hot dry periods with bright sunny days are inimical to the propagation of the fungus, such periods being followed by poor catches of spores. Therefore, *Oidium* control in susceptible clones should be confined to periods of dull, cool, humid weather. Sulphur dusting is not warranted during periods of bright sunny weather and dusting rounds falling due in such periods should be skipped. Considerable economies in sulphur dusting can still be achieved by the vigilance of the man on the spot.

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QUESTIONS AND ANSWERS

Question: (i) Are rubber flowers more susceptible to *Oidium* than the leaf ?

(ii) Could the very meagre pod-set in recent years be due to *Oidium*, and if so what is the answer to obtain more seed? (Anon).

Answer: (i) Yes.

(ii) Poor pod-set may be attributed, at least partly to *Oidium*, especially in clones such as Tjir 1, if they were not dusted as heavily as in previous year. A poor pod-set is an advantage, as *Phytophthora* infection later in the year is restricted if pod-set is poor. However, if you are looking for seed, for nurseries or for sale, from seed gardens, you should take the precaution of sulphur dusting those areas adequately to protect the flowers. (Dr. O. S. Peries).