

## EFFECT OF WEATHER FACTORS ON DISEASE ESTABLISHMENT AND SPORULATION OF *PHYTOPHTHORA MEADII* ON RUBBER PODS

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### ABSTRACT

*Rubber pods inoculated under favourable weather conditions showed early establishment of the disease and produced a large number of sporangia over a long period, but under adverse climatic conditions disease establishment was prolonged and the period of sporangial production was shortened. Sporangia were able to proliferate on relatively dry pod surfaces and in the presence of secondary fungi. A small quantity of water was sufficient to disseminate the sporangia but only a small proportion of it was capable of releasing zoospores.*

### INTRODUCTION

Several species of *Phytophthora* are known to cause pod rot and abnormal leaf fall, in most of the rubber growing areas of the world. They include *P. meadii*, McRae & *P. palmivora* (Butl.) Butl. (Sri Lanka) *P. palmivora* (Butl.) Butl. *P. meadii* McRae (India) and *P. botryosa* Chee and *P. palmivora* (Butl.) Butl. (Thailand & Malaysia).

It is the most serious disease of rubber in South India where 75% defoliation is probable in the absence of treatment, resulting in a 30 - 50% reduction in the yield (Ramakrishnan, 1960). In Sri Lanka severe outbreaks of the disease are generally confined only to isolated pockets in the wet rubber growing districts, and is not of much economic significance to warrant routine control measures (Lloyd, 1963). *Phytophthora* leaf fall occurs widely in certain regions of Java and Sumatra, but it is considered to be of minor importance (Nara, Widjanarko and Hartana, 1968). In Malaysia, an epidemic of the disease was noticed in the island of Langkawi off the North West coast of West Malaysia (Chee, Lim and Wastie, 1967) and at the same time an outbreak of this disease was found both in North East and South West Thailand (Turner, 1969).

In Sri Lanka and India the leaf fall phase of the disease is preceded by the green mature pods becoming infected after the commencement of the South West monsoon rains around May and June. This close relationship between pod set and *Phytophthora* leaf fall has been clearly demonstrated (Petch, 1921; Peries, 1964).

Laboratory and field investigations have been undertaken by Peries (1969) to examine the growth of the fungus on various organs of the rubber plant. This study examines the influence of various environmental factors on the establishment and sporulation of the fungus on rubber pods.

## MATERIALS AND METHODS

## Preparation of inoculum

The inoculum was prepared from 5 - day old cultures of *P. meadii* (Isolate No. 362), grown at room temperature ( $28 \pm 2^\circ\text{C}$ ), on 2% Difco Lima Bean agar (LBA). The zoospore suspension was prepared by scraping the sporangia from five petri dishes into a 100 ml beaker containing chilled sterile distilled water. This was further incubated at  $20^\circ\text{C}$  for 20 min and then kept on the laboratory bench for a few minutes to release the zoospores. The suspension was filtered through two layers of sterile muslin cloth to remove all the extraneous matter. The suspension standardized to give  $10^4$  zoospores per ml, was used for field inoculations.

## Method of inoculation

Sixty undamaged mature green pods of the clone NAB 12 were selected from branches 2 - 4 m from the ground at Dartonfield Estate. Six pods were selected for inoculation on each week day from 14 June to 27 June 1977, three of these pods were protected with a 'polythene skirt' and the other three pods were left exposed. The pods were inoculated around 0900 h each day, by dipping their lower ends in a petri dish containing 15 ml of the zoospore suspension. The pods were wiped dry if they were wet at the time of inoculation. The inoculum drops in the unprotected pods were kept moist by the addition of sterile distilled water until 6 h after inoculation by which time the 'polythene skirts' were removed, from the protected pods.

## Collection of sporangia

The rain water that drips from each inoculated pod was collected by a funnel and flask arrangement. A funnel was hung below each of the inoculated pods and the rain water was collected in 50 ml conical flasks, containing a few drops of cotton-blue in lactophenol. The water was collected at the end of each shower that occurred between 0600 h and 1800 h. The rain water collected from 1800 h until 0600 h the next day was not separated according to the showers. The quantity of rain water collected at the end of each shower was measured and the number of full and empty sporangia was counted using a haemocytometer. The collection of drip water from pods started on the 19 June was continued until the 20 July when the experiment was terminated.

Weather records such as rainfall and sunshine were obtained from the meteorological station, which was about 100 m from the experimental site. The temperature and humidity records were obtained from a Negretti and Zambra thermohygrograph, kept in the shade about 50 m from the site.

## RESULTS

The effect of weather conditions on the incubation period and sporangial production on rubber pods is shown in Fig. 1. The examination of rain water collected from pods inoculated on 14 June revealed the presence of sporangia, 6 days after the inoculation.

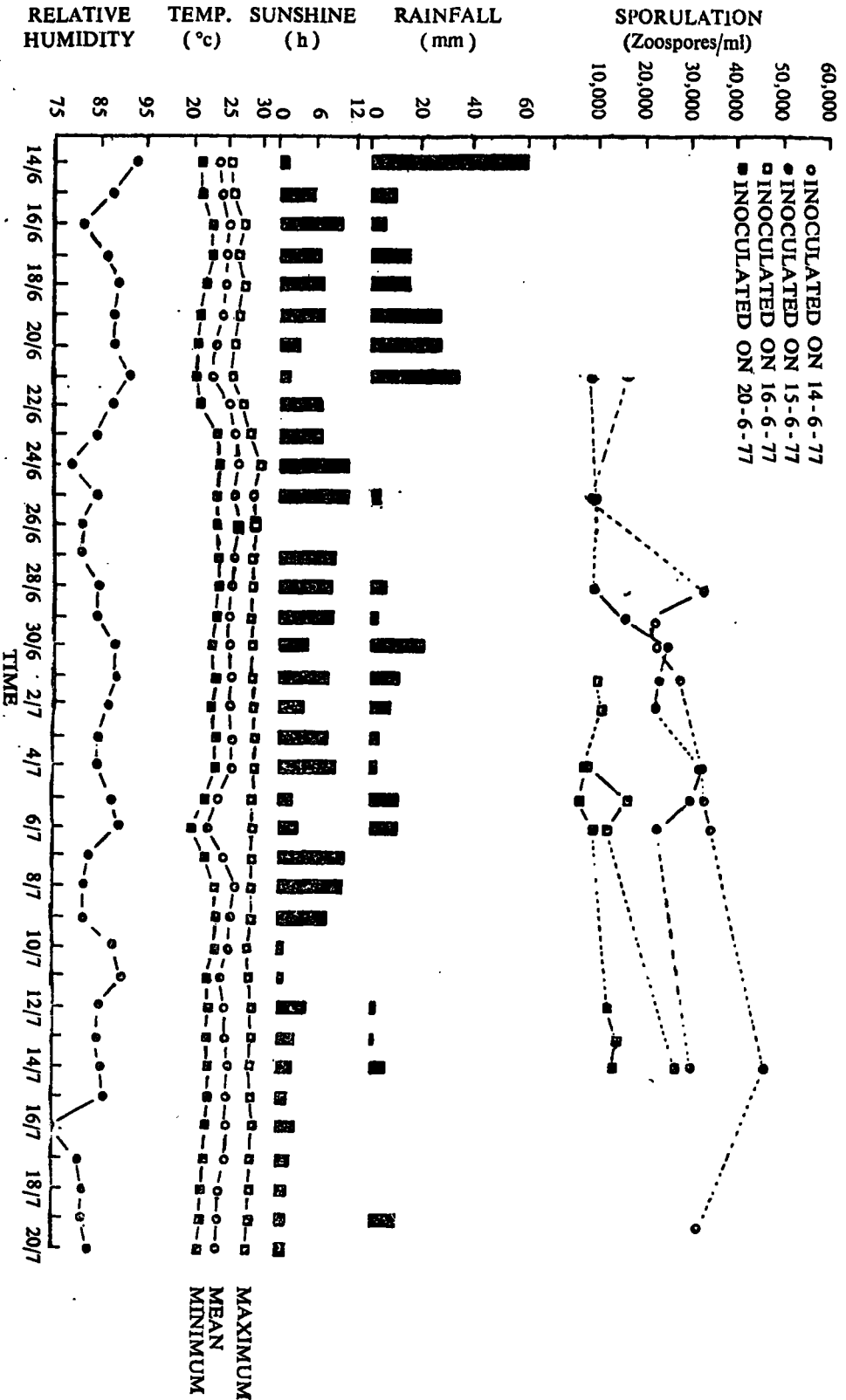


Fig. 1. Effect of weather factors on sporulation of *P. meadii* on rubber pods. Note. Rainy and non-rainy periods are indicated by solid and broken lines, respectively.

These pods produced sporangia in large numbers at the end of each shower until 19 July, with the maximum number of sporangia being collected on 14 July. Similarly, the pods inoculated on 15 June yielded sporangia on the 6th day after inoculation, and continued to produce sporangia in abundance until 14 July, after which they ceased to produce any sporangia.

The weather conditions on 14 June were conducive for disease establishment with rain occurring at regular intervals, a relative humidity of over 90% throughout the day, few bright sunny periods with most of the day being overcast and gloomy and a low mean temperature. The inoculation itself was interrupted by rain. A heavy shower that occurred 15 min after completing the inoculation washed off the inoculum drops from unprotected pods, while it was kept intact in the pods protected by the 'polythene skirt'. Similar weather conditions were experienced on 15 June but light dry winds were prevalent throughout the day.

Although weather conditions were less favourable for the pods inoculated on 16 June, sporangial production commenced 4 days after inoculation. There was little rain. Temperature was high, accompanied by a low relative humidity with bright sunny periods. The sporangia were collected until 14 July but their numbers were less than that recorded for 14 and 15 June inoculations.

The weather conditions prevalent at the time of inoculation on 20 June and on the following day were favourable for the establishment of the disease, but these pods commenced sporulation only 9 days after inoculation. There were 6 consecutive days of bright sunshine, high temperature, low relative humidity and no rain except for a very light shower. These pods produced sporangia until 19 July.

The inoculations done on 24 and 27 June coincided with weather conditions that were inimical for establishment of the pathogen, being extremely hot and sunny with very high temperature and low relative humidity. It took 6 and 7 days, respectively for the fungus to commence sporulation on the inoculations done on 24 and 27 June. The number of sporangia produced by these pods was much less compared to those inoculated on any other day. These pods produced sporangia only for about 3 weeks.

Generally, it took about 7 to 11 days for the pods to be fully infected, depending on the weather conditions. Wet weather appeared to hasten the process while dry weather retarded it. It was observed that secondary fungi colonized the pods in about 10-14 days, after the inoculation of pods. The pods which were colonized by secondary invaders continued to yield sporangia in abundance despite their presence. It was also observed that pods which appeared to be dry for over 2 to 3 weeks yielded large numbers of sporangia during the rainy periods, that followed.

When the weather conditions were wet at the time of inoculation, there was no difference in the time taken to produce disease symptoms and sporangial production in the protected and unprotected pods. However, under adverse weather conditions, the pods which were protected after inoculation showed better establishment of the disease compared to the pods that were left exposed.

The results in Table 1 indicate that the amount of rain falling on the pods in the canopy was very small compared to the rainfall in an open space. There was pod to pod variation with regard to the amount of water collected between rainy periods. This was due to the position of the pod in relation to the canopy of the trees. The pods which were concealed received less rain than those which were exposed. It was shown that the amount of sporangia collected during heavy rain appears to be generally less than those collected during light showers. A rainfall less than 1 mm was sufficient to wash down a large number of sporangia. The highest number of sporangia was collected from water condensed as dew on the rubber pods.

It is apparent from the results shown in Table 2 that although a large number of sporangia was detached after each shower, only a small proportion of them was capable of releasing zoospores. The pods which were inoculated during favourable weather (14/6/77 and 15/6/77 inoculation) produced more sporangia capable of releasing a large number of zoospores than those pods which were inoculated during unfavourable weather conditions (22/6/77 and 27/6/77).

#### DISCUSSION

Abnormal leaf fall caused by *P. meadii* occurs during prolonged wet weather periods in the presence of green mature pods (Peries, 1969). The formula for forecasting epidemics of abnormal leaf fall postulated by Peries in 1969 states that "if the temperature is not above 20°C ; relative humidity above 80% ; at least 0.1 inch of rain per day and less than 3 hours of sunshine per day prevail for 4 consecutive days, when infected fully mature green pods are present on the trees, leaf fall epidemics can be expected to occur within the next fourteen days". Satchuthananthavale and Dantanarayana in 1973 suggested that daily rainfall is more important in governing the severity of the disease during the period when mature pods are present in the field. These studies indicate that the influence of weather factors on the establishment of the disease and sporulation appear to be very complex. The inoculations done on 14, 15, 16 and 20 June coincided with favourable weather conditions for the establishment of the disease but there were differences in the individual climatic factors on each of these days. The weather conditions on 22 and 27 June were less favourable to disease establishment. It took 7 days to produce sporangia in both inoculations. The pods inoculated on 27 June were subjected to favourable weather conditions for 9 consecutive days from the day after the inoculation, but these pods produced less sporangia, over a short duration, than those inoculated on 22 June which were exposed to 4 days of dry weather interspersed by a very light shower. This suggests that individual weather factors and their combinations play a role in determining the time taken for the fungus to start sporulating on pods as well as the duration of sporulation.

These studies also showed that a small amount of rain was adequate to wash down sporangia and release zoospores. In fact, the highest number of spores was trapped in water droplets collected from dew. It was also shown that the zoospores have to remain in contact with the pods only for a short period, to cause infection, provided the weather conditions were favourable. Another interesting feature was that the sporangia were able to proliferate on dry pod surfaces and in the presence of secondary fungi. However, the viability of such spores was not tested. There are several complicated factors which have to be taken into account. Therefore, an understanding of the influence of weather factors, singly and in combination is an essential prerequisite for the development of disease forecasting models.

Table 1. *The relationship between rainfall and drip water collected from pods on different days*

Date of sampling	Date of inoculation											
	14/6/77			15/6/77			22/6/77			27/6/77		
	Rainfall (mm)	Pod water (mm)	Sporangia per ml	Rainfall (mm)	Pod water (mm)	Sporangia per ml	Rainfall (mm)	Pod water (mm)	Sporangia per ml	Rainfall (mm)	Pod water (mm)	Sporangia per ml
21/6/77	37.3	3.5	11,500	37.3	4.6	8,000						
25/6/77	2.1	0.05	58,500	2.1	0.1	7,000						
28/6/77	4.5	0.05	33,000	4.5	0.25	8,000						
29/6/77	2.1	0.2	19,500	2.1	4.9	15,000						
30/6/77	23.0	2.0	21,500	23.0	4.7	23,000						
1/7/77	11.2	2.4	26,500	11.2	2.7	22,000	11.2	4.8	8,500			
2/7/77	8.2	NR	NR	8.2	0.8	21,000	8.2	0.4	9,500			
4/7/77	1.0	NR	NR	1.0	1.1	32,000	1.0	0.5	8,000	1.0	0.9	8,000
5/7/77	10.8	0.95	31,500	10.8	0.3	29,000	10.8	1.7	15,000	10.8	0.4	4,500
6/7/77	10.6	0.5	33,000	10.6	1.2	21,000	10.6	0.4	10,500	10.6	3.2	8,000
12/7/77	1.0	NR	NR	1.0	NR	NR	1.0	NR	NR	1.0	0.5	10,500
13/7/77	0.4	NR	NR	0.4	NR	NR	0.4	NR	NR	0.4	0.6	12,500
14/7/77	7.3	0.9	44,500	7.3	5.5	28,000	7.3	1.4	26,000	7.3	6.6	11,000
19/7/77	9.6	1.8	31,500	9.6	NR	NR	9.6	4.5	Nil	9.6	NR	NR

NR = Not recorded

Table 2. *The number of empty and full sporangia collected in rain water from pods inoculated on different days*

Date of sampling	Date of inoculation											
	14/6/77			15/6/77			22/6/77			27/6/77		
	Total No. sporangia	No. sporangia Full	Empty	Total No. sporangia	No. sporangia Full	Empty	Total No. sporangia	No. sporangia Full	Empty	Total No. sporangia	No. sporangia Full	Empty
20/6/77	Nil	Nil	Nil	Nil	Nil	Nil						
21/6/77	11,500	9,500	2,000	8,000	6,000	2,000						
25/6/77	58,000	52,000	6,500	7,000	5,500	1,500						
28/6/77	33,000	31,500	1,500	8,000	5,500	2,500						
29/6/77	19,500	16,000	3,500	15,000	11,500	3,500						
30/6/77	21,500	17,000	4,500	23,000	16,000	7,000	Nil	Nil	Nil			
1/7/77	26,500	22,500	4,000	22,000	19,000	3,000	8,500	7,000	1,500			
2/7/77	NR	NR	NR	21,000	19,500	1,500	9,500	7,500	2,000	Nil	Nil	Nil
4/7/77	NR	NR	NR	32,000	22,500	9,500	8,000	8,000	Nil	8,000	6,000	2,000
5/7/77	31,500	28,000	3,500	29,000	23,500	5,500	15,000	12,500	2,500	4,500	2,500	2,000
6/7/77	33,000	30,000	3,000	21,000	19,500	1,500	10,500	9,000	1,500	8,000	6,500	1,500
12/7/77	NR	NR	NR	NR	NR	NR	NR	NR	NR	10,500	9,500	1,000
13/7/77	NR	NR	NR	NR	NR	NR	NR	NR	NR	12,500	11,500	1,000
14/7/77	44,500	40,000	4,500	28,000	26,500	1,500	26,000	22,000	4,000	11,000	10,500	500
19/7/77	31,500	8,500	23,000	NR	NR	NR	Nil	Nil	Nil	NR	NR	NR

NR — Not recorded

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