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EFFECT OF CLIMATIC FACTORS ON *PHYTOPHTHORA* LEAF INFECTION IN BLACK PEPPER GROWN IN ARECANUT-BLACK PEPPER MIXED CROPPING SYSTEM

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ABSTRACT

Effect of climatic factors on the occurrence of foliar infection in black pepper caused by *Phytophthora palmivora* MF4 was studied during the years 1984-86 in arecanut-black pepper mixed cropping system. The correlation studies between the disease recorded at weekly intervals and the meteorological factors prevailing during the preceding seven days showed a positive correlation between the rainfall, number of rainy days and relative humidity whereas temperature and sunshine hours had a negative correlation. Average climatic factors worked out during increasing and decreasing phases of the disease showed that factors such as low temperature (22.7–29.6°C), shorter duration of sunshine (2.8–3.5 h/day) high rainfall (15.8–23.0mm/day) and high relative humidity (81–99%) contributed to the increase n disease.

INTRODUCTION

The fungus *Phytophthora palmivora* MF4 (morphological form–4) infects all parts of the black pepper vine, *Piper nigrum*. The infection on roots and collar region results in 'quick wilt' or 'foot rot' leading to outright death of the affected vines. The infection on the aerial parts like leaves, stems, spikes and berries occurs under favourable micro-climatic conditions and results in complete destruction of vines in severe cases. Disease incidence is noticed both in pure plantations as well as in mixed cropping systems like arecanut-black pepper, coffee-black pepper etc. Foliar infections are severe in arecanut-black pepper mixed cropping system. The microclimatic conditions are more conducive to the disease development in the mixed cropping systems. The disease is most severe during the south-west monsoon (June–September) and is sporadic during north-east monsoon (October–November) period. The fungus is soil-borne and the infection first appears on the tender leaves and succulent stems of the runner shoots that emerge at the base of the vines following the pre-monsoon showers. The infected runner shoots support good growth and sporulation of the fungus. From these primary foci, the infection spreads further quite rapidly with the onset of the monsoon which ensures favourable microclimate. During this

period, the availability of susceptible tissue is in abundance as the vines put-forth new leaves and spikes. Precise information on the factors that promote or limit the disease initiation and development is lacking. Hence, the present study was undertaken to understand the role of climatic factors in the disease development.

MATERIALS AND METHODS

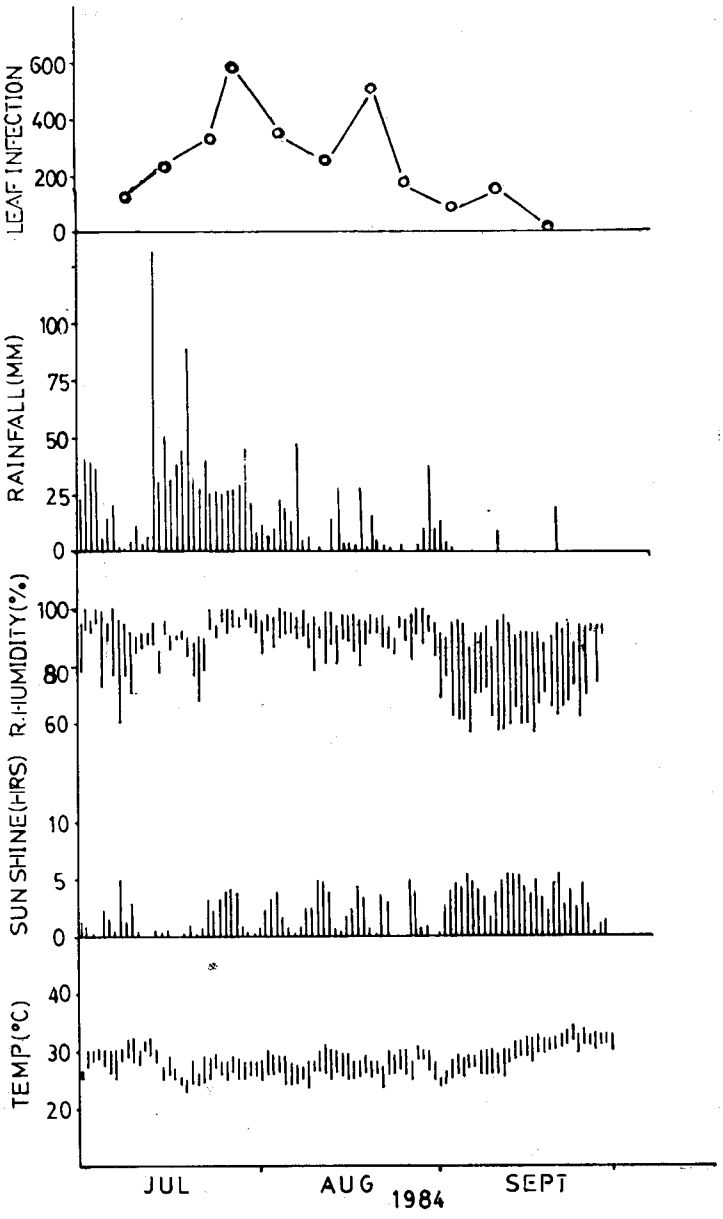
The studies were conducted in an arecanut *(Areca catechu* L.*)*-black pepper *(Piper nigrum* L.*)* mixed cropping system at Central Plantation Crops Research Institute, Research Centre, Kannara, Trichur District, Kerala. The soil was of alluvial type and promoted luxuriant growth of pepper vines some of which have attained heights of over 10 metres. The pepper hybrid, Panniyur-1 was trained on areca palms and the usual agronomic practices were followed. The vines were about 7 years old. The number of vines present in the garden were 120, 108 and 95 respectively during the years, 1984, 1985 and 1986 and they occupied a spacing of 1.8 × 3.6 m. The meteorological parameters *viz.*, ambient temperature, relative humidity, rainfall and sunshine were continuously monitored for the period June-September during the years 1984–86 (Figs. 1–3). The foliar infection was recorded by counting the number of infected leaves in two 0.5 × 0.5 metre areas in the canopy of each vine at weekly intervals and the sum of this for all the infected vines was taken as the quantum of the disease and was compared with the average conditions of climatic factors during the preceding seven days. The days that received more than 10 mm of rainfall were counted as rainy days. The correlation coefficients of these factors for the disease incidence were worked out (Table I) to find out the favourable range of climatic factors to the disease. The entire disease progress was categorised into (a) increasing phase and (b) declining phase depending on the increase or decrease in disease recorded during any particular week compared to the preceding observation. Average weather conditions that prevailed during these phases were worked out. Further, to understand the combined effect of climatic factors, multiple regression analysis was done taking climatic factors, as independent variables and weekly quantum of foliar infection as dependent variable.

RESULTS AND DISCUSSION

The disease incidence recorded during three years showed that the average rainfall and rainy days preceding the first appearance of the disease had good correlation (Table III). It is seen from the Figs. 1–3 that the disease was maximum during July and August in the years 1984 and 1985 and the infection was the lowest in 1986. The number of increasing and decreasing phases were 6&5.9&8 and 5&10 during 1984, 1985 and 1986 respectively. Disease peaks were always preceded by heavy and continuous rainfall conditions, high relative humidity, accompanied by low temperatures and short sunshine hours.

A positive correlation existed between the disease incidence and the weather factors like rainfall, number of rainy days and relative humidity

ig. 1. Meteorological factors (vertical lines representing daily total of rainfall and sunshine and minim and maximum of temperature and relative humidity) and *Phytophthora* leaf infection in bl pepper during 1984



ig. 2. **Meteorological factors (vertical lines representing daily total of rainfall and sunshine and minimum and maximum of temperature and relative humidity) and *Phytophthora* leaf infection in black pepper during 1985**

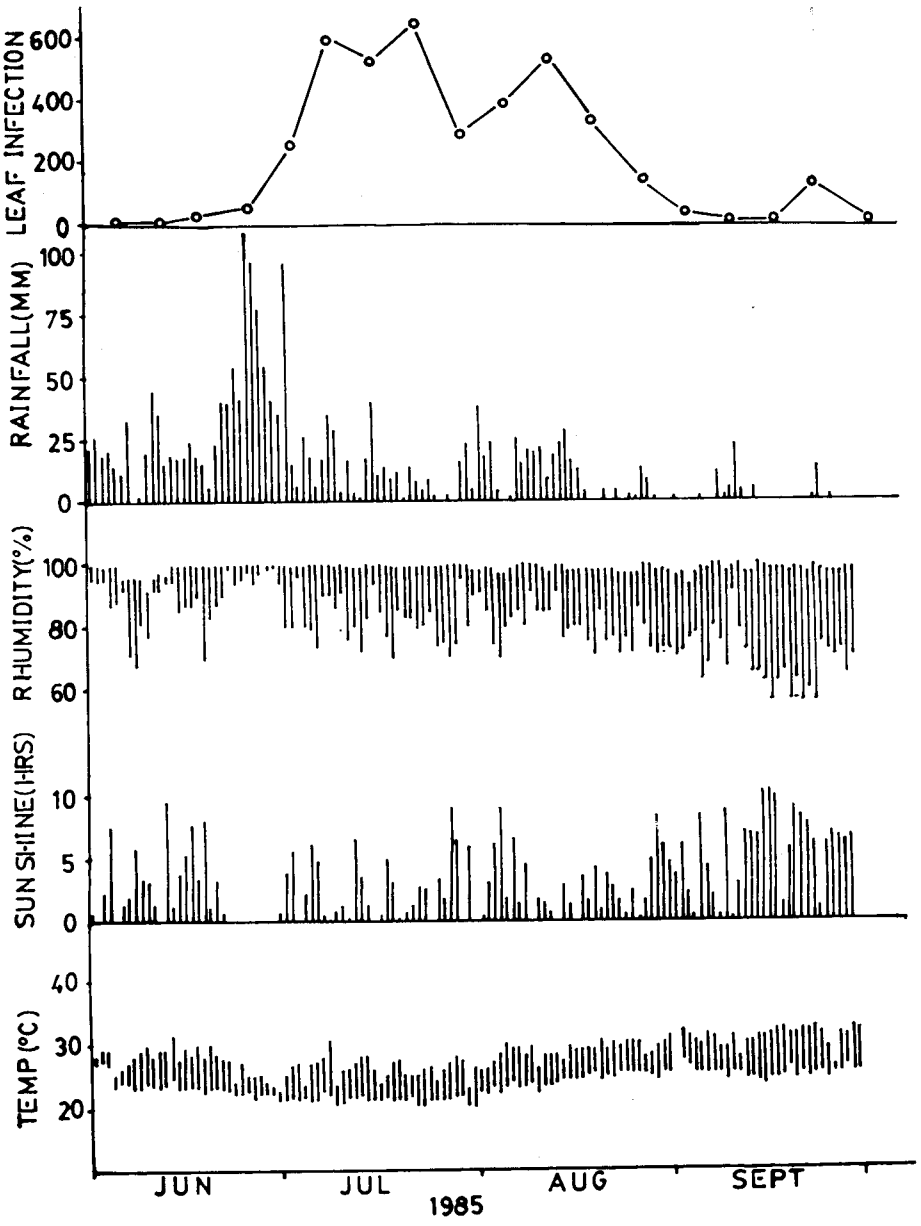


Fig. 3. Meteorological factors (vertical lines representing daily total of rainfall and sunshine and minimum and maximum of temperature and relative humidity) and *Phytophthora* leaf infection in black pepper during 1986

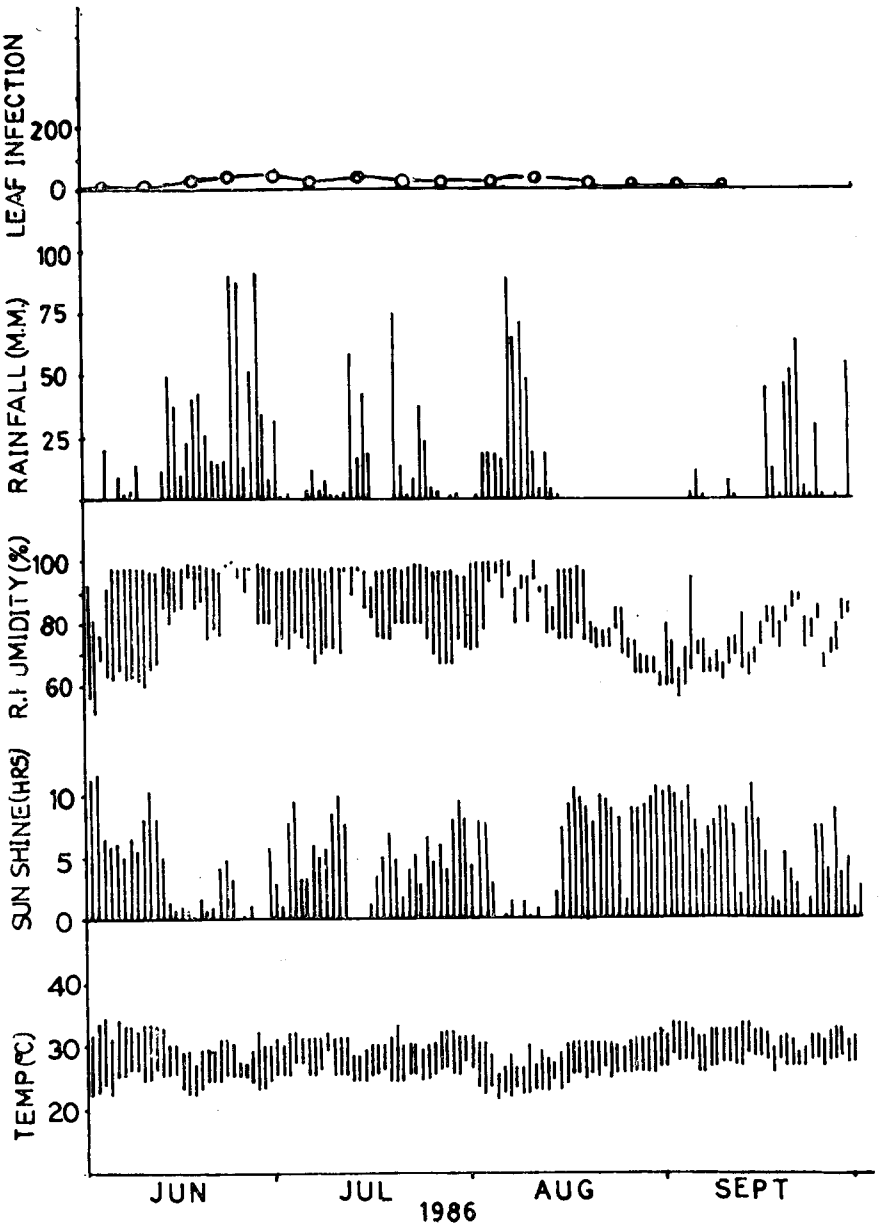


Table I. *Correlation coefficients of climatic variables with number of infected leaves as dependent variable*

Climatic factors	Correlation coefficient		
	1984	1985	1986
Temperature (Min.)	-0.4940	-0.6882**	-0.5216*
Temperature (Max.)	-0.3344	-0.5612*	-0.5297*
Relative humidity (Min.)	0.6844*	0.1771	0.7522**
Relative humidity (Max.)	0.4477	0.4859*	0.5570*
Rainfall (Total)	0.070	0.0139	0.7955**
Rainy days	0.2152	0.2392	0.8478**
Sunshine hours	-0.1614	-0.3586	-0.8460**

* Significant at P = 0.05
** Significant at P = 0.01

(Table I). During the years 1984 and 1985, the disease showed low correlations with total rainfall and was not statistically significant. However, this was highly significant during 1986 since the variability in disease was well discernible eventhough it was less severe compared to 1984 and '85. Number of rainy days was maximum (62) during 1985 when maximum incidence of disease was noticed (Table IV). Though almost equal quantities of rainfall were received during June to September periods of all the three years (Table IV) infection noticed in 1986 was almost negligible. This might be due to the delayed occurrence of the disease (Table III) and also due to reduction in both the number and size of the canopies because of severe infections during the previous years. In case of late blight of potato the reduction in foliage due to earlier infection is known to change the microclimate and also to reduce the infection (Hirst and Stedman, 1960).

Rainfall is one of the important factors in view of the requirement of water by all stages of *Phytophthora* starting from sporulation (Waterhouse, 1931). Rainfall further helps in maintaining high relative humidity which is required for sporulation by all species of *Phytophthora* that sporulate aerially on host surfaces (Waterhouse, 1931) and to maintain leaf wetness. In potato a film of water or water droplets are pre-requisites for infection by *P. infestans* (Lapwood, 1968). In contrast to Indian conditions, in Sarawak *Phytophthora* infection was noticed throughout the year, the maximum being during the wettest period of the year-October to March. The mean maximum and minimum temperatures were 26 and 21°C and the rainfall was 318 653 mm; besides a mean sunshine of 4.3 h/day during this period (Holliday and Mowat, 1963). High relative humidity and rainfall were found to favour the foot rot of black pepper in India (Lakshmi-

Table II. *Climatic factors (means) during increasing and decreasing phases of* Phytophthora *leaf infection in black pepper*

	Year	No. of observ-ations	Temperature (oC)		Relative humidity		Rainfall (mm)		Sunshine (h/day)
			Min.	Max.	Min.	Max.	Per day	Days/week receiving 10 mm & above	
Increasing phase	1984	6	26.0	29.0	82.0	94.4	15.8	2.8	3.5
	1985	9	22.7	27.3	83.8	99.2	22.2	4.81	2.8
	1986	5	24.0	29.6	81.0	97.9	23.0	4.4	3.2
Decreasing phase	1984	5	26.3	28.6	82.4	95.6	8.4	1.8	4.8
	1985	8	23.6	28.7	76.4	97.9	8.4	2.2	3.5
	1986	10	24.7	30.8	70.9	88.9	10.0	1.8	6.8

kantha Sastry, 1982). The negative correlations seen between the disease incidence and sunshine as well as temperature reveal the adverse impact of these factors which are reported to affect the viability of sporangia (Duniway, 1983). Temperature also affects different growth stages of both host and the pathogen (Colhoun, 1973).

Regarding temperature, not much differences are seen between the increasing and declining phases of the disease during all the three years (Table II). The mean minimum of relative humidity always remained above 80% under the increasing phase of the disease whereas under declining phase it was found to be less. However, considerable differences are seen with regard to rainfall, number of rainy days and sunshine hours (Table II). Of all the three years maximum amount of foliar infection was noticed during the year 1985 when all the factors such as low temperature (22.7–27.3°C) and sunshine (2.88 hrs/day) besides high relative humidity (83.8–99.2%), rainfall (22.2mm/day) and rainy days (4.8 days/week) were found to favour the disease. The number of rainy days was also the highest of the three years (Table IV). Disease also appeared quite early during the year (Table III).

It is known that the effects of the individual meteorological factors on the disease occurrence is only relative and the unfavourable effect of any factor may be compensated for by the highly favourable factors as per the hypothesis of compensation (Rotem, 1978; Rotem, Cohen and Putter, 1971). The role of each factor may vary from one set of

Table III. *Rainfall and soil temperature preceding the initiation of runner shoot infection by* Phytophthora palmivora *in black pepper*

Year	Date of onset of monsoon	Rainfall (mm)			Soil temperature at 5 cm depth		Date of disease intiation
		Total until disease initiation	Average/ day	Days with 10mm and above	Min.	Max.	
1984	29th May	317.8	21.8	7	NR	NR	12th June
1985	23rd May	259.5	17.3	13	24.27	27.5	6th June
1986	28th May	248.8	10.99	9	27.7	29.8	18th June

NR = Not recorded

conditions to another. This probably explains the variation in the correlation coefficients of individual factors from year to year. However, during the year 1986 when the amount of the disease was the lowest, many of the factors bear significantly high correlation, the maximum being shown by the rainy days, sunshine hours and the rainfall. This shows that the role of meteorological factors is well correlated at the lower level of disease. Based on multiple regression analysis, it was found that all above factors were found to have fairly high R^2 values (0.855; 0.768 and 0.884 for the years 1984, 1985 and 1986 respectively), thus accounting for more than 76% of the variability in infection observed.

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Table IV. *Rainfall distribution and death of pepper vines due to infection by* Phytophthora palmivora

Year	Rainfall (June to September)						Death of vines (%)
	Total (mm)	No. of rainy days*	No. of days with 10 mm and above				
			June	July	August	September	
1984	1833	90	19	17	10	2	10.0
1985	1837	95	27	17	15	3	12.0
1986	1829	82	18	10	10	8	2.1

* irrespective of quantity of rainfall received

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