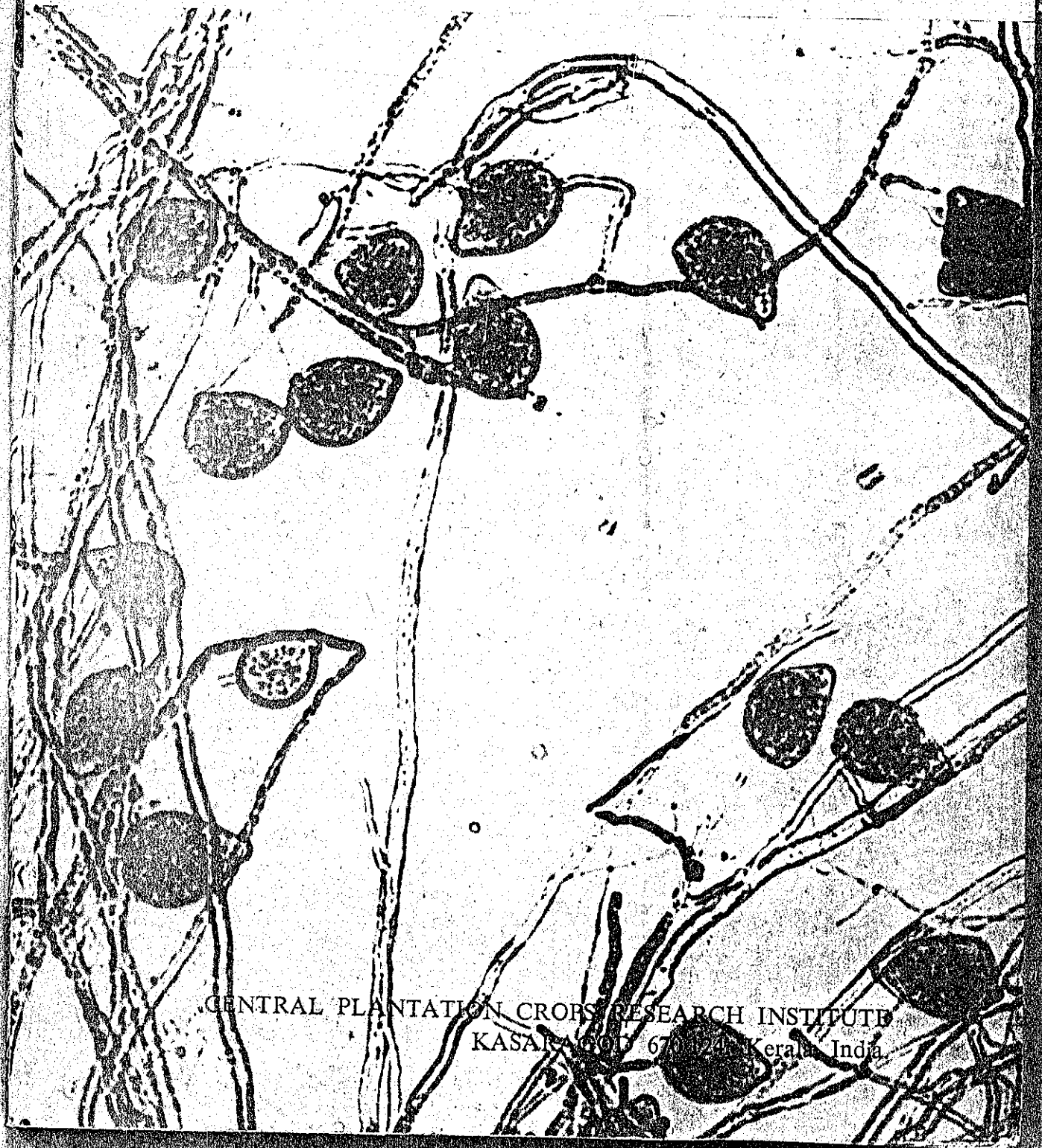
Work shop on

phytophthora diseases

OF TROPICAL CULTIVATED PLANTS



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SOME ASPECTS OF EPIDEMIOLOGY OF FOOT ROT OF BLACK PEPPER

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ABSTRACT

Foot rot caused by *Phytophthora palmivora* is the most important disease of black pepper, *Piper nigrum*, and causes severe losses to the crop in many countries were pepper is grown. Studies on the disease incidence showed that the disease spread in a centrifugal fashion. The incidence was more in years of heavy rainfall during South West monsoon period. During July the temperature especially soil temperature used to be around 20-24°C for a few days when R. H. also used to be above 90%. The fungus was isolated in greater frequency during July-August mainly from stem, root and soil. The fungus could not be isolated in summer when the soil moisture was less and soil temperature high. The fungus was present at higher intensity at the basal soil and increased with increasing soil moisture. On the vines the fungus could be isolated in higher frequency from soil particles adhering to vines at 25-50 cm height than at higher points.

INTRODUCTION

Among the diseases affecting black pepper, *Piper nigrum* L., foot rot (quick wilt) is by far the most important one inflicting severe losses to pepper gardens in India (Samraj and Jose, 1966, Nambiar and Sarma, 1977), in Indonesia (Muller, 1936), in Sarawak (Robertson, 1955, Holliday and Mowat, 1963) etc. The disease usually occurs during the South West monsoon period (June to September) in India. In Sarawak, maximum disease incidence was observed during October-March, the wettest months of a year (Holliday and Mowat, 1963). Holliday (1961) and Holliday and Mowat (1963) made some preliminary studies on epidemiology of foot rot disease of black pepper. In this paper disease spread in a garden over a period of 6 years, the effect of rainfall, temperature and humidity on disease development and the seasonal effects on fungus are presented.

MATERIALS AND METHODS

The study was carried out in a pepper garden at Bandadka, about 60 km away from Kasaragod, on the Western Ghats. The pepper vines are 25 years old. The cultivar of pepper is locally called "Wynadan Valli" which is very much similar to Balancotta. The disease incidence was judged from the number of vines dead after showing the typical symptoms of the disease.

Air temperature and relative humidity were continuously recorded in a two-point automatic thermohygrograph kept in the garden under a shelter. Soil temperature was

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recorded at 5, 15 and 30 cm depths in the garden. In the absence of any rainfall data available for the garden or in the locality, rainfall measurements made at CPCRI Kasaragod were made use of in this study.

Soil cores were taken at monthly intervals from April onwards and soil moisture content determined. A portion of the soil sample (50 g) was used for determining the presence of fungus using castor seed and leaf disc bait techniques at 24°C. The soil samples were taken at 0, 5, 15 and 30 cm depths at 0 and 50 cm distances. Soil samples were also taken from the surface at 100 and 150 cm distances from the vines.

Soil particles were caught at 25, 50 and 75 cm heights on the undersurface of microscopic slides covered in the centre longitudinally with cellotape strips of 10 mm × 70 mm with the adhering surface facing downwards. The slides were recovered after the rains and examined directly under microscope and the number of soil particles adhering to the entire length of the cellotape strip was counted. Soil particles adhering to the basal portions of five vines of more or less uniform thickness were also collected at 25, 50, 75 and 100 cm heights and using castor baits, the presence of the fungus was assessed.

Results

Spread of the disease : The data on the incidence of the disease observed from 1974 onwards in the pepper garden at Bandadka are presented in Table 5.1 and Fig. 5.1.

Table 5.1. Incidence of foot rot disease of pepper during 1974-79 period in Bandadka (Total No. of vines in the garden is 1060).

Year	Vines killed by foot rot		Rainfall in mm*	
	Number	Percentage	From May-September	Total
Earlier to 1974	368	34.71	—	—
1974	25	2.36	3292 A	3550
1975	12	1.13	3978 B	4332
1976	18	1.69	2708 C	3052
1977	27	2.55	3167 A	3705
1978	51	4.81	4356 A	4656
1979	14	1.34	2899 C	3095

*In the absence of rainfall data at Bandadka, data from Kasaragod are used here.

A. Received good premonsoon showers in May followed by heavy rains in June-July.
B. Comparatively less rainfall in July.
C. Practically no premonsoon rains.

From the data it is seen that in some years (1974, 1977 and 1978) the percentage incidence was more than that in other years. It is also seen from FIG. 1. that the disease spreads in centrifugal fashion from a single infection point. Scattered incidence of disease also is seen from which the disease again spreads outwards.

The maximum disease incidence (4.8%) in 1978 coincides with the highest rainfall received during the year (4656 mm) with 93.5% of rains precipitated during S. W. monsoon period. However, in 1975 recording, the second highest rainfall during the period of study, the disease incidence was only 1.13%. It is observed that during July 1975, the rainfall was comparatively less (950 mm) than in other years (1128-1587 mm). Comparatively no rain was received during summer of 1976 and 1979 and the S.W. monsoon rainfall (2700-2900 mm during May-September) was the lowest in those years.

During July-August months the relative humidity was maximum (mean 87-90%) and ambient temperature ranged between 22.5-28.0°C (Table 5.2). The mean soil temperature ranged between 22-28°C. It was also noticed that the soil temperature ranged between 22-24°C for 6 days in July in 1977, 20-24°C for 8 days in July in 1978 and above 23°C only in 1979. In 1978 July, RH was above 90% for most of the days.

Table 5.2. Rainfall, temperature and relative humidity during different months in a pepper garden at Bandadka during 1977-79 (Mean of 3 years)

	Rainfall		R.H.	Ambient temp.		Soil temp. range A (°C)
	mm	No. of rainy days	%	Max. °C	Min. °C	
January	—	—	71	32.0	21.0	26.5 — 28.5
February	—	—	73	32.0	22.0	28.0 — 30.5
March	6.4	1	74	33.0	23.0	30.5 — 33.0
April	27.4	2	73	33.0	24.0	29.0 — 32.5
May	267.2	12	75	33.0	24.5	28.5 — 33.0
June	1040.3	26	86	33.0	24.0	24.0 — 31.0
July	1335.3	29	90	28.0	22.5	22.0 — 26.0
August	603.7	21	87	28.0	23.0	23.5 — 28.0
September	224.1	12	84	29.0	25.0	24.0 — 27.5
October	135.4	9	81	29.0	24.5	24.5 — 28.5
November	155.1	10	80	32.0	23.5	23.0 — 27.0
December	20.2	2	70	31.0	22.0	23.5 — 28.5

A The soil temperatures at 5 cm, 15 cm and 30 cm depths were recorded in the forenoon generally between 8.30–10.30 am.

Isolation of the Pathogen

The pathogen, *Phytophthora palmivora* was frequently isolated from soil/tissue samples collected from different pepper gardens from June to December during 1972-79. Positive isolation, though at a lower frequency, was obtained also in January—February from

soil in a garden provided with irrigation (Table 5.3). It is also seen from Table 5.4 th from all parts of the vine showing various symptoms of the disease, the fungus could isolated. Majority of the isolation was, however, made from soil, stem and root.

Table 5.3. Frequency of isolation of *P. palmivora* from soil/tissues of black pepper from Infected gardens (1972–79).

Month	No. of samples made from soil/tissues	Positive isolation	Percentage
January	15	1	6.6
February	12	1	8.3
March	10	—	—
April	10	—	—
May	10	—	—
June	29	7	24.1
July	28	14	50.0
August	30	16	53.3
September	22	10	45.4
October	18	7	38.8
November	15	5	33.3
December	15	4	26.6
Total	214	65	30.4

Table 5.4. Different sources from which *P. palmivora* was isolated during 1972-1979 (June–December period)

Locality	Different sources*						
	Root	Stem	Twig	Leaf	Spikes	Soil	Tota
Bandadka	5/10	12/20	2/3	4/8	1/4	11/25	35/72
Kuttikol	2/3	—	—	—	—	1/3	3/6
Malom	1/4	2/4	1/3	1/2	2/15	—	7/28
Mercara	—	1/3	—	—	—	—	1/3
Siddapur	—	1/3	—	—	2/6	—	3/9
Thaliparamba	—	3/7	1/2	1/5	—	—	5/14
Thamarasseri	3/6	3/8	—	—	—	1/3	7/17
Wynad	—	2/8	—	—	—	—	2/8
Total	11/23	24/53	4/10	6/15	5/25	13/31	63/157
Percentage	47.8	45.3	40.0	40.0	20.0	41.9	40.1

*Nominator stands for the number of samples from which isolation of the fungus was positive, and denominator stands for the total number of samples tested.

Inoculum at various distances, depths and heights

The amount of inoculum present in 50 g soil sample at various distances from the vines and at various depths of soil was assessed indirectly by the number of castor seeds

infected on incubation. Samples were drawn during April-July. No fungus could be recovered during April, when the soil moisture at various depths ranged from 3.5 to 10.5%. In May, from the soil sample collected at 5 cm depth from the base of the vine, only 5% of the baits were infected. The soil moisture ranged from 11.6-14.5% at various depths. In June, July and August samples, with moisture percentage ranging from 20.6-28.7, the percentages of positive isolation of the fungus at 0 to 5 cm depths from the base of vine ranged from 10-20.

The data presented in Table 5.5 show that the slides kept at 25 cm heights caught maximum number of particles (58) as against a mean of one particle at 75 cm height. The weight of soil particle also was maximum (0.143 g) on the vines at 25 cm height and gradually reduced as the height increased. The percentages of baits infected were 27.5 and 12.5 at 25 cm and 50 cm heights respectively. No infection occurred in soil particles collected at 75 and 100 cm.

Table 5.5. Isolation of *P. palmivora* from soil particles on the vines at different heights

Height (cm.)	No. of soil particles per slide (Mean of 4 replications)	Weight of soil/vine(g) (Mean of 5 replications)	Isolation of *Phytophthora* (% of baits infected)
25	58	0.143	27.5
50	26	0.139	12.5
75	1	0.062	Nil
100	NR	0.007	Nil

*The soil particles were collected from 5 cm area around the vine, 2.5 cm on either side of the desired height. NR = Not recorded.

Discussion

From the occurrence of the disease, it is observed that the disease spreads from a central point in a centrifugal fashion initially with scattered infections occurring later. From these points again the disease spreads radially. Similar pattern of disease spread was recorded by Harvey (1944) in avocado decline and by Holliday (1961) and Holliday and Mowat (1963) in foot rot disease of pepper. It is also noted that the northern side of the plot (Fig. 5.1) is at the bottom of a hill slope and according to the owner of the garden it was here that the disease outbreak occurred first. Incidentally a foot path passes through the plot where higher concentration of the dead vines exists. Holliday and Mowat (1963) also recorded similar results in Sarawak. Perhaps the labourers moving along the path for various operations in the garden or cattle grazing in the garden might be aiding in the spread of the disease in addition to other natural means of spread.

The pathogen could be isolated in greater frequency from soil, root and stem. The fungus was either undetectable or at its lowest level in summer months when soil moisture was very low and soil temperature high (28.5-32.5°C). The fungus population increased

during rainy months, as judged from the higher frequency of isolation. Holliday and Mowat (1963) reported that during the wettest months of October-March, the incidence of foot rot was more and isolation was more frequent during those months. Marks *et al.* (1975) working on dieback of Jarrah (*Eucalyptus marginata*) caused by *P. cinnamomi* found that low soil temperature limited the fungal population in winter months and when soil temperatures were favourable during summer months, population levels were dependent on soil moisture, increasing with increasing soil moisture. Ecological factors like temperature and soil moisture were found to be limiting factors in the development of disease caused by *P. cinnamomi* (Hine *et al.*, 1964; Chee and Newhook, 1965), *P. palmivora* on cacao (Lellis, 1952, Tarjot, 1972, Dakwa, 1974) and *P. parasitica* var. *piperina* in betelvine (Venkata Rao *et al.*, 1969; Selvaraj *et al.*, 1973). Holliday and Mowat (1963) and Dawka (1974) also found that the incidence of foot rot or black pod respectively occurred more during wettest months and in areas of heavy rainfall. The data presented in Tables 5.1 and 5.2 are in conformity with the above findings. During July-August, the soil temperature dropped to 20-24°C with high relative humidity (>90%) in most of the days. The intensity of premonsoon showers also seems to play an important role in deciding the disease incidence. In years of heavy premonsoon and monsoon showers, with high R. H. and low soil temperature in July-August, the disease occurred in higher intensity.

The general trend was that during wettest months of a year, the fungus could be isolated in higher frequency, and the percentage of successful isolation reduced gradually towards November-December. During summer months, the isolation made was either negligible or nil. Kliejunas and Nagata (1979) reported that population of *P. cinnamomi* was the lowest in winter months when minimum soil temperature was10°C and increased as soil temperature increased till October up to about 20°C. From an irrigated arecanut garden having pepper as a mixed crop, we isolated the fungus during January-February also, though the percentage of isolation was very meagre. In irrigated arecanut garden, high soil moisture was prevalent and the minimum temperature used to be around 20°C (Nambiar and Sarma 1977). In such gardens root rot symptoms occurred generally, rather than collar rot symptoms (Nambiar and Sarma, 1977).

The fungus could be isolated in higher frequency from soil, basal stem or root. In the case of soil samples, the fungus was present more at the base of the vines than at farther points. Medeiros (1977) found in black pod of cacao that the highest concentration of *P. palmivora* propagules occurred at 20 cm from cacao trunk than at 40 cm or 60 cm distances. At the same site the amount of propagule at 10-12 cm depths was about one-third of the soil surface. In our studies we found that the soil moisture was the highest at 5 cm depths where the infection of baits was also higher. Similar findings have been reported by Flowers and Hendrix (1972) and Gray and Hine (1975) working on *P. parasitica var. nicotianae* on tobacco and *P. megasperma* on alfalfa respectively.

Studies on fungal isolation from soil particles sticking on to the vines at different heights above ground indicated that the infection of the bush at the lower region might be due to inoculum carried through rain splash, as suggested by Muller (1936), and Holliday and Mowat (1963). Spread of *Phytophthora* spp. by rain splash was also reported by Pereis (1956) in rubber and Newhall *et al.* (1966) and Okaisabor (1971) in cacao. It is

also possible that the soil particles are deposited by termites. Sarma (unpublished) could get isolation of *P. palmivora* from the soil deposited by termites or ants on standards having disease-affected vines. Turner (1972) could isolate *P. pamivora* from soil deposited on standard by *Crematogaster* ants.

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DISCUSSIONS

P. H. Tsao : The slide showing effect of height on splashing of soil pathogen is very interesting and this type of work is needed for various crops, because the inoculum at different heights play an important role in infection of aerial parts.

R. S. Mehrothra : What do you mean by soil particles?

Answer : Soil fractions of minute size deposited on the slide as a result of splash.