Indian Phytopath. 43 (3): 414-419, (1990)

VERTICAL PROGRESSION AND SPREAD OF PHYTOPHTHORA LEAF INFECTION IN BLACK PEPPER IN ARECA-BLACK PEPPER MIXED CROPPING SYSTEM

N. RAMACHANDRAN, Y. R. SARMA AND M. ANANDARAJ

National Research Centre for Spices, Calicut 673 012

Abstract : Vertical progression and lateral spread of foliar infections caused by '*Phytophthora palmivora*' MF_4 in black pepper, *Piper nigrum* L., *vis-a-vis* the role of rain splash were studied in a pepper garden mix-cropped with arecanut (*Areca catechu* L.). Infections first appeared on the tender leaves and terminal portions of runner shoots creeping on the ground indicating that soil was the primary source of inoculum. The infection gradually spreads upwards in a step-wise manner and also across the adjacent vines. In a few vines, the infection was recorded even at heights over 9 m. The splash water collected at 1,2 and 3 m away from the infected vines and at heights of 0, 0.5 and 1 m contained '*P. palmivora*' MF_4 (*P. capsici*). This confirmed the spread of the pathogen through rain splashes.

Keywords : '*Phytophthora palmivora*' MF_4 (*P. capsici*), Black pepper, Mixed cropping, Progression and spread

Phytophthora is a major threat to black pepper in all pepper growing tracts of the world. In India, black pepper is grown as a pure crop trained on live standards or supports like *Erythrine indica* and also as a mixed crop in coconut, arecanut, coffee and cardamom plantations. In Uttara Kannada and Dakshina Kannada districts of Karnataka and some parts of Kerala, arecanut-black pepper mixed cropping is very popular (Sannamarappa and Muralidharan, 1982). Foot rot caused by '*P. palmivora*' MF_4 (morphological form 4) is most serious in all pepper plantations.

Foliar infections are noticed wherever microclimatic condition is favourable for aerial infection and these earliest visible symptoms are severe in arecanut-pepper mixed cropping system. Foot rot results in complete death of the vine, whereas foliar infection (leaf spots) spreads rapidly and results in heavy defoliation and may cause complete destruction of the vine. Arecanut palms require regular irrigation from November/December onwards till the onset of South-West monsoon. In such gardens, presence of soil moisture during this period ensures better survival of *Phytophthora* propagules.

'*P. palmivora*' MF_4 spreads through soil and surface water (Sarma and Nambiar, 1982), rainsplash (Nambiar and Sarma, 1982; Anon, 1983), and through biological agents like snails (Turner, 1967) and insects (Turner, 1972; Sarma *et al.*, 1981). In Sarawak, the foliar infections appear only on lower leaves, usually within a few centimetres from the surface of the mound (Holliday and Mowat, 1963). But according to Turner (1969), foliar infections do not occur at the base of the vines up to a height of 0.5 m. The present investigation was carried out to understand the initial occurrence of foliar infection and its course of spread over the height of the vines vertically and also laterally from plant to

Contribution No. 82 of National Research Centre for Spices, Calicut 673 012

Received for publication October 27, 1987.

plant. Studies were also conducted to know the possibility of rain splash acting as a dispersal medium.

MATERIALS AND METHODS

An arecanut-black pepper mixed crop garden at the Central Plantation Crops Research Institute Research Centre, Kannara (Trichur District, Kerala), where a severe incidence of foliar infection was noticed during 1983, was selected. The pepper vines were predominantly of Panniyur-1, a hybrid susceptible to '*P. palmivora*' MF_4. The vines were trained on arecanut palms planted at spacings ranging from 1.83 × 3.66 m to 3.66 × 3.66 m. The soil was alluvial and supported luxuriant growth of the vines some of which attained a height of over 9 m. The dense canopy in the cropping system provided microclimatic conditions that favoured *Phytophthora* infections on aerial parts of the vines. Except for a circular area of about 75 cm radius around the base of the palms where the soil was exposed, the garden had an undergrowth of grass and weeds. Two blocks of black pepper having 120 and 40 vines respectively were kept unsprayed with any fungicide. The disease incidence was recorded during May–September in 1984 and 1985.

Vertical progression : The upward spread of foliar infection over the canopies of the vines was measured in terms of length of the infected portions of the vines. A minimum of 25 vines were selected for the study based on the presence of runner shoot infection at the beginning of the season. As the infections spread further upwards with the progress of monsoon, the heights were recorded at weekly intervals and the observations were continued until further spread was not noticed. The mean infection height was calculated as the average for all the vines (Fig. 1). Towards the end of the season, vertical progression in all the 160 vines was recorded.

Lateral spread : The spread of the disease was recorded by marking the relative positions of the vines infected in the layout map of the experimental garden having 120 vines. The incidence was recorded at weekly intervals.

Role of rainsplash in the disease spread : A modified version (Rajasab *et al.*, 1979) of the uni-directional splash trap developed by Waller was used for collection of rain splashes. Glass bottles (500 ml) were used to mount the traps made of galvanized iron sheets. One set of splash traps was installed at 1,2 and 3 m away from an infected vine and another at 0, 0.5 and 1 m heights from ground level near the vines where the infection was just noticed on the runner shoots. Wooden supports were used to fix the traps at different heights. The samples of water collected in the bottles were removed after one, two or three days of exposure depending on the amount of rainfall. The quantities of water were measured and from each sample thirty ml of rain water was transferred to 9 cm dia Petri plates and baited with ten 1 cm dia discs of black pepper leaves. The leaves used for baits were collected from an uninfected garden and were thoroughly washed before use. After three days, the infected baits were surface sterilized and plated on a selective medium (Tsao and Guy, 1977). The number of baits positive for '*P. palmivora*' MF_4 isolation were recorded and were further confirmed by observing sporangia. The experiment was repeated seven times from 17 July to 4 August 1984.

RESULTS AND DISCUSSION

The infection started as dark brownish lesions first on the runner shoots (Fig. 2.2) that were in direct contact with the infested soil, which served as the primary source of inoculum. The infected shoots and leaves supported profuse growth and sporulation of the fungus. This contributed to the further spread of the disease to the upper regions of the vines aided by rain splashes. Positive baiting to pepper leaf discs in splash water collected at heights up to 1 m lends support to this. Production of high amounts of inoculum is evident from the multiple lesions on the leaves (Fig. 2.3), where the lesions develop very fast under favourable weather conditions. This results in complete defoliation and destruction of the vines in most cases. Since black pepper puts forth new flushes during May/June coinciding with the onset of the monsoon, the tender leaves and terminal shoots interspersing the thick foliage of the vines serve as an ideal continuum of suscept tissue over the entire height of the vine. This promotes the stepwise progression of the disease and increases the 'ladder effect' as reported in the case of black pod disease of cocoa (Newhook, 1982).

Holliday and Mowat (1963) reported foliar infection to occur only on the lower portions of the vines and they implicated rain splashes as probable medium of spread. But according to Turner (1969), the lower portions of the vines remained free from infection up to a height of 0.5 m and the pathogen moved aerially up to a height of 3.3 m. Our studies have shown that the initial infections invariably started from the creeping runner shoots and soil acted as the main source of inoculum. The infections were seen to progress over the entire height of the vines and in some vines the infections were

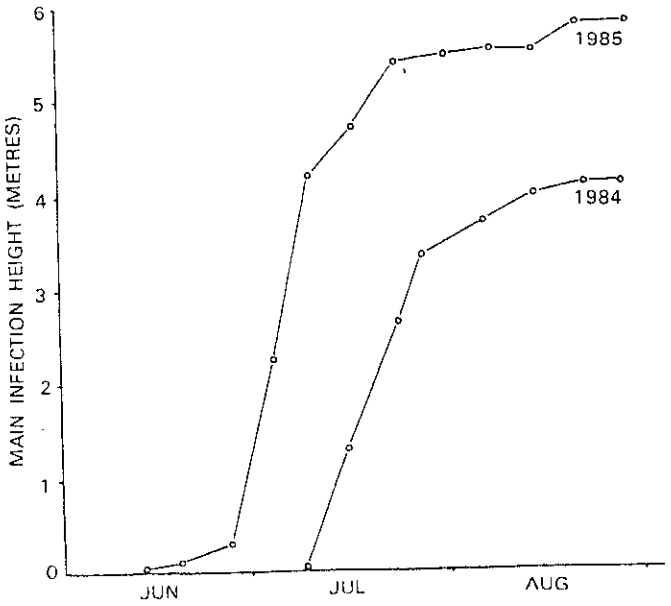

Fig. 1 : Vertical spread of foliar infection caused by *P. palmivora* MF4 in black pepper.

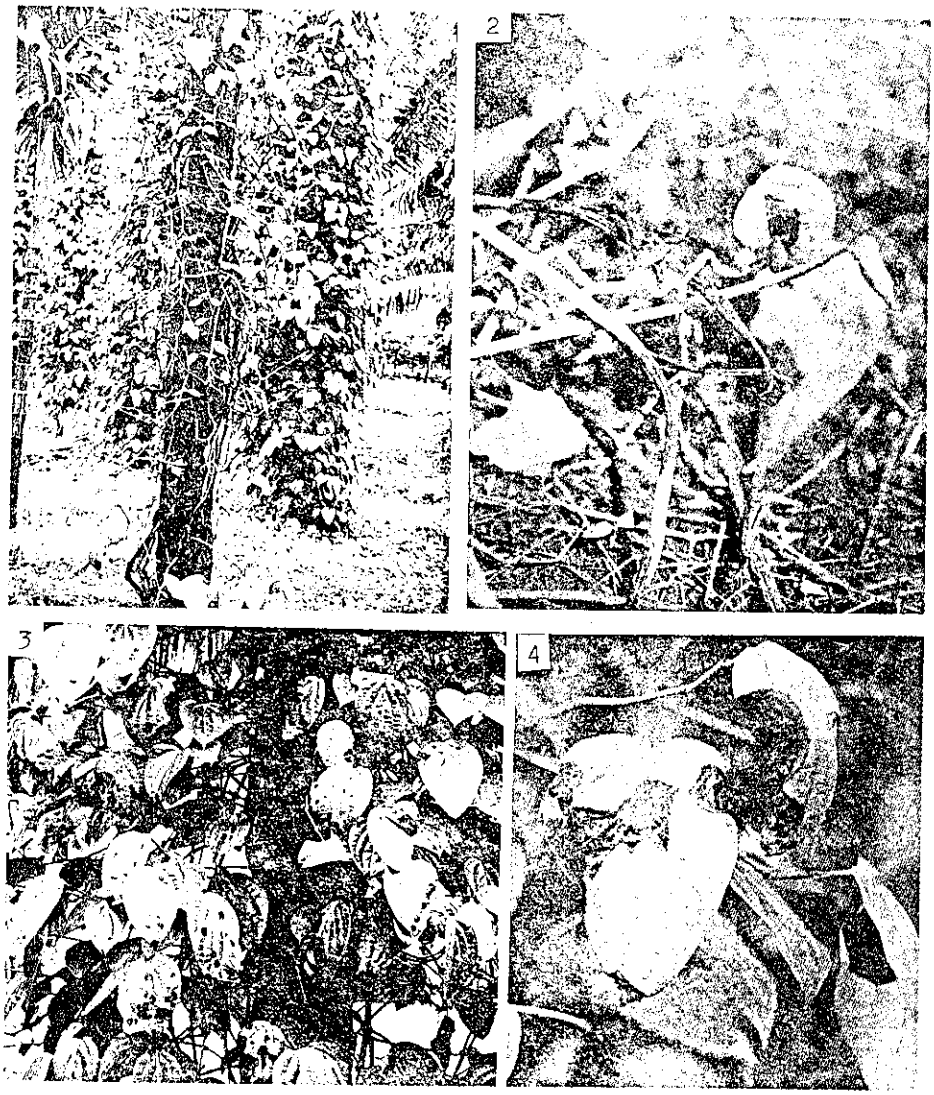

Fig. 2 : Different stages of foliar infection in black pepper caused by *P. palmivora* MF4
2.1 : Defoliated vine with uninfected vines in the background; 2.2 : Infected tender leaves and stems of runner shoots; 2.3 : Multiple lesions on leaves; 2.4 : Close-up view of infected tender leaves.

noticed above nine metres. In 9.3 per cent of the vines, the infection had spread over the entire height whereas in 10.6 and 13.1 per cent of vines, the infection was found to spread up to 3/4 and 1/2 of the height of vines. The mean height of the vines in the garden was 6.12 m. Maximum increase in the infection heights was noticed in July, both in 1984 and 1985 (Fig. 1). The spread decreased towards the end of the monsoon. As the disease progressed, lateral spread was noticed and in such cases the infection was initially confined to the sides of the vines facing the source of inoculum. The leaves on the sides opposite to the source of spread were also infected later. This agrees with the observations of Turner (1969).

TABLE 1 : Percentage of bait infection in the water collected in splash traps kept at three different heights (m) and three distances (m)

Dates	Rainfall (mm)	Percentage of bait infection					
		Distance (m)			Height (m)		
		1	2	3	0	0.5	1
17.7.1984	30.5[1]	10(56)	30(93)	0(60)	10(70)	—	—
19.7.1984	80.5[2]	100(294)	0(272)	0(305)	100(275)	60(254)	0(244)
21.7.1984	94.6[2]	100(263)	0(235)	—	100(329)	0(305)	40(158)
24.7.1984	15.5[2]	90(66)	20(70)	20(48)	40(161)	30(104)	20(53)
30.7.1984	47.5[2]	50(151)	10(285)	0(212)	50(266)	10(176)	30(228)
1.8.1984	27.9[2]	0(43)	20(74)	60(114)	50(90)	10(75)	0(61)
4.8.1984	31.4[3]	0(70)	0(55)	0(46)	20(190)	0(50)	0(34)

Figures in parentheses are the amounts of water collected in splash traps in ml.
Figures superscripted with 1, 2 and 3 show the total rainfall during one, two and three days respectively.
— = Samples not collected.

The rain splashes collected from the three locations and three heights contained '*P. palmivora* MF4 but concentration was higher at 1 m distance and at ground level (50 and 52.8 per cent of bait infection respectively). From samples collected at 2 and 3 m distances, and 0.5 and 1 m heights, the percentages of baits infected were low (11.4, 13.3, 18.3 and 15.0 per cent respectively) (Table 1). This suggests that rain splashes effectively dispersed the inoculum and mainly contributed to the spread of the infection both vertically and laterally. Rainfall combined with wind may spread the inoculum still farther because in cocoa, *Phytophthora palmivora* and *P. megakarya* were found to be dispersed through rain splashes even to a distance of 12 m (Maddison and Griffin, 1981). Though some biological agents could act as carriers (Turner, 1967; Sarma *et al.*, 1981), their role in the overall spread of the disease within the garden may be negligible in view of the rapid spread as evidenced by multiple infections on leaves (Fig. 2.3).

The present epidemiological observations established the major role of the splash-borne dispersal of inoculum and the runner shoots are the first to contact the disease. The early detection of runner shoot infection in a garden serves as an indication of the disease potential and pruning of runner shoots during May–June, the disease initiation phase, might result in possible reduction of disease incidence and spread.

REFERENCES

Anonymous. (1983). Quick wilt and slow wilt diseases of pepper—Epidemiological studies. p. 168, Annual Report 1981, Central Plantation Crops Research Institute, Kasaragod, Kerala, 279 pp.

Holliday, P. and Mowat, W. P. (1963). *Foot rot of Piper nigrum L. (Phytophthora palmivora).* Phytopathological Paper No. 5, Commonwealth Mycological Institute, Kew, Surrey, London, 69 pp.

Maddison, A. C. and Griffin, M. J. (1971). Detection and movement of inoculum. In *Epidemiology of Phytophthora on Cocoa in Nigeria* (Gregory, P. H. and Maddison, A. C., Eds.), pp 31-49, Phytopathological Paper No. 25, Commonwealth Mycological Institute, Kew, Surrey, London, 188 pp.

Nambiar, K. K. N. and Sarma, Y. R. (1982). Some aspects of epidemiology of foot rot of black pepper. In *Phytophthora Diseases of Tropical Cultivated Plants* (Nambiar, K. K. N., Ed.), pp 225–235, Central Plantation Crops Research Institute, Kasaragod, Kerala (India), 284 pp.

Newhook, F. J. (1982). Epidemiology in the genus *Phytophthora*. In *Phytophthora Diseases of Tropical Cultivated Plants* (Nambiar, K. K. N., Ed.), pp 83-89, Central Plantation Crops Research Institute, Kasaragod, Kerala (India), 284 pp.

Rajasab, A. R., Shenoi, M. M. and Ramalingam, A. (1979). Epidemiology of sorghum downy mildew III—Dispersal of inoculum by air and water. *Kavaka* **7** : 63-67.

Sannamarappa, M. and Muralidharan, A. (1982). Multiple cropping. In *The Areca Palm* (Bavappa, K. V. A., Eds.), pp 133-149, Monograph series No. 2, Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala (India), 340 pp.

Sarma, Y. R., Ramachandran, N. and Nambiar, K. K. N. (1981). Sources of inoculum of *Phytophthora palmivora* of black pepper (*Piper nigrum* L.) in disease spread and the importance of morphology of the fungus (Abstr.). Third International Symposium on Plant Pathology, New Delhi, 14-18 December 1981, Indian Phytopathological Society, IARI, New Delhi (India), 127 pp.

Sarma, Y. R. and Nambiar, K. K. N. (1982). Foot rot disease of black pepper (*Piper nigrum* L.). In *Phytophthora Diseases of Tropical Cultivated Plants* (Nambiar, K. K. N., Ed.), pp 209-224, Central Plantation Crops Research Institute, Kasaragod 670 124, Kerala (India), 284 pp.

Tsao, P. H. and Guy, S. O. (1977). Inhibition of *Mortierella* and *Pythium* in a *Phytophthora* isolation medium containing hymexazol. *Phytopathology* **67** : 796-801.

Turner, G. J. (1967). Snail transmission of species of *Phytophthora* with special reference to foot rot of *Piper nigrum* L. *Trans. Brit. mycol. Soc.* **50** : 251-258.

Turner, G. J. (1969). Leaf lesions associated with foot rot of *Piper nigrum* and *P. betle* caused by *Phytophthora palmivora*. *Trans. Brit. mycol. Soc.* **53** : 407-415.

Turner, G. J. (1972). Isolations of *Phytophthora palmivora* from ant runs on *Piper nignum*. *Trans. Brit. mycol. Soc.* **59** : 317-319.