Phytophthora root rot of black pepper in relation to age of the host and its culmination in foot rot*

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Among the various diseases of black pepper (*Piper nigrum* L.), the foot rot caused by *Phytophthora* is very serious in all the black pepper growing areas (3, 9, 8). To investigate the presence of juvenile resistance/tolerance, if any, an experiment was conducted in micro plots under simulated field conditions.

Black pepper vines of the variety Panniyur-l were raised in micro plots. Each micro plot consisted of 1 m^3 cement tub filled with nursery mixture (forest soil : sand : FYM, 3 : 1 : 1) which was buried in the soil upto the brim, with the drain holes pointing towards the channel dug on either side of the tubs. Plants were raised in batches of twenty for five consecutive years and allowed to trail on teak poles. Thus, at the end of sixth year, one hundred plants of five age groups viz., 1-5 years were available for the study.

Black pepper vines were artificially inoculated using sporulating culture discs of *Phytophthora capsici*. The fungus was grown on carrot agar for 72 h and 1 cm diam. mycelial discs were cut and incubated under light with a thin film of water around the discs. After 48 h incubation, these sporulating discs were used for inoculation. For each batch, there were four treatments each with four vines. The four treatments were : (i) 8 discs/plant, (ii) 16 discs/plant, (iii)24 discs/plant, and (iv) uninoculated control. The inoculum was placed around the collar portion of vines after removing a small quantity of soil and replacing the soil back. All the tubs were given copious irrigation. Observations were recorded on the physical condition of the vines at fortnightly intervals right from the start of the experiment. The soil population of *Phytophthora capsici* was monitored by estimating the disease potential index (10, 11) using the baiting technique (2).

The inoculated vines remained healthy upto four months and later, irrespective of the inoculum load, inoculated vines showed gradual declining symptoms such as yellowing, wilting, drying up of some branches and defoliation. The vines showing one or a combination of symptoms were considered diseased and were monitored regularly. Some of the vines showing severe defoliation started sprouting during the next monsoon season (June-September) and others succumbed. The collar infection noticed were of the following three types where the root infection culminated in collar rot (Fig. 1a, b, c). In black pepper, roots arise from the nodes of the underground stem in 3-4 tiers : (i) if the infection has spread from root system of the tier closer to the soil

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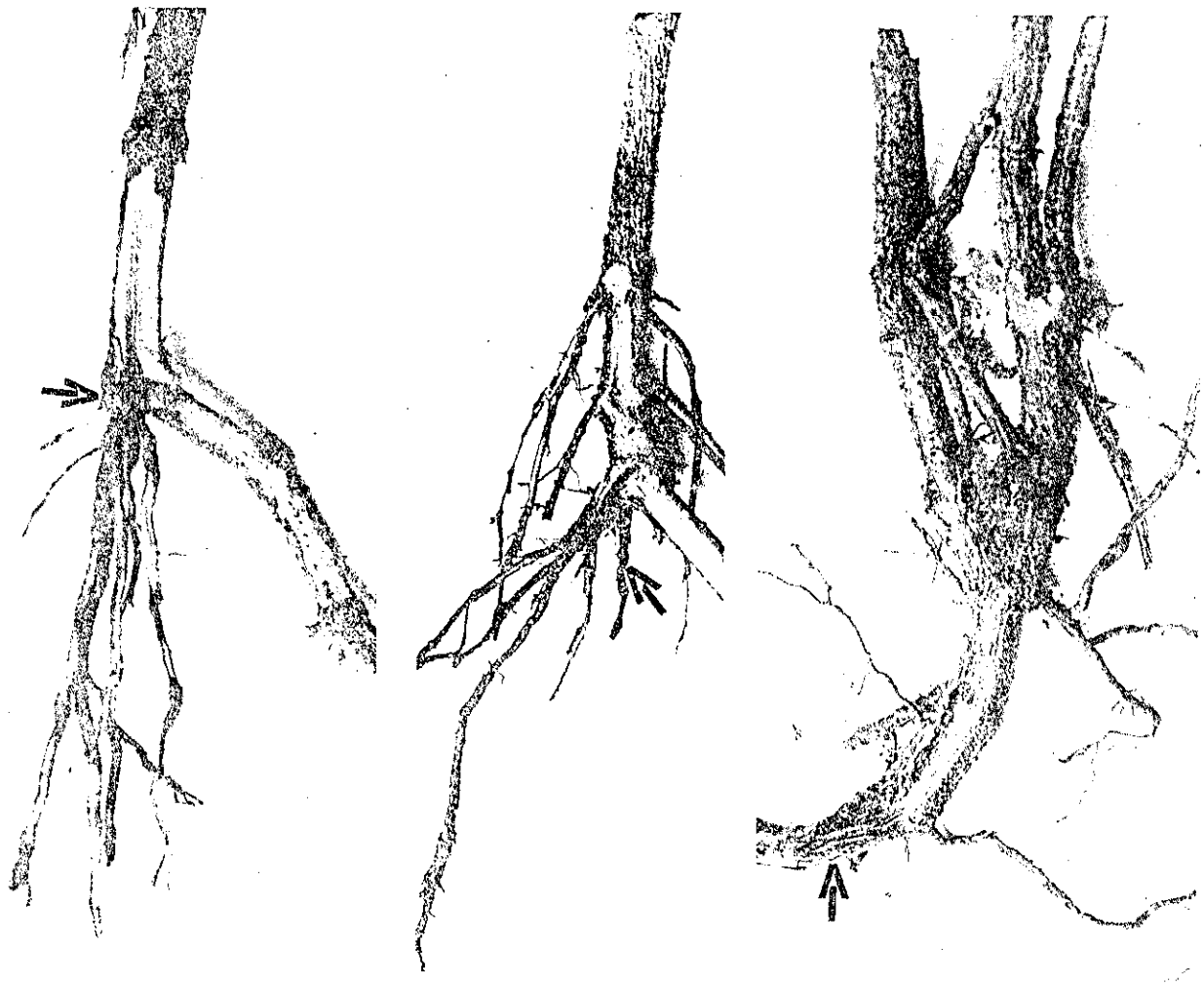

Fig. 1 : Foot rot of black pepper as a result of root infection. Arrows indicate the cite of infection of collar : (a) infection spreading from roots of upper tier to collar; (b) infection of middle tier of roots leading to collar rot; and (c) infection of lower portion of collar through roots of lower tier.

(Fig. 1a), the vines showed sudden wilting and collapse often without yellowing. (ii) if the infection reached the main stem through the roots of the lower tier, the vines showed declining symptoms and yellowing was more pronounced (Fig. 1b); (iii) in some other cases, if the infection has reached only a branch of the underground main stem, it resulted in partial death of the vine (Fig. 1c). In all cases the root infection ultimately culminated into foot rot leading to the death of the vine. Mortality of vines at different periods after inoculation is given in Table 1. The different levels of inoculum neither showed any significant difference in reaction nor the DPI varied much (Table 2).

Black pepper is grown as pure crop or as a mixed crop in coconut and arecanut plantations. *Phytophthora* foot rot occurs in India mostly during the monsoon period (June-September). The fungus is soil borne and infects all parts of the plant. The aerial phase of the disease is well

Table 1 : Death of vines at different periods after inoculation

Age	Per cent vines dead						
	Months after inoculation						
	6	9	12	15	18	21	24
5 years	0.0	0.0	0.0	16.6	25.0	25.0	41.6
4 years	0.0	8.3	8.3	8.3	41.6	41.6	66.6
3 years	0.0	0.0	0.0	0.0	50.0	50.0	66.6
2 years	0.0	0.0	0.0	0.0	8.3	8.3	25.0
1 year	0.0	8.3	16.6	25.0	33.3	33.3	41.6

Table 2 : Disease potential index (DPI) of soils in different age groups of black pepper vines

	Disease potential index																			
	Age group and level of inoculum																			
	5 years				4 years				3 years				2 years				1 years			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
1 month after inoculation	0	4	16	16	0	32	64	64	0	4	32	32	0	2	2	4	0	1	1	1
1-year after inoculation	0	2	2	2	0	4	32	32	0	2	2	2	0	1	1	1	0	1	1	1
At the end of the experiment after 2 years	0	2	2	2	0	4	32	2	0	2	2	2	0	2	2	2	0	1	1	1

T_0 = No inoculum (control); T_1 = 8 discs/plant; T_2 = 16 discs/plant; T_3 = 24 discs/plant.

understood in India than the soil phase (1, 5, 6). New flushing and feeder root regeneration also coincides with this period (data unpublished). The effect of feeder root damage is seen only when the declining symptoms appear after the cessation of rains. After the monsoon, when the availability of free soil water decreases, fresh root infection also decrease, whereas the plant continues to produce newer roots with the available soil moisture to sustain the plant. The ratio of root rot to root regeneration determines the health of the vines. Being a vegetatively propagated crop the plant survives as long as the main stem is intact, and new roots arise. Once the infection reaches the main stem, the entire vine succumbs to infection.

Declining symptoms such as foliar yellowing and defoliation are the symptoms of slow decline associated with plant parasitic nematodes viz., *Radopholus similis* and *Meloidogyne incognita* (4). Black pepper vines showing such symptoms in this experiment were found to be free from nematode infestation. This further indicated the potential of *P. capsici* in causing feeder root damage resulting in slow decline symptoms.

When the experiment was concluded two years after inoculation, the surviving vines were uprooted to study the health of the root system. The vines which showed declining symptoms had lost the entire feeder root system. Even if most of the feeder roots were damaged, the vines

did not show any external symptoms. This might be due to the availability of soil moisture through out, which sustained the plant. The occurrence of foot rot was considered to be severe in older plantations than the younger ones (7). In this experiment, vines of all the five age groups (1-5 years studied) showed susceptible reaction. In field condition, the disease prevalence was more in plantations which were more than five years old. This might be due to the inoculum build up prior to causing sufficient damage or that the symptoms were not expressed till a considerable portion of the roots was damaged. Root rot affected vines were not killed in the same year because the feeder root damage lead to declining symptoms. Thus, it explains why the incidence of foot rot is noticed more frequently in older plantation than younger ones.

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