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Suppressive Effects of VAM on Root Damage Caused by *Phytophthora capsici, Radopholus similis* and *Meloidogyne incognita* in Black Pepper

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ABSTRACT

Black pepper (*Piper nigram* L.), a native of Western Ghats of Kerala, is cultivated for its berries which form an important spice. In its natural haibtat the vines are free from disease. However, under intensive cultivation both as pure and mixed crop in coconut and arecanut plantations it is affected by *Phytophthora capsici, Radopholus similis* and *Meloidogyne incognita* either separately or in combination resulting in slow decline due to loss of feeder roots. When *P. capsici* infects the main stem it results in death of the affected vine. The suppressive effect of VAM, *Glomus fasciculatum* on these three pathogens was studied in a pot culture experiment. VAM inoculated plants showed enhanced growth and dry matter production as compared to uninoculated ones, irrespective of subsequent inoculation with pathogens. The extent of root damage and foliar yellowing was less in VAM inoculated plants. Thus, prior inoculation of black pepper with VAM provided better protection of the root system against the challenge posed by the three pathogens.

INTRODUCTION

Among the diseases of black pepper, foot rot caused by *Phytophtora capsici* and slow decline caused by *P. capsici, Radopholus similis* and *Meloidogyne incognita* are considered as serious problems (Sarma et al., 1991; Anandaraj et al., 1991). Being soil-borne, these organisms are amenable for control by biological agents. Root-knot nematode, *M. incognita* was reported to be supporessed by four VAM fungi (Anandaraj et al., 1990). The suppressive effects of *Glomus fasciculatum* on the root damage caused by *P. capsici, R. similis* and *M. incognita* were studied in a pot culture experiment.

MATERIALS AND METHODS

Experimental details

The design of the experiment was split plot with VAM inoculation and uninoculated control as two main plot treatments. There were seven sub-plot treatments as follows:

1. Control
2. *Phytophthora capsici* (Pc)
3. *Radopholus similis* (Rs)
4. Pc + Rs
5. Rs + *Meloidogyne incognita* (Mi)
6. Pc + Rs + Mi
7. Pc + Mi

Preparation of black pepper cuttings

Single node rooted black pepper cuttings of cv. Karimunda were raised in fumigated soil mixture (soil:sand:farm yeard manure 3:1:1 and fumigated with 4% formalin). These cuttings were planted in 30 cm diameter earthern pots filled with fumigated soil.

Preparation of VAM inoculum

Glomus fasciculatum was cultured on *Chloris guyana* grown in pots containing perlite and soil (1:1). When the plants were 8-week-old, the shoots were removed. After a week the roots were removed, cut into 1 cm bits and mixed thoroughly with the soil + perlite potting medium (1:1). One hundred cubic centimeter of this medium was used as inoculum in each pot.

Inoculation of pathogens

Phytophthora capsici was inoculated on black pepper leaves and after infection the leaves were cut into bits and mixed with autoclaved soil in the proportion of 1:9. This infested soil was used as inoculum @ 100 cm^3 per pot. *Radopholus similis* was cultured on sterilised carrot discs and 100 nematodes were added to each pot. Freshly hatched second stage juveniles of *M. incognita* from the egg masses collected from black pepper roots were inoculated @ 200 nematodes/pot as per the treatment. The vines were inoculated with pathogens one month after inoculation of VAM. Growth of vines and expression of symptoms were recorded at regular intervals. The foliar yellowing was scored in a scale of 0-3, where 0 = no yellowing, 1 = up to 25% of leaves showing yellowing. Root rot index was scored in the same way adopting a scale of 0-3. After eight months the experiment was terminated, plants were uprooted, observations on fresh and dry weight of shoots and roots, foliar yellowing and root rot were recorded.

RESULTS AND DISCUSSION

There was rapid growth of VAM treated vines, irrespective of presence of pathogens. At the end of the experiment, VAM treated vines were found to be significantly taller and healthier than the plants which were not treated with VAM, the mean height being 262.93 cm as against 133.75 in non-VAM plants (Table 1). The mean dry weight of shoot and root was also higher in VAM treated vines (Table 2). Among the sub-plot treatments under VAM, wherever *R. similis* was inoculated either alone or in combination with *P. capsici* the dry weight was lower. This suggests that there is no apparent protection against *R. similis* in VAM inoculated plants, but the protection offered is because of the enhanced production of roots. In treatment with *P. capsici*, the dry weight of shoot is next to control where no VAM was added. In non-VAM, the lowest weight was recorded with treatment of *P. capsici*. In VAM treated plot the mean yellowing index was 0.14 as against 1.25 in non-VAM plot (Table 3). Root rot was 2.37 in non-VAM as against 1.39 in VAM plot. Foliar yellowing was seen only in plots treated with *R. similis* or where all the pathogens were present followed by *P. capsici* combinations. Maximum root rot index in VAM plot was noticed in plants inoculated with *R. similis* either alone or in combination with other pathogens. This suggests that there is apparently no suppression of *R. similis* infestation. Mycorrhizal inoculations have been reported to cause both positive and negative effects on the reaction of hosts to *Phytophthora* infection, depending on the density of pathogens (Davis et al., 1978; Davis and Menge, 1981).

Table 1. Effect of VAM on the height (cm) of black pepper (M x S Table of Means - Average of four replications)

Sub-plot	VAM	NON-VAM	S-MEAN	DIFF
Con	348.50 b*	172.25 a	260.38	176.26
Pc	420.50 b	91.75 g	256.13	328.75
Rs	296.00 c	150.75 b	223.38	145.25
PcRs	190.50 e	144.00 c	167.25	46.50
RsMi	223.00 d	112.75 f	167.88	110.25
PcRsMi	176.25 g	131.50 e	153.88	44.75
PcMi	185.75 f	133.25 d	159.50	52.50
Mean	262.93	133.75	198.34	129.18

* In a column, means followed by a common letter are not significantly different at 5% level in DMRT.

M = Main Plot; S = Sub-plot; Con = Control; Pc = *Phytophthora capsici*; Rs = *Radopholus similis*; Mi = *Meloidogyne incognita*.

Table 2. Effect of VAM on dry weight of shoot and root of black pepper (M x S Table of means) (Average of four replications)

Sub-plot	Shoot (g)		Root (g)	
	VAM	Non-VAM	VAM	Non-VAM
Con	78.75 a*	15.00 b	10.25 a	2.15 a
Pc	55.00 b	5.10 g	6.00 c	1.38 d
Rs	26.25 e	15.75 a	2.60 f	1.58 c
PcRs	19.50 g	7.25 f	2.25 g	1.77 b
RsMi	25.00 f	8.00 e	3.00 e	1.13 e
PcRsMi	27.25 d	8.75 d	3.50 d	1.58 c
PcMi	42.50 c	9.75 c	9.75 b	0.08 f
Mean	38.18	9.93	5.34	1.38

* In a column, means followed by a common letter are not significantly different at 5% level in DMRT.

M = Main Plot; S = Sub-plot; Con = Control; Pc = *Phytophthora capsici*; Rs = *Radopholus similis*; Mi = *Meloidogyne incognita*.

Table 3. Effect of VAM on foliar index and root rot index in black pepper (M x S Tables of means) (Average of four Replications)

Sub-plot	Foliar index		Root Rot index	
	VAM	Non-VAM	VAM	Non-VAM
Con	0.00 c*	0.25 f	0.00 f	1.00 e
Pc	0.00 c	1.50 c	0.75 e	3.00 a
Rs	0.25 b	1.00 d	2.25 a	2.00 d
PcRs	0.75 a	0.75 e	1.75 c	2.00 d
RsMi	0.00 c	1.00 d	2.00 b	2.50 c
PcRsMi	0.00 c	2.25 a	2.00 b	3.00 a
PcMi	0.00 c	2.00 b	1.00 b	2.75 b
Mean	0.14	1.25	1.39	2.37

* In a column, means followed by a common letter are not significantly different at 5% level in DMRT.

M = Main Plot; S = Sub-plot; Con = Control; Pc = *Phytophthora capsici*; Rs = *Radopholus similis*; Mi = *Meloidogyne incognita*.

Table 4. Effect of VAM on the population of *M. incognita* in black pepper (M x S of Means) (Average of four replications)

Sub-plot	Soil		Root (1g)	
	VAM	Non-VAM	VAM	Non-VAM
Con	0.0 d*	0.0 d	0.0 c	0.0 d
Pc	0.0 d	0.0 d	0.0 c	0.0 d
Rs	0.0 d	0.0 d	0.0 c	0.0 d
PcRs	0.0 d	0.0 d	0.0 c	0.0 d
RsMi	43.8 a	112.3 a	100.0 a	295.0 a
PcRsMi	17.5 c	24.0 c	90.0 b	65.0 b
PcMi	25.0 b	27.3 b	100.0 a	60.0 c
Mean	12.3	23.4	41.4	60.0

* In a column, means followed by a common letter are not significantly different at 5% level in DMRT.
M = Main Plot; S = Sub-plot; Con = Control; Pc = *Phytophthora capsici*; Rs = *Radopholus similis*; Mi = *Meloidogyne incognita*.

Table 5. Effect of VAM on the population of *R. similis* in Black Pepper (M x S of Means) (Average of four replications)

Subplot	Soil (100 cc)		Root (1g)	
	VAM	Non-VAM	VAM	Non-VAM
Con	0.0 e*	0.0 e	0.0 e	0.0 e
Pc	0.0 e	0.0 e	0.0 e	0.0 e
Rs	30.0 e	49.0 a	175.0 a	250.0 a
PcRs	15.5 c	16.3 d	75.0 c	50.0 c
RsMi	18.8 b	29.3 b	130.0 b	210.0 b
PcRsMi	14.0 d	17.0 c	40.0 d	30.0 d
PcMi	0.0 e	0.0 e	0.0 e	0.0 e
Mean	11.2	15.9	60.0	77.1

* In a column, means followed by a common letter are not significantly different at 5% level in DMRT.
M = Main Plot; S = Sub-plot; Con = Control; Pc = *Phytophthora capsici*; Rs = *Radopholus similis*; Mi = *Meloidogyne incognita*.

VAM activity is also reported to limit nematode infestation and improve plant health (Shenck, 1977; Davis et al., 1978, 1980; Ewald, 1991; Hussey and Roncodri, 1982). In this experiment also the effect of nematode infestation is reduced. The population of *M. incognita* and *R. similis* is lower in VAM inoculated plants both in soil and roots (Tables 4, 5). In case of *P. capsici* and *M. incognita* the site of entry is the tender roots especially the zone of elongation. If these sites are already occupied by VAM the entry of pathogen itself is prevented. Recent studies have also shown that VAM colonization results in altered gene expression of host plants due to the morphological and physiological changes (Garcia-Garrido et al., 1993). Reduction in root rot caused by *P. capsici* could be due to the altered physiology of the host. However, the plants were able to sustain the injuries due to the enhanced production of roots.

Thus, because of VAM colonization of Black pepper roots, it is clearly evident from the results that the plants resist colonization of *P. capsici* and *M. incognita* and overcome the damage by *R. similis* due to increased root mass.

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