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INTERACTION OF VA-MYCORRHIZA WITH *MELOIDOGYNE INCOGNITA* AND *PYTHIUM APHANIDERMATUM* AFFECTING GINGER (*ZINGIBER OFFICINALE* ROSC.)

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ABSTRACT

The growth of ginger plants was significant when inoculated with VA mycorrhizal fungi whereas *M. incognita* and *P. aphanidermatum* inoculations suppressed the plant growth. VA mycorrhizal fungi effectively reduced the nematode population in roots. Plants that received the inoculum of *P. aphanidermatum* were fully diseased within 15 days of the inoculation, whereas those inoculated with nematodes did not die quickly, even though there was general reduction in plant growth and rhizome weight. The inoculation with VA mycorrhizal fungi was found to be the most favourable treatment in relation to plant growth, rhizome yield of ginger as also in suppressing the nematode population.

INTRODUCTION

Soft rot or rhizome rot of ginger incited by *Pythium* spp. is responsible for more than 50 per cent losses in most of the ginger growing areas (Joshi and Sharma, 1982). The crop was also found to be infested with root-knot nematode *Meloidogyne incognita* causing upto 46.4 per cent loss in yield in Kerala (Charles, 1978). Vesicular-arbuscular (VA) mycorrhizal fungi are reported to be useful as biological control agents against root-invading fungi and nematodes (Roncadori and Hussey, 1977; Bagyaraj, Manjunath and Reddy, 1979; Ghai and Thomas, 1986; Grandison and Cooper, 1986; Thomas *et al.*, 1989) apart from their role in increasing plant growth through increased uptake of nutrients and moisture. The present study reports the individual and interactive effects of VA mycorrhizal fungi (*Glomus fasciculatum* and *G. multicaulae*), the root-knot nematode, *M. incognita* and a fungal pathogen *Pthium aphanidermatum* on ginger with emphasis on plant growth, rhizome yield, root-gall severity, disease intensity, mycorrhizal colonization and nematode population dynamics.

MATERIALS AND METHODS

Ginger rhizomes of variety "Maran" harvested in the previous year and stored for 3-4 months in sand lined pits after treating with 0.3 percent Dithane M-45 and 0.5 per cent Ekalux were washed and treated with hot water (40-42°C) for 30 min. Seed bits weighing, on an average, 50 g. each, having about five 'eyes' (buds) were sown during May, 1986 in 100 earthen pots (25 x 20 cm). The pots contained 10 kg sandy loam soil fumigated with Methyl bromide. After thirty days, 75 plants of uniform growth were selected and given the following fifteen treatments, replicated five times. The treatments were

T_1 uninoculated control in non-fumigated soil (CNS)
T_2 Uninoculated control in fumigated soil (CFS)
T_3 Nematode alone (N)
T_4 *Pythium* alone (P)
T_5 VA mycorrhizae alone (V)
T_6 Nematode + *Pythium* simultaneously (N+P)
T_7 Nematode + VA mycorrhizae simultaneously (N+V)

T_8 VA - mycorrhizae + *Pythium* simultaneously (V+P)
T_9 Nematode + *Pythium* + VA mycorrhizae simultaneously (N+P+V)
T_{10} Nematode followed by *Pythium* after 21 days (N→P)
T_{11} Nematode first followed by VA mycorrhizae after 21 days (N→V)
T_{12} *Pythium* first followed by nematode after 21 days (P→N)
T_{13} *Pythium* first followed by VA mycorrhizae after 21 days (P→V)
T_{14} VA mycorrhizae first followed by nematode after 21 days (V→N)
T_{15} VA mycorrhizae first followed by *Pythium* after 21 days (V→P)

The pots were arranged in a randomized manner under a thatched shed and watered daily (boiled and cooled water). The freshly hatched second stage juveniles of *M. incognita* from the egg masses collected from root-knot infested pepper roots were used as nematode inoculum. Each plant under the treatment was inoculated with 1000 nematodes through four holes provided at different depths around the base of the plant. Mycorrhizal inoculum multiplied on sorghum plant was placed at the rate of 150 spores of each of the two species of VAM, namely *Glomus multicaulae* and *Glomus fasciculatum* per plant at the base of the clump, and the soil was gently raked to mix the inoculum in the pot. Pythium culture isolated from ginger plants and maintained on PDA, was added to the respective treatments at the rate of 100 mm diameter pertridish growth of mycelium at the base of the plant and covered with the soil. This dose was arrived at based on the results of a previous trial with ginger using the same inoculum.

The experiment was terminated in January, 1987. The plants were depotted carefully with the root system intact. Roots were washed thoroughly to remove the adhering soil particles. Growth characters such as number of tillers, length of root, weights of root and fresh rhizome were recorded. (Table 1.) Visual observations on root-gall index were recorded for each plant based on the method developed by Koshy and Sundararaju (1979). After indexing, roots were cut into small pieces, mixed thoroughly and samples of 5 g each were stained in boiling acid-fuschin-lactophenol. These were blended, and nematode population (eggs, different stages of larvae and adult) was assessed. Nematode population from soil was estimated by using Cobb's sieving and decanting technique followed by modified Baermann's funnel method.

A portion of hairy roots was cleared in 10 per cent KOH and stained in 0.5 per cent trypan blue in lactophenol (Phillips and Hayman, 1970) and mycorrhizal colonization was assessed by light microscopy.

RESULTS AND DISCUSSION

There was a significant reduction in root length, number of tillers and weight of root and fresh rhizome in all the plants inoculated with nematode and *P.aphanidermatum* compared to control (Table I). Maximum decrease in growth of plants was noticed treatments in where *P. aphanidermatum* was inoculated followed by nematodes. On the other hand, significant increase in plant growth was noticed in plants inoculated with VA mycorrhizae alone or VAM first followed by the inoculation of nematode or *P. aphanidermatum.* Maximum fresh weight of rhizome (129.5g) and number of tillers (6.6) was recorded in plants inoculated with VAM first followed by nematode (treatment 14) compared to uninoculated control plants with respect to rhizome weight (37 g) and number of tillers (4.5). Maximum colonization of VAM (59.0%) was recorded in plants inoculated with VAM first

followed by *P. aphanidermatum* and closely followed by VAM inoculation alone (51.5%). The maximum root length (32.2 cm) was recorded in plants inoculated with VAM alone whereas maximum root weight (15.6 g) was noticed in treatment with VAM first followed by *P. aphanidermatum* and closely followed by VAM alone (15.2 g).

When VAM was inoculated with nematode or *P. aphanidermatum* simultaneously or inoculation of nematode or *P. aphanidermatum*

Table I. ***Effect of individual and combined inoculation with Meloidogyne incognita, Pythium aphanidermatum and a mixture of Glomus fasciculatum and G. multicaulae on ginger (Av. of five replication)***

Treatments		Root Length (cm)	Weight (g)	Tillers (No.)	Rhizome fresh weight (g)	VAM infection (%)	Root knot index	Total nematode population (Soil & root)
1		2	3	4	5	6	7	8
CNS	1	32.2	12.1	3.7	56.7	48.7 (44.1)	3.0	14814 (4.1)
CFS	2	24.5	8.0	4.5	37.0	11.5 (14.0)	0.0	0.0
N	3	29.8	8.8	4.7	32.2	6.0	4.6	51480 (4.7)
P	4	0.0	0.0	1.7	0.0	0.0	0.0	0.0
V	5	33.5	15.2	3.7	112.5	51.5 (48.2)	0.0	0.0
N+P	6	0.0	0.0	0.7	0.0	0.0	0.0	1344 (3.0)
N+V	7	31.0	8.8	3.3	66.8	9.2 (12.6)	2.4	8160 (3.8)
V+P	8	0.0	0.0	1.3	0.0	0.0	0.0	0.0
N+P+V	9	0.0	0.0	2.2	1.0	0.0	2.6	1362 (3.1)
N→P	10	19.7	9.2	5.3	44.7	0.0	2.6	8760 (3.9)
N→V	11	19.2	11.2	4.5	60.7	12.5	2.0	2896 (3.4)
P→N	12	1.5	0.4	1.0	0.0	0.0	1.4	688 (2.8)
P→V	13	0.0	0.0	1.8	0.0	0.0	0.0	0.0
V→N	14	29.2	14.6	6.6	66.3	22.7	2.6	2872 (3.4)
V→P	15	28.8	15.6	5.5	71.6	59.0 (52.9)	0.0	0.0
S E		7.3	4.6	1.7	25.7	17.5	0.5	0.2
G M		16.6	6.9	3.4	39.8	30.3	2.7	3.6
C V (%)		44.0	65.9	50.1	64.5	57.6	20.1	6.2
C D		8.4	5.8	1.9	29.5	20.5	0.7	0.3

Figures in parentheses represent transformed values

first followed by VAM, the degree of plant growth response induced by VAM was less than in plants inoculated with VAM alone or VAM first followed by nematode or *P. aphanidermatum* inoculations. This indicated that activities of nematodes affected the symbiotic relationship and less favourable environment was formed for the fungus. The detrimental effects of nematode on the growth of ginger was more pronounced when nematode was inoculated separately or in combination with *P. aphanidermatum.* Similar results have been reported on coconut (Koshy and Sosamma, 1987) and arecanut (Sundararaju and Koshy, 1987). Maximum damage was noticed in the plants inoculated with *P. aphanidermatum* alone or in combination with nematode and VAM. However, when VAM was inoculated prior to nematode or *P. aphanidermatum*, the mycorrhizae-induced plant growth response was not affected by inoculation with *M. incognita* or *P.aphanidermatum.* Prior inoculation with VAM resulted in colonization of roots by VA mycorrhizae and further inoculations with the nematode or *P.aphanidermatum* did not affect the already established symbiosis. Similar reports are available in literature to show that mycorrhizal plants are less affected by nematodes as compared to non-mycorrhizal plants (Sikora and Schoenbeck, 1975; Roncadori and Hussey, 1977; Bagyaraj, Manjunath and Reddy, 1979; Hussey and Roncadori, 1982).

Significant differences in root-knot indices were recorded in plants inoculated with nematode alone or with combination of fungus *P.aphanidermatum* and VAM compared to control or plants inoculated with VAM or *P.aphanidermatum* alone (Table 1.). Maximum root-knot index (4.6) and nematode populations (51480) was observed with inoculation of *M. incognita* alone, whereas, nematode population was significantly reduced when VA mycorrhizae and nematodes were inoculated simultaneously or one after the other. This indicated that presence of mycorrhizae in the root system interfered with the entry and or development of nematodes. Sikora and Schoenbeck (1975) reported a significant reduction in the number of *M. incognita* larvae in a well established mycorrhizal root system. The exact mechanism of suppression of nematodes by mycorrhizal fungi is not known, but it may be due to the physiological changes brought about by mycorrhizae in the root system or due to suberization of root occurring subsequent to mycorrhizal entry and this in turn, preventing the entry of nematodes (Suresh and Bagyaraj, 1984). Maximum suppression of nematodes was noticed when plants were inoculated with *P. aphanidermatum* and nemaode simultaneously or in sequence. However, the fungus-inoculated plants succumbed to soft-rot.

The plants survived only in the treatment where the VAM was inoculated first followed by *P. aphanidermatum.* It could be that the plants had escaped the susceptible stage or the VAM must have afforded protection through altered host physiology and or by preventing entry of the pathogen.

Root-knot nematode and *P.aphanidermatum* are serious threats to ginger, causing drastic reduction in rhizome yield and plant growth. The present study suggested that prior inoculation with VA-mycorrhizae, particularly a mixture of *Glomus fasciculatum* and *G. multicaulae* (300 spores) each was effective in ameliorating the deleterious effects of nematode and *P. aphanidermatum* on ginger.

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