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Combined Efficacy of the Bacterial Spore Parasite, *Pasteuria penetrans* (Thorne, 1940) and Nematicides in the Control of *Meloidogyne javanica* on Tomato

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ABSTRACT

Experiments were carried out under greenhouse conditions to test the efficacy of *Pasteuria penetrans* (Thorne, 1940) Sayre and Starr (1985) in combination with five nematicides viz., aldicarb, carbofuran, miral, phorate and sebufos for control of *Meloidogyne javanica* (Treub, 1885) Chitwood, 1949 on tomato var. Pusa Ruby. Results revealed that the application of *P. penetrans* in combination with nematicides significantly improved plant growth characteristics and the increase in growth was more than additive when compared with their individual effects. Combined application resulted in additive reduction of *M. javanica* galling. When *P. penetrans* and nematicides were applied together, there was a high degree of nematode control wherein a maximum of 89.37 per cent reduction in final nematode population was recorded with *P. penetrans* and carbofuran combination.

Key words : *Pasteuria penetrans, Meloidogyne javanica,* combined effect of bacterium and nematicide.

The bacterial spore parasite, *Pasteuria penetrans* (Thorne, 1940) Sayre and Starr, 1985 has been reported as a pathogen of nematodes (Mankau, 1975) and it has the attributes of a successful biocontrol agent against root-knot nematodes (Mankau, 1980; Sayre, 1980). The addition of the bacterial spores to soil reduced galling on plant roots caused by *Meloidogyne* spp. Goeldi (Mankau, 1975, 1980; Sayre, 1980; Stirling, 1984) and increased crop yields (Brown *et al.*, 1985). Brown *et al.* (1985) suggested a combination of biocontrol agents as a possibility for sustainable long term control of *Meloidogyne* spp. The other alternative may be the application of biocontrol agents in combination with nematicides. As the spores of *P. penetrans* are not affected by nematicides (Stirling 1984; Brown and Nordmeyer, 1985), a combination of the bacterial spores and a nematicide may provide effective multiple stresses on the target nematode population. Keeping this in view, an attempt was made during the present investigation to test the efficacy of *P penetrans* in combination with certain nematicides in the control of *M. javanica* (Treub, 1885) Chitwood 1949, on tomato.

MATERIALS AND METHODS

The required inoculum of *P penetrans* was obtained by multiplying on *M javanica* as per the procedure outlined by Stirling and Wachtel (1980). The dried and well ground powder of tomato roots containing the bacterial spores was designated as the spore powder.

A preliminary test was carried out with five nematicides each at three concentrations viz., 0.25, 0 5 and 1.0 ppm to determine the sub-lethal concentration of nematicides to be used in combination with *P. penetrans*. The concentration of 0.25 ppm was considered to be sub-lethal at which less than 50 0 per cent reduction in gall count was recorded when compared with control. A series of 10 cm dia wax-coated paper cups were filled with 100 g of moist sterilized soil mixture containing soil and sand in the ratio of 1 : 1. The spore powder, nematicides and second stage juveniles of *M. javanica* were added into paper cups @ 1.5 mg per 100 g of soil 0.25 ppm (w/w) and 200 juveniles per 100 g of soil respectively, and incorporated with the soil mixture Three weeks old tomato seedlings var. Pusa Ruby were individually transplanted in paper cups and maintained under greenhouse conditions. Suitable control treatment was maintained and all the treatments were replicated three times. Observation on gall count was recorded after 20 days.

An experiment was carried out under pot culture conditions filling 15-cm dia earthen pots with one kg of moist sterilized soil mixture. Spore powder, nematicides and inoculum of *M. javanica* were mixed well in pots @ 150 mg, 0 25 ppm and 3000 second stage juveniles per kg soil respectively. Four weeks old tomato seedlings were transplanted individually in all the pots. Suitable control treatments were included and all the treatments were replicated five times. Observations on plant growth characters, number of galls and nematode population in soil were recorded after 60 days. One gram of roots taken from homogenous root mixture was macerated for 45 sec in a waring blender for counting the number of eggs and larval stages within the roots. All data were analysed following standard procedures for analysis of variance. Differences between means were evaluated for significance according to modified Duncan's multiple range test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The application of *P. penetrans* and nematicides individually and in combination significantly improved the growth characteristics such as fresh and dry weight of shoot and fresh weight of root when compared with inoculated control (Table 1). Considering the most reliable growth parameter, namely, dry weight of shoot, there was 15.93 per cent and 37.17-45.72 per cent increase by the individual application of *P. penetrans* and nematicides, respectively. On the other hand, in *P. penetrans* and nematicide combinations, there was a marked increase in dry weight of shoot ranging from 56.93 to 66.67 per cent and the increase was found to be more than additive. Among the various combinations, *P. penetrans* and carbofuran/aldicarb combinations were the best in improving the growth of tomato plants

Host infestation by *M. javanica* as expressed by gall formation was adversely affected and gall count was additively reduced by the combined application when compared with the individual application of *P. penetrans*, and nematicides (Table 2). Similar-

TABLE 1. Effect of soil application of *Pasteuria penetrans* in combination with nematicides on growth characters of tomato var. Pusa Ruby inoculated with *M. javanica*

Treatments	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Final nematode population (Soil + Root) (000)	% reduction from inoculated control
Control (Inoculated)	25.84 a	3.39 a	3.15 a	74.13 j	—
Control (Uninoculated)	37.62 j	5.72 i	5.48 i	—	—
P. penetrans	28.16 cd	3.93 b	3.65 b	32.7 f	53.30
Aldicarb	28.55 de	4.86 de	4.67 de	35.3 fg	52.38
Carbofuran	29.15 e	4.94 e	4.93 e	35.05 fg	52.71
Miral	28.17 cd	4.76 cd	4.76 cd	36.36 g	50.94
Phorate	27.07 b	4.65 c	4.65 c	43.04 i	41.49
Sebufos	27.74 bc	4.73 cd	4.73 c	37.87 h	48.92
P. penetrans + Aldicarb	35.23 h	5.59 gh	5.28 gh	9.86 b	86.69
P. penetrans + Carbofuran	36.32 i	5.65 h	5.34 h	7.45 a	89.37
P. penetrans + Miral	34.33 g	5.54 fg	5.23 fg	14.98 c	79.78
P. penetrans + Phorate	33.37 f	5.32 f	5.13 f	21.21 e	71.38
P. penetrans + Sebufos	33.98 fg	5.53 fg	5.19 fg	16.51 d	76.46

Mean of 5 replications

Data in columns followed by a common letter are not statistically different (P=0.05) by DMRT.

TABLE 2. Effect of *Pasteuria penetrans* in combination with nematicides on galling by *Meloidogyne javanica* on tomato var. Pusa Ruby

Treatments	No. of galls/ Plant	% reduction over inoculated control
Control (Inoculated)	152.33 e	—
P. penetrans	79.67 c	47.69
Aldicarb	102.00 d	33.04
Carbofuran	94.00 cd	38.29
Miral	109.33 d	28.23
Phorate	114.33 d	24.94
Sebufos	111.67 d	26.69
P. penetrans + Aldicarb	21.33 a	85.99
P. penetrans + Carbofuran	18.67 a	87.74
P. penetrans + Miral	31.20 b	79.52
P. penetrans + Phorate	38.00 b	75.05
P. penetrans + Sebufos	32.33 b	78.00

Mean of 3 replications
Data in columns followed by a common letter are not statistically different (P=0.05) by DMRT.

ly, individual application of *P. penetrans* and nematicides resulted in significant reduction in nematode multiplication to the extent of 41.49 to 53 36 per cent as observed from the final nematode population (Table 1) The efficacy of *P. penetrans* was equal to that of aldicarb and carbofuran applications which were at par with each other However, *P. penetrans* and carbofuran combination was the most effective treatment in checking the multiplication of *M. javanica*, wherein a maximum of 89.37 per cent reduction in final nematode population was recorded It was closely followed by *P. penetrans* plus aldicarb, miral, sebufos or phorate combinations.

Our results confirm the absence of adverse effects of aldicarb, carbofuran, miral, phorate and sebufos at 0.25ppm concentration on *P. penetrans*. Besides, the results strongly suggest that a high degree of nematode control can be achieved by the combined application of *P. penetrans* as well as the nematicides. Stirling (1984) and Brown and Nordmeyer (1985) did not observe any detrimental effect of carbofuran and aldicarb on *P. penetrans* and the present findings agree with the earlier reports. The high rate of nematode control achieved during the present investigation could be due to the increased spore attachment of *P. penetrans* in the presence of nematicides. Carbamate nematicides, at low concentrations, affect the movement and orientation of nematodes towards the host roots rather than killing nematodes directly (White, 1981). In the present investigations, nematicides might have affected the host finding mechanism of the nematode. Besides, they might have increased the movement of nematodes in soil and thereby the probability of nematodes coming in contact with bacterial spores.

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Biological Control of Sheath Blight Disease of Rice

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ABSTRACT

Trichoderma aureoviride restricted the mycelial growth and sclerotial initiation in a virulent isolate of *Rhizoctonia solani* over culture medium by 52.7 and 95.3% respectively. Microscopic examination of the *R. solani* mycelium near the inhibition zone revealed that more than 25% of the mycelia were lysed and most of the hyphal tips showed bulb-like terminal enlargements. Pot culture experiments showed that soil amendment with *T. aureoviride* brought down considerably the incidence and severity of the sheath blight disease in TKM-9 rice.

Key words : Sheath blight, rice, *Rhizoctonia solani*, biological control, *Trichoderma aureoviride*.