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Plant Growth Promoting Rhizobacteria in the Management of *Radopholus similis* and *Meloidogyne incognita* in Black Pepper

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Field trials were conducted in black pepper cv. Karimunda and Panniyur in 2010 - 2011 to assess the efficacy of *Pseudomonas fluorescens* (Pfbv 22) and *Bacillus subtilis* (Bbv 57) against *Radopholus similis* and *Meloidogyne incognita* in Kanyakumari and Dindigul districts of Tamil Nadu. Talc based formulations of Pfbv 22 and Bbv 57 were prepared and applied through soil @ 10 g individually and as consortium (Pfbv 22 + Bbv 57 each @ 5g) /vine in the fields naturally infested with the above mentioned nematodes. Efficacy of talc formulations was compared with the standard chemical, carbofuran. Growth and yield parameters of black pepper and nematodes infestation in roots and soil were assessed at harvest of the berries. Soil application of consortia formulation of Pfbv 22 and Bbv 57 at 10 g per vine significantly enhanced the growth and berry yield of vine and reduced the nematode population over untreated control in both cultivars.

Key words: Black pepper, biological control, root knot nematode, burrowing nematode, *P. fluorescens, B. subtilis*.

Black pepper (*Piper nigrum* L.) is the most important export oriented commodity among Indian spices. Root knot nematode, *Meloidogyne incognita* and burrowing nematode, *Radopholus similis* are often associated with this crop and causing serious damage resulting in reduction of berry yield. Plant growth promoting rhizobacteria,(PGPR), *P. fluorescens* and *B. subtilis* have been reported to reduce the nematode infestation in many crops (Swarna kumari, 1996; Jonathan *et al*., 2006 and Liza Barua and Bora, 2008). Therefore an investigation was undertaken for the management of root knot and burrowing nematodes using *P. fluorescens* and *B. subtilis* individually and in combination.

Materials and Methods

Field experiments were conducted in 2010 - 11 at two different places in Kanyakumari and Dindigul districts of Tamil Nadu, India with varieties Karimunda and Panniyur respectively. Fields with black pepper vines (3 years old) infested with root knot (1.5 J_2 / g soil) and burrowing nematode (1 J_2 / g soil) were identified for the experiment. The experiments were conducted in randomized block design (RBD) with five treatments (Table 1) replicated five times (3 vines/replication). Talc based formulation of *P. fluorescens*, Pfbv 22 (2.5 X 10^8 cfu / g) and *B. subtilis*, Bbv 57 (2 X 10^8 cfu / g) obtained from the Centre for Plant Protection Studies, Tamil Nadu Agricultural University, India were used for the study and applied to soil at the time of initiation of experiments made at preflowering season (June, 2010) and compared with the standard chemical, carbofuran and untreated control. At the time of harvest made at 240 days after treatment (January, 2011), population of *M. incognita* and *R. similis* in soil and root were recorded. Growth parameters and yield of green pepper per vine were also recorded. Data were statistically analyzed as per Gomez and Gomez (1984).

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Result and Discussion

In the results of the experiment furnished in Table 1, there was significant reduction in the population of *M. incognita* in soil (167.2 juveniles / 250 cc soil) and root (9.4 adult females and 7.8 egg mass / g root) and *R. similis* in soil (105.6 / 250 cc soil) and root (29.6 nematodes / g root) accompanied with increase in the growth and yield of black pepper cv. Karimunda (113.2 spikes/vine, 42 berries/spike and 3.94 kg berries/ vine/ year) (Table 2) in vines treated with the consortial formulation of Pfbv 22 + Bbv 57 (each at 5 g / vine) followed by Pfbv 22 (10 g /vine). Untreated control recorded the highest population of nematodes in soil and root with reduced growth and yield parameters.

In black pepper cv. Panniyur, results were similar to those obtained with the cv. Karimunda. In black pepper cv. Panniyur, the lowest population of *M. incognita* (172 juveniles / 250 cc soil; 13.6 adult females and 11.2 egg mass / g root) and *R. similis* (74 juveniles / 250 cc soil and 25.4 nematodes / g

Table 1. Bioefficacy of *P. fluorescens* and *B. subtilis* in the Management of *Meloidogyne incognita* and *Radopholus similis* in black pepper cv. Karimunda in Kanyakumari District*

Treatment	Root knot nematode				Burrowing nematode	
	Population/ 250 cc soil	No. of females/ g root	No. of egg masses/g root	Gall index	Population/ 250 cc soil	No. /g root
P.fluorescens (Pfbv 22)(10 g / vine)	197.4	11.6	10.2	2	123	34.8
	(64.0)	(50.4)	(50.4)	(6.0)	(51.2)	(52.8)
B. subtilis(Bbv 57)(10 g / vine)	228.4	14.8	13.6	3	133.8	38.8
	(58.3)	(36.7)	(34.0)	(4.0)	(46.9)	(47.4)
P. fluorescens (Pfbv22) +*B. subtilis*	167.2	9.4	7.8	2	105.6	29.6
(Bbv 57) (each @ 5g / vine)	(69.5)	(59.8)	(62.1)	(6.0)	(58.1)	(59.8)
Carbofuran(1 kg a.i./ha)	234.2	16.2	13.0	3	146.4	42.4
	(57.3)	(30.7)	(36.9)	(4.0)	(41.9)	(42.5)
Control	548.8	23.4	20.6	5	252.2	73.8
SE d	9.138	0.77	0.94		2.04	1.36
CD (0.05)	19.37	1.64	2.0		4.32	2.89

* Pooled data of two field experiments, Figures in the parentheses are per cent decrease over control

root) (Table 3) with improved growth and yield parameters (249.6 spikes/vine, 47.8 berries/spike and 12.8 kg berries/ vine/year) (Table 4) was observed with Pfbv 22 + Bbv 57 treatment. Increase in yield and reduction in nematode population in the PGPR, *P. fluorescens* and *B. subtilis* treated vines might be due to the production of plant growth regulators *viz.,* auxin, gibberellin and cytokinin and also through the induction of systemic resistance (Bakker *et al*., 2003).

Table 2. Influence of *P. fluorescens* and *B. subtilis* on growth and yield parameters of black pepper cv. Karimunda in Kanyakumari District*

Treatment	Spikes/vine	Spike length (cm)	Berries /spike	Yield (kg/vine/year)
P.fluorescens (Pfbv 22)(10 g / vine)	100.4	8.6	39.6	3.64
	(24.3)	(25.5)	(21.7)	(32.5)
B. subtilis (Bbv 57)(10 g / vine)	94	7.8	39.4	3.72
	(19.1)	(17.9)	(21.4)	(33.8)
P. fluorescens (Pfbv22) +*B. subtilis*	113.2	9.4	42	3.94
(Bbv 57) (each @ 5g / vine)	(32.8)	(32.0)	(26.2)	(37.5)
Carbofuran (1 kg a.i./ha)	114	7.6	36.6	3.38
	(33.3)	(15.7)	(15.4)	(27.2)
Control	76	6.4	31	2.46
SE d	1.36	0.77	1.01	0.264
CD (0.05)	2.83	1.60	2.12	0.560

* Pooled data of two field experiments, Figures in the parentheses are per cent increase over control

Jonathan and Rajendran (2000) and Jonathan *et al*. (2004) observed that *P. fluorescens* and *B. subtilis* induced root development in banana, tomato and betel vine and reduced the infestation of *M. incognita*. The combined application of *P. fluorescens* (Pfbv 22) and *B. subtilis* (Bbv 57) as

Table 3. Bioefficacy of *P. fluorescens* and *B. subtilis* in the Management of *Meloidogyne incognita* and *Radopholus similis* in black pepper cv. Panniyur in Dindigul district*

Treatment	Root knot nematode				Burrowing nematode	
	Population/ 250 cc soil	No. of females/ g root	No. of egg masses/g root	Gall index	Population/ 250 cc soil	No./g root
P.fluorescens (Pfbv 22) (10 g / vine)	193.2	15.6	13.2	3	105.6	31.4
	(61.2)	(38.4)	(40.6)	(40.0)	(58.9)	(51.9)
B. subtilis (Bbv 57) (10 g / vine)	206.8	18.6	15.4	3	110.2	33.6
	(58.3)	(26.2)	(30.7)	(40.0)	(56.8)	(48.5)
P. fluorescens (Pfbv22) + *B. subtilis*	172.0	13.6	11.2	2	74.0	25.4
(Bbv 57) (each @ 5g / vine)	(65.8)	(46.1)	(49.5)	(60.0)	(71.0)	(61.1)
Carbofuran	202.4	19.4	18.4	3	123.2	36.2
(1 kg a.i./ha)	(59.2)	(23.0)	(17.2)	(40.0)	(51.7)	(44.5)
Control	496.8	25.2	22.2	5	254.6	65.2
SE d	2.66	0.98	0.91		1.89	1.04
CD (0.05)	5.65	2.08	1.94		4.01	2.21

* Pooled data of two field experiments, Figures in the parentheses are per cent decrease over control

Table 2. Influence of *P. fluorescens* and *B. subtilis* on growth and yield parameters of black pepper cv. Karimunda in Kanyakumari District*

Treatment	Spikes/vine	Spike length(cm)	Berries /spike	Yield (kg/vine/year)
P.fluorescens (Pfbv 22) (10 g / vine)	244	10.2	45.4	9.2
	(35.9)	(17.7)	(23.4)	(30.5)
B. subtilis (Bbv 57) (10 g / vine)	222.6	9.2	41.6	8.2
	(29.7)	(8.7)	(16.4)	(22.0)
P. fluorescens (Pfbv22) + *B. subtilis*	249.6	11.8	47.8	12.8
(Bbv 57) (each @ 5g / vine)	(37.3)	(28.9)	(27.2)	(50.0)
Carbofuran(1 kg a.i./ha)	247.4	9.6	41.8	7.6
	(36.8)	(12.5)	(16.8)	(15.8)
Control	156.6	8.4	34.8	6.4
SE d	1.64	0.58	0.83	0.78
CD (0.05)	3.42	1.20	1.74	1.66

* Pooled data of two field experiments, Figures in the parentheses are per cent increase over control

seed treatment and soil application significantly reduced *M. incognita* and *Rotylenchulus reniformis* infestation in tomato and enhanced its plant growth parameters (Jonathan *et al*., 2009). Similar study was conducted by Devapriyanga (2010) in black pepper cv.Panniyur where the talc formulation of *P. fluorescens* showed the antagonistic effect against *M.incognita*.

The result showed negative co-relation between *P. fluorescens* and *B.subtilis* density and the nematode population in the rhizosphere (Hackenberg *et al*., 2000) and it is concluded that *P. fluorescens* and *B. subtilis* can be exploited for the management of nematodes in black pepper.

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