J. Biol. Control, 12 (2):135-141, 1998

Management of rice root nematode, *Hirschmanniella gracilis* (de Man) Luc & Goodey with *Pseudomonas fluorescens* Migula

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ABSTRACT: Field experiments were conducted with rice cvs. CO43, DT36 and ADT 38 during Kuruvai (June-September), Samba (August-January), and Navarai (January-April) seasons, respectively, to evaluate the efficacy of plant growth promoting rhizobacterium, *Pseudomonas fluorescens* Migula strain Pf-1 available with Tamil Nadu Agricultural University, Coimbatore, as commercial formulation in the control of the rice root nematode *Hirschmanniella gracilis* (de Man) Luc & Goodey. The biocontrol agent was evaluated as seed treatment and nursery soil application separately and either with or without soil application of carbofuran 3G and compared with soil application of carbofuran 3G @ 1.3 g a. i. / m^2 and an untreated control for the management of the nematode. Application of the biocontrol agent as seed treatment at a dosage of 10 g / kg of seed was superior to all the treatments. Maximum bacterial colonization and nematode suppression was observed in plants treated with *P. fluorescens* as seed treatment and it increased yield by 13 per cent.

KEY WORDS: *Heterodera spp, Hirschmanniella gracilis, Meloidogyne incognita, rice*

Worldwide, rice yield loss due to plant parasitic nematodes is estimated at 10 per cent (Sasser and Freckman, 1987). Among the nematode pests of rice, the root infesting *Hirschmanniella* spp. prevail in all rice growing areas causing an yield loss of 60 per cent and is considered as a key pest of rice in India (Prasad *et al.*, 1987).

Biological control of nematodes appears to be an alternative strategy, as the management of nematode disease is

difficult particularly in developing countries where nematicides are very expensive besides hazardous to ecosystem. Although more than 200 pathogens, parasitoids and predators are known to attack nematodes, past research in the biological control of nematodes has not been too successful (Kerry, 1990). Recently the fluorescent *Pseudomonas spp.* associated with plant rhizosphere emerged as a potential biocontrol agent of plant disease (Kloepper *et al.*, 1988) and plant parasitic nematodes (Oostendrop and Sikora, 1989). However, limited work has been carried out in general and almost nil in rice for biocontrol of nematodes using *Pseudomonas spp.* Preliminary studies conducted in laboratory and glasshouse showed that the rhizobacterium, *Pseudomonas fluorescens* Migula protected rice against *Hirschmanniella. gracilis* (de Man) Luc & Goodey. Based on these results, three trials were conducted at Tamil Nadu Agricultural University, Coimbatore, to evaluate the biocontrol agent for its field efficacy against the rice root nematode.

MATERIALS AND METHODS

Field experiments were conducted with rice cvs. ADT 36, CO 43 and ADT 38 during Kuruvai (June-September), Samba (August-January) and Navarai (January-April) seasons, respectively in wetland, at Tamil Nadu Agricultural University, Coimbatore following the recommended agronomic practices to evaluate efficacy of the biocontrol agent *P. fluorescens* strain Pf-1 in the control of rice root nematode *H. gracilis*. The biocontrol agent was treated at 10 and 20g / kg seed as seed treatment and 3 and 6g /m^2 as nursery soil application separately either with or without combination of carbofuran 3G and compared with the standard chemical treatment of carbofuran 3G and untreated control (Table 1). Rice seeds were soaked in water containing the talc based commercial product of *P. fluorescens* strain Pf-1 @ 10g or 20g /400 ml / kg seed for 12h. Excess water drained off and treated seeds were incubated for 12h. before sowing. In case of soil application required quantity of *P. fluorescens* was calculated, mixed with sand in the proportion of 1:1 and broadcast just before sowing. The treatments were replicated thrice under randomized block design with plot size of 10 m^2 and 20 m^2 in nursery and main field, respectively.

Ten plants selected at random in nursery and main field were used to estimate soil (200 ml) and root (2g) nematode population using Baermann funnel and blender method (Cobb, 1918; Schindler, 1961) besides recording the plant growth parameters. Grain yield from each plot and count on bacterial root colonization in selected ten plants at random per plot (King *et al.*, 1954) were recorded at harvest. Three seasons data were pooled and analysed statistically.

RESULTS AND DISCUSSION

The results of the experiment (Table 1) showed that the reduction in root population of *H. gracilis* in plants treated with *P. fluorescens* strain Pf-1 as seed treatment @ 10 and 20g per kg seed was significant and maximum in nursery stage

Table 1. Nursery management of *H. gracilis* with *P. fluorescens*

Treatment	Before planting			
	Nematode population		Seedling length	Seedling weight
	Soil (200 ml)	Root (2 g)	(cm)	(g)
S.T. with *P. fluorescens* @ 10 g/kg of seed	33.0 (70.1)	2.1	29.3 (60.1)	2.18 (21.8)
S.T. with *P. fluorescens* @ 20 g/kg of seed	31.0 (71.9)	2.3	26.6 (45.4)	2.01 (12.3)
Tr.1 + carbofuran 3G @ 1.3 g a.i./m^2 nursery	21.8 (80.2)	4.2	28.2 (54.1)	2.30 (28.5)
Tr.2 + carbofuran 3G @ 1.3 g a.i./m^2 nursery	18.3 (83.4)	4.1	27.4 (49.7)	2.20 (22.9)
S.A. *P. fluorescens* @ 3 g/m^2 nursery	22.9 (79.3)	5.1	28.1 (53.6)	2.26 (26.3)
S.A. *P. fluorescens* @ 6 g/m^2 nursery	23.4 (78.8)	7.7	26.0 (42.1)	2.05 (14.5)
Tr.5 + carbofuran 3G @ 1.3 g a.i./m^2 nursery	21.8 (80.3)	8.3	27.2 (48.6)	2.08 (16.2)
Tr.6 + carbofuran 3G @ 1.3 g a.i./m^2 nursery	14.1 (87.2)	7.6	28.8 (57.4)	2.18 (21.8)
Carbofuran 3G @ 1.3 g a.i./m^2 nursery	16.9 (84.7)	9.2	21.7 (18.6)	2.12 (18.4)
Control	110.5	26.1	18.3	1.79
CD (P=0.05)	8.27	4.62	1.37	0.17

Note: S. T.: Seed Treatment; S. A.: Soil application
Figures in parentheses are percentage of increase or decrease over control

(92%) followed by at harvest (90%) and maximum tillering (81%) stages, respectively compared to the untreated control. However, difference in the reduction of root population of *H. gracilis* at different stages was not significant between the dosage of seed treatment with *P. fluorescens* strain Pf-1. Further, the biocontrol potential of *P. fluorescens* strain Pf-1 as seed treatment in the control of rice root nematode was not differing significantly when combined with chemical application of carbofuran 3G. Highest colonization of *P. fluorescens* noticed in the plants treated with P. fluorescens as seed treatment and was significantly different from other treatments (Table 1 and 2). Earlier reports on the effectiveness of *P. fluorescens* in the control of Heterodera avenae, *H. cajani*, *H. zeae* and *Meloidogyne incognita* under in vitro and in vivo conditions (Gokte and Swarup, 1988; Santhi and Sivakumar, 1995) supported the present finding of biocontrol potential of *P. fluorescens* in the control of *H. gracilis* in rice.

Nursery soil application of *P. fluorescens* strain Pf-1 was not as effective as seed treatment in the control of root population of *H. gracilis* in nursery and main field in the present study. More colonizing ability of *P. fluorescens* strain Pf-1 in seed treatment may be explained as a probable reason for the higher control of nematode (Table 2). Santhi and Sivakumar (1995) also viewed that the nematode suppressing ability of *Pseudomonad* bacterial strain related to their root colonizing ability.

With regard to soil nematode population, the higher dosage of *P. fluorescens* as soil application in nursery with carbofuran 3G resulted in maximum reduction of *H. gracilis* population. The effect of this treatment was on par with P. *fluorescens* applications as soil or seed treatments in combination with carbofuran 3G and nursery soil application with carbofuran 3G alone. It is clear that combined treatment of *P. fluorescens* with carbofuran 3G had significantly better control of soil population of *H. gracilis* in nursery than application of the biocontrol agent alone either as seed treatment or soil application (Table 1). However, the same trend was not observed after transplanting in the main field as there was no significant difference in the control of soil nematode among the treatments. The significant effect of control in nursery soil nematode population of *H. gracilis* by the combined *P. fluorescens* strain Pf-1 and carbofuran 3G treatment could be attributed to the chemical effect of carbofuran 3G. But the same significant effect in the control of soil population of *H. gracilis* was not observed in the main field by the chemical carbofuran 3G. The result fall in line with the finding of Ramakrishnan (1995) who reported Management of rice root nematode with *P. fluorescens* that nursery treatment with chemical may not be sufficient and repeated application of plant protection measures in the main field is essential for the control of rice root nematode.

The increase in yield components was significant with all the treatments compared to control. The increase over control was

Table 2. Field evaluation of *P. fluorescens* strain Pf-1 in the control of rice root nematode *H. gracilis*

Treatment	At maximum tillering stage			At harvest		
	Nematode population/ root 2 g	Tiller number	Plant height (cm)	Nematode population/ root2g	Grain yield / ha (kg)	Bacterial colonization (cfu /g root)
S.T. with *P. fluorescens* @ 10 g/kg of seed	5.00 (81.3)	10.1 (26.3)	68.6 (8.0)	3.8 (90.7)	4761 (12.5)	255.8 (494)
S.T. with *P. fluorescens* @ 20 g/kg of seed	4.50 (83.2)	9.4 (17.5)	66.3 (2.8)	3.5 (91.4)	4656 (10.0)	236.1 (448)
Tr.1 + carbofuran 3G @ 1.3 g a.i./m2 nursery	5.60 (79.1)	8.8 (10.0)	68.7 (8.2)	12.1 (70.3)	4531 (7.1)	146.4 (240)
Tr.2 + carbofuran 3G @ 1.3 g a.i./m2 nursery	4.50 (83.2)	8.4 (5.0)	65.7 (2.2)	9.6 (76.5)	4547 (7.5)	151.1 (251)
S. A. *P. fluorescens* @ 3 g/m2 nursery	11.80 (56.0)	8.8 (10.0)	66.6 (4.8)	19.2 (52.9)	4389 (3.7)	126.2 (193)
S. A. *P. fluorescens* @ 6 g/m2 nursery	11.40 (57.4)	8.7 (8.0)	68.9 (5.4)	21.0 (48.5)	4609 (8.9)	147.6 (242)
Tr.5 + carbofuran 3G @ 1.3 g a.i./m2 nursery	11.10 (58.5)	8.8 (10.0)	65.5 (3.1)	12.9 (68.4)	4534 (7.2)	141.7 (229)
Tr.6 + carbofuran 3G @ 1.3 g a.i./m2 nursery	5.10 (81.0)	8.8 (10.0)	65.6 (3.3)	12.7 (68.9)	4684 (10.7)	151.9 (252)
Carbofuran 3G @ 1.3 g a.i./m2 nursery	7.96 (70.3)	9.0 (12.3)	66.4 (4.6)	16.3 (60.0)	4509 (6.4)	169.6 (294)
Control	26.8	8.0	63.5	40.8	4231	43.1
CD (P=0.05)	4.18	0.88	3.87	6.3	38.5	28.59

Note: S. T.: Seed Treatment; S. A.: Soil application

Figures in parentheses are percentage of increase or decrease over control

maximum in the most effective treatment for the control of nematode namely seed treatment of *P. fluorescens* strain Pf-1 @ 10g / kg seed in respect of seedling length (60%), tiller number (25%) and grain yield (13%). Whereas the increase in weight of seedling (29%) and plant height (8.3%) was maximum when the same treatment tried in combination of carbofuran 3G. However, the effect of seed treatment with *P. fluorescens* @ 10g / kg seed with or without combination of carbofuran 3 G was on par in increasing the plant growth parameters except number of tillers. The effect of this seed treatment was significantly higher than soil application of *P. fluorescens* or carbofuran 3G individually or in combination (Table 1 and 2). Therefore, it is concluded from the present study that the rhizobacterium, *P. fluorescens* strain Pf-1 could be used as potential agent for the control of rice root nematode, *H. gracilis* and to promote the growth of rice.

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