BIOEFFICACY OF *PSEUDOMONAS FLUORESCENS* ON *MELOIDOGYNE INCOGNITA* IN BANANA

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Summary. Native strains of *Pseudomonas fluorescens* were isolated from the rhizosphere of banana and tested for their efficacy to control *Meloidogyne incognita* infesting banana. Among the 24 isolates of *P. fluorescens* tested, isolates PfB 22, PfB 23, PfB 21, PfB 17 and PfB 2 did not inhibit germination and enhanced the vigour index of rice under roll towel and pot culture conditions. *In vitro*, the greatest reduction in nematode egg hatch and the greatest mortality of *M. incognita* were observed in the culture filtrate of PfB 22 at 100% concentration. In the experiments conducted under glasshouse conditions, plants treated with *P. fluorescens* PfB 22 grew significantly better than untreated plants. Nematode infestations were reduced in all the treated plants both in soil and roots, with the least number of adult females, number of egg masses, number of eggs per egg mass and gall index of *M. incognita* in plants treated with PfB 22.

Key words: Biological control, *Musa* spp., rhizobacterium.

The root knot nematode, *Meloidogyne incognita* (Kofoid *et* White) Chitw., is a major pest of banana (*Musa* spp. L.) and is estimated to cause a yield loss of 30.9% (Jonathan and Rajendran, 2001). The plant growth promoting rhizobacterium, *Pseudomonas fluorescens* Migula is reported to be effective in suppressing *M. incognita* in many crops *viz.*, tomato (Jonathan *et al.*, 2000), chickpea (Khan *et al.*, 2001) and turmeric (Srinivasan *et al.*, 2001). Therefore, an investigation was undertaken for the management of root knot nematode infesting banana using the rhizobacterium *P. fluorescens*.

MATERIALS AND METHODS

Soil samples were collected from the rhizosphere of healthy banana plants to isolate native strains of *P. fluorescens* by a serial dilution agar plate technique (Aneja, 2002). One ml each of 10^{-5} and 10^{-6} dilutions was pipetted into sterile Petri dishes. King's B medium (King *et al.*, 1954) was cooled to 30 ± 1 °C, poured into the Petri dishes, rotated and incubated at room temperature (28 ± 1 °C) for 24 h. The colonies with raised surfaces showing fluorescent colour were individually purified and subcultured.

Suspensions of the *P. fluorescens* isolates were tested for their plant growth promotion activity on rice (IR 20) under *in vitro* conditions by the standard roll-towel method (ISTA, 1993) and in pots containing 1 kg of sterilized field soil. An untreated control was also maintained. The germination percentage of rice seeds was recorded and the vigour index of the resulting seedlings was calculated using the formula Vigour index = germination (%) × seedling length (shoot length + root length) (Baki and Anderson, 1973).

Promising isolates of *P. fluorescens* were selected based on their growth promotion activity and their effects on *M. incognita* were then assessed *in vitro.* These isolates are maintained at the Department of Nematology, Tamil Nadu Agricultural University, Coimbatore, India. The effects of the culture filtrates of the isolates were tested for their effect on hatching of *M. incognita* eggs at different concentrations (100, 50, 25 and 10%). Ten egg masses of *M. incognita* were placed in Syracuse dishes with each bacterial filtrate of each isolate and kept at 28 ± 1 °C. King's B broth without bacteria and tap water were separately used for controls. Three replications were maintained for each treatment. After 24, 48, 72, 96 and 120 h of exposure, the numbers of hatched juveniles were recorded.

To study the nematicidal activity of *P. fluorescens* isolates *in vitro*, one ml of each of the bacterial culture filtrates at different concentrations (100, 50, 25 and 10%) were poured into separate Syracuse dishes. Egg masses of *M. incognita* were collected from an infested root and hatched separately in distilled water with good aeration. After 48 h, 100 second stage juveniles (J_2) were introduced into each dish and incubated at 27 ± 1 °C. King's B broth without bacteria and tap water were used as controls. Each treatment was replicated three times. Observations on the mortality of juveniles after 24, 48, 72, 96 and 120 h of exposure were recorded and per cent mortality was calculated.

Pseudomonas fluorescens isolates were formulated in purified talc powder (sterilized at 105 °C for 12 h) with calcium carbonate 15 g (to adjust the pH to neutral) and carboxy methyl cellulose (CMC) 10 g (adhesive), following the method described by Vidhyasekaran and Muthamilan (1995). At the time of application, the pop-

Table I. Effect of *Pseudomonas fluorescens* isolates on seed germination and seedling vigour of rice, *Oryza sativa*, using the roll towel method.

P. fluorescens isolates	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index
PfB 1	87.5	7.6 d-h	17.1 ab	2157
PfB 2	100.0	8.2d-g	14.8 a-f	2294
PfB 3	62.5	6.5 hi	12.8 e-h	1208
PfB 4	87.5	7.3 e-h	14.0 c-g	1866
PfB 5	75.0	7.2 e-h	13.4 d-g	1543
PfB 6	87.5	7.5 d-h	13.8 c-g	1866
PfB 7	75.0	7.6 d-h	13.4 d-g	1575
PfB 8	62.5	7.0 e-h	16.4 abc	1463
PfB 9	50.0	5.4 ij	8.6 ij	702
PfB 10	25.0	2.3 k	3.0 k	133
PfB 11	75.0	7.3 e-h	13.0 d-h	1525
PfB 12	75.0	6.8 ghi	15.2 a-e	1646
PfB 13	75.0	6.7 ghi	13.8 c-g	1538
PfB 14	87.5	6.8 f-i	14.6 a-f	1875
PfB 15	100.0	9.8 c	10.4 hi	2020
PfB 16	87.5	11.4 b	11.3 gh	1981
PfB 17	100.0	8.1 d-g	15.3 a-d	2393
PfB 18	50.0	7.4 e-h	3.2 k	532
PfB 19	87.5	7.3 e-h	7.1 j	1257
PfB 20	75.0	6.5 hi	12.2 fgh	1400
PfB 21	100.0	7.8 d-h	16.7 abc	2450
PfB 22	100.0	14.3 a	12.0 fgh	2633
PfB 23	100.0	8.5 cde	17.3 a	2583
PfB 24	90.0	8.4 def	14.3 b-f	2040
Pf 1	100.0	9.0 cd	15.7 a-e	2467
Control	62.5	4.7 j	11.2 gh	992

Means in the same column sharing a common letter are not significantly different at 5% level by DMRT.

Table II. Effect of *P. fluorescens* isolates on seed germination and seedling vigour of rice, *O. sativa*, using the pot culture method.

P. fluorescens isolates	Germination (%)	Shoot length (cm)	Root length (cm)	Vigour index
PfB 1	40	12.9 bcd	6.4 cde	773
PfB 2	100	15.4 ab	7.6 bc	2297
PfB 3	20	7.7 fg	3.3 c-f	252
PfB 4	50	7.4 fg	5.4 cde	640
PfB 5	70	7.4 fg	6.0 cde	935
PfB 6	70	7.8 fg	3.4 c-f	778
PfB 7	60	13.4 bc	5.7 cde	1148
PfB 8	20	1.7 i	2.1 ef	77
PfB 9	70	8.1 fg	5.5 cde	951
PfB 10	60	10.1 def	3.2 def	793
PfB 11	80	9.1 efg	2.8 def	954
PfB 12	80	11.6 cde	11.0 ab	1813
PfB 13	40	6.1 gh	6.3 cde	493
PfB 14	20	3.4 hi	3.0 def	127
PfB 15	90	3.7 hi	3.6 c-f	654
PfB 16	40	1.07 i	4.9 c-f	239
PfB 17	100	15.4 ab	13.8 a	2920
PfB 18	100	3.6 hi	4.2 c-f	786
PfB 19	60	5.8 gh	2.7 def	516
PfB 20	50	1.9 i	2.6 def	227
PfB 21	100	18.5 a	12.7 a	3120
PfB 22	100	16.8 a	14.7 a	3150
PfB 23	100	15.5 ab	12.8 a	2827
PfB 24	20	18.2 a	0.8 f	379
Pf 1	100	16.1 ab	13.5 a	2963
Control	70	9.0 efg	6.9 cd	1111

Means in the same column sharing a common letter are not significantly different at 5% level by DMRT.

Table III. Effect on egg hatch of *Meloidogyne incognita* as affected by different concentrations and exposure times to culture filtrates of five isolates of *P. fluorescens*.

Treatment	C1					C2					C3					C4				
	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5
PfB 2	457.3	529.3	569.3	691.3	782.7	527.7	608.0	677.7	752.0	808.3	608.0	687.3	796.7	846.0	940.0	854.3	923.3	981.0	1029.7	1116.3
	(21.4)	(23.0)	(23.9)	(26.3)	(28.0)	(23.0)	(24.7)	(26.0)	(27.4)	(28.4)	(24.7)	(26.2)	(28.2)	(29.1)	(30.7)	(29.2)	(30.4)	(31.3)	(32.1)	(33.4)
PfB 17	162.0	230.0	358.3	386.0	396.3	331.3	376.7	443.3	503.3	545.3	402.0	532.0	596.0	673.0	722.3	571.0	622.3	718.0	786.7	855.3
	(12.7)	(15.2)	(18.9)	(19.6)	(19.9)	(18.2)	(19.4)	(21.1)	(22.4)	(23.4)	(20.1)	(23.1)	(24.4)	(25.9)	(26.9)	(23.9)	(24.9)	(26.8)	(28.0)	(29.2)
PfB 21	314.7	365.7	447.0	553.7	621.0	451.0	537.0	591.7	690.3	738.0	581.7	658.0	770.7	812.0	853.7	811.3	916.0	944.0	996.7	1018.0
	(17.7)	(19.1)	(21.1)	(23.5)	(24.9)	(21.2)	(23.2)	(24.3)	(26.2)	(27.2)	(24.1)	(25.6)	(27.8)	(28.5)	(29.2)	(28.5)	(30.3)	(30.7)	(31.6)	(31.9)
PfB 22	125.0	141.7	322.0	367.0	374.0	225.3	289.7	373.7	473.3	522.7	312.3	434.7	543.3	626.7	683.0	327.0	473.7	582.3	745.0	802.7
	(11.2)	(11.9)	(17.9)	(19.2)	(19.3)	(15.0)	(17.0)	(19.3)	(21.8)	(22.9)	(17.7)	(20.8)	(23.3)	(25.0)	(26.1)	(18.1)	(21.8)	(24.1)	(27.3)	(28.3)
PfB 23	225.7	279.7	390.0	432.0	451.0	379.0	415.3	493.7	559.3	614.7	479.0	572.0	690.3	732.0	763.0	684.0	723.3	784.3	860.7	903.7
	(15.0)	(16.7)	(19.7)	(20.8)	(21.2)	(19.5)	(20.4)	(22.2)	(23.6)	(24.8)	(21.9)	(23.9)	(26.2)	(27.1)	(27.6)	(26.2)	(26.9)	(28.0)	(29.3)	(30.1)
Pf 1	182.0	260.7	362.7	398.7	411.0	359.3	393.0	483.3	531.7	593.0	422.3	545.0	622.3	698.3	735.3	614.3	656.3	734.0	812.0	883.0
	(13.5)	(16.1)	(19.0)	(20.0)	(20.3)	(19.0)	(19.8)	(22.0)	(23.1)	(24.4)	(20.6)	(23.3)	(24.9)	(26.4)	(27.1)	(24.8)	(25.6)	(27.1)	(28.5)	(29.7)
KB broth	1716.7	1821.7	1890.7	1928.0	1993.7	1665.3	1684.3	1787.3	1886.7	1964.3	1681.7	1683.0	1694.7	1772.0	1892.3	1680.3	1682.7	1687.7	1850.3	1858.3
	(41.4)	(42.7)	(43.5)	(43.9)	(44.7)	(40.8)	(41.0)	(42.3)	(43.4)	(44.3)	(41.0)	(41.0)	(41.2)	(42.1)	(43.5)	(40.9)	(41.0)	(41.1)	(43.1)	(43.1)
Water	1993.7	1994.7	1999.0	2001.7	2004.7	1990.3	1996.7	2006.3	2005.7	2024.7	2008.0	2007.3	2008.3	2011.0	2013.0	2012.0	2013.0	2012.7	2014.7	2017.7
	(44.7)	(44.7)	(44.7)	(44.7)	(44.8)	(44.6)	(44.7)	(44.8)	(44.8)	(44.9)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)	(44.8)

Figures in parentheses are square root transformed values.
C 1 - 100 per cent concentration; C 2 - 50 per cent concentration; C 3 - 25 per cent concentration; C 4 - 10 per cent concentration.
H 1 - 24 hours; H 2 - 48 hours; H 3 - 72 hours; H 4 - 96 hours; H 5 - 120 hours.

	SED	CD (0.05)
T (treatment)	0.04	0.08
C (concentration)	0.03	0.06
H (exposure, hours)	0.03	0.06
T × C	0.08	0.16
C × H	0.07	0.13
T × H	0.09	0.18
T × C × H	0.19	0.37

Table IV. Effect of exposures to different concentrations of five culture filtrates of *P. fluorescens* on the mortality of second stage juveniles of *M. incognita*.

Treatment	C1					C2					C3					C4				
	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5	H1	H2	H3	H4	H5
PfB 2	42.7 (40.8)	53.0 (46.7)	67.0 (54.9)	80.0 (63.5)	84.0 (66.6)	37.0 (37.5)	46.0 (42.7)	65.0 (53.7)	70.0 (56.8)	72.0 (58.1)	26.3 (30.9)	33.7 (35.5)	49.0 (44.4)	53.3 (46.9)	56.7 (48.8)	21.3 (27.4)	29.0 (32.6)	34.3 (35.9)	39.3 (38.8)	45.0 (42.1)
PfB 17	74.7 (59.8)	85.3 (67.6)	91. (72.6)	98.0 (83.4)	100.0 (89.9)	62.0 (51.9)	75.7 (60.5)	86.3 (68.4)	90.7 (72.2)	93.7 (75.5)	55.7 (48.3)	65.7 (54.1)	79.0 (62.7)	82.0 (64.9)	84.3 (66.7)	40.7 (39.6)	43.3 (41.2)	62.7 (52.3)	64.3 (53.3)	72.3 (58.3)
PfB 21	58.0 (49.6)	66.3 (54.6)	80.3 (63.7)	84.7 (67.0)	85.0 (67.3)	45.0 (42.1)	56.7 (48.8)	64.0 (53.1)	73.0 (58.8)	75.0 (60.0)	30.0 (33.2)	39.3 (38.8)	46.0 (42.7)	52.3 (46.3)	53.0 (46.7)	24.0 (29.3)	36.7 (37.2)	45.3 (42.3)	51.0 (45.6)	52.0 (46.1)
PfB 22	76.7 (61.1)	92.3 (74.1)	100.0 (89.9)	100.0 (89.9)	100.0 (89.9)	68.0 (55.6)	85.3 (67.6)	98.0 (83.4)	100.0 (89.9)	100.0 (89.9)	60.7 (51.2)	72.3 (58.3)	84.0 (66.5)	86.3 (68.4)	90.0 (71.6)	49.0 (44.4)	62.7 (52.3)	71.3 (57.6)	74.7 (59.8)	77.7 (61.8)
PfB 23	68.3 (55.8)	79.3 (63.0)	86.3 (68.3)	94.0 (75.9)	95.0 (76.0)	55.3 (48.1)	63.7 (52.9)	79.0 (62.7)	86.0 (68.1)	90.0 (71.6)	47.0 (43.3)	52.3 (46.3)	66.7 (54.7)	71.0 (57.4)	73.3 (58.9)	32.3 (34.6)	43.3 (41.2)	55.3 (48.1)	62.0 (51.9)	64.7 (53.5)
Pf 1	72.3 (58.3)	86.7 (68.6)	95.3 (78.3)	100.0 (89.9)	100.0 (89.9)	63.3 (52.7)	79.3 (63.0)	88.3 (70.1)	92.0 (73.6)	95.0 (77.1)	57.0 (49.0)	65.3 (53.9)	85.0 (67.3)	86.0 (68.1)	88.0 (69.7)	47.3 (43.5)	57.3 (49.2)	65.7 (54.1)	70.3 (57.0)	76.3 (60.9)
KB broth	0.0 (0.13)	0.0 (0.13)	1.3 (5.3)	1.7 (60.1)	1.3 (6.5)	2.3 (8.7)	1.3 (6.5)	2.7 (9.4)	1.7 (7.2)	2.0 (7.9)	2.0 (7.9)	2.0 (7.9)	2.7 (9.4)	3.0 (9.9)	2.3 (8.5)	3.0 (9.9)	2.3 (8.5)	3.0 (9.9)	2.7 (9.1)	3.0 (9.6)
Water	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)	0.0 (0.13)

Figures in parentheses are arc sine transformed values.
C 1 - 100 per cent concentration; C 2 - 50 per cent concentration; C 3 - 25 per cent concentration; C 4 - 10 per cent concentration.
H 1 - 24 hours; H 2 - 48 hours; H 3 - 72 hours; H 4 - 96 hours; H 5 - 120 hours.

	SED	CD (0.05)
T (treatment)	0.32	0.62
C (concentration)	0.22	0.44
H (exposure, hours)	0.25	0.49
T × C	0.63	1.25
C × H	0.50	0.99
T × H	0.71	1.40
T × C × H	1.42	2.79

ulations of bacteria in the talc formulations were 2.5-3 $\times 10^8$ cfu/g.

The talc-based formulations of promising *P. fluorescens* isolates were tested against *M. incognita* infesting banana under glasshouse conditions. The experiment was arranged at the Department of Nematology, Coimbatore, during December, 2003 to February, 2004. Tissue culture banana plantlets cv. Robusta obtained from Spic Agro Biotech, Coimbatore, were planted in pots filled with 5 kg of a steam-sterilised pot mixture (Red soil : Sand : Farmyard manure; 2 : 1 : 1) and maintained in the glasshouse. At the time of planting, 10 g of each of the *P. fluorescens* isolates in talc formulation were applied to the soil in each pot and mixed thoroughly. A standard biocontrol product, Pf 1, and the chemical, carbofuran 3G, were also included as treatments at 2 g per plant. Untreated banana plants were maintained for comparison. A completely randomized design was adopted with three replications for each treatment. Five days after planting, freshly hatched, two-day-old juveniles of *M. incognita* were inoculated in the root zone at 5000 J_2/pot. Regular watering was with tap water passed through a 325-mesh sieve. The experiment was repeated during March to May, 2004, to confirm the biocontrol potential of the *P. fluorescens* isolates.

Plant height, shoot weight, pseudostem girth, number of leaves per plant, root length and root weight were measured 90 days after nematode inoculation. The plants were carefully uprooted and root samples were washed free of soil and stained with 0.1% acid fuchsin in lactophenol solution to examine the number of females, egg masses and eggs per egg mass per 5 g root. Nematode populations in soil were determined as per Cobb (1918) and modified Baermann funnel techniques (Schindler, 1961). The gall indices were graded by rating on a 0 to 5 scale (Taylor and Sasser, 1978). All the data were statistically analysed and critical differences determined (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Twenty four native isolates of *P. fluorescens* were obtained from banana rhizospheres. In the roll-towel and pot culture studies, seeds treated with five isolates, *viz.* PfB 22, PfB 23, PfB 21, PfB 17 and PfB 2, all germinated and also produced plants with greater root and shoot length than plants from seed treated with other isolates, leading to enhanced vigour indices compared to the effects of other bacterial isolates (Tables I and II). These five isolates were selected for further studies.

Under *in vitro* conditions, a negative relationship existed between the concentration of the culture filtrates of the promising five isolates and the hatching of *M. incognita* eggs (Table III). The greatest reduction in egg hatch was observed after treatment with PfB 22 at 100% concentration. Nematode mortality also increased with the increase of the concentration of the culture filtrates. Culture filtrate of PfB 22 caused the greatest nematode mortality, at 100% concentration after 72 h of exposure (Table IV).

Similar observations were also made by Becker *et al.* (1998) and Tian and Riggs (2000), who proved the antagonistic effect of culture filtrates of *P. fluorescens* on eggs and juveniles of *M. incognita.* Aalten *et al.* (1998) reported that the presence of secondary metabolites in the culture filtrates was responsible for the nematicidal action.

In the glasshouse, the growth of all the *P. fluorescens* treated banana plants was significantly improved compared to untreated plants. Among the treatments, plants treated with PfB 22 produced the most growth and supported the smallest nematode infestations (Tables V and VI).

Pseudomonas fluorescens is capable of surviving in and colonising the rhizosphere of all field crops and is reported to promote plant growth by secreting auxins, gibberellins and cytokinins (Vidhyasekaran, 1998). Reduction in the multiplication of *M. incognita* by *P. fluorescens* treatment has also been reported in several other crops

Table V. Effect of talc formulations of *P. fluorescens* isolates on the growth of banana cv. Robusta infested with *M. incognita* (mean of two experiments).

Treatment	Plant height (cm)	Shoot weight (g)	Root length (cm)	Root weight (g)	Pseudo-stem girth (cm)	No. of leaves
PfB 2 (10 g/pot)	56.6	202.3	10.9	185.4	10.0	8.3
PfB 17 (10 g/pot)	58.6	260.4	12.1	225.1	10.8	8.5
PfB 21 (10 g/pot)	64.8	257.7	12.9	229.3	11.2	8.9
PfB 22 (10 g/pot)	71.3	286.0	16.3	314.2	14.5	9.4
PfB 23 (10 g/pot)	67.0	282.4	15.1	260.0	11.4	9.3
Pf 1 (10 g/pot)	69.2	282.7	14.9	262.0	12.1	9.2
Carbofuran 2 g/pot	59.5	204.6	11.7	172.6	9.1	9.0
Control	46.2	178.7	9.0	160.0	7.8	6.3
CD (0.05)	5.0	5.3	1.2	6.4	1.2	0.9

Table VI. Efficacy of talc formulations of *P. fluorescens* isolates on *M. incognita* infestation in banana cv. Robusta (mean of two experiments).

Treatment	No. of females/ 5 g root	No. of egg masses/ 5 g of root	No. of eggs/egg mass	Gall Index	Root population (all nematode stages) (5 g)	Soil population of J2 (200 cm^3)
PfB 2 (10 g/pot)	182.5 (13.6)	48.5 (7.8)	255.6 (16.0)	3.3	249.0 (15.8)	400.0 (19.5)
PfB 17 (10 g/pot)	172.7 (13.2)	44.6 (6.7)	260.2 (16.1)	3.0	239.6 (15.3)	368.0 (19.1)
PfB 21 (10 g/pot)	150.8 (12.3)	38.5 (6.3)	232.3 (15.2)	3.0	218.2 (14.9)	333.3 (18.1)
PfB 22 (10 g/pot)	34.5 (5.9)	6.7 (2.6)	189.8 (13.7)	1.5	76.3 (9.0)	212.8 (14.5)
PfB 23 (10 g/pot)	81.1 (9.0)	28.1 (5.3)	205.8 (14.4)	2.3	197.3 (14.1)	299.1 (17.5)
Pf 1 (10 g/pot)	68.7 (9.3)	33.0 (5.7)	208.5 (14.5)	1.8	184.6 (13.5)	280.5 (17.6)
Carbofuran 2 g/pot	142.6 (10.0)	48.5 (7.0)	212.6 (14.6)	3.0	218.8 (14.8)	268.5 (16.3)
Control	222.8 (15.0)	60.5 (7.8)	331.7 (18.4)	4.6	261.6 (16.2)	525.0 (22.8)
CD (0.05)	1.10	1.22	0.64	0.32	0.90	1.93

Figures in parentheses are square root transformed values. CD (0.05) on transformed data.

(Corgan *et al.*, 1985; Jonathan *et al.*, 2000). The suppression of phytonematodes by the application of *P. fluorescens* has been attributed to several mechanisms, such as induced systemic resistance, production of antibiotics and siderophores, competition for nutrients, and alteration of specific root exudates such as polysaccharides and amino acids, which modify nematode behaviour (Oostendorp and Sikora, 1990; Aalten *et al.*, 1998).

Thus, the present study clearly indicated that *P. fluorescens* treatment significantly enhanced banana growth and reduced root-knot nematode populations and that it may be possible to use it as an efficient and eco-friendly bionematicide.

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