Management of *Pratylenchus coffeae* through organic and inorganic amendments

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The root-lesion nematode *Pratylenchus coffeae* is considered one of the economically important nematode pests of banana and is reported to have spread through infested corms. In India, the nematode is known to occur on banana and plantain in all the states of South India, Gujarat, Orissa, Bihar and Assam (Sundararaju 1996). Crop losses caused due to *P. coffeae* in cv. 'Nendran' were reported to be 25.4% (Sundararaju *et al*. 1999). Several chemical products have been developed to manage this nematode, but they are expensive, cause environmental pollution and are health hazards. Organic farming is gaining in importance because of its beneficial effects, notably reduced use of chemical fertilizer and improved soils (better physico-chemical properties and increased beneficial micro flora). Organic amendments and plant residues have been showed to reduce plant parasitic nematodes in several crops (Singh and Sitaramaiah 1973, Vemana *et al.* 1999, Adekunle and Fawole 2002). However, few studies looked at the effect of organic and inorganic fertilisers on plant growth and yield in banana, and on plant parasitic nematodes. In the present study, the effect of organic and inorganic amendments were tested on six commercial cultivars of banana infested with *P. coffeae*.

Materials and methods

The field experiment was conducted over two crop cycles on six commercial cultivars: 'Robusta' (AAA), 'Rasthali' (AAB), 'Poovan' (AAB), 'Nendran' (AAB), 'Karpuravalli' (ABB) and 'Monthan' (ABB). The cultivars were planted in clay soil in a field infested with *P. coffeae* at National Research Centre for Banana (NRCB) farm in Podavur, Trichy. The experiment was laid out in a randomized block design. There were 6 treatments replicated three times with five beds per replication and eight plants per bed. The treatments were:
T1: 25% FYM[1] + 75% inorganic (urea)
T2: 25% neem cake + 75% inorganic
T3: 25% FYM + 25% neem cake + 50% inorganic
T4: 25% FYM + 50% neem cake + 25% inorganic
T5: 25% FYM + green manure + 75% inorganic
T6: 100% inorganic (200 g N/434 g urea)

The banana cultivars were planted at a spacing of 1.8 x 1.8 m. Healthy suckers of uniform size, weighing about 1 kg, were pared to a depth of 1 cm to remove the superficial tissues. In addition to the scheduled treatments, recommended doses of 30 g and 300 g of P_2O_5 and K_2O were applied in all treatments 3, 5 and 7 months after planting. Normal agronomical practices, i.e. weeding, de-suckering and removal of dried leaves, were performed during the plant growth. Nematode population was assessed in soil samples collected before treatment and in soil and root samples collected at the vegetative and harvesting stages. Observations on height, girth, number of functional leaves at flowering, total crop duration and yield were recorded. The root-lesion index was recorded at harvesting using a 1-5 scale (Pinochet 1988). The roots were cut into small pieces and mixed thoroughly. Three aliquots of 10 g were collected from each plant, stained in boiling acid fuchsin lactophenol for 3 minutes, cleared and macerated for 40 seconds using a blender. Nematode populations from 250 cm^3 of soil from each plant were extracted by using Cobb's sieving method. An analysis of variance and a multiple comparison test were performed on the averages.

Results and discussion

The initial population per 250 cm^3 of soil varied between 70 and 245 nematodes. A significant reduction was recorded for all cultivars.

A significant reduction in nematode population was noted at harvest for all the organic applications compared to 100% inorganic treatment (Table 1). Among the cultivars, 'Nendran' was found to be highly susceptible to *P. coffeae*, followed by 'Robusta', 'Rasthali' and 'Poovan', whereas 'Monthan' and 'Karpuravalli' had the lowest levels of nematode infection.

In 'Nendran', 375 nematodes were recorded from 10 g of root at harvest in the 100% inorganic treatment (T6) compared to 130 nematodes per 10 g of roots in the 50% neem cake treatment (T4). The value for the root-lesion index also followed the same pattern (Table 2). Due to the heavy nematode infestation, a ratoon crop was not practiced with 'Nendran'.

The nematode population was moderately high in 'Robusta', 'Poovan' and 'Rasthali'

[1] Farm yard manure.

Table 1. Effect of organic and inorganic fertilization (T1 à T6) on the number of *Pratylenchus coffeae* per 10 g of roots in six commercial cultivars.

	Number of *Pratylenchus coffeae* per 10 g of roots																					
	Robusta				Rasthali				Poovan				Karpuravalli				Monthan				Nendran	
	Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop	
T[1]	VS[2]	H[3]	VS	H	VS	H	VS	H	VS	H	VS	H	VS	H	VS	H	VS	H	VS	H	VS	H
T1	225	195	125	85	210	95	55	35	210	130	100	65	75	65	55	65	55	35	25	15	345	250
T2	240	180	110	65	185	65	30	15	190	110	75	40	25	15	10	40	30	10	10	-	375	310
T3	310	95	75	20	140	20	10	10	175	50	20	-	-	-	-	-	15	-	-	-	365	210
T4	245	60	30	-[4]	120	-	-	-	115	45	10	-	-	-	-	-	-	-	-	-	315	130
T5	270	185	135	95	165	85	60	55	90	95	85	70	30	30	20	70	45	25	15	10	380	320
T6	225	210	190	145	215	125	110	75	245	155	125	110	85	70	60	110	65	50	40	25	410	375
DC[5]	14.9	25.2	43.8	33.3	2.1	34.5	17.9	15.4	40.1	30.3	32.4	22.6	26.9	20.9	14.7	22.6	17.5	3.21	12.4	4.9	25.0	42.2

[1] Treatments (T1: 25% FYM + 75% inorganic (urea); T2: 25% neem cake + 75% inorganic; T3: 25% FYM + 25% neem cake + 50% inorganic; T4: 25% FYM + 50% neem cake + 25% inorganic; T5: 25% FYM + green manure + 75% inorganic; T6: 100% inorganic)

[2] Vegetative stage.

[3] Harvest.

[4] No nematodes found.

[5] Critical difference at P=0.05.

Table 2. Effect of organic and inorganic fertilization (T1 to T6) on the root-lesion index of six commercial cultivars infected with *Pratylenchus coffeae*.

	Root-lesion index										
	Robusta		Rasthali		Poovan		Karpuravalli		Monthan		Nendran
	crop	crop	crop	crop	crop	crop	crop	crop	crop	crop	crop
T1	2.5	1.5	1.5	1.3	2.0	1.5	1.5	1.3	1.3	1.1	3.5
T2	2.5	1.5	1.5	1.3	2.0	1.3	1.2	1.0	1.1	1.0	4.2
T3	1.5	1.3	1.3	1.0	1.5	1.0	1.0	1.0	1.0	1.0	3.2
T4	1.5	1.0	1.5	1.0	1.4	1.0	1.0	1.0	1.0	1.0	2.5
T5	2.5	1.5	1.5	1.5	1.5	1.5	1.3	1.2	1.2	1.1	4.2
T6	3.0	2.5	2.0	1.5	2.5	2.5	1.5	1.4	1.5	1.2	4.5
DC[2]	0.8	0.6	0.7	0.5	0.9	0.3	0.5	0.3	0.3	0.1	0.8

[1] Treatments (T1: 25% FYM + 75% inorganic (urea); T2: 25% neem cake + 75% inorganic; T3: 25% FYM + 25% neem cake + 50% inorganic; T4: 25% FYM + 50% neem cake + 25% inorganic; T5: 25% FYM + green manure + 75% inorganic; T6: 100% inorganic)

[2] Critical difference at P=0.05.

subjected to T6, in both plant and ratoon crops. However, no nematode was recorded in the ratoon crop of the same cultivars subjected to T4. For the 'Monthan' and 'Karpuravalli', absolute control of nematode was observed in the T3 and T4 treatments for both the plant and ratoon crops.

Significant differences between the treatments were observed for all plant growth parameters, except for plant height in the plant crop of 'Karpuravalli' and in the ratoon crop of 'Rasthali' and 'Monthan'; girth and the number of functional leaves at flowering in the ratoon crop of 'Monthan'; and time from planting to harvest in the ratoon crop of 'Karpuravalli'.

Among the six banana cultivars tested, the largest values for height, girth, number of healthy leaves at flowering and the shortest time from planting to harvest were recorded in T4 for 'Nendran' 'Poovan', 'Rasthali' and 'Robusta' and generally T3 for 'Karpuravalli' and 'Monthan'.

Significant differences were recorded in bunch weight and total yield per hectare between the treatments (Table 3). The largest bunch weight and total yield per hectare were recorded in T4 for the plant crop of 'Nendran' and the ratoon crop of 'Poovan', 'Robusta' and 'Rasthali'; and in T3 for the plant and ratoon crops of 'Karpuravalli' and 'Monthan'. The smallest bunch weight and lowest yield were observed in T6 for all cultivars.

The gross and net income, based on the costs of organic and inorganic fertilizers, were compared between the treatments. The lowest costs were observed in T6 and the highest in T4. Production costs were higher with organic fertilization.

For the plant crops of 'Robusta', 'Rasthali', 'Poovan' and 'Nendran' the highest gross income was observed in T4 and the lowest in T6. For the plant crops of 'Monthan' and 'Karpuravalli', T3 provided the highest gross income and T6 the lowest. A similar trend in gross income was observed for the ratoon crops of all the cultivars except 'Nendran'. But although the highest gross incomes were recorded in T4 or T3, the best benefit to cost ratio were usually observed in T6 and the worst in T4. The reason is probably the higher cost of organic fertilizers which are included in all treatments, except T6.

Table 3. Effect of organic and inorganic fertilization (T1 to T6) on the yield (Y) and benefit to cost ratio (B/C) of six commercial cultivars.

	Robusta				Rasthali				Poovan				Karpuravalli				Monthan				Nendran	
	Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop		Ratoon crop		Plant crop	
T[1]	R[2]	B/C	R	B/C	R	B/C	R	B/C	R	B/C	R	B/C	R	B/C	R	B/C	Y	B/C	Y	B/C	Y	B/C
T1	41.7	2.4	45.6	3.5	33.1	1.9	36.1	32.8	37.7	2.2	40.6	2.7	50.7	2.5	46.4	3.1	43.5	2.6	45.3	3.5	24.8	1.9
T2	42.8	2.1	44.9	3.0	33.3	1.7	38.2	2.6	39.2	1.7	41.6	2.4	48.2	2.1	49.5	2.8	46.6	2.3	46.2	3.1	26.3	1.7
T3	43.3	2.0	47.9	3.0	35.3	1.7	38.1	2.4	42.6	1.7	43.2	2.3	54.7	2.2	53.6	2.9	49.7	2.3	49.1	3.1	29.5	1.8
T4	48.8	1.9	52.8	2.8	39.8	1.6	43.6	2.3	45.1	1.6	46.9	2.1	51.8	1.8	51.8	2.4	48.5	1.9	48.6	2.6	32.4	1.7
T5	44.7	2.5	45.5	3.4	33.6	1.9	37.1	2.9	42.6	2.1	43.1	2.8	48.5	2.3	48.1	3.1	43.5	2.5	45.5	3.4	27.0	2.0
T6	41.6	2.6	43.2	3.5	32.4	2.0	35.0	2.9	38.6	2.0	37.4	2.6	46.2	2.4	44.8	3.2	43.5	2.7	43.8	3.5	21.8	1.8
DC[3]	2.3		3.3		2.18		3.8		2.9		2.9		1.1		3.7		2.3		2.3		0.03	

[1] Treatments (T1: 25% FYM + 75% inorganic (urea); T2: 25% neem cake + 75% inorganic; T3: 25% FYM + 25% neem cake + 50% inorganic; T4: 25% FYM + 50% neem cake + 25% inorganic; T5: 25% FYM + green manure + 75% inorganic; T6: 100% inorganic).

[2] Yield (tonne/ha).

[3] Critical difference at P=0.05.

The present findings agree the results of Echevery Navarro (2001).

The results indicate that the integration of organic, inorganic and green manure is more effective in reducing the nematode population and subsequently increasing plant growth and yield than the inorganic treatment. Significant reductions in the number of nematodes and time from planting to harvest, and increases in plant growth, bunch weight and yield were recorded in T4, followed by T3. Though organic amendments significantly reduced nematode numbers and increased plant growth in the six banana cultivars tested, the impact on plant growth, time from planting to harvest and bunch yield varied significantly between the cultivars. 'Nendran' was found to be heavily infested with *P. coffeae*. 'Robusta', 'Poovan' and 'Rasthali' were similar to each other, whereas absolute nematode control was observed in 'Monthan' and 'Karpuravalli' subjected to treatments T3 and T4. The application of neem cake increased vegetative growth and yield and significantly reduced the number of nematodes compared to T6.

The present study demonstrates the combined effect of nitrogen applied through the combination of farm yard manure, neem cake, green manure and urea in controlling *P. coffeae* on banana. Channabasappa (1994) has similarly reported that the integration of neem cake, carbofuran, mycorrhizae (*Glomus mosseae*) and bacteria was effective in increasing height, girth, number of leaves, leaf area, maximum root length, fresh and dry root weight of banana. Channabasappa (1994) and Shivakumar (1995) reported that application of neem cake, carbofuran, *Pasteuria penetrans* and *G. fasciculatum* significantly reduced the population of *Radopholus similis*, a migratory endoparasite. Reddy *et al.* (1997) observed that integrating oil cakes, like castor karanji and neem, had a profound effect on the yield of banana by suppressing *R. similis* in field conditions. Integrating oil cakes, like neem and pongamia, with bioagent, *Trichoderma viride* lowered the number of *R. similis* in the soil and banana roots (Harish and Gowda 2001).

In conclusion, the highest numbers of nematodes were recorded in treatments where neem cake was not applied. Thus, neem cake, along with farm yard manure as an organic source of fertiliser, was found to be very effective in controlling nematodes as well as increasing yield compared to inorganic fertilization. Though the cost of organic fertilization was higher than that of inorganic fertilization, the total yield was significantly higher with organic fertilization. T4 was the most effective treatment, followed by T3.

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