Status report on *Musa* nematode problems and their management in India

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Introduction

Banana is known to adapt very quickly and produce higher yields under favourable conditions. It is, however, prone to attack by different pathogens like fungi, viruses, bacteria and nematodes. Among the production constraints, nematodes constitute one of the major limiting factors to banana production, causing extensive root damage, resulting in serious economic losses. Crop losses caused by nematodes to bananas are very high, with average annual yield losses estimated at about 20% worldwide (Sasser and Freckman 1987). This country paper deals with the important nematode problems of banana in the country with special reference to their distribution, crop losses, symptomatology and the integrated nematode management approach including host reaction of different genotypes.

Distribution of banana

India has emerged as the largest producer of banana in the world with a total production of 16.9 million tonnes per annum from 49 000 hectares, having a share of 37% of the total fruit production (Singh 2002). The major banana-growing states are Tamil Nadu, Andhra Pradesh, Kerala, Karnataka, Gujarat, Maharashtra, Bihar, West Bengal and Assam. Other states have limited area and production. Among the states, Tamil Nadu has the maximum area with 83 255 ha with an annual production of 300 700 tonnes (Anonymous 2002), whereas Maharashtra tops the list with the highest productivity of 48 t/ha, followed by Tamil Nadu with 44t/ha.

Major nematode pests of banana

A total of 132 species of nematodes belonging to 54 genera have been reported to be associated with the rhizosphere of banana. Out of these, 71 species of nematodes belonging to 33 genera have been recorded from banana in various parts of India. The important nematode problems encountered in banana are the burrowing nematode, *Radopholus similis*, followed by the root-lesion nematode, *Pratylenchus*

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coffeae. The other economically important nematode pests of banana, which have some regional differences, are the spiral nematodes *(Helicotylenchus multicinctus and H. dihystera),* the root-knot nematodes *(Meloidogyne incognita and Meloidogyne javanica*), the cyst nematode *(Heterodera oryzicola)* and the reniform nematode *(Rotylenchulus reniformis)*. Individual nematode problems on banana and their management are discussed in detail in this country paper.

Nematode survey on economically important banana genotypes in India

An extensive survey was undertaken to examine the biodiversity in plant-parasitic nematodes associated with banana from 1997 to 2002. A total of 220 soil and root samples were collected from various varieties of banana, namely Nendran, Red banana, Robusta, Dwarf Cavendish, Ney Poovan, Poovan, Rasthali, Pachanadan and Jahazi. These varieties are grown in different agro-climatic conditions in South India, Gujarat, Maharastra, Bihar and North Eastern hilly regions of India. The nematode populations were assessed (Table 1). Analysis of the root samples revealed that the root-lesion nematode was the predominant species and ranked first in prominence and importance values. This was followed by the root-knot nematode, the spiral nematode and the burrowing nematode. The cyst nematode was reported for the first time in Robusta in Tamil Nadu (Sundararaju *et al*. 2001). Analysis of soil samples collected from bananas revealed the presence of 17 genera of plant-parasitic nematodes. Among them, *R. reniformis*, *Helicotylenchus* spp., *Meloidogyne* spp., *Hoplolaimus* spp., *P. coffeae*, *Tylenchorhynchus* spp., *Criconemoides* spp. and *Tylenchus* spp. were the

Table 1. Occurrence of major plant-parasitic nematodes recorded in major banana-growing states of India.

State	No. of samples	No. of samples containing the following species			
		Radopholus similis	*Pratylenchus coffeae*	*Meloidogyne incognita*	*Helicotylenchus multicinctus*
Tamil Nadu	122	10	74	38	41
Pondicherry	10	0	4	4	2
Kerala	26	12	5	5	6
Andra Pradesh	6	0	4	3	3
Karnataka	12	0	6	8	4
Gujarat	7	4	2	2	0
Maharashtra	9	4	0	3	4
NEH Regions	28	0	4	1	12
Total	220	30	99	64	68

Table 2. Occurrence, absolute frequency and relative frequency of plant-parasitic nematodes recorded from 250 g soil sample in major banana-growing states of India.

Species	No. of samples	Absolute frequency (%)	Relative frequency (%)
Aphelenchus sp.	21	9.5	3.7
Aphelenchoides sp.	15	6.8	2.7
Criconemoides sp.	15	6.8	2.7
Helicotylenchus multicinctus	49	22.3	8.7
Heterodera oryzicola	47	9.5	3.7
Hemicriconemoides sp.	21	21.4	8.4
Hirschmanniella sp.	13	5.9	2.3
Hoplolaimus indicus	35	15.9	6.2
Longidorus sp.	31	14.1	5.5
Meloidogyne incognita	65	29.5	11.6
Pratylenchus coffeae	70	7.7	3.0
Radopholus similis	28	12.7	5.0
Rotylenchulus reniformis	95	18.6	7.3
Rotylenchus sp.	41	43.2	16.9
Tylenchus sp.	25	11.4	4.5
Tylenchorynchus sp.	32	11.4	4.5
Xiphinema sp.	18	8.2	3.2
TOTAL	**220**	**100**	**100**

most predominant species associated with banana. The analysis of plant-parasitic nematodes such as frequency, density and prominence value were also calculated and presented in Table 2 (Sundararaju *et al*. 2002).

The burrowing nematode, Radopholus similis

Radopholus similis enjoys a wide geographical distribution in the tropical and subtropical banana-growing regions of the world. In India, the first occurrence of the nematode was reported on banana from Palghat District of Kerala (Nair *et al*. 1966). Subsequently, this nematode was reported from banana in almost all banana-growing states in the country, including the isolated pockets like Andaman and Lakshadweep Islands. Economic loss due to the nematode infestations was estimated at 50% when the nematode load was 3000 per plant (Davide and Marasigan 1985). A density of 10 000 nematodes per 100 g root was reported to be the damaging level in Central America (Volkers and Gamboa 1988). In India, *R. similis* infestation on banana is responsible for 31-41% yield loss in banana (Nair 1979). The survival and multiplication of the nematode deep in the cortex of rhizomes or planting material helped in its faster spread to new areas. The suckers removed for transplanting from nematode-infected banana clumps and planted in new areas produced infected plants. The transmission of the organisms is therefore presumed to be through suckers used for propagating the crop vegetatively.

The root-lesion nematode, Pratylenchus coffeae

Pratylenchus coffeae is the next most important nematode to the burrowing nematode. In India, crop losses due to root-lesion nematode in banana cv. Nendran was reported to be 44.4% (Sundararaju *et al*. 2003). The nematode is reported to have spread to different banana-growing regions through the infested corm, with various intensities in different soils. In India, the nematode is known to occur on plantain (AAB) in South India, Gujarat, Orissa, Bihar and Assam. *Pratylenchus thornei*, another important species, was found to infest banana plants from Assam only. The nematode also spreads like burrowing nematode from one locality to another through the planting materials, as well as through the water that drains from infested areas to non-infested areas. This nematode has more similarities with *R. similis* and often, its damage is attributed to *R. similis*. Since the lesion-producing nematodes such as *R. similis* and *P. coffeae* are considered to be the economically important nematode pests of banana and are widely distributed in South India (Koshy *et al*. 1978; Sudha and Sundararaju 1996), studies were initiated to determine the seasonal fluctuations of these nematode populations in different cultivars of banana roots. This was done through the periodic sampling of nematode-infested banana plants at NRCB Farm. The results revealed that maximum population was recorded in the months of October to December and minimum during the months of March to August. Cultivars Nendran and Kalyan Bale were found to be highly susceptible to *P. coffeae* and *R. similis*, respectively (Sundararaju 2002). Studies were also conducted to find out the effect of different soil types, namely alluvial, sandy loam, silty clay, black soil, laterite and red soil on the multiplication of *P. coffeae* and growth of banana plants. The results revealed that maximum plant growth was noticed in alluvial soil followed by sandy loam soil, whereas minimum plant growth and maximum root-lesion index were noticed in silty clay soil. The reproduction factor of nematode population based on root lesions and final root and soil population was maximum in silty clay soil followed by alluvial soil while minimum nematode population was recorded in red soil. The multiple regression equations pertaining to the soil's physico-chemical properties versus nematode populations in both soils and roots were derived (Sundararaju and Jeyabhaskaran 2002).

The root knot nematode, Meloidogyne incognita

Meloidogyne incognita was found to attack banana roots and has wide distribution in major banana-growing regions in the country (Rajendran *et al.* 1979; Tiwai and Dave 1985), whereas *M. javanica* is confined mainly to mid hills and plains where the temperature is higher. The root-knot nematode is highly pathogenic to Poovan banana causing 30.9% yield loss in Tamil Nadu (Jonathan and Rajendran 2000). Since root-lesion and root-knot nematodes jointly affect banana and cause considerable yield loss, studies were initiated to know about the penetration and development of *P. coffeae* and *M. incognita* in susceptible cultivars of banana, namely Nendran and Poovan. The time taken by the root-lesion nematode to penetrate into the roots of a banana was 48 hours in cv. Nendran and 72 hours in cv. Poovan. A similar trend was observed in the case of the root-knot nematode. The multiplication of nematodes was more favoured in cv. Nendran than in Poovan. This suggests that cv. Nendran is more susceptible to both nematodes when compared with Poovan (Sundararaju *et al.* 2002).

The spiral nematode, Helicotylenchus multicinctus

Helicotylenchus multicinctus has been found to infest all varieties of banana throughout the tropics and subtropics. Among the 17 *Helicotylenchus* species reported to occur on banana, *H. multicinctus, H. dihystera, H. africanus and H. erythrinae* are the most important pests in banana, causing severe economic loss. *Helicotylenchus multicinctus* was the major nematode problem in subtropical regions such as Israel and Taiwan where *R. similis* is absent. It caused a serious decline of banana and was responsible for 33.83% loss in yields. The pathogenicity of *H. multicinctus* on banana studied in a pot-culture experiment revealed that plant growth was significantly reduced at 1250 nematodes per plant (Rajendran and Sivakumar 1996).

Studies carried out on the biochemical alterations in 28 accessions of banana plants grown under nematode-infested soil under field conditions revealed that higher levels of tannic acid (phenol), sugars, amylase, cellulose, protein and chlorophyll were recorded in cv. Gros Michel and lower levels in FHIA-23, whereas the remaining germplasm had similar levels (Sundararaju *et al.* 2002).

The nematode population build-up was studied in banana cv. Robusta (AAA) cultivated in different systems such as single row, paired row and three suckers per hill. Analysis of the root samples revealed the presence of *P. coffeae, M. incognita* and *H. multicintus*. Maximum populations of all three nematodes were recorded in the system with three suckers per hill with a fertigation level of 50% N and K, whereas in paired-row system, minimum nematode population was recorded in both soil and root samples (Sundararaju *et al*. 2002).

The cyst nematode, Heterodera oryzicola

Heterodera oryzicola is an important nematode found in banana cv. Nendran in Kerala. It was found that an initial inoculum of 100 to 1000 viable cysts per plant at planting time could reduce the bunch weight by 20.5-56.5%. Another important species, which attacks on banana is *H. oryzae*. The pathogenecity of *H. oryzicola* in banana was studied by Charles and Venkitesan (1993). They reported that all the growth characteristics and fruit yield were reduced in nematode-inoculated plants. *Heterodera oryzicola* increased leaf nitrogen, reduced sugars in fruit and decreased non-reducing sugars. The total sugar content was less in the fruit of infected plants. This nematode was recorded from cvs. Robusta and Nendran in Tamil Nadu (Sundararaju *et al*. 2002).

Nematode fungal complex disease on banana

Fusarium wilt disease caused by *Fusarium oxysporum* f.sp. *cubense* (FOC) is recognized as one of the most widespread and destructive plant diseases in the recorded history of agriculture (Simmonds 1966). It also still remains as a major constraint to banana production worldwide (Ploetz *et al.* 1990). Fusarium wilt is often present together with plant-parasitic nematodes such as *P. coffeae* and *M. incognita* and causes serious economic losses to several crops in India. Since these two nematodes cause considerable yield loss to banana and are closely associated with FOC, an investigation was carried out in order to find out the individual and interactive effects of nematodes (*P. coffeae* and *M. incognita*) along with the fungal pathogen (FOC) in banana cv. Rasthali (AAB). The results revealed that the plants inoculated with nematodes either singly or in combination followed by fungus led to the early onset and increased severity of the fusarium wilt disease. Maximum reduction of plant growth was observed when all three pathogens (FOC, *P. coffeae* and *M. incognita*) were present together compared with when only one or two pathogens were inoculated. This indicates a positive interaction among all three pathogens (Sundararaju and Thangavelu 2001).

Nematode management

Non-chemical methods

Effective prophylactic measures are of considerable importance to reduce the initial inoculum level and to curb their progressive multiplication by intercropping and by some appropriate cultural practices. Nowadays, non-chemical methods are receiving greater attention in view of the cost of chemical control and the pollution potential of the soil environment. Different non-chemical methods for controlling nematodes on banana are carried out at NRCB as well as in other institutions. These are as follows:

Cultural methods

Rajendran *et al.* (1979) found that fallowing for a period of 3 months after banana harvest effectively suppressed the burrowing nematode population, while fallowing for 5 months destroyed not only burrowing nematode but also *Fusarium* sp. Crop rotation with rice, sugarcane, green gram or cotton suppressed the nematode population and increased the yield of banana. Intercropping banana with *Crotalaria juncea* was found to reduce *R. similis* population, besides causing better growth and higher yield (Venkitesan and Charles 1983). Soil covered with black polyethylene, sugarcane trash and banana trash were also reported to reduce *R. similis* and *Pratylenchus* sp. in the soil and roots of banana (Bhattacharya and Rao 1984). Subramaniam and Selvaraj (1990) reported that the application of carbofuran at planting and intercropping with *Tagetes, Crotalaria* or radish significantly reduced the *R. similis* population, with carbofuran having the greatest effect. Jonathan *et al.* (2000) studied the effect of organic amendments on the management of root-knot nematode and the spiral nematode on banana. This resulted in a significant reduction in the nematode population and an increase of yield in plants treated with press mud (a by-product from sugar factory) (15 t/ha) or neem cake (1.5 t/ha). The organic amendments were comparable with the carbofuran treatment. Shanthi *et al.* (2001) reported that sunhemp intercrop in banana field was found to be effective in reducing *R. similis, P. coffeae* and *H. multicinctus* population to 38%, followed by marigold and cowpea which recorded 29% and 22% reduction, respectively. However, the effect of carbofuran 3G and monocrotophos 0.05% were found superior in increasing the fruit yield (47% and 43%, respectively) and reducing the nematode population by 56% and 46%, respectively.

A field experiment was conducted in farmer's field on cv. Nendran (AAB) using intercrop *Tagetes* spp. in comparison with the recommended practice of paring of suckers, and with Monocrotophos 36 EC dipped at 0.05% at the time of planting. Results showed that significant reduction in root-lesion nematode population (85%) was observed in the banana field where *Tagetes erecta* was grown as intercrop, followed by Monocrotophos dip treatment (75%), whereas maximum nematode population was recorded in untreated control plants. Further, the yield of banana significantly increased (12 kg/plant) when intercropped with *Tagetes* spp., compared with the untreated control (9 kg/plant) (Sundararaju *et al.* 2002).

The effect of organics and inorganics for management of root-lesion nematode, *P. coffeae* was studied in six commercial cultivars of banana *viz.*, Nendran, Karpuravalli, Rasthali, Robusta, Monthan and Poovan. The results revealed that a significant reduction in *P. coffeae* population and increase in yield were recorded in plants which received 50% N applied through neem cake (Sundararaju and Kumar 2002). An attempt was also made to study the best treatment and variety based on nematode population on banana using artificial networks (Sundararaju *et al.* 2002). They studied the population pattern of plant- parasitic nematodes from a field trial carried out on locally available organic manures in banana cv. Karpuravalli (ABB). Analysis of soil and root samples revealed the presence of *P. coffeae, M. incognita, H. multicinctus* and *H. oryzicola*. All four nematodes were found to be significantly lower in plants which received distillery sludge at 2.5 kg + vermicompost at 1 kg + neem cake at 1 kg + poultry manure at 2.5 kg at 3, 5, 7 months after planting compared with control plants. It was also at par in treatment with distillery sludge at 2.5 kg + 1 kg neem cake applied at the same time intervals. The root-lesion and root-gall indices were higher in control plants registering 4.0 and 3.7, respectively. Thus, the present study exhibits the significant role of organic amendments in the nematode management strategies on banana (Sundararaju *et al.* 2002).

An investigation was also carried out for the management of major nematodes infesting banana, namely *P. coffeae* and *M. incognita,* using different neem formulations (Econeem, Nimbicidine and Neemgold) and plant growth promoter (Biovita). These were then compared with the standard treatment (Carbofuran 3 G). The results revealed that all treatments were found effective in reducing the nematode population with enhanced plant growth compared with control plants. Among the three neem formulations evaluated, Econeem and Nimbicidine showed maximum efficacy in reducing the nematode population with increased plant growth. However, the plants treated with Carbofuran 3G recorded the maximum plant growth with absolute control of nematode population. Maximum bunch weight of 18 kg was recorded in plants treated with Carbofuran at 50 g/plant and Biovita at 30 ml/plant applied twice a year. Meanwhile, 17 kg, 16 kg and 15 kg bunch weight was recorded with respect to Biovita at 20 g/plant, Carbofuran at 40 g/plant and Neemgold at 10 and 20 g/plant, Biovita at 15 ml/plant and Nimbicidine at 30 ml/plant. Thus, both nematodes not only delayed the duration of crop cycle but also limited the yield up to 44.4% in cv. Nendran (Sundararaju and Cannayane 2003).

A field experiment carried out for the management of *P. coffeae* using press mud recorded significant reduction in nematode population and increased plant growth as compared to the control. However, press mud application was at par with Carbofuran treatment. The use of press mud is economical and environmentally safe as compared to chemical nematicides (Sundararaju *et al.* 2002).

Another experiment was carried out with locally available plant species against *P. coffeae* under *in-vitro* conditions. Among the ten plant extracts tested, *Azadirachta indica* (Neem tree) exhibited maximum mortality of *P. coffeae* when exposed to 20 h at 80% concentration of plant extract. This was followed by *Vitex negundo* and *C. juncea* (Sundararaju and Cannayane 2002). These plant species were further tested using their dry and fresh leaves against the root-lesion nematode, *P. coffeae* in banana cvs. Nendran and Rasthali under field conditions. All the botanicals were effective in reducing the nematode population and significantly increased the plant growth and yield compared to untreated control. Among the different botanicals tried, *A. indica, Calotropis procera, Datura stramonium, C. juncea* and *V. negundo* were found to be superior and effective in significantly reducing the nematode population and increasing the yield (Sundararaju *et al*. 2003).

Biocontrol agents

Management of banana nematodes with the use of synthetic nematicides poses several problems like ground-water pollution, effect on beneficial organisms, resurgence of pest, etc. Biomolecules having an antagonistic effect on target nematodes is one such approach to solve the aforementioned ill effects of chemical nematicides (Sundararaju 2000). Fungi that colonize the healthy roots exhibiting antagonistic effect to invading nematodes are termed as endophytic fungi. This fungi are regarded as the best alternative to manage banana nematodes.

Studies were further undertaken to isolate endophytic fungi from 12 accessions belonging to different genomic groups of banana; and to evaluate its bio-efficacy on *P. coffeae* and *M. incognita* under *in-vitro* conditions. The endophytic fungi isolated from banana were identified as *Fusarium* spp and their biocidal effects on *P. coffeae* and *M. incognita* were studied. The culture filtrates of endophytic fungi isolated from diploids exerted higher nematicidal effect than those isolated from triploids *in vitro*. The nematicidal effects of endophytic fungi on *P. coffeae* and *M. incognita* juveniles were increased with increasing exposure period to the culture filtrates (Sundararaju *et al.* 2002).

An attempt was made to mass-produce the nematode egg-parasitic fungal bioagent, *Paecilomyces lilacinus*, on banana wastes (leaf, petiole and pseudostem), castor and pungam leaves and their combinations and a standard check with pre-soaked sorghum grains. Highest spore load of 8 x 10^6 *P. lilacinus* per g of substrate was harvested in sorghum grains, banana petiole and castor leaf mixture. Banana pseudostem and pungam leaves were comparable in their substrate nature to the fungus (Sundararaju and Cannayane 2002). The root-knot nematode was recorded for the first time in an ornamental banana, *Ensete superbum*. The eggs of root-knot nematode were parasitized by the fungus naturally and the fungus was identified as *P. lilacinus*. Although *P. lilacinus* has been reported to be a potential egg pathogen of root-knot nematodes, the present isolate has shown its antagonistic effect on root-knot nematode (Sundararaju *et al.* 2003).

Jonathan and Rajendran (2000) reported that the application of *P. lilacinus* at 15 or 20 g per plant significantly reduced the root gall index, number of egg masses, eggs per mass, females and soil population of *M. incognita* in banana cv. Poovan under greenhouse conditions. The effect of this treatment was comparable with 40 g Carbofuran per plant. *Paecilomyces lilacinus* applied at 30 g/kg of soil at planting (30 days before nematode inoculation) was comparatively effective in controlling the population of *R. similis* in banana (Devarajan and Rajendran 2001). Devarajan and Rajendran (2002a) reported that the greatest reduction in the population of *M. incognita* infesting banana cv. Robusta was obtained with the highest level of application of *P. lilacinus* (30 g/kg of soil) during planting compared with 10, 20 g/ kg of soil during planting or at 30 or 60 days after planting, respectively. Field and greenhouse experiments were conducted by using different doses of bio-agent, *Trichoderma viride* on susceptible cultivars viz., Virupakshi and Rasthali. Significant yield increase and reduction in nematode population were noticed from the treated plants. The effect of *T. viride* on the growth of cv. Rasthali infected with root-lesion nematode, *P. coffeae* and fungus, *F. oxysporum* f.sp. *cubense* in pots under the greenhouse conditions showed a significant reduction in nematode population. Two applications of biocontrol agent, *T. viride* at 20 g/plant: one at the time of planting and one after 3 months of planting, were found effective in controlling nematodes (*P. coffeae* and *M. incognita*) as well as in reducing the incidence of panama wilt disease in cvs. Rasthali and Virupakshi (Sundararaju *et al.* 2001).

An experiment on the effect of *Verticillium chlamydosporium* culture filtrates on second-stage juveniles and eggs of *M. incognita* was carried out under *in-vitro* conditions. The results revealed that the marked deleterious effect of culture filtrates (25, 50, 75 and 100%) were observed on *M. incognita* second-stage juveniles. Among the different dilutions of *V. chlamydosporium* culture filtrates, 100% concentration of the fungus-culture filtrate showed highest percent mortality of *M. incognita* juveniles (78.7%). The nematode egg-parasitic fungus, *V. chlamydosporium,* was also multiplied on the locally available organic substrates like farm yard manure (FYM), neem cake, wheat bran, cumbu grains, banana wastes (petiole, leaf and pseudostem) and sorghum grains. It was observed that neem cake showed profuse growth of the fungus when compared with the rest of the substrates (Sundararaju *et al.* 2003).

Chemical methods

Since the root-lesion nematode causes serious decline and considerable yield loss in banana, a field experiment was conducted in fields heavily infested with root-lesion nematode on three commercial cultivars of banana *viz.*, Karpuravalli (ABB), Monthan (ABB) and Nendran (AAB). This was done by using two nematicides *viz.*, Monocrotophos and Carbofuran, at different doses and at different periods of application, along with the recommended practice of paring and pralinage of the suckers. Results revealed that both chemicals applied at different periods were found to be effective in reducing the nematode population and in significantly increasing plant growth and yield compared with untreated control. Some treatments were found to be very effective in reducing the nematode population and significantly increasing the yield of Karpuravalli, Monthan and Nendran (26.0 kg, 22.3 kg and 9.9 kg, respectively) compared with untreated control (16.2 kg, 15.1kg and 4.7 kg, respectively) (Sundararaju *et al.* 1999). Among these are the combination of sucker dip with Monocrotophos at 0.5%, Bavistin at 0.1% followed by Carbofuran at 50 g/plant applied at 3 and 6 months after planting or application of Carbofuran at 50 g/plant once at the time of planting in the pit or dipping of the suckers with mud slurry and sprinkling with Carbofuran at 50 g/sucker and two applications after planting at 3-month intervals.

Integrated nematode management

Chennabasappa (1994) reported that the integration of neem cake (400 g/plant), Carbofuran (20 g/plant), mycorrhiza (500 chlamydospores/plant) and *Pasteuria penetrans* (100 g soil containing an average of 20 *P. penetrans)* infected second-stage juveniles of *M. incognita* race I (each of which had an average of 15 spores attached to their cuticle) and were effective in improving the growth parameters of the banana plant, besides giving the highest reduction in nematode population in root and soil as well as a reduction in the lesion index. Parvatha Reddy *et al.* (1996) found that by integrating eco-friendly components such as oil-seed cakes of castor, karanj and neem at 400 g/plant with endomycorrhiza *Glomus mosseae* (containing 25 chlamydospores per g of inoculum) reduced the population of *R. similis* both in soil and roots and increased plant-growth parameters and fruit yield of banana. Roy *et al.* (1998a) reported that dipping disease-free banana suckers in 0.2% solution of Bavistin for 45 min was effective in reducing disease intensity of wilt complex disease (*F. oxysporum*, *Pseudomonas solanacearum* and *M. incognita*). Other effective measures were flooding and application of inorganic fertilizers (NPK at 225, 75 and 60 kg/ha, respectively) in soil, which amended with organic compounds like compost or oil-seed cake and pesticides.

Vidya and Reddy (1998) reported that the integration of neem cake (neem extracts), Carbofuran, *P. penetrans* and *Glomus fasciculatum* was the most effective in enhancing the plant growth and yield of banana, raising the cost:benefit ratio to 1:2.65, and reducing the *R. similis* population both in soil (95.16%) and roots (89.27%). Ravi *et al.* (2000) reported that integration of 250 g neem cake, 20 g *T. viride* and Carbofuran 3G at 10 g/sucker resulted in the reduction of *R. similis* population in soil and roots of banana.

Investigations were carried out on the management of the burrowing nematode, *R. similis*, infesting banana cv. Dwarf Cavendish, by integrating eco-friendly components such as oil cakes (neem and pongamia, each at 500 g/plant), a biological control agent (*T. viride* at 10 g/plant) and a nematicide (carbofuran 3G at 40 g/plant). Among the different treatments, combination of neem cake, Carbofuran and *T. viride* was most effective in reducing the nematode population, improving plant growth and increasing fruit yield (76.3 t/ha) with wider cost:benefit ratio (1:2.9) (Harish and Gowda 2001). Kumar (2001) reported that the *R. similis* population in soil and root was significantly reduced when the banana plants were treated with Carbofuran 3G at

Host reaction of different genotypes

Table 3. Reaction of *Musa* clones for nematode resistance.

Musa clones	Host response	Nematode spp.	Reference
Kadali, Padalimoongil, Ayiranka Poovan, Peykunnan, Vennettukunnan, Tongat, Anaikomban	R	*R. similis*	Rajendran *et al.* 1979
Amas, Senora, Bunga, Lacatan, Alaswc, Dadakan	R	*R. similis,* *M. incognita*	Davide and Marasigan 1985
Yelakkibale	R	*M. incognita*	Ravichandran and Krishnappa 1986
Karpooravalli	T	*R. similis*	Kulasekaran 1986 Subramaniyan and Selvaraj1990
Patkapura, Mendhi, Kothia	HR	*R. similis*	Ray and Parija 1987
Anaikomban	R	*R. similis*	Sathiamoorthy 1987
Bantala, Dwarf Cavendish	MR	*R. similis*	Ray and Parija 1987
Padali Moongil, Kunnan, Ayiramka Poovan	R	*R. similis*	Saeed *et al.* 1988
Athia	T	*H. dihystera*	Choudhury and Phukan 1990
Kunnan, Poom Kadali, Nalli Poovan	R	*R. similis*	Anitha *et al.* 1996
Palayankodan	MR	*R. similis*	Sudha and Sundaraju 1996
Anaikomban, Adakkakunnan, Kunnan	T	*R. similis*	Johnson and Sathiamoorthy 1999
Ambalakadali, Anaikomban, Eraichivazhai, Paka, Pisang Jari Bouya, Manoranjtham, Chinali	MR	*R. similis, P. coffeae* and *H. multicinctus*	Elain Apshara 2000
Pisang Lilin, Sannachenkadali Co-1, Cheenabale, Dakshinsagar, Kalibow, Kerala – 1, Krishnavazhal, Mysore, Neyvazhai, Sandanavazhai, Thiruvananthapuram, Vannan, Ladan Klue Teparod (ABBB), Bodles Altafort (AAAA), Neyvannan x *M.balbisiana* (ABBB)	T	*R. similis, P. coffeae* and *H. multicinctus*	Elain Apshara 2000
Matti, Kullan, Chinali, Nallabontha, Burharia	MR	*R. similis, P. coffeae* and *H. multicinctus*	Shanthi *et al*. 2001
Anaikomban, Namarai, H 59, H 65 Tongat, H 84, H 109, H 110	MR R	*R. similis* and *P. coffeae*	Devarajan and Rajendran 2001
Agnieswar, Mottapoovan, CO.1, Neyvazhai, Vannan, Ladan Padathi, Melakali, Cheenabale,	T	*R. similis, P. coffeae* and *H. multicinctus*	Shanthi *et al*. 2002
Nendrakunnan, Lambi, Batheesa Ashy, Alshi, Neyvannan, Sambarani, Boothibale, Rajavazhai, Beula, Kanthali, Kothia and Muthia	T	*R. similis, P. coffeae* and *H. multicinctus*	Shanthi *et al*. 2002
Pisang Mas, Pisang Berlin, Kanaibansi, Namarai, Cultivar Rose	T	*P. coffeae*	Sundararaju *et al*. 2002
Namarai, Hatidat	R	*H. multicinctus*	
Burrow Cemsa and hybrid E.A.0322 FHIA-01 in Pome group	R	*R. similis, P. coffeae, M. incognita* and *H.multicinctus*	Sundararaju and Uma 1999

R=resistant; MR=medium resistant; T=tolerant

40 g/sucker followed by *Pseudomonas fluorescens* at 6.25 kg/ha with FYM 500 kg/ha and neem cake 500 kg/ha. The fruit yield was increased by 165.40 kg/40m^2 in Carbofuran 3G at 40g/sucker followed by *T. viride* 2.5 kg/ha with FYM 500 kg/ha (147.25 kg/m^2).

A field experiment conducted with banana cv. Basrai in root-knot nematodes (*M. incognita and M. javanica)* infested field showed that the combined application of *P. lilacinus* (25 kg/ha) and Carbofuran (33 kg/ha) recorded the significantly lowest root-knot index (1.8), with higher plant height and better growth, and also gave the highest fruit yield of 42 t/ha (Vyas *et al.* 2001).

IMTP Phase – III

Twenty one hybrids and cultivars of banana were screened for their reaction to *P. coffeae*, *M. incognita* and *H. multicinctus* in pots under greenhouse conditions as part of IMTP Phase-III. Twenty-one cultivars were found susceptible to root-knot nematode, *M. incognita,* in various intensities. For the root-lesion nematode, *P. coffeae,* 19 out of 21 cultivars were susceptible. This nematode was not recorded in two cultivars, namely Kanai Bansi and GCTCV-215. However, these cultivars are found susceptible to two other nematodes, *M. incognita* and *H. multicinctus.* Similarly, this spiral nematode, *H. multicinctus,* was recorded in 15 out of 21 cultivars in various intensities. Anaikomban, Pisang Berlin, Namarai, Hatidat, FHIA – 03 and Pisang Ceylan did not show symptoms of *H. multicinctus* infection but these cultivars were found susceptible to *P. coffeae* and *M. incognita.* Hence, none of the cultivars tested against these three nematodes were found resistant (or immune).

Future perspectives

1. Development of nematode-resistant cultivars either by conventional breeding or by genetic engineering using identified resistant banana varieties.
2. Identification of effective trap or antagonistic crops with economic value to reduce the severity of nematode problem.
3. Study the nutritional status and biochemical alterations in banana roots infected by major nematode pathogens.
4. Isolation of native virulent strains of bioagents for effective management of nematodes.
5. Induction of systemic resistance through easily available and economically feasible methods.

6. Screening of *Musa* germplasm in pots in the greenhouse and in the field against major nematode pathogens.
7. Eco-friendly management of root-knot and lesion nematodes in banana and plantain through integration of bio-fertilizers and phyto-extracts.

References

Anitha, N., L. Rajamony and T.C. Radhakrishnan. 1996. Reaction of banana clones against the major biotic stress. Planter 72:315-321.

Anonymous. 2002. Season and Crop Report, Department of Economics and Statistics, Government of Tamil Nadu, Chennai. 6pp.

Bhattacharya R.K. and V.N.M. Rao. 1984. Effect of soil covers and soil moisture regimes on nematode population in soil and in root of banana. J. Res. Assam Agri. Univ.5 :206–209.

Charles J.S.K. and T.S. Venkitesan. 1993. Pathogenicity of *Heterodera oryzicola* (Nemata : Tylenchina) towards banana (*Musa* AAB cv. Nendran). Fundamental and Applied Nematology 16(4):359-365.

Chennabasappa B.S. 1994. MSc (Ag) thesis, *University of Agricultural Sciences*, Bangalore. 117pp.

Choudhury B.N. and P.N. Phukan, 1990. Distribution and occurrence of certain plant-parasitic nematodes in different cultivars of banana. Curr. Nematol.1:153–156.

Devarajan K. and G. Rajendran. 2001. Reaction of some banana clones to the burrowing and lesion nematodes. Indian Journal of Nematology 31(2):159-178.

Devarajan K. and G. Rajendran. 2001. Effect of fungus *Paecilomyces lilacinus* on the burrowing nematode, *Radopholus similis* in banana. Pest Management in Horticultural Ecosystems 7:171–173.

Devarajan K. and G. Rajendran. 2002. Effect of fungal egg parasite, *Paecilomyces lilacinus* (Thom.) Samson on *Meloidogyne incognita* in banana. Indian J. Nematol. 32:88–90.

Elain Apshara S. 2000. Breeding bananas for resistance to nematodes and sigatoka leaf spot. PhD (Hort.) thesis, Tamil Nadu Agricultural University, Coimbatore.

Harish M. and D.N. Gowda. 2001. Management of the burrowing nematode, *Radopholus similis* (Cobb) Thorne infesting banana. Indian J. Nematol. 31:23–25.

J.Ent. 28:553-554.

Johnson R.N. and Sathiamoorthy, S. 1999. Reaction of diploid banana cvs. to the burrowing nematode, *Radopholus similis*. South Indian Horticulture, 47(1/6):170-171.

Jonathan E. I and G. Rajendran. 2000. Assessment of avoidable yield loss in banana due to root-knot nematode, *Meloidogyne incognita.* Indian J. Nematol 30(2):162-164.

Jonathan E.I. and G. Rajendran. 2000. Biocontrol potential of the parasitic fungus *Paecilomyces lilacinus* against the root-knot nematode *Meloidogyne incognita* in banana. J. Biol. Control 14:67–69.

Jonathan E.I., G. Rajendran and W.W. Manuel. 2000. Management of *Meloidogyne incognita* and *Helicotylenchus multicinctus* in banana with organic amendments. Nematologia Mediterranea 28(1):103–105.

Koshy P.K., P. Sundararaju, and V.K. Sosamma. 1978. Occurrence and distribution of *Radopholus similis* (Cobb) Thorne in South India. Indian J. Nematol. 8:49-58.

Krishnamoorthy V. 2002. Breeding for resistance to sigatoka leaf spot and nematodes in banana (*Musa* sp.) PhD (Hort.) thesis, Tamil Nadu Agricultural University, Coimbatore.

Kulasekaran M. 1986. Banana breeding. Tamil Nadu Agri. Univ., Tech. Bull. No. 2:24.

Kumar S. 2001. Management of burrowing nematode, *Radopholus similis* in banana. Pp 351-355 *in* Proceedings of the National Seminar on Emerging Trends in Pests and Diseases and their Management held at CPPS, TNAU, 11-13 October 2001.

Nair K.K.R. 1979. Studies on the chemical control of banana nematodes. Agric. Res. J. Kerala. 17:232-235.

Nair M.R.G.K., N..M. Das and M.R. Menon. 1966. On the occurrence of the burrowing nematode *Radopholus similis* (Cobb) Thorne on banana in Kerala, India.

Parvatha Reddy, P., M.S. Rao and M. Nagesh. 1996. Integrated management of the burrowing nematode, *Radopholus similis* using endomycorrihiza, *Glomus mosseae* and oil cake *in* 'Conference on Challenges for Banana Production and

Utilization in 21st Century' held at Trichy on 24-25 September 1996.

Patel A.D., D.J. Patel and N.B. Patel, 1999. Determination of threshold level of *Meloidogyne incognita* and *M.javanica* pt. 1 on banana cv. Basrai. Pp 91-97 *in* Proceedings of national symposium on rational approaches in nematode management for sustainable agriculture, Anand, India, 23-25 November 1998.

Ploetz R.C., J.P. Herbert, K Sebasigari, J.H. Hernandez, K. G. Pegg, J. A. Ventura and L. S. Mayato. 1990. Importance of *Fusarium* wilt in different banana growing regions. Pp 9-26 *in* Fusarium Wilt of Banana, (R.C. Ploetz, *ed.*), APS, St. Paul, USA.

Rajendran G., T. N. Naganathan and S. Vadivelu. 1979 Studies on banana nematodes. Indian Journal of Nematology 9:54.

Rajendran G. and C.V. Sivakumar. 1996. Pathogenicity of the spiral nematode, *Helicotylenchus multicinctus* and effect on yield and nutrient status of banana. Pest Management in Horticultural Ecosystems 2:23–27.

Ravi K., D.Nanjegowda and P.P. Reddy. 2000. Integrated Management of the burrowing nematode, *Radopholus similis* (Cobb) Thorne on banana. Pest Management in Horticultural Ecosystems 6:124 –129.

Ravichandran N.G. and K. Krishnappa, 1986. Reaction of banana cultivars popularly grown in Karnataka to the burrowing nematode, *Radopholus similis,* Indian Journal of Nematology 15:240.

Ray S. and A.K.Parija, 1987. Community analysis of nematodes in the rhizosphere of banana in Puri district, Orissa, Indian J. Nematol. 17:159-61.

Roy S. P.K. Ojha, K.L. Ojha, M.M. Jha and K.N. Pathak. 1998a. Integrated management of wilt complex diseases of banana (*Musa* sp.). J. Applied Biol. 8:46–49.

Saeed M., A. Khan and F. Qamar. 1988. Reaction of two commercial varieties of banana to root-knot nematode, Pak. J. Sci. Indul. Res.31:632–633.

Sasser J. N and D.W. Freckman. 1987. A world perspective on Nematology: the role of resistance of banana cultivars to the nematodes *Radopholus similis* (Cobb) Thorne and *Meloidogyne incognita* Chitwood. Philippine Agriculturist. 68:335-49.

Sathiamoorthy S. 1987. Studies on male breeding potential and certain aspects of breeding bananas. PhD (Hort.) thesis, Tamil Nadu Agricultural University, Coimbatore.

Shanthi A., G. Rajendran, N. Kumar and K. Soorianathasundaram. 2001. Screening of Banana cultivars for nematode resistance *in* Proceedings of National Seminar on Emerging Trends in Pests and Diseases and their management held at TNAU, 11-13 October 2001.

Shanthi A., G. Rajendran, N. Kumar and K. Soorianathasundaram. 2002. Evaluation of promising cultivars of banana against major nematodes *in* Proceedings of National Symposium on Biodiversity and Management of nematodes in cropping systems for sustainable agriculture, 11-13 November 2002, Durgapura, Jaipur (Rajasthan).

Shanthi A., K. Poornima, G. Rajendran, N. Kumar and K. Soorianatha Sundaram. 2001. Management of nematodes in banana. Pp 326-330 *in* Proceedings of National Seminar on Emerging Trends in Pests and Diseases and their Management held at CPPS, TNAU, 11-13 October 2003.

Shanthi A., S.R. Gowen, S. Sathiamoorthy, S.B. Nirmal Johnson and K. Soorianathasundaram. 1999a. Response of certain banana cultivars and hybrids to burrowing nematode and root-knot nematode under glass house condition. Pp 131-133 *in* Proceedings of the Third Int. Sym. Afro-Asian Soc. Nematologists, 16-19 April 1999, Coimbatore.

Shanthi A., S.R. Gowen, S. Sathiamoorthy, S.B. Nirmal Johnson and K.Soorianathasundaram, 1999. Field screening of synthetic banana hybrids for nematpde resistance. Pp. 133-135 *in* Proceedings of the Third Int. Sym. Afro-Asian Soc. Nematologists, April 16-19, Coimbatore.

Simmonds N. W. 1966. *Bananas 2nd ed.*, London, Longmans Scientific and Technical, London, UK. 512pp.

Singh H.P. 2002. Scenario of banana production, utilization and trade. Pp. 1-17 *in* Global Conference on Banana and Plantain, 28-31 October 2002.

Subramaniam S. and P. Selvaraj. 1990. Effect of antagonistic intercrops on burrowing nematode in Robusta banana. South Indian Horti. 38:216–217.

Sudha S. and P. Sundararaju.1996. Reaction of some banana cultivars to the burrowing nematode, *Radopholus similis*. Pp. 341-343 *in*

Proceedings of Banana – Improvement, Production and Utilization (H.P. Singh and K.L. Chadha, *eds.*). National Research Centre for Banana, Trichy.

Sundararaju P. and I. Cannayane. 2002. Production of nematode egg parasitic fungus, *Paecilomyces lilacinus*, on banana wastes and certain plant leaves. Indian J. Nematol.32:188-189.

Sundararaju P. and I. Cannayane. 2002. Antinemic activity of plant extracts against *Pratylenchus coffeae* infecting banana. Indian J Nematol. 32:121-124.

Sundararaju P. and I. Cannayane. 2003. Evaluation of different biopesticides against major nematode pathogens infesting banana cv. Nendran. National Symposium on Organic Farming in Horticulture for Sustainable Production. 29-30 August, 2003. CISH, Lucknow. pp. 66-67.

Sundararaju P. and R. Thangavelu. 2001. Influence of *Pratylenchus coffeae* and *Meloidogyne incognita* on the Fusarium wilt complex of banana cv. Rasthali. Nematol medit.(accepted for publication)

Sundararaju, P. and S. Uma. 1999. Evaluation of promising hybrids and cultivars of banana against Major Nematode pathogens. Pp. 122-125 *in* Proceedings of Third International Symposium of Afro-Asian Society of Nematologist, (TISAASN) (U.K.Mehata, *ed.*), Sugarcane Breeding Institute, Coimbatore.

Sundararaju P. 1996. Nematode pests of banana and their management *in* 'Challenges for Banana Production and Utilization in 21st Centrury', NRC for Banana, Trichy, 24-25 September 1996. pp.17-19.

Sundararaju P. 2000. Biocontrol agents of Plant-parasitic nematodes in Banana. Paper presented in 'Inod-UK Workshop on Innovative Pest and Disease management in Horticultural and Plantation Crops: Technology Improvement, Validation and Transfer' organized by British Council at SPIC, Chennai on 10-11 March 2000.

Sundararaju P. 2002. Seasonal fluctuations of *Radopholus similis* and *Pratylenchus coffeae* in certain cultivars of banana. Infomusa 11:16-18

Sundararaju, P. and I. Cannayane. 2002. Management of root-lesion nematode, *Pratylenchus coffeae* in banana cv. Nendran by using trap crop. National Symposium on biodiversity and management of nematodes in Cropping Systems for Sustainable Agriculture, Nematological society of India, Jaipur, 11-13 November 2002, 91pp.

Sundararaju P. and V. Kumar. 2003. Management of root-lesion nematode, *Pratylenchus coffeae* in six commercial cultivars of banana through organic and inorganic amendments. Infomusa 12:21-25

Sundararaju P., B.Padmanaban and S. Sathiamoorthy. 2001. An eco-friendly approach for the management of root-lesion nematode, *Pratylenchus coffeae* in plantain (Nendran AAB) fields.

Sundararaju P., B. Padmanaban and S. Sathiamoorthy. 2003. Efficacy of certain botanicals against root-lesion nematode, *Pratylenchus coffeae* in banana. Nematol. medit. (accepted for publication).

Sundararaju P., B. Padmanaban and S. Uma. 2001. Field evaluation of *Musa* germplasm against major nematode pathogens.

Sundararaju P., B. Padmanaban, and S. Sathiamoorthy. 1999. Control of root-lesion nematode, *Pratylenchus coffeae* in certain cultivars of banana. Pp. 46-47 *in* Abstracts of 'National Seminar on Nematological Research in India' at C.S. Azad University of Agri & Tech., Kanpur, 17 December 1999.

Sundararaju P., I. Cannayane and R. Ramesh. 2002. Penetration and development of *Pratylenchus coffeae* and *Meloidogyne incognita* in susceptible cultivars of banana. Pp. 189 *in* Abstracts of 'National Seminar on Nematological Research in India' at C.S. Azad University of Agri & Tech., Kanpur, 17 December 1999.

Sundararaju P., I. Cannayane and S. Sathiamoorthy. 2001. New pests of banana reported in Tamil Nadu, India:Cyst nematode, *Heterodera oryzicola* Rao & Jayaprakash,1978. Infomusa 10:44–45.

Sundararaju P., I. Cannayane and S. Sathiamoorthy. 2002. Evaluation of promising diploids banana against major banana nematodes. Global conference on banana and plantain, 28-31 October 2003, Bangalore, p.176.

Sundararaju P., I. Cannayane and S. Sathiamoorthy. 2002. Occurrence and distribution of plant-parasitic nematodes associated with banana in India with special reference to North-Eastern Hills region. Global conference on banana and plantain, 28-31 October 2003, Bangalore, p.192.

Sundararaju P., I. Cannayane and S. Sathiamoorthy. 2002. Occurrence and parasitism of root-knot nematode, *Meloidogyne incognita* in ornamental banana, *Ensete superbum* and its associated antagonist. Infomusa (In press).

Sundararaju P., I. Cannayane, and S. Sathiamoorthy. 2002. Investigations on the biodiversity of plant-parasitic nematodes associated with banana in India. Global conference on banana and plantain, 28-31 October 2003, Bangalore, p.5.

Sundararaju P., I. Cannayane, and S. Sathiamoorthy. 2002. Investigations on the biodiversity of plant-parasitic nematodes associated with banana in India.

Sundararaju P., I. Cannayane, S.D. Pandey, and S. Sathyiamoorthy. 2002. Effect of population levels of plant-parasitic nematodes on high density planting with different fertigation levels in banana cv. Robusta *in* Emerging Trends in Pests and Disesase and their management (S. Doraiswamy, G. Rajendran, G. Ramakrisdhan, S. Palaniswamy and A. Subramanian, *eds*). Tamil Nadu Agricultural University, Coimbatore.

Sundararaju P., I. Cannayane., T. Senthilkumar and S. Kalpana. 2002. Biochemical alterations in different accessions of banana in response to nematode infection. *Ibid,* p.188.

Sundararaju P., M.M. Mustaffa, V. Kumar, I. Cannayane and B. Tanuja Priya. 2002. Effect of organic farming on plant-parasitic nematodes infesting banana cv. Karpuravalli, Current Nematology 13: 39-43.

Sundararaju P., R. Leela Devi and M. Manimekalai. 2002. Analysis of best treatment and variety based on nematode population on banana using artificial neural networks. Indian J. Nematol. 32:84-85.

Sundararaju P., R. Selvarajan and S. Sathiamoorthy. 2001. Management of nematode-Fusarium wilt complex in banana through bioagent, Trichoderma viride(Bio-T). Paper presented in 15th Nematological Congress at Skukuza Kruger National Park, South Africa during 20-24 May, 2001.

Sundararaju P., R. Thangavelu and I. Cannayane.2002. Management of *Pratylenchus coffeae* and *Meloidogyne incognita* on banana by using endophytic fungi. Current Nematology 13: 77-81.

Sundararaju P., T. Sasikala, and I. Cannayane. 2003. Effect of *Verticillium chlamydosporium* on second stage juvenile mortality and egg hatching of *Meloidogyne incognita* under *in vitro* conditions. Current Nematology 13: 67.

Sundraraju P. and K. J. Jeyabhaskaran. 2002. Evaluation of different soil types on multiplicatin of *Pratylenchus coffeae* and growth of banana seedlings var. Nendran. Nematol medit.(accepted for publication)

Sundraraju P. and I. Cannayane. 2002. Management of root-lesion nematode, *Pratylenchus coffeae* in banana cv. Nendran by using trap crop. National Symposium on biodiversity and management of nematodes in Cropping Systems for Sustainable agriculture, Nematological society of India, Jaipur, 11-13 November, 2002. 91p.

Tiwai S.P. and Dave, G.S. 1985. Burrowing nematode *Radopholus similis* (Cobb) Thorne on banana in Madhya Pradehs. *Curr. Sci.* 54: 1286.

Venkitesan T.S. and J.S.K. Charles. 1983. Sucker dip treatment for banana nematode control *in* Abstracts of Third Nematology Symposium, Solan, India. 24-26 May 1983. 45p.

Vidya K. and B.M.R. Reddy. 1998. Integrated management of *Radopholus similis* infecting banana using plant product, nematicide and biocontrol agents. Mysore J. Agric. Sci., 32 : 186–190.

Volkers E.E.L. A. and Gamboa. 1988. Nematodes on plantain. Boletin informative Manejo integrado de plagas No. 7, 3-4.

Vyas R.V., N.B. Patel and D.J. Patel. 2001. Management of root-knot nematodes in banana. Indian J. Nematol., 31 : 86–87.