NEMATODE DIVERSITY IN BANANA RHIZOSPHERE FROM WEST BENGAL, INDIA

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Abstract: Survey on plant and soil nematodes associated with banana plantations in different banana growing districts of West Bengal (India), revealed that the occurrence of the most economically important genera of plant parasitic nematodes were *Pratylenchus, Meloidogyne, Helicotylenchus, Tylenchorhynchus, Hoplolaimus, Rotylenchulus, Hirschmanniella, Criconemoides*. Altogether there were seventeen species of plant parasitic nematodes viz. *Pratylenchus coffeae, P. brachyurus, P. similis, Meloidogyne incognita, M. javanica, Hoplolaimus indicus, Rotylenchulus reniformis, Helicotylenchus multicinctus, H. abunaamai, H. incisus, H. gratus, H. dihystera, Tylenchorhynchus nudus, T. mashhoodi, T. coffeae, Hirschmanniella mucronata* and *Criconemoides* sp. Among the plant parasitic nematodes, *P. coffeae, P. brachyurus, M. incognita*, *H. multicinctus* and *R. reniformis* were found as serious pests of banana in West Bengal. The occurrence of the most damaging species, *Radopholus similis* and *Heterodera oryzicola* was not detected in West Bengal, although *R. similis* is reported to occur in Midnapore and Jalpaiguri. Distribution of plant parasitic nematodes associated with the rhizosphere of banana in important banana growing districts of West Bengal, was presented on the basis of information available in the state. Observation of the effects of some banana cultivars/types on the nematode fauna, showed that the cooking banana type *Musa* (ABB) cv. Kanchakala and *Musa* (BBB) cv. Seed Banana supported a huge population of *M. incognita* which induced severe root galling symptoms. The lesion nematode, *P. coffeae* was found infesting all the cultivars/types. It maintained high population densities in the rhizosphere of *Musa* (AA) cv. Matti and *Musa* (ABB) cvs. Kanchkala, Krishna Kanthali whereas the Seed Banana cultivar had a suppressive effect on *P. coffeae.* The rhizosphere of banana cultivar, Matti exhibited a high population of *H. multicinctus*. *R. reniformis* population was recorded in extremely high levels in the rhizosphere of all cultivars/types. Free-living nematodes including rhabditids, dorylaimids, mononchids, were found in abundance in the banana rhizosphere.

Key words: plant parasitic nematodes, free-living nematodes, banana, cultivars, nematode diversity, West Bengal

INTRODUCTION

Banana (*Musa paradisica* L.) is an important fruit crop cultivated on about 22 000 ha in West Bengal with a production of 47 2000 tons (Anonymous 2000a). In the last five years about a 42% area of banana cultivation has increased. Among several biotic and abiotic stresses inflicting damage to banana, plant parasitic nematodes constitute one of the major limiting factors for profitable cultivation. Nematodes are of serious concern for banana cultivation. Some species are highly pathogenic in nature. More than 151 nematode species of 51 genera have been documented worldwide on *Musa* sp. (Gowen and Queneherve 1990; Koshy and Gulsar Banu 2000) and yield losses are estimated to be 19.7% amounting to US $17.8 million (Sasser and Freckman 1987). In India, 71 species of plant parasitic nematodes are known to be associated with banana (Krishnappa and Reddy 1995; Koshy and Sosamma 2001). Only seventeen species recorded from West Bengal (Mukherjee and Dasgupta 1983a, b). Khan *et al.* (2004) identified twenty-one species of fourteen genera from the banana rhizosphere in West Bengal. Ghosh *et al.* (2004) recorded preliminary effects of some cultivars on nematode fauna in the rhizosphere of banana. The present investigation was carried out for survey and identification to determine the effects of some banana cultivars on nematode fauna. The plan is to generate information on nematode problems for profitable cultivation of banana and for preparation of Pest Risk Analysis (PRA) in West Bengal.

MATERIALS AND METHODS

Soil along with root samples were collected from the rhizosphere of banana grown in cultivated fields/orchards of the Nadia, Burdwan, Birbhum and Murshidabad districts of West Bengal (located between 21°31′–27°14N latitude and 85°51′–89°53E longitude), India. Samples were also taken from the rhizosphere of different cultivars grown under varietal experiment at Mondouri farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia (India). The sampling was done from four month-old banana plants. The sampling root rhizomes were first critically examined for the occurrence of root galling, lesions, and rotting

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symptoms caused by plant parasitic nematode inhabiting the banana rhizosphere. Samples were processed by Cobb's Decanting Sieving method followed by a modified Baermann's technique. Root samples (10 g) were cut into small pieces and placed over double-layered tissue paper supported by a wire-gauge soaked over a Petri dish filled with water. After incubation, the nematode which had emerged from the roots were collected from the nematode suspension in the Petri dish. Nematodes specimens were killed by hot-water bath and fixed in 3% formaldehyde. For identification of the species, nematode specimens were processed by Seinhorst's glycerol-ethanol method (Seinhorst 1959) and mounted in anhydrous glycerine on glass slides. The nematode infected roots were stained by NaOCl-Acid Fuchsin method (Byrd *et al.* 1983). The root-knot nematode species was identified on the basis of the perineal pattern of the mature female. The works carried out by other workers (Mukhopadhyay and Haque 1974; Mukherjee and Dasgupta 1981; Dasgupta *et al.* 1985; Khan 2004: Ghosh 2008) from the state were also included in preparation of nematode distribution in West Bengal.

RESULTS AND DISCUSSION

The most common genera of plant parasitic nematodes associated with banana were *Pratylenchus, Meloidogyne, Helicotylenchus, Tylenchorhynchus, Hoplolaimus, Rotylenchulus, Hirschmanniella, and Criconemoides* (Table 1). Seventeen species of plant parasitic nematodes viz. *Pratylenchus coffeae, P. brachyurus, P. similis, Meloidogyne incognita, M. javanica, Hoplolaimus indicus, Rotylenchulus reniformis, Helicotylenchus multicinctus, H. abunaamai, H. incisus, H. gratus, H. dihystera, Tylenchorhynchus nudus, T. mashhoodi, T. coffeae, Hirschmanniella mucronata* and *Criconemoides* sp. were identified. Survey results (Table 2) in the important banana growing areas of Nadia, Burdwan, Birbhum and Murshidabad districts of West Bengal showed that the sample contained large densities (216–1686 J_2 per 200 cc soil + 10 g root) of second stage juveniles of *Meloidogyne* spp. from Gayespur, Chakdah, Ranaghat, Krishnagar and Devagram of the Nadia district and Mayapur (960 J_2 per 200 cc soil + 10 g root) of the Burdwan district and Bataspur (1460 J_2 per 200 cc soil +10 g root)

Table 1. Distribution of plant parasitic nematodes associated with banana in West Bengal

Species	District									
	Nadia	Hooghly	Burdwan	24-Paragonas (north)	Birbhum	Bankura	Midnapore	Murshidabad	Cooch-behar	Jalpaiguri
Boleodorus sp.	–	+		–	–	–	–	–	–	–
Caloosia parlona	–	–	+	–	–	–	–	–	–	–
Criconemoides spp.	+	–	–	+	–	+	–	–	–	–
Helicotylenchus abunaamai	+	+	–	+	–	–	+	–	–	–
H. belurensis	+	+	–	+	–	–	–	–	–	–
H. dihystera	+	+	–	–	–	–	–	–	–	–
H. gratus	+									
H. incisus	+	–	–	–	–	–	–	–	–	–
H. indicus	+	+	+	+	+	–	+	+	+	–
H. multicinctus	+	+	–	–	–	–	+	–	–	+
Hemicriconemoides mangiferae	–	–	–	–	–	–	–	–	+	–
H. mucronata	+	–	–	–	–	–	–	–	–	–
H. columbus	+	+	–	–	–	–	–	–	–	–
H. indicus	+	+	+	+	+	–	+	+	–	–
H. seinhorsti	+	+	–	–	–	–	–	–	–	–
M. incognita	+	+	–	+	+	–	+	+	+	+
M. javanica	+	+	–	–	–	–	–	+	–	–
Meloidogyne spp.	–	–	+	–	–	–	–	–	–	–
P. brachyurus	–	+	–	–	–	–	–	–	–	–
P. coffeae	–	+	+	+	–	–	+	–	–	–
P. similis	+	–	–	–	–	–	–	–	–	–
**R. similis*	–	–	–	–	–	–	+	–	–	+
R. reniformis	–	+	+	–	+	+	+	+	–	+
Sakia indica	–	+	–	–	–	–	–	–	–	–
Scutellonema simense	–	+	–	–	–	–	–	–	–	+
T. coffeae	–	+	+	–	–	–	–	+	–	–
T. leviterminalis	–	+	–	–	–	–	–	–	–	–
T. mashhoodi	+	–	–	+	+	–	+	–	–	–
T. nudus	+	–	+	+	–	–	–	–	–	–
T. zeae	–	+	+	–	–	–	–	–	–	–
Xiphinema index	–	+	+	–	–	–	–	–	–	–
X. insigne	–	+	+	–	–	–	–	–	–	–

*occurrence of *R. similis* in West Bengal is doubtful

Table 2. Plant parasitic nematodes associated with banana in different districts of West Bengal

District	Location	No. of sample	Mean nematode population density/200 cc soil + 10 g root							
			Melo.	*Praty.*	*Heli.*	*Tylen.*	*Hoplo.*	*Roty.*	*Crico.*	others
Nadia	Mondouri	6	34 (50)	39 (33.33)	51 (66.66)	148 (50)	–	–	–	1190 (100)
	Gayespur	4	1686 (50)	172 (25)	52 (100)	93 (100)	–	469 (75)	34 (25)	344 (100)
	Chakdah	2	922 (100)	20 (100)	59 (100)	–	–	998 (100)	–	1209 (100)
	Ranaghat	2	932 (100)	–	29 (50)	–	44 (50)	133 (100)	21 (25)	639 (100)
	Santipur	4	96 (50)	64 (25)	–	288 (50)	80 (25)	108 (50)	29 (25)	672 (100)
	Krishnagar	2	216 (50)	37 (50)	–	67 (100)	39 (100)	289 (50)	35 (50)	892 (100)
	Devagram	2	623 (50)	53 (50)	–	160 (100)	–	93 (100)	–	1370 (100)
Burdwan	Katwa	4	82 (100)	38 (50)	–	32 (50)	27 (100)	435 (50)	78 (50)	625 (100)
	Mayapur	2	960 (100)	–	–	48 (100)	64 (50)	512 (50)	–	1120 (100)
Birbhum	Panisail	4	202 (100)	33 (100)	–	33 (50)	51 (50)	235 (100)	–	1075 (100)
	Bataspur	2	1460 (100)	115 (50)	58 (100)	–	36 (100)	558 (100)	–	1132 (100)
Murshidabad	Domkal	2	122 (100)	83 (100)	61 (100)	–	46 (100)	2489 (100)	–	834 (100)

Figures in parentheses are percent frequency of occurrence; *Melo.* – *Meloidogyne*, *Praty.* – *Pratylenchus*, *Heli.* – *Helicotylenchus*, *Tylen.* – *Tylenchorhynchus*, *Hoplo.* – *Hoplolaimus*, *Roty.* – *Rotylenchulus*, *Crico.* – *Criconemoides*, others – other free living nematodes

of the Birbhum district. The root-knot nematode was found to produce typical root galling symptoms in most of the root samples. Soil samples exhibited abundant J_2 of *Meloidogyne* spp. but the banana plants in the orchard did not showed any external above ground symptoms. There is no doubt that the galled roots are prone to attacks by various soil microorganisms which interact with nematode, resulting in root rotting decay of the root system. The attack of *M. incognita* caused 30.95% yield loss, deterioration of fruit quality and delayed crop duration (Jonathan and Rajendran 2000). Mukherjee and Dasgupta (1983a, b) did not encounter the root galling in root-knot infested banana orchards in the Hooghly districts, though numerous juvenile (J_2) populations were recorded.

The lesion nematode, *Pratylenchus* spp. was found in low densities (Table 2) in most of the samples, however, cortical lesion on the roots of banana was found in this survey. The presence of *P. coffeae* in banana rhizosphere from West Bengal also indicated their pan-tropical distribution. *P. coffeae* is one of most serious pests of banana (Bridge *et al.*1997). The spiral nematode, *H. multicinctus* in the banana was encountered along with other nematodes which caused superficial lesions on feeder roots. The nematode species attack over 40 host plant species including banana and cause yield reduction in banana (Ploetz *et al.* 2003). The reniform nematode, *R. reniformis* recorded in high population densities (Table 2) in rhizosphere of banana in most of the locations, indicates a major pathogenic role played by this nematode. *R. reniformis* is an important pathogen of banana (Koshy and Sosamma 2001) and the nematode species was found in high density (961/200 cm^3 + 10 g root) in the banana rhizosphere of West Bengal (Khan *et al.* 2004). Similarly, several ectoparasitic nematodes like the lance nematode, *Hoplolaimus*, stunt nematode, *Tylenchorhynchus,* and ring nematode, *Criconemoides* were recorded in the soil samples but they were less frequent. These nematode groups are mostly frequent feeders of banana roots. They cause injury to roots which in turn exposes the root system making it prone to attack from other soil pathogens. The occurrence of *H. mucronata* in banana rhizosphere was found. The possible reason for the presence of *H. mucronata* could be due to the rice-banana crop sequence practiced by the growers in the areas. Thus, multi-nematode species infestation in banana is common in West Bengal. In this investigation, the occurrence of the most damaging species, *R. similis* and *H. oryzicola* were not detected in West Bengal. Similar investigations were undertaken in the All India Coordinated Research Project on plant parasitic nematodes from the Hooghly, 24-Pargonas (North) and Nadia districts of West Bengal but the nematode species were not encountered (Anonymous 2000b). However, occurrence of *R. similis* was known to occur in the Midnapore (Gantait *et al.* 2007) and Jalpaiguri districts of West Bengal (per omm. P. Sundararaju).

Observation of different banana cultivars/types for the rhizospheric nematode fauna indicated that cooking types, *Musa* (ABB) cv. Kanchakala and *Musa* (BBB) cv.

Seed Banana supported a huge population (J_2 299–996 per 200 cc soil) of root-knot nematode, *M. incognita* (Table 3). This nematode induced severe root galling symptoms. However, the cultivars like *Musa* (AA) cv. Matti, *Musa* (AAA) cv. Red banana, *Musa* (AAB) cvs. Martaman, Champa, Kanthali Champa and *Musa* (ABB) cvs. Krishna Kanthali, Pantharaj supported a low population (J_2 62–164 per 200 cc soil) of *M. incognita* with only a few galls on the root system. These variations in nematode population in the rhizosphere of banana cultivars are attributed to the varietal effects on nematode survival and multiplication. Varieties/cultivars respond differently to nematode pathogen presumably due to their constituent chemicals or toxic principles. Positive correlations occur between the concentration of phenolics, chlorogenic acid, total sugars of tomato and banana cultivars and resistance response to root-knot and burrowing lesion nematodes, respectively (Singh and Choudhury 1973; Huang and Rohde 1973; Devrajan and Rajendran 2002). Root exudates of plants also play an important role for attracting and repelling nematodes (Huang 1985). Therefore, abundance of nematode fauna in a crop is greatly influenced by the chemical nature of crop rhizosphere. *P. coffeae* was also found infecting all types of cooking bananas. *P. coffeae* produced lesions on feeder roots leading to rotting and final decay of the root system. The rhizosphere of Matti, Krishna Kanthali and Kanchakala (cooking type) also supported a high population density (423, 332 and 220 per 200 cc soil + 10 g root, respectively) of *P. coffeae*. A very low population of *P. coffeae* (17 per 200 cc soil + 10 g root) was found in Seed Banana. This further indicated that those cultivars could be susceptible or favourable to *P. coffeae* for multiplication resulting in high population. The low nematode population in seed banana could be presumably due to a suppressive effect or resistance response on *P. coffeae*. A high population of the spiral nematode, *H. multicinctus* was found in the rhizosphere of 'Matti, although, Singh and Uma (1996) found that the nematode can affect the banana irrespective of the varieties and growing regions. *R. reniformis* was recorded in profusely high population densities ranging from 370 to 8,078 per 200 cc soil + 10 g root in the rhizosphere of all the cultivars/types. Among the other plant parasitic nematodes, *T. coffeae*, *H. indicus*, *Criconemoides* sp. were found in various densities, though their clear-cut symptoms and pathogenic potential in banana has not yet been established. The banana orchards were not completely free from weeds; therefore, high populations of ectoparasites were supported by the weed hosts. Abundant population of free-living nematodes including rhabditids, dorylaimids and mononchids were recorded in the cultivars of banana rhizosphere. This group of nematodes play an important role in essential soil processes (Neher 2001), however, their exact role in the crop production system is not yet clearly known.

On the basis of the above observations, it may be concluded that banana roots are prone to attack from the most serious nematode species viz. *P. coffeae P. brachyurus*, *H. multicinctus* and *M. incognita*; they co-inhabit in large densities and form a nematode species-complex. Therefore, their yield reduction potential is yet to be thoroughly investigated either alone or in association with other soil-pathogens for profitable cultivation of banana in West Bengal. The information generated through this investigation could be useful for undertaking pest risk analysis. Nematode advisory services from the state could be developed for combating nematode problems in banana. Effects of banana cultivars/types on the associated predominant nematode species were found but biochemical basis for resistance or susceptible response is essential for understanding causal effects.

Table 3. Effect of cultivars on nematode fauna in banana rhizosphere

Cultivar/Type	Mean nematode population density/200 cc soil + 10 g root							
	Melo.	*Praty.*	*Heli.*	*Tylen.*	*Hoplo.*	*Roty.*	*Crico.*	others
Matti (AA)	92	423	202	130	18	8,078	–	460
Red Banana (AAA)	83	195	–	104	234	2,951	–	1066
Martaman (AAB)	69	87	163	222	205	5841	–	5273
Kanthali Champa (AAB)	62	131	63	129	25	1830	–	1410
Champa (AAB)	164	120	98	236	145	2274	–	2293
Kanchakala (ABB)	299	332	108	979	133	2274	–	2141
Krishna Kanthali (ABB)	968	220	120	830	105	1431	–	1463
Pantharaj (ABB)	78	61	–	–	123	862	130	3265
Kanchakala -5 (ABB)	847	77	46	216	169	3188	65	1817
Kanchakala-4 (ABB)	996	81	92	549	115	1152	40	2168
Kanchakala -3 (ABB)	346	93	–	26	132	370	–	1188
*Kanchakala -2 (ABB)	452	165	38	309	79	2607	33	1561
Seed banana (BBB)	464	17	–	33	83	2955	23	2257

Melo. – *Meloidogyne*, *Praty.* – *Pratylenchus*, *Heli.* – *Helicotylenchus*, *Tylen.* – *Tylenchorhynchus*, *Hopl.* – *Hoplolaimus*, *Roty.* – *Rotylenchulus*, *Crico.* – *Criconemoides* sp., others – other free living nematodes

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POLISH SUMMARY

RÓŻNORODNOŚĆ NICIENI W RIZOSFERZE BANANA Z ZACHODNIEGO BENGALU, INDIE

Badanie występowania na roślinach i w glebie nicieni związanych z plantacjami banana, w różnych rejonach jego uprawiania, w zachodnim Bengalu wykazało, że najważniejszymi ekonomicznie rodzajami patogenicznych dla roślin nicieni były rodzaje: *Pratylenchus*, *Meloidogyne*, *Helicotylenchus*, *Tylenchorhynchus*, *Hoplolaimus*, *Rotylenchulus*, *Hirschmanniella*, *Criconemoides*. Razem było 17 gatunków nicieni patogenicznych dla roślin, a mianowicie: *Pratylenchus coffeae*, *P. brachyurus*, *P. similis*, *Meloidogyne incognita*, *M. javanica*, *Hoplolaimus indicus*, *Rotylenchulus reniformis*, *Helicotylenchus multicinctus*, *H. abunaamai*, *H. incisus*, *H. gratus*, *H. dihystera*, *Tylenchorhynchus nudus*, *T. mashhoodi*, *T. coffeae*, *Hirschmanniella mucronata* i *Criconemoides* sp. Wśród nicieni patogenicznych dla roślin *P. coffeae*, *P. brachyurus*, *M. incognita*, *H. multicinctus* i *R. reniformis* uznano za poważne szkodniki banana w zachodnim Bengalu. Występowanie najbardziej szkodliwych gatunków *Radopholos similis* i *Heterodera oryzicola* nie zostało stwierdzone w zachodnim Bengalu, chociaż występowanie *R. similis* stwierdzono w Midnapore i Jalpaiguri. Rozmieszczenie nicieni patogenicznych dla roślin związanych z rizosferą banana, w różnych rejonach uprawy, w zachodnim Bengalu, zostało zaprezentowane na podstawie informacji dostępnych w stanie. Obserwacje efektów niektórych odmian banana/typów fauny nicieni wykazały, że typ banana do gotowania Musa (ABB), odmiana Kanchakala i Muza (BBB), odmiana Seed Banana, nosiła na sobie olbrzymią populację *M. incognita*, która wywoływała poważne symptomy powstawania narośli na korzeniach. *P. coffeae* wywołującego rany, uznano za nicienia zakażającego wszystkie odmiany/typy. Nosił on na sobie duże gęstości populacji w rizosferze Musa (AA) odmiana Matti i Musa (ABB), odmiany Kanchakala, Kriszna Kanthali, podczas gdy odmiana Seed Banana miała efekt ograniczający na *P. coffeae*. Rizosfera banana odmiany Matti wykazywała wysoką populację *H. multicinctus*. Populacja *R. reniformis* została wykryta w rizosferze wszystkich odmian/typów. Wolno żyjące nicienie, włączając rhabditids, dorylaimids, monochids, były znalezione w obfitości, w rizosferze bananowców.