

Biodiversity and management of nematodes associated with rice in Eastern India

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Abstract. The nematode populations associated with rice and the effect of different management practices on them in farmers' fields in Patna, Bihar, eastern India in 2002-2003 are presented. *Hirschmanniella oryzae*, *Tylenchorhynchus mashhoodi*, *Hoplolaimus indicus*, *Meloidogyne* sp., *Rotylenchulus reniformis*, *Ditylenchus* sp., *Helicorylenchus indicus*, *Tylenchus* sp., *Hemicriciconemoides* sp. were encountered in the fields along with non-parasitic nematodes. *H. oryzae*, *T. mashhoodi* and *Meloidogyne* sp. were the dominant species. The treatment with carbofuran @ 1kg a.i/ha in nursery beds and in fields, 40 days after transplantation reduced total population of plant parasitic nematodes in soil by up to 23.5% from initial levels and increased the yield by 27.6%. Deep summer ploughing also reduced the population by 36.9% and increased the yield by 23.3%.

Keywords. Control, plant parasitic nematodes, rice, survey, wet season, winter (dry).

INTRODUCTION

Rice is the most important staple food for about half of the human race (Hawksworth, 1985). There are various limiting factors responsible for the low yield of this crop. Plant parasitic nematodes are one of the groups of pests which cause considerable damage to the crop. Over 144 different species of stylet bearing nematodes occur in association with rice culture (Gedder and Smart, 1987) but only a few are predominant. Among the various rice nematodes, *Hirschmanniella* spp. are the most widely distributed nematode pests under lowland conditions. *Pratylenchus* spp., *Hoplolaimus indicus*, *Tylenchorhynchus* spp., and several other ectoparasitic nematodes having a wide host range were found to co-exist under upland conditions in the rice rhizosphere causing significant yield losses (Prasad *et al.*, 1987). On a worldwide basis losses in yield are estimated to be as high as 10% in rice due to nematodes (Sakhia *et al.*, 1993).

Considering the importance of nematode pests on rice, studies were undertaken in farmers' fields in Patna, Eastern

India to observe the nematode problems of the crop and the effect of different management practices adopted by farmers on nematode density and yield of crop.

MATERIALS AND METHODS

Some canal project of Bihar (India), completed in 1875, has 6.42 M ha GCA and net irrigated area of 5.2 M ha with cropping intensity of about 140%. It is situated between 84°51'N latitude and 84°55' E longitude. Transplanted rice is the main crop in the area during wet season as there are hardly any options for any other crops barring some patches of uplands alongside the Right Parallel Channel-5 (RPC-5) where farmers normally grow fodder. Wet and winter (dry) are the two main seasons in this area, and activities for wet crops start from the last week of May and last until the end of November while winter (dry) sowing starts by the end of October or 1st week of November and ends by April every year. The average rainfall pattern for 40 years (1960-1999) is 1142.5 mm. Most of the activities for nursery raising and rice transplanting in the area is done between 15th June to 31st July.

Table 1. Biodiversity and management of nematodes associated with rice in farmer's fields (mean of 2002-2003).

Treatment	Average nematode population/100g soil													
	Av. of plots under observation	<i>Hirschmanniella</i>	<i>Roylenchus</i>	<i>Tylenchorhynchus</i>	<i>Meloidogyne</i>	<i>Ditylenchus</i>	<i>Tylenchus</i>	<i>Helicotylenchus</i>	<i>Hoplolaimus</i>	<i>Hemierhynchus</i>	Total plant parasitic nematodes	Saprotic nematodes	Total	Yield q/ha
1	71	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial, av.	126.6	7.1	141.7	44.0	43.7	8.0	11.1	20.9	128.7	569.8 (+49.1)	1455.6	2026.6	803.6	
Variation	0-405	0-121	0-710	0-320	0-210	0-190	0-90	0-72	0-490	382.2	390-3320	923-3912	126-2345	
% Frequency	73.2	14.7	89.7	45.2	61.5	48.0	14.6	33.3	33.3		100	100	100	
T ₁ *	15	149.7	262.9	7.6	7.6	20.9	128.7	0-72	0-490	569.8 (+49.1)	1455.6	2026.6	803.6	55.8 (+1.5)
Variation	0-360	66.7	70-670	0-35	0-35	0-72	0-72	33.3	33.3		390-3320	923-3912	126-2345	
% Frequency	66.7	14.7	100	33.3	33.3	33.3	33.3	33.3	33.3		100	100	100	
T ₂ **	15	160.5	66.0	8.0	8.0	57.7	292.2 (-23.5)	292.2 (-23.5)	292.2 (-23.5)	292.2 (-23.5)	268.2	1030.3	340-2785	70.2 (+27.6)
Variation	44-370	100	5-110	0-33	0-33	21-161	66.7	66.7	66.7		110-2310	340-2785	1030.3	
% Frequency	100	100	100	33.3	33.3	66.7	66.7	66.7	66.7		100	100	100	
T ₃ ***	15	161.3	100.3	100.3	100.3	25	25	25	25	8.3	751.4	1006.2	803.6	56.4 (+2.6)
Variation	25-210	100	15-560	100	100	0-90	0-90	0-90	0-90	0-40	480-1400	605-2100	126-2345	
% Frequency	100	100	100	100	100	100	100	100	100	33.3	100	100	100	
T ₄	15	176.9	34.1	15	15	15	15	15	15	33.3	1558.8	1786.3	803.6	67.8 (+23.3)
Variation	65-350	100	0-60	0-50	0-50	0-45	0-45	0-45	0-45		720-2535	855-2600	126-2345	
% Frequency	100	100	87.5	41.7	41.7	37.5	37.5	37.5	37.5		100	100	100	
T ₅ Untreated control	15	243.4	185.2	54.5	54.5	86.3	86.3	86.3	86.3	596.1 (+56.0)	5632.3	1647.4	803.6	55.0
Variation	120.31	100	26-290	0-175	0-175	0-75	0-75	0-75	0-75		218-3100	746-3591	126-2345	
% Frequency	100	100	100	93.3	93.3	40	40	40	40		100	100	100	
(T ₅) at 5 %														6.9

T₁* Seedlings from beds treated with carboruran @ 1 kg a.i./ha. T₂** Seedlings from treated beds + carboruran @ 1 kg a.i./ha in fields 40 DAY. T₃*** Deep summer ploughing.

Winter (dry) season in the area does provide options for growing various types of crops in addition to wheat such as pulses, oilseeds and vegetables. But the major area in winter (dry) season is occupied by wheat and lentil (a pulse crop). The sowing of wheat normally takes place after the last week of November and continues by the end of December and even up to the early days of January in some cases. There is a common practice of broadcasting lentil in standing rice fields, which provides a cheaper option as a winter (dry) crop to the farmers in the area. Most of the soil in the command is silty clay loam. Hence, due to excessive watering in the paddy fields or rainfalls in October, the prolonged moisture conditions up to November and December in many cases, delay the sowing of winter (dry) crops. The irrigation in the area is provided by the canal mainly alongside the RPC-5 and Tangrila distributary, while most of the area falling at the tail end of the canal command uses groundwater through shallow tube wells using diesel pumps. The incomplete dissemination and adoption of crop production technologies in this canal command area have resulted in low productivity as well as low water use efficiency. Besides this, there are other key constraints in crop production responsible for low productivity. To determine these constraints extensive surveys on soil, pest and diseases, and socio-economic factors were conducted in command of RPC-5. For estimation of initial and final nematode populations, soil samples were collected before transplantation and after harvest of rice crop from farmers' fields and analysed in the laboratory by modified Cobb's decanting and sieving methods (Christie and Perry, 1951). For management of nematodes the following treatments were applied during 2002 and 2003:

- T₁ - Transplantation of seedlings from beds treated with carbofuran @ 1 kg a.i/ha
- T₂ - Transplantation of seedlings from treated beds + application of carbofuran @ 1 kg a.i/ha 40 days after transplantation.
- T₃ - Deep tillage
- T₄ - Deep summer ploughing
- T₅ - Untreated control

RESULTS AND DISCUSSION

The nematode populations associated with rice in farmers' fields and the effect of different management practices on them were studied. Plant parasitic nematodes *Hirschmanniella oryzae*, *Rorylenchulus reniformis*, *Tylenchorhynchus mashhoodi*, *Meloidogyne* sp., *Ditylenchus* sp., *Helicotylenchus indicus*, *Tylenchus* sp., *Hemicriconemoides* sp. and *Hoplolaimus indicus* were encountered in most of the samples. *H. oryzae*, *Meloidogyne* sp., and *T. Mashhoodi* were found to be dominant. The average population was observed to be 126.6 and 141.7 per 100 g soil with variation of 0-405 and 0-710, and frequency of distribution was 73.2

and 89.7%, respectively (Table 1).

At the time of harvest of rice, a 56% increase in total population of plant parasitic nematodes was observed in untreated control fields. A maximum increase of 92.3% was noticed in population of *H. oryzae* followed by *T. Mashhoodi* (30.7%) and *Meloidogyne* (23.9%). Populations of other nematodes were more or less at par or below the initial level.

Among the different management practices transplantation of seedlings from treated nursery beds had no effect on the final population of nematodes in the fields at the time of harvest. In this treatment a 49% increase was noticed but a 23.5 per cent reduction was noticed in plots having transplantation of seedlings from treated beds together with treatment of fields with carbofuran @ 1 kg a.i/ha. In this treatment an increase of 27.6% in crop yield was recorded against the untreated control.

Among the effect of cultural practices, deep summer ploughing recorded a maximum reduction of 36.9% on nematode populations and a 23.3% increase in rice yield followed by deep tilled plots. The reason for this might be that in deep summer ploughed or deep tilled fields nematodes were exposed to external environmental conditions and they were disturbed as their food resources were also adversely affected. Deep summer ploughing increases the temperature of the soil. The temperature of the soil and its associated and antagonistic effect also play an important role in the survival of microbes. The maximum microbe count was reported in spring, the lowest being in the summer and winter (Sarkar and Khan, 2002, Khan *et al.*, 2002). Most micro-organisms prefer a range of 25 to 35°C (Chang *et al.*, 1977). The temperature of soil rose up to 50°C during May and June in deep summer ploughed fields (Khan *et al.*, 2002).

Deep ploughing causes a decrease in the soil reflection coefficient. This is mainly due to the removal of the insulating layer from the soil surface and the exposure of the darker, more energy absorbing soil due to which deep ploughed fields warmed up more rapidly (Khan, 1988). The increase in temperature of the soil and exposure of insulating layer from the soil surface caused the decrease of nematode growth in deep summer ploughed fields. Due to control of nematode populations, a significant increase in rice yield was observed.

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LITERATURE CITED

- Chang, A. C., L. J. Lund, A. L. Page, J. E. Warneke 1977. Physical properties of fly ash amended soil. *Journal of Environmental Quality* 6, 267-270.
- Christie, V. R. and E. G. Perry 1951. Removing nematodes from soil. *Proceedings of the Helminthological*

- Society of Washington* 18, 106-108.
- Gedder, K. and G. C. Smart 1987. Plant parasitic nematodes associated with vascular plants. In: *Vistas in Nematology* (eds J. A. Veech and D. W. Dickson), pp 486-502. Hyansville, Maryland, USA: Society of Nematology.
- Hawksworth, D. L. 1985. Foreword. In: *Rice diseases*, (Ed. S. H. Ou). Slough, UK: Commonwealth Institute of Mycology, CABI, 380 pp.
- Khan, A. R. 1988. Effect of tillage on soil temperature. *International Agrophysics* 4, 317-324.
- Khan, A. R., S. S. Singh, L. K. Prasad, S. S. Prasad, B. Singh, S. R. Singh and J. L. Gaunt 2002. On-farm tillage trials for rice-wheat cropping system in Indo-Gangetic plains of eastern India. International Centre for Theoretical Physics (UNESCO & IAEA). Trieste, Italy: *Int. Report*, IC/IR/2002/ 5, 1-19.
- Khan, A. R., R. C. Srivastava, A. K. Ghorai and S. R. Singh 2003. Efficient soil solarization for weed control in the rainfed upland rice ecosystem. *International Agrophysics* 17, 99-103.
- Prasad, J. S., M. S. Panwar and Y. S. Rao 1987. Problems of rice in India. *Tropical Pest Management* 33, 127-136.
- Sakhia, P. K., J. Bayer, I. Singh and N. Kaur 1993. Host range of rice-root nematode *Hirschmanniella oryzae* (Agst) *Indian Journal of Nematology* 23, 15.
- Sarkar, S. and A. R. Khan 2002. Soil microbial population and nitrogen fixation in peanut crop at varying doses of fly ash and sewage sludge. International Centre for Theoretical Physics (UNESCO & IAEA). Trieste, Italy: *Int Rep IC/IR/2002/ 18, 1-13.*