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Vol. 8(32), pp. 3025-3028, 6 August, 2014
DOI: 10.5897/AJMR2014.6692
Article Number: 8B899B146551
ISSN 1996-0808
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African Journal of Microbiology Research

Full Length Research Paper

Effect of resource conservation practices and conventional practices on population dynamics of *Meloidogyne graminicola* (Golden and Birchfield, 1965) under rice-wheat cropping system

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Received 7 February, 2014; Accepted 28 July, 2014

Study on effect of resource conservation practices and conventional practices on population dynamics of *Meloidogyne graminicola* under rice-wheat cropping system revealed that the fields with the intervention of resource conservation practices showed high population densities, root knot index and narrow nematode to root biomass ratio of *M. graminicola* as compared to conventional ones. It was also found that those tillage practices where residues were left on the field (with residues) has high population, root knot index and narrow nematode to root biomass ratio as compared to practices where crop were harvested from ground level without leaving residues in the field. Contrarily, zero till rice-zero till wheat + *Sesbania* sp. showed low population densities, root knot index and wide nematode to root biomass ratio and thus may serve as a better option for the management of *M. graminicola*.

Key words: *Meloidogyne graminicola*, resource conserving technologies, nematode-to-root biomass ratio, root knot index.

INTRODUCTION

The rice-wheat cropping system is the most important food grain production system in India. This cropping system is practiced by farmers of the Indo-Gangetic plains, over an area of about 2.7 million hectare. The resource-conserving technologies (RCTs) such as zero- or no-tillage and reduced tillage systems have been found beneficial in improving soil health, water use, crop productivity and farmers' income (Gupta and Seth, 2007). In addition, it also allow early and timely sowing of wheat (Tomar et al., 2006) and reduce the cost of production through less use of fossil fuels and herbicides, etc. Zero tillage is widely adopted by farmers in the Northwestern Indo-Gangetic plains of India, particularly in areas where rice is harvested late. As in zero- or no-tillage and

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Table 1. Size and biomass of different stages of root knot nematode recovered from roots of rice plant.

Stages	Length			Width			Size (μm)	Nematode biomass (μg)
	Min (μm)	Max (μm)	Mean (μm)	Min (μm)	Max (μm)	Mean (μm)		
Eggs	89.96	96.88	93.07	37.84	41.28	38.40	93.07×38.40	0.085
Second stage juvenile	385.28	412.80	397.66	15.57	17.30	16.78	397.66×16.78	0.069
Adult male	1183.36	1348.48	1281.05	27.68	31.14	29.23	1281.05×29.23	0.68
Developing female	357.76	467.84	410.50	137.60	165.12	146.77	410.50×146.77	5.52
Adult female	550.40	660.48	597.93	288.96	440.32	370.26	597.93×370.26	31.69

reduced tillage, wheat crops are planted with minimum disturbance of the soil by placing the seeds in a narrow slit (3-4 cm wide and 4-7 cm deep) without any land preparation. In both conventional and resource conservation technologies, rice or wheat are harvested either from the ground level (without residues) or from the top, leaving residues on the field itself (with residues). Zero tillage and reduced tillage has impact on soil biota especially soil borne pathogens, insects, and nematodes. Leaving plant debris on the surface or partially buried in the soil in resource conservation technologies may allow a number of pathogens to overwinter or survive until next crop is planted (Sumner et al., 1981). One of the most important soil-borne biotic factors is the nematode trophic groups. The nematode community structure varies in time and space, both in zero/minimum tillage and in conventionally tilled soil (Anonymous, 2000; Dabur, 2001). About 300 nematode species belonging to 35 genera have been reported infesting rice. Among them *Meloidogyne graminicola* (Golden and Birchfield., 1965) is one of the most damaging pests of rice and affects rice production by causing rice root knot and it has recently emerged as a major pest in rice-wheat cropping system (Soriano et al., 2000; Singh et al., 2006; Singh and Singh., 2009). However, detail studies on effect of resource conservation practices and conventional practices on population dynamics of *M. graminicola* under rice-wheat cropping system have not been conducted. In view of this, the present studies were made.

MATERIALS AND METHODS

Soil from the long term established (5-6years) wheat fields following rice-wheat cropping system adopted under the resource conservation practice and conventional practice showing patches of stunted plants caused by *M. graminicola* were collected in zig zag pattern at mature stage from different villages of Ballia district of Eastern Uttar Pradesh (India) during the month of March, 2011.

Different types of tillage practices chosen for the study

a) Conventional practices includes: i) Conventional tilled puddle transplanted rice (CTTPR) – conventional tilled broadcasted wheat (CTBCW) without residues; ii) CTTPR –CTBCW with residues

b) Resource conservation technologies include: iii) CTTPR – zero till (ZT) wheat without residue; iv) CTTPR- ZT wheat with residue; v) reduced till direct seeded rice (DSR) - ZT wheat without residue; vi) DSR- ZT wheat with residue; vii) zero till rice- zero till wheat (Double ZT) without residue; viii) Double ZT with residue and ix) Double ZT with sesbania.

All the collected soil samples were then bulked and about five kg soils was kept separately in polyethylene bags and brought to the laboratory. Then part of soil (500 g) were processed as per technique of Christie and Perry (1951) to estimate the initial population of 2nd stage juvenile from each option and remaining soil was separately filled into the earthen pots for further studies. Each treatment had three replications. The rice seeds (var.MTU-7029) were sown in each pot with 30 seeds at equal space. After 30 days of sowing of rice in earthen pots, observations were recorded on root knot index of rice seedlings and 2nd stage juvenile population of pot soil (500 g). From each of the representative pots 15 plants were uprooted gently, collected in polyethylene bags and brought to the laboratory and were then washed with running tape water on the same day. Special care was taken to avoid any chance of loss of the roots by placing them in a plastic tray having sufficient water in order to facilitate the loosening of the soil adhered with the roots. Plants were then taken for the estimation of the different growth and disease parameter. Plant height was measured in centimeter (cm). Shoot weight was estimated in milligram (mg) using the electronic balance (make-Sartorius). The root gall index was assessed following the scale given by Prot and Matias (1995) [1 = no gall, 2 = 1-25% roots with galls, 3 = 26-50% roots with galls, 4 = 51-75% roots with galls and 5 = > 76% roots with galls]. Thereafter, root systems of each plant were placed in boiling 0.1% (w/v) acid fuchsin in lactic acid, glycerol and distilled water (1:1:1) for staining roots (Bridge et al., 1981). Whenever possible, root galls of each root system were cut with a sharp blade and placed on a slide containing 2-3 drops of clear glycerol solution (equal parts glycerol and water). Then these galls were teased with the help of two fine needles for release of the different developing stages of the nematode. After removing the gall debris, the recovered developing stages including the eggs were taken for their measurement (Table 1). Then mean nematode biomass was calculated using formula given by Andrassy (1956) with slight modification.

$$G = \frac{a^2 b}{(1.6)\ (1{,}000{,}000)}$$

Where, G = biomass (μg); a = the greatest body width (μm); b = body length (μm); 1.6 = constant for correcting volume of nematode; and 1,000,000 is a factor for converting μm^3 to μg

For calculating the biomass of females, biomasses of neck and head and of the body were calculated separately. The width of the female body below the neck was measured at three points

Table 2. Population study of *M. graminicola* in rice plants grown on soil samples collected from wheat fields adopted under various resource conservation practices and conventional practices in rice-wheat cropping system under pot condition.

RCTs† options	Year of adoption of RCTs options	Initial population of 2nd stage juvenile (500 g soil)	Population of 2nd stage juvenile, 30 DAS ø (500 g soil)	Nematode biomass (µg)	Net root biomass (µg)	NB : RB ratio	Root knot index (RKI)
CTTPR- CTBCW (Without residue)	2004	65	138	703.200	70956.800	1:101	1.4
CTTPR- CTBCW (With residue)	2003	400	968	747.021	64552.979	1:86	2.3
CTTPR- ZT wheat (Without residue)	2004	918	3873	2018.067	62681.933	1:31	4.1
CTTPR- ZT wheat (With residue)	2005	982	3780	2369.114	78130.886	1:33	4.4
RTDSR- ZT wheat (Without residue)	2004	768	3264	1460.260	66289.740	1:45	4.5
RTDSR- ZT wheat (With residue)	2004	1030	3965	4414.204	77015.796	1:17	5.0
ZT rice- ZT wheat (Without residue)	2006	824	4317	2426.517	156973.483	1:65	5
ZT rice- ZT wheat (With residue)	2005	886	4102	1639.294	60110.706	1:37	5
ZT rice- ZT wheat with sesbania	2005	296	800	786.913	79043.087	1:100	2.5
CD at 5%	-	16.42	15.28	17.21	15.52	-	-
SEM	-	5.52	5.14	5.79	5.22	-	-

NB : RB = Ratio of nematode biomass to root biomass; root knot Index, 1) No gall, 2) 1-25% gall, 3) 26-50% gall, 4) 51-75% gall, 5) >75% gall (Prot and Matias,1995); **†,** resource conservation technologies; ****,** 1) Conventional tilled transplanted puddle rice (CTTPR) – Conventional tilled broadcasted wheat (CTBCW) without residues (farmers' practice); 2) CTTPR–CTBCW with residues (farmers' practice); 3) CTTPR-zero tillage (ZT) wheat without residue ; 4) CTTPR-ZT wheat with residue; 5) reduced tillage direct seeded rice (RTDSR) – ZT wheat without residue; 6) reduced tillage direct seeded rice (RTDSR) – ZT wheat with residue; 7) ZT rice –ZT wheat (double ZT) without residue; 8) ZT rice - ZT wheat (double ZT) with residue; 9) ZT rice-ZT-wheat (Double ZT) with brown manuring (sesbania); ø, population of 2nd stage juvenile estimated 30 days after sowing.

and the biomass was calculated with the average width to get the realistic value.

In order to calculate nematode-to-root biomass ratio, measurements and biomass of the developing nematode and associated roots were taken. The fresh weight of roots was taken as the root biomass. Nematode biomass was then subtracted from infected root biomass to calculate net root biomass. The net root biomass of the infected plants was divided by the corresponding nematode biomass to obtain the nematode-to-root biomass ratio. This ratio was calculated from 15 rice plants and was averaged. All observations were rounded off to two and three digit after decimal. CD at 5% and SEM value were estimated statistically using STPR software for completely randomized design experiment.

RESULTS AND DISCUSSION

Effect of different tillage practices on development of root knot disease revealed that population of second stage juveniles of *M. graminicola* at initial stage was found higher in resource conservation practices (768-1030) as compared to conventional practices (65-400) and double zero tillage with sesbania (296) (Table 2). Chandel et al. (2002) found that the population density of the root-knot nematodes was higher in the non-puddled soils especially in unsubmerged conditions as compared to puddled and submerged soil. In the case of conservation tillage practices such as reduced tillage or zero tillage, Pankaj et al. (2006) observed that zero-tillage fields had population densities of plant parasitic nematodes (*Tylenchorhynchus brevilineatus* and *Pratylenchus* spp.) higher than those of conventionally tilled fields because of ploughing that decreased nematode population densities significantly, irrespective of fertilizer application. After 30 days of sowing, two to three fold increases in population was found as compared to initial populations.

Decline in nematode population densities with intervenetion of sesbania as brown manure with zero tillage rice-zero tillage wheat (double zero tillage) clearly showed that sesbania plays significant role in the management of populations of *M. graminicola.* Decomposition of organic residues results in the accumulation of specific compounds that may be nematicidal (Rodriguez-Kabana, 1986; Rodriguez-Kabana and Morgan-Jones, 1987). The green manure crops (leguminous crops) like *Sesbania rostrata* and *Aeschynomere afaraspera*, when grown in rotation have been shown to significantly increase yields of irrigated rice in the presence of rice root nematode (*Hirschmanniella oryzae)* by acting as trap crops of the nematodes (Germani et al., 1983).

Nematode biomass was much higher in RCTs as compared to double zero tillage with sesbania and conventional practices. Puddling of soil prior to planting paddy significantly reduces the population densities of root-knot nematode, *M. graminicola*, *Meloidogyne triticoryzae* and *Tylenchorhynchus mashoodi* (Gaur and Singh., 1993). However, increase in nematode biomass was also found associated with initial population of second stage juvenile of *M. graminicola.* Nematode to root biomass ratios was found narrow (1:17 to 1:65) in RCTs as compared to conventional practices which showed broad nematode to root biomass ratio (1:86 to 1:101). Double zero tillage with sesbania also shows broad nematode-to-root biomass ratio (1:100). Nematode-to-root biomass ratio was found inversely proportional to population densities of nematode. Development of root knot nematode in relation to different cultivation practices can also be understood from root knot index which was 4.0 to 5.0 (more than 50% roots formed gall) in the case of RCTs (Option No.3-9) over double ZT with sesbania and conventional methods which showed less than 3.0 root knot index (less than 25% roots formed gall). It was also found that those tillage practices where residues were left on the field itself (with residues) has high population densities, root knot index and narrow nematode to root biomass ratio as compared to practices where crops were harvested from ground level without leaving residues in the field.

The study revealed that those plots which got the intervention of resource conservation practices showed high population densities, root knot index and narrownematode to root biomass ratio of *M. graminicola* as compared to conventional ones. Contrarily, zero till rice- zero till wheat + sesbania sp. showed low population densities, root knot index and wide nematode to root biomass ratio which may serve as a better option for the management of *M. graminicola*. With the recent developments of genetic tools in *M. graminicola*, it may also be of interest to follow the population dynamic of nematodes under different treatments in order to test more precisely the effects of agricultural practices on the biology of *M. graminicola* (Besnard et al., 2014).

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