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Rice-Root Nematode, *Hirschmaniella oryzae*, Infecting Rice Selections and Weed Genotypes

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Abstract.- The occurrence of *Hirschmaniella oryzae* in roots of 11 rice, *Oryza sativa,* selections and 10 weed genotypes belonging to 7 families was recorded during 2006-07. Nematode density in composite root samples was determined by a Modified Sieving-Baermann Funnel technique. Root population levels of the nematode varied among rice selections and weeds. Ten rice cultivars including Super Basmati, Basmati-198, Basmati-2000, Basmati-370, Basmati-385, KSK-133, KSK-201, KSK-282, IR-6, and IR-9 exhibited nematode population levels in excess of the damage threshold level (5-30 nematodes per g of root). Only Basmati Pak supported nematode populations below the damage threshold level. The Basmati selections supported varying levels of nematodes with Basmati-370, Basmati-385 and Super Basmati supporting significantly greater nematode populations than Basmati 370, Basmati 198, Basmati Pak and Basmati 2000 selections. Two IR selections supported similar numbers of nematodes but fewer than KSK selections. Six weed species including *Echinochloa colona, E. glabrescens* (poaceae), *Chenopodium album* (chenopodiaceae), *Cyperus difformis, Rumex dentatus* (polygonaceae), and *Scripus maritimus* (cyperaceae), supported nematodes at population levels similar to that recovered from rice roots. Four other weed species including *Coronopus didymus* (brassicaceae) *Marsilea minuta* (marsileaceae), *Paspalum distichum* (poaceae), and *Sphenoclea zeylanica* (campanulaceae) were consistently infected by the nematode but at population levels reduced from those found in rice roots. This study indicates that rice-root nematode is able to infect all commercially grown cultivars and weeds common to Pakistani rice fields. These results further demonstrate that weed hosts act as a reservoir for over-wintering *H. oryzae.*

Key words: Rice cultivars, rice-root nematode, *Hirschmaniella oryzae,* weed genotypes.

INTRODUCTION

Rice (*Oryza sativa* L. Family : Gramineae) is the most important food grain crop in Pakistan and is commonly planted in all agro-ecological areas suited for rice production. Rice is a major rainy season crop and the best quality rice is grown in central Punjab. Despite an increasing trend to use more inputs and adopt improved production technologies, yield is 22% less than that found in other developed countries (FAO, 2008; Regmi *et al.,* 2002). Various factors are responsible for reduced yield including lack of irrigation as well as outbreaks of specific insects, pests, and diseases (Pimente *et al.,* 1984). Among the diseases, rice blast, bacterial blight, and sheath blight are important diseases of rice (Dahal *et al.,* 1990). Nematodes feed on roots and reduce their potential for uptake of water and nutrients (Mojtahedi and Lownsbery, 1975), but this hidden pest and its associated damage are generally hidden from the growers. More than 150 genera of plant parasitic nematodes have been reported to be associated with rice production throughout the world (Fortuner and Merny, 1979). Rice-root nematode (*Hisrschmanniella* spp.) and root-knot nematode (*Meloidogyne* spp.) are the most important pests of rice (Fortuner and Merny, 1979). The extent of damage by these nematodes in rice depends upon the location, environment, varieties, soils, and other cultural practices associated with rice production.

Numerous weed species are common in rice fields and can reduce yield and quality of rice by competing for light, nutrients and space. In addition, their seeds can be a contaminants of harvested grain. Although competition is the most important effect weeds have on crop production; they are also alternative hosts for plant-parasitic nematodes and have long been recognized for their ability to maintain nematode populations. Weeds can serve as a reservoir for many nematode species (Bélair and

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Benoit, 1996; Castillo *et al.*, 2008; Davidson and Townshend, 1967; Tedford and Fortnum, 1988; Venkatesh *et al.*, 2000). Numerous species of grass and broadleaf weeds can be found infesting rice fields of Pakistan (Anwar *et al.*, 2008, 2009).

The objective of this study was to determine the relative population levels of rice-root nematode, *H. oryzae*, in roots of eleven rice, *O. sativa*, selections and ten weeds commonly associated with rice grown in the Punjab.

MATERIALS AND METHODS

Nematode sampling in each of our field experiments was done according to the methods of Barker (1985). Five samples consisting of roots and soil were collected from each plot of eleven rice selections at panicle stage planted at the farm of Rice research Institute, Kala Shah Kaku, Sheikpura. The selections included Super Basmati, Basmati-198, Basmati-2000, Basmati-370, Basmati-385, Basmati Pak, KSK-133, KSK-201, KSK-282, IR-6, and IR-9. Five plants of each weed species from each plot were randomly sampled. Each sample was comprised of the aerial part of the plant and the corresponding roots with adhering soil collected between the 5 and 30-cm depth. After identification of the plant to species level (Fournet and Flore, 1978; Fournet and Hammerton, 1991) all root samples were carefully washed under tap water to remove adhering soil particles and entangled foreign or weed fibrous roots. The soil suspension was passed through a 60-mesh sieve nested over a 325-mesh sieve. The material over the 325-mesh was transferred onto funnels and extracted by Modified Sieving-Baermann Funnel technique (McKenry and Roberts, 1985).

The collected rice root samples were washed thoroughly, cut into 1-5 cm lengths and the nematodes extracted from a fresh rice root composite sub-sample of 20 g by placing them in a mist-chamber for 5 days (McKenry and Roberts, 1985). A weed root sub-sample of 3 g per plant was processed as above.

Data analysis

Data were subjected to analysis of variance using SAS (SAS Institute, Cary NC). Significant differences in means of nematode reproduction were separated using Duncan's Multiple Range Test at (P = 0.05).

Table I.- Rice-root nematode, *Hirschmaniella oryzae* associated with 11 rice selections.

Rice selections	Nematode population in 100 ml^3 soil and root g^{-1}	
	Soil	**Root**
Basmati 370	23c	32ab
Basmati 198	15d	22d
Basmati Pak	12d	02e
Basmati 385	35a	32ab
Super Basmati	26bc	33ab
Basmati 2000	23c	26cd
IR-6	26bc	26cd
IR-9	27bc	29bc
KSK 282	31ab	34ab
KSK 133	28b	30abc
KSK 201	30ab	35a

*Means within a column followed by the same letter are not significantly different according to Duncan's Multiple Range Test at P = 0.05.

RESULTS

Population levels of H. oryzae

Nematode root populations varied among rice selections (Table I). A significantly low root population level was detected on rice selection Basmati Pak only. Meanwhile, soil population levels were lowest on Basmati 198 and Basmati-Pak selections. Rice selections including, Basmati-385, Super Basmati, KSK-282, KSK-133, and KSK-201 supported high root nematode populations, while Basmati-385, and KAK-201 also had high soil population levels. Three rice selections namely Basmati 2000, IR-6, and IR-9 had intermediate root and soil populations. Nine rice selections including Super Basmati, Basmati-2000, Basmati-370, Basmati-385, KSK-133, KSK-201, KSK-282, IR-6, and IR-9 exhibited nematode population levels in excess of the damage threshold level (5-30 nematodes per g of root) (Ying *et al.*, 1996; Zin *et al.*, 2010). Two selections including Basmati-198 and Basmati Pak supported nematode populations below the damage threshold level. The Basmati selections supported varying levels of nematodes. Basmati-370, Basmati-385, and Super Basmati supported significantly greater nematode populations than three other Basmati selections.

Two IR selections supported the same number of nematodes but significantly fewer than KSK selections.

Weeds infesting rice crops

Ten weed species belonging to 9 genera and 7 families were found infesting rice fields. Among these ten weed genotypes, there were six annual weed species (*Chenopodium album, Coronopus didymus, Cyperus difformis, Echinochloa colona, E. glabrescens, Sphenoclea zeylanica*) and four perennial species (*Marsilea minuta, Paspalum distichum, Rumex dentatus, Scripus maritimus*) (Table II).

Hirschmaniella oryzae *in association with weeds*

All the weed genotypes supported varying levels of nematodes during rice cropping season as well as during the off-season (Table III). Six weed genotypes including *C. album, C. difformi, E. colona, E. glabrescens, R. dentatus,* and *S. zeylanica* sampled from rice fields exhibited high soil nematode populations, while soil of four other genotypes comprising of *C. didymus, M. minuta, P. distichum* and *S. maritimus* exhibited reduced nematode populations in soil. The nematode populations from roots were highest (P= 0.05) from *E. glabrescens,* intermediate from *C. difformi* and *E. colona,* and lowest from roots of the other seven weed genotypes.

Weed genotypes *C. difformis* and *E. glabrescens* had similar root nematode populations during off and on season. Weed genotype *P. distichum* supported the lowest nematode population during both harvests. Nematode populations found in rhizosphere soil were also variable among weed genotypes. Two weed genotypes *M. minuta* and *P. distichum* supported lowest soil nematode populations during both sampling seasons. Only one weed genotype *E. glabrescens* exhibited low soil nematode populations during off-season. Six other weed species including *C. album, C. didymus, E. colona, P distichum, R. dentatus* and *S. maritimus* supported high soil nematode populations during both seasons.

DISCUSSION

The primary objectives of this study were to determine the host status of *H. oryzae* in association with rice selections and weed genotypes in Punjab rice production (See Table I). Eleven rice cultivars and ten weed genotypes were evaluated in several rice plantings. The results showed statistical differences in *H. oryzae* population development in association with both rice and weed genotypes. These differences among nematode population levels were due to variation in the genetic make-up of genotypes (Brian *et al*., 2010). Differences in host status may also have been due to variations in farm practices, location, environment, soils and other cultural practices in rice production (Prasad, 1987). These findings are similar to results obtained by Pokharel, 1991.

This study has demonstrated that population levels of rice-root nematode, *H. oryzae* exceeded accepted damage threshold levels on roots of ten out of eleven rice selections (Ying *et al.,* 1996; Zin *et al.,* 2010). Data suggest that rice-root nematode might be the most important damaging soil pest in rice growing areas of the Punjab. The occurrence of this nematode has been reported from rice producing regions throughout the world (Bridge *et al.,* 2005).

The eleven rice selections we studied were derived from three sources including Basmati, IR and KSK. Six Basmati selections demonstrated high variability to infection by rice-root nematode populations. Abundance of nematodes on Basmati 385, intermediate levels on Super Basmati and Basmati 370 but low levels on two others, Basmati Pak and Basmati 198, suggests these selections differ in their level of resistance and this source warrants screening for an improved source of nematode resistance. Meanwhile, IR and KSK selections exhibited statistically similar levels of infestation within their respective group and may prove less worthy as a source for improved resistance.

In this study, 10 weed species hosted *H. oryzae* and all life stages could be found in the cortical tissue of the roots (Table III). The presence of abundant rice-root nematode in roots of weed genotypes during the off-season could provide a useful bio-indicator of the level of *H. oryzae* in fallow fields prior to rice replanting. Nematode and weed populations interact in numerous ways and the

Table II.- Listing of 10 common weeds assessed for their nematode host status

Weed genotypes	Common name	Family	Life span
Chenopodium album	Lamb's-quarters	Chenopdiaceae	Annual
Coronopus didymus	Swine cress	Brassicaceae	Annual
Cyperus difformis	Flate sedge	Cyperaceae	Annual
Echinochloa colona	Jungle rice	Poaceae	Annual
E. glabrescens	Orange torch	Poaceae	Annual
Marsilea minuta	Water clover	Marsileaceae	Perennial
Paspalum distichum	Knot grass	Poaceae	Perennial
Rumex dentatus	Curled dock, Sour dock	Polygonaceae	Perennial
Scripus maritimus	Bulrush	Cyperaceae	Perennial
Sphenoclea zeylanica	chickenspike	Sphenocleaceae	Annual

Table III.- Population levels of rice-root nematode, *Hirschmaniella oryzae*, on weeds.

Weed genotypes	Nematode population during			
	Rice growing season		Rice land, off-season	
	Soil per 100 ml^3	Root g^{-1}	Soil per 100 ml^3	Root g^{-1}
Chenopodium album	61bc	12bc	71ab	15ab
Coronopus didymus	55de	11bc	65ab	17ab
Cyperus difformis	65ab	13b	60b	13b
Echinochloa colona	68a	14b	69ab	15ab
E. glabrescens	60c	19a	77a	18a
Marsilea minuta	45f	9bc	44c	8c
Paspalum distichum	39g	7c	43c	9c
Rumex dentatus	67a	12bc	62ab	17ab
Scripus maritimus	53e	11bc	58b	15ab
Sphenoclea zeylanica	59c	13b	69ab	17ab

*Means within a column followed by the same letter are not significantly different according to Duncan's Multiple Range Test at P = 0.05.

persistence of weeds growing among rice roots or between two successive rice crops is an important source of nematode survival and infestation. This study suggests that weeds can be an important reservoir of rice-root nematode, *H. oryzae* (Table III). Four annual weeds including two *Echinochloa* species (jungle rice, orange torch), one *Paspalum* species (knot grass), one *Cyperus* species (flat sedge) are the most widespread and aggressive weeds of rice. It is also interesting to note that plants from the Cyperaceae, Poaceae, Sphenocleaceae families were hosts of *H. oryzae*. They are also a good host of rice-root nematode (Babatola, 2006). This suggests that rice cultivation, which favors the re-growth of these weeds may favor survival of *H. oryzae* and help to explain the re-infestation of rice after a fallow period. Conversely, the good weed host for nematodes will also be damaged along with the cash crop resulting in less competition. Gonzalez Ponce *et al*. (1995) showed that tomatoes infected with *M. incognita* were less competitive with black nightshade (*Solnum nigrum*), a good host for root-knot nematode. The growth of relatively poor weed hosts to nematodes is likely to be unaffected leading to more competition with crop plants. Starr (1998) found that nematode parasitism reduces cotton growth but the growth of weeds being poor host is not affected. Nematode parasitism of a crop has been shown to increase the effects of competition from weeds when soybean (*Glycines max*) growth was reduced by soybean cyst nematode (*Heterodera glycines*) damage (Alston *et al*., 1991).

Our findings suggest that weed plants provide a means of survival for nematode populations which may contribute to the maintenance, reinfestation, multiplication and spread of *H. oryzae* within a field, and thus increase the potential for crops to be damaged by nematode attacks (Castillo *et al*., 2008). Infested fields act as an important reservoir of nematodes and may aid in the dissemination of nematodes within or among crops by many agricultural operations like irrigation water (Orr and Newton, 1971) that can reduce the beneficial effects of the nematode resistant crops. We had also demonstrated that rice selections differ in their level of resistance and this source warrants screening for an improved source of nematode resistance. Our findings further suggest that rice selection Basmati-Pak offers resistance over other selections, which is a better choice for grower to plant in the nematode infested fields.

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