



Survey for Alternate Weed Hosts of Rice Root-Knot Nematode, *Meloidogyne graminicola* Associated with Rice Crops in Haryana, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice root-knot nematode, *Meloidogyne graminicola* is one of the most serious nematode pest associated with rice throughout the world. With other species of root-knot nematode, *M. graminicola* can also infect wide range of weed flora which is commonly grown in or near the rice field. To study the alternate weed hosts of *M. graminicola* a survey was conducted in the major rice growing blocks of Fatehabad and Sirsa districts of Haryana during Kharif season 2022. A total of 726 samples were collected from rice fields, both from transplanted (TR) and direct seeded rice (DSR) from Phoolan, Bharpur, Ratta Khera, and Jandwala Sotter villages of Fatehabad and Bahauddin and Sikanderpur, Dhottar, Ding and Chopta villages of Sirsa. Out of which 353 samples were found free from nematode infestation while 373 samples (209 from DSR and 164 from TR) were found infested. The juveniles and galls were recorded ranging from 4-190 on the roots of different weed plants. Hence,

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it is concluded from the present investigation, that nematodes favor more DSR and its weed flora than TR for infection and survival.

Keywords: Alternate weed host, *Meloidogyne graminicola*, rice, survey.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop throughout the world, just after wheat and maize, playing a strategic role in solving food security issues. It is a primary crop grown widely over 161 mh in more than 100 countries of the world [1]. Approximately 90 percent of the world's rice is grown and consumed in Asia, which is native of 60 percent of the world population [2]. In India, it was cultivated from ancient times and ranked first in area and second in production after China. In India, it grew 46.27 mh with a total production of 129.47 m tonns with an average productivity of 2798 kg/ha [2].

Rice cultivation is affected by various biotic and abiotic factors which contribute to the lower productivity of rice in India. Among the biotic factors, nematode infestation is considered an important factor responsible for up to 72% of yield loss [3,4]. Rice root-knot nematode, *M. graminicola* is a serious pest of rice, and is economically most important plant-parasitic nematode infesting rice. This nematode has been recorded in many states of India, such as Jammu and Kashmir [5], Kerala [6], Orissa [8], Karnataka [9,10], West Bengal [11,12], Haryana, Himachal Pradesh, Panjab [13-15], and Uttar Pradesh [16,17]. Previously, *M. graminicola* was only seen in upland rice, but it has rapidly expanded to irrigated and deep-water rice in the last two decades. But recently due to government efforts (intensive-based subsidies) and increasing water shortage during paddy season, farmers are shifting from TR to DSR. Due to a congenital condition, this nematode becomes a channeling task in DSR. *M. graminicola* is an obligate sedentary endoparasite adapted to a wide range of water regimes and soil conditions and in India, this causes 16-32 percent yield loss under irrigated and 11-73 percent under flooded conditions [18].

Due to its wide polyphagia, *M. graminicola* survives and reproduces in the off-season on certain weeds which commonly grown in or near the rice field, contributing to the increase of inoculum in the soil and then parasitizing rice cultivation in the next season [19]. In addition to the main host, rice, *M.*

graminicola has a wide range of alternative hosts, including cereals and grasses, as well as dicotyledonous plants [20]. The broad host range of this nematode is beneficial for maintaining the population in the absence of the main host, many researchers have reported that *M. graminicola* maintain the population multiplies on various weed host and maintain the population on weeds for the next season [8,21]. Commonly occurring weeds of the family Poaceae like barnyard grass (*Echinochloa* spp.), *Dactyloctenium aegyptium*, and *Leptochloa chinensis* were reported as good hosts of *M. graminicola* [21]. Moreover, *M. graminicola* complete its life cycle within 15 days at 27-37 °C [22]. It indicates that nematodes complete many generations in one crop season. Several reports show that various populations of *M. graminicola* have varying host ranges [23]. The investigation was designed to gather information on by examining the alternate weed host of the rice root-knot nematode, *M. graminicola*, associated with rice crops in Haryana, since *M. graminicola* is a serious nematode pest of rice in many non-traditional rice growing districts of the state where it is primarily used by the farmers.

2. MATERIALS AND METHODS

A survey was conducted for alternate weed host of rice root-knot nematode, *M. graminicola* associated with rice crops in the major rice growing blocks of Fatehabad and Sirsa districts of Haryana during the kharif season of 2022. During the survey, eight locations/village Panchayats of Fatehabad and Sirsa districts were randomly selected for weed host identification of *M. graminicola*. The weed hosts were identified based on the field symptoms like patchy growth and characteristics hook shaped gall formation on plant roots. Terminated weeds are categorized on the number of galls /plants indexed on a 0-5 scale [24]. The confirmation of nematode species was done based on a perineal pattern of *M. graminicola* by following Taylor and Sasser's [24] technique through mature females of stained root for each weed host in the Department of Nematology, CCS HAU, Hisar. The susceptibility/resistant response of the weed host was recorded in terms of galls that developed on each root system as follows

0. 0 galls/egg masses = Immune

1. 1-2 galls/egg masses = H.R. (Highly resistant)
2. 3-10 galls/egg masses = R (Resistant)
3. 11-30 galls/egg masses = MR (Moderately resistant)
4. 31-100 galls/egg masses = S (Susceptible)
5. >100 galls/egg masses = HS (Highly susceptible)

3. RESULTS AND DISCUSSION

A survey for alternate weed host of rice root-knot nematode, *M. graminicola* associated with rice crops in the major rice growing blocks of Fatehabad and Sirsa districts of Haryana during the Kharif season was conducted and data is presented in Tables 1 & 2. A total of 726 samples of common weeds from rice fields with five samples for Poaceae and two samples for broad leaf weeds from both TR and DSR were collected. The collected samples were analyzed for number of infected samples and number of galls. All the plants viz., *Dactyloctenium Egyptian* Beauv., *Echinochloa crus-galli*, *E. colona*, *Cynodondactylon*, *Leptochloa chinensis*, *Cyperus rotundus*, and *C. difformis*, except *Euphorbia hirta*, *E. prostrata*, and *Portulaca oleracea*, were found hosts of *M. graminicola*, although variation occurred in respect of number of galls/plant in different plant species.

A maximum number of galls/plant was observed in *Echinochloa colona* followed by *Echinochloa crus galli* and *Cyperus difformis* having 185.50,

163.75, and 163.75, respectively at village Sikanderpur of Sirsa district in DSR. Whereas in TR maximum number of galls/plants (137.75) was observed in the village Bahauddin. A perusal of data in Tables 1&2 indicated that *Euphorbia hirta*, *E. prostrata*, and *Portulaca oleracea* were found nonhosts for *M. graminicola*. Developmental stages of nematode were also recorded in the roots of all the weed hosts, except *Euphorbia hirta*, *E. prostrata*, and *Portulaca oleracea*. *M. graminicola* is frequently associated with other cereals, as well as dicotyledonous and grass plants, including many weed flora that may constitute a major reservoir of nematodes [8].

3.1 Results

Our results are in conformity with those of Devi et al.[25] who observed that barnyard grass, chottisavank and badisavank (scientific name capital and italic) were good hosts of *M. graminicola*.Kumar et al.[26] reported that *Dactyloctenium aegyptium* and *Leptochloa chinensis* were host of *M. graminicola*. Roy [27] evaluated 46 weeds commonly grown in or around rice fields of Assam and many weeds were found as moderate to good hosts of *M. graminicola*. *M. graminicola* also has several alternative/collateral hosts such as *E. colonum*, *C. compressus*, *C. rotundus*, *Brachiaria ramosa*, *Ranunculus pusillus* etc. These weeds were commonly encountered in rice fields of the Southern US and South-East Asian countries [14].



Photo 1.Galls on *Cyperus difformis* and rice plant; Photo 2. *Leptochloa chinensis*

Table 1. Survey of weed alternate host for rice root-knot nematode, *Meloidogyne graminicolain* Fatehabaddistrict

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index
Phoolan	Transplanted Rice	<i>(Dactylocteniumaegyptium</i> Beauv.)	5	3	2	7.25	2
		<i>Echinochloa crus-galli</i>	5	4	1	115.50	5
		<i>Echinochloacolona</i>	5	4	1	137.30	5
		<i>Cynodondactylon</i>	5	2	3	9.70	2
		<i>Leptochloa chinensis</i>	5	3	2	93.25	4
		<i>Cyperus rotundus</i>	5	3	2	97.50	4
		<i>Cyperus difformis</i>	5	4	1	87.40	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
	Direct Seeded Rice	<i>(Dactylocteniumaegyptium</i> Beauv.)	5	4	1	9.00	2
		<i>Echinochloa crus-galli</i>	5	5	0	125.25	5
		<i>Echinochloacolona</i>	5	5	0	167.50	5
		<i>Cynodondactylon</i>	5	3	2	9.40	2
		<i>Leptochloa chinensis</i>	5	4	1	105.35	5
		<i>Cyperus rotundus</i>	5	3	2	99.45	4
		<i>Cyperus difformis</i>	5	5	0	94.25	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
Bharpur	Transplanted Rice	<i>(Dactylocteniumaegyptium</i> Beauv.)	5	2	3	4.30	2
		<i>Echinochloa crus-galli</i>	5	4	1	87.25	4
		<i>Echinochloacolona</i>	5	3	1	117.45	5
		<i>Cynodondactylon</i>	5	2	3	19.70	32
		<i>Leptochloa chinensis</i>	5	3	2	86.50	4
		<i>Cyperus rotundus</i>	5	2	3	91.50	4
		<i>Cyperus difformis</i>	5	4	1	92.25	4

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index	
Ratta Khera	Direct Seeded Rice	<i>Euphorbia hirta</i>	2	0	2	0	0	
		<i>Euphorbia prostrata</i>	2	0	2	0	0	
		<i>Portulaca oleracea</i>	2	0	2	0	0	
		(<i>Dactyloctenium aegyptium</i> Beauv.)	5	2	3	16.25	3	
		<i>Echinochloa crus-galli</i>	5	5	0	109.50	5	
		<i>Echinochloa colona</i>	5	5	0	127.20	5	
		<i>Cynodactylon</i>	5	2	3	19.45	32	
		<i>Leptochloa chinensis</i>	5	4	1	89.75	4	
		<i>Cyperus rotundus</i>	5	2	3	93.25	4	
		<i>Cyperus difformis</i>	5	4	1	96.50	4	
		<i>Euphorbia hirta</i>	2	0	2	0	0	
		<i>Euphorbia prostrata</i>	2	0	2	0	0	
		<i>Portulaca oleracea</i>	2	0	2	0	0	
		(<i>Dactyloctenium aegyptium</i> Beauv.)	5	1	4	3.25	2	
	Transplanted Rice	<i>Echinochloa crus-galli</i>	5	3	2	90.25	4	
		<i>Echinochloa colona</i>	5	4	1	117.30	5	
		<i>Cynodactylon</i>	5	1	4	19.45	32	
		<i>Leptochloa chinensis</i>	5	4	1	76.50	4	
		<i>Cyperus rotundus</i>	5	2	3	74.75	4	
		<i>Cyperus difformis</i>	5	3	2	95.50	4	
		<i>Euphorbia hirta</i>	2	0	2	0	0	
		<i>Euphorbia prostrata</i>	2	0	2	0	0	
		<i>Portulaca oleracea</i>	2	0	2	0	0	
		Direct Seeded Rice	(<i>Dactyloctenium aegyptium</i> Beauv.)	5	3	2	8.29	2
			<i>Echinochloa crus-galli</i>	5	4	1	134.50	4
			<i>Echinochloa colona</i>	5	5	0	137.75	5
			<i>Cynodactylon</i>	5	2	3	21.30	32
			<i>Leptochloa chinensis</i>	5	4	1	76.45	4
<i>Cyperus rotundus</i>	5		2	3	78.35	4		

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index
Jandwala Sotter	Transplanted Rice	<i>Cyperus difformis</i>	5	4	1	99.75	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrata</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
		(<i>Dactyloctenium aegyptium</i> Beauv.)	5	3	2	7.45	2
		<i>Echinochloa crus-galli</i>	5	4	1	105.75	5
		<i>Echinochloa colona</i>	5	5	0	127.50	5
		<i>Cynodactylon</i>	5	2	3	21.75	3
		<i>Leptochloa chinensis</i>	5	4	1	79.50	4
		<i>Cyperus rotundus</i>	5	3	2	67.25	4
	Direct Seeded Rice	<i>Cyperus difformis</i>	5	4	1	96.50	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrata</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
		(<i>Dactyloctenium aegyptium</i> Beauv.)	5	4	1	4.40	3
		<i>Echinochloa crus-galli</i>	5	5	0	105.25	5
		<i>Echinochloa colona</i>	5	5	0	137.35	5
		<i>Cynodactylon</i>	5	3	2	31.50	3
		<i>Leptochloa chinensis</i>	5	4	1	109.75	5
		<i>Cyperus rotundus</i>	5	4	1	67.50	4
<i>Cyperus difformis</i>	5	4	1	102.25	5		
<i>Euphorbia hirta</i>	2	0	2	0	0		
<i>Euphorbia prostrata</i>	2	0	2	0	0		
<i>Portulaca oleracea</i>	2	0	2	0	0		

Table 2. Survey of weed alternate host for rice root-knot nematode, *Meloidogyne graminicolain* Sirsa distict

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index
Bahauddin	Transplanted Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	1	4	5.00	2
		<i>Echinochloa crus-galli</i>	5	3	2	105.50	5
		<i>Echinochloacolona</i>	5	2	3	137.75	5
		<i>Cynodondactylon</i>	5	2	3	13.25	3
		<i>Leptochloa chinensis</i>	5	3	2	93.50	4
		<i>Cyperus rotundus</i>	5	4	1	87.25	4
		<i>Cyperus difformis</i>	5	4	1	92.50	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
	<i>Portulaca oleracea</i>	2	0	2	0	0	
	Direct Seeded Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	2	3	7.50	2
		<i>Echinochloa crus-galli</i>	5	4	1	115.75	5
		<i>Echinochloacolona</i>	5	3	1	139.25	5
		<i>Cynodondactylon</i>	5	2	3	13.75	3
		<i>Leptochloa chinensis</i>	5	4	1	96.50	4
		<i>Cyperus rotundus</i>	5	4	1	89.75	4
		<i>Cyperus difformis</i>	5	4	1	92.50	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
<i>Portulaca oleracea</i>	2	0	2	0	0		
Sikanderpur	Transplanted Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	4	1	9.75	2
		<i>Echinochloa crus-galli</i>	5	5	0	87.25	4
		<i>Echinochloacolona</i>	5	5	0	127.50	5
		<i>Cynodondactylon</i>	5	2	3	15.75	3
		<i>Leptochloa chinensis</i>	5	4	1	76.20	4
		<i>Cyperus rotundus</i>	5	3	2	91.45	4
		<i>Cyperus difformis</i>	5	4	1	106.66	5

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
	Direct Seeded Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	4	1	13.50	3
		<i>Echinochloa crus-galli</i>	5	5	0	163.75	5
		<i>Echinochloacolona</i>	5	5	0	185.50	5
		<i>Cynodondactylon</i>	5	3	2	15.35	3
		<i>Leptochloa chinensis</i>	5	5	0	112.25	5
		<i>Cyperus rotundus</i>	5	4	1	103.20	5
		<i>Cyperus difformis</i>	5	5	0	126.75	5
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
Dhottar	Transplanted Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	0	5	0	0
		<i>Echinochloa crus-galli</i>	5	3	2	76.50	4
		<i>Echinochloacolona</i>	5	4	1	97.00	4
		<i>Cynodondactylon</i>	5	1	4	16.75	3
		<i>Leptochloa chinensis</i>	5	3	2	79.25	4
		<i>Cyperus rotundus</i>	5	2	3	82.50	4
		<i>Cyperus difformis</i>	5	3	2	95.75	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrate</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
	Direct Seeded Rice	(<i>Dactylocteniumaegyptium</i> B eauv.)	5	4	1	6.20	2
		<i>Echinochloa crus-galli</i>	5	3	2	79.35	4
		<i>Echinochloacolona</i>	5	4	1	108.75	5
		<i>Cynodondactylon</i>	5	2	3	12.50	3
		<i>Leptochloa chinensis</i>	5	4	1	73.25	4
		<i>Cyperus rotundus</i>	5	3	2	85.50	4

Locations/village	Planting System	Weed (Scientific name)	Number of sample	Infected	Uninfected	Average no. of galls/plant	Scale index
		<i>Cyperus difformis</i>	5	4	1	99.75	4
		<i>Euphorbia hirta</i>	2	0	2	0	0
		<i>Euphorbia prostrata</i>	2	0	2	0	0
		<i>Portulaca oleracea</i>	2	0	2	0	0
Ding Chopta	Transplanted Rice	(<i>Dactyloctenium aegyptium</i> B eauv.)	5	1	4	6.60	2
		<i>Echinochloa crus-galli</i>	5	4	1	114.75	5
		<i>Echinochloa colona</i>	5	3	2	107.50	5
		<i>Cynodactylon</i>	5	2	3	26.75	3
		<i>Leptochloa chinensis</i>	5	4	1	73.20	4
		<i>Cyperus rotundus</i>	5	1	4	61.25	4
		<i>Cyperus difformis</i>	5	3	2	89.75	4
		<i>Euphorbia hirta</i>	1	0	1	0	0
		<i>Euphorbia prostrata</i>	1	0	1	0	0
		<i>Portulaca oleracea</i>	1	0	1	0	0
	Direct Seeded Rice	(<i>Dactyloctenium aegyptium</i> B eauv.)	5	2	3	7.2	2
		<i>Echinochloa crus-galli</i>	5	4	1	124.50	5
		<i>Echinochloa colona</i>	5	5	0	117.40	5
		<i>Cynodactylon</i>	5	3	2	13.75	3
		<i>Leptochloa chinensis</i>	5	5	0	67.76	4
		<i>Cyperus rotundus</i>	5	2	3	59.26	4
			5	3	2	95.67	4
		<i>Euphorbia hirta</i>	1	0	1	0	0
		<i>Euphorbia rostrata</i>	1	0	1	0	0
		<i>Portulaca oleracea</i>	1	0	1	0	0

How we can count 7.5 galls kindly galls must be a real count number



Photo 3. Galls in close association of *Cyperus difformis* and rice; Photo 4. *Cynodondactylon*

Khan et al. [28] observed 17 weeds associated with kharif and boro rice grown in Nadia district of West Bengal (India) and all these were supporting *M. graminicola* for their survival and multiplication in field situations. Some of the weeds like *Bothriochloa intermedia*, *Physalis minima*, *Alternanthera sessilis*, *Agropyron repens*, *D. aegyptiacum*, and *Sporobolus diander* were reported as new hosts of *M. graminicola*. Bajaj and Dabur [29] reported that *C. difformis* (motha) a common weed of rice in Haryana as a host of *M. graminicola* and demonstrated that it could multiply on the weed under rice-wheat crop sequence. Mac Gowan and Langdon [30] also assessed 100 host plants of *M. graminicola*, which includes food, fodder, fruits, ornamentals and also certain weeds. Among 14 weeds observed in rice, 5 (*Echinochloacolona*, *Echinochloacrusgalli*, *Dinebraretroflexa*, *Eleusine indica*, and *Eclipta alba*) as alternate hosts of root *M. graminicola*[31].

4. CONCLUSION

This study revealed that among 10 weeds observed in rice, 7 (*Echinochloacolona*, *Echinochloacrusgalli*, *Dactylocteniumaegyptium*, *Cynodondactylon*, *Leptochloa chinensis*, *Cyperus rotundus*, and *C. difformis*) were alternate hosts of rice root-knot nematodes *M. graminicola*. Among all villages/location of Fatehabad and Sirsa *M. graminicola* problem is more in DSR than TR.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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