Host Studies and Reactions of Rice Cultivars to *Meloidogyne graminicola*

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Portion of Masters thesis submitted by senior author to Louisiana State University, Baton Rouge.
Accepted for publication 20 November 1978.

ABSTRACT

YIK, C.-P., and W. BIRCHFIELD. 1979. Host studies and reactions of rice cultivars to *Meloidogyne graminicola*. Phytopathology 69:497-499.

Meloidogyne graminicola readily reproduced on 21 of 26 cultivars tested. Based on root gall development, two cultivars showed resistance to the rice root-knot nematode, nine cultivars were mildly resistant, and 15 were susceptible. The rice root-knot nematode has a narrow host range among dicotyledonous plants. *Ranunculus pusillus* Poir is now reported as the second dicotyledonous host. The sedge, *Cyperus compressus* L., also is a new host.

Additional key words: host range, rice resistance.

A root-knot nematode parasitizing rice, *Oryza sativa* L., was first reported by Tullis (13) in 1934 in Stuggart, Arkansas. The infected plants were dwarfed and yellowed and had lost vigor. The roots were galled and deformed. The nematodes were identified by Steiner as *Heterodera marioni* Cornu 1879. In 1934, Steiner (12) reported root-knot nematodes on *O. sativa* and on two weeds associated with rice fields, *Amaranthus spinosus* L. and *Echinochloa crusgalli* (L.) Beauv.

Golden and Birchfield observed *Meloidogyne graminicola* Golden & Birchfield 1965 on roots of barnyard grass, *Echinochloa colonum* (L.) Link (5). They stated that no symptoms were visible in the tops of infected barnyard grass and concluded that the host and parasite had a long-standing relationship. We believe that the root-knot nematode described as *H. marioni* on rice in the 1930s was *M. graminicola*.

Birchfield (1) found *M. graminicola* to be primarily a parasite of grasses and to prefer hosts such as *E. colonum, Avena sativa* L., *Poa annua* L., *Eleusine indica* (L.) Gaertn, and *Aleopecurus carolinianus* Walt. *Phaseolus vulgaris* L. 'Henderson Greenpod' is the only reported dicotyledonous host. Many dicotyledonous plants such as sweet potato, cucumber, tomato, cotton, watermelon, and peppers grown in fields infested by *M. graminicola* are not hosts of this nematode.

M. graminicola has a 23–27 day life cycle (egg to egg) at 26 C (17,18) and occurs in many rice growing regions, including Laos (6), India (9), Thailand, and the southern United States. Golden and Birchfield (6) reported that seven foreign and 23 local rice varieties are susceptible to the rice root-knot nematodes. This study examined the host range of *M. graminicola* and the genotypic diversity of several rice cultivars that may offer germ plasm for resistance selections.

MATERIALS AND METHODS

Weed, crop, and ornamental plants. Barnyard grass was planted in soil flats (originally infested with *M. graminicola* at Burden Research Farm, Louisiana State University) in the greenhouse at 30 C. After 6 mo, soil samples had a population of 800 larvae per 500 cm^3. Seeds of test plants were planted in rows, 6 in. apart in the infested soil. The test plants consisted of six weeds, 14 crop cultivars, and three ornamental species (Table 1) representing 11 plant families, of which 18 were dicotyledons and five were monocotyledons. The plants were watered regularly, fertilized with N-P-K, 8-8-8, and sprayed with Malathion once every three weeks to control insects and aphids. Barnyard grass was planted in rows alongside the test plants to check the viability of the nematodes.

After 60 days, the roots were removed, washed, and examined (Table 1) for root galls and *M. graminicola* egg masses.

Rice cultivars and resistance. Infested soil and root galls from greenhouse cultures were mixed with sterilized soil to provide 200 larvae per 100 g of soil. The soil was placed in 10-cm sterilized clay pots. Of 26 rice cultivars evaluated, seven are grown commercially in Louisiana (Table 2). Twelve seeds of a cultivar were planted in the pots. Three replications of each cultivar were used in the test. Barnyard grass planted in infested soil in five replications served as the controls.

Roots of the rice plants and barnyard grass were removed after 60 days; 10 plants of each cultivar from each replicate were examined (Table 2) for root galls and egg masses, using a modification of Horsfall and Barratt's method (7). Root galling was used as a measure of resistance and susceptibility for the rice cultivars.

RESULTS

Weed, crop, and ornamental plants. Large terminal and root axil galls developed in abundance in *E. colonum*. The galled tissues contained mature females, egg masses, males, and hatched second-stage larvae. The rice root-knot nematode reproduced on two (*Cyperus compressus* and *Ranunculus pusillus*) of the six weed species (Table 1). *C. compressus* had spindle-shaped galls containing females and egg masses. Elliptical galls were observed on *R. pusillus*. The mature females and egg masses were surrounded by a brown crustlike gelatinous matrix not present on the barnyard grass and the sedge.

Root galls were formed on five of the 21 crops and ornamentals (Table 1). The root systems of *Chrysanthemum morifolium* 'Babytears,' *G. max* 'Lee,' *E. indica*, and *Z. mays* 'Shoepeg' had a few galls and slight swellings. Slightly swollen and weak larvae were observed in these galls. *Solanum melongena* had a moderate number of long swellings in the roots. Obese females with no egg masses were removed from these tissues. None of the 21 crop and ornamental cultivars was considered a host because either no galls were formed, the larvae were unable to develop, or females were unable to reproduce in the swellings.

Rice cultivars and resistance. The 26 rice cultivars displayed a wide range of resistance and susceptibility to *M. graminicola* (Table 2). Cultivars LA 110 and Bonnet 73 were resistant, based on average root galling of less than 1%. Toride 1, Lebonnet,

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TABLE 1. Host reactions of 24 test plants to *Meloidogyne graminicola*

Plant	Family	Root gall index[a]	Egg mass	Host status[b]
Alternanthera philoxeroides (Martius) Grisebach	Amaranthaceae	0	−	NH
Amaranthus viridis L.	Amaranthaceae	0	−	NH
Capsicum annuum L.				
'Greenleaf Tobasco'	Solanaceae	0	−	NH
'Jalapeno'	Solanaceae	0	−	NH
'Tanokatsum'	Solanaceae	0	−	NH
Capsicum fructescens L. 'Yolo'	Solanaceae	0	−	NH
Chrysanthemum morifolium Ramat				
'Babytears'	Compositae	1	−	NH
'Jackpot'	Compositae	0	−	NH
Citrullus vulgaris Schrad.	Cucurbitaceae	0	−	NH
Cucumis melo L. var. *cantalupensis*	Cucurbitaceae	0	−	NH
Coleus blumei Benth.	Labiatae	0	−	NH
Cyperus compressus L.	Cyperaceae	2	+	H
Glycine max (L.) Merr.				
'Bragg'	Leguminosae	0	−	NH
'Lee'	Leguminosae	1	−	NH
Echinochloa colonum (L.) Link[c]	Gramineae	3	+	H
Eleusine indica (L.) Gaertn.	Gramineae	1	−	NH
Gossypium hirsutum L. 'Deltapine 16'	Malvaceae	0	−	NH
Hibiscus esculentus L. 'Clemson Spinless'	Malvaceae	0	−	NH
Oxalis sp. L.	Oxalidaceae	0	−	NH
Ranunculus pusillus Poir.	Ranunculaceae	2	+	H
Solanum melongena L. 'Long Green'	Solanaceae	2	−	NH
Zea mays L.				
'Cherokee Pop'	Gramineae	0	−	NH
'Pioneer 3009'	Gramineae	0	−	NH
'Shoepeg'	Gramineae	1	−	NH

[a] Gall index: 0 = no galls, 1 = few galls, 2 = moderate galls, 3 = abundant galls.
[b] NH = nonhost, H = host.
[c] Control plant.

Bellepatna, PI 338694, Dawn, Magnolia, Toride 2, SS Starbonnet, and I-Geo-Tze were moderately resistant with a range of about 1–10% of the roots galled. Of the 26 varieties, 13 were susceptible and 16–55% of the roots had galls (Table 2). CI 9835 and Brazos were the most susceptible, with 60–70% of the roots heavily galled. Barnyard grass had 90–100% malformed roots.

All the rice plants, except the five cultivars in the resistant and mildly resistant group, were hosts and had egg masses in the galled tissues. LA 110, Lebonnet, Bellepatna, Magnolia, and SS Starbonnet were not hosts of *M. graminicola*. Our study confirmed the status of Dawn, Caloro, and Taichung Native 1 as hosts (6).

DISCUSSION

Methods of determining host resistance to root-knot nematode infections differ (4,10,11). Winstead and Sasser (16) and Bouquet et al (2) used egg mass numbers as an index for resistance, but Brodie et al (3) used the amount of root necrosis on cotton seedlings, gall development, and failure of *M. incognita acrita* to reach maturity. Minton (8) used a root gall index rather than soil populations to rate host damage. Rohde (ll) stated that a resistant plant may allow nematodes to penetrate but that the nematodes were unable to develop to maturity. Susceptible plants would allow the root-knot nematodes to feed and reproduce successfully, resulting in plants with a greater amount of galls in the roots. Our study also used the amount of galling as an index to rate plant resistance in the rice cultivars.

All cultivars exhibited some degree of root galling when infected by *M. graminicola*. The range of resistance and susceptibility was assigned to the cultivars according to significant differences in the gall index. LA 110 and Bonnet 73, with gall indices of less than 1, were resistant; nine cultivars had indices between 1 and 2 and were moderately resistant. The remainder, with an index greater than 2, were susceptible. CI 9835 and Brazos were very susceptible.

Hosts of *Meloidogyne* spp. allow the nematodes to penetrate, feed, reproduce, and complete their life cycles (11). Webber and

TABLE 2. Cultivar response and resistance of *Oryza sativa* L. to *Meloidogyne graminicola*

Cultivars	Root gall index[u]	Resistance rating[v]	Egg mass	Hosts status[w]
LA 110	0.33 a[x]	R	−	NH
Bonnet 73[y]	0.67 a	R	+	H
Lebonnet[y]	1.0 ab	MR	−	NH
Bellepatna	1.0 ab	MR	−	NH
Toride 1	1.0 ab	MR	+	H
Magnolia	1.33 ab	MR	−	NH
SS Starbonnet	1.33 ab	MR	−	NH
PI 338694	1.33 ab	MR	+	H
Dawn	1.33 ab	MR	+	H
Toride 2	1.33 ab	MR	+	H
I-Geo-Tze	1.67 ab	MR	+	H
Juma I	2.0 b	S	+	H
Nortai[y]	2.0 b	S	+	H
CP 231	2.33 b	S	+	H
Blubelle[y]	2.33 b	S	+	H
Sunbonnet[y]	2.33 b	S	+	H
Starbonnet[y]	2.67 b	S	+	H
Caloro	3.0 b	S	+	H
Labelle[y]	3.0 b	S	+	H
Colusa	3.0 b	S	+	H
Mo-R-500	3.0 b	S	+	H
Guang Hsiang	3.33 b	S	+	H
Taichung Native 1	4.67 c	S	+	H
Remei	4.67 c	S	+	H
CI 9835	5.0 cd	VS	+	H
Brazos	5.67 cd	VS	+	H
Echinochloa colonum[z]	6.0 d	VS	+	H

[u] Means of three replicates where 0 = 0%, 1 = 1–15%, 2 = 16–30%, 3 = 31–45%, 4 = 46–60%, 5 = 61–75%, 6 = 76–100% roots galled.
[v] R = resistant, MR = moderately resistant, S = susceptible, VS = very susceptible.
[w] NH = nonhost, H = host.
[x] $P = 0.05$ according to Duncan's multiple range test.
[y] Cultivars commercially grown in Louisiana.
[z] Control plant.

Barker (14) and Williams and Laughlin (15) used the criteria of reproduction in host range tests. The two new hosts of *M. graminicola* were *R. pusillus* and *C. compressus*. In our study, *M. graminicola* did not reproduce on *E. indica*, which was formerly reported as a host (1). Of the 26 rice cultivars, 21 were hosts. *M. graminicola* readily reproduced on most rice cultivars and its common name, the rice root-knot nematode is justified. This nematode's ability to attack oats and cereals in addition to rice in South East Asia, where most rice is grown, makes this nematode a potential threat to small-grain agriculture. It also has alternate and collateral hosts in *E. colonum, C. compressus,* and *R. pusillus.* These weeds are common in rice fields of the southern United States and South East Asian countries.

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