HOST STATUS OF SELECTED TROPICAL ROTATION CROPS TO FOUR POPULATIONS OF ROOT-KNOT NEMATODES†

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ABSTRACT

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The susceptibility of selected tropical rotation crops to *Meloidogyne incognita* races 1 and 3, *M. arenaria* race 1, and *M. javanica* was evaluated in a series of greenhouse inoculation tests. 'Rutgers' tomato (*Lycopersicon esculentum*) and (or) 'Clemson Spineless' okra (*Hibiscus esculentus*) were included as hosts susceptible to all of the nematode populations, and 'Florunner' peanut (*Arachis hypogaea*) and 'Deltapine 90' or 'Deltapine 51' cotton (*Gossypium hirsutum*) were included as hosts susceptible only to *M. arenaria* race 1 and *M. incognita* race 3, respectively. Horsebean (*Canavalia ensiformis*), 'Sesaco 16' sesame (*Sesamum indicum*), and 'Kirby' soybean (*Glycine max*) exhibited intermediate levels of galling and egg mass production in response to several of the root-knot nematode populations. No egg masses were observed on crotalaria (*Crotalaria spectabilis*), 'Hale' castor (*Ricinus communis*), partridge pea (*Cassia fasiculata*), 'SX-17' sorghum-sudangrass (*Sorghum bicolor* × *S. sudanense*), or 'Mississippi Silver' cowpea (*Vigna unguiculata*) in any of the tests. Velvetbean (*Mucuna deeringiana*) had only a few galls and egg masses of *M. arenaria* race 1 and *M. javanica*, but none from either race of *M. incognita*. The response of jointvetch (*Aeschynomene americana*) was similar to that of cotton, with susceptibility only to race 3 of *M. incognita*. Since several of the tropical rotation crops showed resistance to different *Meloidogyne* spp., they may have potential use in cropping systems in the southeastern United States and other regions where these species and races of root-knot nematodes predominate.

Key words: Aeschynomene americana, Arachis hypogaea, Canavalia ensiformis, Cassia fasiculata, cropping systems, *Crotalaria spectabilis, Glycine max, Gossypium hirsutum*, host plant resistance, *Indigofera hirsuta, Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica, Mucuna deeringiana*, nematode management, *Ricinus communis, Sesamum indicum, Sorghum bicolor, Vigna unguiculata*

RESUMEN

McSorley, R., D.W. Dickson y J.A. de Brito. 1994. Condición de hospedantes de selectos cultivos tropicales de rotación a cuatro problaciones de nematodos agalladores. Nematrópica 24:45-53.

La susceptibilidad de selectos cultivos tropicales de rotación a *Meloidogyne incognita* raza 1 y 3, *M. arenaria* raza 1, y *M. javanica* fue evaluada en pruebas seriadas de inoculación. El tomate (*Lycopersicon esculentum*) 'Rutger' y/o la okra (*Hibiscus esculentus*) 'Clemson spineless', fueron los hospedantes susceptibles a todas las poblaciones de nematodos. El maní (*Arachis hypogaea*) y el algodonero (*Gossypium hirsutum*) 'Deltapine 90' o 'Deltapine 61' se incluyeron como susceptibles solamente para *M. arenaria* raza 1 y *M. incognita* raza 3, respectivamente. La *Canavalia ensiformis*, el ajonjolí (*Sesamum indicum*) y la soya (*Glycine max*) 'Kirby' mostraron niveles intermediarios de agallamiento y producción de masas

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de huevos en respuesta a varias de las poblaciones de nematodos agalladores. No se observaron masas de huevos en ninguno de los ensayos con la crotalaria (*Crotalaria spectabilis*), ni la higuerilla 'Hale' (*Ricinus communis*), la arveja codorniz (*Cassia fasciculata*), el pasto-sorgo SX-17 (*Sorghum bicolor* × *S. sudanense*) y el caupí (*Vigna uniguiculata*) 'Mississippi Silver'. La *Mucuna deeringiana* tuvo pocas agallas y masas de huevos con *M. arenaria* raza 1 y *M. javanica*, pero ninguno con las dos razas de *M. incognita*. La respuesta de *Aeschynomene americana* fue parecida a la del algodonero, es decir susceptible a la raza 3 de *M. incognita*. Debido a que varias especies de leguminosas tropicales de rotación resultaron resistentes a diferentes poblaciones de *Meloidogyne* spp., se podría considerar su uso potencial en los sistemas de cultivación del sureste de los E.U.A. y otras regiones similares donde también predominan las especies y razas de estos nematodos agalladores.

Palabras clave: Aeschynoneme americana, Arachis hypogaea, Canavalia ensiformis, Cassia fasiculata, sistemas de cultivación, *Crotalaria spectabilis, Glycine max, Gossypium hirsutum*, resistencia de plantas hospedantes, *Indigofera hirsuta, Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica, Mucuna deeringiana*, manejo de nematodos, *Ricinus communis, Sesamun indicum, Sorghum bicolor, Vigna unguiculata.*

INTRODUCTION

In the southeastern United States, as in many other parts of the world, crop rotation is an important means of limiting damage by root-knot nematodes (*Meloidogyne* spp.) to susceptible crops (9). Traditional crops such as cotton (*Gossypium hirsutum* L.) and sorghum [*Sorghum bicolor* (L.) *Moench*] or sorghum-sudangrass [*S. bicolor* × *S. sudanense* (Piper) Stapf] are useful against several species and races of root-knot nematodes (11,21). Furthermore, the year-round growing season in many parts of the southeastern United States allows the introduction of nontraditional tropical rotation crops which may be beneficial for suppressing root-knot nematodes (15,20). In Alabama, reduced densities of *M. arenaria* (Neal) Chitwood have resulted following the use of a number of these crops, including velvetbean [*Mucuna deeringiana* (Bort.) Merr.] (17), jointvetch (*Aeschynomene americana* L.) (22), hairy indigo (*Indigofera hirsuta* L.) (22), crotalaria (*Crotalaria spectabilis* Roth.) (16), horsebean [*Canavalia ensiformis* (L.) DC.] (16), sesame (*Sesamum indicum* L.) (15,

Table 1. Experimental conditions for five tests involving inoculation of tropical crops with *Meloidogyne* spp.

	Test 1	Test 2	Test 3	Test 4	Test 5
Nematode	*M. arenaria* race 1	*M. javanica*	*M. incognita* race 3	*M. incognita* race 3	*M. incognita* race 1
Initial inoculum[z]	2000 J2	2000 J2	2000 J2	1000 J2	1000 J2
Treatments (crops)	14	13	12	9	9
Replications	5	5	5	6	6
Starting time	August 1992	June 1992	January 1993	June 1993	June 1993
Duration	60 days	60 days	70 days	61 days	57 days
Location	Shadehouse	Shadehouse	Shadehouse	Greenhouse	Greenhouse
Cotton cultivar	Deltapine 90	Deltapine 90	Deltapine 90	Deltapine 51	Deltapine 51

[z]Initial density of second-stage juveniles (J2) added per pot.

20), castor (*Ricinus communis* L.) (15,19, 20), and partridge pea (*Cassia fasiculata* L.) (15,20). Several of these crops, including velvetbean, crotalaria, jointvetch, and hairy indigo, have reduced numbers of *M. incognita* (Kofoid & White) Chitwood in the field in Florida (14).

The objective of the current study was to compare the relative resistance or susceptibility of these and several other candidate crops to the four most common root-knot nematodes present in Florida: *M. arenaria* race 1, *M. incognita* races 1 and 3, and *M. javanica* (Treub) Chitwood. Relative resistance or susceptibility was evaluated in terms of root galling and egg mass production on the crops tested.

MATERIALS AND METHODS

Five separate experiments were conducted, using four different species and races of *Meloidogyne* spp. (Table 1). All experiments involved inoculation of up to 14 different plant species with a particular *Meloidogyne* population. The crop plants examined were: 'Rutgers' tomato (*Lycopersicon esculentum* Mill.), 'Clemson Spineless' okra (*Hibiscus esculentus* L.), 'Florunner' peanut (*Arachis hypogaea* L.), 'Sesaco 16' sesame, 'Kirby' soybean [*Glycine max* (L.) Merr.], horsebean, 'Deltapine 90' or 'Deltapine 51' cotton, jointvetch, velvetbean, 'Flamingo' hairy indigo, showy crotalaria, 'Hale' castor, 'SX-17' sorghum-sudangrass, partridge pea, and 'Mississippi Silver' cowpea [*Vigna unguiculata* (L.) Walp.]

Crops were planted in steam-sterilized soil (92% sand, 3% silt, 5% clay; pH 6.0; 1.3% organic matter) in clay pots (15 cm high × 15 cm top diam). Three seeds of the same plant species were planted per pot. Seeds of crotalaria and hairy indigo were scarified before planting, and those of partridge pea were soaked overnight in water prior to planting. Partridge pea and sesame were planted 4-5 days before crotalaria, hairy indigo, jointvetch, and tomato. The latter four crops were planted 10 days before the rest of the crop species. Plants were inoculated about 2 weeks after the remaining crops were planted, so that seedling age at the time of inoculation ranged from 2-4 weeks, depending on plant species. All seedlings were thinned to one plant per pot prior to inoculation.

Root-knot nematode inoculum was maintained in a greenhouse on 'Rutgers' tomato. Nematode populations were developed from single egg masses collected several years before from various sites in Florida. The response of each population was verified with a differential host test (23).

The starting times and durations of the five experiments varied (Table 1). Four days before inoculation of an experiment, eggs of a given nematode population were extracted from tomato roots in 0.525% NaOCl (8). Extracted eggs were incubated at 22 °C on modified Baermann trays (18) for collection of second-stage juveniles (J2). An inoculum dosage of 1 000–2 000 J2 per pot was divided and delivered into two holes (2 cm deep) at the base of the plant.

Numbers of crop treatments and replications varied among the five experiments (Table 1). In all cases, pots were arranged on raised benches in a randomized complete-block design and maintained in a shadehouse (covered translucent top and screened sides) at ambient temperature or in a greenhouse at 28 ± 5 °C. Plants were watered as needed and sprayed weekly with 3.8 g/L of a 20:20:20 (total $N:P_2O_5:K_2O$) soluble fertilizer. Whiteflies and other insects were managed as needed by spraying 0.85 g a.i./L of methomyl, 0.20 g a.i./L of (S)-cyano (3-phenoxyphenyl) methyl (S)-4-chloro-α-(1-methylethyl) benzene-ac

Table 2. Gall and egg mass ratings and eggs per root system of plant hosts inoculated with *Meloidogyne* spp. in three tests.

	Test 1 (*M. arenaria* race 1)			Test 2 (*M. javanica*)			Test 3 (*M. incognita* race 3)		
Plant host	Gall rating[x]	Egg mass rating[x]	Eggs per root system	Gall rating	Egg mass rating	Eggs per root system	Gall rating	Egg mass rating	Eggs per root system
Tomato	5.0 a[y]	5.0 a[y]	248 960 a	4.8 a	4.2 a	410 720 a	5.0 a	4.8 a	115 076 a
Okra	5.0 a	4.6 ab	97 200 b	5.0 a	4.2 a	280 160 b	4.6 ab	3.6 b	15 458 b
Peanut	4.0 b	4.0 bc	69 120 c	0 e	0 d	—	0 e	0 e	—
Sesame	2.4 c	2.0 d	—[z]	3.4 b	4.0 a	14 896 c	—	—	—
Soybean	3.8 b	3.8 c	25 616 d	1.2 d	0.4 d	5 092 c	0 e	0 e	—
Horsebean	0 e	0 e	—	2.2 c	2.6 b	14 192 c	2.2 d	2.6 c	3 606 b
Cotton	0.2 e	0.2 e	0 e	0 e	0 d	—	3.6 bc	1.0 d	974 b
Jointvetch	0 e	0 e	—	0 e	0 d	—	3.4 c	1.8 cd	628 b
Velvetbean	1.4 d	1.4 d	720 e	1.8 cd	1.2 c	6 205 c	0 e	0 e	—
Hairy indigo	0.4 e	0.4 e	48 e	—	—	—	—	—	—
Crotalaria	0 e	0 e	—	0 e	0 d	—	1.2 de	0 e	—
Castor	0.2 e	0 e	—	0 e	0 d	—	1.8 d	0 e	—
Partridge pea	0 e	0 e	—	0 e	0 d	—	0 e	0 e	—
Sorghum -sudangrass	0.6 e	0 e	—	0 e	0 d	—	0 e	0 e	—

[x]Galls and egg masses rated on a 0 to 5 scale such that 0 = 0, 1 =1–2, 2 =3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls or egg masses per root system.
[y]Data are means of five replications. Means in columns followed by the same letter are not different ($P \leq 0.05$) according to Duncan's multiple range test.
[z]Dashes (—) indicate data not evaluated.

etate, or 18.5 ml/L of a 49% (w:w) concentrate of potassium salts of fatty acids (Safer® Insecticide Concentrate, Newton, Massachusetts), on a rotating basis. Disease management, when needed, was by spraying with 2.85 g a.i./L of chlorothalonil.

At the termination of each experiment, root systems were washed free of soil and stained (1) to facilitate recognition of egg masses. Galls and egg masses were rated on a 0 to 5 scale such that 0 = 0, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls or egg masses per root system (23). Eggs were extracted in 1.05% NaOCl (7) from root systems containing egg masses and counted. All data were subjected to analysis of variance followed by mean separation ($P \leq 0.05$) using Duncan's multiple range test (4).

RESULTS AND DISCUSSION

Most plants had lower ($P \leq 0.05$) levels of galling and egg masses than did the highly susceptible hosts, tomato and okra (Tables 2,3). As expected, peanut was susceptible to *M. arenaria* and cotton to *M. incognita* race 3, although the latter nematode resulted in more galling and egg masses in the test in which 'Deltapine 90' cotton was used (Table 2) than in the test with 'Deltapine 51' (Table 3). Race 1 of *M. incognita* did not reproduce on any of the hosts tested except okra (Table 3).

No egg masses were observed on crotalaria, castor, partridge pea, sorghum-sudangrass, or cowpea in any of the tests (Tables 2,3). Root-knot nematodes do not complete their life cycle on crotalaria, and previous tests showed only very light galling (6) or no galling (24) in response to *M. javanica, M. arenaria,* and *M. incognita.* We obtained light galling in response to race 3 of *M. incognita,* but not from *M. javanica* or *M. arenaria* race 1. Although castor produced aborted giant cells in response to *M. incognita,* some reproduction still occurred on this host in a previous study (7). We found light galling in two of five tests, but no reproduction. A

Table 3. Gall and egg mass ratings of plant hosts inoculated with *Meloidogyne incognita* in two tests.

	Test 4 (*M. incognita* race 3)		Test 5 (*M. incognita* race 1)	
Plant host	Gall rating[y]	Egg mass rating[y]	Gall rating	Egg mass rating
Okra	5.0 a[z]	5.0 a	5.0 a	4.7 a
Sesame	1.7 c	1.2 c	0 b	0 b
Soybean	1.8 c	1.3 c	0 b	0 b
Cotton	0.5 d	0.3 d	0 b	0 b
Jointvetch	3.0 b	3.0 b	0 b	0 b
Velvetbean	0.2 d	0 d	0 b	0 b
Castor	0 d	0 d	0 b	0 b
Cowpea	0.7 d	0 d	0 b	0 b
Sorghum-sudangrass	0 d	0 d	0 b	0 b

[y]Galls and egg masses rated on a 0 to 5 scale such that 0 = 0, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, and 5 = more than 100 galls or egg masses per root system.
[z]Data are means of six replications. Means in columns followed by the same letter are not different ($P \leq 0.05$) according to Duncan's multiple range test.

previous inoculation study (15) found no galling by *M. arenaria* race 1 on partridge pea, although a few juveniles entered roots. Crotalaria, castor, and partridge pea have been used in Alabama to reduce densities of *M. arenaria* in field and microplot tests (15,16,19,20). Although the response of sorghum cultivars to *Meloidogyne* spp. varies, most are poor hosts (3,13). The sorghum-sudangrass SX-17 has been one of the most useful cultivars for limiting *M. incognita* race 1 in the field in Florida (11). Mississippi Silver cowpea was one of the most effective cowpea cultivars in lowering densities of *M. incognita* race 1 in the field (5). In a previous study, Mississippi Silver was more effective against *M. arenaria* race 1 than against *M. incognita* race 3 (10), and we also observed slight galling in response to *M. incognita* race 3 (Table 3). Other cowpea cultivars of course can be susceptible to various *Meloidogyne* spp. isolates (5,10).

Responses of the other hosts tested varied with the nematode population used. Horsebean showed intermediate levels of egg mass production in response to *M. javanica* and *M. incognita* race 3, but not to *M. arenaria* race 1 (Table 2). Previous work with this host is not encouraging either, with galling observed in response to *M. incognita* race 1 and *M. javanica*, and with variable responses to *M. arenaria* race 2, depending on the population used (16). Sesame and soybean had low to intermediate levels of galling and egg masses in response to all species and races tested except *M. incognita* race 1 (Tables 2,3). Reproduction of *M. incognita* race 3 on soybean varied in the two tests. Very low levels of root galling from *M. incognita* are reported on sesame (15). Low to moderate galling from *M. arenaria* race 1 was reported (13), but sesame was still effective in lowering densities of this nematode in the field (20). No reproduction from *M. incognita* races 1 or 3 was observed on velvetbean, but both *M. arenaria* race 1 and *M. javanica* had some reproduction on this host. Some velvetbean accessions are reported to be non-hosts of *M. arenaria* race 2, *M. incognita* race 1, and *M. javanica* (17), and the crop reduced densities of *M. arenaria* race 1 in microplots (17) and *M. incognita* race 1 in the field (12). Jointvetch was a non-host to *M. arenaria* race 1, *M. javanica*, and *M. incognita* race 1, but was susceptible to *M. incognita* race 3 (Tables 2,3). Reproduction of *M. incognita* race 3 on jointvetch was similar to that on Deltapine 90 cotton (Table 2), but was greater ($P \leq 0.05$) on jointvetch than on Deltapine 51 (Table 3). American jointvetch was a useful rotation crop for lowering population densities of *M. arenaria* (22) and *M. incognita* (14) in the field, but was galled by *M. incognita* race 3 in a greenhouse test (24).

Hairy indigo was difficult to germinate and was available for only one test. Very low levels of galling and reproduction from *M. arenaria* race 1 were observed on hairy indigo (Table 2), and the crop has been used to lower densities of this nematode in the field (22). There is variation in the response of hairy indigo germplasm to root-knot populations, however (2).

Based on our results, a good potential exists for using several of the crops examined here as rotation crops against the four most common species and races of root-knot nematodes found in Florida (Table 4). Traditional crops such as peanut and cotton should be effective against three of the four root-knot nematodes, and the response of jointvetch is similar to that of cotton. Successful use of sesame or 'Kirby' soybean will depend on knowledge of the *Meloidogyne* species or races present. Horsebean may be useful only in very limited situations (*M. arenaria* race 1), if at all, since response even to *M. arenaria* populations has been variable in other tests (16). Velvetbean is very effective against both *M.*

Table 4. Potential for use of candidate crop plants in rotations against four Florida populations of *Meloidogyne* spp., based on results of five inoculation tests.

Candidate crop[y]	*M. arenaria* race 1	*M. javanica*	*M. incognita* race 3	*M. incognita* race 1
Peanut	No[z]	Yes	Yes	Yes
Sesame	No	No	Maybe	Yes
Soybean	No	Maybe	Maybe	Yes
Horsebean	Yes	No	No	—
Cotton	Yes	Yes	No	Yes
Jointvetch	Yes	Yes	No	Yes
Velvetbean	Maybe	Maybe	Yes	Yes
Hairy indigo	Maybe	—	—	—
Crotalaria	Yes	Yes	Yes	—
Castor	Yes	Yes	Yes	Yes
Partridge pea	Yes	Yes	Yes	—
Sorghum-sudangrass	Yes	Yes	Yes	Yes
Cowpea	—	—	Yes	Yes

[y] See text for crop cultivars used; responses may vary with cultivar.
[z] Yes = useful rotation crop; No = crop not effective; Maybe = low levels of reproduction possible; Dash (—) = not evaluated.

incognita races and may support only limited reproduction of *M. arenaria* and *M. javanica.* Although a few nematode-host combinations have not been evaluated, available data suggest that five of the crops may be effective across the nematode species and races examined (Table 4). This is particularly advantageous when the *Meloidogyne* species or race in a field is unknown, or when mixed populations occur.

Of course, it is possible that some of these plants may increase populations of nematodes other than *Meloidogyne* spp. Some of the plants, such as hairy indigo, crotalaria, castor, and partridge pea are considered weeds in Florida, and crotalaria and castor can be toxic to livestock (6,15). Establishment and management of hairy indigo is particularly difficult (25), and so its use as a rotation crop may be very limited. Additional research will be needed to determine optimum cultural practices for some of these candidate crops, and response of crop cultivars (for crops with cultivars available, *e.g.*, sesame, sorghum, cowpea) to *Meloidogyne* spp. and other plant-parasitic nematodes. Nevertheless, it is very encouraging that a number of poor or non-host crops are available with potential for managing root-knot nematodes in rotations in the southeastern United States.

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