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Host Suitability of Potential Cover Crops for Root-knot Nematodes[1]

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Abstract: Several potential cover crops were evaluated for their susceptibility to *Meloidogyne arenaria* race 1, *M. incognita* race 1, and *M. javanica* in a series of five greenhouse experiments. No galls or egg masses were observed on roots of castor (*Ricinus communis*), cowpea (*Vigna unguiculata* cv. Iron Clay), crotalaria (*Crotalaria spectabilis*), or American jointvetch (*Aeschynomene americana*). Occasional egg masses (rating ≤1.0 on 0–5 scale) were observed on marigold (*Tagetes minuta*) in one test with *M. incognita,* on sesame (*Sesamum indicum* cv. Paloma) in a test with *M. arenaria,* and on sunn hemp (*Crotalaria juncea* cv. Tropic Sun) in 1 of 2 tests with *M. incognita;* otherwise, these crops were free of egg masses. Numbers of second-stage juveniles (J2) hatched from eggs per root system were low (≤10/pot) for the above-mentioned crops. Egg-mass levels and numbers of hatched J2 of *M. incognita* on pearl millet (*Pennisetum typhoides,* Tifleaf II hybrid) were comparable to those on a susceptible tomato (*Lycopersicon esculentum* cv. Rutgers). In a test with *M. arenaria,* egg mass levels and numbers of J2 on Japanese millet (*Echinochloa frumentacea*) were similar to those on tomato. Japanese millet was susceptible to each of the nematode isolates tested. However, several of the crops evaluated were very poor hosts or non-hosts of the nematode isolates, including several legumes (cowpea, crotalaria, jointvetch, sunn hemp) that have potential use in both nematode and nitrogen management.

Key words: Aeschynomene americana, castor, cowpea, *Crotalaria juncea, Crotalaria spectabilis, Echinochloa frumentacea,* host-plant resistance, jointvetch, marigold, *Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne javanica,* millet, nematode, nematode management, *Pennisetum glaucum, Pennisetum typhoides, Ricinus communis,* sesame, *Sesamum indicum,* sunn hemp, sustainable agriculture, *Tagetes minuta, Vigna unguiculata.*

The use of crop rotation and cover crops remains an important method for managing populations of plant-parasitic nematodes (McSorley, 1998; Noe, 1998). Knowledge of the host status of candidate crops is critical for the successful use of these methods. The wide host range of the most common root-knot nematodes (*Meloidogyne* spp.) limits the choices of potential cover crops that may be antagonistic or non-hosts to these important pests. Researchers continue to search for and evaluate crops that have potential for the management of *Meloidogyne* spp., particularly in the warmer regions of the United States (Sipes and Arakaki, 1997; Starr and Black, 1995; Weaver et al., 1995).

In Florida, a number of different cover crops have reduced population densities of *Meloidogyne* spp. in the greenhouse and in the field (McSorley et al., 1994; McSorley and Dickson, 1995). Unfortunately, some of the more effective crops for nematode management have important disadvantages. For example, seeds of castor (*Ricinus communis*) or showy crotalaria (*Crotalaria spectabilis*) could pose a toxicity hazard to livestock. However, sunn hemp (*C. juncea*), a related species, is non-toxic and can be useful in nitrogen management (Rotar and Joy, 1983). This cover crop is adapted to Florida growing conditions (H. H. Bryan, Pers. comm.) and did not increase population levels of *M. javanica* during a test in Hawaii (Sipes and Arakaki, 1997). The objectives of this study were to determine the relative host suitability of several potential cover crops that had not been tested against Florida populations of *Meloidogyne* spp., and to compare these crops with several of the most suppressive cover crops identified from previous studies.

Materials and Methods

Five separate experiments were conducted, using various test plants and isolates of *Meloidogyne* spp. The plants examined

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were: castor (*Ricinus communis,* obtained from Bothwell Enterprises, Plainview, TX), cowpea (*Vigna unguiculata* cv. Iron Clay, from Adam Briscoe Seed Co., Jackson, GA), showy crotalaria (*Crotalaria spectabilis,* seed collected locally), Japanese millet (*Echinochloa frumentacea,* from Adam Briscoe Seed Co.), American jointvetch (*Aeschynomene americana,* from C. M. Payne and Son, Sebring, FL), marigold (*Tagetes minuta,* from Dr. P. A. Stansly, University of Florida SWFREC, Immokalee, FL), pearl millet (*Pennisetum typhoides,* syn. *P. glaucum,* Tifleaf II hybrid from Adam Briscoe Seed Co.), sesame (*Sesamum indicum* cv. Paloma, from Sesaco Corp., San Antonio, TX), and sunn hemp (*Crotalaria juncea* cv. Tropic Sun, from Dr. W. D. Tooke, USDA Natural Resource Conservation Service, Gainesville, FL). Tomato (*Lycopersicon esculentum* cv. Rutgers) was used as a nematode-susceptible control in all experiments. Seeds were planted in approximately 825 cm^3 of steam-sterilized soil (92% sand, 3% silt, 5% clay; pH 6.2, 1.2% organic matter) in 12.5-cm-diam. plastic pots. Seedlings were thinned to one per pot soon after emergence for all crops except jointvetch, both millets, and sunn hemp, which were thinned to three plants per pot. Pots were infested with nematodes within a week after plants were thinned.

Isolates of *Meloidogyne arenaria* race 1, *M. incognita* race 1, and *M. javanica* were maintained in a greenhouse on 'Rutgers' tomato (McSorley and Frederick, 1994) and verified by differential host tests (Taylor and Sasser, 1978). Four days before inoculation, eggs of the nematode isolate used were extracted from tomato roots in 0.525% NaOCl (Hussey and Barker, 1973). Extracted eggs were incubated at 22 °C on modified Baermann trays (Rodríguez-Kábana and Pope, 1981) for collection of second-stage juveniles (J2). Inoculum was delivered into two holes (2 cm deep) at the base of the plant(s) in each pot. Inoculation dates and amounts of inoculum used for each experiment are summarized in Table 1.

In each experiment, pots were arranged on raised benches in a randomized complete block design with five replications and

Table 1. Nematode inoculation and harvest information for five greenhouse experiments.

Nematode	Inoculum per pot	Inoculation date	Duration of experiment (days)
Meloidogyne incognita	550	1 Nov. 1997	109
M. incognita	950	24 Mar. 1998	70
M. javanica	550	1 Nov. 1997	109
M. javanica	950	2 Apr. 1998	90
M. arenaria	550	2 Apr. 1998	76

maintained in a greenhouse. Temperatures ranged from 5–20 °C for experiments conducted from November to February, and from 15–32 °C for experiments conducted from March/April to June. Plants were watered as needed and fertilized every 2 weeks with 3.8 g/liter of a 20:20:20 ($N:P_2O_5:K_2O$) soluble fertilizer.

At the harvest of each experiment, root systems were removed from pots, washed free of soil, and rated for galls and egg masses on a 0–5 scale: 0 = 0 galls, 1 = 1–2, 2 = 3–10, 3 = 11–30, 4 = 31–100, 5 > 100 galls or egg masses (Taylor and Sasser, 1978). The rating represented the total galls or egg masses present in one pot, since pots contained one or three plants, depending on the crop. Because gall and egg mass indices were usually similar, only egg mass indices are reported. Following rating of root systems, eggs were extracted in 0.525% NaOCl and incubated on Baermann trays as described previously to obtain J2 for counting. Data were subjected to analysis of variance followed by mean separation ($P \leq 0.05$) with Duncan's multiple-range test using MSTAT-C software (Michigan State University, East Lansing, MI).

Results and Discussion

Egg masses and galls did not develop on most of the crops tested (Table 2), and few J2 were collected per pot because few eggs were produced on most plants (Table 3). The exceptions were the two millets, on which egg mass indices and J2 numbers were, in some cases, similar to those on the tomato control (Tables 2,3). Pearl millet cul-

TABLE 2. Egg mass indices on plants inoculated with isolates of *Meloidogyne incognita* race 1, *M. javanica,* or *M. arenaria* race 1.

	Egg mass rating[a]				
	M. incognita		*M. javanica*		*M. arenaria*
Crop	1997	1998	1997	1998	1998
Castor	0 b	—[b]	0 b	—	0 b
Cowpea	0 b	0 b	—	0 c	—
Crotalaria	0 b	0 b	—	0 c	0 b
Japanese millet	0 b	4.6 a	0.8 b	3.6 b	5.0 a
Jointvetch	0 b	0 b	0 b	0 c	0
Marigold	0 b	0.2 b	0 b	0 c	—
Pearl millet	2.0 ab	—	0 b	—	1.0 b
Sesame	0 b	—	0 b	—	0.2 b
Sunn hemp	0 b	1.0 b	0 b	0 c	0 b
Tomato	5.0 a	5.0 a	4.0 a	5.0 a	5.0 a

Data are means of five replications. Means in columns followed by the same letter do not differ ($P \leq 0.05$) according to Duncan's multiple-range test.

[a] Egg masses rated on 0–5 scale: 0 = 0 egg masses, 1 = 1–2; 2 = 3–10; 3 = 11–30; 4 = 31–100; 5 > 100 egg masses/root mass in a single pot (Taylor and Sasser, 1978).

[b] Not tested.

tivars vary in their response to *Meloidogyne* spp. (Johnson et al., 1977, 1995). Johnson et al. (1995) observed little galling, but large numbers of J2 produced on 'HGM-100' peral millet. In the present study, few galls were noted on the very fine, fibrous roots of either pearl millet or Japanese millet, but numerous small egg masses and female nematodes were observed on or protruding from the roots. The differences in egg mass production on Japanese millet in the two tests with *M. incognita* and in the two tests with *M. javanica* (Table 2) are attributed to temperature differences in the greenhouse for tests begun in November 1997 vs. tests begun in March or April 1998. The high levels of egg mass production during the warmer spring test suggest that Japanese millet would not be suitable as a summer cover crop against any of the nematode isolates tested.

Results with castor, crotalaria, and jointvetch were similar to those obtained previously (McSorley et al., 1994) and verify their potential as nematode-suppressive cover crops. Similar results were also

TABLE 3. Numbers of nematodes extracted from roots of plants inoculated with isolates of *Meloidogyne incognita* race 1, *M. javanica,* or *M. arenaria* race 1.

	Nematodes per pot				
	M. incognita		*M. javanica*		*M. arenaria*
Crop	1997	1998	1997	1998	1998
Castor	0 b	—[a]	10 c	—	0 c
Cowpea	2 b	<1 b	—	3 b	—
Crotalaria	0 b	0 b	—	1 b	0 c
Japanese millet	0 b	11 b	8 c	3 b	397 ab
Jointvetch	0 b	0 b	0 c	0 b	0 c
Marigold	0 b	0 b	0 c	0 b	—
Pearl millet	268 a	—	45 b	—	52 bc
Sesame	0 b	—	1 c	—	0 c
Sunn hemp	0 b	1 b	3 c	3 b	<1 c
Tomato	237 a	440 a	210 a	138 a	2550 a

Data are means of five replications. Means in columns followed by the same letter do not differ ($P \leq 0.05$) according to Duncan's multiple-range test.

[a] Not tested.

achieved with cowpea, marigold, sesame, and sunn hemp (Tables 2,3). Results with sesame were similar to those obtained previously with other cultivars (McSorley et al., 1994; Starr and Black, 1995), except that sesame is known to be highly susceptible to *M. javanica* (McSorley et al., 1995; Starr and Black, 1995). The low reproduction on sesame in this test is attributed to the low greenhouse temperatures during the winter months. The same cultivar was highly susceptible to *M. javanica* in a test conducted during the summer (McSorley et al., 1995).

Cowpea 'Iron Clay' is an old cultivar that appeared to have a high level of resistance to the nematode isolates tested. Cowpea cultivars vary in their susceptibility to root-knot nematodes, and 'Mississippi Silver' supported only low levels of *M. incognita* race 1 in field tests in Florida (Gallaher and McSorley, 1993). A preliminary greenhouse test conducted for 11 weeks in early 1997 (data not shown) resulted in similar ($P > 0.10$) egg mass indices on 'Mississippi Silver' (mean = 0.25) and 'Iron Clay' (mean = 0.0).

The marigold species tested (*T. minuta*) was highly resistant to both *M. incognita* and *M. javanica.* This species performed well as a summer cover crop in one test in southern Florida (P. A. Stansly, pers. comm.). It is possible that *T. minuta* may be more tolerant of warm summer temperatures than the more commonly used *T. erecta* and *T. patula* that are often used as winter or spring bedding plants in Florida (McSorley and Frederick, 1994).

'Tropic Sun' sunn hemp was highly resistant, but not immune, to the *Meloidogyne* spp. tested. Results obtained with sunn hemp were similar ($P > 0.10$) to those obtained with crotalaria, its toxic relative. In Hawaii, sunn hemp was used as a rotation crop for managing *M. javanica* on taro (Sipes and Arakaki, 1997).

Legumes such as 'Iron Clay' cowpea, American jointvetch, and 'Tropic Sun' sunn hemp, which show a high degree of resistance to several *Meloidogyne* spp., are particularly desirable as cover crops. In addition to suppressing root-knot nematode levels, they may be helpful in nitrogen management as well. In Hawaii, sunn hemp used as a green manure added 150–165 kg N/ha to the soil (Rotar and Joy, 1983). This combination of nematode and nitrogen management could be especially useful in organic production systems where neither nematicides nor synthetic nitrogen fertilizers could be used. Continuing research is needed to identify additional cultivars of legumes and other potential cover crops that may be useful for nematode management.

Literature Cited

Gallagher, R. N., and R. McSorley. 1993. Population densities of *Meloidogyne incognita* and other nematodes following seven cultivars of cowpea. Nematropica 23: 21–26.

Hussey, R. S., and K. R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Disease Reporter 57: 1025–1028.

Johnson, A. W., G. W. Burton, and W. C. Wright. 1977. Reactions of sorghum-sudangrass hybrids and pearl millet to three species of *Meloidogyne.* Journal of Nematology 9:352–343.

Johnson, A. W., W. W. Hanna, and C. C. Dowler. 1995. Effects of irrigation, nitrogen, and a nematicide on pearl millet. Supplement to the Journal of Nematology 27:571–574.

McSorley, R. 1998. Alternative practices for managing plant-parasitic nematodes. American Journal of Alternative Agriculture 13:98–104.

McSorley, R., and D. W. Dickson. 1995. Effect of tropical rotation crops on *Meloidogyne incognita* and other plant-parasitic nematodes. Supplement to the Journal of Nematology 27:535–544.

McSorley, R., D. W. Dickson, and J. A. de Brito. 1994. Host status of selected tropical rotation crops to four populations of root-knot nematodes. Nematropica 24: 45–53.

McSorley, R., D. W. Dickson, and J. A. de Brito. 1995. Reproduction of *Meloidogyne javanica* on sesame varieties. Soil and Crop Science Society of Florida Proceedings 54:58–59.

McSorley, R., and J. J. Frederick. 1994. Response of some common annual bedding plants to three species of *Meloidogyne.* Supplement to the Journal of Nematology 26:773–777.

Noe, J. P. 1998. Crop- and nematode-management systems. Pp. 159–171 *in* K. R. Barker, G. A. Pederson, and G. L. Windham, eds. Plant and nematode interactions. Madison, WI: ASA, CSSA, SSSA.

Rodríguez-Kábana, R., and M. H. Pope. 1981. A simple incubation method for the extraction of nematodes from soil. Nematropica 11:175–186.

Rotar, P. P., and R. J. Joy. 1983. 'Tropic Sun' sunn hemp. *Crotalaria juncea* L. Research Extension Series 036, University of Hawaii, Honolulu.

Sipes, B. S., and A. S. Arakaki. 1997. Root-knot nematode management in dryland taro with tropical cover crops. Supplement to the Journal of Nematology 29: 721–724.

Starr, J. L., and M. C. Black. 1995. Reproduction of *Meloidogyne arenaria, M. incognita,* and *M. javanica* on sesame. Supplement to the Journal of Nematology 27: 624–627.

Taylor, A. L., and J. N. Sasser. 1978. Biology, identification, and control of root-knot nematodes (*Meloidogyne* species). Raleigh, NC: North Carolina State University Graphics.

Weaver, D. B., R. Rodríguez-Kábana, and E. L. Carden. 1995. Comparison of crop rotation and fallow for management of *Heterodera glycines* and *Meloidogyne* spp. in soybean. Supplement to the Journal of Nematology 27:585–591.