

Host Range and Distribution of the Clover Root-knot Nematode, *Meloidogyne trifoliophila*

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Abstract: The ability of *Meloidogyne trifoliophila* to gall 230 species and cultivars of plants was determined in a greenhouse. All clovers (*Trifolium* spp.) were severely galled regardless of species or cultivar. Most soybean cultivars were moderately to severely galled. Among other legumes, broad bean, garden pea, Korean lespedeza, sweetclover, and common vetch were good hosts, but alfalfa, bird's-foot trefoil, peanut, and pole bean were poor or nonhosts. Among other plant families, most Apiaceae (Umbelliferae) and Brassicaceae (Cruciferae) were galled, but Cucurbitaceae, Iridaceae, Malvaceae, Poaceae, and Solanaceae were rarely or never galled. Results for Amaryllidaceae, Asteraceae, Lamiaceae, and Liliaceae were variable. This nematode was not found in a survey of pasture and soybean fields in southwestern Tennessee.

Key words: clover, distribution, host range, *Heterodera trifolii*, *Meloidogyne graminicola*, *Meloidogyne trifoliophila*, nematode, rice, root-knot nematode, soybean, symptom.

Meloidogyne trifoliophila Bernard & Eisenback (Bernard and Eisenback, 1997) was originally collected from a mixed tall fescue-white clover pasture at Ames Plantation, Fayette County, Tennessee. This species produced spongy, spherical galls on white clover but not on fescue. A preliminary host range study (E. C. Bernard, unpubl.) demonstrated its ability to gall soybean. Consequently, a broader study was initiated to determine the potential of *M. trifoliophila* to infect a wide range of crop and ornamental plants.

MATERIALS AND METHODS

Inoculum of *M. trifoliophila* was increased originally on white clover. Because a trace of *M. incognita* (Kofoid & White) Chitwood also was present in the original field collection, two different procedures were used to eliminate it. In the first procedure, galled

white clover roots were shaken in a 1% sodium hypochlorite solution (Hussey and Barker, 1973) for 5 minutes to remove eggs from exposed *M. incognita* egg masses. Because *M. trifoliophila* egg masses were completely enclosed within galls, they were not removed with this method. Roots were washed with water to remove the hypochlorite solution, then placed in a blender with 200 ml of 5% sodium hypochlorite and 500 ml tapwater, and blended 1 minute to comminute roots. After 30 seconds, roots were further comminuted with a 2-second burst. The suspension was poured through nested sieves with 74- μ m and 25- μ m pores. Egg suspensions were added to pots of autoclaved soil containing ball clover, which was reported to be resistant to *M. incognita* (Pederson and Windham, 1989). Stock cultures of *M. trifoliophila* subsequently were maintained on ball clover. At each of three renewals of stock cultures, eggs were extracted from roots and added to pots containing 'Rutgers' tomato as a bioassay for the presence of *M. incognita*. Tomato is a nonhost of *M. trifoliophila* (E. C. Bernard and P. L. Jennings, unpubl.). In the second procedure, ball clover also was used as a maintenance host without pretreatment of roots with sodium hypochlorite to remove *M. incognita* eggs. At each of three renewals of stock cultures, 5,000 eggs were added to each of several tomato plants. Sixty days later, roots were examined for galling by *M. incognita*. At the end of both procedures, tomato roots

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TABLE 1. Galling of *Trifolium* species and cultivars by *Meloidogyne trifoliophila*.

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>T. alexandrinum</i> L.	Berseem clover	Bigbee	7.0	—
<i>T. balansae</i> Boiss.	Balanse clover	Paradana	5.8	5-7
<i>T. hirtum</i> All.	Rose clover	Kondinin	6.0	—
		RH-18	6.4	5-7
<i>T. incarnatum</i> L.	Crimson clover	Chief	6.8	6-7
		Tibbee	7.0	—
<i>T. nigrescens</i> Viv.	Ball clover	(Common)	6.0	5-7
		Segrest	7.0	—
<i>T. pratense</i> L.	Red clover	Arlington	6.4	6-7
		Atlas	6.2	6-7
		FL-MTC	5.6	5-7
		FL-5	6.0	5-7
		F1-6-EF	6.0	4-7
		HK	5.8	5-7
		ISI-84-KM	5.8	5-6
		Kenland	5.8	5-6
		Kenstar	5.4	4-6
		Marathon	5.8	5-7
		Persist	6.6	6-7
		Reddy	5.8	5-6
		Redland	5.4	4-6
		Redland II	5.0	4-7
		Redman	6.6	6-7
		Starglo	5.6	5-6
		W-115	5.8	5-6
<i>T. repens</i> L.	White clover	(Common)	7.0	6-8
		Brown Loam Synthetic No. 2	6.8	6-7
		California Ladino	7.4	7-8
		Louisiana S-1	7.6	7-8
		Osceola	6.4	6-7
		Regal	7.0	—
		SC-1	6.4	6-7
		SRVR	6.8	6-7
<i>T. subterraneum</i> L.	Subterranean clover	Larisa	6.8	6-7
		Mt. Barker	7.0	—
		Woogenellup	7.0	—
<i>T. vesiculosum</i> Savi	Arrowleaf clover	Meeche	7.0	—
		Yuchi	7.0	—

^a Ratings based on the Zeck visual index, where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

^b Each mean is the average of five plants.

^c A dash without numbers in the range column indicates that all plants had the same rating.

were free of galls. Therefore, *M. incognita* was considered eradicated from ball clover cultures, and these cultures were used for all subsequent experiments.

Seedlings or rooted cuttings of each tested plant species or cultivar were transplanted into an autoclaved, sandy loam soil mix in 10-cm-diam. clay pots. Each pot held one plant, except for some smaller Poaceae,

for which 4 to 6 seedlings were transplanted. Soil in each pot was infested with 5,000 eggs 1 or 2 weeks after transplanting by pouring a 5-ml egg suspension into a 2-cm-deep hole extending into the rhizosphere. Because of the large number of plant species and cultivars used in this study, 15 separate experiments were conducted over time to accommodate all entries. Plant treatments were

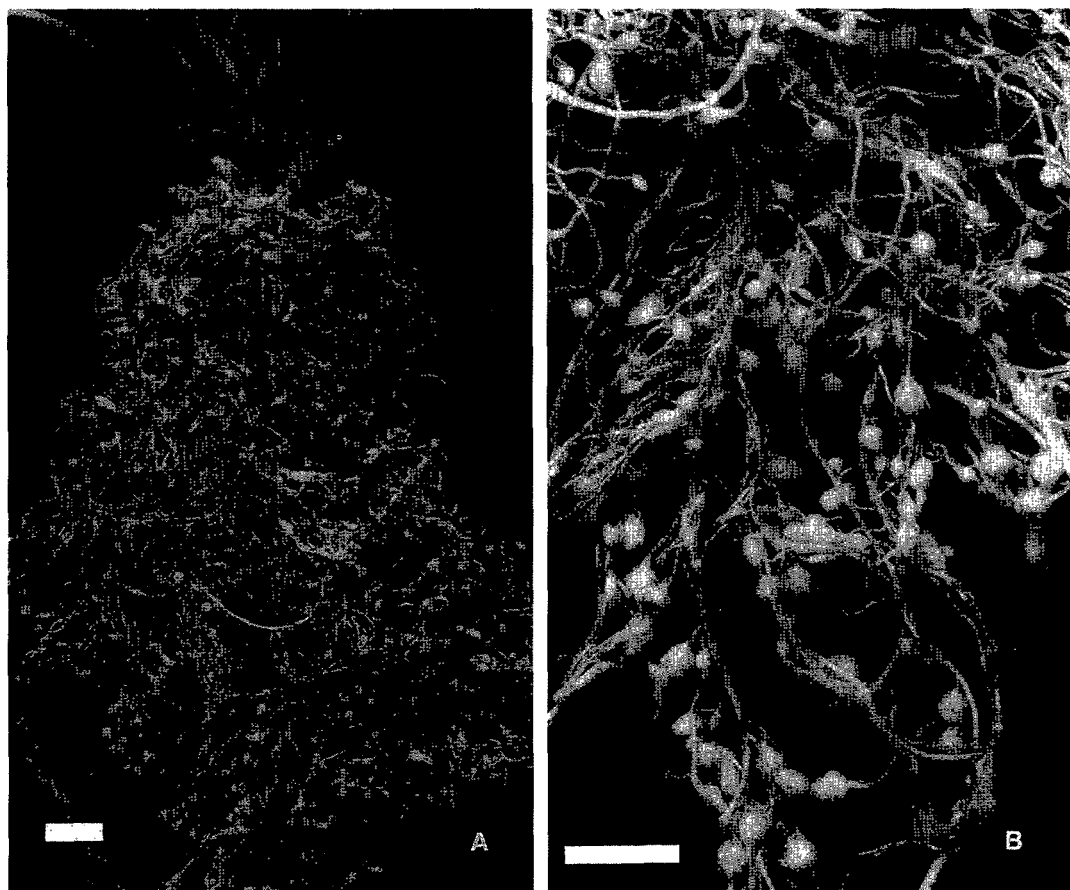


FIG. 1. *Meloidogyne trifoliophila* galls on white clover. A) Entire plant. B) Galls on root system. Scale bars = 10 mm.

replicated five times and placed in a randomized complete-block design. The purpose of this approach was to account for microclimatic differences in the greenhouse, not to perform statistical analyses of the results within experiments. A white clover treatment was included in each experiment to ensure inoculum viability and to estimate whether high variability occurred in the experiments over time. Plants were grown for 60 days. The root systems were then harvested and rated for galling with the Zeck visual index (Zeck, 1971), where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system

out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

To determine whether *M. trifoliophila* might occur in other western and southern counties in Tennessee, 91 soil samples were obtained from the University of Tennessee Extension Entomology and Plant Pathology Department. The samples had been gathered from both clover-fescue pastures and soybean fields in 10 counties. The soil from each sample was placed in a 10-cm-diam. clay pot, into which a 1-month-old white clover plant was transplanted. After 60 days, soil was washed from each root system, and the roots were examined for galling. The peri-

neal patterns of 10 female root-knot nematodes from each galled root system were examined for specific identification.

RESULTS

Common white clover was a suitable standard test entry in all of the experiments, with average gall ratings of 6.4 to 7.4. All true clovers tested were highly suitable hosts for *M. trifoliophila* (Table 1). Galls were spongy, spherical to oval, and often terminal (Fig. 1). Soybean, Korean lespedeza, sweet-clover, pea, and *Vicia* spp. and cultivars also were galled (Tables 2,3). Galls on soybean usually were spindle-shaped and intercalary (Fig. 2A,B). Galling was less abundant on Cordell and Ransom soybeans than on the other cultivars. Among other Fabaceae, peanut, pole bean, sericea lespedeza, bird's-foot trefoil, and alfalfa were lightly galled or free of symptoms (Table 3). Spotted burclover was susceptible to galling, but Australian burclover was nearly immune.

Monocotyledonous plants generally exhibited little or no galling (Table 4). However, kangaroo paw (Amaryllidaceae) had large, yellow-brown, terminal galls. Onion and chives (Liliaceae) were prominently galled, also with large, terminal galls (Fig. 2C). *Meloidogyne trifoliophila* produced numerous small galls on annual ryegrass but not on perennial ryegrass. Galls were not observed on rice or oat, and wheat roots rarely had very small, intercalary galls.

Meloidogyne trifoliophila produced numerous galls on most or all tested species of Apiaceae, Brassicaceae, and Chenopodiaceae (Table 5). On the other hand, Cucurbitaceae, Malvaceae, and Solanaceae were not galled. Asteraceae and Lamiaceae were generally resistant, but each family contained some hosts.

There was little difference in gall rating among cultivars of tested legumes, except in soybean. In general, galls on plants with ratings greater than 4.0 were easily seen, spherical to oval, often terminal, and spongy due to massive cortical hyperplasia (Fig. 2C,D). Females were easily dissected from such galls. On plants with low ratings, galls

TABLE 2. Galling of soybean (*Glycine max* L.) cultivars by *Meloidogyne trifoliophila*.

Cultivar or breeding line	Gall index ^a	
	Mean ^b	Range ^c
Asgrow A4906	3.8	3-4
Asgrow A5474	3.8	3-4
Bryan	5.2	5-6
Centennial	5.8	5-6
CNS	4.4	4-5
Coker 485	4.8	4-5
Cordell	2.8	2-3
Davis	6.0	—
Deltapine 415	4.6	4-5
Epps	4.4	4-5
Essex	6.4	6-7
Hutcheson	4.6	4-5
Jackson	6.2	5-7
Lee 74	5.0	—
Peking	4.4	4-5
PI 437654	6.2	5-7
Pickett	4.2	3-6
Ransom	3.0	—
TN 4-86	3.4	3-4
TN 5-85	3.8	3-4
TN 85-55	4.0	—
TN 85-157	4.2	4-5
Williams	3.4	3-4
York	6.0	—
Young	6.4	6-7
<i>Trifolium repens</i> (white clover) ^d	7.0	6-8

^a Ratings based on the Zeck visual index, where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

^b Each mean is the average of five plants.

^c A dash without numbers in the range column indicates that all plants had the same rating.

^d Standard entry in each test.

were small, usually intercalary, spindle-shaped, and less spongy.

In the 91 soil samples bioassayed with white clover for the presence of *M. trifoliophila*, three samples contained *Heterodera trifolii* Goffart and 10 contained *M. incognita*. *Meloidogyne trifoliophila* was not found in any sample.

DISCUSSION

Meloidogyne trifoliophila has the potential to be a significant pest in leguminous crops.

TABLE 3. Gallings of various legumes by *Meloidogyne trifoliophila*.

Species	Common name	Cultivar	Gall index ^a			
			Mean ^b	Range ^c		
<i>Arachis hypogaea</i> L.	Peanut	Florunner	0	—		
<i>Lespedeza cuneata</i> (Dum. Cours.) G. Don	Sericea lespedeza	AU Donnelly	2.0	—		
		AU Lotan	0	—		
		Interstate	1.2	1-2		
		Interstate 76	0	—		
		Serala	0.8	0-3		
		Serala 76	0	—		
<i>L. stipulacea</i> Maxim.	Korean lespedeza	—	6.0	—		
<i>Lotus corniculatus</i> L.	Bird's-foot trefoil	AU Dewey	1.4	1-2		
		Carroll	2.6	2-3		
		Dawn	1.0	—		
		Empire	0	—		
		Fergus	1.4	1-2		
		Leo	2.6	2-3		
		Mirabel	1.2	1-2		
		Norcer	2.0	1-3		
		Viking	1.8	1-2		
		<i>Medicago arabica</i> (L.) Huds.	Spotted burclover	New Albany	3.0	2-4
				Springer	2.6	2-3
		<i>M. polymorpha</i> L.	Australian burclover	Circle Valley	0.2	2-4
				Serena	0.2	0-1
<i>M. sativa</i> L.	Alfalfa	Apollo	0.2	0-1		
		Cimarron	0.2	0-1		
		Florida 77	0.6	0-1		
		HiPhy	2.4	2-3		
		Lahontan	0.4	0-1		
		Liberty	0	—		
		Moapa 69	0	—		
		Southern Special	0	—		
		Team	0	—		
		—	—	3.4	3-4	
<i>Melilotus indica</i> (L.) All.	Yellow sweetclover	—	3.4	3-4		
<i>Phaseolus vulgaris</i> L.	Pole bean	Kentucky Wonder	0.4	0-1		
<i>Pisum sativum</i> L.	Garden pea	Alaska	5.2	5-6		
<i>Vicia faba</i> L.	Broad bean	—	7.0	—		
<i>V. sativa</i> L.	Common vetch	Cahaba White	7.0	—		
		Nova II	6.6	6-7		
		Vanguard	6.4	6-7		
		Vantage	6.4	6-7		
		(Common)	7.8	7-8		
<i>Trifolium repens</i> ^d	White clover	(Common)	7.8	7-8		

^a Ratings based on the Zeck visual index, where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

^b Each mean is the average of five plants.

^c A dash without numbers in the range column indicates that all plants had the same rating.

^d Standard entry in each test.

The nematode's known range in the United States is restricted to the southwestern corner of Tennessee. However, its ability to infect many clovers could ensure its widespread, suitable hosts over much of the United States. Recently, *M. trifoliophila* has

been identified from New Zealand, where it is an important pest of white clover in pastures (Mercer, 1997).

Previously listed host ranges of *Meloidogyne* Group 11 (Jepson, 1987), to which *M. trifoliophila* belongs, need to be reexamined.

TABLE 4. Galling of various monocotyledons by *Meloidogyne trifoliophila*.

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>Trifolium repens</i> ^d	White Clover	(Common)	7.4	6-8
AMARYLLIDACEAE				
<i>Anigozanthos manglesii</i> D. Don.	Kangaroo-paw		3.2	1-4
<i>Hemerocallis fulva</i> (L.) L.	Daylily	Stella d'Oro	0	—
<i>Narcissus</i> × sp.	Daffodil	Paperwhite Ziva	0	—
ARACEAE				
<i>Philodendron</i> × sp.	Heart-leaf philodendron	—	0.8	0-1
<i>Pothos</i> × sp.	Pothos	—	0	—
IRIDACEAE				
<i>Chasmanthe floribunda</i> (Salisb.) N.E. Br.	—	—	0.2	0-1
<i>Diets iridioides</i> (L.) Sweet	Fortnight lily	—	0	—
<i>Ferraria crispa</i> Burm.	—	—	0.4	0-1
<i>Iris lactea</i> Pallas	—	—	0	—
<i>I. setosa</i> Pallas ex Link	—	—	0	—
<i>I. sibirica</i> L.	Siberian iris	Sky Wings	0	—
<i>I.</i> × sp.	Dwarf bearded iris	Grape Orbit	0	—
<i>Pardanthopsis dichotoma</i> (Pallas) Lenz	—	—	0	—
<i>Phaiophleps nigricans</i> (Phl.) Fos.	—	—	0.8	0-2
<i>Sisyrinchium angustifolium</i> Mill.	Blue-eyed grass	—	0	—
LILIACEAE				
<i>Allium ampeloprasum</i> L.	leek	Giant Flag	2.0	0-4
<i>A. cepa</i> L.	onion	Everlasting Bunching	4.8	4-5
<i>A. schoenoprasum</i> L.	chives	—	4.6	4-5
<i>Asparagus officinalis</i> L.	asparagus	Mary Washington	0	—
<i>Ornithogalum umbellatum</i> L.	Star-of-Bethlehem	—	1.4	0-2
<i>Tulbaghia violacea</i> Harv.	Society garlic	—	0.6	0-2
POACEAE				
<i>Agrostis stolonifera</i> L.	Creeping bentgrass	—	0	—
<i>Avena sativa</i> L.	Oat	Noble	0	—
<i>Cynodon dactylon</i> (L.) Pers.	Bermudagrass	—	0	—
<i>Dactylis glomerata</i> L.	Orchardgrass	Benchmark	0.6	0-2
		Hallmark	0.2	0-1
<i>Eleusine indica</i> (L.) Gaertn.	Goosegrass	—	1.8	1-2
<i>Festuca arundinacea</i> Schreb.	Tall fescue	Jaguar	0	—
		Phyter	0.8	0-2
		Rebel II	0	—
<i>F. rubra</i> L.	Red fescue	—	0	—
<i>Hordeum vulgare</i> L.	Barley	Volbar	0	—
<i>Lolium multiflorum</i> Lam.	Annual ryegrass	—	3.6	3-4
<i>L. perenne</i> L.	Perennial ryegrass	Birdie II	0	—
		Commander	0	—
		Cutlass 88	0	—
		Linn	0	—
		Manhattan Isle	0	—
<i>Oryza sativa</i> L.	Rice	Cypress	0	—
		Katy	0	—
		Mars	0	—

TABLE 4. Continued

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>Phleum pratense</i> L.	Timothy	Mohawk	1.4	0-4
<i>Poa annua</i> L.	Annual bluegrass	—	0.4	0-1
<i>P. pratensis</i> L.	Kentucky bluegrass	—	0.4	0-2
<i>Saccharum officinarum</i> L.	Sugarcane	—	0	—
<i>Sorghum bicolor</i> (L.) Moench	Sorghum	Funk G522R	0.2	0-1
<i>Stenotaphrum secundatum</i> (Walter) Kunze	Saint Augustine grass	—	0	—
<i>Triticum aestivum</i> L.	wheat	Caldwell	0	—
		Coker 916	0.6	0-2
		Florida 304	0	—
		McNair 1003	0	—
		Pioneer 2550	0.6	0-2
<i>Zea mays</i> L.	Maize	Golden Cross	1.0	0-3
		Seneca Chief	0	—
		Silver Queen	0	—
ZINGIBERACEAE				
<i>Hedychium coronarium</i> J. Konig ex Retz	White ginger	—	0	—

^a Ratings based on the Zeck visual index, where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

^b Each mean is the average of five plants.

^c A dash without numbers in the range column indicates that all plants had the same rating.

^d Standard entry in each test.

The previously described species in this group (*M. graminicola*, *M. naasi*, *M. oryzae*, *M. ottersoni*, *M. triticoryzae*) are morphologically similar to *M. trifoliophila*. Some host reports, particularly for *M. graminicola*, could be erroneous. A nematode identified in Mississippi as *M. graminicola* reproduced well on most of 23 *Trifolium* spp. (Windham and Pederson, 1992). Perineal patterns of the Mississippi isolate, provided through the courtesy of Dr. G. L. Windham, more closely resembled *M. trifoliophila* than *M. graminicola*. The two species are similar, and further analysis of the Mississippi isolate is required before conspecificity should be accepted. *Meloidogyne trifoliophila* differs from all other Group II species in being a non-parasite of rice, wheat, and barley.

Reproduction was not determined in this study. However, we observed that egg production was prolific in root systems with gall ratings greater than 4. Small galls widely

scattered on a root system rarely contained mature females with more than a few eggs.

Ball clover was used as the stock host for *M. trifoliophila* cultures, primarily to avoid contamination of the experiments with *M. incognita*. This clover species can be highly variable with regard to galling by *M. incognita*. McGlohon and Baxter (1958) reported that ball clover was susceptible to *M. incognita acrita*. Pederson and Windham (1989) found that *M. incognita* on ball clover had a galling mean of 2.0 on a 0-5 rating scale. Of 40 plants tested, 13 had a rating of 0 or 1 (0-2 galls per root system) and were considered resistant to *M. incognita*. In a later experiment (Windham and Pederson, 1992), *M. incognita* increased fourfold on ball clover, produced a mean of 7,509 eggs per gram of fresh root, and had a mean gall rating of 3.0. Individual ball clover plants used in the above two studies had a wide range of susceptibility. The ball clover used

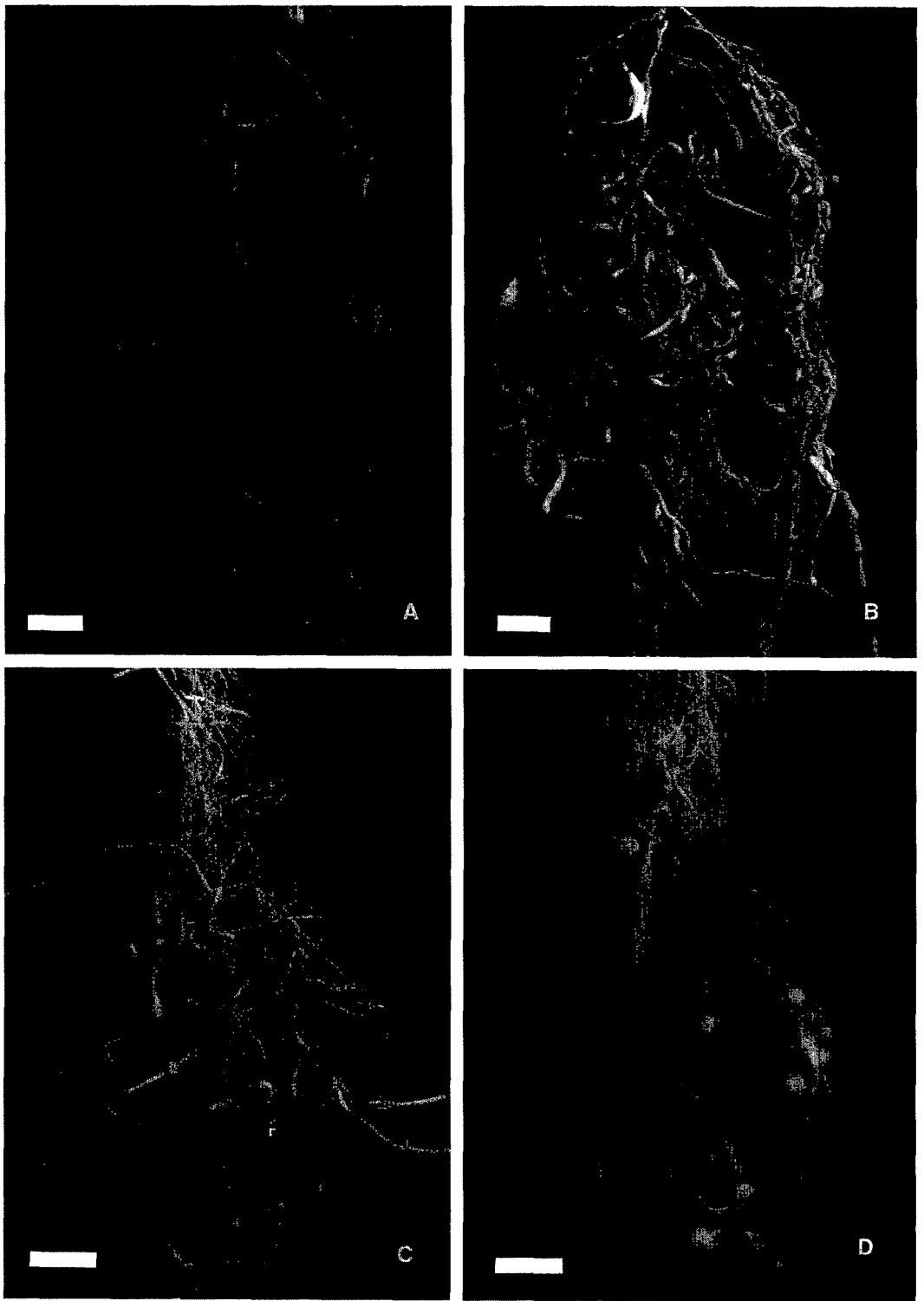


FIG. 2. *Meloidogyne trifoliophila* galls on various root systems. A) 'Essex' soybean. B) PI437654 soybean. C) Onion. D) Canary creeper. Scale bars = 10 mm.

TABLE 5. Gallings of various dicotyledons by *Meloidogyne trifoliophila*.

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>Trifolium repens</i> ^d	White clover	(Common)	6.4	5-7
AMARANTHACEAE				
<i>Celosia cristata</i> L.	Celosia	Golden Triumph	5.4	5-6
ANONACEAE				
<i>Anethum graveolens</i> L.	Dill	—	4.6	4-5
APIACEAE				
<i>Apium graveolens</i> L.	Celery	—	3.8	3-4
<i>Carum carvi</i> L.	Caraway	—	6.6	6-7
<i>Corandrum sativum</i> L.	Coriander/Cilantro	—	4.4	3-5
<i>Daucus carota</i> L.	Carrot	Chatanay	4.2	3-5
<i>Foeniculum vulgare</i> Mill.	Fennel	—	3.0	2-4
<i>Pasinaca sativa</i> L.	Parsnip	Hollow Crown	2.6	2-4
ASTERACEAE				
<i>Ageratum</i> sp.	Floss flower	Pink Powderpuff	0	—
<i>Anacyclus depressus</i> Ball.	Anacyclus	Garden Gnome	3.6	2-4
<i>Artemisia dracunculus</i> L.	Tarragon	—	0	—
<i>Chrysanthemum leucanthemum</i> L.	Oxeye daisy	Shasta	1.4	0-3
<i>Cineraria maritima</i> L.	Dusty miller	Silverdust	0	—
<i>Helianthus annuus</i> L.	Sunflower	Russian Mammoth	4.2	2-6
<i>Lactuca sativa</i> L.	Lettuce	Black Seeded Simpson	0.4	0-1
<i>Spilanthes americana</i> L.	Toothache plant	—	0	—
<i>S. oleracea</i> L.	Brazil cress	—	0	—
<i>Tanacetum vulgare</i> L.	Tansy	—	0	—
<i>Zinnia elegans</i> Jacq.	Zinnia	—	0	—
BORAGINACEAE				
<i>Borago officinalis</i> L.	Borage	—	0.2	0-1
BRASSICACEAE				
<i>Brassica napus</i> L.	Rapeseed	Viking	3.4	3-4
<i>B. oleracea</i> L. <i>acephala</i> DC.	Collards	Georgia Southern Creole	4.4	4-5
<i>B. o. botrytis</i> L.	Broccoli	Italian Green Sprouting	5.4	4-6
	Cauliflower	Early Super Snowbank	5.8	5-6
<i>B. o. capitata</i> L.	Cabbage	Late Flat	4.0	3-5
<i>B. o. gemmifera</i> DC.	Brussels sprouts	Long Island	5.4	4-6
<i>B. rapa</i> L.	Turnip	Purple Top White Globe	5.0	4-6
<i>Nasturtium officinale</i> R. Br.	Watercress	Truewater	5.0	4-6
<i>Raphanus sativus</i> L.	Radish	White Tip	1.2	1-2
CAPRIFOLIACEAE				
<i>Cleome spinosa</i> Jacq.	Spiderflower	Rose Queen	3.6	3-4
CARYOPHYLLACEAE				
<i>Dianthus caryophyllus</i> L.	Carnation	—	0.4	0-1
CHENOPODIACEAE				
<i>Beta vulgaris</i> L.	Beet	Golden	4.4	4-5
<i>Spinacia oleracea</i> L.	Spinach	Bloomsdale	4.4	4-6
CONVOLVULACEAE				
<i>Ipomoea batatas</i> (L.) Lam.	Sweet potato	—	0	—
CUCURBITACEAE				
<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	Watermelon	Charleston Gray	0	—
<i>Cucumis melo</i> L. var. <i>cantalupensis</i> Naudin	Cantaloupe	Vedrantais	0	—
<i>C. melo</i> var. <i>flexuosus</i> (L.) Naudin	Banana melon	—	0	—
<i>C. melo</i> var. <i>inodorus</i> Naudin	Honeydew melon	—	0	—

TABLE 5. Continued

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>C. melo</i> var. <i>reticulatus</i> Naudin	Muskmelon	Burpee Hybrid	0	—
<i>C. pepo</i> L.	Pumpkin	New England Pie	0	—
	Squash	Bush Early Summer Crookneck	0	—
<i>C. sativus</i> L.	Cucumber	Ohio Pickling	0.2	0-1
		Bush Cucumber	0	—
<i>Loofa aegyptica</i> Mill.	Loofah	—	0	—
DIPSACACEAE				
<i>Scabiosa stellata</i> L.	Starflower	—	4.8	4-5
EUPHORBIACEAE				
<i>Euphorbia milii</i> Des Moul.	Crown-of-thorns	—	0	—
GERANIACEAE				
<i>Pelargonium graveolens</i> L'Her ex Aiton	Geranium	Chocolate Mint	0	—
LAMIACEAE				
<i>Coleus blumei</i> Beauth.	Coleus	Vertschaffelti	0	—
<i>Marjorana hortensis</i> (Thunb.) Ker-Gawl	Sweet marjoram	—	0	—
<i>Mentha piperata</i> L.	Peppermint	Maury Mitchum	0	—
<i>Mentha spicata</i> L.	Spearmint	—	0	—
<i>Nepeta cataria</i> L.	Catnip	—	3.2	2-4
<i>Ocimum basilicum</i> L.	Sweet basil	—	2.8	2-3
<i>Rosmarinus officinalis</i> L.	Rosemary	—	0	—
<i>Salvia officinalis</i> L.	Sage	—	0	—
<i>Salvia splendens</i> Sellow ex Roem. & Schult	Salvia	—	0	—
<i>Satureia hortensis</i> L.	Summer savory	—	0.4	0-2
<i>Thymus vulgaris</i> L.	Thyme	—	0	—
MALVACEAE				
<i>Abelmoschus esculentus</i> (L.) Moench	Okra	Emerald	0.4	0-1
<i>Gossypium hirsutum</i> L.	Cotton	DES 119	0	—
		DPL 20	0	—
		LA 887	0	—
		Everglades 41	0	—
<i>Hibiscus cannabinus</i> L.	Kenaf	Everglades 71	0	—
		Tainung 1	0	—
		—	0	—
POLEMONIACEAE				
<i>Phlox subulata</i> L.	Moss-pink	—	2.8	2-4
POLYGONACEAE				
<i>Rumex acetosa</i> L.	Garden sorrel	—	0.2	0-1
ROSACEAE				
<i>Rosa multiflora</i> Thunb. ex J. A. Murray	Rose	—	0	—
SAXIFRAGACEAE				
<i>Astilbe</i> × sp.	Astilbe	—	0	—
SCROPHULARIACEAE				
<i>Antirrhinum majus</i> L.	Snapdragon	—	3.0	2-4
SOLANACEAE				
<i>Capsicum annuum</i> L.	Chile	Carolina Cayenne	0	—
		Scotch Bonnet	0	—
		Hungarian Yellow	0	—
<i>Lycopersicon esculentum</i> Mill.	Tomato	Rutgers	0	—

TABLE 5. Continued

Species	Common name	Cultivar	Gall index ^a	
			Mean ^b	Range ^c
<i>Nicotiana tabacum</i> L.	Tobacco	Burley 21	0	—
		Judy's Pride	0	—
		TN 86	0	—
<i>Solanum melongena</i> L.	Eggplant	Black Beauty	0	—
<i>S. tuberosum</i> L.	Potato	Russet Burbank	0	—
TROPAEOLACEAE				
<i>Tropaeolum peregrinum</i> L.	Canary creeper	—	5.8	5-6

^a Ratings based on the Zeck visual index, where 0 = no galling; 1 = very few individual galls detected upon close examination; 2 = individual root galls visible upon cursory inspection; 3 = numerous galls, a few of them coalescing; 4 = small and large galls, most roots still appearing functional; 5 = 25% of the root system out of function due to severe galling; 6 = up to 50% of the root system out of function; 7 = 75% of the root system heavily galled and not functioning; 8 = all roots heavily galled, plant crown still green; 9 = root system totally galled, plant dying; 10 = dead plant.

^b Each mean is the average of five plants.

^c A dash without numbers in the range column indicates that all plants had the same rating.

^d Standard entry in each test.

in the tests reported here was highly resistant to the *M. incognita* originally found with *M. trifoliophila*.

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