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Suitability of Small Grains as Hosts of *Meloidogyne* Species[1]

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Abstract: Seven cultivars of wheat, five of oat, one of rye, and four of barley were tested as hosts for *Meloidogyne incognita, M. javanica,* or *M. arenaria* under greenhouse conditions where soil temperature ranged from 21 to 34 C. Reproduction rates of all nematode species were high on all cultivars, except *M. javanica* and *M. arenaria* on 'Brooks' and 'Florida 501' oat. *Meloidogyne incognita* and *M. javanica* produced more eggs on roots of 'Rutgers' tomato than on cultivars of wheat, oat, rye, or barley.

Key words: Avena sativa, barley, *Hordeum vulgare, Meloidogyne arenaria, M. incognita, M. javanica,* oat, root-knot nematode, rye, *Secale cereale, Triticum aestivum,* wheat.

Some cultivars of wheat (*Triticum aestivum L.), oat (Avena sativa* L.), rye (*Secale cereale* L.), and barley (*Hordeum vulgare* L.) are susceptible to *M. incognita acrita* Chitwood (4,15,18), *M. incognita* (Kofoid & White) Chitwood (11,13–15,17,18), *M. arenaria* (Neal) Chitwood (11,15), and *M. javanica* (Treub) Chitwood (8,11–18) and resistant to *M. hapla* Chitwood (4,13), *M. javanica* (6), and *M. incognita* (1,6). Several, most notably Florida-developed oat cultivars, did not support reproduction of *Meloidogyne* spp. (11).

Small grains (wheat, oat, rye, and barley) are important winter forage crops for livestock in Georgia (10). They can be grazed, used as greenchopped material for immediate feeding or silage, and may also be harvested for grain. *Meloidogyne* spp. may not be economically damaging to a winter small grain crop, but the combination of a mild winter season and a susceptible cultivar could greatly affect the levels of *Meloidogyne* spp. juveniles to which the subsequent crop may be exposed.

Small grains, planted as winter cover crops, are suggested as rotation crops (1,10), but little information is available on the effect of small grain crops on *Meloidogyne* spp. (1,5,6,9,11,17). The objective of this study was to determine the host suitability of wheat, oat, rye, and barley commonly grown in the southeastern United States to three *Meloidogyne* spp. under greenhouse conditions.

Materials and Methods

Steamed sandy loam soil and builder's sand (3:1 v/v) sieved through a 7-mm screen was prepared as a potting medium. Seeds of cultivars of wheat, oat, rye, barley, and tomato (*Lycopersicon esculentum* Mill. cv. Rutgers) recommended for the southeastern United States were germinated in vermiculite. Seedlings of uniform size (ca. 8 cm tall) were transplanted one each to 8-cm plastic pots containing 3,785 cm^3 of potting medium.

Soil in pots was inoculated with eggs of the appropriate *Meloidogyne* spp. extracted from egg masses from 50-day-old infected tomato roots. The eggs were separated from roots and masses by the sodium hypochlorite method (7). A depression, 5 cm^2 and 6 cm deep, was formed in the soil surface of each pot, and 50 ml of egg suspension in water was distributed at the periphery of each depression.

In experiment 1, ca. 8,000 *M. incognita* eggs were added to each pot. In experiment 2, ca. 10,000 eggs of *M. incognita, M. arenaria,* or *M. javanica* were added per pot. In both experiments, four or six replicates for each nematode treatment were

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arranged in a randomized complete block design on a greenhouse bench. In experiment 2, a split plot design was used with crops as whole plots and *Meloidogyne* spp. as subplots. Pots were spaced to prevent contamination. Soil temperature ranged from 21 to 34 C during the experiments. Tomato was included in the tests as a susceptible control. A complete nutrient solution (840 g of commercial fertilizer [VHPF, Miller Chemical Company, Baltimore, MD] plus 148 g of $MgSO_4 \cdot 7H_2O$ in 100 liters of tap water) was added, 50 ml per pot, each week for 2 weeks and then semiweekly until the experiments were terminated 55 days after inoculation.

At the conclusion of each experiment, roots were carefully freed from soil and washed. In experiment 1, roots were stained with 0.05% acid fuchsin in lactophenol and cleared in lactophenol (3), and numbers of juveniles (J2, J3, J4), and females with and without egg masses in the total root system were recorded. In experiment 2, the number of eggs per root system was estimated (7). Data were subjected to analysis of variance and mean separation was by Waller-Duncan multiple-range test.

Results

In experiment 1, *M. incognita* J2, J3, J4, and females with and without egg masses were found in roots of all cultivars of wheat, oat, rye, barley, and tomato (Table 1). Fewer ($P \leq 0.05$) immature nematodes and females without eggs were found in roots of 'GA 1123' than in 'Coker 6815' or 'Arthur 71' wheat. More ($P \leq 0.05$) females with egg masses were found in 'Holley' than in other cultivars of wheat. More ($P \leq 0.05$) immature nematodes were found in roots of 'Elan' oat than in 'Coker 66-22'. There were no differences in numbers of females with or without egg masses among cultivars of oat. More ($P \leq 0.05$) immature *M. incognita* and females with egg masses occurred in roots of 'Barsoy' than in other cultivars of barley. Fewer ($P \leq 0.05$) females without egg masses were found in roots of Barsoy and 'Volbar' than in roots of 'Keowee'.

Table 1. *Meloidogyne incognita* in different stages of development on roots of plants 55 days after inoculation.

	Number per root system		
	J2, J3, J4	Females without egg masses	Females with egg masses
Wheat			
GA 1123	10 b	4 b	79 b
Coker 6815	56 a	24 a	183 b
Arthur 71	56 a	24 a	183 b
Holley	44 ab	12 ab	352 a
Oat			
Coker 66-22	25 b	10 a	149 a
Coker 277	77 ab	22 a	156 a
Elan	143 a	32 a	292 a
Rye			
Wren Abruzzi	58	20	121
Barley			
Keowee	79 b	31 a	117 b
Volbar	70 b	7 b	171 b
Barsoy	177 a	9 b	438 a
Tomato			
Rutgers	195	154	727

Values are means of four replications. Means in columns for each crop followed by the same letter are not significantly different ($P < 0.05$) according to Waller-Duncan multiple-range test.

Meloidogyne incognita, M. javanica, and *M. arenaria* produced eggs on roots of all crops and cultivars (Table 2). There were no differences ($P \leq 0.05$) in egg production by the three species of nematodes among cultivars of wheat or oat, but *M. arenaria* produced more eggs on 'Red Hill' than on Volbar barley. *Meloidogyne incognita* and *M. javanica* produced more eggs on tomato than other crops. Mean data for crops across all *Meloidogyne* spp. indicate that the most nematode eggs were produced on roots of tomato. More eggs were produced on barley and wheat than on rye and oat. Mean data for nematode species across all crops indicate that *M. javanica* produced the most ($P \leq 0.05$) eggs and *M. incognita* produced the fewest.

Discussion

Meloidogyne incognita, M. javanica, and *M. arenaria* can infect, develop, and repro-

TABLE 2. Nematode eggs on roots of plants 55 days after inoculation with three *Meloidogyne* spp.

	Eggs per root system (× 1,000)			
	M. incognita	*M. javanica*	*M. arenaria*	Crop mean
Wheat				
Coker 797	79.5 bc	126.5 c	115.3 bc	
Fla. 301	87.8 bc	140.5 c	150.8 b	113.8 c
Stacy	65.0 bc	124.8 c	134.0 bc	
Oat				
Brooks	27.3 c	11.0 d	41.8 d	
Fla. 501	28.5 c	12.0 d	43.8 d	28.0 e
Rye				
Wren Abruzzi	46.3 bc	110.0 c	81.5 cd	79.3 d
Barley				
Red Hill	101.8 b	231.5 b	238.3 a	
Volbar	65.5 bc	277.5 b	172.3 b	181.1 b
Tomato				
Rutgers	141.0 a	451.1 a	104.9 c	232.3 a
Nematode mean across all crops	71.4 z	165.0 x	120.3 y	

Values are means of six replications. Means in columns or rows followed by the same letter are not significantly different ($P < 0.05$) according to Waller-Duncan multiple-range test.

duce on roots of wheat, oat, rye, and barley when soil temperatures range from 21 to 34 C. The temperature range is well above that considered minimal (15–18 C) for nematode development and reproduction (14,18). Soil temperature, rather than host suitability of cereals for *M. javanica,* appeared the important factor controlling population levels (18). Minimum soil temperature in southern Georgia at the time of planting small grain crops in October and November is usually above the development threshold of about 10 C for *M. incognita* (13,14) and does not decline below the threshold until after November.

Damage to wheat by *M. javanica* has been reported (12,16), and our study shows that *M. incognita, M. javanica,* and *M. arenaria* reproduced on wheat and other small grain crops. Eggs of *Meloidogyne incognita acrita* may survive for several months in moist soil at 10–16 C (2) and may be the primary source of inoculum on the succeeding crop by hatching when the soil temperature increases (18). Damage occurs to susceptible summer crops following small grain crops on soil infested with *M. javanica* and *M. incognita* (9,18). Numbers of *M. incognita* or *M. hapla* did not increase on 'Oasis' wheat in a sweet corn–soybean–wheat–soybean–spinach cropping system (5).

Our findings support observations that *Meloidogyne* spp. can reproduce on small grain crops commonly seeded in the fall in the southeastern states (11,13–15,18), but are contrary to findings that wheat is resistant to *M. incognita* (1). In this region and in warmer regions where small grain crops are grown in winter, reproduction of *M. incognita, M. javanica,* and *M. arenaria* can be avoided by delaying planting on infested fields until soil temperature declines below 18 C, the activity threshold for invasion (13). Pathogenicity varies widely among geographic populations and races of *Meloidogyne* spp. (6) and should, therefore, be considered when evaluating crop rotations with small grains. Additional information is needed to determine the effects of planting dates and destruction of small grain crops for livestock grazing on managing *Meloidogyne* spp. in crop production systems.

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