Reproduction of Three Root-Knot Nematodes on Winter Small Grain Crops

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ABSTRACT

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Survival of *Meloidogyne arenaria* was compared on wheat and rye in field microplots during the winter cropping season in northern Florida. Small grain cultivars commonly grown in the southern United States were screened against these *Meloidogyne* spp. in growth room (24–28 C) experiments. None of these species increased in number on either wheat or rye in the microplot experiment, although significantly greater numbers of *M. arenaria* than either *M. incognita* or *M. javanica* were recovered at harvest. In screening experiments, many commercially used small grain cultivars were susceptible to *M. arenaria*, *M. incognita*, and *M. javanica*. Several cultivars, most notably Florida-developed oat cultivars, did not support reproduction of these *Meloidogyne* spp.

Additional keywords: *Avena sativa* L., crop rotation, host resistance, root-knot nematode, *Secale cereale* L., *Triticum aestivum* L.

Double cropping soybeans (*Glycine max* (L.) Merrill) with winter small grains can maximize total crop production and help conserve soil. The most popular system in the southeastern U.S. is a small grain crop (wheat [*Triticum aestivum* L. em. Thell], or rye [*Secale cereale* L.]) harvested for grain followed by late-maturing soybeans (7,10). The use of small grains, however, could increase nematode disease problems for subsequent crops if the grain crop should support their reproduction. Of particular importance in the Southeast Coastal Plain are the root-knot nematodes *Meloidogyne arenaria* (Neal) Chitwood, *M. incognita* (Kofoid and White) Chitwood, and *M. javanica* (Treub) Chitwood.

Many commercial cultivars of wheat have been reported as hosts of *M. incognita* and *M. javanica* (4,11,15). Reports from Egypt and Brazil indicate that *M. javanica* may restrict yield of wheat (6,13). All of 21 wheat cultivars evaluated in Brazil supported high populations of *M. javanica*; numbers of egg masses varied from 60 to more than 100 per plant (14). Of 29 accessions of commercial and wild wheat species screened against *M. incognita* and *M. javanica* in the U.S., no sources of resistance to either species in *Triticum* spp. were detected (9). However, one accession of *Aegilops squarrosa* L. from Afghanistan was resistant to both *Meloidogyne* spp. Another U.S. study showed nine wheat cultivars commonly grown in the southern U.S. to be highly resistant to *M. incognita* (3). In California, however, *M. incognita* is capable of infecting winter wheat and may complete one life cycle during the growing season (8).

In view of the importance of winter-grown small grains in double-cropping systems in the southeast and these reports of root-knot nematode reproduction in small grains, the survival and reproduction of *Meloidogyne* spp. on wheat and rye cultivars during the winter cropping season were investigated in northern Florida. The objective of the screening experiment was to evaluate the reproductive potential of *M. arenaria*, *M. incognita*, and *M. javanica* on small grain crops commonly grown in Florida in

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order to more effectively select cultivars to manage these pests.

MATERIALS AND METHODS

Microplot experiment. This experiment was conducted in field microplots (76 cm diameter) at the University of Florida Agricultural Research and Education Center, Live Oak, from December 1982 through early May 1983. The soil was Lakeland Fine Sand composed of approximately 93% sand, 4% silt, 3% clay, and <1% organic matter. The microplots had been infested previously with separate and varying levels of *M. arenaria* (race 1), *M. incognita* (race 3), and *M. javanica* for a soybean experiment. After soybeans were harvested from the plots in early December, soil samples were taken to determine nematode populations. Five cores (20 cm deep, 2.5 cm diameter) were taken from each microplot, mixed, and processed by sugar flotation-centrifugation (1). The soil in the microplots was then turned and leveled. One week later, on 14 December 1982, 5 grams of Florida 301 soft red winter wheat or Wrens Abruzzi rye seed were planted in uninfested plots and in microplots containing various population densities of the three nematodes. Fertilization and other agronomic practices were as recommended (16). Each nematode/crop combination was replicated nine times in a completely randomized design.

Plots were harvested on 17 May 1983 and samples were taken to determine nematode populations as described above. Heads of wheat and rye were dried until moisture content was approximately 11%, and seed weight was recorded. The Student's *t* test (8 df) was employed to test the null hypotheses of no differences in *Meloidogyne* spp. development between wheat and rye. The Waller-Duncan procedure for mean separation was used to examine the relationships between final population (P_f) and initial population (P_i) for the three *Meloidogyne* spp. on each host.

Screening experiments. Six oat (*Avena sativa* L.) and 12 soft red winter wheat cultivars were included in these experiments. Three seeds were planted in a Super Cell Conetainer (Ray Leach Cone-Tainer Nursery, Canby, OR; volume 0.15 L) containing sterilized sand from the surface 40 cm of an Arredondo Fine Sand composed of approximately 93% sand, 4% silt, and 3% clay. Seeds were then covered with a layer of vermiculite. There were three identical racks of cones, each containing four cones of each cultivar. Seven days after seedling emergence, the seedlings were thinned to one plant per cone, and 3,000 eggs and juveniles of *M. arenaria*, *M. incognita*, or *M. javanica*, obtained by hypochlorite extraction (30-sec exposure) (5), were added to the soil in each cone using a repeating pipette. Each species was confined to a single rack and the racks were kept physically separate to avoid cross-contamination. The plants were cultured for 65 days in a growth room and maintained at 24–28 C. Roots were washed free of soil and stained with Phloxine B to facilitate counting of egg masses. Egg-mass numbers were rated according to the following scale: 1 = no egg masses, 2 = 1–10, 3 = 11–30, 4 = 31–75, and 5 = >75 egg masses per plant. There were four replications per cultivar arranged in a completely random design. The test was conducted twice. Seeds for each trial were from the same seed lot and all nematodes in each test originated from the same stock cultures. A combined analysis of variance was conducted for each *Meloidogyne* species over both tests, and data were subjected to Duncan's multiple range test to detect differences in egg mass rating among cultivars. Rutgers tomato (*Lycopersicon esculentum* Mill.) seedlings were inoculated, maintained, and harvested in the same manner as the grain plants as a susceptible check on the viability of the inoculum.

RESULTS AND DISCUSSION

The mean ratio of final population to initial population in the microplot experiment (P_f/P_i) was less than one for all species on each cultivar (Table 1). *M. arenaria* had higher P_f/P_i ratios than *M. incognita* and *M. javanica* on rye ($P = 0.001$) and wheat ($P = 0.009$). Soil population decline of *M. arenaria* and *M. javanica* could not be attributed to differences between wheat and rye as hosts. *M. incognita* populations were greater following rye than wheat ($P = 0.03$), but none of the *Meloidogyne* spp. affected grain yields (Table 1).

In the screening experiments, Rutgers tomato was severely galled and numerous egg masses were recovered from the roots. There was some variation between tests in cultivar responses, but this was mainly in the magnitude of response rather than entirely different egg-mass ratings. Tests involving *M. incognita* exhibited the most variation. For each species, the mean square error from analysis of variance was <1.0. Among the oat cultivars, FL 501 and FL 502 were generally less susceptible to *M. arenaria* and *M. javanica* than were any other oats and all wheats (Tables 2,3). With the exception of Coker 820, all oats screened against *M. incognita* showed moderate susceptibility. FL 502 was consistent across the three *Meloidogyne* spp., but FL 501 was much more susceptible to *M. incognita* than to either *M. arenaria* or *M. javanica*. There was much variation in reproduction by all three *Meloidogyne* spp. among the oat cultivars tested,

Table 1. Populations of *Meloidogyne* spp. on Wrens Abruzzi rye and Florida 301 wheat crops in microplots during the 1982–1983 winter season

Population	P_i[y]	P_f[y]	P_f/P_i	Yield (g/plot)
	No./100 cm³			
		Rye		
M. arenaria	2,202	788	.38 a[z]	76
M. incognita	2,573	221	.12 b	81
M. javanica	2,840	102	.05 b	80
Control	...	...	...	73
		Wheat		
M. arenaria	3,655	743	.36 a	85
M. incognita	3,452	189	.07 b	83
M. javanica	2,360	158	.08 b	80
Control	...	...	...	95

[y] P_i = initial population, P_f = final population. Numbers are juveniles/100 cm³ soil.
[z] Means followed by the same letter are not different according to the Waller-Duncan procedure for mean separation ($P = 0.01$). Data are means of nine replicates.

Table 2. Response of oat cultivars to three *Meloidogyne* spp.

Cultivar	Egg-mass rating[y]		
	M. arenaria	*M. incognita*	*M. javanica*
Coker 820	4.3 a[z]	4.1 a	4.7 ab
Coker 81-21	4.0 a	3.1 bc	5.0 a
Coker 227	3.5 b	3.0 c	3.1 c
FL 70Q1153	3.3 b	2.9 c	3.3 c
FL 502	2.1 c	2.0 d	1.8 d
FL 501	1.2 d	3.1 bc	1.2 e

[y] Egg-mass rating: 1 = no egg masses, 2 = 1–10, 3 = 11–30, 4 = 31–75, 5 = >75 egg masses per plant.
[z] Means followed by the same letter are not different according to Duncan's multiple range test ($P = 0.05$). Data are means of eight replicates over two tests.

suggesting some cultivars may carry genes for resistance to one or more of the nematode species. The three Florida-developed cultivars were consistently among the least susceptible.

The wheat cultivars tested showed less variation in response than did the oats (Tables 2,3). All wheat cultivars were extremely susceptible to *M. javanica*. Most wheat cultivars tested exhibited intermediate susceptibility to *M. incognita*, with Coker 762 being the least susceptible. In general, it appears that Florida-adapted wheat cultivars are much more susceptible to *M. arenaria* and *M. javanica* than are Florida-adapted oats, and are only slightly more susceptible to *M. incognita*.

Low reproduction ratios from the microplots suggested that Florida 301 wheat and Wrens Abruzzi rye were poor hosts for the three *Meloidogyne* spp. However, because Florida 301 clearly supported abundant reproduction of all three species in the screening trials, it seems likely that nematode reproduction in the microplot trial was inhibited by environmental factors, particularly temperature, rather than by genetic resistance. Wrens Abruzzi was not evaluated in the screening trials due to very poor early growth. Other rye cultivars tested did support some reproduction of all three nematode species (Opperman, *unpublished data*). The greater numbers of *M. arenaria* may indicate that this species was better able to survive the winter conditions than *M. incognita* or *M. javanica*, or that it developed more rapidly and thus reached greater numbers than the other two species before soil temperatures dropped below favorable levels in early winter. Further field studies are needed to confirm the tentative conclusions from the microplot study. The lack of effects of *Meloidogyne* spp. on yields of wheat and rye may explain why these nematodes are popularly considered to be inconsequential on these grains.

The greenhouse screening tests suggested that the selection of a small grain cultivar in a crop rotation scheme could influence population growth of *Meloidogyne* spp. However, the single microplot study indicated that in the field all three nematode populations declined on wheat and rye. Two Florida oat cultivars were consistently resistant in the greenhouse to all *Meloidogyne* spp., and all *Meloidogyne* spp. reproduced well on wheat. Oats have been reported to be resistant to *Meloidogyne* spp. in previous studies (11). Genetic studies may be able to identify the factor(s) responsible and allow their use to produce improved cultivars. The general susceptibility of wheat was surprising because a number of these cultivars had been previously reported as resistant to *M. incognita* (2). Most of the cultivars screened were clearly capable of supporting *Meloidogyne* spp. growth and reproduction. Genetic variation within nematode isolates may be responsible for some of the differences reported regarding response of small grains to root-knot nematodes. Available evidence indicates that pathogenicity may vary widely between geographic isolates and races of *Meloidogyne* spp. and should, therefore, be considered when evaluating crop rotations with small grains.

Previous studies and surveys have indicated that rotation with small grains often results in lower numbers of *Meloidogyne* spp. compared with monoculture of most crops (2,12). Our field results also show a decline in nematode numbers and no adverse impact on yield. The greenhouse results show, however, that *M. arenaria*, *M. incognita*, and *M. javanica* reproduce on the small grains tested, provided the temperature is suitable. Although these root-knot nematodes may not be important to a winter small grain crop itself, the combination of a mild winter season and a susceptible cultivar could substantially affect the levels of *Meloidogyne* spp. juveniles to which the subsequent crop may be exposed. The importance of the environment is clearly indicated by both these experiments and previous reports.

Table 3. Response of wheat cultivars to three *Meloidogyne* spp.

Cultivar	Egg-mass rating[y]		
	M. arenaria	*M. incognita*	*M. javanica*
Terral 817	5.0 ab[z]	3.6 abcd	5.0 a
FL 301	4.9 ab	3.0 ef	4.9 a
McNair 1813	4.9 ab	4.0 ab	4.8 ab
Magnum	4.8 abc	3.9 abc	4.3 bc
Southern Belle	4.5 bcd	3.6 abcd	5.0 a
Pioneer 2550	4.5 bcd	3.5 bcde	4.5 abc
FL 302	4.5 bcd	3.4 cde	4.8 ab
Pike	4.4 cd	4.1 a	4.1 c
Bradford	4.3 cd	3.3 de	4.5 abc
Omega 78	4.1 d	3.3 de	4.3 bc
Coker 762	3.1 e	2.6 f	4.1 c
Coker 797	2.6 f	3.1 de	4.1 c

[y] Egg-mass rating: 1 = no egg masses, 2 = 1–10, 3 = 11–30, 4 = 31–75, 5 = >75 egg masses per plant.
[z] Means followed by the same letter are not different according to Duncan's multiple range test ($P = 0.05$). Data are averages of eight replicates over two tests.

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