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Influence of *Meloidogyne chitwoodi* and *M. hapla* on Wheat Growth

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Abstract: *Meloidogyne chitwoodi* reduced the growth of winter wheat 'Nugaines' directly in relation to nematode density in the greenhouse. The relationship between top dry weight and initial nematode density suggests a tolerance limit of Nugaines wheat to *M. chitwoodi* of between 0.03 and 0.18 eggs/cm^3 of soil; the value for relative minimum plant top weight was 0.45 g and 0.75 g, respectively. Growth of wheat in field microplots containing four population densities (0.003, 0.05, 0.75 and 9 eggs/cm^3 soil) was not affected significantly at any inoculum level compared to controls during September to July. However, suppression of head weights of 'Fielder' spring wheat grown May–July occurred in microplots initially infested with 0.75 and 9 eggs/cm^3 soil. Reproduction (P_f/P_i) was poorer at these two inoculum levels as compared to the lower densities. In another greenhouse experiment, roots of wheat cultivars Fielder, 'Fieldwin,' 'Gaines,' 'Hyslop,' and Nugaines became infected by *M. chitwoodi*, but not by *M. hapla*. Reproduction of *M. chitwoodi* was less on Gaines and Nugaines than on Fielder, Fieldwin, or Hyslop.

Key words: Columbia root-knot nematode, northern root-knot nematode, *Triticum aestivum*, damage threshold.

The Columbia (*Meloidogyne chitwoodi* Golden et al.) and northern (*M. hapla* Chitwood) root-knot nematodes are serious pests of potato (*Solanum tuberosum* L.) in the northwestern United States (7). Wheat (*Triticum aestivum* L. em Thell), a host of several root-knot nematode species (3,6,8), is one of several important crops rotated with potato in the Northwest (4). In the Pacific Northwest, *M. chitwoodi* may reduce the productivity of wheat (8). *Meloidogyne hapla* infects some cereals (5), but it is unclear if *M. hapla* infects wheat. Experiments were designed to determine if *M. chitwoodi* and *M. hapla* suppress growth of wheat.

Materials and Methods

Inoculum concentration effect on wheat—greenhouse (Prosser, Washington): Similar greenhouse experiments were initiated in April 1981 and February 1982. Plastic pots (10-cm-d) containing 500 cm^3 methyl bromide fumigated soil (1:1 sand and sandy loam) were inoculated with *M. chitwoodi* eggs in a geometric series of increasing concentration (0 and 0.003; 0.12; 0.47; . . . 144 eggs/cm^3 soil). Nematodes were isolated from a potato field in Washington, increased on tomato (*Lycopersicon esculentum* Mill. 'Columbian') and extracted from galled roots (1). Eggs were added in 50 ml of aqueous suspension to several 5–7 cm deep furrows in the soil in each pot; water was applied to carry the eggs into the soil. A 50-ml aliquot of a nematode-free solution obtained from the egg extraction procedure was added to the soil in control pots. One germinated wheat 'Nugaines' seed was planted per pot. Each treatment was replicated eight times, and pots were randomly placed on a greenhouse bench. Ambient temperatures ranged from 24 to 26 C. Plants were watered daily and fertilized (10-10-10) as needed.

Dry top weights of plants were determined 100 days after planting. Data were subjected to analysis of variance and/or Duncan's multiple-range test. Initial population density (P_i) was also fitted to plant growth parameters using the Seinhorst model (9).

Inoculum concentration effect on wheat—microplot (Prosser, Washington): Seventy fiberglass microplots (81-cm-d × 46-cm-deep) were filled with methyl bromide fumigated (24.71 kg/ha) sandy loam soil (71% sand, 21% silt, and 8% clay) in May 1981. No plant-parasitic nematodes were detected in the soil in the microplots after fumigation.

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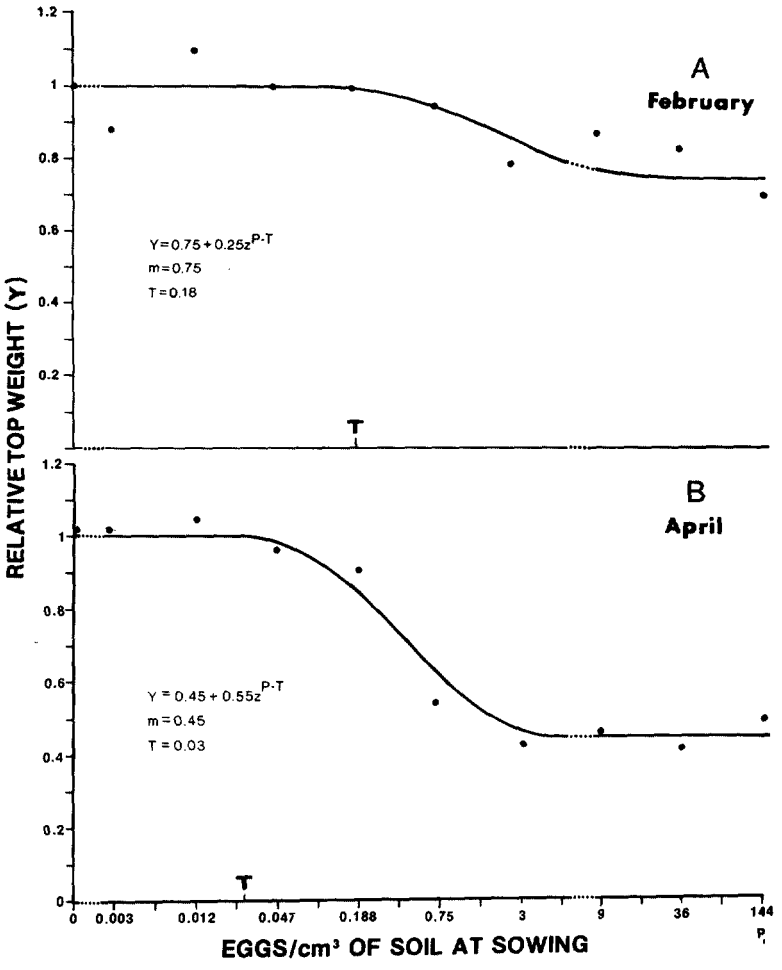

FIG. 1. Relationships between initial soil population density (P_i) of *M. chitwoodi* and dry top weight of Nugaines wheat planted in February 1982 (A) and April 1981 (B), 100 days after inoculation with nematodes. (Weights are expressed as values of the percentage increase or decrease of inoculated plants as compared to noninoculated controls.) $y = m + (1 - m)z^{P-T}$ for $P \geqq T$ and $y = 1$ for $P \leqq T$ (where y = relative yield; m = relative minimum yield; $z < 1$; P = initial nematode density; $z^{-T} = 1.05$; T = tolerance limit; and 1 = 100%).

In September 1981, 40 of the microplots were inoculated with 0 and 0.003, 0.050, 0.750, and 9.00 eggs/cm³ soil using the following procedure. The top 5 cm of soil were removed and set aside. Five random soil cores (7.62-cm-d × 30.48-cm-deep) were then removed; each core was placed in a separate plastic bag and the appropriate number of *M. chitwoodi* eggs pipetted onto this soil. Eggs were mixed into the soil by shaking the bags, and the soil was then poured into the hole it came from. The soil within each microplot was then turned under to a depth of 15 cm to simulate dispersal of nematode eggs during discing. Control microplots were inoculated as previously described with a nematode-free solution. The top 5 cm of soil previously removed was replaced in each microplot. Nugaines winter wheat was planted in four rows per microplot at a rate of 16 seed/31 cm on 20.3 cm centers. Treatments were randomized as whole blocks and replicated eight times. In April 1982, a similar study was initiated with the remaining 30 microplots using 'Fielder' spring wheat and six replicates per treatment. In August 1982, wheat yield was recorded and the final number (P_f) of second-stage juveniles (J2) of *M. chitwoodi* per cm³ soil were extracted by centrifugal-flotation (2) and counted.

TABLE 1. Yield and population changes of *Meloidogyne chitwoodi* on winter (Nugaines) and spring (Fielder) wheat grown in field microplots 11 and 5 months after sowing, respectively.

Eggs/cm³ soil at planting	Number of *M. chitwoodi* juveniles/cm³ soil (P_f/P_i)		Yield (%)	
	Nugaines	Fielder	Nugaines*	Fielder†
0	0	0	1.00	1.00 ab‡
0.003	1.30	6.70	0.94	1.36 a
0.050	0.10	1.00	0.99	1.34 a
0.750	0.10	0.10	0.97	0.59 bc
9.000	0.05	0.01	1.00	0.27 c

* Yield of Nugaines winter wheat is expressed as a % of the controls; as calculated by the weight (g) of seed per microplot (672 heads).

† Yield of Fielder spring wheat is expressed as a % of the controls; as calculated by the dry head weight per microplot.

‡ Values are means of eight and six replicates of Nugaines and Fielder, respectively. Values in column not followed by the same letter differ significantly ($P = 0.05$) according to Duncan's multiple-range test.

Nematode reproduction on wheat cultivars (Logan, Utah): *M. chitwoodi* from potato near Ft. Hall, Idaho, and *M. hapla* from lettuce (*Lactuca sativa* L.), near Ogden, Utah, were increased in the greenhouse on Columbian tomato. Nematodes were extracted from the galled roots as previously described. Two series of 15-cm-d plastic pots containing 1,500 cm³ of methyl bromide fumigated sandy loam soil (72% sand, 18% silt, and 10% clay) were inoculated with either 0 or 5,000 eggs and J2 of *M. chitwoodi* or *M. hapla* per pot (3.3 nematodes/cm³ soil). The inoculum was added to soil in a plastic bag, mixed thoroughly, and the soil with nematodes was placed in pots. Three seedlings each of the following wheat cultivars—'Fielder,' 'Fieldwin,' 'Gaines,' 'Hyslop,' and Nugaines—and tomato 'California Pack' were transplanted into the pots. Tomato, a good host for both nematode species, was used to verify nematode infectivity. Pots were randomized and treatments replicated five times. Twenty days after transplanting, seedlings were thinned to one per pot. Sixty-five days after transplanting, all plants were harvested and nematodes in the soil were extracted (1) and eggs per gram fresh weight of root calculated.

TABLE 2. Number of eggs of *Meloidogyne chitwoodi* recovered from roots of five wheat cultivars grown in the greenhouse for 65 days after inoculation with 5,000 eggs and juveniles.

Cultivars	Eggs/g fresh weight
Fielder	10,047 a*
Fieldwin	9,743 a
Hyslop	6,628 a
Gaines	3,109 b
Nugaines	1,498 b

* Values in a column not followed by the same letter differ significantly ($P = 0.05$) according to Duncan's multiple-range test.

RESULTS AND DISCUSSION

Inoculum concentration effect on wheat—greenhouse (Prosser, Washington): The relationship between dry top weight of Nugaines and the initial number (P_i) of *M. chitwoodi* eggs is shown in Figure 1. Plant response to P_i fitted curves according to the equation $y = m + (1 - m)z^{P-T}$ for $P \geq T$ and $y = 1$ for $P \leq T$ (where y = relative yield; m = relative minimum yield; $z < 1$; P = initial nematode density; $z^{-T} = 1.05$; and T = tolerance limit (9). The tolerance limit of Nugaines to *M. chitwoodi* suggested by curves A and B was between 0.18 and 0.03 eggs/cm³ soil, respectively. The tolerance limit value in the February experiment was greater than that in April, with maximum growth suppression of 25% and 55%, respectively. These differences may be partially attributed to variation in day length and light quality during the time the two experiments were conducted. The larger minimum yield value (m) registered in the February experiment suggests that Nugaines can tolerate a high *M. chitwoodi* P_i density better at that time of year than in April because of the different environmental conditions.

Inoculum concentration effect on wheat—microplot (Prosser, Washington): The field microplot study demonstrated that Nugaines can withstand high nematode population pressures with no effect ($P = 0.05$) on yield (Table 1) substantiating the results of the February greenhouse study. Also, *M. chitwoodi* reproduced poorly on Nugaines, suggesting that this cultivar is a poor host or that reproduction was not favored under the climatic conditions of the experiment.

M. chitwoodi suppressed yield of Fielder spring wheat in the microplot study by 41% and 73% ($P = 0.05$) in plots inoculated with 0.75 and 9.0 eggs/cm^3 soil, respectively (Table 1). The P_f for the two low inoculum levels were either equal to, or greater than, their respective P_i, whereas the P_f values at the two higher inoculum levels were lower than the corresponding P_i. This could have resulted from limited nematode reproduction on a host weakened by extreme nematode pressure.

Nematode reproduction on wheat cultivars (Logan, Utah): M. chitwoodi reproduced on all wheat cultivars tested, but fewer ($P = 0.05$) eggs were recovered from Gaines and Nugaines (Table 2). These results support those of the field microplot experiment in Prosser, Washington, confirming that Nugaines winter wheat is a poor host for *M. chitwoodi* reproduction compared to Fielder spring wheat. The five wheat cultivars tested were nonhosts to *M. hapla.*

In conclusion, Nugaines should be preferred to Fielder and the other cultivars tested when wheat is grown continuously or in rotation in fields infested with *M. chitwoodi.*

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