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Interaction between *Meloidogyne incognita* and *Hoplolaimus columbus* on Davis Soybean[1]

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Abstract: Greenhouse and laboratory experiments were performed to determine if an interaction exists between *Meloidogyne incognita* and *Hoplolaimus columbus* on Davis soybean. Greenhouse tests were performed with three population levels of *M. incognita* and *H. columbus* (0, 1,500, 6,000/1.5-liter pot) separately and in all combinations. Dry root weight (DRT) declined nonlinearly and dry shoot weight (DST) declined linearly with respect to increasing initial populations of *M. incognita* and *H. columbus*. When the two nematode species were added to the soil together, the amount of DRT and DST suppression by one species was dependent on the initial level of the concomitant species. The final root population of *M. incognita* or *H. columbus* declined linearly with increasing initial population density of the concomitant species. *H. columbus* suppressed *M. incognita* populations in the soil nonlinearly, but *M. incognita* had no effect on *H. columbus*.

Key words: *Glycine max*, lance nematode, root-knot nematode, soybean, *Meloidogyne incognita*, *Hoplolaimus columbus*.

Hoplolaimus columbus (Sher) may through competition become the predominant phytoparasitic nematode species, inhibiting *Meloidogyne incognita* (Kofoid & White) on cotton (3). This observation was corroborated by experimental evidence, which also indicated that reproduction of *H. columbus* was enhanced in the presence of *M. incognita* (9). Studies were initiated to determine if an interaction exists between the nematode species on soybean (*Glycine max* (L.) Merr. cv. Davis). The objectives were to determine 1) the effect of mixed populations of *H. columbus* and *M. incognita* on plant growth, 2) the effect of each species on the concomitant species, and 3) the relationship of initial population density of each species on the concomitant species.

MATERIALS AND METHODS

M. incognita was collected from a soybean field at Edisto Experiment Station, Blackville, South Carolina, and increased on tomato (*Lycopersicon esculentum* Mill. cv. Rutgers). Eggs were removed from tomato roots using a dilute NaOCl method (7), washed onto facial tissue supported by a wire screen, placed over a funnel in a modified Seinhorst mist apparatus (1), and sprayed for 30 seconds every 2 minutes with a fine mist of water containing 100 ppm zinc sulfate to facilitate egg hatch (2). Second-stage juveniles (J2) were collected and standardized to 1,000 J2/ml.

H. columbus was initially collected from Braxton soybeans at the Harold Lott Farm, Blackville, and extracted from roots using the mist chamber. The nematodes were cultured on cotton (*Gossypium hirsutum* L. cvs. Coker 310 and Deltapine-16) in the greenhouse at 30 C in temperature-controlled water baths. Soybeans were not used to culture the nematode because cotton is simpler to maintain and has a longer active growth phase. Nematode-infected cotton roots were placed in the mist apparatus, and nematodes were collected every 24 hours for 2–3 days and standardized to 1,000 juveniles and adults/ml water. Inoculum was also collected from culture pot soil using a semiautomatic elutriator (1) and centrifugal-flotation (8).

Nematode treatments of 0, 1,500, and 6,000 of each species singly and in all combinations were prepared—a total of nine treatments. Aliquots of inoculum were prepared by pipetting nematodes from a standard nematode–water mixture. Con-

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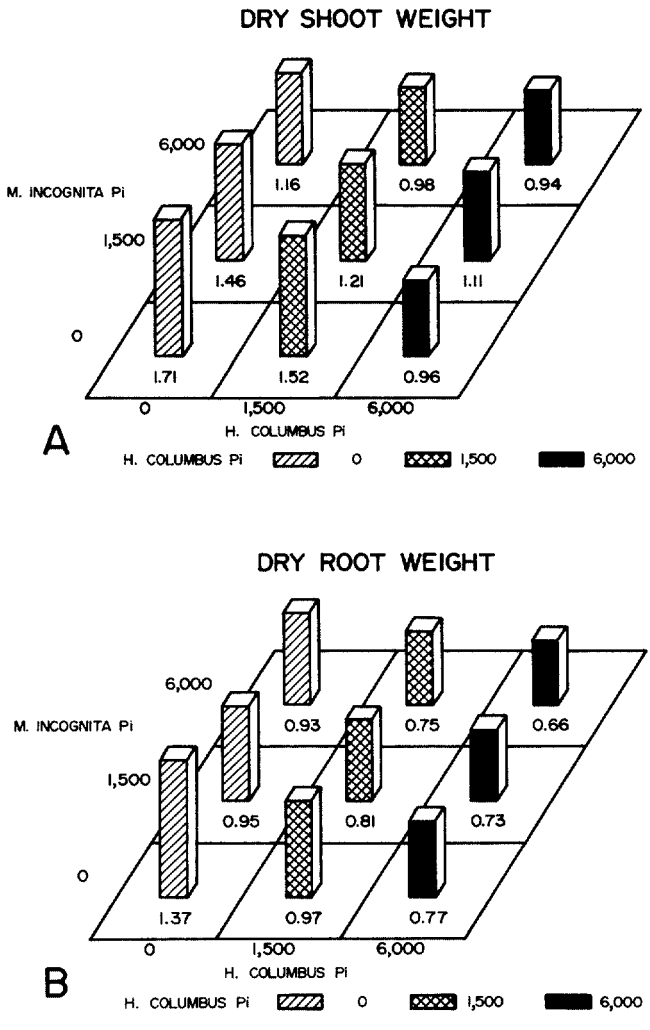

FIG. 1. Dry weights in grams of Davis soybean plants with various initial populations of *Meloidogyne incognita* and *Hoplolaimus columbus* alone and in combination.

trol aliquots were prepared by pipetting from suspensions from which the nematodes had been removed. The experiment was replicated eight times with the treatments arranged in a randomized complete block design. The experiment was performed twice.

Soil for the experiment was a steam-pasteurized 3 sand : 1 Varina sandy loam mix. One-week-old soybean plants were transplanted to 1,200 cm^3 soil in 15-cm-d plastic pots after dipping their roots in a *Rhizobium japonicum* suspension (3 ml/liter water). Aliquots of nematode inoculum were added to the soil immediately before transplanting the soybeans. The experiment was maintained in temperature-controlled water baths at 30 C and terminated after 60 days. Total nematode populations in the roots and soil were then determined, and dry roots and shoots were weighed.

Final nematode populations were determined by extracting the nematodes from the soil and roots. Nematodes were extracted as described previously from 500 cm^3 of mixed soil, after removal of roots from the soil, and 1-cm^3 aliquots of the final nematode suspension were counted in an eelworm slide (Gelman-Hawksley, Sussex, England).

Plants were dried at 65 C for 1 week before weighing. Nematode and plant

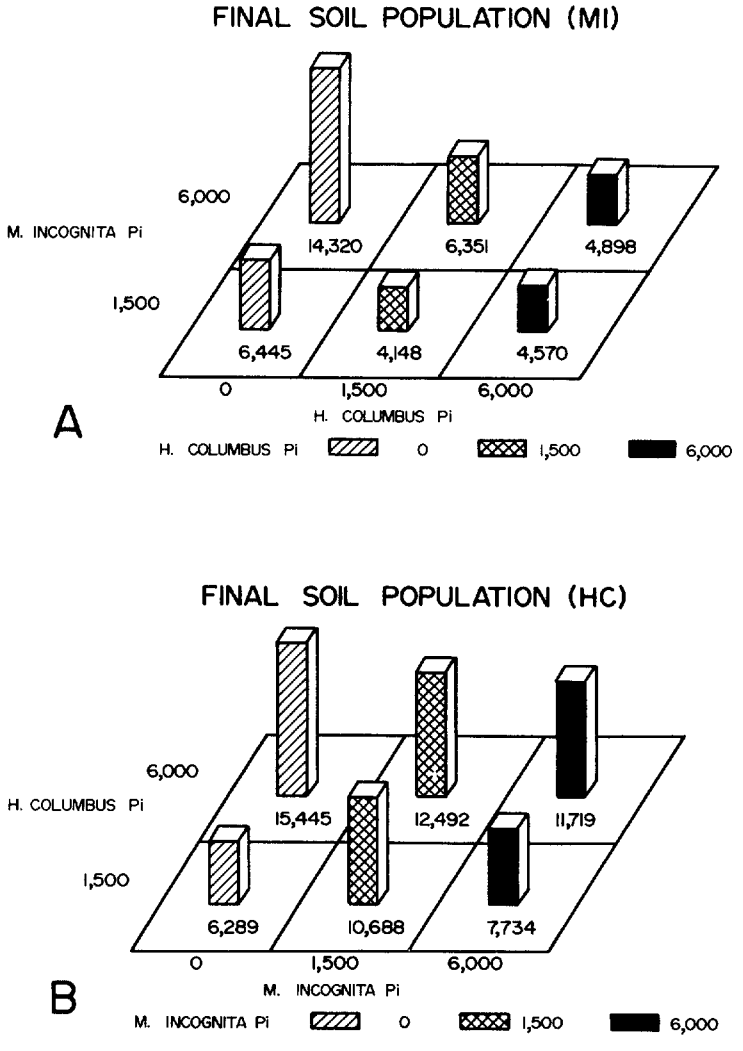

FIG. 2. Initial populations of *Hoplolaimus columbus* (A) and *Meloidogyne incognita* (B) and numbers of nematodes of the concomitant species in the soil after 60 days at 30 C on Davis soybean. Numbers represent mean number of nematodes extracted from the soil in two experiments each replicated eight times.

weight data were analyzed using the ANOVA and GLM procedures of SAS (SAS Institute, Cary, North Carolina). Results of the two experiments were similar, so they were combined for analysis.

RESULTS

Dry shoot weight declined linearly ($P = 0.01$) as initial populations of *M. incognita* or *H. columbus* increased (Fig. 1). Dry root weight was also suppressed, declining nonlinearly ($P = 0.01$) as initial populations of *M. incognita* or *H. columbus* increased (Fig. 1).

With the two species together, suppression of dry plant weight by one species was dependent upon numbers of the concomitant species. If the initial population of *H. columbus* remained constant while the level of *M. incognita* increased, *M. incognita* further suppressed both dry shoot and root weights ($P = 0.01$) (Fig. 1). Conversely, when the initial population of *M. incognita* remained constant and the level of *H. columbus* increased, there was suppression of dry shoot and root weights in addition to that attributed to *M. incognita* alone ($P = 0.01$).

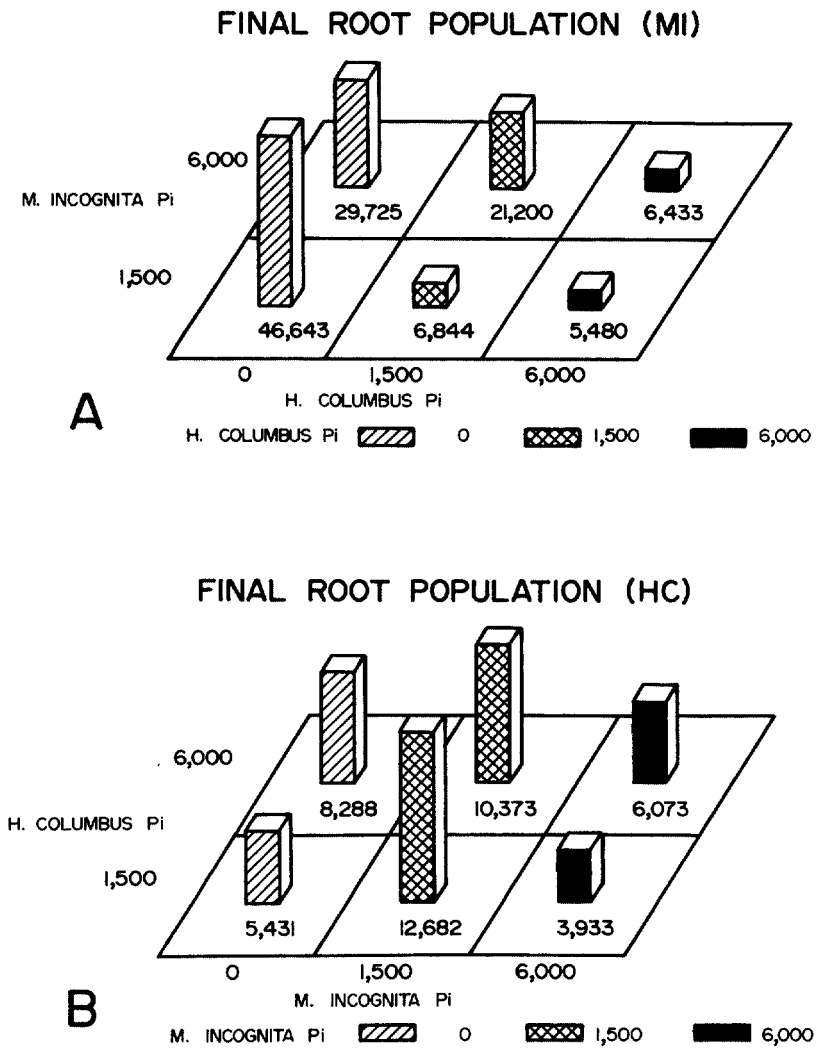

FIG. 3. Initial populations of *Hoplolaimus columbus* (A) and *Meloidogyne incognita* (B) and numbers of nematodes of the concomitant species in the roots after 60 days at 30 C on Davis soybean. Numbers represent mean number of nematodes recovered from the roots in two experiments each replicated eight times.

Final nematode populations in the soil were dependent upon initial population levels of both species. As the initial population density of *M. incognita* or *H. columbus* increased, the final soil population density increased. If the initial level of *M. incognita* was constant while that of *H. columbus* increased, the final soil level of *M. incognita* was suppressed nonlinearly ($P = 0.01$) (Fig. 2). This trend was especially pronounced at the larger infestation level of *M. incognita*. However, if the initial level of *H. columbus* was constant while that of *M. incognita* increased, the final soil level of *H. columbus* was not affected significantly, although a trend toward a lower level is evident at the higher *H. columbus* infestation level.

Final populations of *M. incognita* in the roots were suppressed with increasing numbers of *H. columbus* ($P = 0.01$). Similarly, there was a nonlinear decline ($P = 0.01$) of *H. columbus* if the initial *H. columbus* population was constant while that of *M. incognita* increased. Nevertheless, numbers of *H. columbus* in roots were greater

when *M. incognita* was present at an infestation level of 1,500 compared to when no *M. incognita* infested the soil (Fig. 3).

Discussion

Reproduction of *M. incognita* on soybean was suppressed by *H. columbus* and that of *H. columbus* enhanced by *M. incognita*, as was observed on cotton in a previous study (9). The feeding sites of the two species are quite different, yet their interaction reflects a close relationship. The suppressive effect of *H. columbus* on *M. incognita* may result from retardation, or cessation, of maturation and suppression of penetration (9). Density of *M. incognita* influenced the effect on reproduction of *H. columbus* but was not a qualitative factor in the suppression of *M. incognita* by *H. columbus*.

Since *M. incognita*'s reproduction and feeding depend on an intimate relationship with the host plant, a minor change in host cells due to feeding by *H. columbus* may interfere with feeding and reproduction by *M. incognita* (4,6). Inhibition of *M. incognita* by *Pratylenchus penetrans* was due to feeding site destruction (4), but the effect of *H. columbus* on *M. incognita* could be due to other factors such as inhibition of penetration and maturation (9). Feeding activities of *H. columbus* may alter the physiology of the plant so that it becomes undesirable or unsuitable for parasitism and reproduction by *M. incognita*. Conversely, *M. incognita* may render the root more attractive to *H. columbus* by providing either penetration sites or more attractive chemical cues, perhaps through root exudates. Larger populations of *M. incognita* apparently do not have this effect on *H. columbus*, perhaps because the root system has feeding sites for a fixed number of nematodes (10,11). Also, very large numbers of nematodes may damage the root system, restricting the number of feeding sites. Consequently, offspring of the original nematodes may be unable to find suitable feeding sites on roots and may have to search for suitable roots in the soil. Juveniles of *H. columbus* are able to survive for months (5), perhaps longer than *M. incognita* juveniles, giving them an advantage.

Plant growth was suppressed by both nematode species, with suppression by *H. columbus* being slightly greater. The addition of the other nematode species resulted in a nonadditive suppression of plant growth, with suppression of plant dry weight being a function of the initial population density of both nematode species. Interestingly, the results of the plant growth suppression indicate that the two nematode species may not be strongly competitive, since strong competitors cause less disease in combination with another species than singly. Indeed, in these studies the two species are not mutually antagonistic.

In order to better understand the interactions between *M. incognita* and *H. columbus*, experiments using a greater number of initial population densities should be used. In addition, the nature of the interaction should be studied to better characterize the phenomenon. These studies should include investigations on root attractiveness, penetration rates, maturation rates, and the effect of cultivar and temperature.

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