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Selective Migration and Root Penetration by *Meloidogyne incognita* and *Hoplolaimus columbus* on Soybean Roots In Vitro[1]

DONNELL W. GUY, JR., AND S. A. LEWIS[2]

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Previous studies have shown that *Hoplolaimus columbus* (Hc) suppresses final population densities of *Meloidogyne incognita* (Mi) but Mi has little effect on Hc (4). Jatala and Jensen (6) described a similar association between *M. hapla* and *Heterodera schachtii* on sugar beet. In their study, *H. schachtii* suppressed *M. hapla* but *M. hapla* had no effect on *H. schachtii.* Prior parasitism of a root by one nematode species may alter the ability of a different species to penetrate the root (2,3). In order to better understand the association between Mi and Hc, the effect of parasitism by one of the nematode species on root attractiveness and susceptibility to penetration by the other nematode species was investigated.

The objectives of this study were 1) to determine if preparasitism of a root by Mi or Hc causes the root to be more, less, or equally attractive to the other species of nematode and 2) to evaluate whether cultivar and preparasitism interact to alter the attractiveness of a root to other nematodes.

Glycine max (L.) Merr. cv. Davis (susceptible to both nematode species) and cv. Centennial (resistant to Mi and tolerant to Hc) soybean seeds were surface disinfested in 0.5% NaOCl for 5 minutes and rinsed thoroughly with sterile distilled water. Seeds were placed onto a sterile, moist, highly absorbent sheet of paper wrapped in cellophane and incubated for 72 hours at 24 C to induce germination. On the third day, 15 seedlings were placed in a sterile petri dish and covered with autoclaved sand. A suspension of either Hc or Mi was poured into the plate which was then kept at 24 C for 48 hours. The seedlings were removed, dipped in sterile distilled water, and blotted dry with a sterile paper towel. A 3.6-cm-long section from the terminal portion of the root was excised with a flamed scalpel and placed into a petri dish containing 10 ml of 1.2% water agar.

Mi eggs were extracted from the roots of tomato, *Lycopersicon esculentum* cv. Rutgers, with dilute NaOCl (5), washed onto facial tissue supported by a wire screen, and placed over a funnel of water. After 2 days, the hatched juveniles were collected from the water in the funnel and standardized to 100 juveniles/ml water. Soil infested with Hc was collected from the Harold Lott Farm, Blackville, South Carolina. Inoculum was extracted from the soil using centrifugal-flotation (7) and differential screening and standardized to 100 juveniles and adults/ml water.

To study selective migration, plates of 1.2% water agar were prepared. Davis or Centennial soybean roots (excised sections 3.6 cm long) infected with Hc or Mi or noninfected were placed 7 cm apart on the agar surface in various combinations of infected and noninfected roots. Twenty juveniles of either species were placed onto a strip of filter paper (1 × 3 cm) on the agar surface midway between the two root sections. After 48 hours, plates were viewed under the dissecting microscope to determine the number of nematodes attracted

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[2] Former Graduate Research Assistant and Professor, Department of Plant Pathology and Physiology, Clemson University, Clemson, SC 29631.

TABLE 1. Selective migration of *Meloidogyne incognita* to Davis and Centennial soybean roots parasitized by *M. incognita* (Mi), *Hoplolaimus columbus* (Hc), or not infected.

Nematode on agar	Root treatment†	Repetition I	Repetition II	Repetition III
		Susceptible Davis		
Mi	Mi	1.7 ef	2.3 d	2.0 fg
	0	7.3 a	7.0 a	6.3 b
Mi	Hc	2.7 cd	2.3 d	2.7 e
	0	7.3 a	7.3 a	8.3 a
Mi	Mi	2.3 de	2.3 d	3.7 d
	Hc	2.3 de	2.0 de	3.0 d
		Resistant Centennial		
Mi	Mi	2.0 def	1.3 e	1.7 gh
	0	4.3 b	4.7 b	4.7 c
Mi	Hc	1.3 f	1.7 de	1.3 h
	0	3.3 c	3.3 c	4.3 c
Mi	Mi	3.3 c	4.3 b	3.3 d
	Hc	1.3 f	1.7 de	2.3 ef

† Roots previously inoculated with Mi, Hc, or noninoculated (0), and excised after 48 hours. Twenty Mi juveniles added to filter paper (1 × 3 cm) lying on agar between excised roots of Mi-susceptible Davis or Mi-resistant Centennial, 7 cm apart.

Number of nematodes per 36-mm terminal root piece, average of six replications in each repetition (I, II, III). Means with the same letter are not significantly different ($P = 0.05$).

TABLE 2. Selective migration of *Hoplolaimus columbus* to Davis and Centennial soybean roots parasitized by *Meloidogyne incognita* (Mi), *H. columbus*, or not infected.

Nematode on agar	Root treatment†	Repetition I	Repetition II	Repetition III
		Susceptible Davis		
Hc	Mi	2.7 e	2.0 e	2.3 e
	0	4.7 d	9.0 a	8.3 b
Hc	Hc	3.0 e	3.0 d	3.3 d
	0	5.3 cd	5.3 c	8.0 b
Hc	Mi	7.0 b	9.3 a	10.0 a
	Hc	4.7 d	5.0 c	5.3 c
		Resistant Centennial		
Hc	Mi	1.3 f	2.0 e	1.3 f
	0	3.0 e	9.7 a	10.3 a
Hc	Hc	2.3 ef	2.7 de	2.7 de
	0	9.3 a	5.7 c	5.3 c
Hc	Mi	6.3 bc	6.7 b	7.7 b
	Hc	2.7 e	2.0 e	3.3 d

† Roots previously inoculated with Mi, Hc, or noninoculated (0), and excised after 48 hours. Twenty Hc added to filter paper (1 × 3 cm) lying on agar between excised roots of Mi-susceptible Davis or Mi-resistant Centennial, 7 cm apart.

Number of nematodes per 36-mm terminal root piece, average of six replications in each repetition (I, II, III). Means with the same letter are not significantly different ($P = 0.05$).

to the roots. The 12 nematode-infected root × cultivar combinations were arranged in a randomized complete block design and replicated six times. The experiment was performed three times.

Mi migrated to noninfected roots rather than to Mi-infected or Hc-infected roots of Davis or Centennial soybeans (Table 1). However, Mi migrated to Mi-infected roots rather than Hc-infected roots on Centennial but showed no preference on Davis.

Hc migrated to noninfected roots of the two cultivars rather than roots infected with Hc or Mi in all replicates and to Mi-infected rather than Hc-infected roots of both cultivars in all replicates (Table 2).

Mi and Hc were more attracted to noninfected roots of Davis and Centennial than to roots infected by Mi or Hc. When Mi or Hc was placed in a position to choose between roots parasitized by Mi or Hc, they preferred roots parasitized by Mi. It appears that Mi-infected roots are more attractive than Hc-infected roots to both nematodes.

To study root penetration, plates of 1.2% water agar were prepared as described by Estores and Chen (2). Davis or Centennial roots (3.6-cm-long sections) infected with Hc or Mi or noninfected were placed in the center of an agar plate. Two strips of filter paper (1 × 3 cm) were placed 4 cm to either side of the root. Twenty nematodes of either species were placed on the filter paper. After 72 hours, acid fuchsin-stained roots were viewed under the dissecting microscope to determine the number of nematodes that penetrated the roots. The eight nematode-infected root × cultivar combinations were arranged in a randomized complete block design and replicated six times. The experiment was performed three times.

Penetration by Hc on Mi-infected Davis was greater than on noninfected roots. It appears that Mi in Davis roots stimulates penetration by Hc. The mechanism for this stimulation was not investigated. Hc was attracted to Centennial, but very few penetrated the root, regardless of whether Mi

was infecting. Mi penetrated poorly into Mi-infected or Hc-infected roots and noninfected roots of both cultivars, so the results were inconclusive.

Mi stimulated reproduction of Hc on cotton (8) and may become the dominant species in cotton fields where mixed populations occur (1). These tests show that roots parasitized by Mi are more attractive to Hc than roots of susceptible and, especially, Mi-resistant soybean cultivars infected by Hc. In Davis, Hc is not only attracted to Mi-infected roots but also penetrates these roots more readily than noninfected roots. Attractiveness and suitability of roots for nematode feeding and reproduction are affected by prior nematode activities, but there may be no relation between the attractiveness of a root and its suitability for feeding and reproduction by nematodes.

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