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Management of *Hoplolaimus columbus* with Tolerant Soybean and Nematicides[1]

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Abstract: Two experiments, one site per year, were conducted in Scotland County, North Carolina, to determine the usefulness of selected cultivars and nematicides for limiting soybean losses due to *Hoplolaimus columbus*. Coker 317 was relatively tolerant to this nematode, and Coker 156, Centennial, Deltapine 105, and Gordon were generally intolerant. Most nematicides significantly increased soybean yields, and many gave an economic return.

Key words: columbia lance nematode, *Glycine max*, *Hoplolaimus columbus*, nematicide, soybean, tolerance.

Hoplolaimus columbus Sher was first discovered in North Carolina in 1974 near the South Carolina border. Currently, it occurs in many southeastern counties of the state. This nematode damages soybean (*Glycine max* (L.) Merr.) so severely that the crop is often uneconomical to harvest (4,7). Chemicals and tolerant cultivars have been the primary means of managing this pest on soybean, although subsoiling has been as effective as the nematicides tested (2,9). A number of soybean lines and cultivars have been identified as tolerant, although none were resistant (10,11).

Nematicides, especially fumigants such as DBCP and EDB, have been relatively effective in controlling *H. columbus*. They have resulted in significant yield increases in most cases (6), particularly in water stress years (6). DBCP and EDB plus chloropicrin increased soybean yields more than nonfumigant nematicides (8). Correlations between numbers of *H. columbus* at midseason or late season and yield in response to fumigation, however, were inconsistent (6). The objective of this research was to determine whether selected cultivars and nematicides will minimize losses due to *H. columbus* on soybean in North Carolina and give maximum economic return.

Materials and Methods

Two randomized complete block designed experiments, one per year, were conducted in Scotland County, North Carolina, in fields infested with *H. columbus*. All data were taken from the center two rows of four-row plots that were 12 m long. Ten to twelve 2.5-cm-d soil cores were taken 15–20 cm deep in the row and composited. Nematodes were extracted from 500 cm^3 soil by a combination of elutriation (3) and centrifugation (5) and from roots collected on a 70-μm-pore sieve, then placed in a mist chamber for 5 days. Granular nematicides were delivered through jars with openings in the lids to allow the desired flow rates at a ground speed of 1.34 m/second. These jars were mounted to a commercial planter. Cultural practices consisted of conventional tillage before planting, broadcast application of alachlor (2.2 kg a.i./ha in 75 liters of water), liming to achieve a pH of 6.0, and fertilization according to soil test recommendations (1). Rainfall was the only source of water.

Experiment 1 (1984): Ten treatments with four replications were established in a Wagram loamy sand (81% sand, 14% silt, 5% clay) field infested with *H. columbus* (initial population density [Pi] = 1,630/500 cm^3 soil). Three soybean cultivars—Deltapine 105, Coker 156, and Coker 317—were planted on 14 May in rows spaced 102 cm

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TABLE 1. Effects of nematicide treatments and cultivars on *Hoplolaimus columbus* populations in soil and roots and on soybean yields, 1984.

Cultivar	Nematicide	Dosage		Application†	No. *H. columbus*		Yield (kg/ha)	Net return (U.S.$)‡
		Per m of row	Per ha		14 May	26 Sept		
Deltapine 105	GY-81C	23.8 ml	234 liters	I	2,765 a	4,513 bcd	370 d	
	Carbofuran	0.2 g a.i.	2.2 kg	P	1,805 ab	315 cde	1,244 bc	140.34
	Aldicarb	0.2 g a.i.	2.2 kg	P	2,108 ab	5,890 b	1,957 ab	228.89
	Fenamiphos	0.2 g a.i.	2.2 kg	BI	1,378 ab	2,273 e	1,648 ab	173.27
	Fenamiphos	0.2 g a.i.	2.2 kg	P	1,448 ab	2,635 de	1,863 ab	211.97
	Control				1,483 ab	2,885 de	235 d	
Coker 317	Fenamiphos	0.2 g a.i.	2.2 kg	BI	2,175 ab	2,843 de	2,246 a	95.69
	Control				1,078 ab	9,860 a	1,264 bc	
Coker 156	Fenamiphos	0.2 g a.i.	2.2 kg	BI	900 b	4,180 bcde	1,560 ab	83.45
	Control				1,158 ab	5,140 bc	646 cd	

Numbers followed by the same letter are not significantly different according to the Waller-Duncan K-ratio *t*-test (K-ratio = 100) ($P = 0.05$).
† I = injected 20 cm deep. P = placed in an 18-cm-wide band between seed furrow opener and press wheel. BI = placed in a 30-cm wide band and incorporated 10 cm deep.
‡ Net return from nematicide treatment computations based on (yield from treated plots − yield from control) × \$0.18/kg seed − cost of treatment. Treatment costs: aldicarb and fenamiphos = \$36.85/kg a.i., carbofuran = \$20.65/kg a.i.).

apart. Carbofuran, aldicarb and fenamiphos were applied at planting at 0.2 g a.i./m of row (2.2 kg a.i./ha) on the soil surface in an 18-cm-wide band between the seed furrow opener and the press wheel. In addition, fenamiphos was placed in a 30-cm-wide band at planting and incorporated 10 cm deep with a rolling cultivator. Calcium tetrathiocarbonate (31% a.i.) (GY-81C, Unocal, Los Angeles, CA) was injected 20 cm deep at 23.8 ml formulated material/m row (234 liter/ha) with a single chisel in the row and sealed with cast iron press wheels. Soil samples for nematode assay were collected on 14 May, 13 June, and 26 September. Plots were harvested on 16 November.

Experiment 2 (1986): Fourteen treatments with four replications were established in a Faceville loamy sand (texture was not determined) field infested with *H. columbus* (Pi = 973/500 cm^3 soil). Ten treatments were imposed on the cultivar Gordon (susceptible), and four on Centennial (tolerant; S. A. Lewis, pers. comm.). The soybean cultivars were planted in rows spaced 92 cm apart. On Gordon, 1,3-dichloropropene (1,3-D) was applied 36 cm deep with a commercial subsoiler at 2.56 and 4.30 ml/m of row (28 and 47 liter/ha) on 7 May, and at 1.74, 2.56, and 4.30 ml/m of row (19, 28, and 47 liter/ha) just before planting on 2 June. The chisel slits were sealed with rubber press wheels. Aldicarb at 0.14 g a.i./m of row (1.7 kg a.i./ha) and fenamiphos at 0.2 g a.i./m of row (2.2 kg/ha) were applied in an 18-cm-wide band between the seed furrow opener and press wheel at planting. Aldicarb and fenamiphos were each applied together in-furrow or in an 18-cm band at 0.1 g a.i./m of row (1.1 kg a.i./ha) at planting. Aldicarb at 0.14 g a.i./m (1.7 kg a.i./ha), fenamiphos at 0.2 g a.i./m (2.2 kg a.i./ha), and 1,3-D at 2.56 ml/m of row (28 liter/ha) were also applied to plots planted to Centennial.

Soil samples for nematode assay were collected on 7 May and 5 September. The plots were harvested on 4 December. The herbicides alachlor (3.3 kg a.i./ha) and gly-

TABLE 2. Yield of Gordon and Centennial soybeans and numbers of *Hoplolaimus columbus* resulting from treatment with nematicides, 1986.

Cultivar	Nematicide	Dosage		Date of application	Method of application†	No. *H. columbus*		Yield (kg/ha)	Net return (U.S. $)‡
		Per m of row	Per ha			7 May	5 Sept		
Gordon	1,3-D	2.56 ml	28 liters	7 May	I	588 a	1,256 cd	1,544 a	57.42
	1,3-D	4.30 ml	47 liters	7 May	I	1,558 a	1,863 c	1,550 a	15.75
	1,3-D	1.74 ml	19 liters	2 June	I	1,003 a	814 cd	1,543 a	77.49
	1,3-D	2.56 ml	28 liters	2 June	I	28 a	1,137 cd	1,317 abc	16.56
	1,3-D	4.30 ml	47 liters	2 June	I	1,025 a	131 d	1,369 abc	−16.83
	Aldicarb (A)	0.14 g a.i.	1.7 kg	2 June	P	1,833 a	1,007 cd	1,198 bc	−4.51
	Fenamiphos (F)	0.20 g a.i.	2.2 kg	2 June	P	738 a	1,267 cd	1,149 bcd	−31.75
	A + F	0.1 + 0.1 g a.i.	1.1 + 1.1 kg	2 June	F + P	965 a	237 d	1,420 ab	17.03
	A + F	0.1 + 0.1 g a.i.	1.1 + 1.1 kg	2 June	F + P	1,155 a	383 d	1,310 abc	−2.77
	Control					1,327 a	5,147 a	875 de	
Centennial	A	0.14 g a.i.	1.7 kg	2 June	P	1,065 a	966 cd	1,286 abc	57.77
	F	0.20 g a.i.	2.2 kg	2 June	P	1,190 a	625 cd	1,164 bcd	17.39
	1,3-D	2.56 ml	28 liters	2 June	I	305 a	994 cd	1,101 cd	24.12
	Control					658 a	3,320 b	617 e	

Means followed by the same letter are not significantly different according to the Waller-Duncan K-ratio *t*-test (K-ratio = 100) ($P = 0.05$).

† I = injected 35 cm deep. P = placed in an 18-cm-wide band directly in front of the press wheel. F = in furrow.

‡ Net return computations based on (yield of treated plots − yield of control) × $0.18/kg seed − cost of treatment. Treatment costs: 1,3-D = $2.25/liter, aldicarb and fenamiphos = $36.85/kg a.i.

phosate (2.2 kg a.i./ha) were applied broadcast immediately after planting. On 1 July, 2.3 liter bentazon plus 1.2 liter acifluorfen/ha were applied for post emergence weed control.

Results

Experiment 1: Deltapine 105 was damaged to such an extent that relatively low numbers of *H. columbus* were recovered from nontreated plots 26 September, whereas relatively high numbers were recovered from aldicarb treated plots (Table 1). Carbofuran, aldicarb, and fenamiphos significantly increased yields over the nontreated control and GY-81C. Fenamiphos significantly increased yields of Coker 156, compared with the nontreated control. Coker 317 was moderately tolerant to *H. columbus.* Fenamiphos-treated Coker 317 gave the highest yield in the test. Fenamiphos suppressed population development of *H. columbus* on this cultivar.

Experiment 2: Gordon and Centennial exhibited low tolerance to *H. columbus* (Table 2). All nematicide treatments reduced the number of nematodes and increased yield. Poorest control on Gordon was achieved with aldicarb and fenamiphos applied singly. The fumigant 1,3-D applied at 28 and 47 liter/ha ca. 3 weeks before planting and at 19 liter/ha at planting resulted in the highest yields on this cultivar. These yields, however, were not significantly different from those in plots treated with 1,3-D at 28 or 47 liter/ha applied at plant or fenamiphos + aldicarb. On 5 September, populations of the nematode in soil, in roots, and in soil + roots were significantly ($P = 0.01$) correlated with yield (soil, $r = -0.66$; root, $r = -0.44$; and soil + root, $r = -0.57$).

Discussion

Management of *H. columbus* to achieve maximum soybean yields will require a combination of a tolerant cultivar and nematicide treatment. The 1984 test showed only Coker 317 possessed enough tolerance to justify its use in a *H. columbus*-infested field. Several cultivars identified in South Carolina as tolerant to *H. columbus* (10,11; S. A. Lewis, pers. comm.) were not tolerant in North Carolina. This may be due to differences in the population numbers of the nematode, physiological differences between the nematode populations, or differences in soil factors or climatic conditions. Additional research comparing Coker 317 to other cultivars will be required to determine why yield differences in response to *H. columbus* occurred between North Carolina and South Carolina.

Most nematicides resulted in yield increases of *H. columbus*-infected soybean. Under drought stress, however, neither nematicides nor tolerant cultivars were helpful (data not included since dry soil late in the growing season caused most pods to abort). In the coastal plain region of Georgia, EDB plus chloropicrin and DBCP doubled soybean yields, fenamiphos and aldicarb increased yields by 32–35%, and carbofuran had little effect (8).

The net gain attained with all treatments in 1984, most 1,3-D treatments and aldicarb (in-furrow) + fenamiphos (band) on Gordon, and all treatments on Centennial in 1986 made production of soybean more profitable than without treatment; however, only Coker 317 treated with fenamiphos in 1984 approached an overall production level that would be profitable. About 2,300 kg seed/ha are required to pay for all fixed and variable costs (E. J. Dunphy, pers. comm.).

Although nematicide treatments are relatively expensive, a nematicide treatment on a tolerant cultivar might be an acceptable practice, since most of the commonly grown rotational crops also result in a significant increase of *H. columbus.* Additional research is needed on cultural practices, such as subsoiling, planting date, and cropping systems to determine the most cost effective long-term cropping pattern to minimize economic losses.

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