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Effect of Crop Rotation on Soybean in a Field Infested with *Meloidogyne arenaria* and *Heterodera glycines*[1]

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Abstract: The effect of previous crops—soybean (*Glycine max*) or corn (*Zea mays*)—and aldicarb (2.2 kg a.i./ha) on yield and nematode numbers at harvest for soybean cultivars with various combinations of nematode resistance was determined in a sandy loam soil infested with *Meloidogyne arenaria* race 2 and *Heterodera glycines* races 3 and 4 at Elberta, Alabama, in 1987. Cultivars had an effect on yield and nematode numbers ($P = 0.01$), as did the interaction of previous crop and cultivar. The nematicide treatment × cultivar interaction was significant for yield, and the three-way interaction was significant for numbers of *M. arenaria*. A previous crop of corn had no effect on *M. arenaria* numbers, but it reduced numbers of *H. glycines* from 93 to 25 J2/100 cm^3 of soil and increased soybean yield from 1,963 to 2,560 kg/ha. Aldicarb reduced *M. arenaria* numbers from 230 to 186 J2/100 cm^3 soil and increased yield from 2,062 to 2,460 kg/ha but it had no effect on *H. glycines* numbers. Rotation with corn was an effective control measure for *H. glycines* and enhanced the yields of *H. glycines*-susceptible cultivars.

Key words: Alabama, aldicarb, crop rotation, *Glycine max*, *Heterodera glycines*, host-plant resistance, *Meloidogyne arenaria*, root-knot nematode, soybean cyst nematode, soybean.

Meloidogyne spp. (Goeldi) and *Heterodera glycines* Ichinohe are frequently major pests of soybean (*Glycine max* (L.) Merrill) in the southeastern United States (8). The benefits of crop rotation and resistant soybean cultivars in suppressing yield losses to *Meloidogyne* spp. are well documented (2,8,9). Corn (*Zea mays* L.) in rotation with soybean cultivars resistant to *M. incognita* (Kofoid and White) Chitwood prevents soybean yield loss to *M. incognita* (9). Corn also suppresses post-harvest numbers of *M. incognita* juveniles (J2) compared with continuous soybean (10). Much higher numbers of *M. incognita* are found however, after 4 years of continuous corn than after 4 years of the soybean cultivar Hampton (5).

Nonhost crops reduce numbers of *H. glycines* (3,6,14), but field studies fail to demonstrate any yield advantage of crop rotation employing nonhost crops over monoculturing resistant soybean cultivars in fields infested with *H. glycines* (11,17). Crop rotation, however, can provide a large yield advantage over monoculturing a susceptible cultivar (14). Many fields in the southeastern United States are infested with mixed populations of *Meloidogyne* spp. and *H. glycines* that cause significant yield losses (6,15,16). Corn reduces numbers of *H. glycines*, but it has little effect on numbers of *M. incognita* (6). Aldicarb reduces soybean yield losses caused by *M. incognita*. Our objective was to evaluate the effects of corn and soybean as previous crops on nematode numbers and yield of seven soybean cultivars in a field infested with a mixture of *H. glycines* and *M. arenaria*.

Materials and Methods

This experiment was conducted in 1987 near Elberta, Alabama, in a Norfolk sandy loam soil (fine loamy, siliceous thermic, Typic Paleudults, pH 5.9, < 1.0% organic matter) naturally infested with a mixture of *M. arenaria* race 2 and *H. glycines* races 3 and 4. Soil fertility was maintained at recommended levels (1) and weeds and foliar feeding insects were controlled according to recommended practices for the area (4). The area was tilled with a moldboard plow followed by a disk harrow before planting in 1986 and 1987. Rainfall was adequate both years, and damage from foliar and stem diseases was minimal.

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TABLE 1. Host response of soybean cultivars to *Meloidogyne arenaria* and *Heterodera glycines*, races 3 and 4.

Cultivar	Maturity group	*M. arenaria*	*H. glycines*	
			Race 3	Race 4
Braxton	VII	R	S	S
Centennial	VI	S	R	S
Forrest	V	S	R	S
Gordon	VII	R	R	S
Kirby	VIII	R	R	S
Leflore	VI	S	R	R
Ransom	VII	S	S	S

R = resistant. S = susceptible.

For several years the field had been cropped continuously to soybean. In 1986 a section of the field was divided into two blocks, with half of each block planted to corn cultivar Pioneer 3369A and half to soybean cultivar Kirby. The following year, seven soybean cultivars—Braxton, Centennial, Forrest, Gordon, Kirby, Leflore, and Ransom—representing various maturity groups and combinations of genetic resistance to *M. arenaria* and *H. glycines* (Table 1) were planted 4 June within these split blocks in a 2 × 7 factorial treatment combination with and without aldicarb. Treatments were placed in eight randomized complete blocks within each split block. Aldicarb was applied at 5.3 g a.i./m row (2.2 kg a.i./ha) in a 25-cm band over the row with an electric-driven Gandy applicator (Gandy Company, Owatonna, MN) and incorporated 2–3 cm deep just before planting. Plots consisted of two 7.5-m rows 81 cm apart. At harvest plots were trimmed to a length of 6 m.

Before planting in 1986, 10 500-cm³ soil samples were collected randomly from over the entire field with a 2.5-cm-d sampling tube 20–25 cm deep and each sample was analyzed separately. Average numbers of *M. arenaria* and *H. glycines* J2 in the field were estimated at 70/100 cm³ soil and 10/100 cm³ soil, respectively. A composite soil sample of 15–20 soil cores (2.5 cm d) taken from the root zone 20–25 cm deep was collected from individual plots on 1 October 1987, about 5 weeks before harvest to coincide with maximal population development of *Meloidogyne* spp. in soybean

TABLE 2. Effect of previous crop, aldicarb,† and soybean cultivars on yield and juvenile numbers of *Meloidogyne arenaria* and *Heterodera glycines*.

Previous crop	Cultivar	Seed yield (kg/ha)		Juveniles/100 cm³ soil			
				M. arenaria		*H. glycines*	
		Untreated	Aldicarb	Untreated	Aldicarb	Untreated	Aldicarb
Corn	Braxton	2,719	3,192	176	146	58	43
Soybean		1,398	1,907	122	71	149	164
Corn	Centennial	2,623	2,874	280	166	19	17
Soybean		1,944	2,326	233	266	92	63
Corn	Forrest	1,705	2,408	219	149	10	10
Soybean		1,430	1,940	174	116	81	91
Corn	Gordon	2,298	2,578	204	159	27	39
Soybean		1,860	1,965	131	129	95	95
Corn	Kirby	2,383	2,781	217	172	18	32
Soybean		2,069	2,500	215	152	123	84
Corn	Leflore	2,356	2,917	304	240	1	0
Soybean		2,012	2,502	384	329	6	7
Corn	Ransom	2,247	2,569	277	276	30	47
Soybean		1,633	1,992	279	233	115	137
Corn	$\bar{x}$	2,359	2,760	240	187	23	27
Soybean		1,764	2,162	220	185	94	92
LSD ($P = 0.05$)‡		153		60		27	

Data are averages of eight replications.

† Aldicarb applied at 2.2 kg a.i./ha in a 25-cm band.

‡ LSD values for *H. glycines* J2 numbers and for seed yield are for comparisons among cultivars within previous crop or nematicide treatment. LSD value for *M. arenaria* is for comparison of any previous crop–nematicide treatment–cultivar combination.

TABLE 3. Analysis of variance for soybean cultivar yield and juvenile numbers of *Meloidogyne arenaria* and *Heterodera glycines* following a previous crop of corn or soybean and treated or untreated with aldicarb at 2.2 kg a.i./ha.

Source	df	Mean squares ($\times 10^{-3}$)		
		M. arenaria	*H. glycines*	Soybean yield
Blocks	1			
Replicates (blocks, previous crop)	28			
Previous crop (P)	1	13	513*	39,509*
Error a	1	28	1	36
Nematicide (N)	1	215**	0	18,126**
P × N	1	9	1	0
Cultivar (C)	6	286**	62**	3,211**
P × C	6	43**	16**	1,687**
N × C	6	4	2	294*
P × N × C	6	16*	3	68
Error b	390	7	3	104

* $P = 0.05$. ** $P = 0.01$.

(13). Nematodes were extracted from a 100-cm³ subsample by a modified Baermann technique (12). Seed yield was obtained by harvesting individual plots with a small-plot combine. All data were subjected to analysis of variance, with the previous crop × block interaction mean square used to test the effect of previous crop, and the replications within blocks × all other effects mean squares (pooled) used to test the other main effects and interactions. Means were separated using Fisher's least-significant difference ($P = 0.05$).

RESULTS AND DISCUSSION

Mean yield of soybean in 1987 was 30% higher following corn than following soybean (2,560 vs. 1,963 kg/ha). Corn as a previous crop reduced *H. glycines* J2 (25 vs. 93 J2/100 cm³ soil) but had no effect on the density of *M. arenaria* J2 (Table 2).

The previous crop × cultivar interaction was significant for all variables, whereas the previous crop × nematicide treatment was not significant for any variable (Table 3). As in a previous study with continuous soybean in the same field (15), soybean cultivars affected yield and nematode numbers ($P = 0.01$), but the effect was dependent upon the previous crop. Following corn, Braxton soybean was higher yielding than any other cultivar (averaged over nematicide treatment) and Braxton and Centennial had higher yields than other cultivars in the untreated plots. Following soybean, Kirby, Centennial, and Leflore soybeans were higher yielding than other cultivars and Braxton yielded lower than other cultivars except Forrest and Ransom (Table 2). These converse results were probably due to the reduction in *H. glycines* J2 numbers caused by the corn crop and the susceptibility of Braxton to *H. glycines*. The difference in *H. glycines* J2 numbers between *H. glycines* race 3-resistant cultivars and Leflore (resistant to *H. glycines* races 3 and 4) was much greater following soybean than following corn. In the untreated plots following corn, there were no differences in *H. glycines* J2 numbers between *H. glycines* race 3-resistant cultivars and Leflore: mean of 18 J2 for Centennial, Forrest, Gordon, and Kirby vs. a single J2 for Leflore (Table 2). In untreated plots following soybean, Leflore had lower ($P = 0.05$) *H. glycines* J2 numbers than *H. glycines* race-3 resistant cultivars: six J2 for Leflore vs. mean of 98 J2 for Centennial, Forrest, Gordon, and Kirby. The previous years' soybean crop with *H. glycines* race 3-resistant Kirby probably increased the proportion of *H. glycines* race 4 in the population, thus causing higher *H. glycines* J2 numbers on cultivars that did not have resistance to *H. glycines* race 4.

Aldicarb affected yield and *M. arenaria*

J2 numbers ($P = 0.01$) but produced no effect on numbers of *H. glycines* J2 near harvest. Averaged over previous crop and cultivars, aldicarb increased soybean yield by 19% over the control (2,460 vs. 2,062 kg/ha) and reduced numbers of *M. arenaria* J2 by 24% (230 vs. 186 J2/100 cm^3 soil). The interaction between nematicide and cultivars was significant for yield but small relative to the magnitude of mean squares of other interactions and main effects for yield (Table 3).

In conclusion, corn as a previous crop was followed by an increase in yield of soybean 30% greater than soybean following soybean. This increase was most pronounced in *H. glycines*-susceptible Braxton where yields were increased by 79%. Braxton treated with aldicarb and following corn had the highest yield, almost 700 kg/ha more than a cultivar with multiple nematode resistance (Leflore) following soybean and treated with aldicarb. In the untreated plots following corn, Braxton yielded better than all cultivars except Centennial. Corn did not reduce *M. arenaria* J2 numbers but greatly reduced *H. glycines* J2. Aldicarb also increased yield, although not as much as rotation with corn. The most interesting finding was that cultivar performance was greatly influenced by the effects of the previous crop on the population density of *H. glycines*. When both *M. arenaria* and *H. glycines* occur concomitantly, a corn–soybean rotation can result in higher yield than continuous planting of soybean cultivars resistant to these nematodes.

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