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Nematode Control Related to Fusarium Wilt in Soybean and Root Rot and Zinc Deficiency in Corn[1]

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Abstract: Nematode and disease problems of irrigated, double-cropped soybean and corn, and zinc deficiency of corn were investigated. Ethylene dibromide, phenamiphos, and aldicarb were equally effective for controlling nematodes and increasing yields of corn planted minimum-till and soybean planted in a moldboard plow prepared seedbed. The residual effects on yields of nematicides applied to the preceeding crop occurred during 3 years for soybean and 1 year for corn. Fusarium wilt symptoms of soybean that developed during 2 years of the study were less severe in all nematicide-treated plots than in control plots. Typical zinc deficiency symptoms on 30-day-old corn plants were observed during 1 year of the study in certain plots. Symptoms were not evident on plants grown on plots treated with ethylene dibromide, and only occasional plants had symptoms on plots treated with phenamiphos and aldicarb. The amount of yield response directly related to nematode control could not be determined because of the apparent interaction of nematodes on the expression of Fusarium wilt of soybean. Our study strongly indicates that the expression of Fusarium wilt of soybean and zinc deficiency in corn are influenced by nematodes and that nematicides will reduce their severity.

Key words: *Glycine max, Zea mays, Meloidogyne incognita, Paratrichodorus christiei, Belonolaimus longicaudatus, Pratylenchus brachyurus, Rhizoctonia solani, Fusarium oxysporum,* double-cropped, minimum-tilled, irrigation, nematicides, ethylene dibromide, phenamiphos, aldicarb.

Soybean (*Glycine max* (L.) Merr.) production in the southeastern United States is shifting rapidly from monocultural to a double-cropping system involving conservation tillage practices (1). Corn (*Zea mays* L.) is increasingly being double-cropped with soybean, usually under irrigation. Such intensive cropping may affect nematode and other diseases as well as mineral nutrition of crops. Crop rotation is often recommended for control of soybean and corn diseases (21,22); however, most disease control studies of soybean and corn in rotations have been with only one crop grown each year. Rotation of corn with soybean in Florida has reduced the effects of *Meloidogyne incognita* (Kofoid & White) Chitwood (13) and *Heterodera glycines* Ichinohe on soybean (11). In a 4-year rotation in Georgia that included soybean and corn, cropping sequences affected population densities of several nematode species but not soybean and corn yields (9).

According to the reports of nematode control in soybean recently reviewed by Kinloch (12) and in corn reviewed by Norton (18), fumigant and nonfumigant nematicides have effectively controlled several genera of nematodes in these crops and increased yields. In addition to reducing nematode damage, a nematicide also indirectly reduced Fusarium wilt symptoms of soybean (20). Fusarium wilt may become a major problem in some cultivars (3,20) where soybean is included frequently in a rotation over several years and populations of nematodes become high. However, Fusarium wilt is not usually a problem in soybean grown in rotation with nonhost crops.

Crown and brace root rot, caused by *Rhizoctonia solani* Kuhn anastomosis group (AG)2 type 2, is widespread in irrigated corn in Georgia and is observed frequently in corn in rotation with peanut or soybean (23). The herbicide pendimethalin may interact with the pathogen to increase root disease severity (24). Numerous other fungi cause root diseases in corn in Georgia, and some soilborne pathogens cause symptoms similar to nutrient deficiencies (10).

Zinc (Zn) deficiency is common in corn growing on sandy or calcareous soils (14). Conditions favoring Zn deficiency include

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removal of topsoil, high phosphorus (P) in soils and in-row fertilizer application, high soil pH, and cool, wet soils (2). Symptoms begin to appear 1–2 weeks after corn emergence (2,4,7).

Our objective was to study the nematode problems of irrigated, double-cropped soybean and corn. However, the development of Fusarium wilt on soybean, crown and brace root rot of corn, and Zn deficiency of corn encouraged us to expand the scope of the study to include these problems as well.

Materials and Methods

A double-cropped corn and soybean experiment was conducted at the same location during 1980–83 on a Tifton sandy loam at the Coastal Plain Experiment Station, Tifton, Georgia. The soil was high in P and medium in potassium (K). Limestone (2,000 kg/ha) applied in winter of 1980 increased the soil pH from 6.1 to 6.5 in 1982 and thereafter. In 1980, 22 kg P and 125 kg K/ha were applied broadcast and plowed 28 cm deep before planting soybean. In 1981–83, 60 kg nitrogen (N), 52 kg P, and 149 kg K/ha were applied broadcast only to corn before no-till planting. Corn was sidedressed annually with 267 kg N/ha. Zinc sulfate (11 kg Zn/ha) was applied in preplant fertilizer for corn in 1981 and 1983 and as a foliar spray (0.56 kg Zn/ha) to 4-week-old corn plants in 1982.

The site was infested with *M. incognita*, *Paratrichodorus minor* (Colbran) Siddiqi, *Belonolaimus longicaudatus* Rau, and *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven. 'Funks G-4507' corn was planted in the soybean stubble by the subsoil-plant method (25) on 11 March 1981, 9 March 1982, and 22 March 1983. Soybean was planted after common hairy vetch (*Vicia villosa* Roth) in 1980 and after corn in 1981–83. 'Cobb' soybean was planted on moldboard-plow prepared seed beds 29 May 1980, 16 July 1981, 21 July 1982, and 28 July 1983.

Ethylene dibromide at 26.9 kg a.i./ha, phenamiphos at 2.2 kg a.i./ha, and aldicarb at 2.2 kg a.i./ha were applied to corn only, to soybean only, or to both crops. Nontreated plots served as controls. Ethylene dibromide was applied 30 cm deep at planting to corn by a single chisel beneath the seed row and 20 cm deep at planting to soybean with two chisels per row spaced 25 cm apart spanning the seed row. Phenamiphos and aldicarb were applied to both crops in an 18-cm-wide band behind the planter seed tube and ahead of the press wheel. The experimental design was a randomized split plot replicated six times. The subplots were six rows 6.1 m long spaced 0.9 m apart. Nematicides (ethylene dibromide, phenamiphos, aldicarb) made up the whole plots and nematicide-treated crops (corn, soybean, corn plus soybean, nontreated control) the subplots.

Weeds were controlled in corn with at-plant application of paraquat (0.56 kg a.i./ha), atrazine (1.4 kg a.i./ha), metolachlor (1.8 kg a.i./ha), and cyanazine (1.4 kg a.i./ha); and in soybean with preplant application of trifluralin (0.6 kg a.i./ha) in 1980 and 1983 and pendimethalin (1.1 kg a.i./ha) in 1981 and 1982 combined with cultivation. Soybean insects were controlled with methomyl (0.5 kg a.i./ha) and methyl parathion (0.6 kg a.i./ha). Both crops were irrigated as needed.

Soil samples for nematode assay and plant heights and yields were obtained from the two center rows of each plot. Ten 2.5-cm-d soil cores for nematode assays were taken 20 cm deep about 30 days before and 20 days after planting corn, 15 days before harvesting corn, and 20 and 60 days after planting soybean in 1981–83. Nematodes were extracted from 150 cm^3 soil by centrifugal-sugar flotation (8). Roots of 10 plants of both crops were dug from the second and fifth rows of each plot to evaluate root galling, stubby roots, and lesions. Corn and soybean roots were evaluated about 45 and 80 days after planting, respectively. Root galling was evaluated for both crops each year; stubby-root ratings were made for corn in 1982 and 1983, and for soybean in 1981, 1982, and 1983. Corn roots were rated for lesions in 1982 and 1983, and soybean plants for Fusarium wilt symptoms in 1982 and 1983.

In 1981, 10 corn plants were dug from the second and fifth rows of each plot where nematicides were applied to corn only and the control plots 37 days after planting. Plant height was recorded and Zn deficiency symptoms were rated. Shoots and roots were separated and both were washed

TABLE 1. Fusarium wilt index of soybean plants and fungal lesion index of corn roots as affected by nematicides (averages of three different nematicides).

Treated crop	Year 1982	Year 1983
Soybean wilt index		
Corn	5.0 b	2.3 b
Soybean	4.7 b	1.0 b
Corn + soybean	3.3 c	1.1 b
Control	7.4 a	4.8 a
Corn root lesion index		
Corn	1.4 a	1.1 b
Soybean	1.5 a	1.3 b
Corn + soybean	1.5 a	1.1 b
Control	1.4 a	2.0 a

Values within columns within crops followed by the same letter are not significantly (P = 0.05) different according to Duncan's multiple-range test.

Soybean wilt index based on a scale of 1–10, with 1 = 0–10 and 10 = 90–100% of foliage showing symptoms.

Corn lesion index based on a scale of 1–5, with 1 = no lesions and 5 = 76–100% of roots with lesions.

several times and dried at 70 C before weighing and grinding. Shoots and roots were analyzed for N, P, K, Ca, and Zn (5).

RESULTS

Each year soybean plants exhibited nematode damage symptoms, and in 1982 and 1983 interveinal chlorosis and necrosis resembling Fusarium wilt symptoms developed during September and October. *Fusarium oxysporum* f. sp. *tracheiphilum* race 1 (3) was isolated from stems of plants with wilt symptoms. There was gray to black vascular discoloration in stems 10–25 cm above ground, and frequently the entire stem was gray to black adjacent to the ground. Wilt symptoms were less severe in plants in all nematicide-treated plots than in control plots both years (Table 1). Wilt indices were negatively correlated (P = 0.0001) with soybean yields in 1982 (r = −0.68) and 1983 (r = −0.82) and positively correlated (P = 0.001) with stubby-root indices in 1982 (r = 0.38) and 1983 (r = 0.59).

Crown and brace root rot (CBRR) on roots of corn was observed frequently in 1982. In 1983, CBRR was slightly to moderately severe in some plots. Nematicides applied to the corn reduced the severity of corn root lesions in 1983 but not in 1982 (Table 1).

Zinc deficiency symptoms were observed only in 1981 in certain plots on 30-day-old corn plants (Table 2). Symptoms were not evident on plants grown on plots treated with ethylene dibromide, and only occasional plants had symptoms on plots treated with phenamiphos or aldicarb. Nematicide-treated plots produced taller plants with heavier shoots and roots than did the control plots. The average 1981 corn yield in plots treated with phenamiphos and ethylene dibromide was 25% greater than in control plots.

Concentrations of N, P, and K in corn shoots from nematicide-treated plots were greater than from control plots, but Ca concentrations were greater for shoots from the control and phenamiphos-treated plots than from plots treated with aldicarb and ethylene dibromide (Table 3); concentrations in roots were similar. Concentrations of Zn in shoots or roots were not affected by nematicide treatments.

Correlation coefficients indicate that root-knot nematode injury to corn was pri-

TABLE 2. Influence of nematicide treatments on root-knot index, zinc deficiency rating, plant height, dry weight of plant shoots and roots, and yield of corn, 1981.

Nematicides and rates (kg a.i./ha)	Root-knot index	Zinc deficiency rating	Plant height (cm)	Dry weight (g) Shoots	Dry weight (g) Roots	Grain yield (kg/ha)
Control	3.1 a	2.7 a	15 c	8.6 c	5.7 b	10,200 b
Phenamiphos—2.2	1.3 b	1.6 b	21 b	18.3 b	8.1 a	12,480 a
Aldicarb—2.2	1.0 b	1.2 b	23 a	27.2 a	10.3 a	12,060 ab
Ethylene dibromide—26.9	1.0 b	1.0 b	24 a	29.4 a	9.2 a	13,100 a
CV %	20.9	28.5	8.4	22.4	21.9	14.1

Values within columns followed by the same letter are not significantly (P = 0.05) different according to Duncan's multiple-range test.

Root-knot index based on scale of 1–5 with 1 = no galls, and 5 = 76–100% of roots galled.

Zinc deficiency ratings based on scale of 1–5, with 1 = no symptoms, and 5 = severe symptoms.

TABLE 3. Influence of nematicide treatments on concentration of five elements in shoots and three elements in roots of corn, 1981.

Nematicides and rates (kg a.i./ha)	Shoots N (%)	Shoots P (%)	Shoots K (%)	Shoots Ca (%)	Shoots Zn (μg/g)	Roots Ca (%)	Roots Mg (%)	Roots Zn (μg/g)
Control	3.0 c	0.31 c	4.1 b	0.81 a	13.8 a	0.41 a	0.24 a	14.2 a
Phenamiphos—2.2	3.4 b	0.40 b	4.8 a	0.74 a	15.5 a	0.35 ab	0.23 a	15.0 a
Aldicarb—2.2	3.6 ab	0.47 ab	4.7 a	0.62 b	15.2 a	0.33 b	0.20 a	14.2 a
Ethylene dibromide—26.9	3.7 a	0.48 a	5.0 a	0.52 c	17.2 a	0.26 c	0.16 b	14.3 a
CV %	6.5	14.4	8.2	10.7	23.6	14.6	15.7	10.9

Concentration of elements in plants. Values within columns followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's multiple-range test.

marily responsible for Zn deficiency, reduced shoot heights and weights, reduced concentrations of N, P, and K in shoots, and increased concentrations of Ca in shoots and roots (Table 4).

Yield differences for soybean and corn among the nematicides were not significant ($P = 0.05$), but differences occurred based on the crop to which nematicides were applied (Table 5). Soybean yields each year were greater in plots treated with nematicides than in control plots. Plots in which both corn and soybean were treated with a nematicide yielded more soybeans than did plots in which only corn was treated. Plots in which only soybean was treated produced more soybeans than did plots in which only corn was treated in 1982, but not in 1981 and 1983. However, the 3-year average yield was greater in treated soybean plots than in treated corn plots, and yield of treated corn plots was greater than that of control plots. Thus residual effects of nematicides applied to corn were beneficial but not adequate to produce maximum soybean yields.

Soybean yield increase in nematicide treated plots was apparently due to both increased plant size and seed weight. Soybean plant height was increased when nematicides were applied to soybean or both soybean and corn (data not shown). Plant height was also increased in 1981 and 1983 when nematicides were applied only to corn. Soybean seeds from nematicide treated plots were heavier than seeds from control plots in 1981 and 1983 (data not shown).

Corn yields each year were greater in plots in which corn and both corn and soybean were treated with a nematicide than in nontreated plots (Table 5).

The combined effects of the four nematode species present resulted in damage to both soybean and corn even though population densities of all species were relatively low. Soil nematode data for 1982 for only *M. incognita*, *P. minor*, and *B. longicau-*

TABLE 4. Correlation coefficients of the relationships among certain shoot and root characteristics and yield, zinc deficiency symptoms, and root-knot indices of corn, 1981.

	Yield	Zinc deficiency	Root-knot index	Shoot height	Shoot weight
Yield		−0.17 NS	−0.62**	0.30 NS	0.29 NS
Zinc deficiency	−0.17 NS		0.65**	−0.78**	−0.79**
Root-knot index	−0.62**	0.65**		−0.79**	−0.77**
Shoot N	0.53**	−0.45*	−0.77**	0.78**	0.67**
Shoot P	0.44*	−0.42*	−0.64**	0.78**	0.73**
Shoot K	0.52**	−0.47*	−0.63**	0.77**	0.67**
Shoot Ca	−0.31 NS	0.74**	0.64**	−0.71**	−0.78**
Shoot Zn	0.23 NS	−0.55**	−0.35 NS	0.58**	0.56**
Root Ca	−0.59**	0.71**	0.60**	−0.66**	−0.69**

* Significant at $P = 0.05$.
** Significant at $P = 0.01$.

TABLE 5. Yields of soybean and corn grown in a double-cropping system as affected by nematicides (averages of three different nematicides).

Treated crop	Year				
	1980	1981	1982	1983	Avg. 1981–83
		Soybean seed yield (kg/ha)			
Corn	*	2,190 b	1,330 b	1,530 b	1,680 b
Soybean	2,400 a	2,290 ab	1,670 a	1,770 ab	1,910 a
Corn + soybean	*	2,520 a	1,820 a	1,960 a	2,100 a
Control	2,070 b	1,470 c	760 c	981 c	1,070 c
		Corn grain yield (kg/ha)			
Corn		12,550 a	12,110 a	12,600 a	12,420 a
Soybean		10,120 b	11,090 b	11,070 b	10,760 b
Corn + soybean		12,310 a	11,910 a	12,510 a	12,240 a
Control		10,530 b	11,110 b	9,610 c	10,420 b

Values within columns (within crops) followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's multiple-range test.

* Corn was not grown on these plots in 1980; hence there was no measure of residual effects of nematicides on soybean in 1980.

datus are presented because of the low population density of *P. brachyurus* and because data for all 4 years are similar (Table 6). Maximum population density of *M. incognita* was attained on mature corn in July and on soybean in August. Nematicides applied at corn planting suppressed populations of *M. incognita.* In September, population densities were least in plots in which soybean was treated regardless of treatment on corn. Low densities in September usually resulted in low densities the following February.

Population densities of *P. minor* under corn were greater in all treatments in July than in February but decreased after July under soybean (Table 6). Unlike *M. incognita,* differences in population densities of *P. minor* due to nematicide treatments usually were not significant.

Distribution of *B. longicaudatus* in isolated areas (less than 50% of plots infested)

TABLE 6. Number of nematodes recovered per 150 cm^3 soil from corn-soybean plots on five dates as affected by nematicides (averages of three different nematicides), 1982.

Treated crop	Soil collection dates relative to crops				
	Precorn	Corn		Soybean	
	9 Feb	31 Mar	2 July	5 Aug	19 Sept
		Meloidogyne incognita			
Corn	128 a	66 a	193 b	85 b	69 a
Soybean	52 b	32 b	928 a	161 a	35 b
Corn + soybean	58 b	14 b	279 b	71 b	18 b
Control	108 a	66 a	840 a	139 ab	64 a
		Paratrichodorus minor			
Corn	17 a	16 b	44 a	29 a	19 a
Soybean	25 a	26 a	63 a	23 ab	12 a
Corn + soybean	14 a	8 b	37 a	10 b	10 a
Control	18 a	16 b	44 a	23 ab	9 a
		Belonolaimus longicaudatus			
Corn	2 ab	1 a	4 b	1 b	3 a
Soybean	2 ab	2 a	5 b	1 b	1 a
Corn + soybean	0 b	4 a	6 b	4 b	3 a
Control	5 a	5 a	16 a	10 a	4 a

Data within columns (within nematode species) followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's multiple-range test.

TABLE 7. Root-knot index of soybean and corn grown in a double-cropping system as affected by nematicides (averages of three different nematicides).

Treated crop	Year 1980	1981	1982	1983
	Soybean			
Corn	1.7 a	1.7 a	1.3 a	1.8 a
Soybean	1.0 b	1.2 b	1.1 b	1.2 b
Corn + soybean	1.1 b	1.3 b	1.1 b	1.3 b
Control	1.6 a	1.8 a	1.4 a	1.8 a
	Corn			
Corn	—	1.1 d	1.2 c	1.1 b
Soybean	—	1.9 b	1.6 b	1.2 ab
Corn + soybean	—	1.5 c	1.2 c	1.1 b
Control	—	2.6 a	1.8 a	1.3 a

Root-knot index based on a scale of 1–5, with 1 = no galling, and 5 = 76–100% of roots galled.

Values within columns (within crop) followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's multiple-range test.

TABLE 8. Stubby-root index of soybean and corn grown in a double-cropping system as affected by nematicides (averages of three different nematicides).

Treated crop	Year 1981	1982	1983
	Soybean		
Corn	1.5 b	2.1 ab	1.4 b
Soybean	1.3 b	1.5 c	1.2 b
Corn + soybean	1.3 b	1.7 bc	1.1 b
Control	2.1 a	2.3 a	2.0 a
	Corn		
Corn		1.8 a	1.1 b
Soybean		1.7 a	1.3 b
Corn + soybean		1.8 a	1.1 b
Control		1.7 a	2.0 a

Stubby-root index based on a scale of 1–5, with 1 = no stubby roots, and 5 = 76–100% of roots stubby.

Values within columns (within crops) followed by the same letter are not significantly ($P = 0.05$) different according to Duncan's multiple-range test.

resulted in low average population levels even though relatively large numbers occurred in certain plots (Table 6). Plants in plots with high population levels were usually severely stunted and yielded poorly.

Multiple regression analysis of 3-year-average data for numbers of nematodes in July vs. corn yields attributed 45% of yield variability to the combined effects of all nematode species present. Forty-nine percent of soybean yield variability was attributed to nematodes based on counts made in September. A major portion of the variability was attributed to *B. longicaudatus* with 25% and 35% being attributed to this nematode for soybean and corn, respectively.

Separately, the values assigned to the visual root damage symptoms of galling and stubby roots seem to be of little significance (Tables 7, 8). However, each type of root damage must be considered if the total nematode effect is to be evaluated.

Root-knot indices were relatively low for both corn and soybean roots (Table 7). Cobb soybean, a poor host of *M. incognita,* was lightly galled. Also, Funks G-4507 corn had relatively small galls, and since it also produces numerous fibrous roots and the root-knot index was based on the ratio of galled roots to total root system, root-knot indices were relatively low. In most instances, nematicides reduced the root-knot indices of the crop to which it was applied, but there was little residual effect of nematicides on indices of the succeeding crop. Root-knot indices in 1981 were negatively correlated ($P = 0.0001$) with yields of soybean ($r = -0.50$) and corn ($r = -0.47$).

The stubby-root condition of both corn and soybean probably resulted from the combined effects of all nematodes. Some plants were severely affected, but the average indices suggest a light to moderate level of damage (Table 8). Nematicides reduced stubby-root indices of soybean in all treatments except that applied to corn in 1982. Thus, nematicides applied to corn in 1981 and 1983 had beneficial residual effects on the soybean that followed. Nematicides did not reduce stubby-root indices of corn in 1982, but all treatments were effective in 1983. Stubby-root indices were negatively correlated ($P = 0.0001$) with soybean yields in 1981 ($r = -0.47$), 1982 ($r = -0.47$), and 1983 ($r = -0.62$) and corn yields in 1983 ($r = -0.55$).

DISCUSSION

The generally low population densities of the four nematode genera present may have been due to competition for feeding sites and to Cobb soybean being a poor host for *M. incognita.*

Ethylene dibromide, phenamiphos, and aldicarb were equally effective for controlling nematodes and increasing corn yields in minimum-tilled culture and soybean yields in moldboard plow prepared seed beds. In addition to controlling nematodes, the nematicides reduced the symptoms of Fusarium wilt in soybean and prevented Zn deficiency in corn. The amount of soybean yield response caused directly by nematode control could not be determined because of the effects of Fusarium wilt. Our previous research with soybean demonstrated that the fumigant nematicides—ethylene dibromide, ethylene dibromide + chloropicrin, and dibromochloropropane—were superior to the nonfumigant nematicides—phenamiphos and aldicarb—for nematode control (15–17). The differences in plant response to fumigant and nonfumigant nematicides in this experiment and in previous experiments may be related to differences in nematode species and fungi present. In each of the previous experiments, only one major nematode genus and no apparent fungus disease was present.

The residual effects on yields of nematicides applied to the preceeding crop occurred in all years for soybean but only in 1983 for corn. The reason for the different response for the two crops may be related to differences in nematode densities at the time the two crops were planted. Nematode population densities were generally greater at the time soybean was planted than when corn was planted; therefore, the potential for plant damage was greatest for soybean.

The seemingly disproportionate amount of variability for soybean and corn yield assigned by the multiple regression analysis to *B. longicaudatus* can be attributed to several factors: 1) All genera of nematodes, except *B. longicaudatus,* were relatively evenly distributed across experimental areas, while *B. longicaudatus* was located in less than 50% of the plots. Although, averages across replications tended to minimize the *B. longicaudatus* population densities, low yields were correlated with high numbers of this nematode in the infested plots. 2) *Belonolaimus longicaudatus* is a very destructive nematode, even at low densities; therefore, the effects of this nematode may tend to override the effects of other nematodes in plots where it occurred. 3) Population densities of *P. minor* tend to increase rapidly after nematicides are applied (19). Therefore, the nematode assays made in corn plots several weeks after nematicides were applied may not have reflected the nematode reduction that may have occurred during the critical seedling stage, and the exact differences due to nematicide effects may not have been measured. 4) Corn has an extensive fibrous root system that appears to be able to support relatively large numbers of *M. incognita* with a minimum amount of damage. 5) Cobb soybean used in this experiment has a high tolerance for *M. incognita* and suffered only light root injury.

The results of this experiment corroborate those of Ross (20) indicating that the expression of Fusarium wilt of soybean may be influenced by nematodes and that nematicides will reduce its severity.

In this study, Zn concentration in corn shoots was not a satisfactory measure for determining Zn sufficiency levels, since levels in tissues were essentially the same for deficient and nondeficient plants. Nematicides increased root and shoot growth over that produced in nontreated plots. The increased root growth apparently resulted in a slight increase in Zn supply as evidenced by the lack of deficiency symptoms in nematicide-treated plots. However, the increased shoot growth probably had a dilution effect on the Zn concentration in the shoots, resulting in similar Zn levels in shoots of plants from nematicide-treated and nontreated plots. Ulrich (26) reported that Stout and Pearson (unpubl.) found greater Zn concentrations in extremely Zn-deficient plants growing in soil with a low level of Zn than in plants supplied with more Zn. Recent research by M. B. Parker and F. C. Boswell (unpubl.) on a Tifton soil showed that deficiency symptoms on young corn plants (Funks G-4507) occurred at Zn concentrations of 11–15 μg Zn/g dry weight of shoots. Young plants supplied with sufficient zinc contained 16–41 μg Zn/g dry weight of shoots. Our data show that Zn concentration in shoots of young corn plants was borderline and nematode injury apparently caused the plants to become Zn deficient. The Zn deficiency was corrected as the corn root system increased, as indicated by disappearence of symptoms 3–4 weeks after initial observation. It is not uncommon for moderately Zn-deficient plants to overcome the deficiency with increased root systems (2).

Since nematode-damaged plants often show nutrient deficiency which is not evident on plants grown in soils treated with a nematicide (6), soil scientists and nematologists should conduct research cooperatively to determine the role of nematodes in mineral deficiencies in plants.

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