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Effect of Crop Rotation and Tillage on Nematode Densities in Tropical Corn[1]

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Abstract: Effects of tillage and crop rotation on nematode densities in tropical corn (*Zea mays* cv. Pioneer X304C) were examined in a factorial experiment with two rotation crops and two tillage practices (no-till vs. conventional-till), conducted in each of three seasons (1990–1992) in north Florida. The rotation treatments consisted of sorghum (*Sorghum bicolor* cv. DeKalb BR64) or soybean (*Glycine max*) grown during the 1989 season. Densities of *Meloidogyne incognita* (race 1) remained lower throughout the growing season in corn following sorghum than in corn plots following soybean. This effect was observed clearly even in the third consecutive corn crop. In 1990, densities of *Criconemella* spp. were initially higher in plots planted to sorghum the previous year, but by the end of the subsequent corn crop, no differences were evident. *Paratrichodorus minor* and *Pratylenchus* spp. (primarily *P. scribneri*) were mostly unaffected by the crop rotation treatments, but in a few instances, *Pratylenchus* spp. densities were higher in conventional than in no-till plots. In general, tillage had little effect on densities of most nematodes examined, and rotation appears to be more important than tillage for managing plant-parasitic nematodes under these conditions.

Key words: corn, *Criconemella* spp., crop rotation, cropping systems, cultural practices, *Glycine max*, *Meloidogyne incognita*, nematode, *Paratrichodorus minor*, *Pratylenchus scribneri*, sorghum, *Sorghum bicolor*, soybean, tillage, *Zea mays*.

The decline of nematicide-based technology has left growers in the southeastern United States with relatively few effective options for managing plant-parasitic nematodes in many agricultural crops. Two alternatives that can often be implemented with some degree of success are crop rotation and changes in tillage practices (13,17).

The efficacy of rotation crops in minimizing buildup of certain plant-parasitic nematodes in cropping systems in the southeastern United States is relatively well documented (11,13,18,24). In north Florida, some cover crops grown in the previous winter (12,13,15,19) and rotation crops grown during the previous summer (9,13,14,25) can limit densities of root-knot nematodes (*Meloidogyne* spp.) prior to the establishment of a susceptible summer cash crop. For example, summer rotation crops of certain sorghum (*Sorghum bicolor*) cultivars were beneficial in limiting population growth of *M. incognita* (8,14). Recently, uncommon crops such as velvetbean (*Mucuna deeringiana*) were tested as rotation crops to limit root-knot nematodes (16,23,24).

Effects of tillage practices on nematode densities have been inconsistent, and in general relatively little is known about the impact of conservation tillage on nematode management (17). Densities of some nematode populations have shown slight increases in no-till compared with conventional-till plots (6,27), although in Indiana, densities of *Pratylenchus scribneri* in soybean (*Glycine max*) were greater in patches within plots receiving conventional tillage (1). In other instances, effects of tillage on densities of plant-parasitic or free-living nematodes were temporary, and varied over time (4,20,26). In Georgia (2,3,17) and Florida (8), significant differences in nematode densities between no-till and conventional-till treatments usually have not been observed. In Florida, nematode densities have been affected by more disruptive tillage practices, such as subsoiling (22).

The objective of our study was to determine the effects of tillage and crop rotation on nematode densities. Both treatments were imposed simultaneously so they could be compared directly in terms of nematode population increases on a

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tropical corn (*Zea mays*) crop. The experiment was maintained for 3 years to observe long-term effects of rotation on nematode densities.

Materials and Methods

Experiments were conducted at the University of Florida Green Acres Agronomy Research Farm from 1990 to 1992. The soil type was an Arredondo sand (94% sand, 3.5% silt, 2.5% clay), with pH 6.2 and 1.7% organic matter. Conventional and no-till plots at this site had been maintained for 14 years as part of a double-cropping rotation involving soybean or sorghum during the summer and oat (*Avena sativa*) during the winter. In the spring of the 15th year (1990), a factorial experiment with tropical corn Pioneer Brand X304C was initiated on the site. Corn was planted in plots where 'Centennial' soybean or 'DeKalb BR64' sorghum crops had been planted during the previous summer (1989). The factorial involved the two crop rotations and the two tillage treatments (conventional and no-till). All combinations were replicated four times, and the experiment was repeated in 1991 and 1992 in the same plots. In all seasons, individual plots consisted of four rows, 10 m long.

Before planting a winter crop of 'Florida 501' oat each year (19 November 1989, 20 November 1990, and 13 December 1991), 0.5 kg a.i. gramoxone/ha was broadcast to kill small weeds. Oat plots were fertilized with a total 138 kg N, 25 kg P, and 95 kg K per ha each year. Nitrogen was applied at 39%, 55%, and 6% of the total at planting, mid-February, and early March, respectively. Thirty percent of the P and K was applied at planting and 70% in each March. A rate of 0.56 kg a.i. 2,4-D/ha was sprayed in mid-January each year to control winter broadleaf weeds. Oats were harvested for grain, and plots were mowed in May each season. In conventional-till plots, the soil was rototilled twice before planting corn.

Prior to planting corn (15 May 1990, 14 May 1991, and 29 May 1992), plots were sprayed with 2.2 kg a.i. glyphosate/ha to kill existing weeds. Tropical corn was planted directly into no-till or conventional-till plots in 0.75-m-wide rows with a two-row Brown-Harden Superseeder (Brown Mfg. Co., Banks, AL). Corn plots were also sprayed preemergence each year with 1.7 kg a.i. atrazine/ha plus 1.12 kg a.i. metolachlor/ha for residual weed control. Additional weed control was from a post-directed application of 0.5 kg a.i. gramoxone/ha. Corn plots received a total of 192 kg N, 6 kg P, 160 kg K, 25 kg Mg, and 50 kg S per ha each year. Of the total N, 40% was applied at planting, 20% was sidedressed when corn was 30 cm tall, and 40% was sidedressed when corn was 60 cm tall. Eighty-three percent of K was applied at planting and the remaining 17% of K and all P were applied when corn was 30 cm tall. All Mg and S was applied at planting.

Plots were sampled for initial (Pi) nematode densities at planting of the corn crop each year. Final densities (Pf) were assessed at harvest of the corn crops on 17 September 1990, 24 September 1991, and 21 September 1992. Each soil sample consisted of six cores 2.5-cm × 20 cm deep collected within plant rows in a plot in a systematic pattern. A 100-cm^3 subsample was removed for nematode extraction using a modified sieving and centrifugation procedure (10). Nematode count data were log-transformed ($\log_{10}[x + 1]$) before analysis of variance (7).

Results

Somewhat similar trends were observed in all three seasons (Tables 1–3). In two of three seasons, initial densities of *Criconemella* spp. (primarily *C. ornata* with a few [<20%] *C. sphaerocephala*) showed some effects from the 1989 rotation crop, with Pi higher ($P \leq 0.10$) in plots following sorghum than in those following soybean (Tables 1,3). These differences were more evident in 1990 than in 1992, but in both cases, they disappeared by the final sampling of the corn crop. Densities of *M. in-*

TABLE 1. Effects of tillage and rotation crop on initial (Pi) and final (Pf) nematode densities on tropical corn, 1990.

Tillage	Previous summer crop†	*Criconemella* spp. Pi	*Criconemella* spp. Pf	*Meloidogyne incognita* Pi	*Meloidogyne incognita* Pf	*Paratrichodorus minor* Pi	*Paratrichodorus minor* Pf	*Paratylenchus* spp. Pi	*Paratylenchus* spp. Pf	*Pratylenchus* spp. Pi	*Pratylenchus* spp. Pf
No-till	Soybean	40	138	1	3	4	2	54	2	5	338
No-till	Sorghum	98	202	0	0	3	3	147	2	6	196
Conventional	Soybean	20	246	0	10	3	4	48	0	3	734
Conventional	Sorghum	138	314	0	0	3	5	10	12	0	56
ANOVA effects:											
Tillage		ns	ns	—	ns	ns	10%	ns	ns	**	ns
Previous crop		***	ns	—	*	ns	ns	ns	ns	*	**
Tillage × previous crop		*	ns	—	ns	ns	ns	ns	ns	10%	*

Nematodes/100 cm^3 soil.

Data are untransformed means of four replications. Data were transformed by $\log_{10}(x + 1)$ prior to analysis of variance (ANOVA). *, **, *** indicate significant effects at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively; 10% = significant at $P \leq 0.10$; ns = effect not significant at $P \leq 0.10$. Dashes "—" indicate data too sparse to analyze because all counts were contained in a single replication.

† Crop grown in summer in 1989.

cognita (race 1) were low initially in every season following the winter oat crop and showed no differences ($P \leq 0.10$) with treatment, but Pf on the corn crop was always higher ($P \leq 0.05$) in plots that had been planted to soybean than in those planted to sorghum in 1989 (Tables 1–3). Except for a slight increase in Pf in conventional-till plots compared with no-till plots in 1990 (Table 1), densities of *Paratrichodorus minor* were generally unaffected by the tillage or cropping treatments. Densities of *P. minor* in all plots increased on the oat crop during the winter of 1990–1991 (compare Pf in Table 1 with Pi in Table 2). *Paratylenchus* spp. densities were highly variable and declined on the corn crop in all three seasons. Initial densities of *Pratylenchus* spp. (mostly *P. scribneri* with a few specimens [<2%] of *P. brachyurus*) were affected by tillage in two seasons, but differences disappeared by the end of the corn crop (Tables 1,3). In 1991, however, there were no differences initially, but by

TABLE 2. Effects of tillage and rotation crop on initial (Pi) and final (Pf) nematode densities on tropical corn, 1991.

Tillage	Previous crop†	*Criconemella* spp. Pi	*Criconemella* spp. Pf	*Meloidogyne incognita* Pi	*Meloidogyne incognita* Pf	*Paratrichodorus minor* Pi	*Paratrichodorus minor* Pf	*Paratylenchus* spp. Pi	*Paratylenchus* spp. Pf	*Pratylenchus* spp. Pi	*Pratylenchus* spp. Pf
No-till	Soybean	361	374	10	26	20	24	0	0	48	608
No-till	Sorghum	160	234	0	2	34	48	0	0	186	440
Conventional	Soybean	149	291	1	104	24	64	0	0	221	1,350
Conventional	Sorghum	391	647	0	1	49	52	3	0	189	1,325
ANOVA effects:											
Tillage		ns	ns	ns	ns	ns	ns	—	—	ns	**
Previous crop		ns	ns	ns	*	ns	ns	—	—	ns	ns
Tillage × previous crop		ns	*	ns	ns	ns	ns	—	—	ns	ns

Nematodes/100 cm^3 soil.

Data are untransformed means of four replications. Data were transformed by $\log_{10}(x + 1)$ prior to analysis of variance (ANOVA). *, ** indicate significant effects at $P \leq 0.05$ and $P \leq 0.01$, respectively; ns = effect not significant at $P \leq 0.10$. Dashes "—" indicate data too sparse to analyze because all counts were contained in a single replication.

† Crop grown in summer of 1989; corn was grown in summer of 1990.

TABLE 3. Effects of tillage and rotation crop on initial (Pi) and final (Pf) nematode densities on tropical corn, 1992.

		Nematodes/100 cm^3 soil									
		Criconemella spp.		*Meloidogyne incognita*		*Paratrichodorus minor*		*Paratylenchus* spp.		*Pratylenchus* spp.	
Tillage	Previous crop†	Pi	Pf	Pi	Pf	Pi	Pf	Pi	Pf	Pi	Pf
No-till	Soybean	347	552	1	112	45	39	0	0	199	1,866
No-till	Sorghum	460	643	0	0	40	40	33	0	144	1,964
Conventional	Soybean	448	1,178	3	91	52	23	0	0	341	2,164
Conventional	Sorghum	965	999	0	3	48	38	1	0	241	2,487
ANOVA effects:											
Tillage		ns	ns	ns	ns	ns	ns	—	—	10%	ns
Previous crop		10%	ns	ns	*	ns	ns	—	—	ns	ns
Tillage × previous crop		ns	ns	ns	ns	ns	ns	—	—	ns	ns

Data are untransformed means of four replications. Data were transformed by $\log_{10}(x + 1)$ prior to analysis of variance (ANOVA). * indicates significant effect at $P \leq 0.05$; 10% indicates significance at $P \leq 0.10$; ns = effect not significant at $P \leq 0.10$. Dashes "—" indicate data too sparse to analyze because all counts were contained in a single replication.

† Crop grown in 1989; corn was grown in summers of 1990 and 1991.

the end of the season, Pf was much higher ($P \leq 0.01$) in conventional-till plots (Table 2). Effects from previous crops and interactions on *Pratylenchus* spp. densities were evident only in 1990 (Table 1), when the highest Pf was reached in conventional-till plots that had been previously planted to soybean.

DISCUSSION

Corn is a good host for most of the nematodes present in our study site. A comparison of the data over the three seasons of corn production (Table 1–3) reveal a steady increase in the population densities of most nematodes, particularly *Criconemella* spp. and *Pratylenchus* spp., although *Paratylenchus* spp. declined over the 3 years. The winter oat crop often favored increases in population densities of *Criconemella* spp. and *P. minor*. However, densities of *M. incognita* (race 1) declined in every winter on the oat crop, even though the oat cultivar used (Florida 501) had moderate susceptibility to race 3 of *M. incognita* in a greenhouse test (19).

The cultural practices affected the various plant-parasitic nematodes in different ways. *Paratrichodorus minor* was affected little by tillage or rotation treatments. *Meloidogyne incognita* and *Criconemella* spp. were affected to some degree by rotation, but *Pratylenchus* spp. densities were affected more by tillage.

No-till is important in corn production in the Southeast, primarily as a means of reducing inputs of N fertilizers (21). Previous work in Florida (5,8) and Georgia (2, 3,17) has revealed relatively little impact of tillage on nematode densities. For the most part, these results are confirmed by the present study. Though not consistent, increases in *Pratylenchus* spp. densities in conventional-till over no-till plots were observed in a few cases, i.e., in 1992 Pi, in 1991 Pf, and in an interaction in 1990 Pf resulting from the maximum densities in conventional-till plots following soybean. In our study, the *Pratylenchus* spp. population consisted almost entirely of *P. scribneri*. Alby et al. (1) found higher densities of this species in patches in conventional-till compared with no-till soybean plots, possibly due to increased root vigor. However, results varied with quadrat size (1), and therefore presumably would vary with plot size. Additional studies are needed to clarify the impact of no-till on *P. scribneri*.

Rodríguez-Kábana and Touchton (25) observed that the favorable effects of rotation in reducing nematode densities may be lost if a susceptible crop is grown in the following season. To some extent, we observed this effect with *Criconemella* spp., which typically increase more rapidly on sorghum than on soybean (9). Initial densities of *Criconemella* spp. in the first-year corn crop were higher in plots where sorghum had been grown the year before. However, following corn, a good host for *Criconemella* spp., Pf was similar in all plots. Nevertheless, there was evidence that some rotation effects on *Criconemella* spp. extended even into the second and third corn crops. On the other hand, effects of rotation on *Pratylenchus* spp. lasted only one season and were overshadowed by tillage effects in 1991 and 1992.

Certain cultivars of sorghum, including DeKalb BR64, have been effective in maintaining low densities of *M. incognita* (9,14). In all three seasons during our investigation, Pi of *M. incognita* in the corn plots were low and near the limits of detection, but Pf was higher in corn plots following soybean than in those following sorghum. Pioneer X304C tropical corn appears to be a very favorable host to *M. incognita* (9), but Pf remained exceptionally low (Pf $\leq$ 3/100 cm^3 soil) throughout every season on corn in plots where sorghum had grown in 1989. Root-knot nematode densities failed to build up even in the third consecutive corn crop following sorghum. This situation is much different from that observed with *M. arenaria* in Alabama, for which the beneficial effects of a sorghum rotation were lost when peanut (*Arachis hypogaea*) was grown in the next season (25). Nevertheless, the advantages of sorghum as a rotation crop for managing *M. incognita* in Florida (8,9,14) are confirmed by the results presented here.

Of the nematodes examined, the most damaging species are probably *M. incognita* and *P. minor*. Incentive to adopt a cultural practice specifically for nematode management would depend on its effectiveness in managing these nematodes. Where *M. incognita* is the major concern, it may be advantageous to practice rotation with sorghum, whereas little effect from rotation or tillage on *P. minor* would be anticipated. In general, rotation seems to be more important than tillage for managing nematodes under our conditions. Thus if no-till practices are adopted for some other reason (e.g., N conservation), non-target or unintentional effects on nematode densities should not be of much concern.

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