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Corn Response to Subsoiling and Nematicide Application[1]

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Abstract: A 2-year field study evaluated the influence of subsoiling and nematicide application, alone and in combination, on the growth and yield of field corn in a sandy soil in north-central Florida. The field had a 25–30-cm-deep tillage pan (plowpan) and was infested with *Belonolaimus longicaudatus, Hoplolaimus galeatus, Trichodorus christei,* and *Pratylenchus* spp. Subsoiling increased corn yield both years, and the residual effect of subsoiling in the first year increased yields in the second year. Preplant application of DD injected in-row increased yields and reduced nematode populations. At-planting applications of DD injected in-row and carbofuran in-furrow or in a band were less effective than subsoiling in increasing yields and reducing nematode numbers. Interactions between subsoiling and nematicide treatments occurred in the second year.
Key words: Belonolaimus longicaudatus (sting), *Hoplolaimus galeatus* (lance), *Pratylenchus* spp. (lesion), *Trichodorus christei* (stubby-root), carbofuran, chemical control, DD, tillage pan.

Tillage pans (plowpans) are frequently present in southeastern Coastal Plain soils, and these compaction layers restrict deep rooting and reduce the amount of nutrients and water available to plants (2,6,8,13). Tillage pans limit corn (*Zea mays* L.) production during periods of dry weather and when other stresses restrict functioning of the plant root system (13). Deep tillage in soils with tillage pans has benefited corn production in the Southeast (2,13).

Plant parasitic nematodes reduce nutrient and water absorption by plant roots and depress corn yields in the southeastern Coastal Plain (3,11). Several important damaging plant parasitic nematodes, including *Meloidogyne* spp., *Belonolaimus* spp., *Trichodorus* spp., *Pratylenchus* spp., and *Hoplolaimus* spp., are present in Coastal Plain soils (12,14), and nematode control strategies are important components of corn production schemes.

The influence of practices that alleviate soil compaction layers and reduce plant parasitic nematode damage has been studied in cotton and soybeans (1,4,9,10); however, little information is available for corn (14). Therefore, a 2-year field study was initiated to determine 1) the influence of subsoiling and nematicide application, alone and in combination, on yield of field corn, 2) the residual effects of subsoiling on a corn crop the second year, and 3) the efficacy of rates and methods of nematicide application to control plant parasitic nematodes.

Materials and Methods

The test site was a farmer's field in Hamilton County, Florida, that had been planted to field corn for 5 consecutive years. The soil was a Blanton fine sand (92% sand, 5% silt, 3% clay, < 1% O.M., pH 4.9) and was characterized by a compacted layer at 25–30 cm deep caused by moldboard plowing. Corn grown in the field had a history

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TABLE 1. Influence of subsoiling on corn yield, plant stand and plant vigor in two field tests.

Treatment*		Yield (kg/ha)	Stand count†	Plant vigor‡
1978				
S_0		4,768 b	65 a	6.7 a
S_1		6,216 a	63 b	6.6 a
1978	1979			
S_0	S_0	2,853 c	53 a	7.4 a
S_0	S_1	5,284 ab	54 a	7.8 a
S_1	S_0	4,541 b	55 a	7.4 a
S_1	S_1	5,966 a	54 a	8.0 a

Grouped means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple-range test.

* S_0 = no subsoiling. S_1 = subsoiling with one chisel.

† Stand counts were taken 20 days after planting in 1978 and 15 days after planting in 1979.

‡ Plant vigor was rated 48 days after planting in 1978 and 30 days after planting in 1979; based on a 0–10 scale, with 10 equalling best plot growth in the test.

of damage from nematodes. Plant parasitic nematodes present were *Belonolaimus longicaudatus* Rau, *Hoplolaimus galeatus* (Cobb) Thorne, *Pratylenchus* spp. (*P. brachyurus* (Godfrey) Filip. and Sch. Stek., *P. thornei* Sher and Allen, *P. zeae* Graham), and *Trichodorus christei* Allen.

In 1978 the experimental design was a split plot with subsoil treatments, replicated six times, serving as main plots and nematicide treatments as subplots. The subsoil variable was either no subsoil (S_0) or subsoil (S_1) 40 cm deep with a single chisel under the row. The fumigant nematicide DD (1,2-dichloropropane-1,3-dichloropropene and related C_3 hydrocarbons) was applied 20 cm deep with a single chisel offset 13 cm from the row center. Preplant DD was applied 7 days before planting while the at-planting treatment was applied immediately before seeding. All plots were bedded after subsoiling and preplant DD application. Carbofuran 10G (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate) was applied in-furrow and as a 20-cm-wide band at planting. Nontreated plots served as controls.

Corn (*Zea mays* L. 'DeKalb XL80A') was planted at 54,340 seed/ha in rows 76 cm apart on 23 March 1978. Subsoil plots were 8.2 m long × 20 rows wide, and nematicide subplots were two rows wide. For weed control, butylate and atrazine were applied preplant and alachlor was applied as a preemergence treatment. Corn was fertilized with 219 kg/ha N, 76 kg/ha P_2O_5, and 154 kg/ha K_2O.

Plant emergence was recorded 20 days after seeding, and plant vigor ratings were made 48 days after planting. Vigor ratings were based on a scale of 0 to 10 (0 equalling no plants in the plot and 10 indicating the most vigorous growth in the test). Soil samples for nematode analysis were collected 62 days after planting. Eight soil cores (2.8 cm d × 30 cm deep) were removed from each subplot and composited, and a 250-cm^3 aliquant was processed by a modified centrifugal–flotation technique (5).

TABLE 2. Influence of nematicide application on corn yield, plant stand, plant vigor, and soil nematode populations in 1978.

Chemical and rate/ha	Application method*	Yield (kg/ha)	Stand count†	Plant vigor†	Nematodes/250 cm^3 soil†	
					Hoplolaimus	*Belonolaimus*
Nontreated		4,837 d	63 b	5.8 a	30 bc	54 b
DD, 28 liters	Preplant	5,633 bc	65 ab	7.1 a	18 ab	30 ab
DD, 56 liters	Preplant	6,453 a	66 a	7.3 a	6 ab	9 a
DD, 84 liters	Preplant	6,184 ab	66 a	6.3 a	1 a	11 a
DD, 28 liters	At-plant	4,945 cd	63 b	6.0 a	14 ab	49 b
DD, 56 liters	At-plant	5,422 cd	63 b	6.8 a	10 ab	27 ab
Carbofuran, 1.2 kg a.i.	20-cm band	5,555 bcd	64 ab	7.4 a	51 cd	44 b
Carbofuran, 2.4 kg a.i.	20-cm band	5,215 cd	65 ab	6.3 a	57 cd	35 ab
Carbofuran, 1.2 kg a.i.	In-furrow	5,300 cd	64 ab	6.3 a	60 d	54 b
Carbofuran, 2.4 kg a.i.	In-furrow	5,377 cd	62 b	7.2 a	56 cd	33 ab

Columns means followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple-range test; data analyzed across subsoil treatments.

* DD applied 20 cm deep with a single chisel; carbofuran treatments were applied at planting.

† Stand count, vigor ratings, and soil samples were taken 20, 48, and 62 days after planting, respectively.

TABLE 3. Influence of nematicide application on corn yield, plant stand, plant vigor and soil nematode populations in 1979.

Chemical and rate/ha	Application method	Yield (kg/ha)	Stand count*	Vigor rating*	Nematodes/250 cm^3 soil* *Pratylenchus*	*Hoplolaimus*
Nontreated		3,182 c	58 a	5.6 c	17 b	69 b
DD, 56 liters	Preplant	7,004 a	59 a	9.2 a	4 a	18 a
DD, 56 liters	At-plant	4,332 b	41 b	7.2 b	4 a	17 a
Carbofuran, 2.2 kg a.i.	20-cm band	4,126 b	59 a	8.8 a	11 ab	67 b

Means within the same column followed by the same letter are not significantly different according to Duncan's multiple-range test ($P \leq 0.05$).
* Stand count, vigor ratings, and soil samples were taken 15, 30, and 89 days after planting, respectively.

A similar study in 1979 was conducted at the same site. Fewer nematicide treatments were utilized in 1979, and the main plots from the preceding year were split to evaluate the residual effect of subsoiling. The resultant experiment was a split-plot design, with the combination of 1978 and 1979 subsoil treatments as the four main plots and four nematicide treatments as subplots. 'Funks 2864' corn was planted on 28 March 1979 over the row centers of the 1978 test. Preplant DD was applied 15 days before planting, while the at-plant DD and the carbofuran were applied immediately before seeding. Plant emergence data were recorded 15 days after planting, and vigor ratings were made 30 days after seeding. Soil samples for nematode analysis were collected 89 days after planting as described earlier.

Yields in both years were based on grain harvested from 6.1 m of each row of the two-row subplots. Corn yields were calculated at 15.5% moisture.

RESULTS

In 1978 yield of corn was increased by subsoiling (S_1) compared with no subsoiling (S_0) (Table 1). Plant emergence was reduced by S_1, but plant vigor was not affected. In 1979 subsoiling in 1978 only (S_1, S_0), subsoiling in 1979 only (S_0, S_1), and subsoiling in both years (S_1, S_1) improved yields over no subsoiling (S_0, S_0). Highest yields were obtained from subsoiling in both years followed by subsoiling in 1979 only. Subsoiling had no effect on plant emergence or early season plant vigor in the 1979 test.

In 1978 only the preplant DD treatments improved yields over those obtained in the nontreated plots (Table 2). The preplant DD application at 56 or 84 liters/ha resulted in improved plant emergence, and no nematicide treatment influenced plant vigor. Preplant DD applied at 84 liters/ha was the only treatment that reduced soil populations of *H. galeatus,* while only preplant DD applied at 56 or 84 liters/ha reduced *B. longicaudatus* soil populations. The small populations of *T. christei* were not affected by any nematicide treatment.

In 1979 corn yield and plant vigor ratings were improved by DD applied preplant, or at-planting, and by the carbofuran treatment (Table 3). DD applied at-planting decreased corn emergence. Both the preplant and at-planting DD treatments reduced soil populations of *Pratylenchus* spp. and *H. galeatus,* while the carbofuran did not reduce numbers of these nematodes. Nematicide treatments had no effect on soil populations of *B. longicaudatus* or *T. christei.*

Corn yields in 1979 were influenced by interactions between nematicides and subsoiling (Table 4). Within each subsoiling treatment, nematicide applications produced similar effects on yields and application of preplant DD resulted in higher yields than in nontreated plots.

DISCUSSION

In our tests, subsoiling increased yields of field corn, as has been reported by others working in southeastern soils containing tillage pans (2,13). Subsoiling had little effect on plant stand or early season vigor, indicating that major benefits occurred later in the season. Other authors (13) have suggested the influence of subsoiling on corn growth is variable, depending upon

TABLE 4. Influence of nematicide treatment within a given subsoil treatment on corn yield in 1979.

Nematicide	Corn yield in kg/ha			
	S_0, S_0*	S_0, S_1	S_1, S_0	S_1, S_1
Nontreated	1,626 c	2,829 c	3,944 b	4,328 b
DD, 56 liters/ha preplant	4,225 a	7,998 a	6,937 a	8,856 a
DD, 56 liters/ha at-plant	2,939 b	5,230 b	3,723 b	5,436 b
Carbofuran, 2.2 kg a.i./ha	2,623 bc	5,079 b	3,506 b	5,245 b

Means within the same column followed by the same letter are not significantly different ($P \leq 0.05$) according to Duncan's multiple-range test.
* S_0, S_0 = no subsoiling in 1978 or 1979; S_0, S_1 = no subsoiling in 1978 and subsoiling in 1979; S_1, S_0 = subsoiling in 1978 and no subsoiling in 1979; S_1, S_1 = subsoiling in both 1978 and 1979.

the stage of plant development when stress occurs.

Subsoiling in 1978 increased corn yields, not only in that year but also in 1979. Previous studies (10,13) have generally shown little effect from subsoiling in one year on yields the following year. Since soil characteristics as well as machinery traffic contribute to tillage pans, yield data would be expected to vary among fields. Subsoiling was not shown to affect nematode population levels in the upper 30 cm of soil, but sampling occurred only once during the season.

Application of DD at planting was phytotoxic to corn in 1979, resulting in a poorer stand and decreased early season plant vigor. DD applied at-planting has been shown phytotoxic to soybeans (7). In our tests, phytotoxicity to the corn was probably due to the cool soil that slowed fumigant release. The preplant DD treatment gave the best nematode control and largest corn yield, confirming the results of an earlier study on field corn (3). Yield comparisons between the DD and carbofuran treatments suggested that preplant fumigant application may be a useful alternative in field corn production schemes. Fumigant nematicide application in corn could be coordinated with preplant in the row subsoiling, a method practiced successfully on cotton and soybean in the southeast (4,10).

LITERATURE CITED

1. Bird, G. W., O. L. Brooks, C. E. Perry, J. G. Futral, T. D. Canerday, and F. C. Boswell. 1974. Influence of subsoiling and soil fumigation on the cotton stunt disease complex, *Hoplolaimus columbus* and *Meloidogyne incognita*. Plant Disease Reporter 58: 541–544.

2. Chancy, H. E., and E. J. Kamprath. 1982. Effects of deep tillage on N response by corn on a sandy coastal plain soil. Agronomy Journal 74:657–662.

3. Dickson, D. W., and R. E. Waites. 1978. Chemical control of *Trichodorus christei, Pratylenchus zeae, P. brachyurus,* and *Criconemoides* sp. on field corn in Florida. Journal of Nematology 10:285 (Abstr.).

4. Hussey, R. S. 1977. Effects of subsoiling and nematicides on *Hoplolaimus columbus* populations and cotton yield. Journal of Nematology 9:83–86.

5. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes in soil. Plant Disease Reporter 48:692.

6. Kasirad, A., J. G. A. Fiskell, V. W. Carlisle, and C. E. Hutton. 1967. Tillage pan characterization of selected Coastal Plain soils. Proceedings of the Soil Science Society of America 31:534–541.

7. Kinloch, R. A. 1980. The control of nematodes injurious to soybean. Nematropica 10:141–153.

8. McCloud, D. E. 1955. Water requirements of field crops in Florida as influenced by climate. Proceedings of the Soil Science Society of Florida 15: 165–172.

9. Minton, N. A., M. B. Parker, and B. G. Mullinax, Jr. 1978. Effects of cultivars, subsoiling, and fumigation on soybean yields and *Meloidogyne incognita* populations. Journal of Nematology 10:43–47.

10. Parker, M. B., N. A. Minton, O. L. Brooks, and C. E. Perry. 1975. Soybean yields and lance nematodes as affected by subsoiling, fertility and nematicide treatments. Agronomy Journal 67:663–666.

11. Rhoades, H. L. 1979. Evaluation of nematicides and methods of their application for control of nematodes in field corn. Nematropica 9:43–47.

12. Rich, J. R., L. C. Hammond, R. P. Esser, and M. L. Arens. 1982. Status of plant parasitic nematodes, VA mycorrhizae, and nutrients in soil used for field corn production in North Florida. Proceedings of the Soil and Crop Science Society of Florida 41: 175–178.

13. Robertson, W. K., J. G. A. Fiskell, C. E. Hutton, L. G. Thompson, R. W. Lipscomb, and H. W. Lundy. 1957. Results from subsoiling and deep fertilization of corn for 2 years. Proceedings of the Soil Science Society of America 21:34–36.

14. Thomas, S. H. 1978. Population densities of nematodes under seven tillage regimes. Journal of Nematology 10:24–27.