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Distribution of Field Corn Roots and Parasitic Nematodes in Subsoiled and Nonsubsoiled Soil[1]

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Abstract: A field trial was conducted for 2 years in an Arredondo fine sand containing a tillage pan at 15–20 cm deep to determine the influence of subsoiling on the distribution of corn roots and plant-parasitic nematodes. Soil samples were taken at various depths and row positions at 30, 60, and 90 days after planting in field corn subsoiled under the row with two chisels and in nonsubsoiled corn. At 30 and 60 days, in-row nematode population densities to 60 cm deep were not affected by subsoiling compared with population densities in nonsubsoiled plots. After 90 days, subsoiling had not affected total root length or root weight at the 20 depth–row position sampling combinations, but population densities of *Meloidogyne incognita* and *Criconemella* spp. had increased in subsoiled corn. Numbers of *Pratylenchus zeae* were not affected. Subsoiling generally resulted in a change in distribution of corn roots and nematodes in the soil profile but caused little total increase in either roots or numbers of nematodes. Corn yield was increased by subsoiling.

Key words: subsoiling, field corn, *Zea mays* L., cultural practices, *Meloidogyne incognita, Pratylenchus zeae, Criconemella* spp., root-knot nematode, lesion nematode, ring nematode, nematode ecology.

Tillage pans are present in many southeastern Coastal Plain soils (4,7,10). These compacted soil layers inhibit root penetration of the deeper soil strata thus limiting full utilization of water and nutrients by crop plants. Since tillage pans limit root penetration in the soil profile, plant-parasitic nematodes are restricted mainly to the soil layer above the compacted zone (2). Plant-parasitic nematodes in conjunction with tillage pans accentuate nutrient and water stress in crop plants. Practices that alleviate tillage pans or plant-parasitic nematode problems, or both, have benefited yield of corn, cotton, and soybeans in the Southeast (1,7,9,10).

The influence of subsoiling on distribution of plant-parasitic nematodes in the soil profile has received little attention. In cotton, subsoiling appeared to suppress populations of *Hoplolaimus columbus* in the top 20 cm of soil (2). A depth distribution study in soybean confirmed that the vertical distribution of *H. columbus* was altered significantly by subsoiling (7). The total nematode population over the 0–40-cm depth, however, was not affected. In contrast, vertical distribution of *M. incognita* on soybean was not affected by subsoiling

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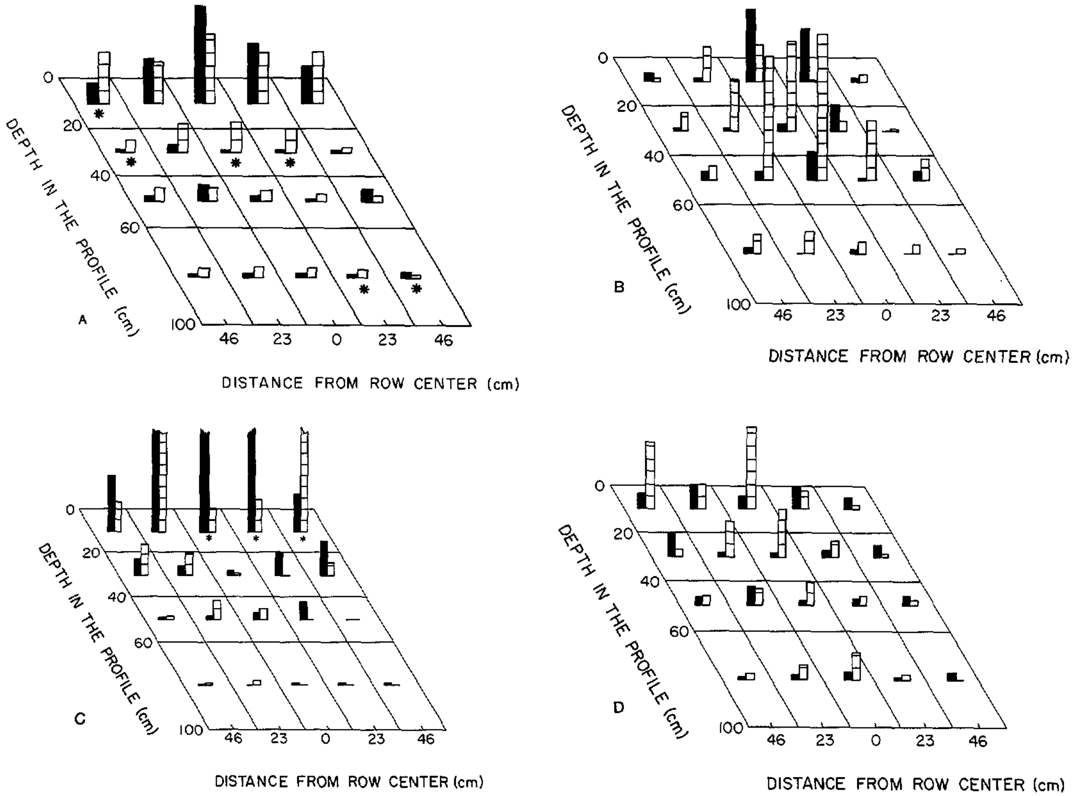

FIG. 1. Distribution of corn roots and nematodes in subsoiled (unshaded bar) and in nonsubsoiled corn (shaded bar) 90 days after planting. Asterisk (*) indicates a significant difference ($P \leq 0.05$) between subsoil treatments. Blocks on unshaded bar represent 100 cm corn root length or 500 nematodes. A) Corn root length. B) *Meloidogyne incognita.* C) *P. zeae.* D) *Criconemella* spp.

(5). These data indicate that the influence of subsoiling on nematode populations in soil may be related to the rooting depth of different plants and the species of plant-parasitic nematodes present. Our objective was to determine the influence of subsoiling on the vertical and horizontal distribution of corn roots and nematodes in soil.

MATERIALS AND METHODS

The field experiment was conducted during 1978 and 1979 at a site planted to corn (*Zea mays* L.) for the previous 5 years. Soil was an Arredondo fine sand (93% sand, 5% silt, 2% clay, < 1% o.m.) containing a compacted layer formed by repeated discing at 15–20 cm deep. Plant-parasitic nematodes present were *Meloidogyne incognita* (Kofoid and White) Chitwood, *Belonolaimus longicaudatus* Rau, *Paratrichodorus minor* (Allen) Siddiqi, *Pratylenchus zeae* Graham, *Xiphinema americanum* Cobb, and *Criconemella* spp.

Experimental variables were no subsoiling or subsoiling 40 cm deep with two shanks each spaced 15 cm from the row center. Plots were 12 m long and two rows wide with 76 cm between rows. Subsoil treatments were replicated six times. Field corn 'DeKalb XL80A' was seeded at 54,340 seeds/ha on 23 March 1978 and 29 March 1979. Fertilizer and herbicides were applied according to recommended practices.

At planting, five 2.5-cm-d soil cores were taken 30 cm deep in-row in each plot. At 30 and 60 days after planting, samples for nematode analysis were collected in the row at 0–20, 21–40, and 41–60 cm deep. Ninety days after planting, sampling was conducted at each of these depths and at 61–100 cm deep. Sampling positions were in-row and 23 and 46 cm to each side of the row center (Fig. 1A). Five 4.6-cm-d soil cores were collected from each row position–depth combination in each plot. The soil cores were composited, and 250 cm^3 soil was processed by a modified centrifu-

TABLE 1. Influence of subsoiling on corn yield, root length, and root weight after 90 days.

		Average in 250 cm soil*	
Treatment	Yield (kg/ha)	Root length (cm)	Root weight (g)
No subsoil	4,451 b	134 a	3.3 a
Subsoil	7,207 a	177 a	3.5 a

Means within the same column followed by the same letter are not significantly different ($P \leq 0.05$) according to Waller Duncan's k-ratio *t*-test.

* Root length and weight are averages in 250 cm^3 soil at 20 depth–position combinations.

TABLE 2. Influences of subsoiling on nematode population densities in 90-day-old corn.

	Nematodes in 250 cm soil*			
Treatment	*M. incognita*	*P. zeae*	*Criconemella* spp.	Total
No subsoil	553 b	1,789 a	433 b	2,784 a
Subsoil	1,485 a	1,319 a	839 a	3,616 a

Means within the same column followed by the same letter are not significantly different ($P \leq 0.05$) according to Waller Duncan's k-ratio *t*-test.

* Average nematode numbers at 20 depth–position combinations.

gal-flotation method (3). Roots recovered from a 425-µm-pore sieve were collected, weighed, and placed on Baermann funnels for 3 days. Nematode numbers were expressed as total from roots and soil in 250 cm^3 soil. Roots recovered from each soil sample were used for root length measurements using a line intercept method (6).

Corn was harvested from 6.1 m of each plot row, and grain yield was calculated at 15.5% moisture. Since data were similar for both years, only results of the first year are presented.

RESULTS

At planting populations of plant-parasitic nematodes in 250 cm^3 soil were 184 *M. incognita*, 331 *P. zeae*, 8 *X. americanum*, 2 *P. minor*, and 1 *B. longicaudatus*. Numbers of *Criconemella* spp. were high, but counts were not made in these samples. Counts of *B. longicaudatus*, *P. minor*, and *X. americanum* were low and variable throughout the season and are not presented further in this report. Thirty and sixty days after planting, subsoiling had not affected total nematode numbers at the three depths. Similarly, individual numbers of *M. incognita*, *P. zeae*, or *Criconemella* spp. were not affected.

After 90 days, average corn root lengths or root weights from across all row positions and depths were not affected by subsoiling (Table 1). However, subsoiling resulted in a 62% increase in corn yield. Population densities of *M. incognita* and *Criconemella* spp. increased in subsoiled plots, whereas *P. zeae* and total numbers of the three nematodes were not affected (Table 2).

When measured across the five row positions, subsoiling resulted in increased corn root length at the 21–40-cm and 61–100-cm sampling depths (Table 3). Numbers of *M. incognita* and total numbers of the three nematodes increased in subsoiled plots at the 41–60-cm and the 61–100-cm depths. Numbers of *P. zeae* and *Criconemella* spp. were not affected by the subsoiling treatment at any depth.

Subsoiling resulted in increased root length at five depth–position combinations and a decreased root length at only one depth–position combination (Fig. 1A). Greatest root length measurements occurred at the 0–20-cm depth and in the row center in both subsoiled and nonsubsoiled plots. Root lengths generally decreased with distance from the row center and with soil depth.

M. incognita was concentrated at the 0–20-cm soil depth in the nonsubsoiled plots (Fig. 1B) and at the 21–40-cm and 41–60-cm depths in subsoiled plots. Few *M. incognita* occurred at the 61–100-cm depth and at the 46-cm row position in both subsoiled and nonsubsoiled plots. No significant differences in *M. incognita* populations between the subsoiled and nonsubsoiled treatments were found at individual depth–position combinations.

Highest population densities of *P. zeae* were found at the 0–20-cm depth in nonsubsoiled and subsoiled plots. Few *P. zeae* were recovered below 20 cm deep, and similar population densities were recovered in the two treatments below this depth (Fig. 1C). *P. zeae* was well distributed at 0, 23, and 46 cm from the row. *Criconemella* spp. were well distributed throughout the 0–40-cm soil depth and at all row

TABLE 3. Effect of subsoiling on corn root length and on associated nematode populations at varying depths 90 days after planting.*

Depth and treatment	Root length (cm)	*M. incognita*	*P. zeae*	*Criconemella* spp.	Total nematodes
0–20 cm					
No subsoil	401 a	1,207 a	5,570 a	685 a	7,461 a
Subsoil	403 a	654 a	4,013 a	1,464 a	6,131 a
21–40 cm					
No subsoil	34 b	375 a	782 a	442 a	1,643 a
Subsoil	161 a	1,277 a	1,030 a	939 a	3,169 a
41–60 cm					
No subsoil	64 a	503 b	257 a	423 a	1,183 b
Subsoil	85 a	3,539 a	271 a	530 a	4,299 a
61–100 cm					
No subsoil	36 b	131 b	46 a	195 a	372 b
Subsoil	59 a	535 a	48 a	450 a	1,033 a

Grouped means within the same column followed by the same letter are not significantly different ($P \leq 0.05$) according to Waller Duncan's k-ratio *t*-test.

* Lengths of roots found in 250 cm^3 soil; nematode numbers represent combined recovery from both roots and soil.

positions (Fig. 1D). No significant differences in *Criconemella* spp. populations were observed between treatments at any depth–position combination.

Several significant and positive ($P \leq 0.05$) correlations were found among the correlation characters of root length, root weight, and nematode population densities. Root length was significantly correlated with *P. zeae* (+0.3438), *Criconemella* spp. (+0.3151), and total nematode population densities (+0.3611). Root weight was correlated with root length (+0.7968), *P. zeae* (+0.2044), *Criconemella* spp. (+0.2563), and total nematode population densities (+0.2698).

DISCUSSION

Subsoiling resulted in increased corn root penetration of soil below the tillage pan. Large differences in total root lengths were not found between treatments, indicating that subsoiling resulted in a change in root distribution rather than a large change in total roots. The increase in corn yield following subsoiling suggests greater amounts of water and nutrients were absorbed by the deeper roots as previously reported (10,11).

Nematode population densities in the various soil strata at 30 and 60 days after planting were unchanged by subsoiling which indicated a lag period required for root development and subsequent nematode reproduction. This hypothesis is supported by the increase in numbers of *M. incognita* and *Criconemella* spp. at 90 days in the lower soil depths in the subsoiled corn. However, since total nematode population densities did not increase significantly with subsoiling, a change in distribution of nematodes probably occurred (1,2,7).

Changes in the distribution of plant parasitic nematodes in the soil profile could be expected to result in increased crop damage during the second year after subsoiling. The extent of nematode problems in the second year after subsoiling, however, may be related to the crop–nematode combination (2,5). *P. zeae* showed little change in distribution in the soil profile as a result of subsoiling, perhaps indicating a slower reproductive rate than *M. incognita* or differences in ecological niches.

Root lengths and root weights correlated with each other and with numbers of *P. zeae* and *Criconemella* spp. The higher correlation coefficients were found with root length, indicating that surface area may be more important than root mass in determining population densities of different nematode species.

These data and those of others (1,2,5,8) suggest that distribution of plant parasitic nematodes in the soil profile is related to the particular crop, nematode species, and edaphic conditions. Further comparative study of the ecology of nematodes such as *Pratylenchus* spp. and *Meloidogyne* spp. may prove useful.

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