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Effect of Tillage System and Irrigation on Population Densities of Plant Nematodes in Field Corn[1]

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Abstract: Soil populations of plant-parasitic nematodes were monitored bimonthly for 18 months in irrigated and nonirrigated corn plantings using four production systems: conventional and minimum tillage with crop residue returned and minimum tillage with 60% or 90% of previous corn crop residue removed. Populations of *Meloidogyne incognita, Scutellonema brachyurum, Pratylenchus scribneri,* and *Paratrichodorus christiei* varied among the tillage, nematicide, and irrigation treatments. *Meloidogyne incognita* and *P. christiei* populations were not significantly affected by tillage method, but *S. brachyurum* populations were highest during April 1981 and 1982 in minimum tillage treatments where crop debris was not removed. In contrast, *S. brachyurum* populations were lowest during the same period in minimum tillage plots where 90% of previous crop debris had been removed or where residues were incorporated with conventional tillage. Populations of *P. scribneri* were lowest in minimum tillage during August 1981 and April 1982. Regardless of tillage system, corn yields in all nonirrigated plots were increased during 1982 by application of carbofuran (2.24 kg a.i./ha). No yield increases were observed following nematicide application in 1981.
Key words: Meloidogyne incognita, Scutellonema brachyurum, Pratylenchus scribneri, Paratrichodorus christiei, carbofuran, *Zea mays.*

Several reports exist of nematode population increases on corn in the field with concomitant yield suppression, but few have related effect of tillage system on soil densities of plant-parasitic nematodes (1,2,5,10). Thomas (13) examined seven tillage regimes and found highest levels of parasitic nematodes, except members of the Tylenchinae, in no-till ridge plots and lowest numbers in plots plowed in spring and fall. Similar results were obtained by Caveness (4) when *Meloidogyne incognita* populations were monitored in corn grown with conventional till and no-till cropping techniques. However, in the same study, populations of *Pratylenchus* spp. were greater in tilled soils. Stinner and Crossleg (12) noted more plant-parasitic nematodes in grain sorghum grown under no-till than under conventional till. The increasing use of conservation tillage systems in the southeastern United States necessitates a better understanding of the effect of tillage systems on soil populations of plant-parasitic nematodes.

Organic materials, such as crop debris, have a profound impact on the soil ecosystem. Lynch and Panting (9) found significantly greater microbial biomass in no-till compared with plowed soil. Organic residues remain relatively stratified on the soil surface under minimum tillage and do not decompose rapidly. Soil amendments rich in organic matter depress populations of nematodes that may affect no-till agroecosystems (11,12).

The present study was conducted to evaluate (i) the effect of tillage system, previous crop residue, irrigation, and nematicide application on soil densities of plant-parasitic nematodes in field corn and (ii) yield response of corn grown under several tillage systems following nematicide application.

Materials and Methods

One conventional and three minimum tillage systems were established during 1979 on a Norfolk (Typic Paleudult) sandy loam containing 75% sand, 17% silt, and 8% clay and naturally infested with *Meloidogyne incognita* (Kofoid & White) Chitwood, *Pratylenchus scribneri* Steiner, *Scutellonema brachyurum* (Steiner) Andrássy, and *Paratrichodorus christiei* (Colbran) Siddiqi. Two weeks following grain harvest, 0, 60, or 90% of the corn stover was removed from minimum tillage plots using a flail chopper. All residues were incorporated by disking to a depth of 20 cm for the conventional tillage system. Corn was grown in 1980 to maintain the four tillage

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systems until nematode sampling began in 1981. Corn was planted with in-row subsoiling in all tillage systems. Experimental design was a split-split block (2 × 4 × 2) with irrigation representing whole plots (91.4 m long × 25.9 m wide), tillage system representing subplots (25.9 m long × 22.8 m wide), and nematicide treatment representing sub-subplots (6 m long × 1.5 m wide). Each treatment was replicated five times.

All plots received 67–29–167 kg/ha N–P–K fertilizer plus 2.9 kg/ha of B and 3.7 kg/ha of Zn. Additional nitrogen (134 kg/ha) was applied sidedress as anhydrous ammonia 5 weeks following emergence. Glyphosate (0.9 kg a.i./ha), atrazine (1.7 kg a.i./ha), and alachlor (2.2 kg a.i./ha) were applied immediately postplant for weed control. Late season broadleaf weeds were controlled by an application of 2,4-D (0.5 kg a.i./ha) during grain fill.

Coker 21 hybrid corn (*Zea mays* L.) was planted on 10 April 1981 and 9 April 1982. Plots were thinned 4 weeks following emergence to 68,000 plants/ha in irrigated blocks and 51,000 plants/ha in nonirrigated blocks. Carbofuran 10G (2.24 kg a.i./ha) was applied in the furrow at seeding to subplots. A nontreated adjacent plot served as a control. Soil samples consisting of a composite of 20 cores (2 cm d × 20 cm deep) removed from the rhizospheres of corn plants were collected bimonthly. A 500-g soil sample from each sub-subplot was assayed for nematodes utilizing a semiautomatic elutriator and the centrifugal flotation method (3,7). Nematode data were transformed as follows: $\log_{10}(x + 1)$, where x is the original nematode count. Plants were hand harvested on 2 September 1981 and 30 August 1982, ears shelled, and corn weighed. Shelled corn weight was standardized to 15.5% moisture equivalent.

TABLE 1. Numbers of four species of nematodes extracted from the rhizospheres of corn grown in four tillage systems.

	Mean number of nematodes/100 cm³ soil†			
Tillage system*	Pi 1981	Pf 1981	Pi 1982	Pf 1982
Meloidogyne incognita				
Conventional	2 a‡	37 a	11 a	39 a
Minimum	4 a	52 a	17 a	44 a
Minimum—60% residue	2 a	41 a	5 a	79 a
Minimum—90% residue	3 a	40 a	6 a	49 a
Pratylenchus scribneri				
Conventional	10 a	45 ab	13 a	33 a
Minimum	11 a	15 b	4 b	31 a
Minimum—60% residue	22 a	71 a	10 a	10 a
Minimum—90% residue	23 a	39 ab	8 ab	13 a
Scutellonema brachyurum				
Conventional	95 ab	168 a	53 b	73 a
Minimum	242 a	209 a	168 a	53 a
Minimum–60% residue	129 ab	129 a	72 ab	83 a
Minimum—90% residue	52 b	72 a	43 b	44 a
Paratrichodorus christiei				
Conventional	5 a	10 a	7 a	9 a
Minimum	8 a	9 a	7 a	13 a
Minimum—60% residue	5 a	14 a	7 a	9 a
Minimum—90% residue	3 a	9 a	4 a	10 a

* Conventional and minimum tillage with crop residue returned and minimum tillage with 60% or 90% of previous crop residue removed.

† Pi = initial nematode population, 10 April 1981 and 9 April 1982; Pf = final nematode population, 2 September 1981 and 30 August 1982.

‡ Data followed by the same letter in columns are not different ($P = 0.05$) according to Duncan's multiple-range test performed on $\log_{10}(x + 1)$ transformed data where x = the nematode count. Data are presented as antilogs.

RESULTS

Differences ($P = 0.05$) in soil populations of nematodes occurred among irrigation, tillage, and nematicide treatments. No general relationship between tillage system and total nematode population existed, but differences in populations of nematode species were observed. Populations of *M. incognita* fluctuated throughout the sampling period (Fig. 1). Irrigation and nematicide application significantly increased root-knot nematode populations in 1981, but no clear trend was observed in 1982. Tillage system had no effect on *M. incognita* populations (Table 1; Fig. 1).

Populations of *P. scribneri* and *S. brachyurum* were affected by tillage system (Table 1). In April 1982, *S. brachyurum* populations were higher under minimum tillage where all corn residues were left on the soil surface than under conventional tillage where residues had been incorporated. Also, in April 1981 and 1982, sampling

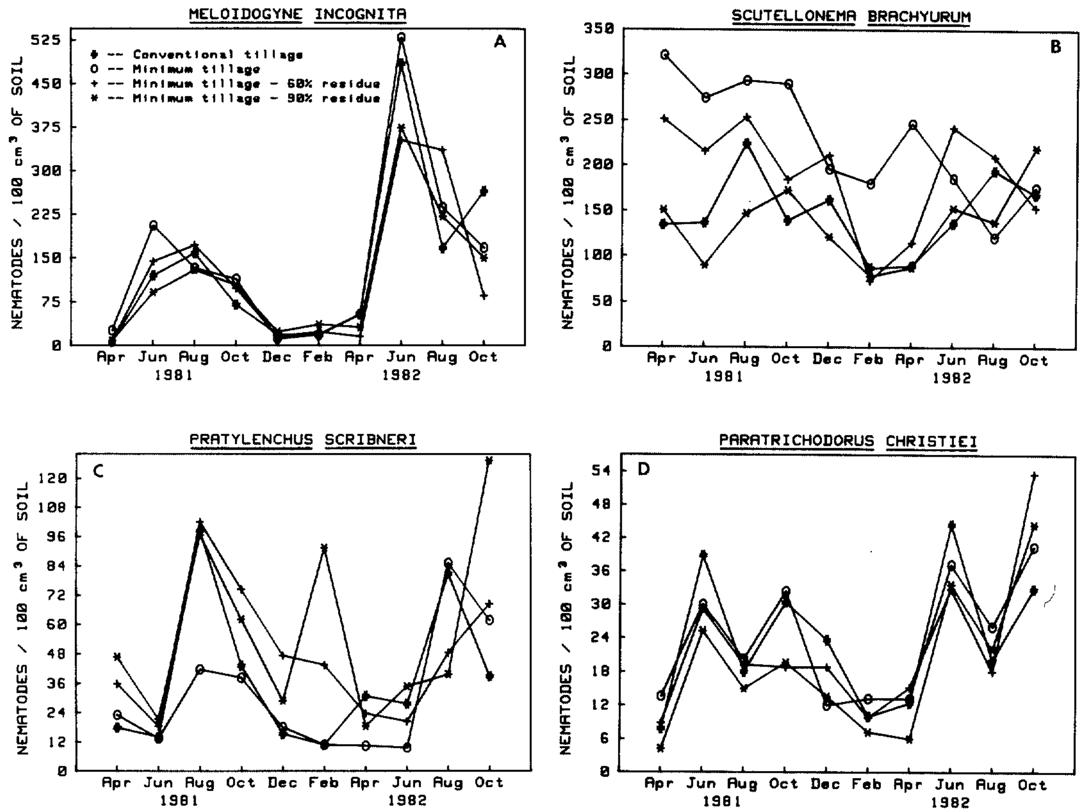

FIG. 1 (A–D). Populations of four species of nematodes/100 cm^3 of soil extracted from rhizospheres of corn grown in four tillage systems: conventional and minimum tillage with crop residue returned and minimum tillage with 60% or 90% of previous crop residue removed.

showed significantly lower populations of *S. brachyurum* under minimum tillage where 90% of the crop residues had been removed for approximately 6 months. Irrigation had no effect on *S. brachyurum* populations in soil. Carbofuran decreased populations of *S. brachyurum* in August, December 1981, and February 1982. In April 1982, *P. scribneri* populations were higher under conventional tillage than under the minimum tillage system (Table 1). Removal of crop debris tended to suppress overwintering populations of *S. brachyurum,* while *P. scribneri* populations increased following crop debris removal (August 1981, April 1982) (Table 1). Populations of *P. scribneri* in soil were higher in nonirrigated treatments during August 1981, but no trends were observed in 1982. Carbofuran reduced ($P = 0.05$) populations of *P. scribneri* in June 1981 and February1982; *P. scribneri* populations were generally lower at other sampling dates in plots treated with carbofuran. Populations of *P. scribneri* and *S. brachyurum* in soil varied by season (Fig. 1).

Populations of *P. christiei* were unaffected by tillage or irrigation (Table 1). Carbofuran reduced ($P = 0.1$) *P. christiei* levels in June, December 1981, and April 1982. Nematicide application tended to suppress *P. christiei* populations at other samplings but not at the $P = 0.1$ level of significance. Populations of *P. christiei* remained relatively static during the study, although modest increases were observed during the growing season, especially in conventional tillage (Fig. 1).

Grain yields were highest both years with irrigation (Table 2). Application of carbofuran significantly increased corn yields in nonirrigated plots during 1982 but had no influence on yield in irrigated plots in either 1981 or 1982 (Table 2).

TABLE 2. Effect of irrigation and carbofuran application on yield of shelled Coker 21 hybrid corn.

	Mg/ha 1981	Mg/ha 1982
Irrigated	10.4 a*	10.7 a
Irrigated + carbofuran 2.24 kg a.i./ha	10.4 a	10.4 a
Nonirrigated + carbofuran 2.24 kg a.i./ha	6.6 b	9.9 b
Nonirrigated	6.5 b	8.6 c

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

DISCUSSION

Population trends observed among four nematode species suggest that one cannot generalize about the effect of tillage systems or biomass removal on soil population dynamics of nematodes. The effects of tillage systems on *S. brachyurum* populations were different from the effects on populations of *M. incognita.* In evaluating effects of tillage systems on nematode populations, each species should be examined individually. Populations of *S. brachyurum* decreased more with removal of stover than without stover removal. Agronomic decisions such as whether to harvest corn for silage or for grain may have a bearing on long-term nematode population trends since crop debris appeared to have an effect on populations of specific nematodes.

Our data on population trends of *P. scribneri* and the effect of minimum tillage are similar to those of Caveness (4). With the exception of *S. brachyurum,* populations of parasitic nematodes did not show an increasing population trend in minimum tillage. Four years of growing continuous corn in minimum tillage at this experimental site did not significantly increase populations of *M. incognita, P. scribneri,* or *P. christiei.* The higher numbers of *M. incognita* observed on all tillage treatments during 1982 occurred simultaneously with an epiphytotic of *Meloidogyne* spp. on other crops in the Pee Dee region of South Carolina (6). The unseasonably warm spring of 1982 may have contributed to the higher numbers of *M. incognita* observed in our study (8). When crop debris was removed from minimum tillage plots, populations of *P. scribneri* and *S. brachyurum* were similar to conventional tillage. This suggests that crop residue may play as great a role as soil tillage in altering nematode populations.

The yield response observed following carbofuran application and lack of a tillage × nematicide interaction suggest that crop debris affected carbofuran efficacy minimally under the conditions of our study.

LITERATURE CITED

1. Baldwin, J. G., and K. R. Barker. 1970. Host suitability of selected hybrids, varieties, and inbreds of corn to populations of *Meloidogyne* spp. Journal of Nematology 2:345–350.

2. Barker, K. R., and T. H. A. Olthof. 1976. Relationships between nematode population densities and crop responses. Annual Review of Phytopathology 14:327–353.

3. Byrd, D. W., Jr., K. R. Barker, H. Ferris, C. J. Nusbaum, W. E. Griffin, R. H. Small, and C. A. Stone. 1976. Two semi-automatic elutriators for extracting nematodes and certain fungi from soil. Journal of Nematology 8:206–212.

4. Caveness, F. E. 1974. Plant-parasitic nematode population differences under no-tillage and tillage soil regimes in western Nigeria. Journal of Nematology 6:138 (Abstr.).

5. Di Vito, M., N. Vovlas, and R. N. Inserra. 1980. Influence of *Meloidogyne incognita* on growth of corn in pots. Plant Disease 64:1025–1026.

6. Fortnum, B. A., J. P. Krausz, and N. G. Conrad. 1984. Increasing incidence of *Meloidogyne arenaria* on flue-cured tobacco in South Carolina. Plant Disease 68:244–245.

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

8. Kittrell, B. U., G. D. Christenbury, J. P. Krausz, D. G. Manley, L. A. Stanton, and M. I. Loyd. 1983. South Carolina tobacco grower's guide—1984. Clemson University Cooperative Extension Service Circular 569.

9. Lynch, J. M., and L. M. Panting. 1979. Cultivation and the soil biomass. Soil Biology and Biochemistry 12:29–33.

10. Norton, D. C., J. Tollefon, P. Hinz, and S. H. Thomas. 1978. Corn yield increases relative to nonfumigant chemical control of nematodes. Journal of Nematology 10:160–166.

11. Mashkoor, A. M., S. A. Siddique, and A. M. Kahn. 1977. Mechanism of control of plant parasitic nematodes as a result of the application of organic amendments to the soil. III. Role of phenols and amino acids in host roots. Indian Journal of Nematology 5:27–31.

12. Stinner, B. R., and D. A. Crossleg, Jr. 1982. Nematodes in no-tillage agroecosystems. Pp. 14–28 *in* D. W. Freckman, ed. Nematodes in soil ecosystems. Austin: University of Texas Press.

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