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Nematode Trophic Structure in Conventional and No-Tillage Agroecosystems[1]

ROBERT W. PARMELEE[2] AND DIANE G. ALSTON[3]

Abstract: The effect of tillage intensity on nematode community trophic structure and the role of nematodes in the regulation of decomposition rates in agroecosystems were examined. Conventional (CT) and no-tillage (NT) agroecosystems were sampled monthly for 1 year. Tillage affected nematode trophic structure and total abundance. Monthly mean densities of bacterivorous, fungivorous, and total nematodes were greater in CT than in NT plots. In the summer, however, fungivorous and plant parasitic nematodes were more abundant in NT. No difference was detected for omnivore-predator nematodes.
Key words: agroecosystem, bacterivore, decomposition, ecology, fungivore, plant parasite, tillage, trophic structure.

Decomposition of crop residues is faster in conventional tillage (CT) agroecosystems, where the soil is moldboard plowed and disked, than in no-tillage (NT) systems, where the soil remains undisturbed except for a surface slit cut at summer planting (3). In Georgia the decomposition rate of CT buried litter was four times faster than NT surface litter (19). Tillage and burial of litter may accelerate decomposition by favoring higher densities of bacteria and by shifting the decomposer community organisms with higher rates of metabolic activity (9). In contrast, the slower decay rates in NT systems are associated with localization of crop residues on the soil surface and increased abundance of fungi (2,11,17).

Tillage may further influence decomposition and nutrient release by affecting the abundance of secondary decomposers such as microarthropods, beetles, earthworms, and enchytraeids (12). The effect of tillage on the nematode community is less well known, and research effort has concentrated on how tillage affects plant parasites (8,24,26). Recently, Baird and Bernard (1) concluded that single season changes in cropping and tillage regimes had little effect on nematode communities.

Our main objective was to determine the effect of 5 years of continuous CT and NT on the trophic structure of the nematode community. We also discuss the potential role of nematodes, through their interaction with the microflora, in the decomposition processes of CT and NT agroecosystems.

MATERIALS AND METHODS

Sampling for nematodes was conducted between March 1983 and April 1984 at the Horseshoe Bend Agroecosystem Research (HSB) site on a piedmont floodplain adjacent to the Oconee River at Athens, Georgia. The soil at HSB is a well-drained, moderately acidic sandy clay loam. Annual mean minimum and maximum soil temperatures at the 10-cm depth were 8.3 and 19.3 C for CT and 9.5 and 17.5 C for NT plots. Soil properties for HSB have been summarized (10).

The 1-ha agroecosystem has been under continuous cropping since 1978 with no insecticide applications since 1966. A yearly rotation was used, with a summer crop of sorghum and a winter cover crop of either rye or crimson clover. Split plots of rye and clover were imposed on two different tillage treatments. In CT the soil was moldboard plowed, disked, and rotary tilled following fall harvest (18 October 1983) and again in spring (10 May 1983) before planting the summer crop. In NT the soil remained undisturbed except for a surface slit cut at the time of summer crop planting. Seeds of winter cover crops were surface broadcast in both treatments in the fall. The winter crop was mowed in the spring and left in the field as a green manure. The site and treatment history have been described (25).

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[2] Institute of Ecology, University of Georgia, Athens, GA 30602.
[3] Department of Entomology, Box 7630, North Carolina State University, Raleigh, NC 27695.
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TABLE 1. Representative nematode genera and trophic classification.

Plant parasite	Bacterivore	Fungivore	Omnivore-predator
Criconema	*Acrobeles*	*Aglenchus*	*Dorylaimus*
Criconemella	*Acrobeloides*	*Aphelenchoides*	*Mononchus*
Diptherophora (?)	*Cephalobus*	*Aphelenchus*	*Tripyla*
Ecphyadophora (?)	*Cryptonchus* (?)	*Neotylenchus*	
Helicotylenchus	*Diplogaster*	*Psilenchus*	
Merlinius	*Prismatolaimus*	*Tylenchus*	
Pratylenchus	*Rhabditis*		
Quinisulcius			
Trichodorus			
Xiphinema			

(?) Feeding habits uncertain.

Each treatment—CT clover/sorghum, CT rye/sorghum, NT clover/sorghum, and NT rye/sorghum—had four replicate plots (14 m × 27 m). Soil was collected monthly from each plot by sampling in a zig-zag pattern to a depth of 20 cm using a standard oakfield probe (2.5 cm i.d.). Ten soil cores per plot were composited and mixed, and a 500-cm^3 sample was removed for extraction of nematodes by elutriation and centrifugal flotation (4,14). Nematodes for the March to September 1983 period were transported within 24 hours to North Carolina State University for extraction and enumeration. Nematodes for the October 1983 to April 1984 period were extracted and counted at the University of Georgia.

Nematodes were separated into bacterivore, fungivore, plant parasite, and omnivore-predator trophic groups based on feeding habits reported in the literature for common, recognizable genera; and by esophageal morphology for unrecognizable genera or for genera whose feeding habits are unknown (15,16). Nematodes from September 1983 were used as specimens for identification to genus (identifications were made by A. Bell, Department of Nematology, University of California, Riverside). These exemplify the diversity of nematodes at HSB and their known or assumed trophic categories (Table 1).

TABLE 2. Monthly mean number of nematodes in trophic groups for conventional tillage (CT) and no-tillage (NT) sorghum/rye and sorghum/clover agroecosystems (n = 56).

	Nematodes/500 cm^3 soil			
	CT		NT	
Trophic group	Rye	Clover	Rye	Clover
Plant parasites	2,227	2,059	2,139	2,821
Bacterivores*	4,218	4,044	2,294	2,285
Fungivores*	1,616	1,460	1,146	880
Omnivore-predators	417	361	425	426
Total*	8,478	7,924	6,004	6,412

* CT vs. NT comparison significant at $P < 0.01$.

RESULTS

Tillage affected nematode trophic structure and total abundance. Monthly mean total nematode abundance was significantly greater in CT than in NT plots (Table 2). Seasonally, however, total abundance was similar in both tillage treatments except during late winter and early spring (Fig. 1A). There was little effect of winter cover crop on nematode trophic structure or abundance (Table 2).

Seasonal abundances of trophic groups under a winter cover crop of clover are presented in Figure 1. Numbers of plant parasites were greater from June to October in NT plots (Fig. 1B), but were significantly greater only in June ($P < 0.05$). For the rest of the year, however, numbers were similar and monthly means were not different between CT and NT (Table 2).

Bacterivores were significantly more abundant in CT than in NT based on monthly means (Table 2). From June to September bacterivores were significantly more abundant in CT; however, numbers were similar in both tillage treatments at fall plowing (Fig. 1C). Abundance of bacterivores increased after spring plowing in CT and after fall plowing in CT and fall mowing in NT.

Differences in fungivore abundance be-

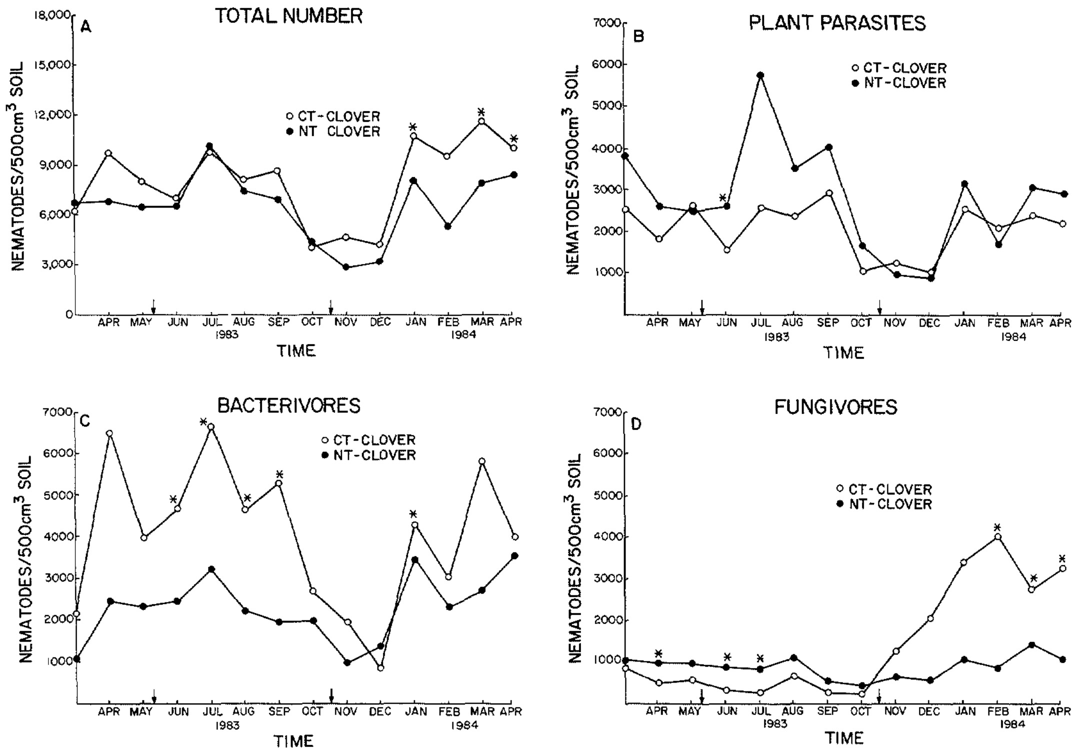

FIG. 1. Seasonal abundance of total nematodes (A), plant parasites (B), bacterivore nematodes (C), and fungivore nematodes (D) in conventional tillage (CT) and no-tillage (NT) agroecosystems with summer sorghum and winter clover. Arrows indicate plow dates and asterisks indicate significance differences at $P < 0.05$.

tween CT and NT were influenced by season and timing of tillage practices (Fig. 1D). Fungivorous nematodes were more abundant in NT than CT systems in the summer (April, June, and July, $P < 0.05$, and August, $P < 0.10$) but more numerous in CT during the winter (February to April, $P < 0.05$). Aphelenchoid nematodes increased in CT after fall plowing and contributed to a significantly greater monthly mean fungivore abundance in CT plots (Table 2). The fungivores in NT plots remained at nearly constant levels throughout the year.

Densities of omnivore-predator nematodes were similar in both tillage treatments (Table 2), and numbers remained relatively low and constant throughout the year.

DISCUSSION

Although nematodes are one of the most abundant groups of the soil invertebrate community, often reaching several million per square meter, their role in the process of decomposition is not fully known. Nematodes, despite high densities, contribute little to direct mineralization of organic matter, accounting for probably less than 1% of total soil respiration (20,22). However, nematodes appear to be significant regulators of decomposition and nutrient release in natural ecosystems through their interactions with the microflora (6,13,18,21), and they should have a similar role in agroecosystems. Nematodes feeding on the microflora could be important in the regulation of energy fluxes in the soil and enhance internal cycling of nutrients in agroecosystems (9,23).

Although overall microbial activity is slightly greater in NT systems, CT systems are characterized by periods of intense microbial activity as indicated by flushes of CO_2 directly after plowing (3). In CT plots at HSB, bacterivores increased after spring and fall plowing and fungivores increased after fall plowing. Bacterivores increased after fall mowing in NT, but fungivores remained relatively constant in the absence of tillage. Changes in nematode trophic structure indicate increased bacterial abundance after plowing and fall mowing and suggest that fungi were important decomposers of wide carbon to nitrogen ratio summer crop residues in CT systems.

During summer, the higher densities of bacterivores in CT and fungivores in NT may be a response to greater bacterial and fungal populations in each system. There is a positive relationship between bacterial densities, bacterial production, and densities of bacterivore nematodes (5,9,23). The trophic response of the nematodes to greater microbial populations may partially explain the different decay rates of crop residues observed between CT and NT systems. In two similar studies on the decomposition of buried straw, a two-phase decay process was observed; an initial period of rapid decay dominated by bacteria and bacterivores was followed by a second slower phase with an increase in fungi and fungivores (7,23). The difference in nematode trophic structure observed at HSB during the summer reflects the greater relative contributions of bacteria in CT and fungi in NT to the decomposition of crop residues.

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