RESEARCH NOTE - NOTA DE INVESTIGACION

RELATIONSHIP OF SOIL MANAGEMENT HISTORY AND NUTRIENT STATUS TO NEMATODE COMMUNITY STRUCTURE

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ABSTRACT

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Historical effects of long-term yard-waste compost and tillage treatments on nematode community structure were compared separately between soils receiving high-yard-waste compost (HYWC) and no-yard-waste compost (NYWC) for 5 years; or between soils under no-tillage (NT) and conventional tillage (CT) for 25 years at the time of soil sampling. All the field sites had been left fallow for 1.5 years since the last soil cultivation. Tillage did not affect most nematode trophic groups, except for some fungivores. The yard-waste compost treatment increased the soil organic matter (OM) content greatly, and had a significant impact on many nematode genera. Most of the nematodes affected ($P \leq 0.05$) by yard-waste compost were bacterivores and predators. The lower fungivore to bacterivore ratio, and lower channel index, but higher enrichment index also suggested that the HYWC soil was N-enriched and was undergoing a bacteria-dominated decomposition channel. Population densities of several genera of bacterivorous and predatory nematodes were positively correlated with most nutrient concentrations and OM, but were negatively correlated with concentration of Cu and Fe. Population densities of most genera of fungivorous nematodes correlated with concentrations of most nutrient elements except N, K and Mg and were always negatively correlated with OM. While effects of tillage practices on the soil nematode community were generally short-lived, the long-term yard-waste compost applications that enhanced OM had a lasting impact on nematode community structure and nutrient cycling.

Key words: bacterivores, community structure indices, compost, conventional tillage, fungivores, no tillage, nutrient cycling, predators, organic amendments.

RESUMEN

Wang, K.-H., R. McSorley y R. N. Gallaher. 2004. Relación entre la historia del manejo del suelo y el estado de nutrientes, y la estructura de la comunidad de nemátodos. Nematropica 34:83-95.

Efectos históricos de abono de desechos de jardín y tratamiento de labranza en la estructura de comunidades de nemátodos fueron comparados separadamente entre suelos recibiendo un nivel alto de abono (HYWC) y suelos sin abono por 5 años; o entre suelos bajo no-labranza y labranza convencional por 25 años al momento de toma de muestras. Todos los sitios del campo fueron dejados en barbecho por 1.5 años desde la ultima cultivación. La labranza no afectó la mayoridad de los grupos tróficos, excepto por algunos nemátodos fungívoros. El tratamiento con abono de desechos de jardín incrementó el material orgánico en el suelo considerablemente, y tuvo un impacto significativo en muchos géneros de nemátodos. La mayoridad de los nemátodos afectados ($P \leq 0.05$) por el abono de desechos de jardín fueron bacterívoros y predatores. La proporción de fungívoros en relación con bacterívoros, y el índice de canal más bajos, y el índice de enriquecimiento más alto también propone que el suelo HYWC era enriquecido con N, y estaba pasando por un canal de decomposición dominada por bacterias. Las densidades de varios generos de nemátodos bacterívoros y predatorios estaban positivamente relacionadas con las concentraciones de la mayoridad de los nutrientes y de material orgánico, pero estaban relacionadas negativamente con las concentraciones de Cu y Fe. Densidades de las populaciones de los más generos de nemátodos fungívoros relacionados con concentraciones de la mayoridad de los elementos nutrientes excepto N, K y Mg, y siempre eran relacionadas negativamente con material orgánico. Mientras el efectos de las prácticas de labranza sobre las comunidades de nemátodos de suelo eran normalmente por poco tiempo, las aplicaciones de largo plazo de abono de desechos de jardín cuales mejoraban el material orgánico tenían un impacto de largo plazo sobre la estructura de las comunidades de nemátodos y los ciclos de nutrientes.

Palabras clave: bacterívoros, indices de estructura de comunidad, abono, labranza convencional, fungívoros, no-labranza, ciclo de nutrientes, predatores, enmiendas orgánicas.

INTRODUCTION

Sustainable agricultural practices including organic farming are gradually gaining wider interest among agricultural practitioners due to environmental concerns. A soil ecosystem that is effective in the decomposition of an organic amendment and active in nutrient cycling is critical for the success of an organic farming system. Many organisms are involved in soil decomposer food webs, among which are microbial-feeding nematodes (e.g., bacterivores and fungivores) that graze on bacteria and fungi, thus accelerating nutrient mineralization (Ingham *et al.*, 1985). These nematode grazers can contribute up to 30% of total N mineralization (Verhoef and Brussaard, 1990). Nematodes play an important role in the soil food web because of their abundance, high turnover rate, and strong interactions with soil microbes (Ingham *et al.*, 1985; Freckman, 1988; Ferris *et al.*, 1997) and their predators (Allen-Morley and Coleman, 1989; Laakso and Setälä, 1999; Yeates and Wardle, 1996). The predatory and omnivorous nematodes higher up in the soil food web also have a potential direct (Yeates and Wardle, 1996) or indirect effect on decomposition by controlling biomass of microbivores (Laakso and Setälä, 1999), but they are more sensitive to soil disturbance than microbivorous nematodes (Bongers, 1990). In spite of the important role played by nematodes in mineralization of the macronutrients, N and P (Ingham *et al.*, 1985; Ferris *et al.*, 1998), there is a scarcity of information on the relationship of nematodes with many of the soil micronutrients that are essential for plant growth.

Many studies have been conducted to understand the differences in the soil ecosystem in an organic farming system as compared to a conventional agricultural system. The effect of organic management treatment on nematode communities has been examined in various agroecosystems including grassland (Yeates *et al.*, 1997), cultivated sites subsequent to cover crops (Ferris *et al.*, 1995; Neher, 1999), cultivated area treated with poultry manure (Porazinska and Coleman, 1995), and citrus orchard with perennial peanut (*Arachis glabrata*) as a living mulch (Porazinska *et al.*, 1999). In these studies, however, the effects of an organic management on nematode communities have been inconsistent. In the current study, two agroecosystems with extreme differences in organic matter content were selected to evaluate the effect of organic matter content on nematode communities.

No-tillage cropping is another agricultural practice that fits into sustainable agricultural systems and can result in more efficient use of land as well as savings in labor, equipment, and fuel, and reduced soil erosion. This concept has been widely promoted for over 30 years (Gallaher, 2002). Many nematologists also have explored the effects of tillage systems on nematode communities (Baird and Bernard, 1984; Fiscus and Neher, 2002; Fu *et al.*, 2000; Laakso and Setälä, 1999; Parmelee and Alston, 1986; Stinner and Crossley, 1982), but inconsistent results were observed among these studies. In some cases, tillage increased bacterivores, but decreased plant-parasitic nematodes (Lenz and Eisenbeis, 2000; Parmelee and Alston, 1986). However, Stinner and Crossley (1982) found that tillage had no effect on free-living nematodes but increased plant-parasitic nematodes. Baird and Bernard (1984) concluded that a single season of tillage had little effect on nematode communities. On the other hand, Fu *et al.* (2000) found that no tillage resulted in higher numbers of nematodes in all nematode-trophic groups. In the current study, the effect of an unusually long history of no tillage on nematode communities was examined.

Unique field sites with unusually long histories of specific sustainable agricultural practices were used to accomplish several objectives: (i) to examine the effect of long-term compost application (and subsequent enhancement of soil organic matter) on nematode communities, (ii) to determine the effect of long-term no-tillage practices on nematode communities; and (iii) to document which nematodes showed a close relationship with soil nutrients, organic matter and other soil properties in these historical sites.

MATERIALS AND METHODS

Sites and Soil Descriptions

Four soils of similar type but with very different histories of long-term agricultural practices were collected in March, 2001, from two field sites previously used for long-term yard-waste compost (McSorley and Gallaher, 1996) and tillage studies (McSorley and Gallaher, 1993) at the former (closed in late 2001) University of Florida Green Acres Agronomy Research Farm in Alachua County, Florida. All soils were Arredondo loamy sand (loamy, siliceous, hyperthermic, Grossarenic Paleudult) (Thomas *et al.*, 1985), with 94% sand, 2% silt, and 4% clay. These four soils are characterized as high yard-waste compost (HYWC), no yard-waste compost (NYWC), no-tillage (NT) treatment and conventional-tillage (CT) treatment. The HYWC soil was collected from field plots amended with 269 Mg/ha/yr of composted yard-waste plant materials including sticks, clippings, and wood fragments, each year from 1993 to 1998, planted with a double-crop of corn (*Zea mays*), and cowpea (*Vigna unguiculata*) during both 1998 and 1999. The composting process and application is described in detail elsewhere (McSorley and Gallaher, 1996). At the time of collection for the current study, it contained 8.44% organic matter. The NYWC composted of soil from the same experimental site as the HYWC but was from plots to which no yard-waste compost was ever added. It contained 2.42% organic matter. The NT soil was from cotton (*Gossypium hirsutum*) plots that were continuously under no-tillage practices for the previous 25 years as part of a double-cropping rotation involving cotton or soybean (*Glycine max*) in the summer and oat (*Avena sativa*) in the winter (McSorley and Gallaher, 1993). The CT soil was from cotton plots in the same site as the previous treatment that were rototilled twice before planting summer crops for the last 25 years. The NT and CT soils contained 2.87% and 2.10% organic matter, respectively. The four soils were left fallow with weeds for 1.5 years and remained undisturbed until the date of sampling, when only sparse plant cover was present following the previous winter. Each of the four soils collected was mixed to improve homogeneity of the bulk soil sample by reducing variability associated with uneven spatial distribution of nematodes (McSorley, 1998). The soil was sieved through a coarse mesh (2-mm-pore) sieve and three subsamples were taken from each soil and subjected to the following analyses.

Nematode Assay

Nematodes were extracted from a 100-cm^3 soil subsample by sieving and centrifugal flotation (Jenkins, 1964). All nematodes were identified to genus (family in some cases), counted, and assigned to one of five trophic groups: bacterivores, fungivores, herbivores, omnivores, and predators (Yeates *et al.*, 1993); algivores were rare. Feeding habits of Tylenchidae (mainly *Filenchus* and *Tylenchus*) and *Ecphyadophora* were classified as fungivores (McSorley and Frederick, 1999). *Monhystera* was grouped as a bacterivore rather than a substrate ingestor (Yeates *et al.*, 1993). The total number and the percentage of every trophic group in the community were calculated. Nematode richness was the total number of different taxa recorded per sample. Simpson's index of dominance (Simpson, 1949) was calculated as $\lambda = \Sigma\ (p_i)^2$, where p_i is the proportion of each of the *i* genera present (those identified to the family or order level were excluded). Simpson's index of diversity was calculated as $1/\lambda$. The fungivore to bacterivore (F/B) ratio was calculated to characterize decomposition and mineralization pathways (Freckman and Ettema, 1993). Total maturity index (MI) as defined by Yeates and Bird (1994) was calculated as $\Sigma\ (p_i c_i)$, where c_i is the c-p rating of taxon *i* according to the 1 to 5 c-p scale (Bongers and Bongers, 1998). The nematode fauna was also analyzed by a weighting system for the nematode functional guilds in relation to enrichment and structure of the food web (Ferris *et al.*, 2001). The enrichment index (EI) assesses food web responses to available resources, and structure index (SI) reflects the degree of trophic connectance in food webs of increasing complexity as the system matures, or progressive food web simplicity as the system degrades (Ferris *et al.*, 2001). These indices were calculated as EI $= 100 \times [e/(e+b)]$ and SI $= 100 \times [s/(s+b)]$ where e, s, and b are the abundance of nematodes in guilds representing enrichment (guilds Ba_1 and Fu_2, where Ba_1 = guild of bacterivores with c-p 1, Fu_2 = fungivores with c-p 2), structure (Ba_3-Ba_5, Fu_3-Fu_5, Om_3-Om_5, Ca_2-Ca_5, where Om = omnivores, Ca = carnivores = predators), and basal (guilds Ba_2 and Fu_2) food web components, respectively (Ferris *et al.*, 2001). The channel index (CI) represents the decomposition pathway in the soil food web, calculated as CI $= 100 \times [0.8Fu_2/(3.2Ba_1 + 0.8Fu_2)]$.

Nutrient Analysis

Subsamples of soil were subjected to soil nutrient analyses. Nitrogen was analyzed by a modified micro-Kjedahl procedure involving an aluminum block digester (Gallaher *et al.*, 1975). For other soil mineral analysis, a double acid, or Mehlich I (Mehlich, 1953), extraction procedure was used. Phosphorus was analyzed by colorimetry, K and Na by flame emission spectrophotometry, and Ca, Mg, Cu, Fe, Mn, and Zn by atomic absorption spectrophotometry (Gallaher *et al.*, 1975). Soil pH was measured using a 1:2 soil and water volume ratio, using a glass electrode pH meter (Peech, 1965). Cation exchange capacity was measured by summation of cations (Jackson, 1958), organic matter by the Walkely (1947) method, and mechanical analysis by the hydrometer method (Bouyoucos, 1936).

Statistical Analysis

Data collected were subjected to orthogonal contrast analysis using SAS (SAS Institute, Cary, NC) to compare the measurements for HYWC vs. NYWC, and for NT vs. CT. Correlation coefficients (r) between individual nematode genera or measures of nematode community structure and individual soil nutrient concentrations, soil organic matter content, or other soil properties were computed.

RESULTS AND DISCUSSION

Effect of Cultural Practices on Nematode Population

Compost treatment affected ($P \leq 0.10$) 12 nematode taxa, whereas tillage treatment affected only 5 genera (Table 1). Total nematode population densities were higher under HYWC than NYWC (Table 1), but compost treatment did not affect nematode numbers at the trophic level. However, individual taxa were affected differently by the compost treatments. Most of the taxa affected by compost treatments were in the bacterivorous and predatory groups (Table 1). Population densities of *Cephalobus*, *Cervidellus*, *Monhystera*, Rhabditidae, *Teratocephalus*, *Wilsonema*, and *Tobrilus* were enhanced by HYWC ($P \leq 0.05$; Table 1). Numbers of *Alaimus* and *Mesocriconema* were slightly enhanced by HYWC treatment ($P \leq 0.10$, Table 1), whereas numbers of *Plectus*, *Diphtherophora*, and *Mononchus* were suppressed by HYWC (Table 1). Most of the fungivores were not affected by compost.

Tillage did not affect total nematode numbers but it affected a few genera of fungivorous nematodes (Table 1). Numbers of *Aphelenchoides* were higher in NT than in CT, whereas numbers of *Filenchus* and *Tylenchus* were lower in NT than in CT ($P \leq 0.10$). No-till treatment had no effect on nematode population densities in other trophic groups, except for increasing the numbers of *Plectus* and *Zeldia* ($P \leq 0.05$, Table 1).

Effect of Cultural Practices on Nematode Community Indices

Although compost and tillage did not affect the percentage of nematodes in each trophic group, several nematode community indices were affected (Table 2). The HYWC soil had a lower F/B ratio, CI, and diversity ($P \leq 0.01$), but a higher richness ($P \leq 0.10$), dominance, and EI ($P \leq 0.05$) than NYWC soil (Table 2). Tillage treatment only slightly increased the CI ($P \leq 0.10$, Table 2), consistent with the higher numbers of several genera of fungivores in that soil. A significantly higher EI ($P \leq 0.05$) and lower CI ($P \leq 0.01$) in the HYWC soil than in the other three soils suggested that the HYWC soil was relatively N-enriched and underwent a bacterial-dominated decomposition channel, as supported by higher levels of several bacterivores in the HYWC soil.

Previously, responses of many of these nematode taxa and community indices to the organic management had been inconsistent and were affected by soil edaphic factors such as soil texture (Yeates *et al.*, 1997), type of organic materials (McSorley and Frederick, 1999), and soil metric potential (Neher, 1999). However, in this study, many of the nematode genera involved in decomposition and community indices that reflect decomposition activities and community diversity or richness were differentiated clearly between HYWC and NYWC, even though it had been three years since the last yard-waste compost (YWC) treatment was applied. There are several reasons for these distinct results. First, the treatments chosen were very distinct and somewhat extreme, i.e., a long history of compost application

Table 1. Nematode population densities per 100-cm^3 soil from sites with four different agricultural histories.

Trophic group	Nematode genus (c-p value)	High yard waste compost	No yard waste compost	No tillage	Conventional tillage
Bacterivores	*Acrobeles* (2)	148	93	100	132
	Acrobeloides (2)	139	43	75	95
	Alaimus (4)	12	5[z]	6	1
	Cephalobus (2)	20	6**	11	7
	Cervidellus (2)	52	22*	35	25
	Eucephalobus (2)	17	17	37	37
	Monhystera (2)	6	1**	1	1
	Plectus (2)	2	12*	12	1*
	Prismatolaimus (3)	18	11	5	4
	Rhabditidae (1)	43	7***	13	9
	Teratocephalus (3)	4	0*	1	2
	Wilsonema (2)	14	3*	11	7
	Zeldia (2)	5	3	7	2*
	Total bacterivores	494	226	316	326
Fungivores	*Aphelenchoides* (2)	2	2	13	7**
	Aphelenchus (2)	19	24	24	17
	Diphtherophora (3)	6	27***	3	4
	Filenchus (2)	4	4	2	13[z]
	Neotylenchidae (2)	3	0	1	2
	Tylenchus (2)	9	15	6	26*
	Total fungivores	49	77	53	74
Herbivores	*Mesocriconema* (3)	307	151[z]	42	148
	Meloidogyne (3)	35	39	259	238
	Pratylenchus (3)	24	41	12	20
	Paratrichodorus (3)	8	5	19	20
	Xiphenema (5)	3	1	2	0
	Total herbivores	377	238	334	426
Omnivores	*Aporcelaimellus* (5)	3	7	2	1
	Eudorylaimus (4)	16	26	7	4
	Total omnivores	25	40	12	8
Predators	*Mononchus* (4)	1	10**	0.3	2
	Nygolaimus (5)	5	13	4	4
	Tobrilus (3)	4	0*	0	0
	Total predators	13	27	7	8
Total Nematodes		967	617**	728	849

*, **, ***Difference between high yard-waste compost vs. no yard-waste compost or between no-tillage vs. conventional tillage significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ respectively.

[z]Difference significant at $0.05 < P \leq 0.10$.

Table 2. Nematode community indices from sites with four different agricultural histories.

Index	High yard waste compost	No yard waste compost	No tillage	Conventional tillage
% bacterivores	51.34	38.05	43.59	38.62
% fungivores	5.05	12.42	7.24	8.69
% herbivores	38.88	38.00	45.58	49.93
% omnivores	2.55	6.38	1.72	0.96
% predators	1.35	3.91	1.03	0.97
Fungivores/bacterivores	0.10	0.36**	0.17	0.23
Richness	35.00	29.00[z]	29.00	29.00
Dominance	0.18	0.11*	0.19	0.18
Diversity	6.17	9.03**	5.41	5.53
Maturity index	2.50	2.68	2.56	2.57
Enrichment index	31.81	23.94*	22.51	21.71
Structure index	38.41	52.21	29.51	8.12
Channel index	18.51	59.39***	47.54	63.29[z]

*, **, ***Difference between high yard-waste compost vs. no yard-waste compost or between no-tillage vs. conventional tillage significant at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$ respectively.
[z]Difference significant at $0.05 < P \leq 0.10$.

(HYWC) or none (NYWC). The nature of the original compost material (yard waste including sticks and other debris, C:N > 35:1 at time of application ensured that decomposition would be slow, and still continuing for a long time after application had ceased. Soil in our systems was from old cotton or corn fields under fallow conditions. Due to the previous winter and a long drought season prior to the time of sampling, only minimal weeds were actively growing and weed cover was sparse. In these environmental conditions, impact of the organic management persisted on the soil ecosystem because of the minimal disturbance from actively functioning rhizospheres over the previous 1.5 years. Finally, and perhaps most importantly, the legacy of the long history of compost application was a drastic increase in organic matter (OM) content in the amended HYWC plots (8.44% OM), compared with the natural background level in the NYWC plots (2.42% OM), which undoubtedly contributed to the pronounced response of nematode communities to organic management in this experiment.

Results from our tillage study were similar to previous studies by Stinner and Crossley (1982) and Baird and Bernard (1984) in that tillage had limited long-term influence on nematode communities. Although several taxa of fungivores respond to tillage treatment, the effect was not consistent, with numbers of *Aphelenchoides* were increased in NT, while *Filenchus* and *Tylenchus* decreased. The limited effects from tillage could be due to the fact that the field had been fallowed for a long time, and disturbance of nematode communities from tillage evidently stabilized more quickly than that from YWC amendment. When studying the impact of tillage on nematode communities, it is important to separate the tillage effect from the organic input effect during conventional tillage practices. When Fiscus and Neher (2002) used canonical correspondence analysis to segregate effects of tillage and chemical or nutrient treatments, only 5 out of 46 nematode genera were directly sensitive to tillage treatment, among which only *Aphelenchoides* was significantly affected in our experiment.

Correlation of Nematode Genera with Soil Nutrient Concentration and other Soil Properties

An advantage of monitoring nematode communities in fallow soil with plant residues is that nutrients mineralized from decomposing organic matter would remain in the soil for some time rather than being taken up by plants, complicating the interpretation of soil nutrient data. In addition, soil was sampled during spring, a typically dry weather period in Alachua county (Thomas *et al.*, 1985), irrigation system was removed, and plant debris from previous crop was left on the soil surface. All of these factors contribute to minimum nutrient leaching at this site. Population densities of many nematode trophic groups, particularly bacterivores, fungivores and predators were correlated positively with nutrient concentrations and other soil properties (Table 3). Among the bacterivores that were positively correlated with concentrations of most soil nutrients (including N, P, and K) and other properties (including OM) were *Alaimus*, *Cephalobus*, *Cervidellus*, *Monhystera*, *Plectus*, Rhabditidae, and *Teratocephalus* (Table 3). Population densities of several fungivores, including *Diphtherophora*, *Ecphyadophora*, *Filenchus*, Neotylenchidae, and *Tylenchus* were positively correlated with concentrations of most nutrient elements except N, K, and Mg (Table 3). This is consistent with the result obtained by Ingham *et al.* (1985) that bacterivores are more involved in N mineralization, whereas fungivores are more involved in P mineralization.

Since concentrations of most soil nutrients were correlated positively with numbers of bacterivores and fungivores, results are consistent with the hypothesis that the higher the number of free-living nematodes, the more nutrients were mineralized, as had been suggested by Ferris *et al.* (1997; 1998), Freckman (1988), and Ingham *et al.* (1985). However, concentration of Cu was always negatively correlated with the number of bacterivores, but positively correlated with the number of fungivores (Tables 3 and 4). A similar trend was observed for Fe. Copper may be toxic to many nematodes and is not recommended for making nematode extraction sieves (Pitcher and Flegg, 1968). Bongers and Bongers (1998) suggested that fungivorous nematodes in guild Fu_2 were tolerant to pollutants and other disturbance. Unlike bacterivores, fungivore numbers were always negatively correlated with percent OM whenever significant correlations occurred (Table 3), suggesting that these soils were under bacterial decomposition pathways. Fungivorous nematodes only become prominent as recalcitrant substrates (high in lignin and cellulose) accumulate in the habitat (Bouwman *et al.*, 1993).

In contrast to the free-living nematodes, population densities of herbivorous nematodes (mainly *Meloidogyne* and *Paratrichodorus*) correlated negatively with most nutrient concentrations. These nematodes may have been more abundant in microhabitats where previous plant roots might have taken up soil nutrients, thus resulting in lower soil nutrient concentrations.

The predatory nematodes with their population densities positively correlated with most soil nutrients were *Carcharolaimus* and *Tobrilus* (Table 3). The pattern of correlation of these nematode numbers

Table 3. Correlation coefficients between population density of each nematode and soil nutrient concentration or other soil properties.

	Correlation coefficient (*r*)												
Nematode genus	Ca	Mg	K	P	N	Na	Cu	Fe	Mn	Zn	pH	OM[z]	CEC[z]
Bacterivores													
Alaimus	0.630*[z]	0.649*	0.663*	0.638*	0.644*	ns	ns	ns	0.650*	0.653*	0.517	0.633*	0.630*
Cephalobus	0.702**	0.755**	0.695**	0.624*	0.737**	0.725**	-0.672*	ns	0.696**	0.724**	ns	0.760**	0.738**
Cervidilus	0.604*	0.651*	0.583*	0.515	0.617*	0.649*	-0.573*	ns	0.597*	0.621*	ns	0.655*	0.643*
Monhystera	0.818**	0.833**	0.774**	0.751**	0.801**	0.744**	-0.812**	-0.505	0.811**	0.822**	0.559	0.829**	0.845**
Plectus	0.753**	0.705**	0.754**	0.781**	0.631*	ns	-0.641*	-0.743**	0.746**	0.715**	0.730**	0.670*	0.728**
Rhabditidae	0.876**	0.906**	0.841**	0.792**	0.883**	0.821**	-0.858**	-0.518	0.861**	0.888**	0.572*	0.909**	0.904**
Teratocephalus	0.622*	0.660*	0.508	0.508	0.701**	0.686**	-0.737**	ns	0.573*	0.646*	ns	0.688**	0.652*
Wilsonema	ns	0.518	ns	ns	0.506*	0.589*	ns	ns	ns	ns	ns	0.528	0.500
Fungivore													
Diphtherophora	0.548	ns	ns	ns	ns	0.636*	0.647*	0.663*	0.638*	0.644*	ns	ns	ns
Ecphyadophora	0.922**	ns	ns	0.885**	ns	0.703**	0.755**	0.695*	0.624*	0.737**	0.725**	-0.672*	ns
Filenchus	0.889**	ns	ns	0.886**	0.604*	0.651*	0.583*	ns	0.515	0.617*	0.649*	-0.573*	ns
Neotylenchidae	0.915*	ns	ns	0.717**	ns	0.818**	0.833**	0.774**	0.751**	0.801**	0.744**	-0.812**	-0.506
Tylenchus	0.751**	ns	ns	0.551	ns	0.753**	0.706*	0.754**	0.781**	0.631*	ns	-0.640*	-0.743**
Herbivores													
Meloidogyne	-0.703**	-0.572*	-0.712**	-0.802**	ns	ns	ns	0.958**	-0.726**	-0.622*	-0.937**	-0.547*	-0.621*
Paratrichodorous	-0.505	ns	-0.507	-0.599*	ns	ns	ns	0.811**	-0.501	ns	-0.736**	ns	ns
Mesocriconema	0.720**	0.680*	0.654*	0.698**	0.697**	0.511	-0.752**	-0.625*	0.702**	0.707**	0.663*	0.691**	0.700**
Predators													
Carcharolaimus	0.589*	0.667*	0.528	ns	0.711**	0.787**	-0.638*	ns	0.541	0.628*	ns	0.698**	0.642*
Tobrilus	0.803**	0.805**	0.757**	0.718**	0.766**	0.681*	-0.780**	-0.538	0.772**	0.794**	ns	0.809**	0.819**

[z]OM = organic matter, CEC = cation exchange capacity.

Correlation analysis based on 12 observations; * and ** signify correlation significant at $P \leq 0.05$ and $P \leq 0.01$ respectively; ns = non-significantly correlated at $P \leq 0.10$.

Table 4. Correlation coefficients of the percentage of each nematode trophic group or other nematode community indices and soil nutrient concentrations or other soil properties.

	Correlation coefficient (*r*)						
Community indices	% bacterivores	% fungivores	% herbivores	% omnivores	Enrichment index	Structure index	Channel index
Ca	0.522	-0.507	ns[z]	ns	0.868**	ns	-0.538**
Mg	0.559	-0.628*	ns	ns	0.857**	ns	-0.884**
K	ns	ns	ns	ns	0.882**	ns	-0.810**
P	ns	ns	ns	ns	0.832**	ns	-0.768**
N	0.530	-0.691*	ns	ns	0.825**	ns	-0.877**
Na	0.558	-0.837**	ns	-0.545	0.654*	ns	-0.805**
Cu	ns	0.570	ns	ns	-0.819**	ns	0.747**
Fe	ns	ns	0.5615	-0.664*	-0.682*	-0.646*	-0.823***
Mn	0.537	ns	ns	ns	0.842**	ns	ns
Zn	0.545	-0.577*	ns	ns	0.855**	0.560	-0.866**
pH	ns	ns	-0.5351	0.565	0.708**	ns	-0.541
OM[y]	0.567	-0.653*	ns	ns	0.840**	ns	-0.879**
CEC[y]	0.556	-0.584*	ns	ns	0.858**	ns	-0.857**
% sand	ns	ns	ns	ns	-0.760**	ns	0.680*
% silt	ns	ns	ns	ns	0.718**	ns	-0.534
% clay	ns	ns	ns	ns	ns	-0.689*	ns

[z]Correlation analysis based on 12 means, except for soil texture (n = 4); * and **Signify correlation significant at $P \leq 0.05$ and $P \leq 0.01$ respectively; ns = non-significantly correlated at $P \leq 0.10$.
[y]OM = organic matter, CEC = cation exchange capacity.

and soil nutrients is similar to those of bacterivores, i.e., most of the soil nutrient concentrations were correlated positively with the nematode populations but concentration of Cu was negatively correlated. This is consistent with previous findings that increasing Cu reduced the total abundance, richness, nematode taxa from c-p groups 4 and 5, MI, and percentage of herbivores, omnivores, and carnivores (Korthals *et al.*, 1996, 1998). The role of predators in nutrient mineralization is receiving increased recognition (Yeates and Wardle, 1996), although their mechanisms and outcome are neither clear nor definitive (Laakso and Setälä, 1999). In our studies, *Carcharolaimus* ($r = 0.55$, $P \leq 0.05$) and *Tobrilus* ($r = 0.80$, $P \leq 0.01$) were also correlated positively with the population densities of *Cephalobus* and Rhabditidae. Therefore, involvement of the predatory nematodes in nutrient cycling is most likely an indirect process.

Correlation of Nematode Genera with Soil Texture

Several genera of large size nematodes showed negative correlations with percentage of clay. These included omnivores, *Eudorylaimus* ($r = -0.901$, $P \leq 0.10$) and

Mesodorylaimus (r = -0.923, $P \leq 0.10$); predators, *Mononchus* (r = -0.991, $P \leq 0.01$) and *Nygolaimus* (r = -0.991, $P \leq 0.01$), and a fungivorous dorylaimid, *Diphtherophora* (r = -0.986, $P \leq 0.05$). The inverse relationship between nematode size and particle size is well known, although probably more dependent on pore space than absolute particle size (Norton, 1978).

Correlation of Nematode Community Indices with Soil Nutrient Concentration

Many of the nematode community indices measured are consistent with our other data and conclusion that bacterivores were playing the key role in nutrient cycling. Total number of bacterivores in the soil communities was correlated with N, Na, Cu and OM ($P \leq 0.1$), but total number of herbivores, fungivores, omnivores and predators were not correlated with any soil nutrient ($P > 0.1$ data not shown). Percent bacterivores correlated positively with many nutrient concentrations whereas percent fungivores correlated negatively with many nutrient concentrations (Table 4). Fewer nutrient concentrations correlated with percent herbivores, omnivores, and none were correlated with predators. Among the nematode community indices, EI and CI correlated with most of the soil nutrient concentrations measured (Table 4). Positive correlation between EI (weighted the abundance of nematodes with c-p = 1), or negative correlation between CI (weighted ratio of Fu_2 to total Ba_1 and Fu_2) with many nutrient concentrations are consistent with the hypothesis that bacterivores in Ba_1 guild (Rhabditidae) play an important role in nutrient cycling in this system. Limited correlation of SI (weighted the abundance of nematodes with c-p value > 2, including most of the predators and omnivores) with most of the nutrient concentrations suggests that the overall number of omnivores and predators are not as important in nutrient cycling. Of course, while correlation analyses may provide insight into relationships between variables that may be consistent with known mechanisms and pathways, they cannot actually elucidate mechanisms and pathways. To accomplish this, additional studies of effects of nematodes on specific nutrient cycles are needed.

In conclusion, the sites examined in the current study provided an excellent opportunity to obtain insight into long-term effects of agricultural practices on the soil nematode community. Despite a long history of no tillage (25 years) at one site, few differences existed in nematode community structure between no-tillage and conventional-tillage treatments, suggesting that such impacts are minimal or nematode communities recover quickly. In contrast, long-term yard-waste compost treatment enhanced soil organic matter significantly, and therefore its effects on nematode community members involved in nutrient cycling were obvious even at 3 years after the last YWC treatment and 1.5 years after the last cultivation. Our data are consistent with the fact that bacterivores played the key role in mineralization of a number of soil nutrients besides N and P in this fallow field system. Fungivorous nematodes were also involved in mineralization of most soil elements except for N, K, and Mg, and some predatory nematodes played an indirect role in nutrient cycling. Studying nematode communities in fallow soil after the soil management or prior to crop planting might allow more clear cut relationships between nematodes and soil nutrients to be observed. This preliminary investigation provided some insight into associations of many different nematode genera with macro- and micronutrients, and with soil organic matter, the dynamics of which should be investigated in more detailed studies. Nevertheless, it is clear that a practice that significantly enhances organic matter in a soil with a low background level of organic matter will have a profound and lasting impact on the nematode community and nutrient cycling.

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