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Soil Nematode Abundance in Relation to Diversity in Different Farming Management System

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Abstract: A field experiment of different compost amendment and chemical fertilizers was carried out in Qu-Zhou experimental station, China Agricultural University. The aim was to study the effect of long-term different amendments on soil nematode community. The results showed the following: The total number of soil nematodes and bacterivorous nematodes in EM compost treatment was higher than in traditional compost treatment and in traditional compost treatment was higher than in control and in control was higher than in chemical fertilizer treatment. The 39 nematode genera were found and were composed of 15 genera bacterivorous, 4 genera fungivorus, 14 genera plant-parasites and 6 genera the omnivorus-predators. *Rhabditis*, *Rotylenchus* and *Helicotylenchus* were the dominant taxa. The ratio of bacterivores and fungivores to plant parasites in compost treated was higher than in chemical fertilizer treatment and control plots. The ratio of fungivorus/ (bacterivorus + fungivorus) was higher in chemical fertilizer-treated than in compost-treated plots. The combined maturity index could reflect soil fertility conditions. So, soil nematodes community could be considered as bioindicator of soil ecosystem health.

Key words: Amendments · soil nematodes · trophic groups · ecological index

INTRODUCTION

Soil nematodes are the most abundant metazoan, with rich species, extensive distributing, various configuration and habit [1]. Soil nematodes took up several trophic grade and occupy a central position in the soil food web and correlate with ecological processes such as nitrogen cycling and plant growth [2]. Soil nematodes could keep stabilization of soil ecosystem, promote substance cycling and energy flowing [3]. Nematodes are usually classified into free-living and plant-parasitic nematodes according to whether harmful or beneficial to plant [4]. Free-living nematode could promote decomposition of soil organic matter, mineralization of plant nutrients and nutrient cycling, loosen soil, amend soil physico-chemical property and improve soil fertility [5]. Moreover, some free-living nematodes could suppress bacterial, fungal and nematode diseases [6]. Therefore, soil nematode community could be used as an bioindicator of soil health [7]. Yet, plant-parasitic nematodes mainly feed on plant root, made root malformation and rot, so crop yield is reduced. The prevention of harmful and encouragement of beneficial nematodes through different application of fertilization was very important in agricultural fields. In a word, to study different farming management practices affecting nematode community would have important significance.

MATERIALS AND METHODS

Experimental site and design: A field experiment was initiated in 1993 at the Qu-Zhou experimental station (36°52'N and 115°01'E), China Agricultural University. The station is in a continental temperate monsoon zone and the climate in the region is warm, sub-humid and consists of summer rainfall and dry-cold winters. The soil at the study site is a silt fluvo-aquic soil.

The experiment was designed with six treatments, with eighteen plots (3 replicates for each) arranged in a randomized complete block design. Plots of 3 x 10.5 m each planted to winter wheat (*Triticum aestivum* L.) and summer maize (*Zea mays* L.) every year from 1993 to 2004. Six treatments: EM compost at 15 t ha^{-1} (EM1), traditional compost 15 t ha^{-1} (TC1), EM compost at 7.5 t ha^{-1} (EM2),

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traditional compost at 7.5 t ha^{-1} (TC2), chemical fertilizer (CF) at (750 kg ha^{-1} ammonium bicarbonate, 300 kg ha^{-1} urea and at 750 kg ha^{-1} calcium super-phosphate), control (no any manure, CK). Before planting, winter wheat and summer maize every year, experimental plots were treated with the tested materials, while CK plot didn't receive any amendment. Compost composition and effective microorganism agent (EM) saw the report of Hu and Cao [8].

Soil sampling: The soil samples from the upper soil layer (0-20cm) were collected in June 2004 before planting winter wheat. Composite soil samples consisting of fifteen cores (2.5 cm diameter × 20 cm deep) were collected from each plot. The soil samples were stored in insulated and tied plastic bags to prevent moisture loss and was transported to the laboratory where they were kept at a 4°C until biological and chemical analyses were conducted. All soil samples were removed from root fragments and other organic debris. Each soil sample was mixed thoroughly, tested for soil moisture and free-living soil nematodes.

Soil moisture in each sample was determined gravimetrically by weight loss at 105°C for 24 h and expressed as percent dry weight. Soil sub-samples was air-dried for 14 d at room temperature and were used to test the content of alkaline hydrolysable N, available P, available K, organic matter, total N and soil pH. The method and result saw the report of Hu and Cao [8].

Soil nematode extraction and identification: Nematode populations were extracted from 100 g composite fresh soil samples using the sugar flotation and centrifugation method [9]. The nematode populations were expressed per 100 g dry soil. The recovered nematodes were counted and preserved in formalin [10]. One hundred randomly selected specimens per sample were identified, to genus level if possible, using an inverted compound microscope [11, 12]. Nematode counts for each taxon were adjusted to the number of nematodes per 100 g dry soil.

The characteristics of the nematode communities were described by the following approaches: (1) absolute abundance of individuals per 100 g dry soil; (2) trophic structure: (a) Bacterivorus (BF); (b) Fungivorus (FF); (c) Plant Parasites (PP); (d) Omnivores–predators (OP) [13, 14]; (3) WI, ratio of bacterivorus plus fungivorus to plant parasites [15]; (4) F/(B + F), fungivorus/(bacterivorus + fungivorus) ratio [16]; (5) J', evenness, $J' = H'/\ln(S)$, where S is the number of taxa [17]; (6) λ, genus dominance, $\lambda = \Sigma pi^2$, where *pi* is the proportion of individuals in the I-th taxon [18]; (7) H', Shannon Index, $H' = -\Sigma pi(\ln pi)$, where *pi* is the proportion of individuals in the *i*-th taxon [19]; (8) ΣMI, modified maturity index, including plant-feeding nematodes, $\Sigma MI = \Sigma vipi$, where *vi* is the c-p value for free-living and plant parasitic nematodes assigned by Bongers [20] to the *i*-th nematode genus and *pi* is the proportion of the genus in the nematode community [21].

Statistical analysis: The data were also analyzed by one-way analysis of variance (ANOVA) in order to detect differences between different treatments. Differences at a $p<0.05$ level were considered statistically significant using the LSD (least significant difference) test. All statistical analyses were performed using a SPSS 11.5 software package.

RESULTS

Nematode population in different farming management system: The total number of nematodes during the study period ranged from 170 to 376 individuals 100 g^{-1} dry soil (Table 1). The total number of nematodes in EM1 plot was significantly higher than in EM2, TC2, CF and control plot ($p<0.05$). The total number of nematodes in TC1 plot was significantly higher than in TC2 CF and control plots ($p<0.05$). The total number of nematodes in EM2, TC2 plot was significantly higher than in CF and control plots ($p<0.05$). But there had no significant difference among the treatments applied the same amounts of compost and between chemical fertilizer and control plot.

The bacterivorous nematodes in EM1 plot was significantly higher than in EM2, TC2, CF and control plot ($p<0.05$). The bacterivorous nematodes in TC1 plot was significantly higher than in TC2, CF and control plot ($p<0.05$). But there had no significant difference between TC2, CF and control plot. The fungivorous nematodes in TC2 plot was significantly higher than in TC1 and control plot ($p<0.05$). But significant difference wasn't found between EM1, EM2 and CF plot. The plant-parasitic and omnivorous and predacious nematodes had no significant

Table 1: Nematode number in different farming management system

Treatment	EM1	TC1	EM2	TC2	CF	CK
TN	375.78a	325.53ab	274.49bc	251.37c	169.76d	196.18d
BF	219.89a	199.12ab	124.03bc	97.32c	59.70c	71.25c
FF	5.35ab	2.16b	4.30ab	11.32a	7.51ab	2.51b
PP	145.11a	124.24a	142.91a	137.76a	99.62a	118.58a
OP	5.42a	0.00a	3.25a	4.97a	2.92a	3.84a

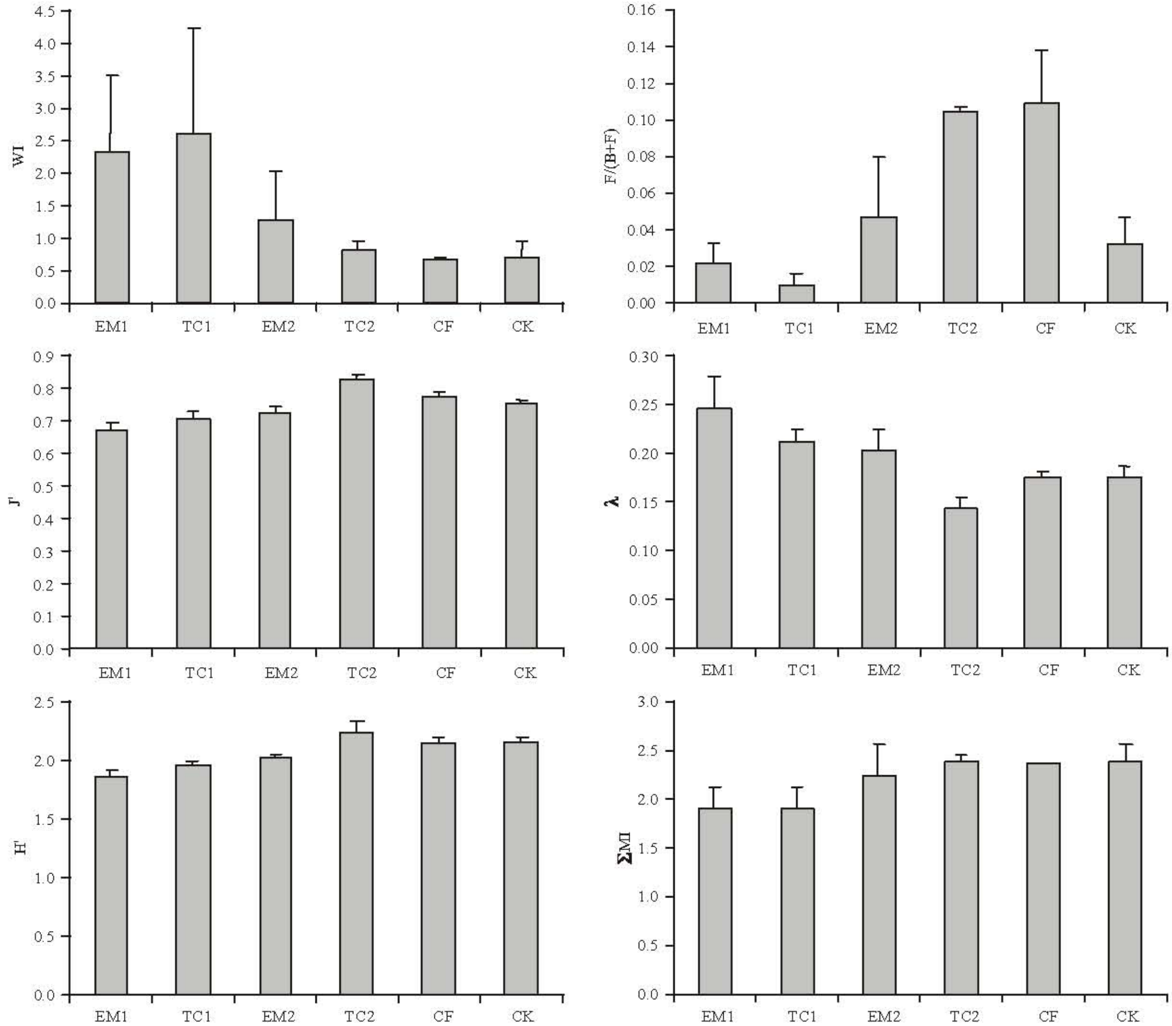

Fig. 1: Nematode ecological indices in different farming management system

difference between treatments. The relative abundance of bacterivorous, fungivorous, plant-parasitic and omnivorous-predacious nematodes in all treatments was 46.21, 2.28, 50.14 and 1.37 %, so plant-parasitic nematodes was dominant trophic group and bacterivorous nematodes was subdominant.

Nematode taxa in different farming management system: The 39 nematode genera in this study were found and were composed of 15 genera bacterivorus, 4 genera fungivorus, 14 genera plant-parasites and 6 genera the omnivorus-predators, belonging to 7 orders and 19 families (Tables 2). *Rhabditis*, *Rotylenchus* and *Helicotylenchus* were the dominant taxa. Their mean relative abundance was 27.81, 23.72 and 13.19%. *Cephalobus*, *Eucephalobus*, *Acrobeles*, *Protorhabditis*, *Rhabditis*, *Plectus*, *Tylenchorhynchus*, *Pratylenchus*, *Hoplolaimus*, *Helicotylenchus*, *Rotylenchus*, *Longidorus* were found in all treatments.

Nematode ecological indices in different farming management system: The ratio of bacterivorus and fungivorus to plant parasites (WI) ranged from 0.67 to 2.61 (Fig. 1). The value of WI in compost-treated plots was higher than in CF and CK plots (Fig. 1). The WI values in TC1 plot was the highest and in CF plot was the lowest. The ratio of fungivorus to (bacterivorus + fungivores) (F/(B+F)) was found to be the highest in CF plot and to be the lowest in TC1 plot, ranged from 0.01 to 0.11 (Fig. 1).

Table 2: Nematode genera, family, order in the present investigation

Trophic group	Order	Family	Genera	c-p value
Bacterivores	Rhabditida	Cephalobidae	*Cephalobus*	2
			Eucephalobus	2
			Acrobeloides	2
			Chiloplacus	2
			Cervidellus	2
			Acrobeles	2
		Brevibuccidae	*Brevibucca*	2
		Panagrolaimidae	*Panagrolaimus*	1
		Rhabditidae	*Protorhabditis*	1
			Mesorhabditis	1
			Odontorhabditis	1
			Poikilolaimus	1
			Rhabditis	1
	Araeolaimida	Plectidae	*Plectus*	2
			Anaplectus	2
Fungivores	Tylenchina	Tylenchidae	*Ditylenchus*	2
	Aphelenchida	Aphelenchidae	*Aphelenchus*	2
		Aphelenchoididae	*Aphelenchoides*	2
	Dorylaimida	Tylencholaimidae	*Tylencholaimus*	4
Plant parasites	Tylenchina	Tylenchidae	*Tylenchus*	2
			Tetylenchus	2
		Belonolaimidae	*Belonolaimus*	2
			Tylenchorhynchus	2
		Pratylenchidae	*Pratylenchus*	3
		Hoplolaimidae	*Hoplolaimus*	3
			Helicotylenchus	3
			Rotylenchus	3
			Rotylenchulus	3
		Criconematidae	*Criconemella*	3
		Tylenchulidae	*Paratylenchus*	2
	Dorylaimida	Longidoridae	*Longidorus*	5
			Xiphinema	5
	Triplonchida	Trichodoridae	*Trichodorus*	4
Omnivores -predators	Dorylaimida	Dorylaimidae	*Dorylaimus*	4
			Mesodorylaimus	4
		Tylencholaimidae	*Enchodelus*	4
		Dorylaimidae	*Eudorylaimus*	4
			Aporcelaimus	5
	Mononchida	Mononchidae	*Mononchus*	4

Evenness (J') values was the highest in TC2 plot and J' values in EM1 plot was the lowest (Fig. 1). Genus dominance (λ) was the highest in EM1 plot and λ values in TC2 plot was the lowest (Fig. 1).The Shannon index (H') values was the highest in TC2 plot and H' values in EM1 plot was the lowest (Fig. 1).

ΣMI values ranged from 1.90 to 2.40 in different treatments, with highest values being observed in CK plot and lowest values being observed in EM1 (Fig. 1).

DISCUSSION

Agricultural fertilization management practices have caused soil ecosystem disturbance and then affect soil nematode community structure [22, 23]. In this investigation, although significant difference wasn't found in plant-parasitic and omnivorous-predacious nematodes between treatments, total number of nematodes, bacterivorus, fungivorus exhibited highly significant treatment effects.

The total number of nematodes in this investigation was 266 individuals 100 g^{-1} dry soil, which is higher than that obtained by [23] in Israel Kfar Saba (84) and lower than that reported by [24] in Michigan (1048).The total number of nematodes in EM compost-treated and traditional compost-treated was significantly higher than in chemical fertilizer-treated and control plots. This may be due to more abundant nutrient substance in EM compost-treated and traditional compost-treated plots than in chemical fertilizer-treated and control plot, which manifested that nutrient substance was a limiting factor for nematode communities [25]. The total number of nematodes in chemical fertilizer-treated was lower than in control plots. The mainly reason was that chemical fertilizer suppress nematode population and may straightly poison nematodes.

The bacterivorous nematodes in EM compost-treated was higher than in traditional compost-treated plots. The possible reason was that microbial community was greater in EM compost-treated plots [26]. The bacterivorous nematodes in compost-treated were higher than in chemical fertilizer-treated and control plot, which was consistent with previous result [27]. The bacterivorous nematodes in chemical fertilizer-treated were lower than in control plot because there had least bacterial community in chemical fertilizer-treated plots [28]. The plant-parasitic nematodes were dominant trophic group in all treatments. This is consistent with the result reported by Neher [29]. Ou *et al.* [30] also observed that plant parasites were the predominant trophic group in a maize field. The relative abundance of plant-parasitic nematodes in compost-treated was lower than that in chemical fertilizer-treated and control plot. This revealed that organic compost suppressed plant-parasitic nematodes [31]. The fungivorous and omnivorous-predacious nematodes were less trophic group in this study.

The number of nematode genera (39) in our investigation was more than that in black soil of Hailun [32], but similar to that found by Li *et al.* [33]. The value of WI in compost-treated plot was higher than in chemical fertilizer-treated and control plots. This manifested that there were more bacterivorus and fungivorus in the traditional compost-treated plots, due to the larger microbial population in these plots. The value of F/(B+F) was found to be higher in chemical fertilizer-treated than in compost-treated plots. This indicated a large fungal population in chemical fertilizer-treated plots, with a dominant fungal decomposition pathway [34].

The maturity index has received much attention in relation to soil health and sustainability. Bongers [35] reported that the maturity index value decreased with increasing soil fertility. The result in this study also manifested variation of soil fertility. Pavao-Zuckerman and Coleman [36] reported that the combined nematode community indices provide a complicated picture of the effects of urbanization in western North Carolina. So, the nematode Maturity Index is one of the key indices of soil health.

In conclusion, application of compost enhanced total number of nematodes, especially bacterivorous nematodes and suppressed relative abundance of plant-parasitic nematodes. Therefore, there will have healthy soil ecosystem.

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