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INFLUENCE OF ORGANIC AND INORGANIC FERTILIZERS ON NEMATODE COMMUNITIES IN CORNFIELD

T. BENKOVIC-LACIC[1], M. BRMEZ[2], M. IVEZIC[2], E. RASPUDIC[2], D. PRIBETIĆ[3], Z. LONCARIC[2] and D. GRUBISIC[4]
[1] *University of Applied Sciences, 35000 Slavonski Brod, Croatia*
[2] *University of Josip Juraj Strossmayer, Faculty of Agriculture in Osijek, 31000 Osijek, Croatia*
[3] *Polytechnic of Rijeka, Agricultural Department, 52440 Poreč, Croatia*
[4] *University of Zagreb, Faculty of Agriculture, 10000 Zagreb, Croatia*

Abstract

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Organic amendments increases soil microbial biomass and nutrient availability, and affect soil nematode community by increasing abundance of bacterivore and fungivore nematodes. The objective of this study was to determine the effect of different organic manures (beef manure - BM, horse manure - HM, swine manure - SM, poultry manure - PM), mineral fertilization (MF) and "no amended" plots (control - CO) on nematode community structure. Research was conducted in 2008, in Krizevci, in northwestern part of Croatia, in field planted with corn (*Zea mays* L). Nematode communities were analyzed to genus level. Significant differences between treatments were observed in MI and in MI25. Statistically lower MI value in MF plots in compared with CO plots indicates more disturbed environmental conditions. A significant difference between CO and MF, HM and PM plots in MI2-5 value also demonstrates change in nematode communities. Diversity and ecological indexes did not show significant differences between treatments and sensitivity to changes in soil. Changes in nematode community structure in soil food web were affected by addition of organic and inorganic fertilizers in soil, and the most disturbed community was observed in treatment with mineral fertilization. Measures of nematode community were functional in providing the information about processes in soil and reflect differences in soil ecosystem.

Key words: Nematodes, organic fertilizers, inorganic fertilizer, indexes

Abbreviations: MF - mineral fertilization, BM - beef manure, HM - horse manure, SM - swine manure, PM - poultry manure, CO - "no amended" plots, MI - Maturity index, MI2-5 - Modified Maturity index, PPI - Plant-parasitic index, PPI/MI - Maturity index ratio, H' - Shannon index, *N*1 and *N*2 - Hills indexes, E - Evenness index, EI - Enrichment index, SI - Structure index, CI - Channel index (CI), F+B/PP - Ratio of bacterivours plus fungivorous to plant parasites, F/B - Ratio of fungi-feeding to bacteria-feeding nematodes

Introduction

Nematode communities are easily influenced by changes in soil environment caused by different management practices in soil (Sohlenius and Wasilewska, 1984; Yeates and Bongers, 1999; Neher and Olson, 1999). Nematodes play an important role in nutrient cycling in soil food webs (Ferris and Matute, 2003; Bulluck et al., 2002; Dong et al., 2008). Brmez et al. (2006) reported that nematodes are useful bioindicators of an

E-mail: mbrmez@pfos.hr

ecosystem healt. Organic manure increases soil microbial biomass (Bittman et al., 2005). Akhtar and Mahmood (1996) associated increased numbers of free-living nematodes with composted manure and urea added to the soil. Free-living nematode could promote decomposition of soil organic matter, mineralization of plant nutrients and nutrient cycling and improve soil fertility (Ferris et al. 2004).

Many authors studied the effect of organic manure on nematode communities in soil. In organically grown tomatoes, Nahar et al. (2006) detected a negative correlation between plant parasitic and free-living nematodes. After the application of acidified liquid hog manure Mahren et al. (2009) observed large numbers of opportunistic bacterial-feeding nematodes of the Rhabditidae. Numbers of bacterivorous nematodes show a disposition to increase after organic amendments are applied to soil (McSorley and Fredreick, 1999), but tend to decrease over time as the food base declines in soils (Bulluck et al. 2002). Green manures or chicken manure suppress plant-parasitic nematodes (Abawi and Widmer, 2000). Bulluck et al. (2002) referred that fungivorous nematodes were greater after planting in soil amended with swine manure, rye-vetch or cotton gin trash, than in soils amended with synthetic fertilizer. Garcia-Alvarez et al. (2004) presented that the populations of bacterivourous nematode decreased in soil implemented with inorganic fertilizers. Changes in soil nematode communities are mostly depended on the types of inorganic fertilizers (Zhang et al., 2009). Gruzdeva et al. (2007) pointed out the nematode genera sensitive to the complete mineral fertilizer (NPK) and suggested optimum application rates of mineral fertilizers ensuring the sustainable development of meadow herbs.

The objective of this study was to determinate the effect of different organic manures (beef manure, horse manure, swine manure, poultry manure), mineral fertilization and "no amended" plots (control) on nematode communities structure.

Materials and Methods

The study site was located at Križevci (46°01′ N, 16°32′ E), in northwest part of Croatia. The soil was classified as gleysol (FAO). Nematode communities were analyzed in cornfield (*Zea mays* L.) in six treatments. In the summer of 2007, experimental field was not planted with any crop, while weeds were treated with glyphosate. In the autumn 2007 deep harrowing was. In the spring 2008 experimental plot was planted with corn. Application of fertilizers was conducted on 01^{st} April 2008 by harrowing. The size of an experimental plot was $70m^2$ (7m x 10m). Six different treatments were organized in randomized block design in four replications: 1. Control plot (CO); 2. Mineral fertilization (MF) with 833 kg ha^{-1} complete mineral fertilizer NPK (6:18:36), 163 kg ha^{-1} urea and 278 kg ha^{-1} calcium ammonium nitrate (KAN) 27%; 3. Beef manure (BM) with 10 t ha^{-1}; 4; Horse manure (HM) with 10 t ha^{-1}; 5. Swine manure (SM) with 10 t ha^{-1}; 6. Poultry manure (PM) with 6 t ha^{-1}. The top soil layer (0-30 cm) was analyzed for pH_{KCl}, humus, phosphorus, potassium and electrolytic conductivity (EC) in July of 2008 (Table 1). Nutritional status of soil was made by extractions with

Table 1
Soil chemical properties of the experimental plots

Soil properties (means of six samples: sampling at July of 2008; 0-300 mm depth)						
Treatments	Humus, %	Concentrations (mg/kg) in 0-300 mm soil depth				
		pH	pH	AL-method mg/100g		EC
		H_2O	KCl	P_2O_5	K_2O	dSm^{-1}
CO	1.58	5.8	4.34	10.04	10.53	0.695
MF	1.54	5.38	4.30	8.43	8.53	1.014
BM	1.56	5.75	4.32	11.27	10.53	0.504
HM	1.65	5.77	4.50	14.07	12.28	0.412
SM	1.65	5.92	4.61	13.59	11.23	0.457
PM	1.65	6.37	5.41	9.89	11.23	0.676

AL-solution (Egner et al., 1960) and with ammonium-acetate + EDTA (pH 4.65) according Lakanen and Ervio (1971). Soil reaction and organic matter were determined according to ISO (1994, 1998).

The samples were collected by probe Ø 2cm, to a depth of 20 cm. Samples were placed in a separate plastic bag and stored in a 4°C until nematodes were extracted from the soil. Nematodes were extracted from 100 g sub sample of soil by the Seinhorst method (Seinhorst, 1956), at the Faculty of Agriculture in Osijek, in Laboratory of Nematology. Nematodes were identified to genus level. Number of genera were determined and compared between treatments. Each of identified nematode genera were qualified to a trophic group (plant-parasitic, bacteria feeder, fungal feeder, omnivore or predatory) as specified by Yeates et al. (1993) and graduate as a colonizer-persister value (c-p value) (Bongers, 1990).

Fourteen community indexes were calculated. Maturity indexes were calculated in four different ways: Maturity index (MI), MI = $\Sigma (v_i \times f_i)/n$, where v_i is c-p value for non-parasitic nematodes to the i-th nematode genus and f_i is the frequency of non-parasitic nematodes and n is the total number of individual nematodes in the sample (Bongers, 1990); Modified Maturity index (MI2-5), MI2-5 = $\Sigma (v_i \times f_i)/n$, same as MI excluding non-parasitic nematodes with cp1 (Bongers, 1990); Plant-parasitic index (PPI), PPI = $\Sigma (v_i \times f_i) / n$ where v_i is c-p value for the plant-parasitic nematodes to the i-th nematode genus and f_i is the frequency of plan-parasitic nematodes genus i and n is the total number of individual nematodes in the sample (Bongers, 1990); Maturity index ratio (PPI/MI) (Bongers et al., 1997). Diversity of trophic groups was calculated with five different indexes: Shannon index (H'), H' = $-\Sigma p_i (\ln p_i)$, where p_i is the proportion of individuals in the i-th taxon (Shannon and Weaver, 1949); Hills index ($N1$), $N1 = e^{H'} = \exp[-\Sigma p_i (\ln p_i)]$ (Neher et al., 2004); Simpson index (λ), $\lambda = \Sigma p_i^2$, where p_i is the proportion of individuals in the i-th taxon (Simpson, 1949); Hills index ($N2$), $N2 = 1/\lambda$(Neher et al. 2004; Ludwig and Reynolds, 1988); Evenness index (E), E = H'/LN(S), where S is number of trophic groups (Ludwig and Reynolds, 1988). Five indexes of trophic group ratios were calculated: Enrichment index (EI), EI = 100 x (e/e+b), where e is nematodes from bacterial-feeding (cp 1) and fungal-feeding (cp 2) groups and b is nematodes of all feeding habits classified as cp 2 (Ferris et al., 2001); Structure index (SI), SI = 100 x (s/s+b), where s is nematodes of all feeding habits classified as cp from 3-5 (Ferris et al., 2001) and Channel index (CI), CI = 100 x ($Fu_2 W_2/e$), where Fu_2 is nematodes from fungal feeding habits classified as cp 2 and $W_2 = 0.8$ (Ferris et al., 2001); Ratio of bacterivours plus fungivorous to plant parasites (F+B/PP), (Wasilewska, 1994); Ratio of fungi-feeding to bacteria-feeding nematodes (F/B), (Hendrix et al.,1986). The data were analyzed statistically on computer program Statistica 6.0.

Results and Discussion

Thirty-nine genera of soil nematodes were determined under six different treatments. There were no significant changes in number of genera between the treatments. Five trophic groups occurred (bacterivorous, plant-parasitic nematodes, fungivorous, omnivorous and predators) in investigation. Bacterivorous and plant-parasitic nematodes were the most abundant trophic groups in all treatments. Plots treated with organic and mineral fertilizer slightly increased number of plant-parasites nematodes in compared to control. Neher (1999) reported similar results of certified organically and conventionally managed soils in the Piedmont region of North Carolina, but some other authors' reports results that numbers of plant-parasitic nematodes decrease after additions of organic amendments (Clark et al., 1998). The fungivorous nematodes slightly increased while the omnivores slightly decreased in soil treated with mineral and organic fertilizers in compared to the control plots. Our results were in agreement with results of Bulluck et al. (2002). Trophic structure presented in Figure 1.

Results of Disturbance indexes (MI, PPI, PPI/MI, MI25) as well as statistic analyses are present in Table 2. Significant differences between treatments were observed in MI and in MI25. Statistically lower MI value in MF plots in compared with CO plots indicates more disturbed environmental conditions. Zhang et al. (2009) confirmed the lower MI values in treatment with inorganic fertilizers (NPK, NP) and connect them with unfavorable environmental conditions. Nematode communities with high MI values are associated with more stable soil ecosystems (Bongers, 1999; Ferris et al., 2001). A significant difference between CO and MF, HM and PM plots in MI2-5 value also demonstrates change in nematode communities. Although PPI and PPP/MI did not show statistically significant differences between treatments slightly increased values in MF plots confirmed considerable disorder in nematodes communities' structure.

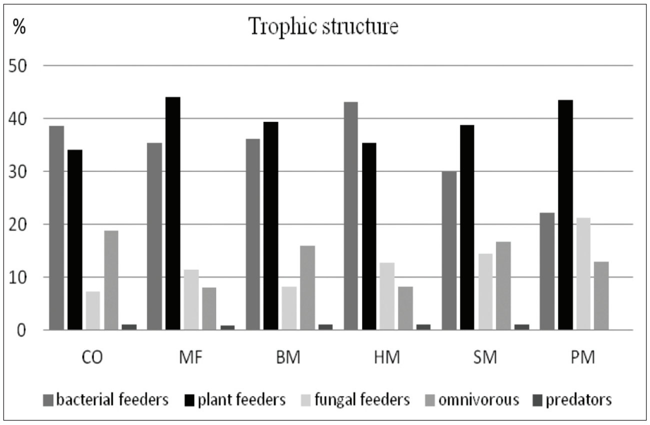

Fig. 1 Trophic structure in different treatments

Results of Diversity indexes (H', *N*1, λ, *N*2) as well as statistic analyses are present in Table 2. Number of abundant species (*N*1) and very abundant species (*N*2) was highest in SM plots and smallest in MF plots with no statistically significant differences between treatments. λ describe the relative abundance and evenness of the occurrence of five nematode trophic groups (Neher et al., 2004) and differences in λ values between the treatments were relatively small.

Results of ecological index E and food web indexes (EI, SI, CI, F+B/PP, F/B) as well as statistic analyses are present in Table 3. E did not show statistically differences between the treatments. EI respond positively to disturbance, where plots treated with MF had highest value. Leroy et al. (2009) observed the values of EI were intermediate between amended and no amended

Table 2
Results and statistically analyses of Disturbance and Diversity indexes

Treatments	Disturbance indexes				Diversity indexes			
	MI	MI2-5	PPI	PPI/MI	H'	N1	λ	N2
CO	2.60 a	3.11c	2.66 a	1.04 a	1.27 a	3.56a	0.31 a	3.20a
MF	1.88 b	2.74ab	2.83 a	1.54 a	1.18 a	3.28a	0.36 a	2.84a
BM	2.10 bc	2.89bc	2.58 a	1.29 a	1.21 a	3.36a	0.33 a	3.02a
HM	1.98 b	2.52a	2.53 a	1.28 a	1.20 a	3.32a	0.35 a	2.90a
SM	2.42 ac	2.89bc	2.76 a	1.16 a	1.28 a	3.60a	0.30 a	3.32a
PM	2.19 abc	2.66ab	2.63 a	1.20 a	1.25 a	3.48a	0.32 a	3.15a
LSD 0.05	0.4294	0.3384	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
n.s. – not statistically different								

Table 3
Results and statistically analyses of Ecological index and Food web indexes

Treatments	Ecological index	Food web indexes				
	E	EI	SI	CI	F+B/PP	F/B
CO	0.79 a	76.42a	82.13c	8.73a	1.41a	0.18a
MF	0.73 a	79.87a	65.22ab	14.68a	1.09a	0.37a
BM	0.75 a	76.93a	80.34bc	15.92a	1.14a	0.25a
HM	0.74 a	76.89a	55.29a	12.70a	1.67a	0.30a
SM	0.79 a	74.22a	73.30bc	21.78a	1.15a	0.50a
PM	0.77 a	75.12a	68.19abc	19.77a	1.22a	0.54a
LSD 0.05	n.s.	n.s.	16.82	n.s.	n.s	n.s
n.s. – not statistically different						

plots with not significant differences between treatments. SI did show significant differences between treatments. Tsiafouli et al. (2007) observed that SI increase with increasing contribution of predators and omnivores, which have the high c-p values. CI increased with the addition of fertilizers to the soil. Higher CI is indicates a shift from a more bacterial to a more fungal mediated decomposition pathway (Ferris et al., 2001). F+B/PP values decreased with the addition of mineral fertilizer, which is related to a smallest density of bacterivorous and fungivorous population. Addition of organic and inorganic fertilizers increased F/B ratio, which indicated a switch to fungal pathway and possibly slower rate of organic matter turnover (Porazinska et al., 1999).

Conclusion

Effect of organic and inorganic fertilizers on nematode communities in cornfield had influence on changing nematode communities. Application of fertilizers in the soil decrease genera of omnivorous nematodes and increases genera of fungivorous and plant-parasitic nematodes. Disturbance indexes, especially MI and MI25, manifested the sensitivity of nematode community's changes in soil and showed differences between untreated soil and soil treated with mineral fertilizer. Diversity and ecological indexes did not show significant differences between treatments and sensitivity to changes in soil. Changes in nematode community structure in soil food web were affected by addition of organic and inorganic fertilizers in soil, and the most disturbed community was observed in treatment with mineral fertilization. Measures of nematode community were functional in providing the information about processes in soil and reflect differences in soil ecosystem. Mineral and organic fertilizers used in the study reduced the total number of nematodes, the number of genera, reduced the population density of omnivorous and increased populations of plant parasitic nematodes and fungivorous. It is necessary to balance fertilization of agricultural land to preserve the richness of biodiversity in the community of soil organisms and ecosystem stability. Differences between treatments confirm that there are differences in the trophic biodiversity in soil nematode communities in the appendix of various organic and mineral fertilizers.

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