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The trophic diversity of nematode communities in soils treated with vermicompost

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Summary

The effects of vermicomposts on plant parasitic, fungivorous and baterivorous nematode populations were investigated in grape (*Vitis vinifera*) and strawberry (*Fragaria ananasa*) field crops. Commercially-produced vermicomposts derived from recycled paper, and supermarket food waste were applied to replicated plots at the rates of 2.5 t ha^{-1} or 5.0 t ha^{-1} for the grape crop and 5.0 t ha^{-1} or10 t ha^{-1} for the strawberry crops. All vermicompost treatments were supplemented with inorganic fertilizer to balance the initial availability of macronutrients especially N, to the crop in all plots. After extraction from soil samples in Baermann funnels, nematodes were identified to trophic levels under a stereomicroscope. Soils from all of the vermicompost-treated plots contained smaller populations of plant parasitic nematodes than soil from inorganic fertilizer-treated plots. Conversely, populations of fungivorous nematodes and to lesser extent bacterivorous nematodes increased in the vermicompost-treated plots in comparison with those in plots treated with inorganic fertilizers.

Key words: Nematodes, vermicomposts, trophic levels, organic wastes

Introduction

Vermicomposts are organic amendments derived from the decomposition and stabilization of organic wastes by interactions between microorganisms and earthworms. The use of vermicomposts in the production of commercial greenhouse crops has been investigated in our laboratory and substitution of small amounts into soilless growth media has proven to be a valuable practice to increase plant growth, boost plant yields and improve the physical properties of soils (Atiyeh et al. 1999, 2000a,b, 2001a,b). Vermicomposting converts soil nutrients into plant-available forms such as extractable N, soluble K, Ca, Mg and exchangeable P that are taken up readily by plants (Edwards 1988; 1998; Atiyeh et al. 2000a,b). Vermicomposts have been reported to increase microbial activity in soils considerably and there is evidence that the production of plant growth regulators such as gibberellins, cytokinins and auxins and humates by microorganisms may promote plant growth independent of nutrient supply (Tomati et al. 1990; Atiyeh et al. 2002). Vermicomposts can suppress plant diseases such as *Plasmodiophora* in tomatoes and cabbages, *Pythium* and *Rhizoctonia* in cucumbers and radishes and

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Verticillium in strawberries (Chaoui et al. 2002). Various forms of organic matter have been reported to suppress populations of plant parasitic nematodes (Addabdo 1995) and preliminary experiments in our laboratory have shown that vermicomposts can diminish populations of plant parasitic nematodes and increase populations of fungivorous and bacterivorous nematodes in field crops (Arancon et al. 2002).

The objective of our investigation was to determine the effects of vermicomposts on the community structure of nematodes in grapes and strawberry crops and particularly on populations of plant parasitic nematodes which cause economic crop losses. We established field experiments on grapes and strawberries treated with vermicomposts to study these effects. Our hypothesis was that populations of plant parasitic nematodes would decrease in plots treated with vermicomposts compared with those receiving inorganic fertilizers only whereas populations of fungivorous and bacterivorous nematodes would increase in these plots.

Materials and Methods

The grape field experiment was at the Ohio Agricultural Research and Development Center (OARDC), Grape Research Branch in North Kingsville, Ohio which had a soil classified as Bogart sandy loam. The strawberry field experiment was at the OARDC, Piketon Research and Extension Center in Piketon, Ohio on a DoA-Doles silt loam soil. There were four replicate plots per treatment. Commercial vermicomposts produced from food waste, cow manure and recycled paper were applied at rates of 2.5 t ha^{-1} or 5.0 t ha^{-1} to grape plots measuring 1.5 × 5.5 m and 5 t ha^{-1} or 10 t ha^{-1} to the strawberry plots measuring 1 × 3 m. Food waste vermicompost contained 1.3 % N, 2.7 % P, 9.2 % K, 4.4 % Mg, 2.6 % S and 1.0 % Na whereas paper waste vermicompost contained 1.0 % N, 2.7 % P, 6.2 % K, 4.5 % Mg, 1.8 % S, and 1.0 % Na. Plots treated with recommended rates of inorganic fertilizers (85–155–125 kg NPK ha^{-1}) as a comparative control were used and all vermicompost – treated plots were supplemented with amounts of inorganic fertilizers to balance the initial levels of available N in all treat-

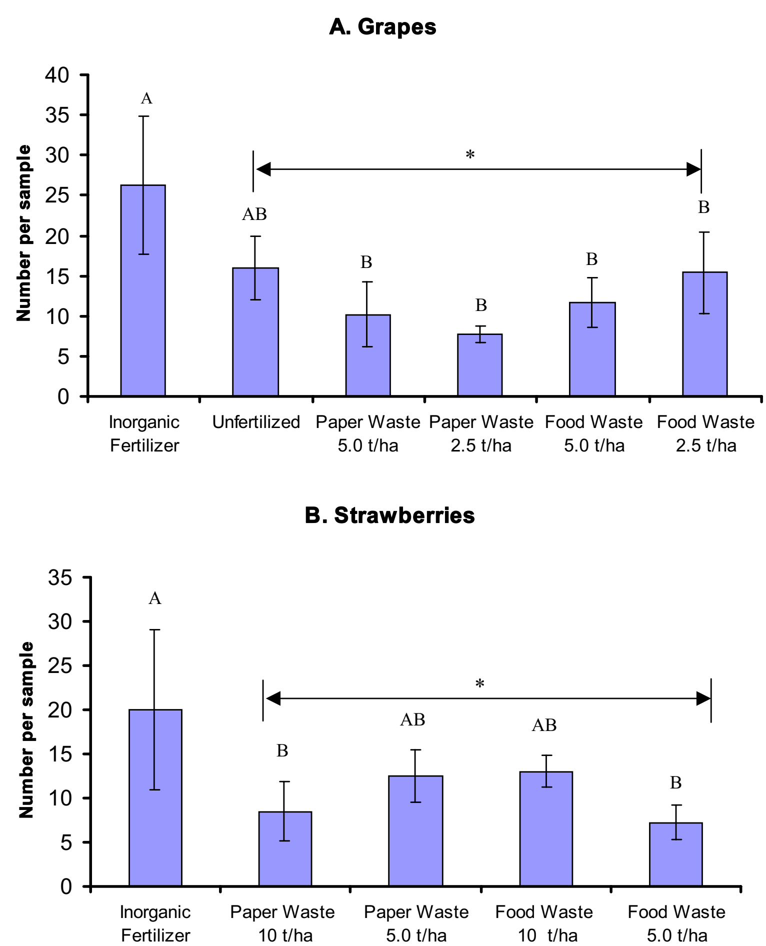


Fig. 1. Numbers of plant parasitic nematodes in inorganic fertilized treated, paper waste treated, food waste treated and unfertilized plots of grapes (A) and strawberries (B). Means ± SE followed by the same letter(s) are not significantly different at P ≤ 0.05. Grouped means designated by inclusion line with an asterisk (*) are significantly different from the control (inorganic fertilizer)

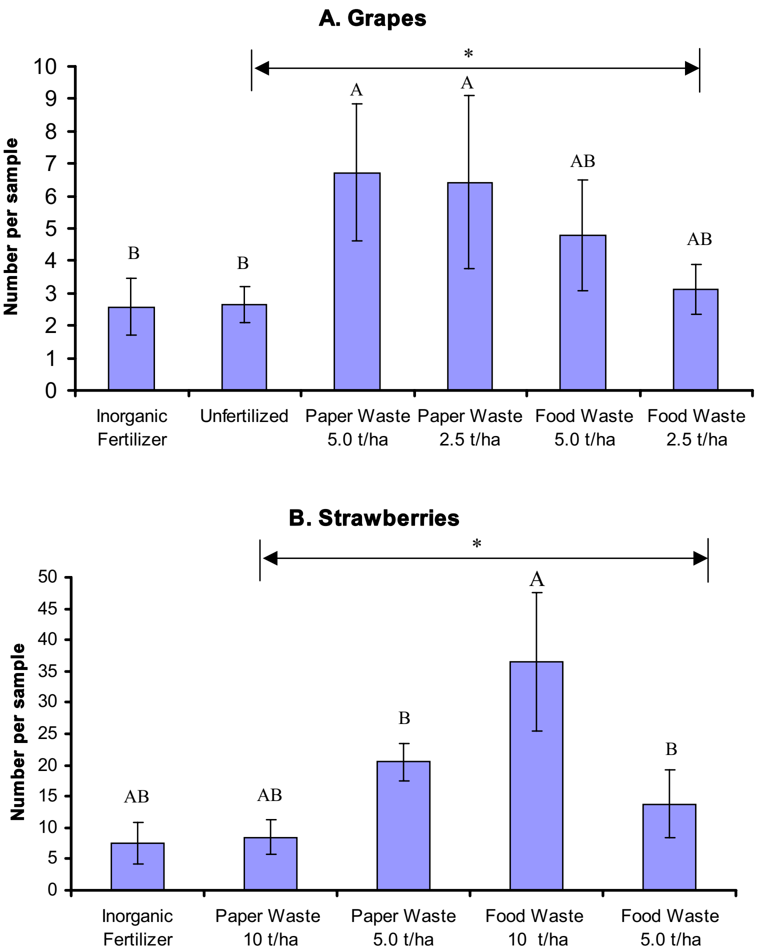


Fig. 2. Numbers of fungivorous nematodes in inorganic fertilized treated, paper waste treated, food waste treated and unfertilized plots of grapes (A) and strawberries (B). Means ± SE followed by the same letter(s) are not significantly different $P \leq 0.05$. Grouped means designated by inclusion line with an asterisk (*) are significantly different from the control (inorganic fertilizer)

ments. A set of plots in the grape experiment was left untreated with inorganic fertilizers or vermicomposts. Vermicomposts were incorporated into top 15 cm of vermicompost strawberry plots using a roto-tiller and applied to the surface of grape plots. After surface vermicompost applications, straw mulch was laid over the soil surface of all grape plots. Black plastic mulch and an irrigation system were installed in all treatments in the strawberry plots.

Eight soil cores (2.5 cm diameter × 20 cm deep) were taken from root zones of each plot 16 weeks after vermicompost applications. Using a Baermann funnel extraction technique (McSorley & Welter 1991), nematodes were extracted into water from 20 g soil samples for 48 h. Nematodes were identified to trophic levels under a stereomicroscope at a 40 to 60 magnification.

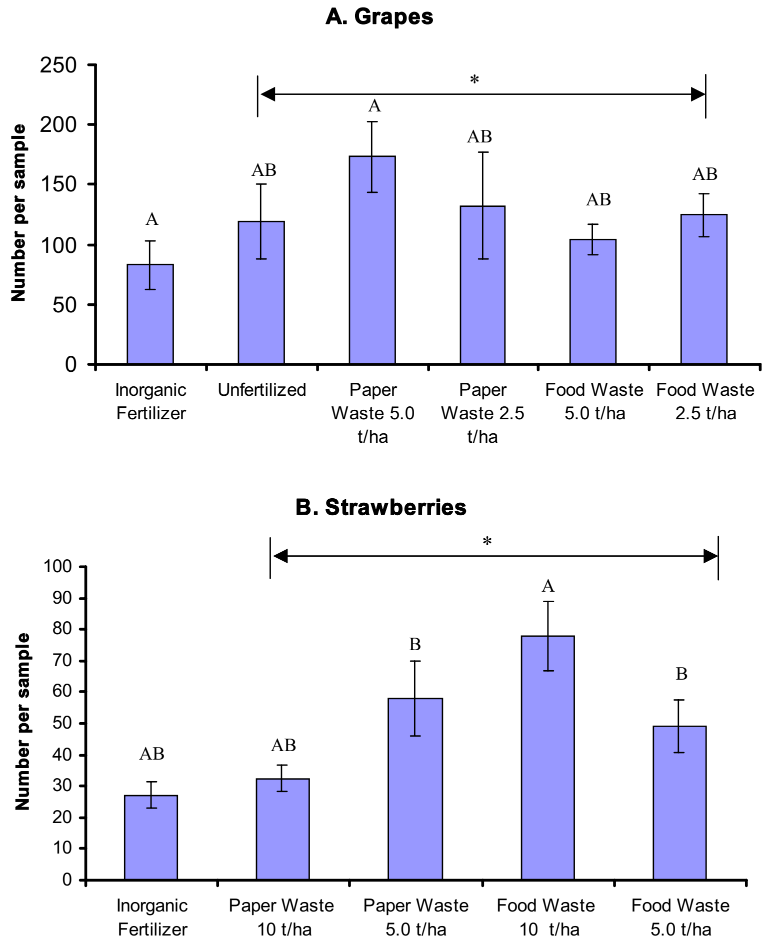
One-way ANOVA was used to determine significant differences among treatments and the Least Significant Difference (LSD) was used to separate differences treatment means at $P \leq 0.05$ level of significance. Grouped mean comparisons were made using orthogonal contrasts with a single degree of freedom, to separate statistical differences between the nematode population means in the inorganic fertilizer control plots and those in the vermicompost treated plots using the SAS (SAS Ins. 1990) statistical package.

Results and Discussion

In the soils, under both grapes and strawberries, there were fewer plant parasitic nematodes in the soil from the vermicompost-treated plots ($P \leq 0.05$) compared to those in soils from the plots treated with inorganic fertilizer (Fig. 1). Moreover, the soils from vermicompost-treated plots had larger populations of fungivorous nematodes (Fig. 2) and tended to also support more bacterivorous nematodes than those from the inorganic control plots (Fig. 3). These results were statistically significant at the $P \leq 0.05$ for the plant parasitic, bacterivorous and fungivorous nematode populations under both crops.

The results from these experiments demonstrate clearly that the treatment of soils with vermicomposts suppressed populations of plant parasitic nematodes significantly and contributed to the increased yields

Fig. 3. Numbers of bacterivorous nematodes in inorganic fertilized treated, paper waste treated, food waste treated and unfertilized plots of grapes (A) and strawberries (B). Means ± SE followed by the same letter(s) are not significantly different $P \leq 0.05$. Grouped means designated by inclusion line with an asterisk (*) are significantly different from the control (inorganic fertilizer)



that were recorded. Other workers have reported similar decreases in populations of parasitic nematode populations in plots treated with vermicomposts (Ribeiro et al. 1998; Morra et al. 1998; Swathi et al. 1998). Arancon et al. (2002) reported significant suppression of plant parasitic nematode populations and increases in fungivorous nematode populations in plots of tomatoes, bell peppers, strawberries and grapes treated with vermicomposts. However, the mechanisms which caused these changes are still only speculative. It may be due to increased competition between plant parasitic nematodes and fungivorous and bacterivorous nematodes, resulting from increased availability of food sources for the latter two groups after the vermicompost treatments. Vermicomposts promote microbial activity by providing resources for growth of soil bacteria and particularly fungi (Edwards 1998). Less organic matter was available for microbial growth in the plots treated with inorganic fertilizers compared to those treated with vermicomposts.

Predator-prey interactions may also have contributed to lower density of plant parasitic nematodes in vermicompost-treated plots. Vermicomposts may increase numbers of predatory or omnivorous nematodes, or arthropods such as mites, that prey selectively on plant parasitic nematodes (Bilgrami 1996). Vermicomposts promote the growth of nematode-trapping fungi and fungi that attack nematode cysts and, may thereby influence populations of plant parasitic nematodes (Kerry 1998). Additionally, rhizobacteria colonize roots and kill plant parasitic nematodes by producing enzymes and toxins that are toxic to them (Siddiqui & Mahmood 1999) and nematodes may be killed by the release of toxic substances such as hydrogen sulphide, ammonia, and nitrites, during vermicomposting (Rodriguez-Kabana 1986).

We found a greater influence of vermicomposts on fungivorous than on bacterivorous nematode populations. Fungi serve as a major source of food for earthworms and earthworms facilitate dispersal of fungi by excreting fungal spores in their casts (Edwards & Fletcher 1998), which may explain the greater impact of vermicomposts on fungivorous than on bacterivorous nematode populations. In addition, cyst fungi and nematode-trapping fungi attack plant parasitic nematodes thereby decreasing the populations significantly (Kerry 1998).

Vermicomposts have demonstrated considerable potential to provide valuable increases in crop yields (Atiyeh et al. 2000a,b, 2001a,b) and our data show that they also control plant parasitic nematodes. The costs of vermicomposts, at the low application rates which have proved to be effective (Arancon et al. 2002) are much lower than those of nematicides. In addition, vermicomposts are a natural way to add nutrients and plant-growth regulators to the soil, control diseases and prevent soil contamination.

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