Management of plant parasitic nematode populations by use of vermicomposts

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ABSTRACT

Commercial vermicomposts, produced from cattle manure, food and recycled paper wastes, were applied at rates of 5 t/ha, 10 t/ha and 20 t/ha, to field plots planted with tomatoes (*Lycopersicon esculentum*) bell peppers *(Capsicum anuum grossum*), strawberries (*Fragaria ananasa*) or grapes (*Vitis vinifera*). Control plots were treated with inorganic fertilizers only, and all vermicompost-treated plots were supplemented with inorganic fertilizers, to equalize levels of available N in all plots. Nematodes populations were estimated by after extraction in Baermann funnels and nematodes were identified and classified to trophic level. Populations of plant-parasitic nematodes were depressed significantly by the three vermicomposts in all four field experiments compared with those in plots treated with inorganic fertilizer. Conversely, populations of fungivorous and bacterivorous nematodes tended to increase consistently compared with those in the inorganic fertilizer-treated plots.

INTRODUCTION

There has been a growing interest in finding ways of decreasing the use of inorganic fertilizer and pesticides in agricultural production. These include adoption of new crop varieties that use soil nutrients more efficiently and better use of organic matter. The use of organic amendments, like traditional thermophilic composts, has been long recognized as an effective means of improving soils, increasing plant growth and yields, and suppressing plant diseases. Vermicomposts are a new form of organic soil amendment that have considerable potential in crop production. Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacities, and low C:N ratios produced from organic wastes stabilized by interactions between earthworms and microorganisms (Edwards, 1998). They contain nutrients such as nitrates, exchangeable calcium, phosphorus, and soluble potassium that are taken up readily by plants. Vermicomposts have large surface areas that provide many microsites for microbial activity and for the strong retention of nutrients. Additionally, vermicomposts have been reported to have outstanding biological properties and have microbial populations that are significantly larger and more diverse compared with those of conventional thermophilic composts (Edwards, 1998). The considerable improvements in plant growth recorded after amending soils with vermicomposts have been attributed to the physico-chemical and biological properties of vermicomposts. However, there is now considerable evidence that other biological factors are involved which cause plants to germinate and grow better (Edwards, 1998). Applications of vermicomposts have been reported to suppress plant diseases such as

Phytophthora, *Fusarium*, and *Plasmodiophora* in tomatoes and cabbage, *Pythium* and *Rhizoctonia* in cucumber and radish and *Verticillium* in strawberries (Chaoui, *et al.*, 2002). A comprehensive review concluded that various forms of organic matter amendments can often suppress plant parasitic nematode populations (Addabdo, 1995). Our experiments were designed to assess whether vermicomposts possess properties which suppress plant parasitic nematode populations.

MATERIALS AND METHODS

Vermicompost treatments

Plots were replicated for each treatment with one of three different types of vermicompost. Commercial cattle manure, food and paper waste-based vermicomposts were applied at rates of 20 and 10 t/ha to tomatoes and peppers. Food waste and paper waste-based vermicomposts were applied at 10 and 5 t/ha to strawberries and grapes. One set of replicate plots received a full recommended rate of inorganic fertilizer for all crops. A second set received recommended rates of traditional leaf composts in the tomato and pepper experiments. The grape experiment had one set of replicated control plots treated with the full recommended rates of inorganic fertilizer and another with no fertilizer. All of the vermicompost- and compost-treated plots were supplemented with inorganic fertilizers, in order to balance the initial nutrient supply as far as possible with that in the inorganic fertilizer treatment (except for the unfertilized control). Vermicomposts, composts and inorganic fertilizers were incorporated into the top 15 cm of the beds in the tomato, pepper and strawberry plots with a roto-tiller and vermicompost treatments were surface-applied and covered with straw mulch in the grape plots.

Test crops

Tomato seedlings (var. BHN 543 F1) were transplanted into a single row in each bed measuring 1.5 x 5.5 m (8.25 m^2 per plot) with 38 cm between plants, totaling 12 four-week-old seedlings in each raised bed. Plastic mulch and drip irrigation systems were constructed over the raised beds after vermicompost and fertilizer applications. Plants were staked 4 weeks after transplanting and tied to a twine trellis accommodating 2 plants between stakes. Suckers were removed up to the one below the first flower cluster. All treatments were replicated four times in a randomized complete block design. Guard rows measuring 1.5 x 5.5 m (8.25 m^2 per plot) were set between each block.

Pepper seedlings (var. 'King Arthur'), 24 four-weeks-old, were transplanted into two rows in each raised bed measuring 1.5 x 5.5 m (8.25 m^2 per plot). Seedlings were planted in a staggered pattern relative to plants in the other row spaced 38 cm between plants and 38 cm between rows. Plastic mulch and drip irrigation systems were constructed over the raised beds. Treatments were replicated four times in a randomized complete block design. Guard rows measuring 1.5 x 5.5 m (8.25 m^2 per plot) were set between each block

Strawberry seedlings (var. 'Chandler') were grown under a high plastic tunnel hoop house structures measuring 9.14 x 14.6 x 3.6 m. Twenty-four six-week-old seedlings were transplanted into each plot (4.5 m^2) spaced 38 cm between plants with three rows spaced 38 cm between rows. Plants in the middle row were planted in a staggered design with respect to the outer rows to maximize distances between plants. Plastic mulch, mini-sprinklers and drip irrigation systems were constructed over the raised beds after vermicomposts and fertilizer applications. Cotton mesh row covers were used for frost protection. Treatments were replicated four times in a completely randomized design. There were guard rows (1.5 wide x 12 m) around the perimeter of the experiment.

Grape vines (var. Seyval) were used in the grape experiment. Each plot measured 1.5 X 3 m (4.5 m^2/plot) and contained three 10-year-old vines. Treatments were replicated 8 times in a randomized complete block design.

Assessment of nematode populations

Eight soil core samples, 2.5 cm diameter x 20 cm deep, were taken randomly from each replicate plot. The samples were taken from the root zones of tomatoes, peppers, strawberries and grapes at the end of the growing season. Nematodes were extracted for 48 hours from 20g subsamples per plot, with 3 replicates, using a Baermann funnel extraction method **(**McSorley & Welter, 1991). Nematodes were identified and classified to trophic level under a stereomicroscope. Grouped means comparisons were made, using orthogonal contrasts, to separate statistical differences between nematode population means in inorganic fertilizer controls, thermophilic composts and vermicompost treatments using SAS statistical package (SAS Ins., 1990).

RESULTS

The effects of vermicomposts on populations of plant parasitic nematodes are summarized in Figure 1, those on fungivorous nematodes in Figure 2 and those on bacterivorous nematodes in Figure 3. Populations of plant parasitic nematodes in all of the vermicompost-treated soils were suppressed significantly for all crops ($P < 0.01$) compared to those in plots treated with inorganic fertilizers only. Populations of plant parasitic nematodes were larger in plots treated with inorganic fertilizer than in those to which no fertilizer was applied. The populations of bacterivorous and fungivorous nematodes were significantly larger in response to most of the vermicompost treatments, compared to those in plots treated with inorganic fertilizer, in the strawberry and grape experiments. There were also increases that were not statistically significant in tomatoes and peppers. The effects did not appear to be correlated with the application rates or type of vermicomposts. Populations of fungivorous and bacterivorous nematodes in the unfertilized grape plots were significantly smaller than those in plots treated with vermicomposts and were similar to those in the inorganic fertilizer plots.

DISCUSSION

The addition of all of the various types of vermicomposts, to the soils in all four experiments, suppressed significantly populations of plant parasitic nematodes (Figure 1). Similar suppressions were reported in a review that concluded that additions of various composted or other types of organic matter to soils often decreased populations of plant parasitic nematodes (Addabdo, 1995).

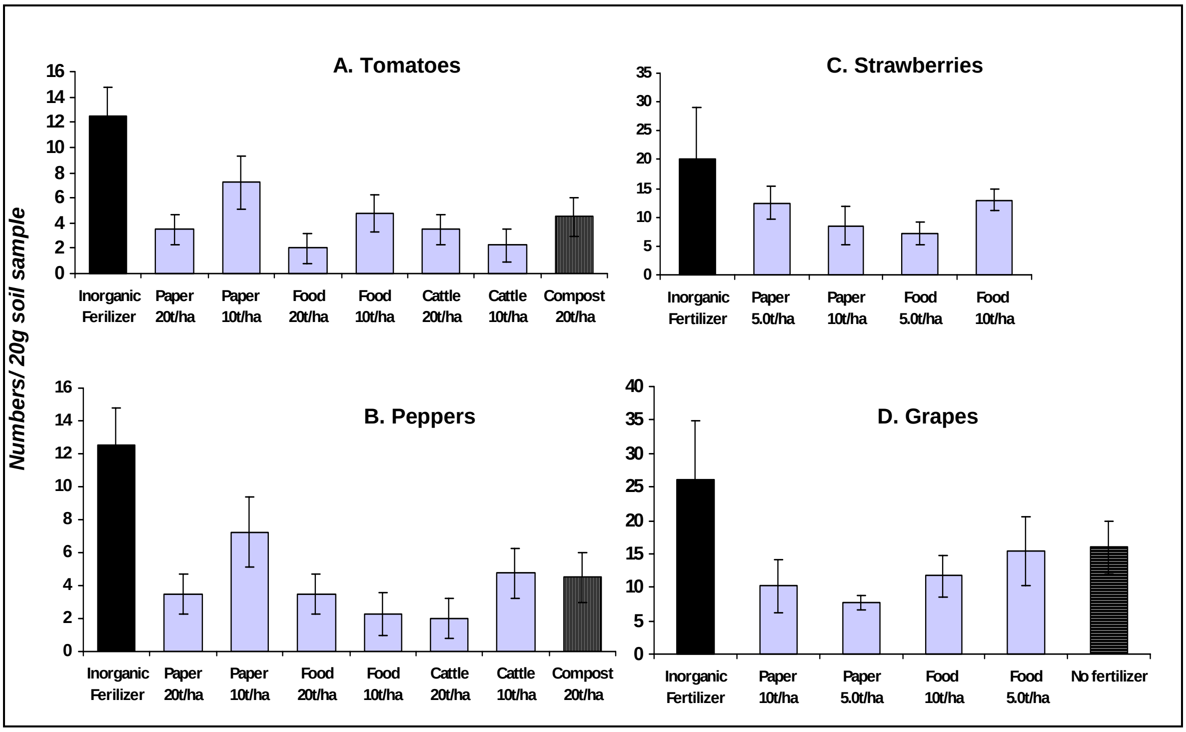
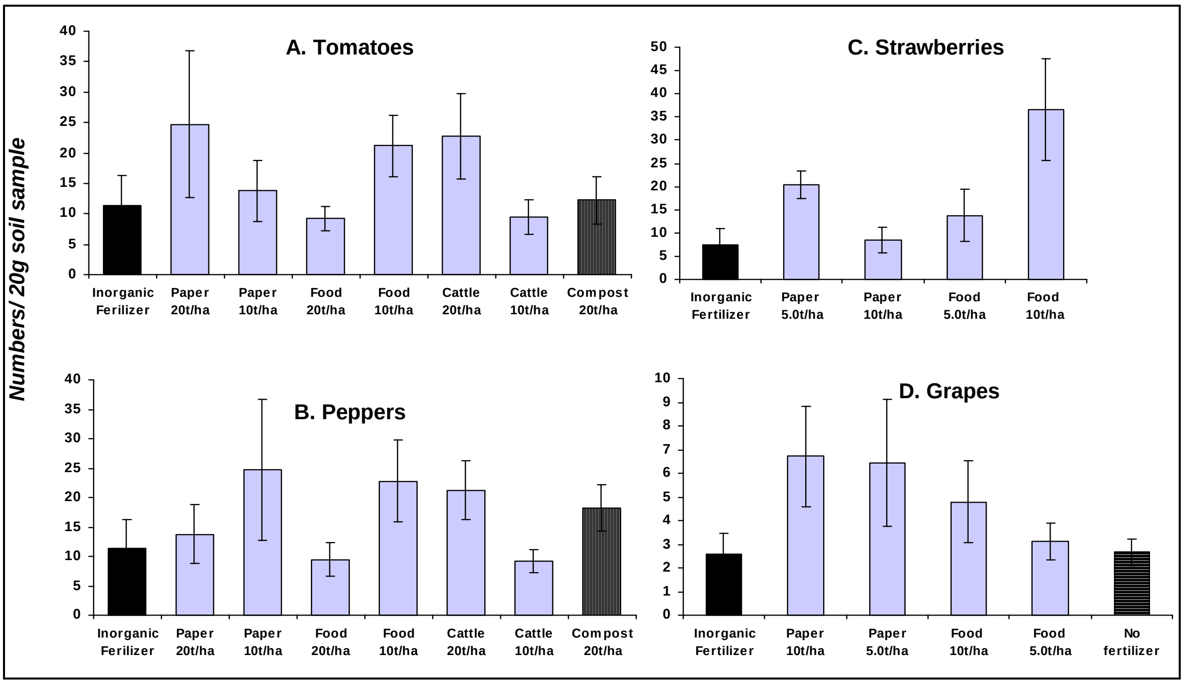


Figure 1: Numbers (Means ± SE) of plant parasitic nematodes in inorganic fertilizer-treated (■), vermicompost-treated (□), compost-treated (▥) and unfertilized (▤) soils planted with tomatoes (A), peppers (B), strawberries (C), and grapes (D).



Figures 2: Numbers (Means ± SE) of fungivorous nematodes in inorganic fertilizer-treated ( ), verm■ompost-treated ( ), comp□t-treated (▥ and unfertilized (▤) soils planted with tomatoes (A), peppers (B), strawberries (C), and grapes (D).

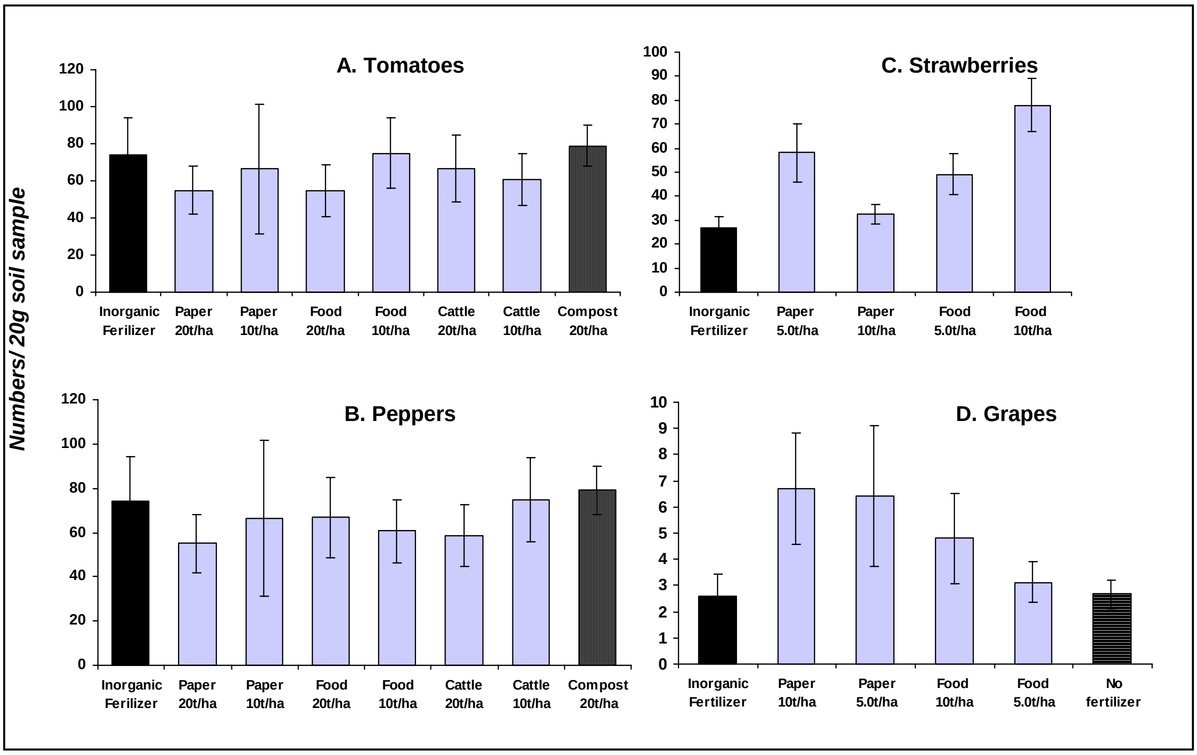


Figure 3. Numbers (Means ± SE) of bacterivorous nematodes in inorganic fertilizer-treated (■), vermicompost-treated (□), compost-treated (▥), and unfertilized (▤) soils planted with tomatoes (A), peppers (B), strawberries (C), and grapes (D).

There are also numerous reports that traditional thermophilic composts can suppress populations of plant parasitic nematodes e.g. McSorley & Gallaher (1995). We recorded similar suppression of plant parasitic nematode populations by vermicomposts in soils planted with tomatoes, peppers, strawberry and grapes (Figs. 1 A, B, C, D). There are a few preliminary reports of vermicomposts suppressing populations of plant parasitic nematodes. Swathi *et al*., (1998) demonstrated that 1 kg/m^2 of vermicompost suppressed attacks of *Meloidogyne incognita* on tobacco plants. Morra et al. (1998) demonstrated partial control of *Meloidogyne incognita* by vermicomposts in a tomato-zucchini rotation. Ribiero et al. (1998) reported that vermicomposts decreased the numbers of galls and egg masses of *Meloidogyne javanica*. The mechanisms by which vermicomposts and composts suppress plant diseases and plant parasitic nematodes are still speculative but it may be due to increased competition from fungivorous and bacterivorous nematodes resulting from increased availability of food sources after vermicompost and compost applications. There is good evidence (Edwards, 1998) that earthworms greatly increase overall microbial activity in organic wastes greatly by providing fragmented organic materials for microbial growth of soil bacteria and fungi. Soils that were treated with inorganic fertilizers only had much less organic matter available for microbial growth compared to those in the vermicompost-treated soils.

The effects of applications of vermicomposts to soils were much greater on fungivorous nematode populations than on bacterivorous nematode populations. Earthworms depend upon fungi as a main source of food and tend to increase fungal activity in their casts by excreting fungal spores (Edwards & Fletcher, 1988) which may also explain why there were greater increases in populations of fungivorous nematodes than in those of bacterivorous nematodes. Moreover, plant parasitic nematodes are attacked by cyst fungi and nematode-trapping fungi populations of which could have increased in response to vermicompost applications (Kerry, 1988). The greater availability of microorganisms as a source of energy could increase the competitive ability of both bacterivorous and fungivorous nematodes as compared to plant parasitic nematodes.

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