Suppression of insect pest populations and damage to plants by vermicomposts

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Abstract

The effects of commercial vermicomposts, produced from food waste, on infestations and damage by aphids, mealy bugs and cabbage white caterpillars were studied in the greenhouse. Vermicomposts were used at substitution rates into a soil-less plant growth medium, MetroMix 360 (MM360), at rates of 100% MM360 and 0% vermicompost, 80% MM360 and 20% vermicompost, and 60% MM360 and 40% vermicompost to grow peppers (Capsicum annuum L.), tomatoes (Lycopersicon esculentum Mill.) and cabbages (Brassica oleracea L.), in pots. Groups of 10 pots containing young plants were distributed randomly in nylon mesh cages (40 cm × 40 cm × 40 cm). Groups of 10 pepper seedlings in a single cage were infested with either 100 aphids (Myzus persicae Sulz.) or 50 mealybugs (Pseudococcus spp.) per cage. Similar groups of tomato seedlings were infested with 50 mealy bugs per cage. Groups of four cabbage seedlings in pots in cages were infested with 16 cabbage white caterpillars (Pieris brassicae L.). Populations of aphids and mealy bugs were counted after 20 days and the shoot dry weights of peppers, tomatoes and cabbages were measured at harvest. Numbers of cabbage white caterpillars and loss in shoot weights were measured after 15 days. The substitution rates of 20% and 40% vermicomposts suppressed populations of both aphids and mealy bugs on peppers, and mealy bugs on tomatoes, significantly. Substitutions with vermicomposts into MM360 decreased losses of dry weights of peppers, in response to both aphid and mealy bug infestations, decreased losses in shoot dry weights of tomatoes after mealy bug infestations significantly. There were significantly decreased losses in leaf areas of cabbage seedlings in response to the cabbage white caterpillar infestations.

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1. Introduction

Vermicomposts are stabilized organic soil amendments that are produced by a non-thermophilic process, in which organic matter is broken down through interactions between earthworms and microorganisms, under aerobic conditions. Vermicomposts have been demonstrated to be valuable soil amendments that offer a balanced nutritional release pattern to plants, providing nutrients such as available N, soluble K, exchangeable Ca, Mg, and P that can be taken up readily by plants (Edwards, 1998; Edwards and Fletcher, 1988). Because the breakdown of organic wastes by earthworms is a non-thermophilic process, vermicomposts have much greater microbial biodiversity and activity than conventional thermophilic composts (Edwards, 1998, 2004).

There is an extensive scientific literature (Buckerfield and Webster, 1998; Atiyeh et al., 2000a–d; Arancon et al., 2003a,b; Edwards and Arancon, 2004a,b) demonstrating that additions of low application rates of vermicomposts, into bedding plant container media in the greenhouse, or as amendments to field soils, improve plant growth and yields significantly, independent of nutrient supply. For instance, Atiyeh et al.
N.Q. Arancon et al. / Bioresource Technology 96 (2005) 1137–1142

reported increases in the rates of germination, growth and yields of tomato plants, grown in a range of concentrations of a soilless commercial container medium MM360, that was substituted with a corresponding range of concentrations of pig waste vermicomposts. Subler et al. (1998) demonstrated improvements in the germination and growth of petunias, marigolds, bachelor buttons, poinsettias, bell pepper and tomatoes in response to similar vermicompost substitutions into bedding plant container media. The potential of vermicomposts to improve plant growth may be due to changes in the physico-chemical properties of soils, overall increases in microbial activity or to the effects of plant growth regulators produced by the micro-organisms.

Organic farmers have long claimed that plants grown with organic amendments are much more resistant to insect pests and diseases than plants grown with synthetic inorganic fertilizer amendments. This is supported by a scientific literature that provides evidence of suppression of specific insect attacks by various forms of organic amendments (Patriquin et al., 1995). For instance, reports have demonstrated that field applications of thermophilic composts can suppress attacks by insect pests such as aphids and scales (Culliney and Pimentel, 1986; Yardim and Edwards, 1998; Huelsman et al., 2000). Additionally, Biradar et al. (1998) showed that additions of vermicomposts to the medium in which Leucaena leucocephala was grown affected the extent of infestation by Heteropsylla cubana. Ramesh, 2000 reported that field treatments with vermicomposts decreased the occurrence of leaf miner, Aphroserema medicella on groundnuts.

The objectives of our investigations were to study the incidence of aphids (Myzus persicae Sulz.) and mealy bugs (Pseudococcus spp.) on tomatoes (Lycopersicon esculentum Mill.) and peppers (Capsicum annuum L.), and cabbage white caterpillars (Pieris brassicae L.) on cabbage (Brassica oleracea L.) in response to vermicompost substitution and to assess the damage caused by these pests. The experiment used a range of substitution rates of food waste vermicomposts, into a soilless plant growth medium (MM 360), compared with the same parameters on plants grown in Metro-Mix 360 only. We hypothesized that the vermicompost substitutions would provide resistance to insect attacks and decrease the extent of pest damage.

2. Methods

The experiments were conducted in the Biological Science Greenhouse at The Ohio State University, Columbus, Ohio in March 2003 and the experimental plants were tomatoes, peppers and cabbages. The growth medium was a soilless commercial greenhouse container bedding plant medium, Metro-Mix 360 (MM360), and the experiments involved substitutions of MM360 (Scotts, Marysville, OH) with one of two concentrations of a commercial food waste vermicomposts. The food waste vermicomposts used contained 1.3% N, 2.7% P and 9.2% K. MM360 is a preparation of vermiculite, Canadian sphagnum peat moss, bark ash, sand and has a starter nutrient fertilizer in its formulation.

Two tomato, pepper or cabbage seeds were sown into each 10 cm diameter pot, containing either 100% MM360, or 80% MM360 mixed with 20% vermicompost or 60% MM360 mixed with 40% vermicompost. Seedlings were thinned out to one seedling per pot seven days after transplanting. The vermicompost and pest treatments were: (1) Tomatoes or peppers grown in MM360 soilless growth medium (no pests); (2) Tomatoes or peppers grown in MM360 soilless medium (exposed to pests); (3) Tomatoes or peppers grown in a 20% food waste vermicompost and 80% MM360 mixture (exposed to pests); (4) Tomatoes or peppers grown in 40% food waste vermicompost and 60% MM360 mixture (exposed to pests).

Each experimental treatment, except for cabbage, involved 10 replicate pots for each plant species, confined in a single mesh cage. There were four experimental pest treatments in each cage for a total of 40 pots per pest species. The seedlings were raised in an insect-free environment for four weeks. In the fifth week, plants were arranged in groups of 10 pots, in mesh (0.2 mm aperture) cages 40 cm × 40 cm × 40 cm, on greenhouse benches. Batches of caged plants were placed on capillary mats for ease of watering under the mesh cages. Control plants were placed in similar cages without insect infestations, to use as a basis for the calculations of dry weight losses, for comparison with those of plants that were artificially infested with insects. The pest thrips released into the cages were reared under controlled conditions (20°C) in a greenhouse insectary.

Adult aphids (Myzus persicae) and mealy bugs (Pseudococcus spp.) and cabbage caterpillars (Pieris brassicae) were collected from the insectary. Each cage, containing either pepper or tomato plants, was infested with either 100 aphids or 50 mealy bugs. Cabbage seedlings were exposed to white cabbage butterflies (Pieris brassicae) in cages in glasshouse for four hours for egg laying. Young caterpillars were removed from the seedlings after three days except four young caterpillars left on each cabbage seedling, which were subsequently confined in similar cages in groups of four pots per cage, one seedling per pot, for each vermicompost/MM360 mixture, with four replicates of each pest treatment. After 20 days plant heights, leaf areas and dry shoot weights were measured and increases or decreases in these parameters were recorded and compared with similar parameters on non-infested plants. Numbers of adult aphids and mealy bugs were counted on each plant.
at the end of the experiment but not numbers of caterpillars since there was no mortality and the duration of the experiment was too short for any adult emergence or reproduction to occur.

The experiments were laid out in a randomized complete block design (RCBD) and one-way analysis of variance (ANOVA) was used to test hypotheses. Treatment means were compared and separated for significant differences by least significant differences (LSD) using SAS (SAS, Inc., 1990).

3. Results

The substitutions of food waste vermicomposts, into the soil-less container medium (MM360), decreased infestations by aphids significantly on pepper plants, grown in either 20% vermicompost with 80% MM360 or in 40% vermicompost with 60% MM360 significantly ($P \leq 0.05$) (Fig. 1A). Percentage losses in shoot dry weights were significantly smaller ($P \leq 0.05$) on pepper plants grown in 40% vermicompost with 60% MM360 than those of plants grown in 100% MM360 (Fig. 1B). Pepper plants grown in pots substituted with 20% vermicompost and 80% MM360, and 40% vermicompost and 60% MM360, suppressed numbers of mealy bugs significantly ($P \leq 0.05$) (Fig. 2A) and losses in shoot dry weights were significantly smaller ($P \leq 0.05$) (Fig. 2B) after mealy bug infestations. Numbers of mealy bugs were suppressed significantly ($P \leq 0.05$) (Fig. 3A) and there were significantly smaller shoot dry weights losses (Fig. 3B) in response to 20% and 40% vermicompost substitutions into MM360 ($P \leq 0.05$). Cabbage plants grown in MM360 substituted with 20% or 40% vermicompost had significantly less losses in leaf area ($P \leq 0.05$) compared with those of plants grown in 100% MM360 (Fig. 4A) whereas plants in pots with

![Fig. 1. Aphid suppression in peppers planted in soil-less medium (MM360) substituted with vermicompost. (A) Number of aphids in pepper plants. (B) Percentage decrease in shoot dry weights. Columns followed by the same letter do not differ significantly at $P \leq 0.05$.](image1)

![Fig. 2. Mealy bug suppression in peppers planted in soil-less medium (MM360) substituted with vermicompost. (A) Number of mealy bugs in pepper plants. (B) Percentage decrease in shoot dry weights. Columns followed by the same letter do not differ significantly at $P \leq 0.05$.](image2)
60% MM360 substituted with 40% vermicompost had significantly smaller losses in shoot dry weights ($P \leq 0.05$) compared to plants grown in MM360 only.

4. Discussion

Clearly, the vermicompost substitutions resulted in major suppression of all three types of insect pest attacks whether sucking or chewing. However, from these experiments the underlying mechanisms of resistance to insect attacks, due to vermicomposts, cannot be identified. It seems probable that there are three main environmental components that could contribute to insect pest or disease suppression: (1) degree of host availability; (2) the presence of the pest; and (3) a favorable environment for pest attack. Understanding the relationships between these three components is central to the success of disease and pest management programs.

Knowledge of the form of a plant’s nutrition, combined with the dynamics and ecology of a pest can often provide an excellent basis for successful pest management (El-zik and Frisbie, 1991). The amounts, timing and types of inorganic or organic fertilization applications can either stimulate or suppress pest populations, dependent upon the pest species and the crop. Excess fertilization, especially with nitrogen, can often promote succulent and excessive vegetative growth, that may provide a micro-environment favorable for increased development of pests and pest damage.

The use of organic amendments to soil has long been recognized as providing a more balanced and better-timed source of nutrition for plant growth, through the gradual decomposition of the organic matter by microorganisms, and slower mineralization and release of nutrients that it contains (Pascual et al., 1997; Zink and Allen, 1998; Patriquin et al., 1995). The organic matter in vermicomposts can usually provide plants with
a balanced source of nutrients that can influence the composition and physiology of plants. Our results demonstrate that substitution of vermicomposts into MM360 had considerable influences on the intensity of attacks and damage by aphids, mealy bugs and cabbage white caterpillars. Vermicomposts could have provided some essential nutrient elements, that are not available in inorganic fertilizers, and these could either have increased the plant’s resistance to pests or made the plants less palatable to the pests. This could also explain the decreased dry weight losses of peppers, tomatoes and cabbage grown with substitutions of different rates of vermicomposts, in response to the aphid and mealy bug and caterpillar infestations.

Eigenbrode and Pimentel (1988) monitored populations of flea beetles on collard greens, grown with either animal manures or chemical fertilizers, and reported fewer adult flea beetles, *Phyllotreta crucifera* and *P. striolata* on plants grown with manure amendments. Phelan et al. (1996) reported less oviposition by European corn borer (*Ostrinia nubilalis*) on plants grown with animal manure amendments than those on grown with inorganic fertilizers. Culliney and Pimentel (1986) reported reductions in the abundance of flea beetles (*Phyllotreta*), final instar caterpillars and aphids, in plots amended with sewage sludge and manure. Although there is an extensive literature on the potential of organic fertilizers to reduce the incidence of insect infestations, there are few research reports on the suppression of insect pest attacks by vermicomposts. Ramesh (2000) reported decreased attacks by sucking pests in response to vermicomposts. Rao et al. (2001) and Rao (2002) reported considerable decreases in populations, of jassids, aphids, coccinellid beetles and spider mites on groundnuts grown in soils amended with vermicomposts, neem cake or farmyard manure, compared to those grown in soils amended with inorganic fertilizer. Biradar et al. (1998) described decreases in populations of *Heteropsylla cubana* after growing *Leucaena leucocephala* with vermicomposts.

Two of the mechanisms for decreasing pest attacks that have been suggested by researchers are based on either differential availability of mineral nutrients to plants or on changes in the balance of available nutrient elements, that could affect aspects of plant morphology and physiology in ways that could render plants more resistant to pest attacks (Patriquin et al., 1995; Fox and Macauley, 1977; Prestidge and McNeill, 1983). Some of the changes in plant characteristics, that are affected by organic or inorganic nutrition, are their growth patterns such as the onset of senescence, thickness and degree of lignification of the epidermal cells, sugar concentrations in the apoplasts, amino-N in phloem sap, and levels of secondary plant compounds (Patriquin et al., 1995). Plants grown in soils with high levels of N resulted in larger infestations of cabbage-worms, diamondback moths and thrips, promoted faster development of aphids (Dixon, 1969) and production of larger lepidopteran larvae (House, 1965). Fox and Macauley (1977) suggested that amounts of N in a plant can often be correlated positively with the extent of insect feeding. Conversely, inadequate nitrogen availability can increase rates of consumption of plant tissues by insects, thereby causing even more damage to crop plants (Hamilton and Morán, 1980). Products of nitrogen metabolism, such as amino acids have also been linked to increased insect pest attacks on plants. For instance, large amounts of amino acids stimulated the growth and fecundity of some herbivorous insects (Prestidge and McNeill, 1983). Wilson and Stinner (1984) suggested that decreased infestations by aphids were due to poor assimilation of ureide N by pests. Additionally, variations in the nutritional status of plant tissues other than N, might influence pest resistance, or result in increased susceptibility to insect attacks, due to deficiencies of K, Ca, Bo, Zn and Si (Patriquin et al., 1995). These issues will be resolved only by further experiments which compare the degree of suppression of insect pests on plants supplied only with inorganic nutrients, with the degree of suppression on plants grown with vermicompost substitutions but with all the needed nutrients supplied as supplements. This research may be onerous because each nutrient element needs to be considered independently.

**References**


