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The Effects of Vermicomposts Produced from Various Organic Solid Wastes on Growth of Pistachio Seedlings

A. Golchin[1], M. Nadi[1] and V. Mozaffari[2]
[1] Department of Soil Science, Zanjan University, Zanjan, Iran.
[2] Vali-e-Asr University; Rafsanjan, Iran.

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Abstract

Vermicomposting and composting are efficient methods for converting solid waste into products. Incorporation of vermicomposts and composts into potting and container media is a potential use for these materials and a suitable alternative for peat and other organic substrates. In a greenhouse trial the effects of eight vermicomposts produced from four different organic wastes, including pistachio solid wastes (PW), cotton residues (CR), date solid wastes (DW) and animal manure (AM) were studied on the growth of pistachio seedlings. Each vermicompost had an iron-enriched counterpart produced by adding iron sulfate to organic wastes at the rate of 20% w during vermicomposting. The mixing proportions of vermicomposts with soil were 0, 10 and 20% of mixture weight and pistachio seedlings were grown in 1.5 kg pots for five months. After growing period, plant height, shoot dry weight, root dry weight, leaf area index, chlorophyll content of the leaves and photosynthesis rate in different treatments were measured. The analysis of variance (ANOVA) of data and comparison of means by Duncan's multiple range test showed that the best means were in treatments with 10% of vermicompost. All growth factors measured, except root dry weight, were better in treatments with vermicompost than in the controls (without vermicompost). Pistachio growth in mixtures containing iron-enriched vermicomposted date waste was better than that of the other mixtures. However, the quality of the vermicomposted date waste with respect to plant growth requirements was poor without enrichment with iron.

INTRODUCTION

Daily production of large quantities of organic solid wastes creates serious disposal problems, environmental pollution and possible health risks (Hashemimajd et al., 2004). These wastes require large quantities of land for disposal, and odor and ammonia are released into the air. These could contaminate ground water with pollutants and might present a health risk (Inbar et al., 1993). They can rarely be applied directly to soil since they might severely damage soil fertility (Senesi, 1989), and result in structural incompatibility, nitrogen immobilization, and phytotoxicity (Inbar et al., 1985). Direct application of organic wastes to soil may have negative effects on soil fertility and cause toxicity to plants (Atiyeh et al., 2000). Solid wastes may be converted into useful products by composting and/or vermicomposting (Dominguez et al., 1997). Composting is generally defined as the biological aerobic transformation of an organic by-product into a different organic product that can be added to the soil without detrimental effects on crop growth (Bace et al., 1992). In the process of composting, organic wastes are recycled into stabilized products that can be applied to the soil as an odorless and relatively dry source of organic matter, which would respond more efficiently and safely than the fresh material to soil organic fertility requirements (Atiyeh et al., 2000). The conventional and most traditional method of composting consists of an accelerated biooxidation of the organic matter as it passes through a thermophilic stage (45°C to 65°C) where microorganisms liberate heat, carbon dioxide and water (Dominguez et al., 1997).

However, in recent years, researchers have become progressively interested in using another related biological process for stabilizing organic wastes, which does not include a thermophilic stage, but involves the use of earthworms for breaking down and stabilizing the organic wastes (Atyeh et al., 2000). Vermicomposting is a biooxidation and stabilization process of organic materials that involves joint action of earthworms and bacteria, but does not undergo a thermophilic stage. The earthworms are the agents of turning, fragmenting and aerating composting materials (Dominguez et al., 1997). Several enzymes, intestinal mucus and antibiotics of earthworm' intestinal tract play an important role in breakdown of organic macromolecules (Doube and Brown, 1998). The ability of some earthworm species to consume a wide range of organic residues, such as sewage sludge, animal wastes, crop residues and industrial refuse, has been well established (Atiyeh et al., 2000). Mixing of biosolids with other organic material, e.g., shredded green wastes, accelerates the rate of composting and makes the vermicomposting system easier to maintain in an aerobic state, resulting in a better product (Doube and Brown, 1998). Mixing sewage sludge with bulking agents and using *Eisenia foetida* for vermicomposting has resulted in considerable reduction of pathogenic organisms (Edwards, 1998; Dominguez et al., 2000).

Because of the low cost of production and excellent physical and chemical properties, vermicompost is used as an alternative for peat and other potting media (Metzger, 1998). Tomato seedling grown in the control/pig wastes vermicomposts at the 10% rate weighed significantly more, three weeks after germination, than the seedlings grown in control alone and supplied with all needed mineral nutrients (Atiyeh et al., 2000). The objectives of the experiment presented here were: 1) To investigate the effects of different vermicomposts produced from various organic solid wastes on the growth of pistachio seedlings grown in potting media; and 2) To determine their optimum mixing proportions in pots.

MATERIALS AND METHODS

Preparation of Vermicomposts

Earthworms (*Eisenia foetida*) were collected from the northern region of Iran and were raised in bins under greenhouse condition. Organic wastes including pistachio solid wastes, cotton residues, date solid wastes and animal manure were collected from Rafsanjan, Gorgan, Jiroft, and Zanjan in Iran. All wastes were converted to vermicompost in outdoor windrows. Before addition of earthworms, wastes were washed once with tap water and kept for one week to allow excess salts and NH_3 to be removed. High salinity and NH_3 content may kill earthworms. Moisture content was controlled at about 60% of water saturation and the temperature maintained between 20 and 30°C during the vermicomposting process. In this trial, each vermicompost had an iron- enriched counterpart made by addition of iron sulfate to organic wastes at the rate of 20%w/w during vermicomposting. After four months, the color of the organic wastes turned dark brown and earthworm's activity was reduced. The vermicomposts were harvested at this stage and air-dried.

Greenhouse Trial

A pot experiment was conducted in greenhouse at Rafsanjan University in Iran. Pistachio seeds (*Pistacia vera*), were sown into 2 kg pot. Filled with a mixture of vermicompost and no sterilized soil with EC = 1.3dsm^{-1}, pH = 7.75, OC = 0.09% and $CaCO_3$ = 9.83%. The pots were filled with three rates of vermicompost (0, 10 and 20% of mixture weight). A total of 24 treatments i.e., eight vermicomposts × three rates in three replicates were used in a complete randomized design. Ten seeds were sown in each pot. The pots were watered to keep moisture close to field capacity (FC) level based on pot weight and all pots received equal water in each time of irrigation. After five months, plant height, shoot and root dry weights, leaf area index, chlorophyll content of leaves and photosynthesis rate in different treatments were measured. Plant (roots and shoots) were dried at 60°C for 48h and weighed. Chlorophyll was measured with chlorophyll meter and photosynthesis rate evaluated with Infrared Gas Analyzer. Also, leaf surface index and plant height were measured. Data were analyzed by one way ANOVA, using MSTATC statistical software. Duncan's multiple range test was used to compare the means and regression analysis was used to determine the relationships between treatments.

RESULTS AND DISCUSSION

The measurements were performed in December, after five months of plant growth, and gave clear indications of responses related to the vermicompost treatments. Statistical significance ($P<0.05$) was determined using ANOVA on individual plant measurements.

Plant Dry Weight

There were significant differences between plant dry weights. This factor involves shoot dry weight and root dry weight. The numbers for plant shoot dry weights ranged from 0.02 to 0.476 $gplant^{-1}$. Most vermicomposts were associated with a significant increase in shoot dry weight. The best rate was 10% and the best treatment was iron enriched animal manure vermicompost (Table 1). Subler et al. (1998) reported similar results indicating that the highest dry matter production occurred when the vermicompost constituent was only 10-20% of the volume potting mixture. Numbers for plant root dry weights ranged from 0.041 to 0.431 $gplant^{-1}$. Control (without vermicompost) with a poor surrounding for growth showed the best result for this factor. So the best rate was 0 % (Table 1). Several researchers have reported the positive effect of vermicompost on plant growth. Atiyeh et al. (1999) reported a significant increase in tomato growth when vermicompost was added to potting mixture. Similarly, Valenzuela et al. (1997) found that 20% vermicompost mixed with soil was suitable for tomato seedling production.

Chlorophyll Content

Values for leaf chlorophyll ranged from 51.27 to 64.10, the best rate of vermicompost was 20% and most of the iron-enriched vermicomposts were better than the other treatments. There was no significant difference between the rates of 20% and 10% of iron enriched vermicomposts with respect to leaf chlorophyll content. The best treatment was iron enriched vermicomposted animal manure (Table 1).

Photosynthesis Rate

The range for this factor was from 0.797 to 2.930 $\mu molm^{-2}s^{-1}$. The best rate of vermicompost for photosynthesis was 20%. All of the vermicomposts except vermicomposted date wastes were better than control. The best treatment was cotton vermicompost (Table 1).

Leaf Surface Index

Plant leaf surface index ranged from 1.515 to 6.917 cm^2. The best rate of vermicompost for this factor was 10%, and the best treatment was iron enriched vermicomposted date wastes (Table 1).

Plant Height

Plant heights ranged from 3.017 to 10.25 cm. The best treatment was iron enriched vermicomposted animal manure and the best rate was 10% (Table 1).

CONCLUSIONS

In this study, we observed that:

- Addition of vermicomposts to potting media increased the growth of pistachio seedlings compared to control.
- Enrichment of solid wastes with iron improved the quality of the produced vermicomposts and increased the chlorophyll contents of the leaves.
- The best mixing rate of vermicomposts with soil was 10% w.
- Iron enriched vermicompost produced from animal manure increased the growth of pistachio seedlings more than the other vermicomposts.

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Tables

Table 1. The effects of different vermicomposts on growth indices of pistachio.

	Shoot dry weight gplant^{-1}		Root dry weight gplant^{-1}		Chlorophyll		Photosynthesis μmolm^{-2}s^{-1}		Leaf surface index cm^2		Plant height cm	
	10%	20%	10%	20%	10%	20%	10%	20%	10%	20%	10%	20%
P	0.353 ABC	0.301 BCD	0.153 DE	0.150 DE	51.67 G	53.27 FG	1.74 DEF	2.48 B	5.75 ABCD	5.76 ABCD	8.42 BCD	8.48 BCD
C	0.320 BC	0.326 BC	0.169 BCD	0.213 BCD	59.20 CD	62.60 ABC	2.93 A	1.94 CDE.	6.06 ABC	5.05 BCDE	8.87 ABCD	7.56 CDE
D	0.271 CD	0.020 E	0.144 DE	0.041 E	52.70 FG	51.27 G	0.84 FGH	0.87 I	4.90 CDE	1.51 F	6.44 E	3.02 F
AM	0.369 ABC	0.303 BCD	0.204 BCD	0.161 CDE	62.40 ABC	63.70 AB	1.41 FGH	1.14 HI	5.36 BCDE	6.01 ABC	10.25 A	8.25 BCD
IP	0.394 ABC	0.247 CD	0.150 DE	0.120 DE	57.10 DE	56.27 DEF	1.61 EFG	1.84 DE	6.43 AB	5.32 BCD	8.37 BCD	7.51 CDE
IC	0.334 ABC	0.154 D	0.215 BCD	0.124 DE	60.43 BC	61.86 ABC	1.72 DEF	2.31 BC	4.91 CDE	4.19 E	8.24 BCDE	7.14 DE
ID	0.355 ABC	0.440 AB	0.275 BC	0.154 DE	61.13 ABC	63.47 AB	1.41 FGH	2.05 CD	6.92 A	5.67 ABCDE	9.49 AB	9.51 AB
IAM	0.476 A	0.387 ABC	0.216 BCD	0.286 B	64.10 A	62.33 ABC	1.24 GH	2.06 CD	5.28 BCDE	5.76 ABCD	9.01 ABC	8.66 ABCD
CL*	0.273 CD	0.273 CD	0.431 A	0.431 A	54.97 EFG	54.97 EFG	0.81 I	0.81 I	4.39 DE	4.39 DE	7.37 CDE	7.37 CDE

Pistachio Vermicompost (P), Cotton Vermicompost (C), Date Vermicompost (D), Animal Manure Vermicompost (AM), Iron Enriched Pistachio Vermicompost (IP), Iron Enriched Cotton Vermicompost (IC), Iron Enriched Date Vermicompost (ID), Iron Enriched Animal Manure Vermicompost (IAM), Control (CL).
* Numbers of 0 % was similar to control.