

Full Length Research Paper

Impact of Vermicompost Application on Soil Chemical and Physical Characteristics in Tomato (*Lycopersicum esculentum*) Cultivation

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In this study, the effects of vermicompost on soil chemical and physical properties was evaluated in tomato (*Lycopersicum esculentum* var Super Beta) field. The experiment was arranged in a randomized complete block design with four replications. Different amounts of vermicompost (0, 5, 10, 15 t ha⁻¹) were incorporated into the top 15 cm of soil. The soil sampling and measurements carried out 3 months after the application of vermicompost in soil and the soil samples were collected from depth of 15 cm. The results showed that addition of vermicompost at rate of 15 t ha⁻¹ significantly ($P < 0.05$) increased contents of soil total organic carbon, total N, P, K, Ca, Zn and Mn substantially compared with control plots. The soils treated with vermicompost had significantly more EC in comparison to unamended plots. The addition of vermicompost in soil resulted in decrease of soil pH. The physical properties such as bulk density and total porosity in soil amended with vermicompost were improved. The results of this experiment revealed that addition of vermicompost had significant ($P < 0.05$) positive effects on the soil chemical, physical properties.

Key word: Vermicompost, soil chemical and physical properties, tomato, sheep manure.

INTRODUCTION

The ability of some species of earthworm to consume and breakdown a wide range of organic residues such as sewage sludge, animal wastes, crop residues and industrial refuse is well known (Mitchell et al., 1980; Edwards et al., 1985; Chan and Griffiths, 1988). The use of organic amendments such as traditional thermophilic composts has been recognized generally as an effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil cation exchange capacity (CEC) and increasing crop yields (Zink and Allen, 1998). Vermicompost contains most nutrients in plant-available forms such as nitrates, phosphates, and exchangeable calcium and soluble potassium (Orozco et al., 1996). There is accumulating scientific evidence that vermicomposts can influence the growth and productivity of plants significant-

ly (Edward, 1998). Various greenhouse and field studies have examined the effects of a variety of vermicomposts on a wide range of crops including cereals and legumes (Chan and Griffiths, 1988), vegetable (Edwards and Burrows, 1988; Wilson and Carlile, 1989; Subler et al., 1998; Atiyeh et al., 2000b) ornamental and flowering plants (Edwards and Burrows, 1988; Atiyeh et al., 2000b), and field crops (Arancon et al., 2004). Annual application of adequate amounts of some organic residues (vermicompost) led to significant increase in soil enzyme activities such as urease, phosphomonoesterase, phosphodiesterase and arylsulphatase (Albiach et al., 2000). Plant growth-promoting bacteria (PGPB) directly stimulate growth by nitrogen fixation (Han et al., 2005), solubilization of nutrients (Rodriguez and Fraga, 1999), production of growth hormones, 1-aminocyclopropane-1-carboxylate (ACC) deaminase (Correa et al., 2004); and indirectly by antagonizing pathogenic fungi by production of siderophores, chitinase, β -1,3-glucanase, antibiotics, fluorescent pigments and cyanide (Han et al., 2005). Despite of the beneficial effects on growth and yield of plants, higher metal concentration in this

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Table 1. Chemical properties of sheep- manure vermicompost and soil.

| Medium | pH | EC (mScm ⁻¹) | C (%) | N (%) | P (%) | K (%) | Fe (ppm) | Mn (ppm) | Zn (ppm) | Cu (ppm) |
|--------------|------|-----------------------------|----------|----------|----------|----------|-------------|-------------|-------------|-------------|
| Vermicompost | 7.7 | 7 | 15 | 1.3 | 1.3 | 1 | 580 | 250 | 170 | 31 |
| Soil | 7.94 | 1.38 | 1.07 | 0.09 | 0.001 | 0.032 | 12 | 10 | 3 | 1.5 |

Table 2. Effect of vermicompost on soil macroelements.

| Treatment with vermicompost (t ha ⁻¹) | Total N (%) | P (ppm) | K (ppm) | Ca (ppm) |
|---------------------------------------------------|----------------------|---------------------|---------------------|---------------------|
| 0 | 0.0700 ^c | 5.590 ^c | 379.00 ^c | 144.33 ^b |
| 5 | 0.0933 ^{bc} | 10.430 ^b | 523.00 ^b | 168.00 ^b |
| 10 | 0.1133 ^{ab} | 13.767 ^a | 555.67 ^b | 227.33 ^a |
| 15 | 0.1300 ^a | 18.733 ^a | 599.67 ^a | 252.67 ^a |

In each column means with similar letters do not significantly differ ($P \geq 0.05$).

material may be a problem and limit its utilization (Jordao et al., 2006). The soil quality includes soil reaction (pH), mineral nutrient elements, water content, composition of soil atmosphere and biotic factors. Mature compost when added to soil directly affected almost all of these factors (Marinari et al., 2000).

The main aim of this study was to determine the effects of different rate of vermicompost on the soil chemical and physical properties in tomato field.

MATERIALS AND METHODS

The experiment was carried out on tomato crop (*Lycopersicum esculentum* L. variety Super Beta) in the experimental farm of Moghan Agricultural Research Center, Iran in 2007. The soil texture of the experimental field was loamy. Sheep-manure vermicompost and soil chemical analysis is given in Table 1.

Sheep manure was composted thermodynamically for three months with mechanical turn cycles every 10 day. For preparing of vermicompost were added numbers of 400 mature worms (*Eisenia fetida*) per m² bed. The worm were removed with a pile of fresh materials that placed in side of the vermicomposted sheep manure which recalled them by attraction of the fresh feed.

In this experiment the seedling of tomatoes were planted in the plotted field which each plot had 5 m long and 4 m wide (20 m²) and was separated by 1 m width from unplanted areas. The vermicompost was applied at the rate of 0 (control), 5, 10 and 15 t ha⁻¹ and it was incorporated into the top 15 cm of soil in the whole experimental plots. The plots were arranged in a Randomized Complete Block Design (RCBD) with four replications.

Seeds were sown in boxes prepared with proper soil mixture on 15th February 2007, and tomato seedlings were transplanted into field soil 9 weeks after seed planting when they had 3 true leaves. Seedlings were planted in a distance of 140 cm row to row and 35 cm plant to plant.

To determine soil physical and chemical properties, the soil samples were collected 3 months after addition of vermicompost from depth of 15 cm. The samples were air dried at room temperature and stored at 4°C. Soil sub-samples before chemical analysis was screened through a 2 mm sieve and homogenated. The pH of soil samples were measured in distilled water [soil: water, 1:2.5 (v/v) ratio] after shaking the solution for 30 min by means of a pH Meter (CD 510, WPA) fitted with a glass electrode. The EC was

measured in a satured solution extract of soil samples using a EC Meter (Sension 7, HACH). The organic carbon was determined by dichromate oxidation method and subsequent titration with ferrous ammonium sulphate (Walkley and Black). Total N was determined by sulphuric acid digestion using CuSO₄ and K₂SO₄ as catalyst. Total N in the digest was determined by the regular Kjeldahl distillation method (Bremner and Mulraney 1982) and the available phosphorus was measured by the method of Olsen et al. (1954). Also the soil K and Ca was measured by a flame photometer (PEP7 and PEP7/C, Jenway). Furthermore the soil Zn, Mn and Cu was measured using the DTPA method (Lindsay and Norvell, 1978).

Bulk density was determined using the core method by weighing the undisturbed soil samples of a volume of 250 m³ (Blake and Hartge, 1986). The Gas Pycnometer method was used for determining total porosity of soil. This method is based of boil law ($P_1V_1=P_2V_2$).

Data obtained from this experiment were subjected to analyses of variance by statically software of SAS (SAS (2002) Institute Inc., Cary, NC, USA), in one-way ANOVA with a general linear model. Least significant difference (LSD; $P = 0.05$) values was used for comparisons of treatment means.

RESULTS AND DISCUSSION

Effect of vermicompost on soil chemical properties

The results showed that the total N concentration in soil was significantly ($P \leq 0.05$) affected by vermicompost treatments (Table 2). The soils treated with sheep manure vermicompost at the rate of 15 t ha⁻¹ had more total N compared to soils without vermicompost application. Vermicompost might have produced more residual N in soil than those in control plots.

The marked decrease in total N in soils without vermicompost application in comparison with vermicompost treated soils may have been due to larger amounts of total C and N in sheep manure vermicompost that could have provided a larger source of N for mineralization (Arancon et al., 2006). There have been other reports of increase of N in soil after application of vermicompost (Nethra et al., 1999). Soils treated with

Table 3. Effect of vermicompost on soil chemical and physical properties.

| Treatment with vermicompost (t ha ⁻¹) | Zn (ppm) | Cu (ppm) | Mn (ppm) | Bulk density (g cm ⁻³) | porosity (%) |
|---------------------------------------------------|----------------------|---------------------|----------------------|------------------------------------|--------------------|
| 0 | 2.2200 ^b | 1.6000 ^a | 2.4700 ^c | 1.6933 ^a | 35.33 ^c |
| 5 | 2.9667 ^{ab} | 1.9033 ^a | 4.1500 ^b | 1.6300 ^b | 37.66 ^b |
| 10 | 3.8400 ^a | 1.9833 ^a | 4.9367 ^{ab} | 1.6133 ^b | 38.66 ^b |
| 15 | 4.2533 ^a | 1.1400 ^a | 5.7067 ^a | 1.5633 ^c | 40.33 ^a |

In each column means with similar letters do not significantly differ ($P \geq 0.05$).

Table 4. Effect of vermicompost on soil chemical properties.

| Treatment with vermicompost (t ha ⁻¹) | pH | EC (mScm ⁻¹) | Organic carbon (%) |
|---------------------------------------------------|----------------------|--------------------------|---------------------|
| 0 | 8.0000 ^a | 1.2970 ^c | 0.624 ^c |
| 5 | 7.6066 ^b | 2.1183 ^{bc} | 1.001 ^b |
| 10 | 7.4833 ^{bc} | 2.8967 ^{ab} | 1.254 ^{ab} |
| 15 | 7.3333 ^c | 3.6700 ^a | 1.323 ^a |

In each column means with similar letters do not significantly differ ($P \geq 0.05$).

vermicompost at the rate of 15 t ha⁻¹ had significantly more P ($P \leq 0.05$) as compared to control plots (Table 2). This implied that the continuous inputs of P to the soil were probably from slow release from vermicompost and release of P was due largely to the activity of soil microorganisms (Arancon et al., 2006). Marinari et al. (2000) showed similar increases in soil P after application of organic amendments. The enhancement of phosphatase activity and physical breakdown of material resulted in greater mineralization (Sharpley and Syres, 1977). In this experiment the more available P probably could have contributed to decrease of soil pH caused from application of vermicompost. The soil available K increased significantly ($P \leq 0.05$) with rising vermicompost rate (Table 2). Application of vermicompost at rate of 15, 10 and 5 t ha⁻¹ increased available K in these treatments 58, 46 and 34% respectively in comparison to control plots. The selective feeding of earthworm on organically rich substances which breakdown during passage through the gut, biological grinding, together with enzymatic influence on finer soil particles, were likely responsible for increasing the different forms of K (Rao et al., 1996). The increase of soil organic matter resulted in decrease K fixation and subsequent increase K availability (Olk and Cassman, 1993).

The results indicated that vermicompost increased Ca content of soil significantly ($P \leq 0.05$). The highest increase was calculated 75 and 54% for 15 and 10 t ha⁻¹ vermicompost, respectively (Table 2). Vermicompost contains most nutrients in plant available forms such as phosphates, exchangeable calcium and soluble potassium (Orozeo et al., 1996).

Furthermore the results showed that the available Zn concentration in soil was significantly ($P \leq 0.05$) affected

by vermicompost treatments (Table 3). The total Zn content, pH, organic matter, adsorption sites and microbial activity of the soil affect the Zn availability (Alloway, 1993). The soil pH is the most important factor controlling Zn availability, which decreases with the increase of the pH (Shuman and Li, 1996). In this experiment increase Zn was attributed to the pH reduction and the greater organic matter degradation. The Mn availability in the soil was significantly ($P \leq 0.05$) affected by vermicompost treatments (Table 3). The highest Mn concentration was 5.7 ppm, in the soil amended with 15 t ha⁻¹ vermicompost. The application of vermicompost increased the available Mn concentration, almost 2.3 times in rate of 15 t ha⁻¹ as compared with the control. High content of extracted Mn with DTPA can be due to the dissolution of Mn precipitates (carbonates, hydroxides and phosphate) caused by microbial activity that changes soil pH and gaseous composition (Jordao et al., 2006). Also the results revealed that the soil Cu concentration did not differ significantly between treatments.

The electrolytic conductivity (EC) in vermicompost was 7dSm⁻¹. The soils amended with vermicompost had significantly ($P \leq 0.05$) higher EC than the untreated soils (Table 4). The soil EC increased with increasing an application rate of vermicompost in soil as reported by Atiyeh et al. (2001) with pig manure vermicompost substituted into Metro-Mix 360. The EC of vermicompost depends on the raw materials used for vermicomposting and their ion concentration (Atiyeh et al., 2002b). The addition of vermicompost in soil change soil pH (Table 4). The highest and lowest pH values were observed at the rate of 0 and 15 t ha⁻¹ vermicompost, respectively. Atiyeh et al. (2001) reported that the increase of vermicompost rate in the soil resulted in the decrease in soil pH. While

Maheshwarapa et al. (1999) reported that the increase of the content of vermicompost decreased soil pH. The production of NH_4^+ , CO_2 and organic acids during microbial metabolism in vermicompost may be contributed to the decrease in soil pH (Albanell et al., 1988).

In other experiment we demonstrated that addition of 5, 10 and 15 t ha⁻¹ vermicompost in soil had significant positive effect on uptake of element nutrients such as P, K, Fe and Zn (Azarmi et al., 2008).

Effect of vermicompost on soil physical properties

The results showed that soils amended with vermicompost had significantly ($P \leq 0.05$) greater soil bulk density in comparison to control plots (Table 3). The increase of the rates of vermicompost reduced soil bulk density. Compost addition caused a significant increase of bulk density due to the more porosity added to the soil (Bazzoffi et al., 1998).

The total porosity was improved by the use of vermicompost (Table 3). The greater porosity in the soil treated with vermicompost was due to an increase in the amount of rounded pores (Marinari et al., 2000). Pagliai et al. (1980) reported that the increase in porosity has been attributed to increased number of pores in the 30 - 50 μm and 50 - 500 size ranges and a decrease in number of pores greater than 500 μm .

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