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Effect of Vermicompost on Growth, Yield and Nutrition Status of Tomato (*Lycopersicum esculentum*)

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Abstract: An experiment was conducted to determine the effects of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum* var. Super Beta) in a field condition. The experiment was a randomized complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t ha^{-1}) was incorporated into the top 15 cm of soil. During experiment period, fruits were harvested twice in a week and total yield were recorded for two months. At the end of experiment, growth characteristics such as leaf number, leaf area and shoot dry weights were determined. The results revealed that addition of vermicompost at rate of 15 t ha^{-1} significantly (at $p<0.05$) increased growth and yield compared to control. Vermicompost with rate of 15 t ha^{-1} increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55, 73, 32 and 36% compared to untreated plots respectively. The result of our experiment showed addition of vermicompost had significant ($p<0.05$) positive effects on growth, yield and elemental content of plant as compared to control.

Key words: Vermicompost, growth, yield, tomato, nutrition, 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 (Dominguez *et al*., 1997; Edwards *et al*., 1985; Kaushik and Garg, 2003). 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 (Marinari *et al*., 2000). 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 significantly (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 (Kaushik and Garg, 2003), vegetable (Tomati *et al*., 1990; Wilson and Carlile, 1989; Subler *et al*., 1998; Atiyeh *et al*., 2000b), ornamental and flowering plants (Atiyeh *et al*., 2000b) and field crops (Arancon *et al*., 2004). Annul 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*., 2000a). 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-amino-cyclopropane-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 material may be a problem and limit its utilization (Jordao *et al*., 2006).

The main aim of this research was to determine the effects of different rate of vermicompost on the growth, yield and fruit quality of tomato under field conditions.

MATERIALS AND METHODS

This experiment was conducted in Moghan Agricultural Research Center in Iran in 2007, to determine the effects of

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Table 1: Chemical properties of sheep- manure vermicompost

	pH	EC (mS cm^{-1})	C (%)	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Vermicompost	7.70	7.00	15.00	1.30	1.300	1.000	580	250	170	31.0
Soil	7.94	1.38	1.07	0.09	0.001	0.032	12	10	3	1.5

vermicompost on growth, yield and fruit quality of tomato variety Super Beta, which is the most popular cultivar in Moghan area because of high yield potential. The soil of the experimental field was loamy texture. Chemical properties of sheep-manure vermicompost and soil are summarized in (Table 1).

In this experiment tomatoes were planted in the plotted field which each plot had 5 m long and 4 m wide (20 m^2) 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. Experiment was carried out based on randomized complete block design 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. In order to obtain uniform and healthy seedlings, sufficient nursing management was carried out. Seedlings were planted in a distance of 140 cm row to row and 35 cm plant to plant.

During the whole growing season period, ripening fruits harvested twice weekly, weighted and counted to determine total yield. At the end of the growing period two plant per plot were removed and their stem and leaves were separated and after measuring their leaf area using a LI-3100C leaf area meter, they were dried at 65°C to determine the shoot dry weight. To evaluate the quality parameters, tomato fruits were harvested at the ripening, full-red stage. Total soluble solids were determined by convex refractometer (Medline-England) corrected for temperature 25°C. For measuring the titratable acidity, 10 g aliquot juices of tomato were added into 200 mL breakers and diluted with 150 mL of distilled water. The diluted sample was agitated mechanically and titrated with 0.1 N NaOH. pH was measured by pH Meter (CD 510, WPA) fitted with a glass electrode and EC measured using an EC Meter (sension 7, HACH). To measure the fruit dry matter content, three fruit with same color and size from samples selected and oven-dried at 100°C. To determine the mineral nutrient content in tomato plants tissues, samples were prepared and dried at 70°C for 48 h, finely grounded, extracted with dilute nitric acid. Potassium content of extracts were determined using a flame photometer (PEP7 and PEP7/C, Jenway). Phosphorus was measured by vanadate molybdat method by using a WPA, Biowave II UV/visible spectrophotometer. The concentration of Fe, Zn, Cu, Mn in plant tissues were determined by atomic-absorption spectrophotometer (Perkin-Elmer, AAnalyst 300).

Data obtained from this experiment were subjected to analyses of variance by statically software of SAS (SAS procedures Guide, Version 8. (2001) SAS Institute, Cary), in one-way ANOVA with a general linear model. Least significant difference (LSD; $p \leq 0.05$) values was used for comparisons of treatment means.

RESULTS

Effect of vermicompost on growth and yield parameters: The number of leaves did not differ significantly between treatments (Table 2). Addition of vermicompost increased total yield of fruits per plant ($p \leq 0.05$). The highest total yield of fruits was obtained with 15 and 10 t ha^{-1} vermicomposts (Table 2). The total yield of fruits per plant increased 1.7 times at rate of 15 t ha^{-1} vermicompost compared to control treatment. Leaf area index increased significantly with raising vermicompost rate ($p \leq 0.05$). Application of vermicomposts at rate of 15, 10 and 5 t ha^{-1} increased leaf area in these treatments 43, 35 and 18% respectively in comparison to control (Fig. 1).

The results showed that vermicompost had significantly effect on shoot dry weights ($p \leq 0.05$). Shoot dry weights of plants at the rate of 15 t ha^{-1} sheep-manure vermicompost were 27% greater than those obtained in control plants (Fig. 1).

The occurrence rate of physiological disorder of Blossom-End Rot was affected by addition of vermicompost ($p \leq 0.05$). So that with increasing in vermicompost rate in soil reduced the numbers of fruits having Blossom- End Rot symptoms (Table 2).

Effect of vermicompost on the quality properties: The addition of Vermicompost to soil has not significant effects on total soluble solids (TSS), titratable acidity (TA) and pH of juice (Table 3). The application ofvermicompost increased the amounts of juice EC in tomato fruits significantly in comparison to untreated plots ($p \leq 0.05$). The EC increased with increasing application rates of vermicompost to soil (Fig. 2). The juice EC increased 1.3 times at the rate of 15 t ha^{-1} vermicompost as compared to control. The addition of vermicompost in soil enhanced fruit dry matter content ($p \leq 0.05$). So that percentages of fruit dry matter in plots treated with rate of 15 t ha^{-1} was 24% greater than plants grown in control plots (Table 3).

Effect of vermicompost on chemical analysis of tomato shoots: The addition vermicompost increased mineral P content in shoots of tomato plants significantly ($p \leq 0.05$). The highest values for shoot P content were obtained at the rate of 15 t ha^{-1} of vermicompost (Fig. 3).

Tomatoes grown in plots treated with 15 t ha^{-1} of vermicompost had significantly higher K concentration ($p \leq 0.05$) than those grown in plots with 0, 5, t ha^{-1} vermicomposts. Increasing vermicompost rate into soil increased Zn content in shoot ($p \leq 0.05$), plants in plots

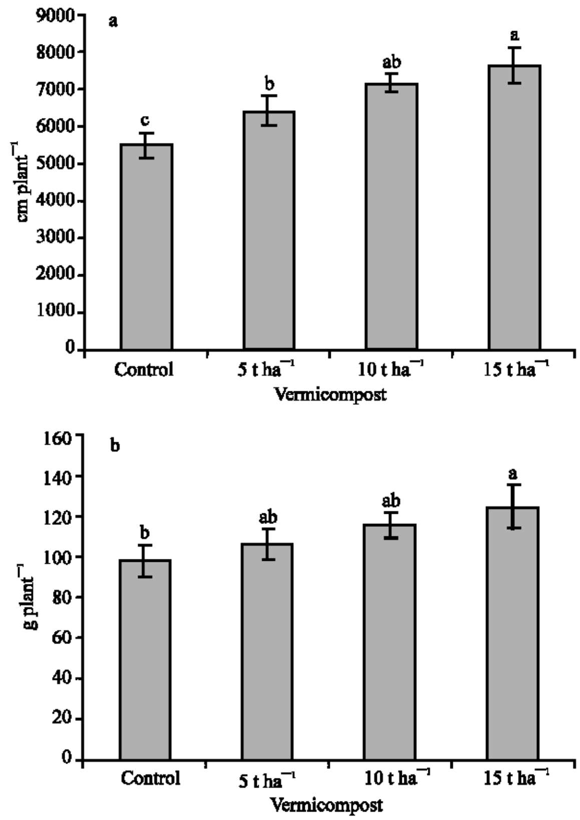

Fig. 1: Leaf area and shoot dry weight of tomatoes grown in soil treated with different rates of sheep-manure vermicompost. Columns followed by the same letters do not differ significantly ($p \leq 0.05$). (a) leaf area and (b) shoot dry weight

Table 2: Effect of vermicompost on growth and yield tomato Super Beta variety

Vermicompost treatment (t ha^{-1})	No. of leaves plant^{-1}	No. of blossom-end rot plant^{-1}	Total yield (kg plant^{-1})
0	77.66^{a}	3.75^{a}	1.92^{c}
5	87.00^{a}	1.50^{b}	2.52^{bc}
10	92.00^{a}	0.75^{bc}	2.83^{ab}
15	94.00^{a}	0.50^{c}	3.26^{a}

Means followed by the same letters do not significantly differ in $p \leq 0.05$

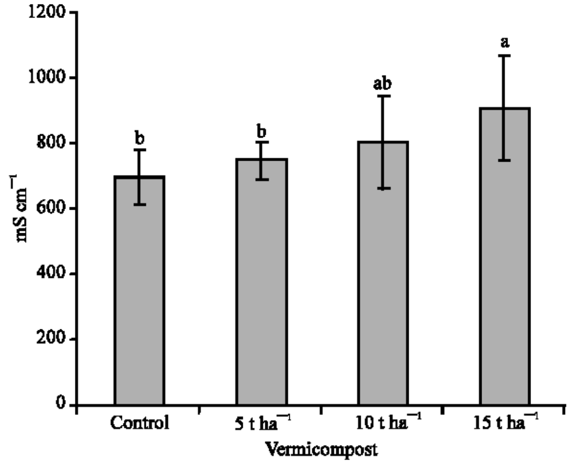

Fig. 2: The amount of Juice EC in tomato fruits grown in soil treated with different rates of sheep-manure vermicompost. Columns followed by the same letters do not differ significantly ($p \leq 0.05$)

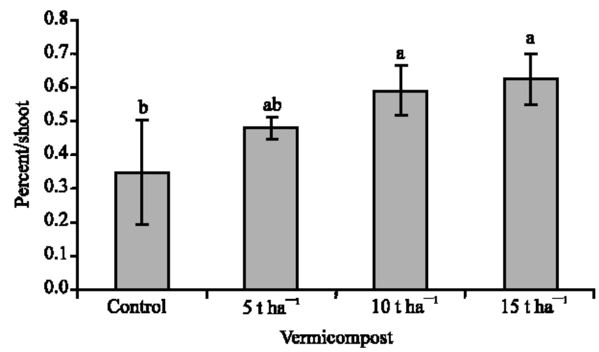

Fig. 3: P concentration of tomato shoots grown in soil treated with different rates of sheep-manure vermicompost. Columns followed by the same letters do not differ significantly ($p \leq 0.05$)

Table 3: Effect of vermicompost on tomato quality properties

Vermicompost treatment (t ha^{-1})	Total soluble solid (%)	Titratable acidity (mg/100 g)	pH	Fruit dry matter (%)
0	4.9000^{a}	1120.5^{a}	4.6425^{a}	4.9675^{b}
5	5.4750^{a}	1284.8^{a}	4.5075^{a}	5.6625^{ab}
10	5.5500^{a}	1380.0^{a}	4.4725^{a}	5.8950^{ab}
15	5.6750^{a}	1460.3^{a}	4.4775^{a}	6.1625^{a}

Means followed by the same letters do not significantly differ in $p \leq 0.05$

Table 4: Effect of vermicompost on nutrient concentration in tomato shoots

Vermicompost treatment (t ha^{-1})	K (%)	Fe (ppm)	Zn (ppm)	Cu (ppm)	Mn (ppm)
0	1.9133^{c}	131.50^{c}	66.66^{c}	14.86^{a}	87.25^{a}
5	2.3000^{bc}	146.36^{bc}	71.63^{bc}	17.96^{a}	100.95^{a}
10	2.8668^{ab}	163.00^{ab}	78.66^{b}	20.55^{a}	105.08^{a}
15	3.3164^{a}	174.00^{a}	90.33^{a}	22.55^{a}	109.25^{a}

Means followed by the same letters do not indicate significant difference at $p \leq 0.05$

treated with 15 and 10 t ha^{-1} of vermicomposts, respectively have significantly greater Zn than plants grown in control plot. Iron concentration of shoot affected by vermicompost treatments ($p \le 0.05$). So that Fe content of shoot at rate of 15 t ha^{-1} was 32% greater than control (Table 4). In contrast, the addition of vermicompost showed no significant differences on Mnand Cu concentration of shoots (Table 4).

DISCUSSION

Several studies have examined the effect of vermicompost on growth and yield of vegetables in container growth media. These studies showed that increases in growth and yield at low amounts of vermicompost in the potting medium could probably be due to improvement in the physicochemical properties of the container medium, increase in enzymatic activity, increases in microbial diversity and activity, nutritional factors and plant growth regulators (Arancon *et al*., 2004; Tomati and Galli, 1995; Atiyeh *et al*., 2000). Results obtained from this experiment revealed that growth and yield parameters such as leaf area, dry shoot weights and weight of fruits were significantly affected by applying vermicompost. Arancon *et al*. (2004) reported positive effects of vermicompost on the growth and yield in strawberry, especially increases leaf area, shoot dry weight and fruit weight in field conditions. Mishra *et al*. (2005) showed that vermicompost had beneficial effects on growth and yield of rice, especially caused significant increase of many growth parameters, seeds germination, chlorophyll concentration and yield. Similar results were noted by Maynard (1995), who reported that tomato yields in field soils amended with compost were significantly greater than those in the untreated plots. Goswami *et al*. (2001) reported that the addition of vermicompost at rates of 0, 20, 30 and 40 t ha^{-1} to tomatoes cultivated in the field produced tomato yields of 114, 138, 163 and 192 t ha^{-1} respectively compared to 56 t ha^{-1} for inorganically fertilized plants.

The decline in numbers of fruits having Blossom-End Rot symptoms with adding of vermicompost could probably be due to increases in Ca uptake by plant (Aggelides and Londra, 1999).

This study indicated that the increase of vermicompost to soil affected some of fruit quality parameters such as juice EC and fruit dry matter content. The EC of vermicompost depends on the raw materials used for vermicomposting and is related to their ion concentration (Atiyeh *et al*., 2000b). Gutierrez-Miceli *et al*. (2007) reported that tomatoes grown in soil, mixed with sheep-manure vermicompost were ideal for juice production because soluble solids>4.5 % and pH<4.4.

The results of this experiment showed that the increase in growth and yield of tomatoes with addition of vermicompost is associated with greater uptake element nutrients such as: P, K, Fe and Zn. The available nutrient status of soil was greatly enhanced by the application of vermicompost as an organic source (Prabha *et al*., 2007).

Vermicompost enhanced P concentration and uptake in soil, increasing the solubilisation of P either by microorganisms activation with excretion of organic acids likes citric, glutamic, tartaric, succinic, lactic, oxalic, malic and fumaric (Subba Roa, 1982) or by higher phosphatase activity (Sainz *et al*., 1998).

Bhasker *et al*. (1992) reported that the increase in K uptake by vermicompost application may be due to enhancement in K availability by shifting the equilibrium among the forms of K from relatively exchangeable K to soluble K forms in the soil. The total Zn content, pH, organic matter, adsorption sites and microbial activity of the soil affect the Zn availability (Jordao *et al*., 2006).

CONCLUSION

The results of this experiment showed that the increase in growth and yield of tomatoes with addition of vermicompost could associate with greater uptake element nutrients such as: P, K, Fe and Zn.

Increasing in Fe and Zn uptake by plant is associated with direct adding these nutrients into soil depending on their amount in vermicompost extract, mineralization of organic matter, decrease of soil pH by organic acids produced in vermicompost and increases micronutrient complexes formation (Gopal Reddy and Suryanarayan Reddy, 1998; Wong *et al*., 1999).

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