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Yield and Nutrient Content of Tomato as Influenced by the Application of Vermicompost and Chemical Fertilizers

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Abstract

A pot experiment was conducted to investigate the yield and nutrient content of tomato (*Lycopersicon esculentum*) as influenced by the application of vermicompost and chemical fertilizers. The experiment was laid out in a completely randomized design (CRD) with 3 replications and comprised of 8 treatments *viz.*, T_1 - control, T_2 - recommended dose of NPK fertilizers (CF), T_3 - vermicompost @ 5 t ha^{-1} (VC_1), T_4 - vermicompost @ 10 t ha^{-1} (VC_2), T_5 - VC_1 + 50% CF, T_6 - VC_1 + 75% CF, T_7 - VC_2 + 50% CF and T_8 - VC_2 + 75% CF. Application of vermicompost @ 10 t ha^{-1} along with 50% chemical fertilizers showed the best performance for plant height, number of leaves $plant^{-1}$, number of flowers $branch^{-1}$, number of fruits $branch^{-1}$, number of fruits $plant^{-1}$, fruit size and yield of tomato. Vermicompost treated soils significantly contributed the highest contents of sugar, pH, N, P, K, Ca, Mg, S, Zn & B in tomato, influenced nutrient status of the postharvest soil and conserved more organic C, N, P, K, Ca, Mg, S, Zn & B contents over control. However, soluble solids and vitamin C content in tomato were not significantly influenced by the application of vermicompost and chemical fertilizers. Results of the study demonstrate that the combined application of vermicompost and chemical fertilizers would help to maintain the long-term soil productivity for sustainable tomato cultivation.

Key words: Chemical fertilizer, Nutrient content, Tomato, Vermicompost, Yield

Introduction

Organic farming is a production system, which avoids or largely excludes the use of synthetic chemical fertilizers. The continued use of organic fertilizers increases soil organic matter, better water infiltration and aeration, higher soil biological activity as the materials decompose in soil and increases yields after the year of application (Ceglarek *et al*., 2002). The effectiveness of such materials can be improved by combining them with chemical fertilizers. Vermicompost can play a vital role in sustaining soil fertility and crop production more than the use of chemical fertilizers. Vermicompost is an excellent product because it tends to hold more nutrients over a longer period without adversely affecting the environment. Among the sources of available organic manures, vermicompost contains a higher percentage of nutrients necessary for plant growth in readily available forms (Theunissen *et al.*, 2010; Bhat and Limaye, 2012). It increases macropore space resulting in improved air-water relationship in the soil, which favorably affects plant growth (Marinari *et al*., 2000). The application of organic fertilizers including vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al*., 1999). The indiscriminate use of chemical fertilizers drastically destroys the physical, chemical and biological properties of soil. Besides, owing to the repeated use of land and chemical fertilizers, our land has become unfertile and lost its productivity. Vermicompost treatment plots displayed better results with regard to growth and fruit yield of tomato plant as compared to control (Arancon *et al*., 2003; Chanda *et al*., 2011; Abduli *et al*., 2013). Chemical fertilizers may be used more efficiently by crops growing on soils with adequate amounts of soil organic matter supplied by organic fertilizers (Chadha *et al*., 2006). Integrated use of vermicompost as organic fertilizer and chemical fertilizers would be quite promising in soil fertility improvement. The present-day-concern about global environmental pollution can be reduced to a considerable extent by either judicious use of chemical fertilizers or increase the use of manures. The use of manures and their proper management may reduce the need for chemical fertilizers, thus allowing the small farmers to save in part the cost of production. In Bangladesh, there is a great possibility of increasing tomato yield per unit area with the judicious use of organic fertilizers. For this reason, the effect of vermicompost along with chemical fertilizers on tomato (*Lycopersicon esculentum*) as one of the important vegetable crops is considered in this study.

Materials and Methods

Experimental set up

Vermicompost was collected from Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh. In this experiment, tomato cv. BARI Tomato-14 was used as a test crop. Seeds were collected from Horticulture Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The experiment was laid out in a completely randomized design (CRD) with 3 replications. The pot experiment comprised of 8 treatments *viz.*, T_1 - control (no compost and chemical fertilizers), T_2 - recommended dose of NPK fertilizers (CF), T_3 - vermicompost @ 5 t ha^{-1} (VC_1), T_4 - vermicompost @ 10 t ha^{-1} (VC_2), T_5 - vermicompost @ 5 t ha^{-1} and 50% CF (VC_1 + 50% CF), T_6 - vermicompost @ 5 t ha^{-1} and 75% CF (VC_1 + 75% CF), T_7 - vermicompost @ 10 t ha^{-1} and 50% CF (VC_2 + 50% CF) and T_8 - vermicompost @ 10 t ha^{-1} and 75% CF (VC_2 + 75% CF). After collection, soil samples were pulverized, air dried and then mixed thoroughly. Soil samples were placed in each pot at the rate of 10 kg pot^{-1}. Vermicompost and recommended doses of NPK fertilizers were mixed thoroughly with soil as per the experimental treatment. All treatments of this experiment were assigned at random to each unit pot for each replication. Different parameters such as plant height, number of leaves plant^{-1}, number of flowers branch^{-1}, number of fruits branch^{-1}, number of fruits plant^{-1}, fruit size and yield were recorded from all tomato plants. Plant samples were collected from each pot, dried in an oven at 60^{o}C for about 72 h and ground to pass through a 20-mesh sieve.

Soil and plant analysis

The biochemical constituents like pH, vitamin C, reducing sugar and total soluble solids were measured from tomato fruits. The pH value of filtrable syrups prepared from fruit samples was measured by pH meter (Model: Jenway-3505); vitamin C was determined by indophenols dye extraction method and sugar content was estimated by determining the volume of unknown sugar solution of tomato pulp required for complete reduction of standard Fehling's solution (Ranganna, 1994). Soil texture of initial and postharvest soils was determined by hydrometer method (Black, 1965). The pH of initial and post harvest soils was determined by pH meter (Model: Jenway 3505) as stated by Jackson (1973). Organic C content of soil samples was estimated by wet oxidation method (Ghosh *et al*., 1983). The determination of total-N in plant samples was performed by semi-micro kjeldahl method (Page *et al*., 1982; Tandon, 1995). Plant and fruit samples were digested by wet oxidation method using di-acid mixture (HNO_3:$HClO_4$=2:1) for the determination of P, K, Ca, Mg, S, Zn and B contents as described by Singh *et al.* (1999). Available P in soil was extracted with $NaHCO_3$ (0.5M) at pH 8.5 and its content in both soil and plant extracts was determined by spectrophotometric method using stannous chloride ($SnCl_2 \cdot 2H_2O$) as reducing agent (Jackson, 1973; Tandon, 1995). Exchangeable K, Ca and Mg were obtained from soil samples by extracting with 1N NH_4OAc at pH 7 and K content in both extracts was determined by flame photometric method (Tandon, 1995). The contents of Ca and Mg were estimated from both extracts by EDTA titrimetric method using Na_2EDTA as a complexing agent (Page *et al*., 1982). Available S was extracted from soil samples using $CaCl_2$ solution and S content in both soil and plant extracts was determined turbidimetrically with the help of spectrophotometer (Model: Labtronics LT-31) as described by Page *et al.* (1982) and Tandon (1995). Available B was extracted with hot water from soil samples and its content in both extracts was determined by spectrophotometer (Model: Labtronics LT-31) using azomethine-H (Page *et al*., 1982; Tandon, 1995). Available Zn was extracted with Na_2EDTA from soil samples (McLaren *et al.,* 1984) and Zn content was directly analyzed by atomic absorption spectrophotometer (Model: Varian-55B) as mentioned by Singh *et al.* (1999).

Statistical analysis

The recorded data were subjected to statistical analysis following Completely Randomized Design (CRD) with the help of computer package program. The significance of difference between treatment means was evaluated by Duncan's Multiple Range Test (DMRT) and the mean comparisons of treatments were adjusted by Least Significant Difference (LSD) test at 1% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Effect of vermicompost and chemical fertilizers on plant characters and yield of tomato

Effect of vermicompost along with chemical fertilizers on plant characters and yield of tomato were statistically significant (Table 1). Plant height varied from 98.33 to 185.00 cm at the harvesting stage. The highest plant height was found from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest plant height was observed in control plant (T_1 treatment). The highest number of leaves plant^{-1} (105) was found from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest number of leaves plant^{-1} (55) was obtained in control plant (T_1 treatment). That result was identical to T_8 treatment where vermicompost at the rate of 10 t ha^{-1}and 75% chemical fertilizers were applied. Maximum number of leaves plant^{-1} (105.00) was obtained from vermicompost treated soil along with 50% chemical fertilizers (T_7 treatment) as compared to control soil. A possible response behind this finding was possibly due to the addition of organic manure (Jin *et al*., 1996). The highest number of flowers branch^{-1} (12) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest number of flowers plant^{-1} (7.67) was obtained in control plant (T_1 treatment). The application of vermicompost up to 2 t ha^{-1} increased secondary branches plant^{-1} (Naresh, 2002). It is evident from the results that the number of flowers branch^{-1} was influenced by the application of vermicompost along with chemical fertilizers. The number of fruits branch^{-1} varied significantly among different treatments. The highest number of fruits branch^{-1} (10.00) was obtained from vermicompost @ at the rate of 10 tha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest number of fruits branch^{-1} (5.00) was obtained in control plant. The highest number of fruits plant^{-1} (20) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest number of fruits plant^{-1} (5) was obtained in control plant. Maximum number of fruits plant^{-1} was obtained from vermicompost treated soil along with chemical fertilizers as compared to control soil. The highest length of fruits (43.50 mm) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest length of fruits (21.00 mm) was obtained in control plant. Plant grown with vermicompost at the rate of 10 t ha^{-1} along with chemical fertilizers gave the longest fruit length as compared to T_1 (control) treatment. The highest breadth of fruits (46.67 mm) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) and the lowest breadth of fruits (31.93 mm) was obtained in control plant. Plant grown with vermicompost at the rate of 10 t ha^{-1} along with chemical fertilizers gave the longest fruit breadth where as the shortest fruit breadth was obtained from T_1 (control) treatment. Vermicompost had significant effect on fruit size of tomato. The highest fruit yield (75.00 t ha^{-1}) was recorded in T_7 treatment where vermicompost at the rate of 10 t ha^{-1} along with 50% chemical fertilizers were applied. In control plant, the lowest fruit yield (24.67 t ha^{-1}) of tomato was obtained (Table 1). The findings indicated that the application of vermicompost had the best effect on fruit yield of tomato. Vermicompost with low level of chemical fertilizer also gave better results compared to higher level of chemical fertilizer. Similar trend of result was reported by Yadav *et al*. (2001). The highest application of vermicompost showed the best performance on plant characters and fruit yield of tomato. All other treatments also showed better results over control but did not exhibit better results as compared to T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) and T_8 (vermicompost @ 10 t ha^{-1} and 75% chemical fertilizers) treatments.

Table 1. Effect of vermicompost and chemical fertilizers on plant characters and yield of tomato

Treatments	Plant height (cm)	No. of leaves $plant^{-1}$	No. of flowers $branch^{-1}$	No. of fruits $branch^{-1}$	No. of fruits $plant^{-1}$	Fruit length (mm)	Fruit breadth (mm)	Fruit yield (t ha^{-1})
T_1 - Control	98.33e	55.00e	7.67e	5.00e	5.00e	21.00e	31.93e	24.67e
T_2 - CF	100.00d	65.78d	7.87d	6.52d	6.33d	27.00d	32.33d	27.33d
T_3 - VC_1	136.00c	71.33c	8.33c	7.59c	8.12c	35.12c	36.00c	40.87c
T_4 - VC_2	139.00c	72.33c	8.67c	7.68c	8.67c	37.33c	37.33c	42.00c
T_5 - VC_1 + 50% CF	181.20b	86.33b	9.87b	9.22b	15.33b	40.67b	42.33b	65.30b
T_6 - VC_1 + 75% CF	181.00b	85.82b	9.67b	9.31b	14.87b	40.33b	42.00b	62.87b
T_7 - VC_2 + 50% CF	185.00a	105.00a	12.00a	10.00a	20.00a	43.50a	46.67a	75.00a
T_8 - VC_2 + 75% CF	182.30a	99.00a	10.33a	9.87a	18.67a	43.33a	45.00a	72.89a
$LSD_{0.05}$	11.46	4.08	0.54	0.23	0.57	3.00	2.76	2.82
Significance level	**	**	**	**	**	**	**	**
CV (%)	4.76	3.17	3.55	5.97	3.10	4.87	4.22	3.71

**Significant at 1% level; VC_1=Vermicompost @ 5 t ha^{-1}; VC_2=Vermicompost @ 10 t ha^{-1} and CF=Recommended dose of chemical fertilizers. In a column, figures with same letter or without letter did not differ significantly whereas figures with dissimilar letter differed significantly as per DMRT.

Effect of vermicompost and chemical fertilizers on biochemical constituent of tomato fruit

The effect of different treatments on pH level of tomato fruits was statistically significant at 1% level of probability (Table 2). The highest pH of fruit (4.48) was recorded in vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment), which was statistically identical with other treatments and the lowest pH of fruit (3.50) was observed at T_1 (control) treatment. Application of vermicompost alone also lowered the pH level of tomato fruit as compared to control treatment. Naresh (2002) opined that acidity of tomato fruits showed a marked increase with increasing level of chemical fertilizer, which was in agreement with the present findings. The highest total soluble solids content (3.17%) was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the content of total soluble solids in fruit was minimum (2.70%) in T_6 treatment where vermicompost at the rate of 5 t ha^{-1} along with 75% chemical fertilizers were applied (Table 2). The results represented that the highest vitamin C content (15.87 mg 100 g^{-1}) was recorded in T_5 (vermicompost @ 5 t ha^{-1} and 50% chemical fertilizers) treatment. On the other hand, the lowest vitamin C content (12.33 mg 100 g^{-1}) was obtained in T_7 ((vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers)) treatment. However, it is evident from Table 2 that application of vermicompost under study individually or in combination had no any influence on vitamin C content of tomato fruits. The reducing sugar content of tomato fruits ranged from 2.12 to 2.89%. The highest sugar content (2.89%) was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest content (2.12%) was observed in T_1 (control) treatment (Table 2). Vermicompost and chemical fertilizers influenced the content of reducing sugar in tomato fruit (Naresh, 2002). Abduli *et al*. (2013) reported that sugar content in tomato increased with using vermicompost.

Table 2. Effect of vermicompost and chemical fertilizers on biochemical constituent of tomato fruit

Treatments	pH	Total soluble solids (%)	Vitamin C (mg 100 g^{-1})	Reducing sugar (%)
T_1 - Control	3.50c	3.02	12.67	2.12d
T_2 - CF	4.45a	2.80	12.67	2.26a
T_3 - VC_1	3.75d	3.00	13.00	2.29c
T_4 - VC_2	3.78c	2.96	15.00	2.28c
T_5 - VC_1 + 50% CF	4.29b	2.97	15.87	2.80b
T_6 - VC_1 + 75% CF	4.14b	2.70	14.70	2.39b
T_7 - VC_2 + 50% CF	4.48a	3.17	12.33	2.89a
T_8 - VC_2 + 75% CF	4.47a	3.00	12.40	2.87a
$LSD_{0.05}$	0.14	0.13	0.99	0.22
Significance level	**	NS	NS	**
CV (%)	2.09	1.09	3.04	5.56

**Significant at 1% level; NSNon-significant; VC_1=Vermicompost @ 5 t ha^{-1}; VC_2=Vermicompost @ 10 t ha^{-1} and CF=Recommended dose of chemical fertilizers. In a column, figures with same letter or without letter did not differ significantly whereas figures with dissimilar letter differed significantly as per DMRT.

Effect of vermicompost and chemical fertilizers on nutrient content of tomato

Vermicompost and chemical fertilizers significantly influenced N, P, K, Ca, Mg, B and Zn contents of tomato (Tables 3 & 4). In this study, the highest nutrient contents of both fruit and plant was recorded from T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment followed by T_8 (vermicompost @ 10 t ha^{-1} and 75% chemical fertilizers) treatment. Nitrogen content in tomato fruits was significantly affected by the use of vermicompost and chemical fertilizers. The content of N in fruits was from 0.27 to 0.59%. The highest N content (0.59%) in fruits was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest N content (0.27%) was recorded in T_1 (control) treatment, which was significantly inferior to all treatments.

Table 3. Effect of vermicompost and chemical fertilizers on nutrient content of tomato fruit

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (µg g^{-1})	Zn (µg g^{-1})
T_1 - Control	0.27e	0.28e	0.76e	0.26e	0.34e	0.05e	20.00e	21.00e
T_2 - CF	0.31d	0.31d	0.79d	0.30d	0.36d	0.08d	21.00d	21.90d
T_3 - VC_1	0.35c	0.35c	0.82c	0.34c	0.44c	0.11c	24.00c	23.50c
T_4 - VC_2	0.37c	0.36c	0.84c	0.37c	0.44c	0.12c	25.00c	23.97c
T_5 - VC_1 + 50% CF	0.53b	0.43b	0.87b	0.42b	0.48b	0.24b	28.00b	28.70b
T_6 - VC_1 + 75% CF	0.51b	0.42b	0.87b	0.41b	0.48b	0.22b	27.00b	27.00b
T_7 - VC_2 + 50% CF	0.59a	0.49a	0.90a	0.45a	0.58a	0.39a	31.00a	32.00a
T_8 - VC_2 + 75% CF	0.56a	0.47a	0.88a	0.43a	0.49a	0.25b	29.00a	29.50a
$LSD_{0.05}$	0.052	0.091	0.052	0.075	0.074	0.053	1.02	2.04
Significance level	**	**	**	**	**	**	**	**
CV (%)	7.36	14.20	4.38	11.95	10.40	17.67	5.44	4.83

**Significant at 1% level; VC_1=Vermicompost @ 5 t ha^{-1}; VC_2=Vermicompost @ 10 t $ha^{-1}$and CF=Recommended dose of chemical fertilizers. In a column, figures with same letter or without letter did not differ significantly whereas figures with dissimilar letter differed significantly as per DMRT.

The content of P in tomato fruits varied from 0.28 to 0.49% (Table 3). The highest P content (0.49%) was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest P content (0.28%) in fruits was found in T_1 (control) treatment. Potassium content in tomato fruits varied from 0.76 to 0.90%. Maximum K content (0.90%) of fruit was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and minimum K content (0.76%) was observed in T_1 (control) treatment. The result showed that K content was increased with the application of vermicompost and chemical fertilizers. Singh (2001) opined that K content in tomato fruits increased due to the combination of vermicompost and chemical fertilizers. The content of Ca in tomato fruits varied from 0.26 to 0.45% and that was minimum (0.26%) in T_1 (control) treatment. Maximum Ca content (0.45%) in fruits was observed in T_7 treatment where vermicompost at the rate of 10 t ha^{-1} along with 50% chemical fertilizers were applied. Maximum content of

Mg (0.58%) in tomato fruits was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and it was minimum (0.34%) in T_1 (control) treatment. The content of Mg in tomato was significantly influenced by the effect of vermicompost with different levels of chemical fertilizers. The content of S in tomato fruits varied from 0.05 to 0.39% (Table 3). Vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated plants (T_7 treatment) gave the highest S content (0.39%) and minimum S content (0.05%) was observed in T_1 (control) treatment. The content of S in tomato fruits was improved in the combined used of organic manure with N, P and K fertilizers (Hossain, 1996). The highest B content (31.00 µg g^{-1}) was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest B content (20.00 µg g^{-1}) was obtained in T_1 (control) treatment. The content of Zn in fruit ranged from 21.00 to 32.00 µg g^{-1}. The highest content of Zn (32.00 µg g^{-1}) was obtained by application of vermicompost at the rate of 10 t ha^{-1} with 50% chemical fertilizers (T_7 treatment) and the lowest Zn content (21.00 µg g^{-1}) was obtained from control (T_1) treatment (Table 3). Application of vermicompost gave the higher nutrient contents as compared to control treatment.

In Table 4, the content of N in tomato plant varied from 0.06 to 0.30%. The highest N content (0.30%) in tomato plant was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest N content (0.06%) was recorded in T_1 (control) treatment, which was significantly inferior to all treatments. Phosphorus content in tomato plant increased significantly due to the application of integrated use of vermicompost and chemical fertilizers. The content of P in tomato plant varied from 0.09 to 0.32%. The highest P content (0.32%) was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest P content (0.09%) in tomato plant was found in T_1 (control) treatment. The results clearly indicated that P content was increased in tomato plant due to the application of vermicompost and chemical fertilizers (Kadu *et al*., 1991). Potassium content in tomato plant ranged from 0.29 to 0.67%. The highest K content (0.67%) of tomato plant was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest K content (0.29%) was observed in T_1 (control) treatment. The result showed that the highest K content was increased with the application of vermicompost and chemical fertilizers. Singh (2001) revealed that K content in tomato plant increased due to the combination of vermicompost and chemical fertilizers. The content of Ca in plant varied from 0.51 to 1.40% (Table 4). Maximum Ca content (1.40%) in tomato plant was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and that was minimum (0.51%) in T_1 (control) treatment. Vermicompost at the rate of 10 t ha^{-1} and 50% of chemical fertilizers (T_7 treatment) gave the highest Mg content (1.32%) in tomato plant and the lowest Mg content (0.75%) was found in control (T_1) treatment.

Table 4. Effect of vermicompost and chemical fertilizers on nutrient content of tomato plant

Treatments	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (µg g^{-1})	Zn (µg g^{-1})
T_1 - Control	0.06e	0.09e	0.29e	0.51e	0.75e	0.12e	2.20e	1.12e
T_2 - CF	0.08d	0.10d	0.31d	0.69d	0.80d	0.21d	2.80d	1.28d
T_3 - VC_1	0.12c	0.17c	0.39c	0.85c	0.87c	0.32c	3.00c	1.52c
T_4 - VC_2	0.14c	0.19c	0.41c	0.86c	0.89c	0.35c	3.17c	1.68c
T_5 - VC_1 + 50% CF	0.25b	0.25b	0.49b	1.22b	1.25b	0.47b	3.87b	2.50b
T_6 - VC_1 + 75% CF	0.23b	0.26b	0.48b	1.12b	1.12b	0.45b	3.80b	2.45b
T_7 - VC_2 + 50% CF	0.30a	0.32a	0.67a	1.40a	1.32a	0.52a	4.50a	2.56a
T_8 - VC_2 + 75% CF	0.29a	0.28a	0.64a	1.30a	1.29a	0.49a	4.39a	2.54a
$LSD_{0.05}$	0.053	0.054	0.092	0.075	0.075	0.10	0.18	0.13
Significance level	**	**	**	**	**	**	**	**
CV (%)	17.95	16.32	13.78	5.69	4.62	17.83	3.10	5.25

**Significant at 1% level; VC_1=Vermicompost @ 5 t ha^{-1}; VC_2=Vermicompost @ 10 t ha^{-1} and CF=Recommended dose of chemical fertilizers. In a column, figures with same letter or without letter did not differ significantly whereas figures with dissimilar letter differed significantly as per DMRT.

The content of S in tomato plant varied from 0.12 to 0.52% (Table 4). The combined application of vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers (T_7 treatment) contributed the highest S content (0.52%) in tomato plant and minimum S content in tomato plant (0.12%) was observed in T_1 (control) treatment. Hossain (1996) obtained that S content in tomato plant was improved by the combined used of organic manure with N, P and K fertilizers. The highest B content (4.50 µg g^{-1}) was observed in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and the lowest content (2.20 µg g^{-1}) was obtained in T_1 (control) treatment. The content of Zn in tomato plant ranged from 1.12 to 2.56 µg g^{-1}. The highest Zn content (2.56 µg g^{-1}) was observed from the application of vermicompost at the rate of 10 t ha^{-1} with 50% chemical fertilizers (T_7 treatment) and the lowest

Zn content (1.12 µg g^{-1}) was obtained from control (T_1) treatment (Table 4).

Effect of vermicompost and chemical fertilizers on nutrient status of postharvest soil

The contents of N, P, K, Ca, Mg, B and Zn in the postharvest soil increased significantly by the application of vermicompost and chemical fertilizers (Table 5). Maximum pH value (6.75) was found in vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and minimum pH value (6.32) was obtained in control (T_1) treatment. The integrated use of vermicompost and chemical fertilizers significantly influenced pH value of the postharvest soil. Maximum organic carbon (OC) content (0.87%) was found from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and minimum organic carbon (OC) content (0.61%) was recorded in control (T_1) treatment. The combined application of organic manure and chemical fertilizers increased organic matter content in soil (Zhang *et al.*, 1996). The highest N content (0.90%) was found from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and the lowest value (0.06%) was recorded in control (T_1) treatment. Total N content gradually increased due to the effect of vermicompost and chemical fertilizers. Vermicompost and chemical fertilizers increased total N content in the postharvest soil (Reddy *et al.*, 1998). Available P content varied from 17.12 to 32.50 µg g^{-1} (Table 5). The highest P content (32.50 µg g^{-1}) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and the lowest P content (17.12 µg g^{-1}) was found in control (T_1) treatment. Interaction between organic and chemical fertilizers also showed an increasing effect of P content in soil. Application of organic fertilizer increased available P content in soil (Mathew and Nair, 1997; Wells *et al*., 2000; Abdel and Hussain, 2001; Iftikhar and Qasim, 2003). The highest content of exchangeable K (0.35 cmol kg^{-1}) in the postharvest soil was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers (T_7 treatment) and the lowest K content (0.22 cmol kg^{-1}) was found in control (T_1) treatment. Significant effect of organic fertilizers improved exchangeable K content in soil as reported by Mathew and Nair (1997) and Wells *et al*. (2000). The highest exchangeable Ca content (11.67 cmol kg^{-1}) was obtained in T_7 treatment when vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers were applied and control (T_1) treatment gave the lowest value (8.87 cmol kg^{-1}) in soils. The content of Mg in soil varied from 2.52 to 4.80 cmol kg^{-1}. The highest Mg content (4.80 cmol kg^{-1}) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and the lowest Mg content (2.52 cmol kg^{-1}) was obtained from control (T_1) treatment. The available S content in the postharvest soil ranged from 10.87 to 21.47 µg g^{-1} (Table 5). The highest and lowest available S contents were obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) and T_1 (control) treatments, respectively. The combined use of organic fertilizer with NPK and S fertilizers improved the level of available S in soil (Hossain, 1996; Azim, 1999). In the postharvest soil, the content of B varied from 0.17 to 0.82 µg g^{-1}. The highest B content (0.82 µg g^{-1}) was obtained from vermicompost at the rate of 10 t ha^{-1} and 50% chemical fertilizers treated soil (T_7 treatment) and the lowest B content (0.17 µg g^{-1}) was recorded from control (T_1) treatment. The content of Zn in the postharvest soil was from 0.85 to 3.45 µg g^{-1} (Table 5).

Table 5. Effect of vermicompost and chemical fertilizers on nutrient status of the postharvest soil

Treatments	pH	OC (%)	Total N (%)	P (µg g^{-1})	K (cmol kg^{-1})	Ca (cmol kg^{-1})	Mg (cmol kg^{-1})	S (µg g^{-1})	B (µg g^{-1})	Zn (µg g^{-1})
T_1 - Control	6.32e	0.61e	0.06e	17.12e	0.22e	8.87e	2.52e	10.87e	0.17e	0.85e
T_2 - CF	6.58d	0.63d	0.21d	19.22d	0.25d	8.94d	2.70d	12.12d	0.34d	0.90d
T_3 - VC_1	6.56c	0.78c	0.28c	20.55c	0.24c	9.56c	3.60c	16.08c	0.65c	1.80c
T_4 - VC_2	6.55c	0.81b	0.32c	20.67c	0.25c	9.65c	3.62c	16.22c	0.67c	2.00c
T_5 - VC_1 + 50% CF	6.64c	0.85a	0.37b	27.78b	0.32b	10.78b	3.87b	20.23b	0.78b	3.37b
T_6 - VC_1 + 75% CF	6.69b	0.82b	0.45b	29.33b	0.31b	10.58b	3.85b	20.16b	0.76b	3.34b
T_7 - VC_2 + 50% CF	6.75a	0.87a	0.90a	32.50a	0.35a	11.67a	4.80a	21.47a	0.82a	3.45a
T_8 - VC_2 + 75% CF	6.68b	0.84a	0.89a	32.13a	0.33a	10.87a	4.78a	21.26a	0.81a	3.41a
$LSD_{0.05}$	0.29	0.054	0.053	0.52	0.094	0.45	0.24	0.092	0.093	0.13
Significance level	**	**	**	**	**	**	**	**	**	**
CV (%)	0.97	4.66	7.65	6.21	2.85	2.66	5.71	3.06	8.98	5.64

**Significant at 1% level; VC_1=Vermicompost @ 5 t ha^{-1}; VC_2=Vermicompost @ 10 t ha^{-1} and CF=Recommended dose of chemical fertilizers. In a column, figures with same letter or without letter did not differ significantly whereas figures with dissimilar letter differed significantly as per DMRT.

The combined effect of vermicompost and chemical fertilizers on Zn content of the post harvest soil was significant. Maximum value (3.45 µg g^{-1}) was obtained in T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment and T_1 (control) treatment recorded minimum value (0.85 µg g^{-1}). Application of vermicompost had a significant influence on the improvement of soil micronutrient including Zn (Ansari and Sukhraj, 2010). Azarmi *et al.* (2008) reported that the addition of vermicompost in soil significantly increased organic C, N, P, K and Zn contents substantially compared with control treatment for tomato cultivation. In this study, T_7 (vermicompost @ 10 t ha^{-1} and 50% chemical fertilizers) treatment showed the best performance, which was identical to T_8 (vermicompost @ 10 t ha^{-1} and 75% chemical fertilizers) treatment as compared to control (T_1) treatment. This finding might be due to the remarkable contribution of vermicompost enriched with nutrients as organic fertilizer.

Conclusions

From the study, it is concluded that vermicompost as organic fertilizer can reduce the application of chemical fertilizer for tomato cultivation and thus may minimize the cost of cultivation. Application of vermicompost at the rate of 10 t ha^{-1} along with 50% chemical fertilizers showed the best performance in terms of yield and quality of tomato as well as soil fertility management. The combined application of vermicompost and chemical fertilizers would help to maintain the long-term soil productivity for sustainable tomato cultivation.

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