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Effect of Vermicomposting and Inorganic Fertilizers on Crop Productivity of Tomato (*Lycopersicum esculentum*) and Soil Fertility

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Abstract

In this comparative study the of vermicomposting and inorganic fertilizers on crop productivity of tomato (*Lycopersicum esculentum* – F_1 Hybrid *Vaishali*) and soil fertility. It was planned to find out the efficacy of vermicomposting on tomato (fruits) productivity and to compare it with the control and vermicomposting + chemical fertilizers (NPK) and on soil fertility. Field experiments were conducted at Sivapuri Village, near Annamalai University, Tamil Nadu and India. The experiment was conducted as follows:T1: Control plots (Without any organic and chemical fertilizer), T2 : plots where recommended dose of vermicompost (5 tons ha ha-1) was applied, T3 : Plots where recommended dose of chemical fertilizer (NPK) alone (110: 40: 75 Kg ha-1) was applied as described by, T4: Plots where 50% vermi composts was supplemented with 50% chemical fertilizers (NPK) W/W. All the treatments were done in triplicates. Experiments were carried out in plot size $2M^2$. In this experimental period minimum and maximum temperature ranged from 18.3 to 31.7^0C and relative humidity ranged from 85 to 90%. These data were periodically collected from the Agricultural Meterological observatory, Annamalai University. The selection of soil used for the field experiments was sandy loam soil (SLS). Chemical fertilizers (NPK) were purchased from local fertilizer shop at Chidambaram town. NPK is used in the form of urea (N), Single super phosphate (P) and Muriate of Potash (K). For field experiment vermicomposting from T_7 was used, because of high nutritive, microbial content and high enzymatic activity. Among the above the mentioned methods of MSW management there is an urgent need to reduce the MSW loadings into landfill, because they cause the air pollution to land and water (even underground water). Since about 30 – 70% of MSW comprises organic waste such as food waste, bio-waste etc. So, the biodegradable part of the MSW can be regard as nontoxic. So, the MSW can be managed well with earthworms in a sustainable manner. Vermicomposting method of MSW management is gaining interest in the reduction of chemical fertilizer to maintain the soil fertility.

Keywords
Vermicomposting, inorganic fertilizers.

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INTRODUCTION

Green revolution of 1960's tremendously enhanced the agricultural production mainly due to the abundant use of various chemical nutrients and insecticides. However, uses of chemical fertilizers and pesticides, devoid of organic sources, has made

our soil sick and problematic, putting agricultural productivity at risk. The awareness of organic matter and concept of sustainable agriculture is gaining impetus among farmers in recent years to produce consumable agricultural products. The national average use of organic manure is about 2.5 to 3 ton/ha/yr (STSS, 2000). The long – term use of inorganic fertilizers without organic supplements damage the soil physical, chemical and biological properties and causes environmental pollution (Albiach *et al.,* 2000).

Organic composts, in general, are beneficial to soil fertility and micro fauna when applied continuously. They improve the physico – chemical, enzymatic and microbiological status and in due course result in the well – defined improvement of crop growth and yield (Wang *et al*., 2004). The production and use of vermicompost in agriculture is economical with regard to food production and more eco-friendly with regard to environment and soil protection. Through the process of vermicomposting, many different kinds of organic wastes can be made into valuable vermicompost. The nutrient level, especially the macro and micronutrients were found to be always higher in vermi composts than the compost derived from other methods (Kale, 1998a). Vermi composts have higher level of available nutrients like nitrate or ammonium nitrogen, exchangeable phosphorus and soluble potassium, calcium and magnesium derived from the waste (Buchanan *et al.,* 1988). Root initiation, increased root biomass, enhanced plant growth and development and sometimes, alternations in plant morphology are among the most frequently claimed effects of vermicompost treatment (Tomati *et al.,* 1988). In tomato, Hilman and Suwandi (1989) reported that among sheep, horse and cow dung manures, the highest yield of 2.15 Kg plant^{-1} was obtained with sheep manure at 30 t ha^{-1}. Santos *et al*. (1993) reported that application of vermicompost to lettuce gave additional yield of 3.4 t ha^{-1} over the application of organic compost. Kale *et al*. (1993) in six ornamental crops such as ladys's lace, dianthus, balsam, celosia, zinnia and marigold, application of vermicompost without any chemical fertilizers yielded similar to the treatment which received the normal dose of chemical fertilizers. Combined application of well decomposed farmyard manure + earthworm gave the maximum yield in tomato, but it was on par with normal practices of application of FYM (25 t ha^{-1}) along with inorganic fertilizers (Thamburaj, 1994).

Edwards (1998) reported that vermicompost could promote early and vigorous growth of seedlings. Vermicompost was found to effectively enhance the root formation, elongation of stem and production of biomass, vegetables, ornamental plants *etc*. (Kale, 1998a). Ghosh *et al.,* (1999b) observed that integration of vermicompost with inorganic fertilizers tended to increase the yield of crops *viz* - potato, rape seed, mulberry and marigold over other traditional composts.

Many research works revealed that the cost incurred on the inorganic fertilizers can be reduced to a greater extent by the application of plant nutrients through organic sources like compost, farmyard manure, pressmud, microbial inoculants and vermicompost (Sankaran and Subbiah Mudaliar, 1997). The application of vermicompost to turmeric crop was found to increase the growth characters and higher yield compared to control due to the microbial activity of vermicompost (Vadiraj *et al*., 1999). Srikanth *et al.* (2000) reported that the soil nutrient value was found to be high in enriched compost applied to soil after the harvest of first and second crop. In brinjal, combined application of organic manures viz., FYM + press mud @ 12.5 t ha^{-1} each, along with 100% recommended dose of inorganic fertilizers increased the plant height, number of branches and leaves and also induced early flowering (Anburani, 2000).

Shankar Raj Pant and Kayo Devi Yami (2008) reported that worm casts contain five times more nitrogen, seven times more phosphorus and eleven times more potassium than ordinary soil, the main minerals needed for plants growth. It also contains a lot of beneficial soil microorganisms. The microorganisms in the worms gut also produce useful compounds like antibiotics, vitamins, plant growth hormones, *etc*. all of which are also present in the casting. Many green house and field studies have been made on the role of variety of vermi composts on a wide range of crops including cereals and legumes (Kaushik and Garg, 2003); vegetable (Atiyeh *et al*., 2000b) ornamental and flowering plants and field crops (Arancon *et al*., 2004).

Tomato in the world's highly used vegetable crop for its flesh. It is considered as commercial and vegetables crop. Atiyeh *et al*. (2000c) concluded that the organic product of tomato decreased the cost, increased the yield and reduced the negative effects on environment. Azarmi *et al*. (2008) observed the growth, yield and nutrition status of tomato after the application of various quantity of vermicompost. Joshi and Vig (2010) studied the effect of 15%, 30% and 45% vermicompost along with soil on the growth, yield and quality of tomato. Role of vermicompost along with microbes on the plant height, number of leaves and yield of tomatoes were studied (Oliva Liaven *et al*., 2010).

Chanda *et al*. (2011) observed variation on tomato growth and yield after the application of various doses of NPK and vermicompost. The above quoted works have been made on the effect of vermicompost made from various substrates on tomato. But only one study was (Begum, 2011) made on role of vermicompost made from municipal sewage sludge on the tomato. So it was intended to study the effect of vermicompost made from MSW by using *E. eugeniae* particularly the vermicompost obtained from T_7 because this treatment was observed to have more nutrients, microbes and higher enzymatic activity. Apart from this the soil parameters before and after plantation of tomato also analysed.

MATERIALS AND METHODS

i) Experimental plot size

In this experiment tomatoes plants were planted in the plots where each plot had 2 m long and 2 m wide ($2M^2$) and was separated by 1 m width from unplanted areas. Experiment was carried out based on randomized complete block design with three replicates.

Experimental details of the present field investigation

Sl.No	Particulars	Details of tomato
1.	Location	Farmer's field at Sivapuri village, Near Annamalai University
2.	Nature of soil	Sandy loam soil
3.	Season	December - March 2009 – 2010
4.	Variety	F_1 Hybrid Tomato – *Vaishali*
5.	Duration	120 days
6.	Experimental design	Randomized block design (RBD)
7.	Replication	Three
8.	Plot size	$2M^2$
9.	Date of seed sowing	December-1
10.	Date of transplantation	December-31 (after 30 days)

The growth and yield parameters of tomato fruits are given below:

a) Young seedlings: To obtain uniform size and healthy seedlings, sufficient nursing management was carried out.

b) Transplantation: After 30 days, young seedlings were transplanted into experimental plots.

c) Growth parameters: The growth parameters of tomato plant were recorded in different days on 30, 60, 90, and 120 days. Growth parameters were measured using by centimetre scale as cm/plant. For each treatment three plants were randomly selected from the experimental fields. The growth parameters are given below:

d) Plant height per plant (cm): The height of the plant from the base to the tip was measured at 30, 60, 90 and 120 days after transplanting and expressed in centimetre (cm).

e) Number of branches (No. p^{-1}): The number of branches per plant was counted in control and experimental plots.

f) Number of leaves per plant (No. p^{-1}): The numbers of leaves in three randomly selected plants were counted and mean value was worked out and expressed in number.

g) Days taken for first flowering: The number of days taken from transplanting to first flowering was recorded and expressed in days.

h) Number of flower clusters per plant (No. p^{-1}): The emerging flower clusters were marked consistently and counted till the final harvest and recorded.

i) Number of flowers per clusters (No. c^{-1}): The number of flowers per cluster was observed on three tagged clusters in each treatment and the average was worked out.

Yield parameters

a) Days to first harvest: Days to first harvest were noted in control and experimental plots.

b) Number of fruits per plant (No. p^{-1}): The numbers of ripe fruits harvested from each plant at every harvest were recorded individually and the mean was computed.

c) Mean single fruit weight (g): Three randomly selected red ripe fruits from each plant at were weighed individually and mean fruit weight was expressed in grams.

d) Total fruit yield per plant (g/p^{-1}): Ripe fruits at each harvest were weighed and totalled up to the final harvest and expressed in grams.

Analysis of physico–chemical parameters of the soil: The purpose of physico-chemical analysis, the soil samples were collected from the experimental plots, before planting (0- day) and after harvesting (120^{days}) of tomato.

Physical Parameters: Porosity (or) pore space of the soil (%) was determined by specific gravity bottle

method of Kanwar and Chopra (1980), Bulk density (BD) (mg m^{-3}) Kanwar and Chopra (1980), Particle density (PD) (mg m^{-3}) Kanwar and Chopra (1980), Water holding capacity of the soil was determined by the method of Baruah and Barthakur (1999).

Chemical Parameters: Available nitrogen present in the soil was estimated by alkaline potassium permanganate method as described by Subbiah and Asija (1956). Available Phosphorus content in the soil was estimated by the method as described by Olsen *et al*. (1954). Available potassium in the soil was estimated by neutral normal ammonium acetate method as described by Stanford and English (1949).

Statistical analysis: The statistical significance between treatments was analysed using critical difference (CD) values at 0.05% level were computed.

RESULTS

Effect of vermicompost and chemical fertilizers (NPK) on growth and yield of tomato plant

The effect of vermicompost and chemical fertilizers (NPK) on the growth, flowering characters and yield of tomato are presented in Tables 1. The growth characters of tomato plants include the plant height, number of branches and number of leaves. The following characters such as - days taken for first flowering, number of flower clusters and number of flowers per cluster are also recorded.

The growth and flowering characters on 30, 60, 90 and 120 DAT are presented in Tables 1 to 6.

The yield parameters on 120 DAT are presented in Table – shows field of tomato plants from FT_1, FT_2, FT_3 and FT_4. In all the treatments the growth parameters showed an increasing trend from 30 DAT to 120 DAT. Among the four treatments FT_4 (50% VC + 50% CF) showed highest growth rate and ranked – I.

The FT_2 plants (VC alone) can be ranked - II whereas the plants of FT_3 (CF) showed moderate growth response and FT_1 (without the application of organic and inorganic fertilizers) showed least response with reference to growth characters.

In the field trail comparison of percentage change over the control values between treatments (FT_1 – FT_4) clearly proved that tomato plants grown in recommended dose of VC 50% + CF 50% (FT_4) plots showed effectively enhanced growth parameters - *i.e.,* plant height (cm) 62.61%, 33.52%, 31.10%, 32.84% respectively in 30, 60, 90 and 120 DAT over the control (FT_1). Number of branches (No. p^{-1}) increased 83.00%, 126.71%, 137.50% and 126.83% respectively in 30, 60, 90 and 120 DAT over the control (FT_1). Number of leaves (No. p^{-1}) increased 44.31%, 65.83%, 40.03% and 66.53% respectively on 30, 60, 90 and 120 DAT over the control of from respective DAT.

Yield characters

The effect of vermicompost and chemical fertilizers (NPK) on yield parameters of tomato plants (*Lycopersicum esculentum*). The comparison of percentage change over the control values between treatments FT_1 to FT_4 clearly proved that the FT_4 (50% recommended dose of vermicompost supplemented with 50% chemical fertilizer) showed the appearance of first flower on 19.92 ± 1.12 days and it was followed by the plants of FT_2 which showed its first flower on 23.94 ± 1.27 days. In the plants of FT_3 the flowers appeared on 25.61 ± 1.31 and finally plants of FT_1 showed the appearance of flowers on the day of 28.10 ± 1.51.

Number of flower clusters (No. p^{-1}) cultivated in FT_4 plots increased 29.11%, 221.20%, 142.31% and 46.91% on 30, 60, 90 and 120 DAT over the control. Number of flowers per cluster (No.c^{-1}) increased in FT_4 plants *i.e.,* 80.00% on 30DAT, 73.81% on 60 DAT, 129.81% on 120 DAT respectively whereas the plots FT_3, FT_2 and FT_1 showed less number of clusters and flowers than FT_4.

Days of first harvesting of tomato fruits in FT_4 plots was done on 62.2 ± 2.99 DAT, next was in FT_2 (VC) on 64.9 ± 3.42 DAT. On 67.4 ± 3.73 DAT first harvests was done in FT_3 (CF) and on 71.8 ± 3.91 DAT the first harvest was made in FT_1. Regarding number of fruits per plant higher quantity was obtained in FT_4 plots *i.e.,* 62.71 ± 2.53 and least quantity were obtained in FT_1 plots.

Mean single fruit weight (g/f^{-1}) was 74.12 ± 3.15 g in FT_4, 64.61 ± 2.87 in FT_3, 70.72 ± 3.72 g in FT_2 and 56.11 ± 3.64 g in FT_1 on 120 DAT. Finally, the fruit yield per plant (g/p^{-1}) was 1638.7 ± 50.85 g; 1542.7 ± 45.97g; 1591.3 ± 38.65g; 1347.50 ± 40.56g in respectively plots in FT_4, FT_3, FT_2 and FT_1. The effect of VC, CF, VC + CF to enhance the growth and yield components of tomato plants could be ranked in the following order: $FT_4 > FT_2 > FT_3 > FT_1$.

Effect of vermicompost on soil

To observe the effect of vermicompost (FT_2), chemical fertilizers (FT_3) and vermicompost and mixed with chemical fertilizers (FT_4) on the field, physical properties and chemical properties of sandy loam soil (SLS), before transplantation (initial soil) and post harvest soil (after 120^{th} day) were analysed and presented (Table -7).

Physico – Chemical properties

The observed physical properties showed fluctuations in their values. After the cultivation of tomato, among the parameters of soil highest value in pore space, WHC and EC were observed in FT_2 (VC). Highest particle density in soil of FT_1 and bulk density

in the soil of FT_3 were found. Among the status of nutrients, the highest quantity of OC, N, P and K were found in FT_2. This shows the superior nature of vermicompost in sustainable agriculture. The value of pH had been increased due to the application of chemical fertilizers (NPK) in FT_3. However, very gradual decreases in pH value were noted in the soils of FT_1 and FT_4. Near neutral pH was observed in FT_2 (VC). Highest variation in EC was noted in FT_2 and FT_4 over the initial.

Table: - 1. 30 days old young seedling plant - characteristics of tomato plants (*Lycopersicum esculentum*) F_1 Hybrid *Vaishali* at the time of transplantation

Growth parameters	
Plant height (cm)	14.3±1.25
No. of branches (No. p^{-1})	-
No. of leaves (No. p^{-1})	6.0±0.95

Table: - 2. Effects of vermicompost and NPK on growth parameters and flowering characters of tomato plants (*Lycopersicum esculentum*) – F_1 Hybrid *Vaishali* on 30 DAT

Growth Parameters	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Plant height (cm)	27.8±1.36	43.4±1.9 (56.12)	41.2±1.51 (48.20)	45.2±2.0 (62.61)	1.599
No. of branches (No. p^{-1})	1.0±0.45	1.46±0.52 (46.00)	1.50±0.47 (50.00)	1.83±0.6 (83.00)	0.030
No. of leaves (No. p^{-1})	24.6±1.11	32.6±1.25 (32.52)	30.7±1.17 (24.81)	35.5±1.25 (44.31)	1.799
Flowering characters					
Days taken for first flowering	28.10±1.51	23.94±1.27 (-14.80)	25.61±1.31 (-8.90)	19.92±1.12 (29.11)	1.569
No. of flower clusters (No. p^{-1})	3.0±0.51	8.4±0.74 (180.00)	6.0±0.81 (100.00)	12.01±0.93 (300.33)	2.199
No. of flowers per cluster (No. c^{-1})	3.0±0.50	4.1±0.62 (36.71)	3.8±0.71 (26.71)	5.4±0.97 (80.00)	0.200

Values are mean of three observations,

Values in brackets are percentage change over the control, CD- Critical Difference at 0.05% level, FT_1- Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3-Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W), p – plant, c – cluster.

Table: - 3. Effects of vermicompost and NPK on growth parameters and flowering characters of tomato plants (*Lycopersicum esculentum*) – F_1 Hybrid *Vaishali* on 60 DAT

Growth Parameters	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Plant height (cm)	43.61±1.27	55.43±1.87 (27.10)	52.84±2.11 (21.20)	58.23±2.15 (33.52)	2.449
No. of branches (No. p^{-1})	1.5±0.36	2.6±0.49 (100.00)	2.3±0.45 (53.33)	3.4±0.64 (126.71)	0.200
No. of leaves (No. p^{-1})	36.0±1.41	52.5±1.23 (45.83)	49.6±1.21 (37.81)	59.7±1.31 (65.83)	2.699
Flowering characters					
No. of flower clusters (No. p^{-1})	5.2±0.49	11.5±0.72 (121.60)	9.2±0.92 (76.92)	16.7±0.91 (221.20)	2.099
No. of flowers per clusters (No.c^{-1})	4.2±0.51	5.5±0.43 (30.10)	4.73±0.84 (12.62)	7.3±0.89 (73.81)	0.660

Values are mean of three observations,

Values in brackets are percentage change over the control, CD – Critical Difference at 0.05% level, FT_1 – Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3 – Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W), p – plant, c – cluster

Effects: - 4. Effects of vermicompost and NPK on growth parameters and flowering characters of tomato plants (*Lycopersicum esculentum*) – F_1 Hybrid *Vaishali* on 90 DAT

Growth Parameters	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Plant height (cm)	54.87±2.69	64.23±2.47 (17.11)	62.68±2.20 (14.23)	71.92±3.15 (31.10)	1.449
No. of branches (No. p^{-1})	2.4±0.31	4.5±0.37 (87.50)	3.9±0.39 (62.50)	5.7±0.92 (137.50)	0.500
No. of leaves (No. p^{-1})	64.2±2.17	85.3±2.27 (32.91)	78.7±2.95 (22.61)	89.9±2.31 (40.03)	3.499
Flowering characters					
No. of flower clusters (No. p^{-1})	7.8±0.51	13.6±0.98 (74.41)	10.4±0.88 (33.33)	18.9±1.10 (142.31)	2.499
No. of flowers per clusters (No. c^{-1})	4.7±0.57	7.3±0.51 (55.32)	6.8±0.79 (44.70)	10.8±0.79 (129.81)	0.400

Values are mean of three observations,

Values in brackets are percentage change over the control, CD – Critical Difference at 0.05% level, FT_1 – Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3 – Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W), p – plant, c – cluste

Table: - 5. Effects of vermicompost and NPK on growth parameters and flowering characters of tomato plants (*Lycopersicum esculentum*) – F_1 Hybrid *Vaishali* on 120 DAT

Growth Parameters	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Plant height (cm)	57.76±3.10	68.31±2.95 (18.31)	65.40±2.74 (13.23)	76.73±2.85 (32.84)	2.799
No. of branches (No. p^{-1})	4.1±0.27	6.7±0.55 (63.41)	6.0±0.31 (46.34)	9.3±0.82 (126.83)	0.600
No. of leaves (No. p^{-1})	70.8±2.32	94.6±2.35 (33.62)	91.3±2.74 (28.10)	117.9±2.66 (66.53)	3.100
Flowering characters					
No. of flower clusters (No. p^{-1})	8.1±0.45	14.2±0.78 (75.31)	11.7±0.87 (44.44)	11.9±0.72 (46.91)	1.199
No. of flowers per clusters (No. c^{-1})	6.6±0.49	9.1±0.67 (37.89)	7.8±0.59 (18.18)	11.1±0.91 (68.20)	1.099

Values are mean of three observations,

Values in brackets are percentage change over the control, CD – Critical Difference at 0.05% level, FT_1 – Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3 – Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W), p – plant, c – cluster.

Table: - 6. Effects of vermicompost on yield parameters of tomato plants (*Lycopersicum esculentum*) on 120 DAT

Growth Parameters	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Days of first harvesting	71.8±3.91	64.9±3.42	67.4±3.73	62.2±2.99	2.299
No. of fruits (No. p^{-1})	40.81±2.75	54.50±1.95	43.73±2.17	62.71±2.53	2.799
Single fruit weight (g)	56.11±3.64	70.72±3.72	64.61±2.87	74.12±3.15	3.099
Fruit yield (g/p^{-1})	1347.50±40.56	1591.3±38.65	1542.7±45.97	1638.7±50.85	22.600

Values are mean of three observations,

Values in brackets are percentage change over the control, CD – Critical Difference at 0.05% level, FT_1 – Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3 – Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W), p – plant, c – cluster.

Table: - 7. Physico-chemical properties of initial and final field soil (before and after cultivation) of tomato

Physico-chemical parameters	Initial day	Post harvest				
	Before plantation	FT1(C)	FT2(VC)	FT3(CF)	FT4(VC+CF)	CD-value
Pore space (%)	33.46±1.36	32.1±1.38 (-4.10)	37.2±1.41 (11.21)	32.8±1.29 (-1.10)	34.7±1.33 (3.71)	1.699
Bulk density (mg m^{-3})	1.52±0.34	1.28±0.41 (-15.81)	1.07±0.45 (-29.61)	1.35±0.64 (-11.20)	1.18±0.47 (-22.41)	0.050
Particle density (mg m^{-3})	3.11±0.15	1.73±0.17 (-44.40)	1.52±0.13 (-51.13)	1.66±0.12 (-46.62)	1.44±0.10 (-53.71)	0.060
WHC (%)	65.13±2.21	61.61±2.36 (-5.41)	85.78±2.54 (31.71)	59.32±1.97 (-8.92)	73.56±2.11 (12.94)	6.949
pH	7.10±0.31	7.20±0.34 (1.41)	6.94±0.42 (-2.25)	7.29±0.27 (2.71)	7.14±0.36 (0.60)	0.050
EC (dSm^{-1})	0.54±0.09	0.69±0.06 (27.81)	1.02±0.09 (88.91)	0.32±0.03 (-40.74)	0.98±0.07 (81.50)	0.030
OC (%)	1.38±0.15	2.48±0.21 (79.71)	7.56±0.27 (447.83)	2.32±0.17 (68.12)	6.71±0.29 (386.23)	0.750
N (Kg ha^{-1})	114.0±5.25	115.4±6.67 (1.23)	144.2±7.54 (26.50)	132.1±6.24 (15.91)	138.9±6.55 (21.84)	5.099
P (Kg ha^{-1})	12.4±1.12	11.7±1.14 (-5.65)	25.3±1.19 (104.03)	14.8±1.17 (19.41)	23.1±1.13 (86.30)	1.999
K (Kg ha^{-1})	160.8±15.41	171.5±16.77 (6.70)	220.6±17.54 (37.21)	190.4±15.50 (18.41)	199.7±16.5 (24.20)	7.299

Values are mean of three observations,

Values in brackets are percentage change over the control, CD – Critical Difference at 0.05% level, FT_1 – Control (without application of inorganic or manure), FT_2 – Recommended dose of vermicompost (5 tons h^{-1}), FT_3 – Recommended dose of chemical fertilizers (NPK) 110:40:75 Kg ha^{-1}, FT_4 – Application of 50% vermicompost + 50% chemical fertilizers (W/W).

DISCUSSION

a) Effect of vermicompost on crop growth and yield

In our observation it was noticed that the FT_4 showed maximum plant height, number of branches, number of leaves, number of flower clusters and number of flowers per cluster and it was followed by FT_2 and FT_3. Krishnamoorthy and Vajrabhiah (1986) reported that the cytokinins and auxins produced from organic wastes were processed by earthworms. Vermicompost contains plant growth regulators and other plant growth influencing materials produced by microorganisms (Tomati *et al.,* 1990). Vermicompost also contains large amounts of humic substances (Masciandaro *et al.,* 1997) and had some effects on plant growth regulators or hormones (Muscolo *et al.,* 1999).

Atiyeh *et al*. (2000c) showed that 10 - 20% vermicompost in Metro-Mix 360 medium significantly increased the weight of tomato seedlings and fruit yields compared to the Metro-Mix 360 control. Kumari and Ushakumari (2002) reported that treatment with enriched vermicompost was superior to other treatments for the uptake of N, P, K, Ca and Mg by cowpea.

Begum (2011) in tomato observed increased plant height, leaf area index and number of branches in the plants by the application of vermicompost. They suggested that it was due to the available NPK in soil treated with NPK and vermicompost. Jeyabal and Kuppuswamy (2001) used different combinations of coir pith/ weeds and cowdung/ sugarcane pressmud/ bio-digested slurry for vermicomposting using earthworm *Eudrilus eugeniae.* They applied it for rice legume crop and the results showed that the combination of bio-digested slurry and weeds was an ideal combination for vermicomposting.

In our studies the appearance of first flower was noticed earlier in FT_4 and it was followed by FT_2 and FT_3. Increased number of flower clusters and flowers per cluster were also noticed in the same patterns. Chanda *et al*. (2011) observed increased height, number of branches, number of fruits and increased weight of fruits in tomato when vermicompost was supplemented with chemical fertilizers. They have studied the effect of NPK, farmyard manure, vermicompost, farmyard manure with NPK and vermicompost with NPK. Among all these, the superior results were noticed in vermicompost with NPK. Falling in line with above study made by

Manivannan *et al*. (2009), Chanda *et al*. (2011) present study showed, significantly higher growth and yield in the tomato plants from the plots of FT_4. This increased growth and yield might be due to the availability of nutrients (NPK) without leaching by the application of vermicompost as suggested by Prabha *et al*. (2007).

Several research workers (Tomati and Galli, 1995; Edwards and Bohlen, 1996; Ghosh *et al.,* 1999a; Rajesh Banu *et al.,* 2008) observed that integration of vermicompost with inorganic fertilizers tended to increase the yield of crop viz. tomato, potato, groundnut, blackgram, paddy, mulberry and marigold. Vermicomposts consistently promote biological activity which can cause higher percentage of germination, flowering, growth and yield better than in commercial container media, independent of nutrient availability (Arancon *et al.,* 2004). Senthilkumar *et al*. (2004) found that vermicompost + NPK significantly enhanced rose growth, yield and quality. Application of 75% RFR (recommended fertilizer rates) + 200 g vermicompost and 100% RFR + 200 g vermicompost per plant resulted in greater plant heights, leaf areas, shoot and root dry weights and numbers of laterals per plant.

Gutierrez-Miceli *et al*. (2007) studied the effects of earthworm-processed sheep manure (vermicompost) on the growth, productivity and chemical characteristics of tomato. Sangwan *et al*. (2010b) conducted a pot culture experiment to assess the quality of vermicompost produced from filter cake mixed with cow and horse dung on the growth and productivity of marigold. The filter cake + cowdung and horse dung vermicomposts have higher manurial value and affects the growth and productivity of plants synergistically. Addition of vermicomposts in appropriate quantities had improved the growth and flowering of plants, plant shoot biomass, root biomass, plant height and flower diameter. Addition of vermicomposts also improved the physical, chemical and biological properties of the potting soil.

When we analysed the soil parameters after the cultivation of tomato, increased pore space, WHC, reduced pH, increased EC, OC, higher available nutrients were observed in the FT_2 plots. This indicates that the application of vermicompost increased favorable parameters such as WHC, pore space, higher available nutrients. The increased porosity, WHC and EC were observed in FT_2 and was followed by FT_4 and FT_3. Long term application of chemical fertilizers damages the soil physical properties (Goyal *et al*., 1999). Vermicompost contain more water stable aggregate than surrounding soil (Edwards and Bohlen, 1996). Tomati and Galli (1995) reported that vermicompost had polysaccharides which act as cementing substance leading to the formation of aggregates which increases the porosity and WHC. The observations of present study support the above investigations.

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