# YIELD RESPONSE OF TOMATO UNDER DIFFERENT COMBINATION OF MANURES AND FERTILIZERS



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A THESIS
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The Author

# ABSTRACT

An experiment was carried out on yield response of tomato (*Lycopersicon esculentum* Mill.) under different combination of manures and fertilizers at Hogladanga village under the Batiaghata upazila of Khulna district during November, 2013 to March, 2014. The experiment was set up in a Randomized Complete Block Design (RCBD) with three replications. The experiment consisted of seven treatments. The treatments were $T_1$ = Recommended doses of NPK (Urea @ 350 kg $ha^{-1}$, TSP @ 250 kg $ha^{-1}$, MoP 300 kg $ha^{-1}$, respectively), $T_2$ = Cowdung @10 t $ha^{-1}$, $T_3$ = Vermicompost @ 10 t $ha^{-1}$, $T_4$ = *Trichoderma* compost @10 t $ha^{-1}$, $T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer, $T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer and $T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer. The response on growth and physio-morphological characteristics, yield attributes and yield of tomato were positively and significantly influenced by the application of vermicompost with recommended dose of NPK and also *Trichoderma* compost with the recommended dose of NPK. In most cases $T_6$ (50 % Vermicompost + 50 % recommended doses of fertilizer ) treatment performed better. However, the maximum yield of tomato (78.02 t $ha^{-1}$) was obtained from the treatment receiving 50 % Vermicompost + 50 % recommended doses of fertilizer and the lowest yield of tomato (42.36 t $ha^{-1}$) was obtained from treatment $T_2$ (Cowdung @10 t $ha^{-1}$). The highest benefit cost ratio (BCR) of tomato (3.15) was obtained from application of 50 % vermicompost + 50% recommended doses of fertilizer due to higher yield and market value. So, 50 % vermicompost + 50% recommended doses of fertilizer treatment ($T_6$) was proved more profitable and sustainable for cultivation of tomato obtaining better yield.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| AEZ | : Agro Ecological Zone |
| Agric. | : Agriculture |
| DAT | : Days After Transplanting |
| RCBD | : Randomized Complete Block Design |
| BAU | : Bangladesh Agricultural University |
| FYM | : Farm Yard Manure |
| RDF | : Recommended Dose of Fertilizers |
| CFU | : Colony Formation Unit |
| PM | : Poultry Manure |
| CD | : Cowdung |
| FRG | : Fertilizer Recommendation Guide |
| EC | : Electrical Conductivity |

# Chapter I

# INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill.), a member of the family Solanaceae, is the most popular vegetable in the world for its taste, colour and high nutritive value and also for its diversified use (Bose and Som, 1986). Tomato is one of the important vegetable crops grown throughout the world and ranks next to potato in terms of the area but ranks first as a processing crop (Mehdizadeh *et al.,* 2013). In Bangladesh tomato is mainly cultivated in winter season, although some recommended summer variety are cultivated during summer season. Popularity of tomato is increasing day by day due to its flavor, food and medicinal value. It is widely using in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. In Bangladesh, tomato is growing in about 13,066 ha of land with the total production of 74,000 metric tons (BBS, 2012). So, this research is designed to identify the way of improving yield capacity of tomato arranged with cowdung, vermicompost, *Trichoderma* compost and NPK fertilizer.

Cowdung is highly familiar manure and used in our agricultural aspect. Vermicompost and *Trichoderma* compost are not much familiar, but use of these two are increasing day by day because of higher nutrient content as alternate of inorganic fertilizer. Vermicompost and *Trichoderma* compost are highly using worldwide as source of organic manure. A good agricultural soil should have around 5% organic matter but in Bangladesh, the soils of most regions have 1.5-2%, some soils even have less than 1% organic matter (Fertilizer Recommendation Guide, 2012). Organic manure such as cowdung, *Trichoderma* compost and vermicompost improve texture, structure, color, water holding capacity, microbial activity, anion and cation exchange capacity, organic matter and carbon-content of soil and, it also promotes the vegetative growth, flowering, fruit set, yield and quality of tomato in ways similar to inorganic fertilizers (Tonfack *et al.*, 2009). Manure and biofertilizers prepared from animal and plant origin are most commonly used for sustainable production (Premsekhar and Rajashree, 2009) due to their beneficial effects on nutrient uptake and retention, pest control and productivity (Barrios-Masias *et al.,* 2011). Among such preparations, vermicompost has been recognized as having considerable potential for soil amendments (Wei *et al.,* 2012).

Cowdung is the most cheap and available qualified manure. The use of available and cheap cowdung can ensure sustainability of production and balanced nutrition. The long term use of cow dung increased aggregate stability, macro pores and lowered bulk density (Olayinka *et al.*, 2006). A great part of the benefit of animal manure lies in slow mineralization and the addition of organic matter to the soil which offers a definite advantage over inorganic fertilizers (Lakshmikathan, 1983).

Vermicompost is a finely divided manure peat like material with high porosity, aeration, drainage and water holding capacity and microbial activity and is stabilized by interaction between earthworms and micro-organisms in a nonthermophilic process (Edwards and Burrows, 1988). Vermicompost contains a high proportion of humic substances (humic acids, fulvic acids and humin) which provide numerous sites for chemical reaction; microbial components known to enhance plant growth and disease suppression through the activities of bacteria (*Bacillus*), yeast (*Sporobolomyces* and *Cryptococcus*) and fungi (*Trichoderma*), as well as chemical antagonists such as phenols and amino acids (Theunissen *et al.,* 2010). With the process of conversion of various organic wastes by earthworms, many of the nutrients are changed to their available forms in order to make them easily utilizable by plants.

Efficient use of *Trichoderma*-enriched biofertilizer may increase yield, reduce the uses of N fertilizers, reduce soil borne pathogens and improve soil health. *Trichoderma* compost is used to produce quality tomato seedlings, capable of withstanding adverse abiotic and biotic stresses after transplanting and improve mineral nutrient uptake, inspire producers to consider a combined pre sowing inoculation of seedling with *Trichoderma harzianum*.

The yield of tomato is not satisfactory in Bangladesh. Several factors such as deficiency of soil nutrients, cultural factors, spacing etc., are considered as the major constraints to successful tomato production. The farmer of our country use excess amount of inorganic fertilizer to gain better yield without considering adverse effect of it. High application of chemical fertilizers has negative effects on physical, chemical and biological properties of soil and may cause soil erosion (Davarinejad *et al.,* 2004). Now-a-days there is more attention to replace chemical fertilizers with biological fertilizers (Kader *et al*., 2002). Excessive use of inorganic fertilizers creates environment related problems and situation can be improved through the use of bio-fertilizer (Saadatnia and Riahi, 2009). One of the possible options to reduce the use of chemical fertilizers could be recycling of organic wastes. Compost as the organic waste can be a valuable and inexpensive fertilizer and source of plant nutrients. Organic waste have Positive effects on soil structure, aggregate stability and water-holding capacity (Odlare *et al*., 2008).

There are many problems in agriculture of Bangladesh among these degradation of soil health is one of the major problems. This problem creates due to higher use of agrochemicals such as fertilizers, pesticides, herbicides etc. in crops fields as well as for intensive cropping to produce more foods for the fast and vast growing populations without considering the negative impact of chemicals on soil. Organic agricultural practices might be a potential alternative to mitigate the soil health degradation problem. However, concept of organic farming is very preliminary in Bangladesh. This practice maintains crops yield at optimum level by assuring soil health.

From the above discussion it is revealed that cowdung, vermicompost and *Trichoderma* compost are highly beneficial with various properties influencing soil fertility, growth and yield of products. So this research was conducted with following objective :

- To assess the effect of different combination of manures and fertilizers on growth and yield of tomato

# Chapter II

# REVIEW OF LITERATURE

Organic manures, which are incorporated with biofertilizer have stimulating effect on plant growth and yield of vegetables. The use of compost in agriculture is beneficial to soil, crops and environment. Due to higher popularity and nutritive value, tomato received much attention to the researchers throughout the world. Very few works were reported where the effect of cowdung, vermicompost, *Trichoderma* with NPK inorganic fertilizers on growth and yield of tomato have been found. However, the available findings have been reviewed here under the following subheadings.

## 2.1 Effect of vermicompost on growth and yield of tomato

Nizam *et al.* (2014) carried out a field experiment to find out the effect of organic manure and spacing on the growth and yield of tomato. The experiment consisted of two factors. Factor A: levels of organic manures, viz. $M_0$: 0 t ha$^{-1}$ (control), $M_1$: 20 t ha$^{-1}$ (Cowdung), $M_2$: 10 t ha$^{-1}$ (Vermicompost) and $M_3$: 15 t ha$^{-1}$ (Leaf rotten compost); Factor B: Three types of spacing, viz. $S_1$: 60 cm x 60 cm), $S_2$: 60 cm x 45 cm and $S_3$: 60 cm x 30 cm. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The significant variations were observed for different parameters. In case of organic manures the highest yield (68.99 t ha$^{-1}$) was found from $M_2$ and the lowest (32.62 t ha$^{-1}$) from $M_0$. In case of Spacing the highest yield (52.58 t ha$^{-1}$) was obtained from $S_1$ (60 cm x 60 cm) and the lowest (43.32 tha$^{-1}$) from $S_3$ (60 cm x 30 cm). For combined effect the highest yield (75.75 t ha$^{-1}$) was obtained from $M_2S_1$ and the lowest (29.07 t ha$^{-1}$) from $M_0S_1$. The highest benefit cost ratio (2.43) was obtained from $M_2S_1$. So, 10 ton ha$^{-1}$ vermicompost with spacing (60 cm x 60 cm) was found suitable for growth and yield of tomato.

Prodhan *et al.* (2014) arranged a field experiment to evaluate the effect of organic manure and spacing on growth and yield of tomato. Four levels of organic manure hectare$^{-1}$ viz. 0, 10 ton cowdung, 5 ton vermicompost and 10 ton leaf rotten compost were treated in tomato plants maintaining three spacing of 60 cm x 60 cm ($S_1$), 60 cm x 45 cm ($S_2$) and 60 cm x 30 cm ($S_3$) arranged in Randomized Complete Block Design with three replications. Vermicompost and wider spacing were most effective for increasing the floral and yield characters of tomato while the highest yield of fruit ha$^{-1}$ was produced in closest spacing due to higher plant densities. Spacing showed significant differences in terms of days required to 1st flowering of tomato. The shortest period were required for 1st flowering (29.70 days) in wider spacing ($S_3$) while more or less same period needed for flowering incase of $S_1$ and $S_2$. Vermicompost produced highest number of flower clusters (10.76) and total flowers plant$^{-1}$ (61.35) where in case of control these were 7.79 and 35.41 respectively. Highest length of fruit (5.13 cm), diameter of fruit (4.61), dry matter content of fruit (10.44%) and yield (58.99 t ha$^{-1}$) were found in case of vermicompost. Highest number of fruits per plant (28.21) was found in case of leaf rotten compost and highest single fruit weight was 64.50 in case of $S_3$.

Chatterjee and Khalko (2013) conducted an experiment to evaluate the influence of organic amendments and inorganic fertilizers on natural infestation of late blight and fruit yield of tomato and it was investigated with an aim to develop best possible nutrient schedule for tomato. The treatments were selected for sole and combined application of varied levels of vermicompost and farmyard manure along with 100% and 75% of recommended dose of fertilizers (RDF-100:60:60 kg N P K ha$^{-1}$) in presence and absence of bio-fertilizer. Fourteen treatment combinations were laid out in RBD with three replications. The result revealed that none of the treatments were found completely free from late blight incidence, however the incidence varied in different treatments. Higher levels of vermicompost emerged as better organic nutrient source over that of farmyard manure and use of biofertilizer exerted more benefits over the uninoculated treatments. Application of 75% RDF along with vermicompost (4 t $ha^{-1}$) inoculated with bio-fertilizer recorded significantly lowest percent disease index (PDI 13.84%) and produced highest marketable fruit yield (26.14 t $ha^{-1}$) compared to highest PDI of 31.62% and lowest fruit yield (15.42 t $ha^{-1}$) by the treatment containing 100% sole inorganic fertilizers.

Bahrampour and Ziveh (2013) conducted an experiment to determine the effect 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 $ha^{-1}$) were incorporated in to the top 15 cm of soil. During experimental 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 with rate of 15 t $ha^{-1}$ significantly increased growth and yield compared to control. Vermicompost rate of 15 t $ha^{-1}$ increased electrical conductivity 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 experiment showed addition of vermicompost had significant positive effect on growth, yield and elemental content of plant as compared to control. The highest number of leaves $plant^{-1}$(94.0) and total yield (3.26 kg $plant^{-1}$) were found from vermicompost with rate of 15 t $ha^{-1}$ where from control was 77.66 and 1.92, respectively.

Najar and Khan (2013) conducted a field experiment to investigate the effect of different rates of vermicompost on germination, growth and yield of tomato (*Lycopersicon esculentum)*. The data revealed that different rates (2, 4 and 6 t $ha^{-1}$) of vermicompost produced varied and significant ($P < 0.05$) effect on the germination, vegetative growth parameters (shoot length, root length, leaf area, dry shoot weight, dry root weight and dry weight of leaves) recorded at different intervals, yield parameters (number of clusters plant$^{-1}$, fruits cluster$^{-1}$, number of fruits plant$^{-1}$, mean fruit weight and total yield plant$^{-1}$) and marketable fruits. Dose of 6 tha$^{-1}$ significantly ($P < 0.05$) increased germination (10.33%), mean fruit weight (41.64%), total yield (146.28%) and marketable fruits (7.19%) as compare to control. Shoot length ranged from 4.72 ± 0.09 to 76 ± 2.01 cm in 6 t ha$^{-1}$, 3.25 ± 0.06 to 69.25 ± 1.49 cm in 4 t ha$^{-1}$, 2.67 ± 0.09 to 65.25 ± 1.88 cm in 2 t ha$^{-1}$ and in control it was 2.57 ± 0.09 to 61 ± 1.55 cm. Fruit clusters plant$^{-1}$ were 7.50 ± 0.42 in 6 t ha$^{-1}$, 6.83± 0.30 in 4 t ha$^{-1}$, 6.33 ± 0.21 in 2 t ha$^{-1}$ and 6 ± 0.25 in control. Fruits per cluster were 5.33 ± 0.21 in 6 tha$^{-1}$, 4.66± 0.21 in 4 t ha$^{-1}$, 4.11 ± in 2 t ha$^{-1}$ and 4 ± 0.36 in control. Fruit weight was 74.08 ± 5.54 g in 6 tha$^{-1}$, 64.28 ±4.16 in 4 tha$^{-1}$, 53.76 ± 2.90 in 2 tha$^{-1}$ and 52.3 ± 1.96 in control. Yield plant$^{-1}$ was 2.98 ± 0.27 Kg in 6 t ha$^{-1}$, 2.05 ± 0.15 Kg in 4 t ha$^{-1}$, 1.40 ± 0.13 Kg in 2 tha$^{-1}$ and 1.21 ± 0.10 Kg in control. Marketable fruits were 91.07 ± 0.93 in 6 tha$^{-1}$,88.66 ± 1.11 in 4 t ha$^{-1}$, 85.38 ± 1.51 in 2 t ha$^{-1}$ and 83.88 ± 1.02 in control. So data suggests vermicompost in 6 tha$^{-1}$ gave more significant result than control.

Abduli *et al.* (2013) observed the effect of using vermicompost on growth rate, fertility and characteristics of tomatoes has been studied. Four vermicompost: soil mixture were supplied with ratios of 1:1, 1:2, 1:3, and 1:4. Total of 24 small globe tomato plants were tested and in each bed combination, six tomato plants were embedded. Rate of growth and yielding of plants grown in each of four beds were investigated in two periods of 40 days and 90 days after planting. The results showed a significant rise in growth of tomato plants by increasing ratio of vermincompost combined with soil. Obviously, the plant was mostly appeared in the main stem of the plant and there was no significant enhancement in the number of leaves. The main stem diameter, height, the number of leaves plant$^{-1}$, and yielding of tomato plants obtained the highest rate in four tested beds after 40 days in vermicompost to soil ratios of 1:3, 1:1, 1:3, and 1:2, respectively. In after mentioned observations some changes were made after 90 days of testing and maximum yielding and height of tomato plants were obtained in 1:1 ratio. Vitamin C and total sugar content in tomatoes increase with using vermicompost. The maximum amount of vitamin C and total sugar, soluble solids, insoluble solids and total nitrites of fresh tomato were observed in ratios of 4:1, 4:1, 3:1, 2:1 and 3:1, correspondingly.

Islam (2011) carried out an experiment to investigate the effects of different organic manures on the growth and yield of tomato and subsequently on red amaranth. The treatments of the experiment consisted of $T_1$ (recommended doses of fertilizers, control), $T_2$ (cowdung @ 15 t $ha^{-1}$ + recommended dose of NPK), $T_3$ (vermicompost @ 15 t $ha^{-1}$ + recommended dose of NPK), $T_4$ (*Trichoderma* compost @ 15 t $ha^{-1}$ + recommended dose of NPK), $T_5$ (cowdung @ 5 t $ha^{-1}$ + vermicompost @ 5 t $ha^{-1}$ + *Trichoderma* compost @ 5 t $ha^{-1}$ + recommended dose of NPK), $T_6$ (vermicompost @ 7.5 t $ha^{-1}$ + *Trichoderma* compost @ 7.5 t $ha^{-1}$ + recommended dose of NPK), $T_7$ (cowdung @ 7.5 t $ha^{-1}$ + vermicompost @7.5 t $ha^{-1}$ + recommended dose of NPK), T8 (cowdung @ 7.5 t $ha^{-1}$ + *Trichoderma* compost @ 7.5 $tha^{-1}$ + recommended dose of NPK). The experiment was laid out in RCBD with three replications. The highest marketable yields of tomato per hectare (20.16 t $ha^{-1}$) was obtained from the application of $T_5$ (cowdung @ 5 t $ha^{-1}$ + vermicompost @ 5 t $ha^{-1}$ + *Trichoderma* compost @ 5 t $ha^{-1}$ + recommended dose of NPK). The highest plant height, the lowest days to first flowering, the highest number of flower clusters per plant, number of flowers per cluster, number of fruit clusters per plant and number of fruits per cluster were obtained from the $T_5$ (cowdung @ 5 t $ha^{-1}$ + 5 vermicompost @ 5 t $ha^{-1}$ + *Trichoderma* compost @ 5 t $ha^{-1}$ + recommended dose of NPK) treatment combination.

Chanda *et al.* (2010) conducted field trials using different fertilizers having equal concentrations of nutrients to treated by different category of fertilizers ( $T_1$ - control, $T_2$ - chemical fertilizers, $T_3$ - farm yard manure (FYM), $T_4$ - vermicompost, $T_5$ and $T_6$ FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively). The treatment plots ($T_6$) showed

73% better yield of fruits than control, determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared where $T_1$ was kept as control and five others were besides, vermicompost supplemented with NPK treated plots ($T_5$) displayed better results with regard to fresh weight of leaves, dry weight of fruits, number of branches and number of fruits plant$^{-1}$ from other fertilizer treated plants.

Joshi and Vig (2010) used cattle dung vermicompost (VC) with preparation of different proportions of soil and vermicompost mixtures viz. Soil (control), VC15 (Soil + 15% VC), VC30 (Soil + 30% VC), VC45 (Soil + 45% VC). Vermicompost was analyzed for various chemical, growth, yield and quality parameters of tomato. Germination percentage was found the maximum at VC15 treatment that decreased in the subsequent treatments. Almost all the growth, yield and quality parameters increased significantly as compared to control. Germination percentage in terms of normal seedlings was maximum (86%) in treatment VC15 (soil + 15% VC). Mean plant height (cm) in treatments VC15, VC30 and VC45 were found to be 63 cm, 63.4 cm and 63.5 cm, respectively, which were significantly greater than mean plant height of 38 cm reported in soil (control). Similarly, mean stem diameter was also observed to be significantly higher in three treatments (0.89, 0.88 and 0.88 cm) than control (0.47 cm). A significant increase was observed in mean number of leaves plant$^{-1}$ in three treatments (105, 111, 104) as compared to control (59). It was observed that number of fruits plant$^{-1}$ in three treatments (10.9, 15.0 and 15.6) was also increased significantly than those in control (5.9). Total yield plant$^{-1}$ (kg) of tomatoes in soil came out to be 0.36 kg, while it came out to be 0.61, 0.79 and 0.85 in treatments VC15, VC30 and VC45, respectively. Mean soluble solids (%) in all the three treatments (5.48, 5.89 and 5.93) showed a significant increase as compared with control (4.57). Similarly, mean insoluble solids of all the three treatments (3.98, 4.44 and 4.16) were observed to be significantly higher than control (3.29). A higher content of ascorbic acid (mg kg$^{-1}$) was recorded in three treatments (131, 141 and 145) and these increased values were significant as compared with control (115).

Singh *et al.* (2010) conducted a field experiment to investigate the effects of vermicompost and NPK fertilizer application on morpho-physiological traits, yield and quality attributes of tomato (*Solanum lycopersicum* L.) with an ultimate aim of optimizing nutrient requirements of tomato in mild-tropical agro-climate. The application of vermicompost together with NPK fertilizer increased plant height, leaf area, leaf weight, fruit weight, fruit yield, fruit density, post-harvest life and TSS of tomato. Application of vermicompost alone too increased the shelf-life by 250% and TSS beyond 4.5%, both of which are traits highly desirable for summer production of tomato and the related processing industry. Present study reveals that application of vermicompost in the amount of 7.5 t $ha^{-1}$ in combination with 50% dose of NPK fertilizer (60:30:30 kg $ha^{-1}$) was optimum for obtaining better quality and productivity of field grown tomatoes in mild-tropical agro-climate.

Rodge and Yadlod (2009) undertook the field experiment to evaluate the effect of organic and inorganic fertilizers on growth, yield and quality of tomato which was undertaken in the Department of Horticulture, Marathwada Agricultural University, Parbhani (M.S.) in Randomized Block Design with 15 treatments on 'Parbhani Yashshri' variety. The treatment consisted that 100% recommended dose of fertilizers (RDF) + 25% through organic sources (Gelrich, FYM, Teracare or vermicompost)., 50% RDF + 50% through organic sources and 25% RDF + 75% through organic sources. No fertilizer or organic source was applied in control. The treatment 50% RDF + 50% FYM ($T_8$) significantly increased the height of plant, number of primary branches and number of leaves at 105 days after transplanting which was followed by the treatment 50% RDF +50% vermicompost. Maximum number of fruits $plant^{-1}$, heaviest fruit, yield per plant and yield per plot were significantly more in case of treatment 50% RDF + 50% vermicompost. The fruit juice, TSS, and ascorbic acid content was highest in the treatment 50% RDF+50% FYM and the shelf life of fruit was maximum in the treatment 50% RDF + 50% vermicompost.

Senapati *et al.* (2007) conducted an experiment to observe the effects of 50 or 100% of the recommended fertilizer rates (NPK at 40:20:20 kg $ha^{-1}$ for ragi and 120:75:100 kg $ha^{-1}$ for tomato), vermicompost 5 $tha^{-1}$, 50% RFR + vermicompost, farmyard manure (FYM; 5 t $ha^{-1}$) vermicompost + FYM, and 50% RFR + vermicompost + FYM on the performance of ragi (cv. Dibyasingh) and tomato (cv.BT-10) grown in the kharif and rabi seasons, respectively, were studied. The application of 50% RFR + vermicompost and FYM resulted in the greatest plant height (117.3 cm), biomass yield (127.3 quintal/ha), grain yield (25.0 quintal $ha^{-1}$) and harvest index (16.4%) for ragi. FYM and vermicompost had favorable residual effects on tomato, and both treatments were more effective when applied in combination than when applied singly. The application of 50% RFR + vermicompost + FYM also gave the higher total fruit yield (290.99 quintal $ha^{-1}$), marketable fruit yield (244.0 quintal $ha^{-1}$) and value of agronomic efficiency for N for tomato. The combination between organic and inorganic fertilizers enhanced the nutrient status of the soil after harvesting. The concentrations of organic carbon and available NPK were 0.41-0.63%, 158.01-185.5kg $ha^{-1}$ (low), 15.5-21.5 kg $ha^{-1}$ (medium), and 136.5-173.5 kg $ha^{-1}$ (medium), respectively.[1.0 quintal=100.0 kg].

Roberts *et al.* (2007) examined the effect of substituting commercial peat based compost with four different vermicomposts produced by the earthworm *Dendrobaena veneta*. Vermicompost was added to peat-based compost at rates of 5%, 10%, 20%, 40% and 100% (v/v) and the following characteristics of tomato (*Lycopersicon esculentum* var. Money maker) assessed: germination, yield, marketability, fruit weight and ascorbic acid concentration. Vermicompost significantly increased germination rates (176%) and improved the marketability of fruits at 40% and 100% substitution rates due to the lower incidence of physiological disorders ("blossom end rot" and fruit cracking). Total fruit yield, marketable fruit yield, fruit number, individual fruit weight and vitamin C concentration were unaffected by the presence of vermicompost. Although vermicompost may provide a viable alternative to peat-based growth media, overall, we found little added benefit from using vermicompost. We conclude that some of previously reported benefits of vermicompost on horticultural production may be overstated and that marketing strategies should reflect this in order to preserve consumer confidence in vermicompost products.

Sable *et al.* (2007) studied the effects of various organic amendments on the performance of tomato (cv. Parbhani Yashshri) in Parbhani, Maharashtra, India, during the rabi season of 2002-03. The treatments consisted of 100% N through neem cake or vermicompost ; 50% N through neem cake + 50% through vermicompost; 25% N through neem cake + 75% N through vermicompost; 75% through neem caqke + 25% N through vermicompost; 100% of the recommended fertilizer rates (N 2100 kg $ha^{-1}$, P 50 kg $ha^{-1}$, K 50 kg $ha^{-1}$); and control (no fertilizers).The organic manures were generally superior to the inorganic fertilizers in the enhancement of the fruit yield and dry matter yield. The percentage of marketable fruits was higher when organic amendments were applied (83-93%) than when inorganic fertilizers were used (77.5%) The fresh fruit weight was lower when 100% of the N was supplied through vermicompost than when N was supplied through various combinations of neem cake and vermicompost.

Reddy *et al.* (2002) conducted a study in Hyderabad, Andhra Pradesh, India, during the rabi seasons of 1999-2002 to determine the effect of organic manure on tomato (cv. Marutham) production. Treatments comprised: 20 t farmyard manure $ha^{-1}$ ($T_1$); 5 t vermicompost $ha^{-1}$ ($T_2$); 10 t FYM $ha^{-1}$ + 2.5 t vermicompost $ha^{-1}$ ($T_3$); 50% N through FYM + 50% N through urea ($T_4$); 50% N through vermicompost + 50% N through urea ($T_5$); and recommended NPK rate (120:60:60 $kgha^{-1}$)($T_6$). Treatment with $T_4$ recorded the highest plant height (55.6 cm), number of branches $plant^{-1}$ (7.4), number of fruits plant$^{-1}$ (16.6), fruit weight (66.7 g) and yield (30.47 t ha$^{-1}$), and these parameters were at par with those of $T_6$ treatment. Compared to the crop yield obtained with $T_6$ treatment, reduced yields were observed with $T_1$, $T_2$ and $T_3$ treatments. A yield reduction of 7.76% was observed with $T_5$ treatment compared to the yields obtained with $T_6$ treatment. A yield increase of 4.7% was observed with $T_4$ treatment, indicating that the integrated application of organic manures along with inorganic fertilizers significantly increased the yield compared to organic or inorganic fertilizer applications alone. The cost-benefit ratio was high (1:3.01) with the application of $T_4$ compared to all other treatments including $T_6$ (1:2.93).

Renuka and Sankar (2001) conducted a field experiment on a sandy loam soil, in Bapatla, Andhra Pradesh, India, during 1998, the effect of organic manures on growth, development, yield and quality of tomato was investigated. Six kinds of organic manures, i.e. farmyard manure (FYM), vermicompost, biogass slurry, neem cake, Azospirillum and phosphobacteria, in different combinations were tested in comparison with inorganic fertilizer treatment as control. It can be deduced that vigorous growth of tomato with early flowering and high yield (46.66 t ha$^{-1}$) could be obtained with the application of FYM + biogass slurry, recording an increased yield of two and half times over the control (18.44 t ha$^{-1}$). Thus, it can be inferred that tomato would respond to application of organic manures either alone or in combination with FYM. Further, application of organic manures maintained the soil pH near to neutral, besides keeping lower levels of electrical conductivity and bulk density.

## 2.2 Effect of *Trichoderma* compost on growth and yield of Tomato

Haque *et al.* (2012) conducted an experiment to evaluate the impact of *Trichoderma* enriched biofertilizer on growth and yield of mustard ( *Brassica rapa* L.) and tomato (*Solanum lycopersicon*

Mill.). He investigated with following treatments : $T_1$ (Control), $T_2$ (NPK fertilizers only), $T_3$ (BioF/compost) , $T_4$ (BioF/pellets), $T_5$ (BioF/suspension), $T_6$ (50% N + 50% BioF/compost), $T_7$ (50% N + 50% BioF/pellets) and $T_8$ (50% N + 50% BioF/suspension). In his experiment he found biofertilizer plays a significant role in crop cultivation with reduced chemical fertilizer use. Three *Trichoderma*-enriched biofertilizers were evaluated in mustard and tomato cultivation at field condition. Sole application of biofertilizers didn't show remarkable contribution but all *Trichoderma* enriched biofertilizers when supplemented with N fertilizer significantly boosted up the growth and yield of mustard and tomato. Application of 50% N fertilizer along with 50% *Trichoderma*-enriched biofertilizers augmented 108 and 203% yields over control both in mustard and tomato, respectively which were 81.90 and 61.82% in mustard and tomato at standard doses of Nitrogen, Phosphorus and Potassium fertilizers. The present results suggest that *Trichoderma*-enriched biofertilizer could save at least 50% N fertilizer uses for mustard and tomato and could reduce excessive uses of NPK for crop cultivation.

In an experiment of Adkins (2010) the overall plant growth of tomato (*Lycopersicon esculentum* L. cv. Glacier) cultivated in greenhouse conditions along with inoculation treatments of beneficial fungi species were observed. This study included two brand name products containing species of fungi which include: 1) *Botanicare Guardian TR* containing *Trichoderma harzianum* 10,000,000 CFU/g, *T. hamatum* 10,000,000 CFU/g, *T. koningii* 10,000,000 CFU/g; and 2) *Botanicare Guardian MY* containing *Glomus intraradices* 57 propagules/g; *G. fasiculatum* 57 propagules/g; *G. etunicatum* 57 propagules/g; *G. clarum* 57 propagules/g. Treatments include: 1) 2g *Botanicare Guardian TR*; 2) 2g *Botanicare Guardian MY*; 3) 1g *Botanicare Guardian TR* + 1g *Botanicare Guardian MY;* and 4) Control. The overall height increase was 55.04 %, 49.36 %, 44.42 % for treatments 3, 2, 1, respectively. The overall fresh weight increase was 50.47 %, 40.95 %, 33.55 % for treatments 3, 2, 1 respectively. The overall dry weight increase was 62.67 %, 53.23 %, 42.60 % for treatments 3, 2, 1, respectively.

Jadhav and Ambadkar (2007) conducted a field experiment during 2002 in Parbhani, Maharashtra, India, to study the effect of *Trichoderma spp*. On seedling emergence and seedling mortality of tomato, chilli and aubergine. In tomato, the highest seedling emergence (82.86 %) was observed in plots where *T. hargianum* was inoculated. The highest seedling emergence (82.02 %) in chilli was obtained with the inoculation of *T. viride*, whereas in aubergine the highest seedling emergenge (80.60 %) was observed with the inoculation of *T. harzianum*. Lowest seedling mortality in chilli, aubergine and tomato was recorded by *T. harzianum* followed by *T. viride* and *T. hamatum*.

Dwivedi *et al.* (2006) conducted the study to identify the most suitable seed treatment based option for the management of root-knot nematode infesting tomato and okra in eastern Uttar Pradesh, India. Maximum plant growth and yield of tomato and okra were observed with the seed treatment of *Trichoderma viride* and *Aspergillus niger* at 5 g $kg^{-1}$ seeds, neem seed powder and neem seed kernel at the rate of 10 g $kg^{-1}$ seeds and also with some chemical pesticide treatments. Thus seed treatment exhibited best and viable results in reduction of gall formation and increase in yield of tomato and okra in experimental research farm as well as in farmers' field condition.

Bal and Altintas (2006) carried out an experiment to observe seedling growing media (a peat and soil-based mixture or greenhouse soil with *Trichoderma harzianum* ) at the time of sowing, at transplanting to vials and at planting. The factorial experiment using 2 seedling growing media, 2 cultivars and 4 dosages of *T. harzianum* at 0 $gm^{-1}$ (control), 4 g $m^{-1}$, 10 g $m^{-1}$ and 24 g $m^{-1}$ showed that the compost dosage had no significant effect on the yield or fruit quality. None of the 3 factor interactions between the criteria studied, that is, total yield, marketable yield, early yield, individual fruit weight, total soluble solids and titratable acidity, were significant except for fruit diameter. The 3 factor combination resulted in the highest total yield, marketable yield and early yield with 1552, 1373 and 681 g $plant^{-1}$, respectively. The interaction between media and cultivars was significant for all the yield characteristics studied. However, the main effect of *T. harzianum* on early yield was the highest at 4 gm, producing 527 g $plant^{-1}$ in comparison to the control with 374 g $plant^{-1}$. It was, therefore, hypothesised that the positive effect of *T. harzianum*, observed in the early yield, may be extended to the whole growing period by further applications, that is, by periodical renewal of the *T. harzianum* population at the root zone.

Ozbay *et al.* (2004) carried out an experiment performed with commercial and noncommercial *Trichoderma harzianum* strains to test whether they have any effect on the growth of tomato seedlings. Tomato (*Lycopersicon esculentum* cv. 'Caruso') seedlings were grown in a greenhouse and watered daily by hand. Eighteen-day-old seedlings were inoculated with *T. harzianum* strains Plant shield and transplanted into plastic pots filled with Pro-Mix potting mix. At 6 weeks, the seedlings were sampled for growth comparisons on seedling emergence, number of true leaves, fresh and dry weights of roots and shoots, stem caliper and shoot height. The results demonstrated that *T. harzianum* strains improved tomato seedling growth. There were differences between the untreated control and the treatments for all of the growth parameters at 4 weeks after inoculation with the exception of root fresh and dry weight.

## 2.3 Effect of cowdung on growth and yield of tomato

Said *et al.,* (2014) conducted an experiment to examine the yield and quality of tomatoes (*Lycopersicon esculentum* Mill.) irrigated with different saline water [electrical conductivity (ECi) = 3, 6 and 9 dS $m^{-1}$] and study the effect of fertilizer: inorganic, organic, and a mixed of both on tomatoes grown under saline conditions. Fruit weight and quality attributes including size, color, soluble solids, acidity, EC, and pH were measured. Plants fertilized with cowdung manure alone produced the lowest total yield compared to those that received inorganic or mixed fertilizers. Fruit quality was more affected by salinity than fertilizer. The best growing conditions for tomatoes were in plots irrigated with 6 ds $m^{-1}$ water under mixed fertilizer treatment. The organic and mixed treatments showed a continuous increase in fruit yield up to the fourth harvest when the highest yields obtained were 609 and 943 g $plant^{-1}$, respectively.

Ibrahim and Fadni (2013) conducted the experiment to investigate the effect of different types of organic fertilizers on soil chemical and physical properties, and on growth, yield and quality of tomato fruits. The experiment consisted of five treatments. The treatments were laid in a randomized complete block designed (RCBD) with three replications. Organic fertilizers have a clear impact on the different stages of plant growth. Compost, cattle manure, chicken manure, cattle manure + chicken manure increased plant height, number of branches, fresh and dry weight of roots and shoots by 48.8%, 63.6%, 71.0%, 88.4%, 32.4%, 60.0% for compost, cattle manure an increase of 22.0%, 27.3%, 44.1%, 48.5%, 23.1%, 40.4%, chicken manure 26.82%, 36.4%, 47.8%, 51.7%,23.4%, 44.2%, Cattle manure + chicken manure gave 39.0%, 63.6%, 59.7%, 69.5%, 28.5%, 50.1% respectively; in contrast to the untreated field i.e. control. The high significant difference found in plant height, number of branches, days to 50% flowering, root length, fresh weight of root and shoot. Dry weight of root and shoot were recorded for compost treatment (10.4, 51.8g), while the untreated recorded (5.5, 32.4g), respectively. Tomato yield was positively affected by organic fertilizers application. Compost and chicken plus cattle manure gave the highest yield parameters compared to other treatments. Compost gave the highest values of number fruits $plant^{-1}$ (36 fruits), fruits marketable size (11.2 kg); and fruits yield (21.5 ton $ha^{-1}$). Compost increased fruits yield by (112%) as compared to the untreated control. The lowest values of tomato yield parameters were obtained in the untreated field i.e. control, which gave fruits number plant$^{-1}$ (16 fruits), fruits marketable size (3.7 kg), and fruits yield (10 ton ha$^{-1}$).

Salam *et al.* (2011) carried out an experiment at the vegetable research farm of the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur to investigate the effect of boron, zinc, and cowdung on quality of tomato. There were 16 treatments comprising four rates of boron and zinc viz., $B_0Zn_0$. $B_15Zn_2$, $B_2Zn_4$ and $B_2.5Zn_5$ kgha$^{-1}$ and four rates of cowdung viz., CDo, CD10, CD15, and CD 20 t ha$^{-1}$. Every plot received 253 kg N, 90 kg P, 125 kg K, and 6.6 kg S per hectare. The results reflected that the highest pulp weight (90.24%), dry matter content (5.82%), ascorbic acid (11.2 mg/100g), lycopene content (147 μg/100g), chlorophyll-a (42.0 μg/l00g), chlorophyll-b (61.0 μg/100g), boron content (36 μg/g), zinc content (51 μg /g), marketable fruits at 30 days after storage (74%) and shelf life (17 days) were recorded with the combination of 2.5 kg B ha$^{-1}$ + 6 kg Zn ha$^{-1}$, and 20 t ha$^{-1}$ cowdung.

Saidu *et al.* (2011) conducted an experiment to determine the effect of different levels of cow dung on the performance of tomato. The experiment was arranged in a randomized complete block design (RCBD) with three replications. The treatments consisted of five levels of cow dung (0, 7.5, 12.5, 17.5, and 22.5 tha$^{-1}$). The application at 17.5 tha$^{-1}$ resulted in the highest plant height and number of fruits, while at 22.5 t ha$^{-1}$ there were no corresponding increase in the number of fruits at harvest. There was no significant ($p>0.05$) differences in plant height at 3 weeks after transplanting (WAT) but significantly ($p <0.05$) different at 6 and 9 WAT. Also, there were significant ($p<0.05$) differences in the number of leaves at 6 and 9 WAT. At 6 WAT, the highest number of flowers (8) was observed when 17.5 tha$^{-1}$ was applied, while the lowest was recorded in 0 tha$^{-1}$. The highest number of leaves (7) were observed when 7.5 tha$^{-1}$ was applied while the lowest (1) was recorded when 0 tha$^{-1}$ was applied. There was no significant ($p>0.05$) difference in fruit weight at harvest. The result showed that application of cow dung at 17.5 $tha^{-1}$ resulted in highest yield of tomato, while additional higher level of cow dung at 22.5 $tha^{-1}$ did not result in corresponding increase in the of yield of tomato.

Noor *et al.* (2011) conducted an field experiment on Tomato-Okra-Indian spinach cropping pattern at a farmer's homestead of Tangail (AEZ 8) during 2007-08 and 2008-09 to find out a suitable combination of chemical fertilizers and organic manure for sustainable crop yield. There were 5 treatments comprising different percentages of the recommended chemical fertilizers (RCF) with two levels (0 and 5 $tha^{-1}$) for tomato and three levels (0, 2.5 and 5 $tha^{-1}$) for okra each of poultry manure and cowdung. No organic manure was used for the third crop Indian Spinach. The treatments were arranged in Randomized Complete Block Design with four replications. An amount of 75% dose of RCF ($N_{150}P_{40}k_{80}S_{15}Zn_2B_1$ $kgha^{-1}$) along with poultry manure @ 5 $tha^{-1}$ appeared as the best suited combination providing tomato yield 95.3 $tha^{-1}$ and 88.2 $tha^{-1}$ for the first year and second year, respectively. The lowest yield (56.4 and 50.1 $tha^{-1}$ for the first and second years, respectively) was obtained from treatment (50% RCF + 5 t CD $ha^{-1}$), which was significantly lower than all other treatments.

Solaiman and Rabbani (2006) carried out a field experiment to assess the effects of inorganic and organic fertilizers on vegetative, flowering and fruiting characteristics as well as yield attributes of Ratan variety of tomato. The plots were treated with three levels each of N (62, 100 and 200 kg $ha^{-1}$), P (11.7, 17.5 and 35 kg $ha^{-1}$), K (26.7, 40 and 80 kg $ha^{-1}$), S (5, 7.5 and 15 kg $ha^{-1}$) and cow-dung (5, 10 15 $tha^{-1}$). There were three replications for each treatment. The highest plant height (75.03 cm) and dry weight of shoot (111.70 g $plant^{-1}$), the maximum number of clusters of flowers $plant^{-1}$ (23.48) and fruits $plant^{-1}$ (33.32), fruit yield (44.11 $tha^{-1}$) were obtained from the application of the recommended dose of nutrients per hectare (200 kg N + 35 kg P + 80 kg K + 15 kg S) , but similar results were obtained from the treatment receiving cow-dung 5 $tha^{-1}$ along with half of the recommended doses of nutrients (100kg N, 17.5 kg P, 40 kg K and 7.5 kg S). The effect of cowdung 10 t $ha^{-1}$, along with one third of the recommended dose of nutrients, was also comparable to effect of employing the recommended dose of nutrients. It was further observed , from a economic standpoint, that the combination of 5 t cow-dung $ha^{-1}$ along with half of the recommended doses of nutrients appeared to be viable treatment which would offer the maximum benefit concerning cost ratio (4.38) for tomato production in the shallow red-brown terrace soil (AEZ-28) of Bangladesh.

Grimme and Stoffella (2006) conducted a field trail with well decomposed cowdung along with vermicompost at a range of different concentrations into a soil-less commercial bedding plant container medium, Metro Mix 360 (MM360), to evaluate their effects on the growth and yields of tomato in the greenhouse. Four-week old tomato *(Lycopersicon esculentum )* were transplanted into 100%, 80%, 60%, 40%, 20% or 10% MM360 substituted with 0%, 10%, 20%, 40%, 60%, 80% and 100% well decomposed cowdung and vermicompost. Tomato grown in potting mixtures containing 40% decomposed cowdung along with vermicomposts and 60% MM360 yielded 45% more fruit weights and had 17% greater mean number of fruits than those grown in MM360 only. The mean heights, numbers of buds and numbers of flowers of tomatoes grown in potting mixtures containing 10-80% vermicompost although greater did not differ significantly from those of tomatoes grown in MM360. There were no positive correlations between the increases in tomato yields, and the amounts of mineral-N and microbial biomass N in the potting mixtures, or the concentrations of nitrogen in the shoot tissues of tomatoes.

It is revealed from the above review of literature that different organic manures had significant effect on growth and yield of tomato as reported by different authors. But the work on yield response of tomato under different combination of manures and fertilizer is meager in Bangladesh. So, the present study was undertaken.

# Chapter III

# MATERIALS AND METHODS

This chapter describes the materials and methods that were used in carrying out the field experiment. A brief description of materials and methods used in different activities of the experiment are presented under the following subheads:

## 3.1 Experimental site

The field experiment was conducted at Hogladanga village under the Batiaghata upazila of Khulna district. The experiment was performed during November, 2013 to March, 2014.

## 3.2 Climatic condition

The experimental area was under the sub-tropical climate which was characterized by heavy rainfall, high humidity, high temperature and relatively long day during the Kharif season (April to September) and scanty rainfall, associated with moderately low temperature and short day period during the Rabi season (October to March). Plenty of sunshine and moderately low temperature is suitable for growing tomato, which prevails during Rabi season in Bangladesh. Details of the meteorological data for the period under study have been shown in Appendix III.

## 3.3 Characteristics of soil

The soil of experiment area was medium high in topography and clay loam to sandy loam in texture belonging to the Ganges Tidal Floodplain Tract under the Agro Ecological Zone-13 (FAO, 1988).

## 3.4 Materials used for the experiment

The tomato cultivar used in the experiment was "Suraksha", which was a high yielding determinate and bacterial wilt resistant variety. The seeds from the "Namdharimalik

Company" imported from india were collected from Shikdar Seed House, Gollamari, Khulna. Vermicompost was collected from Plant Breeding and Biotechnology laboratory under Agrotechnology discipline, Khulna University, Khulna. *Trichoderma* compost was collected from Grameen Krishok Sohayak Sangstha (GKSS), Gabtali, Bogra.

### 3.5 Seedling preparation

Tomato seedlings were raised on one seedbed with special care. The size of the seedbed was 3 m × 1 m. The soil was uniformly ploughed and clods were broken into small pieces by spading. All weeds, stubbles and other unpleasant substances were removed carefully. Heptachlor 40 WP was applied around each seedbed at the rate of 4 kg $ha^{-1}$ as precautionary measure against ants and worm. Six grams of seeds were sown in the seedbed on 06 November, 2013. After sowing , the seeds were covered with light soil. The emergence of seedlings took place within 5 to 6 days after sowing. Irrigation, weeding and mulching were done from time to time to provide a favorable condition for healthy growth till transplanting. Tomato seedlings were raised in Hogladanga village, Khulna with special supervision of Agrotechnology Discipline, Khulna University.

### 3.6 Treatment of the experiment

The single factor experiment was consisted of seven treatments as follows :

$T_1$ = Recommended doses of NPK (Urea 350 kg $ha^{-1}$, TSP 250 kg $ha^{-1}$, MoP 300 kg $ha^{-1}$, respectively.)

$T_2$ = Cowdung @10 t $ha^{-1}$

$T_3$ = Vermicompost @ 10 t $ha^{-1}$

$T_4$ = *Trichoderma* compost @10 t $ha^{-1}$

$T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer

$T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer

$T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

### 3.7 Design and layout of the experiment

The single factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The experimental area was divided into 3 blocks each containing 7 unit plots. In total, there were 21 unit plots. Seven treatments were randomly assigned to each unit plot as a result no repetition was occurred in a block. The unit plot was 2.4 m × 1.6 m in size with block to block distance was 100 cm and unit plot to unit plot distance was 50 cm. Thus each unit plot arranged with 16 plants where plant to plant and row to row distance were 40 cm and 60 cm, respectively.

### 3.8 Land preparation

The selected field for the experiment was opened on 24 November, 2013 with a power tiller. The experimental field was then thoroughly prepared by ploughing and cross ploughing followed by laddering several times to break the clods for obtaining a good tilth. During operation weeding and stubbles from previous crops were collected and removed. The field was leveled and the experimental plots were laid out according to plan. Irrigation channels were prepared in the plots four days before transplanting of seedling.

### 3.9 Soil test

Chemical analysis of soil sample was done after fertilization and after harvesting from SRDI, Daulatpur, Khulna. Here, pH , EC, organic matter, N, P, K, Cu and Zn content of soil was analyzed following standard method. The result of soil analysis have been shown in Appendix I.

### 3.10 Application of manures and fertilizers

The experimental plots which were treated with recommended dose of NPK receiving 350 kg $ha^{-1}$ urea, 250 kg $ha^{-1}$ TSP and 300 kg $ha^{-1}$ MoP. The recommended dose of NPK was followed according to the recommendation of Fertilizer Recommendation Guide of BARC, 2012. Cowdung, vermicompost, *Trichoderma* compost, full amount of TSP , one third amount of urea and MoP were applied during final land preparation in the respective plots. The rest of the MoP and urea was applied in 2 equal installments at 20 and 40 days after transplanting. Each top dressing was followed by irrigation. The different doses organic manures and synthetic fertilizers has been shown in table 1. Composition of different organic manures are presented in Appendix II.

**Table 1. Used doses of manures and fertilizers**

| SL No | Treatments | Name of fertilizers | Dose $ha^{-1}$ | Dose $plot^{-1}$ (2.4 m × ×1.6 m) |
|---|---|---|---|---|
| 1 | $T_1$ | Urea<br>TSP<br>MoP | 350 kg<br>250 kg<br>300 kg | 135 g<br>100 g<br>120 g |
| 2 | $T_2$ | Cowdung | 10 t | 3.85 kg |
| 3 | $T_3$ | Vermicompost | 10 t | 3.85 kg |
| 4 | $T_4$ | *Trichoderma* compost | 10 t | 3.85 kg |
| 5 | $T_5$ | Cowdung<br>Urea<br>TSP<br>MoP | 5 t<br>175 kg<br>125 kg<br>150 kg | 1.92 kg<br>67.5 g<br>50 g<br>60 g |
| 6 | $T_6$ | Vermicompost<br>Urea<br>TSP<br>MoP | 5 t<br>175 kg<br>125 kg<br>150 kg | 1.92 kg<br>67.5 g<br>50 g<br>60 g |
| 7 | $T_7$ | *Trichoderma* compost<br>Urea<br>TSP<br>MoP | 5 t<br>175 kg<br>125 kg<br>150 kg | 1.92 kg<br>67.5 g<br>50 g<br>60 g |

### 3.11 Transplanting of seedlings

Twenty five days old healthy and uniform size seedlings were transplanted in the experimental plots on 6 December, 2013, maintaining a spacing of 60 cm × 40 cm accommodating 16 seedlings in each unit plot. Transplanting was done in the afternoon and lightly watered with watering cane immediately after transplanting for better establishment. The young transplanted seedling were protected from scorching sunlight with the help of banana leaf sheath. At night they were kept open to allow them receiving dew. Shading and watering were continued for four days until the seedlings were established.



### 3.12 Intercultural operations

#### 3.12.1 Gap filling

Plots with transplanted seedlings were regularly observed to find out any damage and dead seedlings for replacement. Gap filling was done by healthy seedlings of the same stock where initial planted seedlings failed to survive.

#### 3.12.2 Weeding

Weeding and mulching were done regularly maintaining frequency for breaking soil crust and better aeration. These practice also helped in minimizing competition for nutrient and conserving soil moisture.

#### 3.12.3 Irrigation

Irrigations were given throughout the growing period by a watering can. Due to severe dry condition, irrigation by water pump at two times, were given at vegetative stage and fruiting stage for proper growth and yield, respectively. Sudden raining minimized requirements of irrigation.

### 3.12.4 Staking

When the tomato plants were well established, staking was given using bamboo sticks to keep the plants erect. It also helps minimizing soil borne diseases and maximizing yield by supplying more plant to plant interspace.

### 3.12.5 Plant protection

**Insect pests:** Malathion 57 EC was applied at the rate of 2 ml litre$^{-1}$ as preventive measure against insect pests like cut worms, white flies, leaf hoppers and fruit borers. The insecticides was applied fortnightly. Neem oil pesticide also applied to minimize the use of chemical pesticides. Furadan 5G was applied into the soil during the final land preparation.

**Diseases:** Precautionary measures against diseases especially late blight of tomato was taken by spraying Dithane M-45 at the rate of 2 g litre$^{-1}$ fortnightly during the early vegetative stage. Due to presence of late blight Sundomil 72 WP was used. The diseased plants by leaf curling virus were uprooted to minimize further spreading.

### 3.13 Harvesting

Harvesting was started from 13$^{th}$ March and completed by 9$^{th}$ April. Fruits were harvested at four days interval during early ripe stage when they attained red color. During harvesting marketable and unmarketable fruits were divided. Diseased, rotten and undersize fruits were termed unmarketable fruits.

### 3.14 Data collection

Ten plants were selected randomly from each unit plot for data collection. Data were recorded from sample plants during the period of the experiment.

Data on the following parameters were recorded:

### 3.14.1 Plant height

Plant height was measured from the sample plants in centimetre from the ground level to the tip of the longest stem and mean value was calculated. Plant height was recorded from 10 days of planting up to 70 days to observe the growth rate of plants. Mean value of the ten selected plants were calculated for each unit plot as expressed in centimeter (cm).

### 3.14.2 Plant spread

Plant spread was measured from the sample plants in centimetre from the tip of the longest leaf one side to another and mean value was calculated. Plant spread was recorded from 10 days of planting up to 70 days to observe the spread rate of plants at 10, 20, 30, 40, 50, 60, 70 Days After Transplanting (DAT) and mean value was calculated for each unit plot and expressed in centimeter (cm).

### 3.14.3 Number of leaves plant$^{-1}$

The total number of leaves plant$^{-1}$ was counted from 10 sample plants from 20 days of planting up to 80 days to observe leaf no. of plants. Mean value of the ten selected plants were calculated for each unit plot as expressed in centimeter (cm).

### 3.14.4 Days to first flowering

Date of first flowering for each treatment was recorded during preflowering season and the number of days required for first flowering was calculated.

### 3.14.5 Number of flower clusters plant$^{-1}$

The number of flower clusters was counted from the sample plants periodically during flowering season, and average number of flower clusters plant$^{-1}$ was recorded.

### 3.14.6 Number of flowers cluster$^{-1}$

The number of flowers cluster$^{-1}$ was calculated as follows:

$$\text{Number flowers cluster}^{-1} = \frac{\text{Total number of flowers from ten plants}}{\text{Total number of flower cluster from ten plants}}$$

### 3.14.7 Number of fruit clusters plant$^{-1}$

The number of fruit clusters was recorded from the ten sample plants, and the average number of fruit clusters produced plant$^{-1}$ was recorded.

### 3.14.8 Number of fruits cluster$^{-1}$

The number of fruits cluster$^{-1}$ was calculated as follows:

$$\text{Number of fruits cluster}^{-1} = \frac{\text{Total number of fruits from ten plants}}{\textit{Total number of fruit cluster from ten plant}}$$

### 3.14.9 Number of fruits plant$^{-1}$

The number of fruits plant$^{-1}$ was recorded from the ten sample plants and the average number of fruits produced per plant was recorded.

### 3.14.10 Fruit length

The length of fruit was measured with a slide calipers from the neck of the fruit to bottom of 30 selected marketable fruits from each plot and their average was calculated in centimeter (cm).

### 3.14.11 Fruit diameter

Diameter of fruit was measured at the middle portion of 30 selected marketable fruits from each plot with a slide calipers and their average was calculated in centimeter (cm).

### 3.14.12 Weight of individual fruit

The weight of fruit was measured with a electric weighing machine of 30 selected marketable fruits from each plot and their average was calculated in gram (g).

### 3.14.13 Weight of fruits plant$^{-1}$

It was recorded from the weight of fruits obtained from the selected plants and their average was calculated in kilogram (kg).

### 3.14.14 Fruit yield plot$^{-1}$

Total weight of fruits from five harvests of sample plants was measured. A pan scale balance was used to take the weight of fruits plot$^{-1}$. It was measured by totaling of fruit yield from each unit plot separately during the period from first to final harvest and was recorded in kilogram (kg).

### 3.14.15 Fruit yield hectare$^{-1}$

It was measured by the following formula:

$$\text{Fruit yield (t hectare}^{-1}) = \frac{\text{Fruit yield plot}-1\text{(kg)} \times 10000}{\text{Area of plot in square meter (m2 )} \times 1000}$$

### 3.15 Benefit cost ratio of tomato

To find out the BCR the following formula was used :

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

### 3.16 Statistical analysis

Recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjusted with Duncun's New Multiple Range Test at 1% and 5 % level of probability (Gomez and Gomez, 1984).

# Chapter IV

# RESULTS AND DISCUSSION

The experiment was conducted to study the effects of different organic manures and fertilizer on the growth and yield of tomato. Data on different parameters were analyzed statistically and the results have been presented in the Tables 2, 3, 4 and the Figures 1, 2, 3, 4. Analysis of variances of data and corresponding degrees of freedom have been shown in appendix IV. The results of each parameter have been discussed and interpretations wherever necessary have been made in this chapter.

## 4.1 Plant height

Plant height was recorded at different days after transplanting (DAT). A marked variation in plant height was observed due to the influence of different organic manures and fertilizers. Statistically the result was highly significant at different DAT (Appendix IV). The maximum height (88.40 cm) at 70 DAT was found in the plants grown under $T_6$ treament which was statistically identical with $T_7$ (85.87 cm), $T_5$ (83.13 cm) and $T_1$ (83.53 cm) treaments, while the shortest plant (78.57 cm) was observed in the plants treated with $T_4$ treament which was statistically identical with $T_2$ (78.87 cm) treatment (Table 2).

Plant height is one of the important growth contributing characters for tomato highly related with yield condition. From the result it can be concluded that combined treatment of inorganic fertilizer and organic manure gave better result than whole NPK or whole manure. But whole vermicompost @ 10 $tha^{-1}$ also gave significant result. Najar and Khan, (2013) found highest shoot length (76 cm) with application of vermicompost @ 6 $tha^{-1}$. Abduli *et al.* (2013) observed the highest plant height with vermicompost : soil (1:1) ratio. Rodge and Yadlod (2009) and Senapati *et al.* (2007) found significant plant height from the treatment combination (50% recommended dose of fertilizer + 50% vermicompost). Singh *et al.* (2010) recorded higher plant height of tomato from treatment combination $T_4$ (50% NPK + 50% vermicompost) than control $T_1$ (100% NPK) or $T_4$ (100% vermicompost) treatment. Vermicompost had significant effect on plant height as reported by different authors. Vermicompost and inorganic fertilizer combination gave higher plant height. It is because vermicompost is a reservoir of many nutrients and it facilitates plant growth. It also creates good soil environment and helps to grow plant vigorously. In case of whole manure treatment mineralization is slow process but in combined condition improved mineralization is found. It is because of rapid conversion of inorganic fertilizer into available form of nutrients to plants. As a result plant height increased day by day significantly at this treatment combination.

**4.2 Plant spread**

Plant spread was recorded at different days after transplanting (DAT). A significant variation in plant spread was observed due to the influence of different combination of organic manures and fertilizer at different DAT (Appendix IV). The maximum spread (106.8 cm) at 70 DAT was found in the plants grown under $T_6$ treatment which was statistically identical with $T_7$ (103.8) treatment, while the lowest plant spread (88.13 cm) was observed in the plants treated with $T_4$ treatment which was statistically identical with $T_1$ (90.53 cm), $T_2$ (89.47 cm) and $T_3$ (89.13 cm) treatments (Table 2). Plant spread increases due to progress of time. It is because vermicompost and recommended doses of fertilizers creates healthy and optimum condition on the soil. As a result, plant spread increased vigorously in the open air. According to Islam (2011) higher tomato plant spread was found from vermicompost and *Trichoderma* compost with NPK fertilizer than NPK.

**Table 2. Effect of different combinations of manures and fertilizers on plant height and plant spread of tomato at different days after transplanting**

| Treatments | Plant height (cm) | | | | | | | Plant spread (cm) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 DAT | 20 DAT | 30 DAT | 40 DAT | 50 DAT | 60 DAT | 70 DAT | 10 DAT | 20 DAT | 30 DAT | 40 DAT | 50 DAT | 60 DAT | 70 DAT |
| $T_1$ | 23.07 b | 29.00 b | 40.27 ab | 54.20 ab | 65.67 ab | 76.07 ab | 83.53ab | 21.93 | 31.73 | 45.47 ab | 58.60 abc | 71.67 b | 81.13 b | 90.53 b |
| $T_2$ | 24.62 ab | 29.40 ab | 38.93 ab | 52.20 b | 61.20 b | 68.13 c | 78.87 b | 19.93 | 29.33 | 42.07 b | 54.67 c | 67.40 c | 76.80 b | 89.47 b |
| $T_3$ | 24.13 ab | 29.47 ab | 38.40 b | 52.60 b | 62.73 ab | 72.93 bc | 81.07 ab | 21.33 | 33.00 | 45.00 ab | 56.93 abc | 69.53 bc | 79.07 b | 89.13 b |
| $T_4$ | 24.33 ab | 30.53 ab | 41.47 ab | 51.07 b | 61.07 b | 68.00 c | 78.57 b | 21.07 | 32.00 | 43.47 ab | 56.27 bc | 69.13 bc | 78.47 b | 88.13 b |
| $T_5$ | 23.67 ab | 28.87 b | 38.33 b | 52.13 b | 62.27 ab | 74.73 ab | 83.13 ab | 21.33 | 32.47 | 45.60 ab | 60.60 abc | 71.93 b | 82.27 b | 93.00 b |
| $T_6$ | 25.53 a | 32.07 a | 43.20 a | 56.80 a | 66.40 a | 79.47 a | 88.40 a | 21.93 | 34.73 | 47.80 ab | 64.00 a | 79.33 a | 95.87 a | 106.8 a |
| $T_7$ | 24.17 ab | 29.07 b | 40.07 ab | 53.73 ab | 63.67ab | 78.40 ab | 85.87 ab | 20.80 | 34.67 | 50.13 a | 63.40 ab | 75.13 ab | 91.67 a | 103.8 a |
| Level of significance | ** | * | ** | ** | * | ** | ** | ns | ns | * | ** | ** | ** | ** |
| CV (%) | 3.49 | 5.21 | 4.60 | 3.13 | 4.28 | 3.27 | 3.77 | 6.23 | 11.87 | 6.91 | 5.05 | 3.69 | 3.17 | 5.38 |

$T_1$ = Recommended doses of NPK (Urea @ 350 kg ha$^{-1}$, TSP @ 250 kg ha$^{-1}$, MoP @ 300 kg ha$^{-1}$ )

$T_2$= Cowdung @10 t ha$^{-1}$, $T_3$= Vermicompost @ 10 t ha$^{-1}$

$T_4$=*Trichoderma* compost @10 t ha$^{-1}$, $T_5$= 50 % Cowdung + 50 % Recommended doses of fertilizer

$T_6$=50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$=50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns – Non significant

### 4.3 Number of leaves plant$^{-1}$

Number of leaves plant$^{-1}$ was recorded at different days after transplanting (DAT). Upto 40 DAT, there was no significant variation, but at 60 DAT and 80 DAT noticeable variation had been observed (Appendix IV). The maximum number of leaves plant$^{-1}$ (116.2) at 80 DAT was found in the plants grown under $T_6$ treatment which was statistically identical to $T_7$ (112.7) and $T_5$ (110.12) treatments, while the lowest number of leaves plant$^{-1}$ (97.07) was observed in the plants treated with $T_2$ treatment which was statistically identical to $T_1$ and $T_2$ treatments (Table 3). Organic manure mainly vermicompost creates good soil environment. It facilitated proper vegetative growth of tomato plants. On the other hand, plant absorbed more sunlight and produced more food for plant growth, that's why the leaves plant$^{-1}$ increased day by day. Joshi and Vig (2010) found higher no. of leaves from 30% vermicompost and soil mixture.

### 4.4 Days to 1$^{st}$ flowering

Days required to 1$^{st}$ flowering of tomato varied significantly due to the application of different levels of organic manures and fertilizers (Appendix IV). Earlier flowering (28.67 days) was found in case of $T_3$ treatment which was statistically similar to $T_6$ (29.67) and $T_4$ (30.33) treatments, on the other hand, $T_1$ treatment produced flowers later than that all other treatments ( 32.33 days) though it was statistically similar to $T_5$ (31.67) and $T_7$ (31.00) treatments (Table 3). Vermicompost helps to initiate flowering earlier and was more effective than other treatments. This might be due to vermicompost undergoes mineralization and releases adequate quantities of N, P, K and smaller amount of micronutrients than other organic sources and helps to vigorous plant growth and flowering. Prodhan *et al.* (2014) and Nizam *et al.* (2014) both found earlier flowering with vermicompost @ 5 tha$^{-1}$ and vermicompost @ 10 tha$^{-1}$ with different spacing, respectively than other manure based treatments

### 4.5 Number of flower clusters plant$^{-1}$

Number of flower clusters plant$^{-1}$ showed significant variation due to the application of different organic sources of nutrients (Appendix IV). The highest number of flower cluster (14.40) was observed in $T_3$ treatment which was statistically identical with $T_6$ treatment (14.03) and the lowest number of flower cluster (12.27) was found from $T_4$ treatment which was statistically identical with $T_2$ treatment (12.57) and $T_7$ treatment (12.53) (Table 3). Vermicompost increased the number of flower clusters plant$^{-1}$ than other treatments. This might be occured because of vermicompost acts as a nutritive 'organic fertilizer' rich in NPK and micronutrients, beneficial soil microbes like nitrogen-fixing bacteria and mycorrhizal fungi which promotes the growth and flowering of plant. This result is in agreement with the findings of Nizam *et al.* (2014) and Prodhan *et al.* (2014) where they reported that, vermicompost stimulates flowering, increasing the number and biomass of the flowers produced in tomato.

### 4.6 Number of flowers cluster$^{-1}$

Number of flowers cluster$^{-1}$ showed significant variation due to the application of different organic and inorganic sources of nutrients (Appendix IV). Vermicompost increased the number of flowers cluster$^{-1}$ than other treatments. The highest number of flowers cluster$^{-1}$ (7.41) was observed from $T_6$ treatment which was statistically identical to $T_3$ treatment (7.34) and the lowest number of flowers cluster$^{-1}$ (6.30) was found from $T_4$ treatment which was statistically identical to $T_1$ treatment (Table 3). Findings of Nizam *et al.* (2014) also obtained higher number of flower cluster$^{-1}$ with vermicompost and recommended doses of fertilizer.

**Table 3. Effect of different combinations of manures and fertilizers on leaves number and flower characters of tomato**

| Treatments | Number of leaves plant$^{-1}$ | | | | Flower characters | | |
|---|---|---|---|---|---|---|---|
| | 20 DAT | 40 DAT | 60DAT | 80DAT | Days to 1$^{st}$ flowering | No. of flower cluster plant$^{-1}$ | No.of flower cluster$^{-1}$ |
| $T_1$ | 7.86 | 14.53 | 55.13 bc | 102.0 cd | 32.33 a | 13.67 ab | 6.38 c |
| $T_2$ | 7.26 | 13.80 | 50.60 c | 97.07 d | 30.67 ab | 12.57 ab | 6.89 ab |
| $T_3$ | 8.06 | 14.13 | 57.33 abc | 104.5 bcd | 28.67 b | 14.40 a | 7.34 ab |
| $T_4$ | 8.14 | 14.13 | 54.33 bc | 101.2 cd | 30.33 ab | 12.27 b | 6.30 b |
| $T_5$ | 7.54 | 14.20 | 58.73 abc | 110.4 abc | 31.67 a | 13.80 ab | 6.73 ab |
| $T_6$ | 7.60 | 14.20 | 63.33 a | 116.2 a | 29.67 ab | 14.03 ab | 7.41 a |
| $T_7$ | 8.00 | 14.20 | 61.53 ab | 112.7 ab | 31.00 ab | 12.93 ab | 6.57 ab |
| Level of significance | ns | ns | ** | ** | ** | ** | ** |
| CV (%) | 7.51 | 3.73 | 4.39 | 3.04 | 5.67 | 5.55 | 6.24 |

$T_1$ = Recommended doses of NPK (Urea @ 350 kg ha$^{-1}$, TSP @ 250 kg ha$^{-1}$, MoP @ 300 kg ha$^{-1}$)
$T_2$= Cowdung @10 t ha$^{-1}$, $T_3$= Vermicompost @ 10 t ha$^{-1}$
$T_4$=*Trichoderma* compost @10 t ha$^{-1}$, $T_5$= 50 % Cowdung + 50 % Recommended doses of fertilizer
$T_6$=50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$=50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer
** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns- non significant

Number of flowers cluster$^{-1}$ increased in vermicompost and recommended doses of fertilizers. It is due to vermicompost undergoes mineralization and return adequate quantities of macro and micro nutrients than other sources and helps to vigorous plant growth and increases flower number.

**4.7 Number of fruit clusters plant$^{-1}$**

No significant variation was found in respect of numbers of fruits cluster$^{-1}$ due to the application of different organic and inorganic source of nutrients (Appendix IV). The highest number of fruits cluster$^{-1}$ (9.73) was recorded from $T_6$ treatment while the lowest number (8.40) derived from $T_2$ treatment (Table 4). Vermicompost helps in vegetative growth and could be attributed to physiological changes within the plant and translocation of sugar at development of the flowering and fruiting stages. Nizam *et al.* (2014) reported that higher number of fruit cluster plant$^{-1}$ was observed in vermicompost @ 10 t ha$^{-1}$ treatment comparing with other organic sources (cowdung, leaf rottern compost).

**4.8 Number of fruits cluster$^{-1}$**

The number of fruits cluster$^{-1}$ of tomato was not significant due to the application of different organic manure and inorganic fertilizer (Appendix IV). The highest number of fruits cluster$^{-1}$ (4.06) was found in case of treatment $T_6$ while the lowest number was obtained from $T_2$ treatment (3.62) (Table 4). Vermicompost facilitated proper vegetative growth of tomato plant and could be attributed to physiological changes within the plant and helped to develop number of fruit cluster$^{-1}$.

### 4.9 Number of fruits plant$^{-1}$

Number of fruits plant$^{-1}$ of tomato showed significant differences for the application of organic manure and inorganic fertilizers (Appendix IV). The highest number of fruits plant$^{-1}$ was recorded from $T_6$ treatment (37.61) followed by $T_7$ treatment (33.49) and $T_5$ treatment (30.15), respectively. On the other hand, the lowest number (27.30) was observed from $T_4$ treatment (Table 4). This result is in agreement with the findings of (Nizam *et al.* 2014, Prodhan *et al.* 2014) where they reported that, vermicompost produces the higher number of fruits plant$^{-1}$ than other manure. Chanda *et al.* (2010) suggested higher number of fruits plant$^{-1}$ from vermicompost supplemented with NPK treated plots. Rodge and Yadlod (2009) found higher number of fruits plant$^{-1}$ from the treatment combination 50% RDF (Recommended dose of fertilizer) and 50% vermicompost. Vermicompost and other recommended doses of fertilizers helps to proper growth of plants. It also supports to physiological changes within the plant. As a result, number of fruits plant$^{-1}$ increased in this combination. Trichoderma with NPK also gave good results. Here it should be concluded that higher number of fruit causes the fruit size in combined treatment was lower than whole organic treatment.

### 4.10 Weight of individual fruit

Significant variation was observed in respect of weight of individual fruit (Appendix IV). The highest weight of individual fruit (75.14 g) was found from $T_6$ treatment followed by $T_5$ and $T_1$ (73.63 g and 73.43 g) treatments, respectively. The lowest weight (70.97 g) was observed in $T_7$ treatment (Table 4). Prodhan *et al* (2014) found higher individual fruit weight of tomato in case of vermicompost @ 5 tha$^{-1}$ (50.14 g) comparing with cowdung @ 10 tha$^{-1}$ (45.25 g) and leaf rotten compost @ 10 tha$^{-1}$ (46.23 g). Vermicompost and recommended dose of fertilizers creates healthy environment in soil. So plant grows vigorously in that environment. Finally, these vigorous plant produced larger fruit. As a result, individual fruit weight increases at that combinations.

### 4.11 Length of fruit

Application of different combination of organic manure and inorganic fertilizers showed significant variation on length of fruit of tomato (Appendix IV). The highest length of fruit (4.84 cm) was recorded from $T_6$ treatment which was statistically identical with all other treatments except $T_1$ treatment having lowest length of fruit (4.06 cm) (Table 4). Optimum doses of organic manure namely vermicompost and other NPK fertilizers facilitates proper growth of the fruit to plant and could be attributed to physiological changes within the plant and helps to increase fruit length. Higher length of fruit in case of $T_6$ treatment gave unique shape to attain consumer appeal.

### 4.12 Diameter of fruit

Diameter of tomato fruit varied significantly due to the application of different sources of organic and inorganic fertilizer (Appendix IV). The highest diameter of fruit (5.33 cm) was recorded from $T_5$ treatment which was statistically similar to all other treatments except $T_6$ (4.29 cm) treatment (Table 4). In case of $T_5$ treatment there was comparatively lower no. of fruits that gave more space to grow up that's why fruit diameter was found higher. In case of T6, treatment fruit number was highest which gave elongated shaped fruit with comparatively lower diameter than other treatments.

**Table 4. Effect of different combinations of manures and fertilizers on fruit characters of tomato**

| Treatments | Fruit characters | | | | | |
|---|---|---|---|---|---|---|
| | Number of fruit clusters $plant^{-1}$ | Number of fruit $cluster^{-1}$ | Number of fruits $plant^{-1}$ | Weight of individual fruit (g) | Length of fruit (cm) | Diameter of fruit (cm) |
| $T_1$ | 8.93 | 3.76 | 28.32 bc | 73.43 ab | 4.061 b | 5.050 a |
| $T_2$ | 8.40 | 3.62 | 27.55 c | 72.63 b | 4.613 ab | 5.054 a |
| $T_3$ | 8.93 | 3.75 | 29.00 bc | 73.18 ab | 4.629 ab | 5.074 a |
| $T_4$ | 8.64 | 3.72 | 27.30 c | 72.40 b | 4.521 ab | 4.987 a |
| $T_5$ | 9.34 | 3.76 | 30.50 bc | 73.63 ab | 4.604 ab | 5.332 a |
| $T_6$ | 9.73 | 4.09 | 37.61 a | 74.62 a | 4.845 a | 4.295 b |
| $T_7$ | 9.66 | 3.96 | 33.49 ab | 70.97 c | 4.393 ab | 5.152 a |
| Level of significance | ns | ns | ** | * | * | ** |
| CV (%) | 10.29 | 12.34 | 8.75 | 3.80 | 8.05 | 4.44 |

$T_1$ - Recommended doses of NPK (Urea @ 350 kg $ha^{-1}$, TSP @ 250 kg $ha^{-1}$, MoP @ 300 kg $ha^{-1}$)
$T_2$= Cowdung @10 t $ha^{-1}$, $T_3$= Vermicompost @ 10 t $ha^{-1}$
$T_4$=*Trichoderma* compost @10 t $ha^{-1}$, $T_5$= 50 % Cowdung + 50 % Recommended doses of fertilizer
$T_6$=50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$=50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

** Significant at 1 % level of probability
* Significant at 5 % level of probability
ns- Non significant

### 4.13 Fruit weight plant$^{-1}$

There was significant variation in weight of fruits plant$^{-1}$ in respect of different organic manures and fertilizers (Appendix IV). The highest weight of fruit yield plant$^{-1}$ (2.55 kg) was observed from $T_6$ treatment which was statistically identical with $T_7$ (2.30 kg), $T_5$ (2.02 kg), $T_1$ (2.07 kg) treatments and the lowest fruit weight plant$^{-1}$ (1.20 kg) was found from $T_2$ treatment which was statistically identical with $T_4$ (1.20 kg) and $T_3$ (1.92) treatments (Figure 1). Vermicompost enriched treatment showed higher fruit weight plant$^{-1}$ although other combined treatment could have shown good result. This result is in agreement with the findings of Singh *et al.* 2010, Najar and Khan, 2013, where they confirmed that, the increased yield potential of vegetables achieved through application of vermicompost. Prodhan *et al.* (2014) found higher fruit weight plant$^{-1}$ with vermicompost. Vermicompot undergoes mineralization and release available plant nutrients which facilitated proper plant growth. As a result vigorous plant produced larger quantities of fruits.

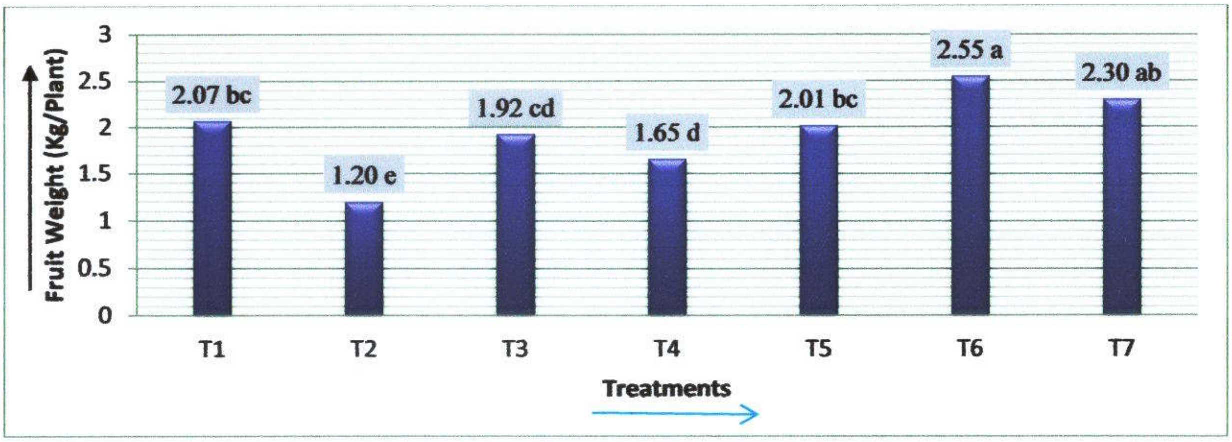


**Fig. 1. Fruit weight plant$^{-1}$ as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers.**

$T_1$ = Recommended doses of NPK (Urea @ 350 kg ha$^{-1}$, TSP @ 250 kg ha$^{-1}$, MoP @ 300 kg ha$^{-1}$)
$T_2$ = Cowdung @10 t ha$^{-1}$, $T_3$ = Vermicompost @ 10 t ha$^{-1}$, $T_4$ = *Trichoderma* compost @10 t ha$^{-1}$
$T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer, $T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

### 4.14 Fruit yield plot$^{-1}$

Organic manures and inorganic fertilizers combination exhibited significant effects on the yield of fruits plot$^{-1}$ (Appendix IV). The maximum yield plot$^{-1}$ (30.03 kg) was achieved by the application of 50% vermicompost + 50% of recommended dose of NPK ($T_6$) which was identical with $T_7$ treatment (27.33 kg), while lowest yield plot$^{-1}$ (16.27) was found from $T_2$ treatment (Fig. 2). Vermicompost and other recommended doses of fertilizer helps to create good soil environment and facilitates proper plant growth. Finally, plant produced higher number of fruits in each plot

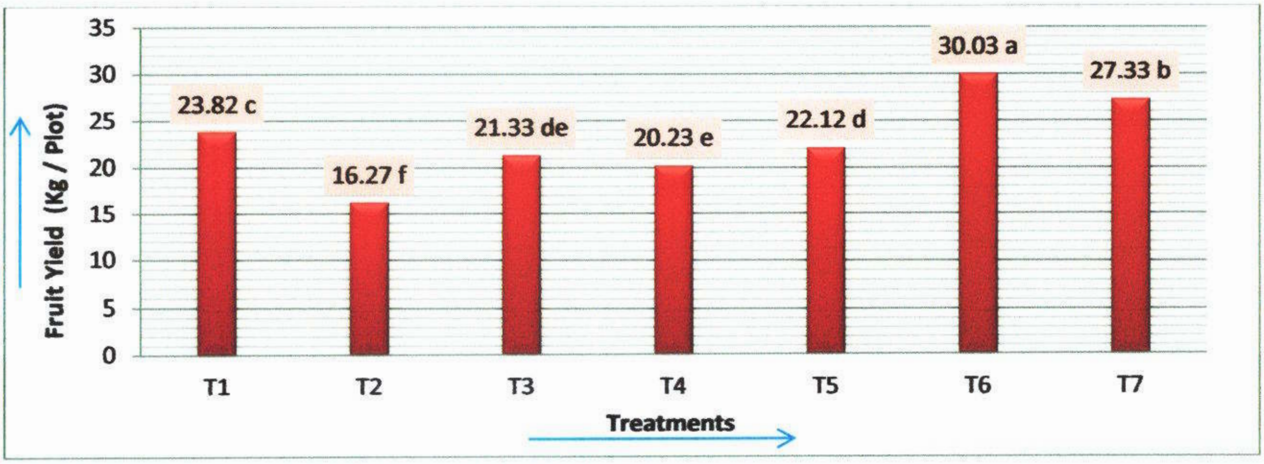


**Fig. 2. Fruit yield plot$^{-1}$ as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers.**

$T_1$ - Recommended doses of NPK (Urea @ 350 kg ha$^{-1}$, TSP @ 250 kg ha$^{-1,}$ MoP @ 300 kg ha$^{-1}$)
$T_2$ = Cowdung @10 t ha$^{-1}$, $T_3$ = Vermicompost @ 10 t ha$^{-1}$, $T_4$ = *Trichoderma* compost @10 t ha$^{-1}$
$T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer, $T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

### 4.15 Fruit yield hectare$^{-1}$

Significant variation was recorded on yield hectare$^{-1}$ due to the different levels of organic manures (Appendix IV). The highest yield hectare$^{-1}$ (78.20 t) was obtained from $T_6$ treatment which was followed by (71.18 t) with $T_7$ treatment, while the lowest yield (42.36 t) from $T_2$ treatment (Fig.3). Prodhan *et al* (2014), found higher fruit yield hectare$^{-1}$ (58.99 t) from vermicompost @ 5 $tha^{-1}$ comparing with compost @ 10 $tha^{-1}$ (53.94 ton). This result is also in agreement with the findings of Rodge and Yadlod, 2009, Singh *et al*. 2010, Theunissen *et al.* 2010, Najar and Khan 2013 and Nizam *et al*. 2014, where they confirmed that, the increased fruit yield per hectare achieved from vermicompost treatment. Organic manure mainly vermicompost goes mineralization and retain available nutrient for proper plant growth and attributed to physiological changes within the plant and helps to increase the number of fruits plot $^{-1}$ and finally the total yield $hectare^{-1}$ increased.

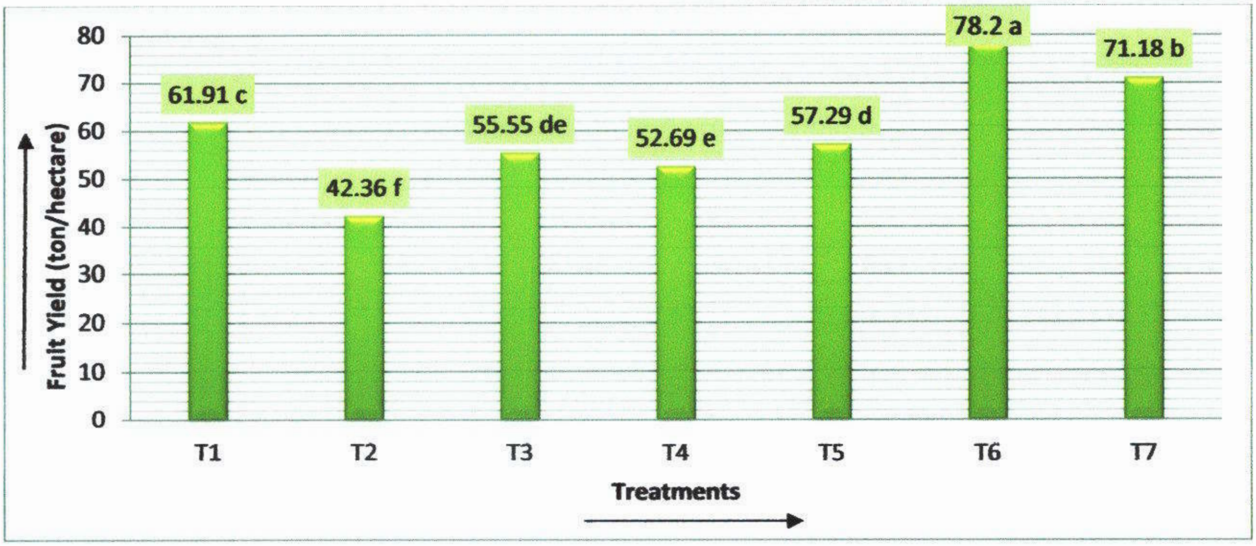


**Fig. 3. Fruit yield per hectare as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers.**

$T_1$ = Recommended doses of NPK (Urea @ 350 kg $ha^{-1}$, TSP @ 250 kg $ha^{-1}$, MoP @ 300 kg $ha^{-1}$)
$T_2$ = Cowdung @10 t $ha^{-1}$, $T_3$ = Vermicompost @ 10 t $ha^{-1}$, $T_4$ = *Trichoderma* compost @10 t $ha^{-1}$
$T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer, $T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

### 4.16 Benefit cost ratio

The combination of organic manure and fertilizer for benefit cost ratio was different in all treatment combinations (Appendix IV). The highest benefit cost ratio (3.15) was observed in $T_6$ treatment followed by $T_7$ treatment (2.80) and $T_1$ treatment (2.79). The lowest benefit cost ratio (1.13) was obtained from $T_4$ treatment (Fig. 4). Vermicompost with recommended doses of fertilizers ($T_6$) was focused as more profitable than any other treatment giving highest benefit cost ratio (3.15) which is not only for higher yield but also quality fruit. Unique shape, size and color carried higher market value than other treatments. *Trichoderma* with recommended doses of fertilizers ($T_7$) also gave better yield with quality fruit, but benefit cost ratio was lower due to high price of compost. So, it is proved that positive effect of vermicompost on growth and yield of tomato easily can compete with inorganic fertilizer having higher benefit cost ratio.

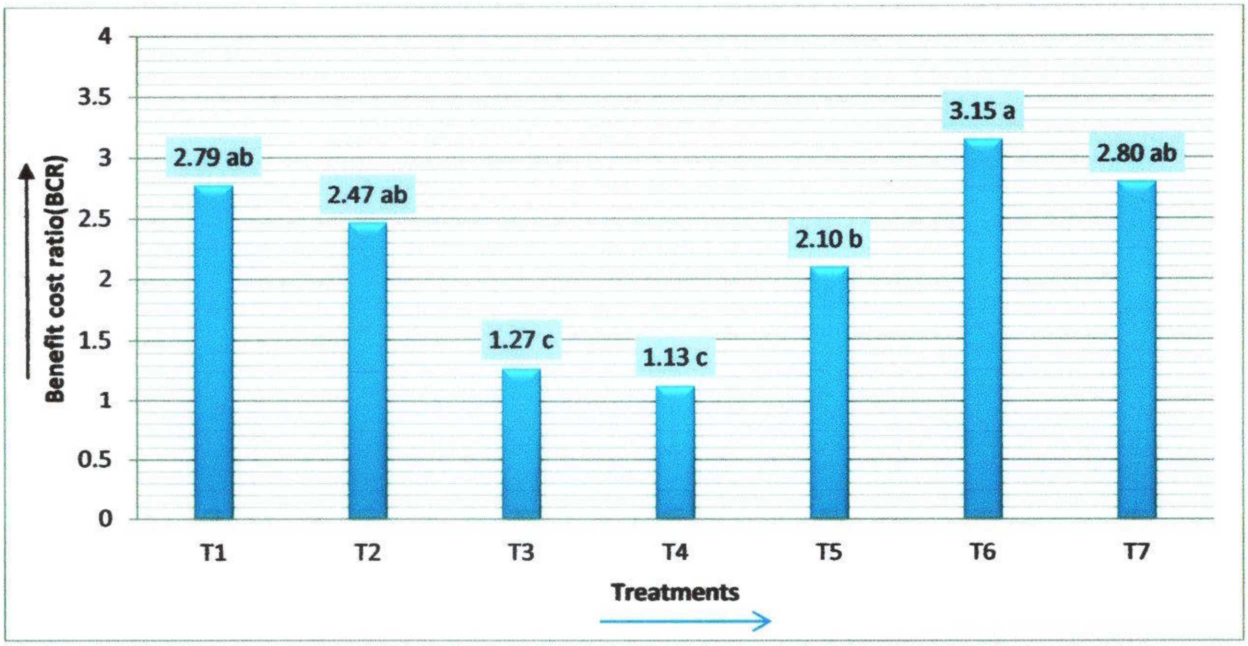


**Fig. 4. Benefit cost ratio as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers.**

$T_1$ = Recommended doses of NPK (Urea @ 350 kg ha$^{-1}$, TSP @ 250 kg ha$^{-1}$, MoP @ 300 kg ha$^{-1}$)
$T_2$ = Cowdung @10 t ha$^{-1}$, $T_3$ = Vermicompost @ 10 t ha$^{-1}$, $T_4$ = *Trichoderma* compost @10 t ha$^{-1}$
$T_5$ = 50 % Cowdung + 50 % Recommended doses of fertilizer, $T_6$ = 50 % Vermicompost + 50 % Recommended doses of fertilizer, $T_7$ = 50 % *Trichoderma* compost + 50 % Recommended doses of fertilizer

# Chapter V

# SUMMARY AND CONCLUSIONS

A field experiment was conducted at Hogladanga village under the Batiaghata upazila of Khulna district during the period from November, 2013 to April, 2014 to investigate the effects of different organic manures and inorganic fertilizer on the growth and yield of tomato. The experiment consisted of seven treatments. The treatments were, $T_1$ : recommended dose NPK fertilizers, $T_2$ : cowdung @ 10 tha$^{-1}$, $T_3$ : Vermicompost @ 10 t ha$^{-1}$ , $T_4$ : *Trichoderma* compost @ 10 t ha$^{-1}$ $T_5$ : 50% Cowdung + 50% recommended dose of NPK, $T_6$ : 50% Vermicompost + 50% recommended dose of NPK, $T_7$ : 50% *Trichoderma* compost + 50% recommended dose of NPK. The single factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The tomato seedlings were planted on 06 December, 2013 and harvested upto 13 March, 2014. Data were collected from 10 randomly selected plants of each unit plot. Recorded data were analyzed statistically with the help of computer package program MSTAT-C and the mean differences were adjusted with Duncun's New Multiple Range Test at 1% and 5% level of probability.

The results of experiment showed that all the parameters studied were significantly influenced by the application of different types of organic manure and recommended dose of NPK. $T_6$ (50% Vermicompost + 50% recommended dose of NPK) had significant influence on growth and yield of tomato. Application of $T_6$ produced the highest plant height (88.40 cm), plant spread (106.80 cm), number of leaves plant$^{-1}$ (116.2), number of flowers cluster$^{-1}$ (7.41), number of fruit clusters plant$^{-1}$ (9.73), number of fruits cluster$^{-1}$ (4.09), number of fruits plant$^{-1}$ (37.61), length of fruit (4.84 cm), weight of individual fruit (74.62 g), weight of fruit plant$^{-1}$ (2.55 kg), fruit yield plot$^{-1}$ (30.03 kg) fruit yield hectare$^{-1}$ (78.02 t) and benefit cost ratio (3.15). On the other hand the lowest plant height (78.57 cm), plant spread (88.13cm), number of leaves plant$^{-1}$ (97.07), number of flowers cluster$^{-1}$ (6.30), number of fruit clusters plant$^{-1}$ (8.40), number of fruits plant$^{-1}$ (23.30), weight of fruit plant$^{-1}$ (1.20 kg), fruit yield plot$^{-1}$ (16.27 kg) and fruit yield hectare$^{-1}$ (42.36 t) was recorded from $T_2$ treatment. Lowest length (4.06) and diameter (4.29) of fruit was found from $T_1$ and $T_6$ treatments, respectively.

The present study revealed that vermicompost combined with NPK fertilizers increased the tomato growth and yield. Based on the findings of the experiment, treatment $T_6$ (50% Vermicompost + 50% recommended dose of NPK) was most profitable than rest of the treatment combinations. So vermicompost can be suggested as organic source to minimize inorganic fertilizer obtaining higher yield of tomato (Suraksha variety).

However the present research work was carried out at Hogladanga village under the Batiaghata upazila of Khulna district under the Agrotechnology Discipline of Khulna University in one season only. Further trial of this research work in different locations of the country is needed before final recommendation in applied level.

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## Appendix I: Chemical analysis of soil sample

| Treatments | Soil pH | | EC ( ds /m) | | Oragic matter ( %) | | Potassium ( mg/ 100 g soil) | | Total nitrogen (%) | | Phosphorus (µg/ g soil) | | Copper (µg/ g soil) | | Zinc (µg/ g soil) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | After application | After harvest | After application | After harvest | After application | After harvest | After application | After harvest | After application | After harvest | After application | After harvest | After application | After harvest | After application | After harvest |
| $T_1$ | 7.2 | 7.0 | 1.7 | 0.9 | 2.37 | 2.89 | 0.38 | 0.31 | 0.138 | 0.167 | 122.6 | 26.97 | 55.07 | 45.51 | 1.6 | 0.79 |
| $T_2$ | 7.2 | 7.2 | 1.6 | 1.4 | 3.15 | 2.82 | 0.41 | 0.33 | 0.182 | 0.163 | 21.05 | 10.65 | 22.93 | 28.03 | 0.81 | 0.64 |
| $T_3$ | 7.0 | 6.8 | 1.4 | 0.9 | 3.14 | 2.75 | 0.47 | 0.37 | 0.182 | 0.159 | 56.39 | 33.33 | 51.15 | 31.38 | 3.28 | 1.2 |
| $T_4$ | 7.1 | 7.0 | 1.2 | 1.1 | 2.47 | 2.84 | 0.41 | 0.33 | 0.143 | 0.164 | 52.91 | 45.89 | 34.78 | 19.42 | 1.28 | 1.1 |
| $T_5$ | 7.1 | 6.9 | 0.8 | 1.2 | 2.58 | 2.88 | 0.41 | 0.34 | 0.149 | 0.167 | 47.1 | 84.65 | 27.34 | 41.94 | 1.1 | 0.81 |
| $T_6$ | 7.1 | 6.9 | 1 | 1.1 | 2.99 | 3.26 | 0.31 | 0.40 | 0.173 | 0.189 | 46.3 | 37.44 | 29.77 | 25.69 | 1.57 | 1.55 |
| $T_7$ | 7.0 | 7.2 | 0.9 | 1.1 | 2.96 | 2.61 | 0.37 | 0.37 | 0.172 | 0.151 | 41.14 | 44.32 | 40.04 | 29.94 | 0.74 | 1.29 |
| Range (Min. to Max.) | 7-7.2 | 6.8-7.2 | 0.8-1.7 | 0.9-1.4 | 2.37-3.15 | 2.61-3.26 | 0.31-0.47 | 0.31-0.40 | 0.13-0.18 | 0.15-0.18 | 21.05-122.6 | 10.65-84.65 | 22.93-55.07 | 19.42-45.51 | 0.74-3.28 | 0.64-1.55 |
| Average | 7.1 | 7.0 | 1.23 | 1.1 | 2..80 | 2.86 | 0.39 | 0.35 | 0.16 | 0.16 | 55.35 | 40.46 | 37.29 | 31.70 | 1.48 | 1.05 |
| SD | 0.08 | 0.17 | 0.35 | 0.17 | 0.32 | 0.20 | 0.04 | 0.03 | 0.02 | 0.02 | 31.77 | 22.83 | 12.13 | 9.12 | 0.86 | 0.32 |
| CV (%) | 1.15 | 2.18 | 28.47 | 15.74 | 11.64 | 6.95 | 12.41 | 8.88 | 11.56 | 7.04 | 57.40 | 56.42 | 32.54 | 28.77 | 58.03 | 30.63 |

(Analyzed from SRDI, Daulatpur, Khulna)

**Appendix II: Compositon of different organic manures**

**Cowdung :**

| | | | |
|---|---|---|---|
| N = 0.5 % | P = 0.15 % | K = 0.5 % | Moisture = 60 ± 6 |

**Source:** Fertilizer Recommendation Guide-2012, Bangladesh Agricultural Research Council

**Vermicompost :**

| | | | |
|---|---|---|---|
| N = 1.9 % | P = 2.0 % | K = 0.8 % | C:N = 13.60 % |
| Mn = 500 ppm | Zn = 100 ppm | Cu = 48 ppm | pH = 8.0 |

***Trichoderma* compost :**

| | | | |
|---|---|---|---|
| Organic carbon = 20% | N = 1.2 % | P = 0.61 % | K = 0.77 % |
| S = 0.24 % | Ca = 1.71 % | Mg = 0.4 % | B = 0.01 % |
| Cu = 0.01 % | Fe = 0.12 % | Mn = 0.026 % | Zn = 0.02 % |

Source : ( Nahar *et al.*, 2012)

**Appendex III.** Monthly record of temperature, relative humidity, rainfall and sunshine during the period from October, 2013 to April, 2014.

| Year | Month | Air temperature ( $^{0}C$ ) | | Monthly relative humidity (%) | Monthly total rainfall (mm) | Monthly average sunshine (hrs) |
|---|---|---|---|---|---|---|
| | | Monthly average maximum | Monthly average minimum | | | |
| 2013 | October | 31.6 | 24.4 | 85 | 260 | 4.425 |
| | November | 30.4 | 18.2 | 76 | 000 | 8.25 |
| | December | 27.0 | 15.0 | 79 | 000 | 5.975 |
| 2014 | January | 24.0 | 12.6 | 82 | 000 | 5.225 |
| | February | 27.7 | 15.2 | 75 | 24 | 7.35 |
| | March | 32.9 | 20.1 | 69 | 5 | 8.375 |
| | April | 37.7 | 25.1 | 65 | 000 | 8.758 |

**Source :** Regional Inspection Centre, Bangladesh Meteorological Department, Gollamari, Khulna, Bangladesh.

**Appendix IV: Analysis of variance of different characters of tomato as influenced by cowdung, vermicompost, *Trichoderma* compost and NPK fertilizers**

| Source of variance | Degrees of freedom | Mean square | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Plant height (cm) | | | | | | | Plant spread (cm) | | | | | | |
| | | 10 DAT | 20 DAT | 30 DAT | 40 DAT | 50 DAT | 60 DAT | 70 DAT | 10 DAT | 20 DAT | 30 DAT | 40 DAT | 50 DAT | 60 DAT | 70 DAT |
| Replication | 2 | 0.77 | 3.93 | 35.48 | 3.60 | 0.97 | 1.08 | 27.98 | 6.85 | 69.53 | 64.03 | 112.04 | 73.67 | 85.89 | 109.52 |
| Treatment | 6 | $1.77^{**}$ | $3.99^{*}$ | $9.43^{**}$ | $5.12^{**}$ | $13.06^{*}$ | $62.79^{**}$ | $37.67^{**}$ | $1.44^{ns}$ | $10.38^{ns}$ | $21.39^{*}$ | $38.64^{**}$ | $49.58^{**}$ | $158.27^{**}$ | $175.18^{**}$ |
| Error | 12 | 0.71 | 2.40 | 3.39 | 8.83 | 7.32 | 5.85 | 9.75 | 1.74 | 14.93 | 9.95 | 8.93 | 7.04 | 7.00 | 5.06 |

**: Significant at 1% level of probability
*: Significant at 5% level of probability
ns: non-significant

## IV (Contd.)

| Sources of variance | Degree of freedom | Mean square | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of leaves plant$^{-1}$ | | | | Flower characters | | | Fruit characters | | |
| | | 20 DAT | 4O DAT | 6O DAT | 80 DAT | Days to 1$^{st}$ flowering | No. of flower cluster plant$^{-1}$ | No. of flower cluster$^{-1}$ | Number of fruit clusters plant$^{-1}$ | Number of fruit cluster$^{-1}$ | Number of fruits plant$^{-1}$ |
| Replication | 2 | 1.09 | 2.56 | 433.56 | 1770.34 | 2.90 | 5.20 | 2.64 | 1.24 | 0.64 | 53.24 |
| Treatment | 6 | $0.31^{ns}$ | $0.13^{ns}$ | $57.38^{**}$ | 144.67** | $4.49^{**}$ | $1.91^{**}$ | $0.57^{**}$ | $0.76^{ns}$ | $0.07^{ns}$ | $42.71^{**}$ |
| Error | 12 | 0.34 | 0.28 | 6.32 | 10.43 | 3.01 | 0.55 | 0.18 | 0.87 | 0.22 | 7.14 |

**: Significant at 1% level of probability
*: Significant at 5% level of probability
ns: non-significant