EFFECT OF DIFFERENT ORGANIC MANURES ON GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum*)

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EFFECT OF DIFFERENT ORGANIC MANURES ON GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum*)

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CERTIFICATE

*This is to certify that thesis entitled, "**EFFECT OF DIFFERENT ORGANIC MANURES ON GROWTH AND YIELD OF TOMATO (Lycopersicon esculentum)**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.) in SOIL SCIENCE**, embodies the result of a piece of bona-fide research work carried out by **MD. ANIK MIA**, Registration no. **19-10134** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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The Author
June, 2021

Dedicated

To

My beloved

Parents

EFFECT OF DIFFERENT ORGANIC MANURES ON GROWTH AND YIELD OF TOMATO (*Lycopersicon esculentum*)

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University during the period from from 05th November, 2019 to 10th March, 2020 for assessing the effect of different organic manure and inorganic fertilizers on growth and yield of tomato. The experiment comprised of single factor comprising eight treatments viz. T_0 = Control, T_1 = Cowdung @ 15.0 t ha^{-1}, T_2 = Poultry litter @ 12.0 t ha^{-1}, T_3 = Vermicompost @ 5.0 t ha^{-1}, T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1}, T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}, T_6 = Poultry litter @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}. Seeds of tomato cv. 'BARI Tomato-15' were used in the experiment. This experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. The results revealed that treatment T_7 [Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}] exhibited its superiority compare to other organic and inorganic fertilizer treatments in terms of fruit yield of tomato. Treatment T_5 out-yielded over T_7 by 7.18%, T_4 by 11.24%, T_6 by 21.51%, T_3 by 31.62%, T_1 by 43.51% and T_2 by 53.02% higher fruit yield. Treatment T_7 also showed the tallest plant at harvest (125.00 cm), the maximum number of leaves plant^{-1} at harvest (89.15), the highest number of branches plant^{-1} at harvest (4.47), the highest number of flower clusters plant^{-1} (16.27), the maximum number of flower cluster^{-1} (5.98), the highest number of fruits plant^{-1} (30.66) and the maximum individual fruit weight (48.29 g) in this experiment. In case of soil properties, the highest soil organic carbon (0.85%) and the maximum soil pH (6.21) was recorded from treatment T_7 in post-harvest soil. Considering the soil nutrients, the maximum soil N content after harvest (0.11%) was noted in T_7 treatment whereas the highest available P content in soil (23.0 ppm) and the maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_4 receiving chemical fertilizer. Vermicompost (2.50 t ha^{-1}) + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} application seemed promising for producing higher fruit yield of tomato and sustaining soil productivity.

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LIST OF ABBREVIATIONS

ABBREVIATION	ELLABORATION
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agra.	Agricultural
Annu.	Annual
Appl.	Applied
Biol.	Biology
Cfu	Colony forming unit
Chem.	Chemistry
cm	Centi-meter
CV	Coefficient of Variance
DAS	Days After Storage
DAP	Days After Planting
Dev.	Development
Ecol.	Ecology
Environ.	Environmental
etci	and others
Exptl.	Experimental
g	Gram (s)
i.e.	that is
J.	Journal
kg	Kilogram (s)
LSD	Least Significant Difference
M.S.	Master of Science
m^2	Meter squares
mg	Milligram
Nutr.	Nutrition
Physiol.	Physiological
Progress.	Progressive
Res.	Research
SAU	Sher-e-Bangla Agricultural University
Sci.	Science
T	Tuber size
Soc.	Society
SRDI	Soil Resource Development Institute
t ha^{-1}	Ton per hectare
UNDP	United Nations Development Programme
Viz	*videlicet* (L.), Namely
%	Percentage
@	At the rate of
µMol	Micromole

LIST OF ABBREVIATIONS (CONT'D)

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
CV %	Percent Coefficient of Variance
cv.	Cultivar (s)
DAS	Days After Sowing
eds.	Editors
et al.	et alia (and others)
etc.	et cetera (and other similar things)
FAO	Food and Agricultural Organization
L.	Linnaeus
LSD	Least Significant Difference
i.e.	id est (that is)
MoP	Muriate of Potash
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TDM	Total Dry Matter
TSP	Triple Super Phosphate
UNDP	United Nations Development Programme
var.	Variety
viz.	Namely

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.), a member of the family Solanaceae is one of the most important vegetables grown in Bangladesh. It has been originated in tropical America that includes Peru, Ecuador, Bolivia and areas of Andes (Kallo, 1986). It ranks third next to potato and sweet potato in terms of world vegetable production (FAO, 2015) and top the list of canned vegetable (Choudhury, 1979). But in Bangladesh, it ranks second which is next to potato (BBS, 2016). It has diversified use as raw like salad, soup etc.

Tomato is highly nutritious as it contains 94.1% water, 23 calories energy, 1.90 g protein, 1.00 g calcium, 7.00 mg magnesium, 1,000 IU vitamin A, 31 mg vitamin C, 0.09 mg thiamine, 0.03 mg riboflavin, 0.8 mg niacin per 100 g edible portion (Mac Gillivary, 1961 and Rashid, 1983). Food value of tomato is very rich because of its higher content of vitamins A, B and C including calcium and carotene (Bose and Som, 1990). Tomato adds flavour to the foods and it is also rich in medicinal value (Uddain *et al*., 2009; Rashid, 1983; Davies and Hobes, 1981). Recent studies have directly linked lycopene to the prevention of certain types of human cancer, particularly prostate cancer and with a lower incidence of heart disease such as arteriosclerosis. Tomato consumption has been associated with decreased risk of breast cancer, head and neck cancers and might be strongly protective against neurodegenerative diseases in human. Tomato contains lycopene pigment which is a vital anti-oxidant that helps to fight against cancerous cell formation as well as other kind of health complications and diseases (Kumavat and Chaudhari, 2013). Tomatoes are rich in Vitamin-K which plays a major role in blood clotting.

In Bangladesh tomato has great demand throughout the year but its production is mainly concentrated during the winter season. Recent statistics showed that tomato was grown in 13066 hectares of land and the total production was approximately 74000 metric tons in Bangladesh during the year 2014-2015. Thus, the average yield of tomato was 18.35 t ha^{-1} (BBS. 2015). While it was 69.41 t ha^{-1} in USA, 65.45 t ha^{-1} in Japan, 48.13 t ha^{-1} in China, 23.79 t ha^{-1} in Thailand, 21.27 t ha^{-1} in India and 19.67 t ha^{-1} in Pakistan (FAO, 2014). The low yield of tomato in Bangladesh is due to the deficiency of soil nutrients and it is now considered as one of the major constraints to successful upland crop production in Bangladesh (Islam and Noor, 1982). The cultivation of tomato requires proper supply of plant nutrient. This requirement can be provided by applying inorganic fertilizer or organic manure or both.

The use of proper amount of organic manure such as cowdung, compost and vermicompost improved texture, structure, humus, color, aeration, water holding capacity and microbial activity of soil. In our country, the soils of most regions have less than 1.5%, some soils even have less than 1% organic matter (BARC, 1997). Organic manure has the largest effect on yield and quality of tomato. It also promotes the vegetative growth, flowering and fruit set of tomato. The macronutrients calcium and micronutrients boron, manganese, molybdenum and iron are important for tomato cultivation. Biologically active soils with adequate organic matter usually supply enough of these nutrients (Singh and Kushwah, 2006).

Composting has been recognized as a low cost and environmentally sound process for treatment of many organic wastes (Hoitink *et al.*, 1993). Bevacqua and Mellano (1993) reported that compost-treated soils had lower pHs and increased levels of organic matter, primary nutrients, and soluble salts. In crop studies, Bryan and Lance (1991) found that tomatoes grown in compost-amended soils yielded more. Maynard (1993) also reported increases in fruit yield of compost-amended plants compared with those growing in soil alone. Furthermore, composting and composts have been reported to suppress plant pathogens.

Our farmers are habituated in the use of nitrogenous, phosphoric and potassic fertilizer than organic manure. On the other hand, organic manure is not always easily available. Moreover, the farmers are not fully aware about the importance of use of organic manure. So, in our country, the application of organic manure needs to be encouraged. Use of chemical fertilizers in crop production is one of the important causes of environmental pollution. Now-a-days, there is growing awareness among the scientists in various parts of the world regarding the problems of environmental pollution through the use of chemicals in crop production. As an alternative to chemicals, scientists in the developed nations are trying to develop various bio-fertilizers for reducing environmental pollution and for obtaining pollution free crop production, especially vegetables. Use of organic manure in crop production has many advantages over chemical fertilizers. Organic manure saves the crop plants from adverse environment.

The increase in vegetative growth of tomato could be attributed to physiological role of organic manure and its involvement in the metabolism of protein, synthesis of pectin, maintaining the correct water relation within the plant, resynthesis of adenosine triphosphate (ATP) and translocation of sugar at development of the flowering and fruiting stages (Bose and Tripathi, 1996). The improvement in quality parameters of tomato fruit due to organic manure application could be the result of overall growth and development of the crop (Naresh and Babu, 2002).

Organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils. Organic manures such as cow dung, poultry manure and vermicompost improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of tomato plants. In Bangladesh, a large number of tomato varieties are grown, which are of exotic origin and were developed long before. Most of them lost their potentiality due to genetic deterioration and disease contamination. Hence in order to improve the present situation of tomato production in

Bangladesh, it is essential to promote better varieties to the growers of Bangladesh.

OBJECTIVES

1. To find out the suitable organic manure for optimum growth and yield of tomato.

2. To determine the optimum level of organic manure for growth and yield of tomato.

3. To identify the suitable combination of organic manure and inorganic fertilizer for ensuring the higher yield of tomato.

CHAPTER II

REVIEW OF LITERATURE

Growth, development and yield of tomato are greatly influenced by environmental factors, variety and agronomic practices. Among the various agronomic practices influencing the crop yield, application of balanced fertilizer is very important. Research on this crop is going on various aspects to increase its potential yield also keeping soil fertility and productivity in mind which are responsible optimum production of any crop. The use of organic fertilizer plays an important role in producing higher yield per unit area and keeping soil health intact. An attempt was taken to review the available literature within and outside the country that are related to the effect of different organic manures on growth and yield of tomato in this chapter.

Carricondo-Martínez *et al.* (2022) carried out a study to evaluate the effects of organic amendments derived from vegetal residues on the yield and quality of tomato. The following fertilisation treatments were carried out: fresh vegetal residues (4 kg m^{-1}), compost (3 kg m^{-1}), and vermicompost at two different doses (3 and 9 kg m^{-1}), all derived from previous tomato crop vegetal residues, an organic treatment with goat manure (3 kg m^{-1}), and a control mineral fertigation treatment. Tomatoes (*Solanum lycopersicum* L.) cv. 'Surcal' (Natursur S.C.A.), grafted onto Beaufort (Monsanto) rootstock, were transplanted. The highest yield was obtained with conventional mineral fertigation management, followed by vermicompost treatments at two different doses (3 and 9 kg m^{-1}), with no statistical differences. The organic treatments with fresh crop residues, compost and goat manure resulted in lower yield. Regarding quality parameters, the lycopene content was higher in the mineral fertilisation and vermicompost at 3 kg m^{-1} treatment, while the other antioxidants measured were more concentrated in tomatoes fertilised with vermicompost treatment at 9 kg m^{-1} and goat manure. The plant nutrient management with vermicompost was the best circular solution, as it allowed to reintegrate the residues generated in previous crop cycles into the soil, obtaining a yield equal to chemical input management and tomatoes with high nutritional quality.

Haque *et al.* (2021) conducted the experiment to find out the useful effects of organic fertilizer on growth and yield of tomato. The experiment was arranged in a randomized complete block design (RCBD) with five treatments. The treatments included T_1 = 100% Recommended Chemical Fertilizer (RCF), T_2 = 85% CF + 3 t ha^{-1} organic Fertilizer (OF), T_3 = 85% CF + 1 t ha^{-1} OF, T_4 = 70% CF + 3 t ha^{-1} OF and T_5 = 70% CF + 1 t ha^{-1} OF. The crop variety was BARI tomato-17. The highest yield was observed in T_2 (50.59 t ha^{-1}) due to higher number of fruit $plant^{-1}$ and weight of fruit $plant^{-1}$ and the lowest was in T_5 (35.32 t ha^{-1}). These results may be due the parameters of growth components increased with increasing amount of organic and inorganic fertilizers applied. Combination of organic and inorganic fertilizer treated plots produced higher yield than plots without combination of organic and inorganic fertilizer. The highest gross return (BDT. 607080) was found in T_2 treatment and the lowest gross return (BDT. 423840) was recorded from T_5. The highest gross margin (BDT. 328520 ha^{-1}) was obtained from T_2. The lowest gross margin (Tk. 145280 ha^{-1}) was obtained from T_5. Integrated nutrient management (combination of organic and inorganic fertilizer) is the best option for higher tomato production in Bangladesh.

Sopha *et al.* (2020) carried out a study to determine the best formula of liquid organic fertilizer for organic tomato. The study consisted of two activities: formulation of liquid organic fertilizer and the evaluation of liquid organic fertilizer on organic tomato growth and yield. The first activity was a material analysis that compared 9 different organic materials. The organic materials were collected from different areas in West Java, Indonesia. The organic materials were collected and analyzed the chemical content, they were leaves of white leadtree (*Leucaena leucocephala*), leaves of velvet bean (*Mucuna pruriens*), leaves of snap bean (*Phaseolus vulgaris*), leaves of elephant grass (*Pennisetum* *purpureum*), chicken (*Gallus gallus domesticus*) manure, cow (*Bos taurus*) manure, rabbit (*Lepus negricollis*) manure, goat (*Capra aegagrus hircus*) manure and bat (Ordo: Chiroptera) manure. The second activity was a glass house experiment that used different rate of solid manure and liquid organic fertilizer. The tomato cultivar 'Zamrud' from Indonesian Vegetable Research Institute was used which was a determinate cultivar. The pot trials were carried out in the greenhouse to understand the effect of liquid organic fertilizer on organic tomato growth and yield. The treatments were: (L0) 100% solid manure + 0 mL L^{-1} liquid organic fertilizer (control), 100% solid manure + 10 mL L^{-1} liquid organic fertilizer (L1), 100% solid manure + 15 mL L^{-1} liquid organic fertilizer (L2), 100% solid manure + 20 mL L^{-1} liquid organic fertilizer (L3), 75% solid manure + 20 mL L^{-1} liquid organic fertilizer (L4) and 50% solid manure + 20 mL L^{-1} liquid organic fertilizer (L5). A full dosage 100% of solid manure was 30 t ha^{-1} horse manure or equal to 1 kg/plant. The liquid organic fertilizer was foliar applied and was given at 15, 30 and 45 days after planting with spraying volume 300-500 L ha^{-1}. The first activity found that white lead tree had a great potential as a nitrogen source, elephant grass and goat manure had a high amount of phosphorus and rabbit manure had the highest amount of potassium content. The second activity found that the application 20 mL L^{-1} of liquid organic fertilizer increased the tomato yield up to 83% and improved vitamin C up to 66% than the control. Liquid organic fertilizer made from manure (rabbit and goat manure) and green manure (white lead tree and elephant grass) doses 20 mL L^{-1} enhanced the fruit yield and vitamin C of organic tomato.

Afsun (2018) conducted a field experiment to study the effect of micronutrients with manure on growth and yield of tomato. There were four levels of manure viz M_0 = 0 t ha^{-1}, M_1 = Cowdung (15 t ha^{-1}), M_2 = Poultry manure (10 t ha^{-1}), M_3 = (Cowdung 7.5 t ha^{-1} + Poultry manure 5 t ha^{-1}). In case of application of organic manures, the highest yield (50.78 t ha^{-1}) was obtained from M_3 (Cowdung 7.5 t ha^{-1} + Poultry manure 5 t ha^{-1}).

Shrestha *et al.* (2018) carried out a field experiment in plastic tunnel to observe the performance of tomato with organic manures in two consecutive years (2014 and 2015). Srijana, a popular tomato hybrid among commercial producers, was purposively selected. Eight treatments (control, recommended doses of chemical fertilizers, compost 15 t ha^{-1} + cattle urine, compost 10 t ha^{-1} + cattle urine, compost 12.50 t ha^{-1} + cattle urine, compost 15 t ha^{-1} + $^{1}/_{4}$ recommended dose of chemical fertilizers, compost 10 t ha^{-1} + ¾ recommended dose of chemical fertilizer and compost 12.5 t ha^{-1} + ½ recommended dose of chemical fertilizer) were laid out in randomized complete block design. The result showed significant positive correlation between the plant height and yield of tomato. The treatment with compost dose of 12.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest incremental yield (85% increment) over other treatments followed by compost 15 t ha^{-1} with cattle urine. Addition of soil organic carbon, soil nitrogen, soil potassium by the increasing level of compost though not significant, but increment in carbon content, nitrogen content and potassium content of soil observed in successive years. For commercial producer at plastic tunnel, compost at the rate 12.5 t ha^{-1} with half dose of recommended level of chemical fertilizer (100:90:40 kg N:P:K ha^{-1}) is recommended to apply in field, while for organic producer, application of 15 t ha^{-1} compost with fermented cattle urine is recommended.

Islam *et al.* (2017) conducted field trials on tomato for yield and quality of fruits using different types of organic and inorganic fertilizers. Two varieties of tomato ca. Roma VF (V_1) and BARI tomato 15 (V_2) were selected for the study. The fertilization treatments were T_1 = vermicompost (12 t ha^{-1}); T_2 = compost (10 t ha^{-1}); T_3 = integrated plant nutrient system (IPNS) or mixed fertilizers (organic ⅔ part and inorganic ⅓ part); T_4 = inorganic fertilizers; and a control (T_5). Results showed growth and yield (20.8 t ha^{-1}) in tomato were higher in the IPNS treatment. A higher number of fruits per plant (73.7) and plant height (73.5 cm) were obtained from mixed fertilizers (organic ⅔ + inorganic ⅓) or IPNS (integrated plant nutrient system) in Roma VF than other treatments. Fruit yield and diameter were found statistically significant. No significant difference was observed in the quality (total soluble solids) of tomato fruits in both varieties' response to the treatments. The electrical conductivity and pH of the soil were improved by the application of organic manure.

Saha *et al.* (2017) conducted an experiment on three types of organic fertilizer (OF) like OF from Co-compost (Faecal Sludge and Municipal Solid Waste), OF from earthworm compost (Vermicompost) and OF from cow dung whereas chemical fertilizer was applied as control treatment in tomato field. Four fertilizer doses viz., T_1 = 100% Chemical Fertilizer (Soil Test Based, FRG, 2012), T_2 = Co-compost @ 2 t ha^{-1} with 50% recommended dose of chemical fertilizer (RDF), T_3 = Vermicompost @ 2 t ha^{-1} with 50% RDF, T_4 = Cow dung @ 5 t ha^{-1}; were set as the treatments. Tomato (BARI Tomato-14) was planted on 15 November 2016; during final land preparation following proper methodology. It was found that treatment T_2 gave the highest yield of tomato fruit (45.94 t ha^{-1}) followed by T_3 (42.16 t ha^{-1}), T_1 (32.50 t ha^{-1}) and T_4 (32.50 t ha^{-1}). From the economic study, it was found that higher income obtained from using co-compost along with chemical fertilizer (198825 Tk. ha^{-1}) followed by T_3 (155025 Tk. ha^{-1}), T_1 (118025 Tk. ha^{-1}) and T_4 (190575 Tk. ha^{-1}). It was clear that 2-ton co-compost with 50% inorganic fertilizer from Recommended Dose of Fertilizer (RDF) gave the highest yield with economic benefit. Also soil salinity was recorded minimum in co-compost treated plot.

Wang *et al.* (2017) conducted a greenhouse pot test to study the impacts of replacing mineral fertilizer with organic fertilizers for one full growing period on soil fertility, tomato yield and quality using soils with different tomato planting history. Four types of fertilization regimes were compared: (1) conventional fertilizer with urea, (2) chicken manure compost, (3) vermicompost, and (4) no fertilizer. The effects on plant growth, yield and fruit quality and soil properties (including microbial biomass carbon and nitrogen, NH_4^+-N, NO_3^--N, soil water-soluble organic carbon, soil pH and electrical conductivity) were investigated in samples collected from the experimental soils at different tomato growth stages. The tested tomato variety was “Gold Crown No. 9”. The main results showed that: (1) vermicompost and chicken manure compost more effectively promoted plant growth, including stem diameter and plant height compared with other fertilizer treatments, in all three types of soil; (2) vermicompost improved fruit quality in each type of soil, and increased the sugar/acid ratio, and decreased nitrate concentration in fresh fruit compared with the CK (control: no fertilizer) treatment; (3) vermicompost led to greater improvements in fruit yield (74%), vitamin C (47%), and soluble sugar (71%) in soils with no tomato planting history compared with those in soils with long tomato planting history; and (4) vermicompost led to greater improvements in soil quality than chicken manure compost, including higher pH (averaged 7.37 vs. averaged 7.23) and lower soil electrical conductivity (averaged 204.1 vs. averaged 234.6 µS/cm) at the end of experiment in each type of soil. It was concluded that vermicompost can be recommended as a fertilizer to improve tomato fruit quality and yield and soil quality, particularly for soils with no tomato planting history.

Kauser (2016) set up an experiment to find out the effect of different manures and potassium on growth and yield of tomato. The experiment consisted of two factors: Factor A: Three levels of manures, viz. M_0 = 0 (control), M_1 = cowdung 15 t ha^{-1} and M_2 = vermicompost 3.75 t ha^{-1}. Factor B: Four levels of potassium, viz. K_0 = (control); K_1 = 200 kg MOP ha^{-1}; K_2 = 220 kg MOP ha^{-1} and K_3 = 240 kg MOP ha^{-1}. In case of manure, the tallest plant at 60 DAT (91.53 cm), maximum number of leaves per plant at 60 DAT (70.02), maximum size of canopy (102.74 cm), maximum size of stem diameter (2.40 cm), maximum number of clusters $plant^{-1}$ (24.75), the maximum number of flowers $cluster^{-1}$ (6.93), maximum number of fruits $cluster^{-1}$ (6.46), the highest length of fruit (5.40 cm), the highest diameter of fruit (6.03 cm), maximum fresh weight of fruit (88.59 g), the maximum dry matter content of fruit (11.32 %), the highest TSS (7.87%), the highest carbon assimilation rate (10.43 %), maximum yield of fruit $plot^{-1}$ (25.24 kg) and the maximum yield $hectare^{-1}$ (69.10 t ha^{-1}) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. The maximum number of branches per plant (7.50) and maximum chlorophyll content in leaf (58.55%) were recorded from the treatment of 15 t ha^{-1} cowdung.

Makinde *et al.* (2016) carried out a field experiment where the effectiveness of organic and inorganic fertilizers in the growth, yield and nutrient composition of tomato were compared with four treatments which include sole application each of NPK and Organic fertilizer, their complimentary application and the control replicated three times. Tomato premier (variety UC-82-B) was planted. The Aleshinloye Compost (Grade B) organic fertilizer was applied two weeks before transplanting at 100 kg N ha^{-1} at the appropriate plots while NPK 15:15:15 was applied 2 weeks after transplanting at 100 kg N ha^{-1}. The fertilizer sources did not affect the growth of tomato but were better than the control plots. At 8 weeks after transplanting (8 WAT), NPK 15:15:15 treated plant had more flower abortion of 34.7 than the lowest flower abortion of 24.67 from the control plots. NPK 15:15:15 at 100 kg N ha^{-1} gave the highest fruit yield of 18.60 t ha^{-1} while the lowest yield (4.07 t ha^{-1}) was obtained from the control plots. Highest value of lycopene content of 2.65% was found in plots supplied with NPK but is comparable with the control plot but higher than other sources. Potassium content of 20.80% was the lowest in NPK plots while potassium accumulation of 23.20% was the highest in the control but not statistically different from each other. Sodium content had the highest percentage in untreated plot with 0.43% and sodium ion was the lowest in NPK + organic treated plot which have the value of 0.31%.

Salem *et al.* (2016) conducted a field experiment to study the effect of some organic fertilizers on four varieties of tomato viz., Sadia F1, Isabella F1, Lelord and Sun cherry for its growth, yield and fruits sensory. The total number of elementary plots was 64 and each plot received only the recommended doses of organic fertilizers: 1- Cow Manure (AL BAQARA) at the rate of 18 kg for plot, 2- Chicken+ cow (AL MROOG) at the rate of 18 kg for plot, 3- Chicken manure pellet at the rate of 18 kg for plot and 4 - Agro fish pellet at the rate 18 kg for plot. The results on the growth parameters of the studied tomato varieties showed that the chicken manure had the significant effect on plant height and root length of Isabella F1, leaf area of sun cherry, root fresh and dry weight and of Lelord, leaves fresh and dry weight of Sadia F1. Whereas, shoot fresh and dry weight of Isabella tomato variety was increased when treated with mixed manure. Agro fish pellet treatment had increased the stem diameter of Isabella F1 significantly. The number of flowers and fruits of sun cherry tomato variety were increased when treated with agro fish pellet. Agro fish also influenced the fruits number in Sadia F1 and fruit yield of lelord followed by Isabella F1 respectively. The sensory evaluation of the fruits of studied tomato varieties revealed that chicken manure had good result on the overall quality of the fruits of Sadia F1 and Sun cherry. Agro fish pellet and mixed manure has influenced the overall quality of Isabella F1 and Lelord variety tomato fruits.

Hyder *et al.* (2015) recorded that tomato fruit yield was the maximum (4.383 t ha^{-1}) at the application of 2.0 t ha^{-1} vermicompost followed by 3.226 t ha^{-1} where vermicompost was applied @ 1.5 t ha^{-1}. N, P and K content in tomato fruit and plant increased significantly with the application of increasing levels of vermicompost. The highest content of N (3.7%), P (0.67%), K (5.17%) in tomato fruit and N (3.4%), P (0.32%), K (3.2%) in tomato plant respectively were registered with soil application of vermicompost @ 2.0 t ha^{-1}. This study confirmed that the vermicompost has a tremendous potential of plant nutrients supply for sustainable crop production.

Solaiman *et al.* (2015) undertook a study to identify the effect of organic manures (OMs) on the productivity, shelf-life and economic efficiency of tomato varieties for minimizing the continuous application of chemical fertilizers in Bangladesh. Three tomato varieties (BARI Tomato-15, BARI Tomato-14, and BARI Tomato-2) were grown in plots with different treatment viz. cow dung (CD), poultry manure (PM), and vermicompost (VC) containing 170 kg ha^{-1} of N_2 and the results were compared with non-fertilized plots (control). The effect of OMs on the vegetative growth was largely depend on the cultivars. Differing from the vegetative growth, the total fruit yield significantly increased with the application of PM and VC, irrespective of the cultivar, while the single fruit weight and fruit number per plant varied largely depending on the cultivar. The shelf-life was also significantly prolonged by the application of PM and VC. On the other hand, the effect of CD on the fruit yield and shelf-life was relatively low. The results of economic analysis revealed that the benefit-cost ratio was low in CD and VC because of the low fruit yield and high cost, respectively. Among the treatment combinations, PM × BARI Tomato-15 showed the best result not only from the viewpoint of fruit yield and storability but also from that of the benefit-cost ratio, indicating the effectiveness of this combination as an alternative option for improving the continuous application of chemical fertilizers on Bangladesh soil.

Abafita *et al.* (2014) obtained results from their research which indicated that applied vermicompost especially at 20% level had significantly improving effects on better growth and development of tomatoes as vermicompost treated tomatoes had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses (40%) produced lower yields of the tomato plants. Generally, the addition of vermicompost led to improve the yield of tomato cultivars as compared to control. Hence, it could be suggested that vermicompost treated plants increased the growth, yield and the above chemical compositions and pH of the soil.

Ali *et al.* (2014) conducted an experiment to investigate the potential of vermicompost and mustard oil cake leachate as foliar organic fertilizer with reference to the growth, yield and TSS status of BARI hybrid tomato 8 and then examined their effects on different parameters. Treatments of the experiment were: No foliar application (T_1); foliar application of leachate from vermicompost (T_2) and foliar application of leachate from mustard oil cake (T_3). The experimental data revealed that significant increase in growth; yield and TSS on BARI hybrid tomato-8 were observed due to foliar application of vermicompost and mustard oil cake. All parameters performed better results with the foliar application of the leachate from vermicompost which was very close the mustard oil cake. However, maximum number of fruit (30.9/plant), yield (14.3 kg/plot) and TSS (4.7%) were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake (28.40/plant, 12.7 kg/plot and 4.2% respectively) whereas the minimum was observed in control treatment.

Reshid *et al.* (2014) conducted an experiment with plastic pot set-up with soil to determine the effects and efficiency level of vermicompost on the growth and yields of tomatoes (*Solanum lycopersicum* L.). The study was conducted through effect of increasing concentration of Vermicompost (control, 10%, 20%, 30% and 40% w/w) in target plant growth. The obtained results from the present research indicated that applied vermicompost especially at 20% level had significantly improving effects on better growth and development of vermicompost treated tomatoes as they had higher leaf area, leaf dry mass, fresh stem and dry weight, number of fruits and yields. Low doses of vermicompost (10%) and high doses (40%) produced lower yields of the tomato plants. Generally, the addition of vermicompost led to improve the yield of tomato cultivars as compared to control.

Ibrahim and Fadni (2013) conducted the study to investigate the effect of different types of organic fertilizers on soil chemical and physical properties, and on growth, yield and quality of tomatoes fruits in Bara locality of North Kordofan state, for two consecutive winter seasons (2009–2010). The experiment consisted of five treatments i.e. the organic fertilizers types were: T_1 = 10-tons ha^{-1} compost, T_2 = 10-tons ha^{-1} fresh cattle manure, T_3 = 10-tons ha^{-1} fresh chicken manure, T_4 = 10-tons ha^{-1} fresh mixed manure (chicken manure 30% + cattle manure 70%) and T_5 = Untreated Control. Tomatoes variety, (Bet086) was used. Soil samples were taken at the start and in the end of the experiments from depths of 0–20 cm and 20–40 cm. Soil analysis showed that the experimental area is dominated by sandy soil texture. Results of soil samples analysis showed significant change in the soil chemical and physical properties and increase in the amount of organic matter content especially, when adding compost compared with the control. The production indicators showed that the tomatoes agronomic parameters were significantly affected by the addition of different sources of organic fertilizers. Organic manure fertilizers addition decreased soil pH values and increased the nutrients uptake by the plant. Increased in tomato yield between different types of organic fertilizer treatments compared with the control were as follows: 112% from compost, 90% from chicken plus cattle manure, 70% from chicken manure and 50% from the cattle manure compared to the untreated control.

Parvin (2012) conducted a field experiment to study the effect of organic manures on growth and yield of tomato varieties and assessment of shelf life. Two factors were used in the experiment, viz. Factor A. four types of organic manure; M_0 = Control, M_1 = Cow dung (20 t ha^{-1}), M_2 = Poultry manure (16 t ha^{-1}) and M_3 = Vermicompost (14 t ha^{-1}) and Factor B. Three varieties; V_1 = BARI tomato-15, V_2 = BARI tomato-14 and V_3 = BARI tomato-2. The results revealed that at final harvest, the tallest plant (83.90 cm), the maximum number of leaves per plant (57.20), the maximum number of flower clusters per plant (9.74), the maximum number of flower per cluster (9.24), the maximum number of flowers per plant (58.25), the maximum number of fruits per plant (42.07), the maximum length of individual fruit (7.97 cm), the maximum diameter of individual fruit (10.43 cm), the maximum weight of individual fruit (123.33 g), the maximum yield per plant (2.06 kg $plant^{-1}$), the maximum yield per plot (44.08 kg $plot^{-1}$) and the maximum yield per hectare (67.36 t ha^{-1}) was recorded from M_2 (Poultry manure).

Chanda *et al.* (2011) conducted field trials using different fertilizers having equal concentration of nutrients to 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 treated by different category of fertilizers (T_2 = Chemical fertilizers, T_3 = Farm Yard Manure (FYM), T_4 = Vermicompost, T_5 = FYM supplemented with chemical fertilizers and T_6 =

Vermicompost supplemented with chemical fertilizer). The treatment T_6 showed 73% better yield of fruits than control. Besides, vermicompost supplemented with NPK treated plots (T_6) displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Harun-Or-Rashid (2011) conducted a field experiment to assess the response of summer tomato to organic and inorganic fertilizer in respect of growth, yield and yield contributing characters. The treatments were as follows: T_1 = Control, T_2 = 200 kg N ha^{-1}, T_3 = 220 kg N ha^{-1}, T_4 = 260 kg N ha^{-1}, T_5 = 145 kg N ha^{-1} + 5 t cowdung ha^{-1}, T_6 = 110 kg N ha^{-1} + 10 t cowdung ha^{-1}, T_7 = 107.50 kg N ha^{-1} + 2.5 t poultry manure ha^{-1} and T_8 = 46.25 kg N ha^{-1} + 5 t poultry manure ha^{-1}. The yield of summer tomato increased significantly due to combined application of poultry manure along with nitrogen fertilizer as the source of urea. Poultry manure along with nitrogen fertilizer as the source of urea at the rates of 2.5 t ha^{-1} and 107.50 kg N ha^{-1} resulted in better yield compared to nitrogen alone or control treatment but the effect of poultry manure was the most pronounced than these of cowdung and nitrogen fertilizer or control treatments on the crop. Treatment T_7 (2.5 t ha^{-1} poultry manure along with 107.50 kg N ha^{-1}) performed the best in recording plant height (107.10 cm) of the crop. However, the optimum dose for maximum length of root (4.30 cm) was 2.5 t ha^{-1} poultry manure with the combination of 107.50 kg N ha^{-1} and for the fruit diameter (4.35 cm), fruit length (4.29 cm) and fruit weight (43.80 g) was 220 kg N ha^{-1}. Treatment receiving 2.5 t poultry manure along with 107.50 kg N ha^{-1} performed the best recording yield of summer tomato. The maximum particle density (2.41 g/cc), organic carbon (0.85%), electrical conductivity (250.00 0S/cm) and soil pH (7.80) was observed in treatments receiving 260 kg N, 10 t cowdung with association of 110 kg N, 5 t poultry manure along with 46.25 kg N and control, respectively. The lowest particle density (2.35 g/cc) was recorded in 10 t cowdung + 110 kg N ha^{-1}. The minimum organic carbon

(0.60%), electrical conductivity (114.00 µS/cm) and pH (7.41) was found in treatment 260 N ha^{-1} treatment on the crop.

Prodhan (2011) conducted an 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: Four levels of organic manures, viz. M_0 = Manure (0 t ha^{-1}), M_1 = Cow dung (20 t ha^{-1}), M_2 = Vermicompost (10 t ha^{-1}) and M_3 = Compost (15 t ha^{-1}); Factor B: Three types of spacing, viz. S_1 = 60 cm × 60 cm, S_2 = 60 cm × 45 cm and S_3 = 60 cm × 30 cm. In case of organic manures, at 60 DAT, the tallest plant (89.97 cm), the maximum number of leaves per plant (55.33) and the maximum number of branches per plant (23.50) was recorded from Vermicompost (10 t ha^{-1}). The minimum days required from transplanting to 1st flowering (28.67) and the minimum days required from transplanting to 1st harvesting (70.88), the maximum number of fruits per plant (45.12), the maximum length of fruit (5.13 cm), the widest diameter of fruit (4.61 cm), the maximum dry matter content in plant (9.04%), the maximum dry matter content in fruit (10.44%), the maximum weight of individual fruit (75.14 g) and the highest yield per hectare (68.99 ton) was obtained from Vermicompost (10 t ha^{-1}).

Yanar *et al.* (2011) evaluated the effects of different organic fertilizers on yield and fruit qualities of indeterminate tomato. Influences of different organic and inorganic fertilizers on yields and fruit quality of tomato were compared during 2006 and 2007 growing periods under field conditions. In 2006 growing period, organic fertilizers used were Ormin K (250 kg ha^{-1} before planting; 30 kg ha^{-1} after first flowering; 80 kg ha^{-1} after first harvest), Coplex (50 kg ha^{-1} every week from planting to last harvest), N of (40 kg ha^{-1} every week, from planting to last harvest), composted poultry manure (CPM) (1 t ha^{-1} before planting; 0.5 ton ha^{-1} after first flowering and 0.5 ton ha^{-1} after first harvest (liquid form)) and composted cattle manure (CCM) (60 t ha^{-1} before planting; 5 ton ha^{-1} after first flowering and 5 ton ha^{-1} after first harvest (liquid form)). Based on the first-year results, organic fertilizers used during 2007 growing periods were F1 (20-

ton ha^{-1} CCM before planting; 1 t ha^{-1} CPM before planting; 40 kg ha^{-1} Coplex and 20 kg ha^{-1} Nof every week) and F2 (20 t ha^{-1} CCM before planting; 500 kg ha^{-1} Ormin K before planting; 30 kg ha^{-1} Coplex and 30 kg ha^{-1} Nof every week). Inorganic fertilizers used as a control were N: 450, P_2O_5: 350, K_2O: 600, CaO: 50, S: 200 and Mg: 50 kg ha^{-1}. Tomato cultivars used in this study were Alida F_1 in 2006 growing period and Alida F_1, Yankı F_1 and Maya F_1 in 2007 growing period. In 2006, the highest yields obtained from CPM, CCM, and control treatments were 128.12, 122.92 and 115.24 t ha^{-1} respectively. In 2007, marketable yield obtained from F1 fertilizer treatment was similar to the control application. Unmarketable yield was not affected from the different fertilizer treatments. There was no significant difference among the treatments. However, fruit cracking rates were higher in organic fertilizer treatments than the inorganic fertilizer treatment. Finally, application of 20 to 40 t ha^{-1} composted cattle manure before planting and addition of commercial organic fertilizers such as Coplex, Nof and Ormin K can be used as an alternative to the chemical fertilizers in indeterminate tomato cultivation.

Miah (2010) conducted an experiment to find out the effect of organic manures and different varieties on the growth and yield of tomato. The experiment consisted with two factors. Factor A: Four types of organic manure such as OM_0 = Control, OM_1 = cowdung (30 t ha^{-1}), OM_2 = poultry manure (25 t ha^{-1}) and OM_3 = vermicompost (20 t ha^{-1}). Factor B: Three varieties such as V_1 = BARI tomato 8, V_2 = BARI tomato 3 and V_3 = BARI tomato 2. In case of organic manure, at final harvest, the tallest plant (83.49 cm), the maximum number of leaves per plant (60.94), the maximum number of flower clusters per plant (7.33), the maximum number of flowers per cluster (7.00), the maximum number of flowers per plant (51.31), the maximum number of fruits per plant (20.10), the maximum length of individual fruit (5.056 cm), the maximum diameter of individual fruit (5.60 cm), the maximum weight of individual fruit (112.5 g), the maximum fresh weight of leaves (496.23 g), the maximum dry matter of leaves (7.56%), the maximum dry matter of fruit (10.71%), the maximum yield per plant (2.26 kg/plant), the maximum yield per plot (40.70 kg/plot) and the maximum yield per hectare at harvest (94.22 t ha^{-1}) was obtained from OM_2 (poultry manure).

Sinha and Valani (2009) observed increase in plant heights and yield in tomato plants provided with exclusive vermicompost and vermicompost with worms maintained very good growth from the very beginning. Number of flowers and fruits per plant were also significantly higher as compared to those on agrochemicals and conventional compost. Presence of live earthworms in soil made a significant difference on the flowering and fruiting of tomatoes.

Chand *et al*. (2008) experimented on tomato plants to find out the effect of natural fertilizers on their yield and quality. They found that significantly the highest yield of tomato fruit was recorded in the treatment receiving enriched vermicompost along with 3 sprays of liquid manure.

Ewulo *et al.* (2008) conducted an experiment to study the effect of poultry manure additions on nutrient availability, soil physical and chemical properties and yield of tomato where five levels of manure, namely 0, 10, 25, 40 and 50 t ha^{-1} were applied. Poultry manure increased soil organic matter, N and P content. Soil bulk density was reduced and moisture content increased with increasing levels of manure. Manure applications increased leaf N, P, K, Ca and Mg concentrations of tomato, plant height, number of branches, root length, number and weight of fruits. The 25-t ha^{-1} poultry manure gave the highest leaf P, K, Ca and Mg and yield relative to control. The 10, 25, 40 and 50 t ha^{-1} manure levels increased average fruit weight by 58, 102, 37 and 31%, respectively.

Manatad and Jaquias (2008) evaluated growth and yield performance of vegetables as influenced by the application of different rates of vermicompost. Findings of their study exposed that fruit length, diameter, weight of fruits/plant and yield was significantly enhanced by vermicompost application in watermelon, egg plant, sweet pepper and tomato.

Olaniyi and Ajibola (2008) conducted a field experiment to study the effects of inorganic and organic fertilizers application on the growth, fruit yield and quality of tomato. The treatments consisted of 2 levels of urea (0 and 60 kg N ha^{-1}) and 5 levels of poultry manure (Pm) (0, 3.0, 4.5, 6.0 and 7.5 t ha^{-1}). The plant height and number of leaves showed increasing response as the amount of applied fertilizer increased. The combined application of the two types of fertilizers resulted in the highest marketable fruit yield. The content of essential nutrient elements increased and was also influenced by fertilizer treatments, except K in all the treatments. The yield and nutritional quality of tomato fruits were significantly improved by the application of sole poultry manure and mineral N fertilizer at 6.0 t Pm and 60 kg N ha^{-1} respectively, or their combined application at 30 kg N by 6.0 t ha^{-1} Pm. The yield and quality of tomato fruits produced with poultry manure were comparable with those obtained using mineral N fertilizer. Poultry manure can therefore be a suitable replacement for inorganic fertilizer in tomato production.

Rahman (2008) conducted an experiment to find out the effect of 'Lalon' an organic fertilizer in maximizing the yield of tomato (var. MS 221). There were seven levels of fertilizers viz. absolute control, Lalon @ 200 kg ha^{-1}, 100% recommended dose (RD) of fertilizer as per BARC Guide 2005, Lalon @ 200 kg ha^{-1} + 100% RD, Lalon @ 200 kg ha^{-1} + 75% RD, Lalon @ 200 kg ha^{-1} + 50% RD and Lalon @ 200 kg ha^{-1} + 25% RD. Recommended dose of fertilizer for tomato was 120-40-100-20-1-0.5 kg ha^{-1} of N-P-K-S-B-Mo + cowdung @ 3 ton ha^{-1}. Different doses of chemical fertilizer in combination with Lalon significantly increased the yield and yield components of tomato. The highest fruit yield (50.79 t ha^{-1}) was recorded with Lalon 200 kg ha^{-1} + 100% RD, which was statistically similar with that of Lalon @ 200 kg ha^{-1} + 75% RD and Lalon @ 200 kg ha^{-1} + 50% RD. Economic analysis showed that the highest gross margin (Tk. 4,94,620) per hectare was obtained with the treatment having

Lalon @ 200 kg ha^{-1} + 100% RD though the variable cost was also highest. The gross margins of treatments having Lalon @ 200 kg ha^{-1} + 75% RD and Lalon @ 200 kg ha^{-1} + 50% RD were found very close with the treatment having Lalon @ 200 kg ha^{-1} + 100% RD. The highest marginal rate of return (MRR) was obtained in the treatment having Lalon @ 200 kg ha^{-1} + 50% RD.

Akanni and Ojeniyi (2007) conducted field experiments to study the relative effect of different levels (0, 10, 20, 40, 50 t ha^{-1}) of poultry manure on selected soil physical properties, nutrient status, growth and fruit yield of tomato (*Lycopersicon esculentum*). Soil bulk density and temperature was reduced with different levels of poultry manure, while moisture content, plant height, number of branches, leaf area and taproot length increased. However, the 20-t ha^{-1} poultry manure gave the highest value of number and weight of fruits. The mean values of fruit weight recorded for 0, 10, 20, 40 and 50 t ha^{-1} manure were 17.6, 27.9, 35.6, 24.4 and 23.0 t ha^{-1}, respectively.

Grigatti *et al.* (2007) and Edwards *et al.* (2004) showed that compost was able to enhance the growth of a wide range of tomato species further what can be expected because of the supply of nutrients. They also reported that addition of vermicompost increased plant heights and yield of tomato (*Lycopersicum esculentum*) significantly.

Monira (2007) conducted the study to investigate the nutrient uptake, growth and yield of tomato (Raton) as influenced by organic fertilizer application. The treatments were T_1 absolute control (−cowdung − urea), T_2 (+cowdung + urea), T_3 (cowdung) and T_4 (urea), respectively. In all of T_2, T_3 and T_4, the applied amounts of N, P, K, S and Mo were 175, 63, 20, 30 and 1 kg ha^{-1}, respectively with urea, cowdung, triple super phosphate (TSP), muriate of potash (MP), gypsum and sodium molybdate as fertilizers. The results indicated that there was a positive impact of organic fertilizer application rate of 21.34-ton ha^{-1} on fruit yield of tomato. The highest fruit yield of 75.67-ton ha^{-1} was obtained with organic fertilizer. Thus, based on the tomato yield obtained it was inferred that cowdung application at 21.34 t ha^{-1} in tomato production might have the potentiality to supplement N as N-source.

Grimme *et al*. (2006) conducted a field trial taking well decomposed cowdung along with vermicompost at a range of different concentrations into a soil-less commercial bedding plant container medium, Metro-Mix 360 (MM 360), 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 17.5% greater mean number of fruits than those grown in MM360 only. The mean heights, number of buds and numbers of flowers of tomatoes grown in potting mixtures containing 10–80% vermicompost were although greater but did not differ significantly from those of tomatoes grown in MM360. There were no positive correlations between the increase 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.

Solaiman *et al*. (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 and yield 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 cowdung (5, 10 and 15 t ha^{-1}). The tallest plant and dry matter weight of shoot, the maximum number of clusters of flowers and fruits/plant as well as the greatest fruit size and fruit yield/plant, fruit yield ha^{-1} were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}, but similar results were obtained from the treatment receiving 5 t cowdung ha^{-1} along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P + 40 kg K + 7.5 kg S ha^{-1}). The effect of 10 t cow dung ha^{-1}, along with one third of the recommended dose of nutrients, was also comparable to the effect of employing the recommended dose of nutrients. It was further observed, from an economic standpoint, that the combination of 5 t cow dung ha^{-1} along with half of the recommended doses of nutrients appeared to be a 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.

Papafotiou *et al.* (2005) stated that compost have shown to enhance tomato plant growth in several occasions and these growth enhancements have been attributed to an improvement of the physical, chemical and biological properties of the growing substrate. Generally, replacement of peat with moderate amounts of compost produced beneficial effects on plant growth due to the increase on the bulk density of the growing media and to the decrease on total porosity and amount of readily available water in the pots.

Akande and Adediran (2004) conducted experiments to observe the effects of poultry manure on soil physical properties and nutrient uptake and sustainability of tomato production systems which is scarce. This experiment showed utilization of poultry manure in tomato production in Nigeria. They found that poultry manure @ 5 t ha^{-1} significantly increased tomato fresh and dry matter yield, soil pH, N, P, K, Ca and Mg and nutrient uptakes.

Sangwoo *et al.* (2004) conducted an experiment taking two cow dung based and two plant-residue-based organic amendments to a simple peat-based potting mix which were tested over two years for their ability to improve seedling biomass, out-planting success and yield in an organic tomato production system. They concluded that from their findings that excellent quality of tomato transplants can be produced using either plant-based or cowdung based organic amendments.

Adediran *et al.* (2003) compared poultry manure, household, market and farm waste and found that poultry manure @ 20 t ha^{-1} showed the highest nutrient contents and mostly increased yield of tomato and soil macro and micronutrients content.

Chaoui *et al.* (2003) observed that the amount of nutrients in different compost amendments varies depending on the parent material from where they were originated and concluded that both the compost from their study constitute a slow release source of nutrients that supply the tomato plants with the nutrients when they are needed.

Arancon *et al.* (2002) reported significantly increased growth and yields of field tomatoes (*Lycopersicon esculentum*) and peppers (*Capsicum anuum grossum*) when vermicompost produced commercially from cattle manure, food waste or recycled paper, were applied to field plots at the rates of 20 t ha^{-1} and 10 t ha^{-1} in 1999 and at the rates of 10 t ha^{-1} and 5 t ha^{-1} in 2000 compared with those receiving equivalent amounts of inorganic fertilizer. They also observed that tomatoes planted in soils which were treated with vermicompost supplemented to recommended rates with inorganic fertilizers, had usually greater amounts of total N, orthophosphates, dehydrogenase enzyme activity and the microbial biomass than those received equivalent amounts of inorganic fertilizers only.

Atiyeh *et al.* (2001) reported that the mixtures containing 25% and 50% pig manure in 75% and 25% Metro-Mix 360 increased the rates of seedling growth of tomatoes and greater increase in seedling growth were recorded with 5% pig manure substitution into MM360, when inorganic nutrients were supplied daily.

Atiyeh *et al.* (2000a) from their experiments showed that tomato plants with decreased growth and yields at substitution rates of pig manure vermicompost greater than 60% into MM360.

Atiyeh *et al.* (2000b) reported that the substitution of Metro-Mix 360 by 10% or 50% pig manure vermicompost increased the dry weights of tomato seedlings significantly compared to those grown in 100% Metro-Mix 360. The largest marketable fruit yields obtained were in response to a mixture of 80% Metro-Mix 360 and 20% vermicompost. Lower concentrations of vermicompost (less than 50%) into the MM360 usually produced greater growth effects than those of large amounts: 20% vermicompost substitution resulted in 12.4% more tomato fruit weights than those in MM360 and substitutions of 10%, 20% and 40% vermicompost reduced the proportions of non-marketable fruits significantly and produced larger tomato fruits.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to study the effect of different organic manure and inorganic fertilizers on growth and yield of tomato. The details of the materials and methods of this research work were described in this chapter as well as on experimental materials, site, climate and weather, experimental design, materials used for experiment, raising of seedling, treatments, land preparation, transplantation of seedlings, intercultural operations, harvesting, collection of data and statistical analysis which are given below:

3.1 Experimental period

This research work was carried out from 05th November, 2019 to 10th March, 2020.

3.2 Location of the research area

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh. The location of the study site is situated in $23^0 46^/$N latitude and $90^0 22^/$E longitude (Anon., 2004). The altitude of the location was 8.6 meters from the sea level (The meteorological department of Bangladesh, Agargaon, Dhaka).

3.3 Agro-Ecological Region

The experimental site belongs to the agro-ecological zone of "Modhupur Tract", AEZ-28 (Anon, 1988a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon, 1988b). The experimental site is shown in the map of AEZ of Bangladesh in Appendix I.

3.4 Climate of the experimental area

During the experimental period the maximum temperature (36.8°C), highest relative humidity (87%) and highest rainfall (45 mm) was recorded for the month of November, 2019 whereas, the minimum temperature (14.60°C), minimum relative humidity (64%) and no rainfall was recorded for the month of January, 2020. Details of the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during study period has been presented in Appendix II.

3.5 Soil condition of the experimental area

Top soil was silty clay in texture, olive-grey with common fine to medium distinct dark yellowish-brown mottles. Soil pH was 6.0 and has organic carbon 0.69%. The experimental area was flat having available irrigation and drainage system and above flood levels. The soil data during the study period at the experimental site are shown in Appendix II.

3.6 Plant materials

Tomato seeds was used as planting material. Seeds of tomato cv. 'BARI Tomato-15' were used in the experiment. The seeds were collected from Olericulture division of Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.6.1 BARI TOMATO-15

Developed by	Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh
Method of development/origin	AVRDC
Year of release	2009
Main characteristics	High yielding winter variety. Thick skin and edible flesh having very good self-life. Fruit oval shape, less seeded fruits with attractive red flesh colon. Average fruit weight plant^{-1} 65–70 g, fruit plant^{-1} 40–45, prolonged harvesting period (40-50 days), life time 100-110 days.
Planting season and time	Rabi and September to October, Medium to late variety
Days to maturity	Days to maturity 30–35 (anthesis to ripening)
Harvesting time	Fruit harvest up to 25–30 days
Yield	80–85 t ha^{-1}
Resistance/tolerance	Yellow leaf curl virus tolerant
Quality of the product	Storage time high due to thick and rigid skin of tomato.

Source: BARI, 2010

3.7 Experimental design

The single factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

3.7.1 Treatment of the experiment

The experiment consisted of single factor:

T_0 = Control,

T_1 = Cowdung @ 15.0 t ha^{-1},

T_2 = Poultry manure @ 12.0 t ha^{-1},

T_3 = Vermicompost @ 5.0 t ha^{-1},

T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},

T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},

T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and

T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

3.8 Experimental layout

An area of 110.00 m^2 was divided into 3 blocks. The whole experimental area was divided into three equal blocks, each representing a replication. The size of each unit plot was 2.00 m × 2.00 m (4.00 m^2). The space was kept 1.00 m between the blocks and 0.50 m between the plots were kept. The distance between row to row and plant to plant was 60 cm and 40 cm, respectively.

3.9 Raising of seedling

The soil was well prepared and converted into loose friable condition in obtaining good tilth. All weeds, stubbles and dead roots were removed. Tomato seedlings were raised in one seedbed of 2.00 m × 1.00 m size. The seeds were sown in the seedbeds on 20th November, 2019. Five grams of seeds were sown in each seedbed. Within 3 to 5 days emergence of the seedlings took place. Then covered with light soil and shading was provided by bamboo mat (chatai) to protect young seedlings from scorching sunshine and rainfall. Light watering, weeding and mulching were done as and when necessary to provide seedlings with a good condition for growth.

3.10 Plot preparation

Sandy loam soil, well dried cowdung and proper amount of fertilizer were mixed as per plot recommendation and then plot was filled with that Furadan 5G (an insecticide) @ 15 kg ha^{-1} was also applied during final soil preparation to control cut worm and other soil insects. Then plots were placed into rooftop and arranged through experimental design. The plots were ready for transplanting seedling.

3.11 Manures and fertilizers

The entire amounts of cowdung, poultry manure and vermicompost were applied during the final land preparation. Cowdung contain 1.00% Nitrogen, 0.50% P_2O_5, 0.50% K_2O; Poultry manure content 1.25% Nitrogen, 0.70% P_2O_5, 0.90% K_2O and Vermicompost contain 3.00% Nitrogen, 2.00% P_2O_5, 1.50% K_2O, respectively (www.organic manures nitrogen, phosphate and potassium status.com).

According to Rashid (2012), Urea as a source of nitrogen, TSP as a source of phosphorus, MoP as a source of potassium, 90% Sulfur as a source of sulphur, Zinc sulphate heptahydrate ($ZnSO_4.7H_2O$) as a source of zinc and Boric acid as a source of boron. TSP, MoP, sulphur, zinc sulphate and boric acid were applied as basal dose during final land preparation. Urea was applied as per treatment in three equal splits at 15, 35 and 55 days after transplanting as ring method.

3.12 Transplanting of seedlings

Healthy and uniform 25 days old seedlings were uprooted separately from the seedbed and 16 seedlings were transplanted in each experimental plot at the afternoon of 15th December, 2019 maintaining experimental design. In order to minimize damage of the root system, the seedbed was watered before uprooting the seedlings. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.13 Intercultural operations

3.13.1 Shading

A transparent polythene shade was provided to protect the plants from excess rainfall and sunlight. It was made with the help of polythene sheet and bamboo sticks. The shade was maintained up to 10 days after transplanting.

3.13.2 Weeding

Weeding was accomplished by hand and when necessary with the help of khurpi (a type of spatula) to keep the crop free from weeds, for better soil aeration and to break the crust.

3.13.3 Gap filling

A few gap fillings were done by healthy seedlings of the same stock where planted seedlings failed to survive. When the seedlings were well established, the soil around the base of each seedling was pulverized.

3.13.4 Irrigation

Irrigation was provided immediately after transplanting and it was continued until the seedlings were established in the plot. High frequency of irrigation was demanded because it was a rooftop experiment. Usual irrigation schedule for field grown tomato was not followed. Irrigation was provided each alternate day in general but sometimes the plants demanded everyday irrigation.

3.13.5 Stalking

After the well establishment of the plants, staking was done to each plant by means of bamboo sticks to keep them upright because tomato is a herbaceous plant with higher fruit weight.

3.13.6 Plant protection

3.13.6.1 Insect pests

Aphid (a leaf sucking insect) infested the crop at vegetative and early reproductive stages, which was controlled by Emitaf 20 SL @ 0.25 ml L^{-1} of water at 7 days interval for three weeks. White fly infested the crop at early reproductive stage, which was controlled by means of spraying with Admire 200 SL @ 0.5 ml L^{-1} of water at 7 days interval for 2 weeks. Melathion 57 EC was applied @ 2 ml L^{-1} of water against the insect pests like leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest.

3.13.6.2 Disease

During foggy weather precautionary measure against disease infestation of tomato was taken by spraying Diathane M-45 fortnightly @ 2 g L^{-1} of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g L^{-1} of water against blight disease of tomato.

3.13.7 Harvesting

Fruits were harvested at 3 days interval during early ripe stage when they developed slightly red color. Harvesting of tomato was started from 20th February, 2020 and was continued up to 7th March, 2020.

3.14 Data collection

The following data were recorded

i. Plant height (cm),
ii. Number of leaves plant^{-1},
iii. Number of branches plant^{-1},
iv. Number of flower clusters plant^{-1},
v. Number of flowers cluster^{-1},
vi. Number of fruits plant^{-1},

vii. Individual fruit weight (g),

viii. Weight of fruit plant^{-1} (kg),

ix. Yield of fruit plot^{-1} (kg),

x. Yield (t ha^{-1}),

xi. Soil organic carbon (%),

xii. Soil pH,

xiii. Nitrogen content in soil (%),

xiv. Phosphorus content in soil (ppm) and

xv. Potassium content in soil (meq. /100 g soil).

3.15 Detailed procedures of data collection

3.15.1 Plant height

Plant height was measured from the sample plants in centimetre from the ground level to the tip of the longest stem and means value was calculated.

3.15.2 Number of leaves plant^{-1}

Number of leaves was counted from the ground level to the tip of the longest stem and mean value was calculated.

3.15.3 Number of branches plant^{-1}

The total number of branches plant^{-1} was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.15.4 Number of flower clusters plant^{-1}

The number of flower clusters was counted from the sample plants periodically and the average number of flower clusters produced per plant was calculated.

3.15.5 Number of flowers cluster^{-1}

The number of flowers per cluster was calculated as follows:

$$\text{Number of flowers cluster}^{-1} = \frac{\text{Total number of flowers in sample plant}}{\text{Total number of flowers clusters in sample plants}}$$

3.15.6 Number of fruits plant^{-1}

Total number of fruits was counted from selected plants and their average was taken as the number of fruits per plant at harvest.

3.15.7 Individual fruit weight

Among the total number of fruits harvested during the period from first to final harvest, the fruits, except the first and last harvest, were considered for determine the individual fruit weight in gram. The weight was calculated from total weight of fruits was divided by total number of fruits of every harvest and finally making the average was made from four times harvesting data.

3.15.8 Weight of fruit plant^{-1}

Yield of tomato per plant was recorded as the whole fruit per plant and was expressed in kilogram (kg).

3.15.9 Yield of fruit plot^{-1}

Yield of tomato per plot was calculated by converting the weight of plant yield into 4.00 m^2 and was expressed in kilogram (kg).

3.15.10 Yield

Yield per hectare of tomato fruits was calculated by converting the weight of plot yield into hectare and was expressed in ton.

3.16 Collection of Samples

3.16.1. Soil Sample collection

The initial soil samples were collected randomly from different spots of the field selected for the experiment at 0–15 cm depth before the land preparation and mixed thoroughly to make a composite sample for analysis. Post-harvest soil samples were collected from each plot at 0–15 cm depth in 10th March, 2020. The samples were air-dried, grounded and sieved through a 2 mm sieve and preserved for analysis.

3.16.2 Soil Sample Analysis

The initial and postharvest soil sample were analysed for both physical and chemical properties in the laboratory of Soil Resource Development Institute (SRDI), Farmgate, Dhaka. The properties studied included soil pH, organic matter, total N, available P and exchangeable K. The properties studied included soil pH and organic matter, total N, available P and exchangeable K. The soil was analysed by the following standard methods:

3.16.2.1 Soil pH

Soil pH was determined by glass electrode pH meter in soil-water suspension having soil: water ratio of 1:2.5 as outlined by Jackson (1962).

3.16.2.2 Organic Carbon

Organic carbon of the soil was determined by wet oxidation method described by Walkley and Black (1934) and Page *et al.* (1982). To obtain organic matter content, the amount of organic carbon was multiplied by the van Bemmelen factor of 1.73 (Piper, 1950). The result was expressed in percentage.

3.16.2.3 Total Nitrogen

Total nitrogen of soil samples was estimated by Micro-kjeldahl Method where soils were digested with 30% H_2O_2 concentrated H_2SO_4 and catalyst mixture (K_2SO_4:CuSO4·5 H_2O:Selenium powder in the ratio of 100:10:1, respectively).

Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate absorbed in H_3BO_3 with 0.01 NH_2SO_4 (Page *et al.*, 1982).

3.16.2.4 Available Phosphorous

Available phosphorous was extracted from the soil by shaking with 0.5 M $NaCO_3$ solution of pH 8.5. The phosphorous in the extract was then determined by developing blue colour using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue colour was measured at 660 mm wave length by spectrophotometer and available P was calculated with the help of a standard curve.

3.16.2.5 Exchangeable Potassium

Exchangeable Potassium in the soil sample was extracted with 1 N neutral ammonium acetate (NH_4OAc) (pH 7.0) and the potassium content was determined by flame photometer (Black, 1965).

3.17 Statistical Analysis

The data obtained for different characters were statistically analysed to observe the significant difference among different treatments. The analysis of variance (ANOVA) of all the recorded parameters performed using MSTAT-C software. The difference of the means value was separated by least significance difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the impact of different organic and inorganic fertilizer on growth and yield of tomato. The results obtained from the study have been presented, discussed and compared in this chapter through table(s) and figures. The analysis of variance of data in respect of all the parameters has been shown in Appendix V to IX. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings. The analytical results have been presented in Table 1 through Table 5 and Figure 1 through Figure 2.

4.1 Plant height

Plant height is one of the important parameters, which is positively correlated the yield of tomato. Application of organic and inorganic fertilizer exhibited a significant influence on the height of tomato plants at final harvest (Figure 1 and Appendix V). Plant height ranged from 90.50 cm to 125.00 cm among the different organic and inorganic fertilizer application. At final harvest, the longest plant (125.00 cm) was recorded from T_7 treatment whereas the shortest (90.50 cm) from T_0 treatment. Vermicompost (2.50 t ha^{-1}) along with inorganic fertilizer (Nitrogen 75.0 kg ha^{-1}, Phosphorus 25.0 kg ha^{-1}, Potassium 45.0 kg ha^{-1}, Sulphur 9.0 kg ha^{-1}, Zinc 1.0 kg ha^{-1} and Boric acid 0.5 kg ha^{-1}) performed best in recording plant height compared to other treatment(s) combination. The lowest plant height was noted from control treatment having no manure or inorganic fertilizer throughout the entire growth period of the crop. Vermicompost is rich in nitrogen and nutrient content. This favourable condition creates better nutrient absorption and favours for vegetative growth. It was found the maximum plant height (131.10 cm) in tomato when application of 250 kg N ha^{-1}, 50 kg P ha^{-1}, 83 kg K ha^{-1}, 30 kg S ha^{-1}, 5 kg Zn ha^{-1}, 1 kg B ha^{-1}, 1 kg Mo ha^{-1} and 5000 kg cowdung ha^{-1} (BARI, 2010). Haque *et al.* (2021) was found that 85%

recommended chemical fertilizer with 3 t ha^{-1} organic fertilizer given the best result on plant height. Shrestha *et al.* (2018) was recorded that the treatment with compost dose of 2.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest plant height over other treatments.

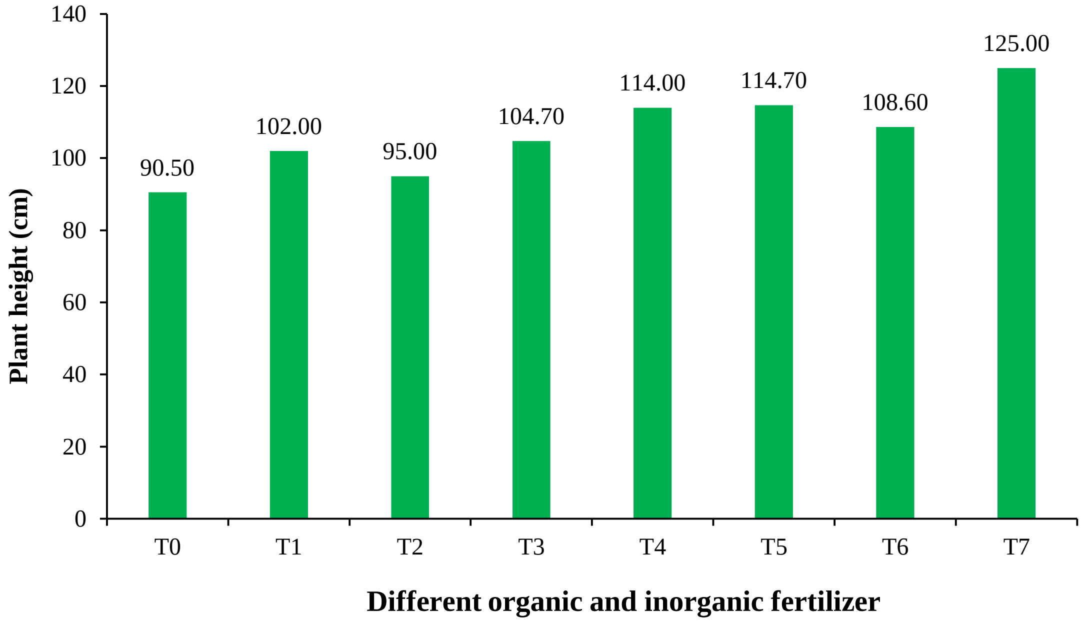

Figure 1. Effect of different organic and inorganic fertilizer on plant height at harvesting time of BARI Tomato 15 (LSD value = 2.04)

Note: T_0 = Control,

T_1 = Cowdung @ 15.0 t ha^{-1},

T_2 = Poultry manure @ 12.0 t ha^{-1},

T_3 = Vermicompost @ 5.0 t ha^{-1},

T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},

T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},

T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and

T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

4.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} is a fundamental morphological character for plant growth and development as leaf is the main photosynthetic organ. To investigate the effect of different organic and inorganic fertilizer combination, change in the number of leaves plant^{-1} of tomato were counted. Different organic and inorganic fertilizer combination showed a significant influenced on the formation of leaves plant^{-1} (Table 1 and Appendix V). At harvesting time, the maximum number of leaves plant^{-1} (89.15) was recorded from T_7 treatment which was statistically identical to T_5 (88.75) and the minimum (68.11) was recorded from T_0 treatment. These results indicate that the highest number of leaves plant^{-1} found from Vermicompost (2.50 t ha^{-1}) with inorganic fertilizer (Nitrogen 75.0 kg ha^{-1}, Phosphorus 25.0 kg ha^{-1}, Potassium 45.0 kg ha^{-1}, Sulphur 9.0 kg ha^{-1}, Zinc 1.0 kg ha^{-1} and Boric acid 0.5 kg ha^{-1}) whereas, the lowest number of leaves plant^{-1} was produced from no organic or chemical fertilizer application. So, the optimum level of organic manure makes the availability of macro and micro nutrients and the ultimate results was the maximum number of leaves plant^{-1}. Vermicompost content appreciable amount of nitrogen and other essential element which encourage the vegetative growth as well as number of leaves. The present findings also supported to the statement of Kauser (2016). Hyder *et al.* (2015) and Abafita *et al*. (2014) confirmed that the vermicompost has a tremendous potential of plant nutrients supply for sustainable crop production Parvin (2012) showed that application of vermicompost at the rate of 8 t ha^{-1} significantly increased tomato leaves compared to control (no fertilizer application).

Table 1. Effects of different organic and inorganic fertilizers on the no. of leaves plant^{-1} and no. of branches plant^{-1} at harvesting time of BARI Tomato 15

Treatment	**Number of leaves plant^{-1}**	**Number of branches plant^{-1}**
T_0	68.11 e	2.83 d
T_1	78.15 cd	3.10 c
T_2	77.25 d	2.87 d
T_3	79.61 c	3.17 c
T_4	85.75 b	3.87 b
T_5	88.75 a	4.40 a
T_6	80.65 c	3.87 b
T_7	89.15 a	4.47 a
$LSD_{0.05}$	**1.76**	**0.18**
CV (%)	**5.84**	**3.97**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: T_0 = Control,

T_1 = Cowdung @ 15.0 t ha^{-1},

T_2 = Poultry manure @ 12.0 t ha^{-1},

T_3 = Vermicompost @ 5.0 t ha^{-1},

T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},

T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},

T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and

T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

4.3 Number of branches plant^{-1}

Different organic and inorganic fertilizer combination showed a significant influenced on the formation of branches plant^{-1} (Table 1 and Appendix V). At harvesting time, the highest number of branches plant^{-1} (4.47) was recorded from T_7 treatment which was statistically identical to T_5 (4.40) treatment. On the other hand, the lowest number of branches plant^{-1} (2.83) was recorded from T_0 treatment which was statistically identical to T_2 (2.87) treatment. These results indicate that the highest number of leaves plant^{-1} found from Vermicompost (2.50 t ha^{-1}) with inorganic fertilizer (Nitrogen 75.0 kg ha^{-1}, Phosphorus 25.0 kg ha^{-1}, Potassium 45.0 kg ha^{-1}, Sulphur 9.0 kg ha^{-1}, Zinc 1.0 kg ha^{-1} and Boric acid 0.5 kg ha^{-1}) whereas, the lowest number of leaves plant^{-1} was produced from no organic or chemical fertilizer application. Chanda *et al.* (2011) and Prodhan (2011) observed that vermicompost supplemented with NPK treated plots displayed better results with regard to number of branches from other fertilizers treated plants. Manatad and Jaquias (2008) evaluated growth and yield performance of vegetables as influenced by the application of different rates of vermicompost. Grigatti *et al.* (2007) and Edwards *et al.* (2004) showed that compost was able to enhance the growth of a wide range of tomato species further what can be expected because of the supply of nutrients. Solaiman *et al.* (2006) carried out a field experiment to assess the effects of inorganic and organic fertilizers on vegetative, flowering and fruiting characteristics of Ratan variety of tomato.

4.4 Number of flower clusters plant^{-1}

In this experiment, there was a significant difference in number of flower clusters plant^{-1} at different organic and inorganic fertilizer (Table 2 and Appendix VI). The highest number of flower clusters plant^{-1} (16.27) was found from T_7 treatment which was flowed by T_5 (14.47) and T_4 (14.03) treatment whereas, the lowest number of cluster (9.37) was recorded from T_0 treatment. These results indicate that vermicompost along with chemical fertilizer increased the formation of number of flower clusters plant^{-1}. Kauser (2016) said that the maximum number of clusters plant^{-1} (24.75) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) and Miah (2010) reported that the maximum number of flower clusters per plant (9.74) was recorded from Poultry manure.

Table 2. Effects of different organic and inorganic fertilizer on no. flower clusters plant^{-1}, no. of flowers cluster^{-1} and no. of fruits plant^{-1} of BARI Tomato 15

Treatment	Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}	Number of fruits plant^{-1}
T_0	9.37 e	2.95 g	15.95 g
T_1	12.17 cd	3.68 e	18.50 f
T_2	11.30 d	3.42 f	17.35 f
T_3	12.93 c	3.88 e	21.50 e
T_4	14.03 b	4.66 c	26.50 c
T_5	14.47 b	5.05 b	28.65 b
T_6	13.36 bc	4.42 d	23.20 d
T_7	16.27 a	5.98 a	30.66 a
$LSD_{0.05}$	**0.79**	**0.21**	**1.27**
CV (%)	**8.46**	**8.03**	**5.46**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: T_0 = Control,
T_1 = Cowdung @ 15.0 t ha^{-1},
T_2 = Poultry manure @ 12.0 t ha^{-1},
T_3 = Vermicompost @ 5.0 t ha^{-1},
T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},
T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},
T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and
T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

4.5 Number of flowers cluster $^{-1}$

Organic and inorganic fertilizer had significant effect on number of flowers cluster^{-1} of tomato (Table 2 and Appendix VI). The maximum number of flowers cluster^{-1} observed from T_7 treatment was (5.98) and the minimum number of flowers cluster^{-1} observed from T_0 treatment was (2.95). From this result it was found that the vermicompost along with chemical fertilizer produce the minimum number of flowers cluster^{-1} than other fertilizer treatment. Kauser (2016) recorded that the maximum number of flowers cluster^{-1} (6.93) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) recorded that the maximum number of flowers per cluster (8.25) was recorded from M_2 (Poultry manure).

4.6 Number of fruits plant $^{-1}$

Significant effect of organic and inorganic fertilizer was found on the number of fruits plant^{-1} of tomato (Table 2 and Appendix VI). The highest number of fruits plant^{-1} (30.66) was obtained T_7 treatment which was flowed by T_5 (28.65) treatment. On the other hand, the lowest number (15.95) of fruits plant^{-1} was obtained from the T_0 treatment which was flowed by T_2 (17.35) and T_1 (18.50) treatment. These results indicate that the highest number of fruits plant^{-1} found from Vermicompost (2.50 t ha^{-1}) with inorganic fertilizer (Nitrogen 75.0 kg ha^{-1}, Phosphorus 25.0 kg ha^{-1}, Potassium 45.0 kg ha^{-1}, Sulphur 9.0 kg ha^{-1}, Zinc 1.0 kg ha^{-1} and Boric acid 0.5 kg ha^{-1}) whereas, the lowest number of leaves plant^{-1} was produced from no organic or chemical fertilizer application. Haque *et al.* (2021) recorded that the higher number of fruit plant^{-1} was observed in 85% recommended chemical fertilizer with 3.00 t ha^{-1} organic fertilizer. Abafita *et al*. (2014) and Reshid *et al.* (2014) obtained that applied vermicompost treated tomatoes had higher number of fruits and yields. Parvin (2012) and Miah (2010) reported that the maximum number of fruits per plant (42.07) was recorded from poultry manure. Chanda *et al.* (2011) and Prodhan (2011) concluded that vermicompost supplemented with NPK treated plots displayed better results with regard to number of fruits per plant from other fertilizers treated plants. Akanni and Ojeniyi (2007) showed that the 10-t ha^{-1} poultry manure gave the highest value of number and weight of fruits. Sinha and Valani (2009) observed that the number of fruits per plant were also significantly higher as compared to those on agrochemicals and conventional compost.

4.7 Individual fruit weight

Individual fruit weight of tomato is highly influenced by different organic manure and chemical fertilizer (Figure 2 and Appendix VII). The maximum fruit weight (48.29 g) was obtained from the T_7 treatment whereas, the minimum (29.04 g) was obtained from T_0 treatment. Haque *et al.* (2021) recorded that the higher weight of fruit $plant^{-1}$ was observed in 85% recommended chemical fertilizer with 3.00 t ha^{-1} organic fertilizer. Kauser (2016) recorded that the maximum fresh weight of fruit (88.59 g) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) reported that the maximum weight of individual fruit (123.33 g) was recorded from poultry manure. Prodhan (2011) showed that the maximum weight of individual fruit (75.14 g) was obtained from Vermicompost (10 t ha^{-1}). Miah (2010) showed that the maximum weight of individual fruit (112.5 g) was obtained from poultry manure. Ewulo *et al.* (2008) stated that the manure applications increased weight of fruits. Manatad and Jaquias (2008) study exposed that the weight of fruits $plant^{-1}$ was significantly enhanced by vermicompost application. Akanni and Ojeniyi (2007) observed that the 10-t ha^{-1} poultry manure gave the highest value of number and weight of fruits. Solaiman *et al*. (2006) recorded that the maximum number of fruits $plant^{-1}$ were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}.

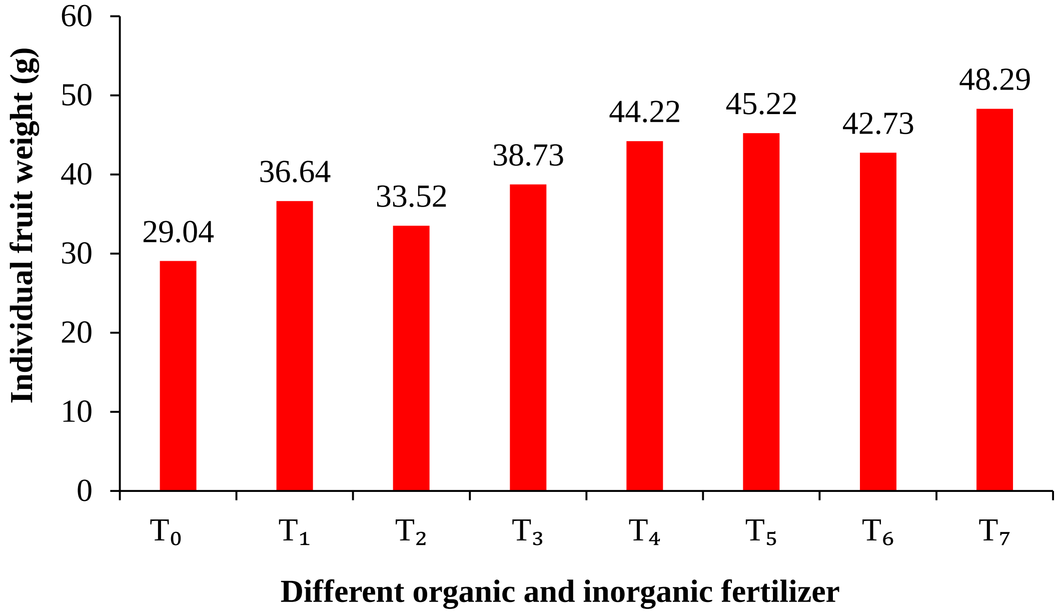

Figure 2. Effect of different organic and inorganic fertilizer on individual fruit weight at harvesting time of BARI Tomato 15 (LSD value = 2.78)

Note: T_0 = Control,
T_1 = Cowdung @ 15.0 t ha^{-1},
T_2 = Poultry manure @ 12.0 t ha^{-1},
T_3 = Vermicompost @ 5.0 t ha^{-1},
T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},
T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},
T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and
T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

4.8 Yield of fruit plant^{-1}

At different organic manure and chemical fertilizer combination application significant difference on yield of fruit plant^{-1} was found (Table 3 and Appendix VII). Yield of fruit plant^{-1} increased with adding vermicompost and chemical fertilizer. The highest yield of fruit plant^{-1} (0.83 kg) was obtained in T_7 treatment which was statistically similar to T_5 (0.78 kg) treatment. On the other hand, the lowest (0.50 kg) yield of fruit plant^{-1} was obtained in T_0 treatment. Parvin (2012) observed that the maximum yield (2.06 kg plant^{-1}) was recorded from poultry manure. Miah (2010) recorded that the maximum yield per plant (2.26 kg) was obtained from poultry manure. Solaiman *et al*. (2006) found that the greatest fruit yield/plant were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}, but similar results were obtained from the treatment receiving 5 t cowdung ha^{-1} along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P + 40 kg K + 7.5 kg S ha^{-1}).

Table 3. Effects of different organic and inorganic fertilizer on yield characteristics of BARI Tomato 15

Treatment	Weight of fruit $plant^{-1}$ (kg)	Yield of fruit $plot^{-1}$ (kg)	Yield (t ha^{-1})
T_0	0.50 d	8.28 d	20.69 g
T_1	0.58 bcd	9.65 cd	24.13 e
T_2	0.54 cd	9.05 cd	22.63 f
T_3	0.63 abcd	10.52 bcd	26.31 d
T_4	0.75 abc	12.45 ab	31.13 b
T_5	0.78 ab	12.92 ab	32.31 b
T_6	0.68 abcd	11.40 abc	28.50 c
T_7	0.83 a	13.85 a	34.63 a
$LSD_{0.05}$	**0.21**	**2.50**	**1.51**
CV (%)	**5.90**	**8.31**	**4.93**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: T_0 = Control,
T_1 = Cowdung @ 15.0 t ha^{-1},
T_2 = Poultry manure @ 12.0 t ha^{-1},
T_3 = Vermicompost @ 5.0 t ha^{-1},
T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},
T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},
T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and
T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

4.9 Yield of fruit plot^{-1}

At different organic manure and chemical fertilizer combination application significant difference on yield of fruit plot^{-1} was found (Table 3 and Appendix VII). The maximum yield of fruit plot^{-1} (13.85 kg) was obtained in T_7 treatment and the minimum value (8.28 kg) was obtained in T_0 treatment. Kauser (2016) recorded that the maximum yield of fruit plot^{-1} (25.24 kg) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) recorded that the maximum yield per plot (44.08 kg) was recorded from poultry manure. Miah (2010) reported that the maximum yield (40.70 kg plot^{-1}) was obtained from poultry manure. Integrated nutrient management (combination of organic and inorganic fertilizer) is the best option for higher tomato production in Bangladesh.

4.10 Yield

There was significant difference in yield of tomato in respect of organic manure and chemical fertilizer of tomato (Table 3 and Appendix VII). The highest yield (34.63 t ha^{-1}) of tomato was found in the T_7 treatment which was followed by T_5 (32.31 t ha^{-1}) and T_4 (31.13 t ha^{-1}) treatment whereas, the lowest yield (20.69 t ha^{-1}) of tomato was found in the T_0 (control) treatment which was followed by T_2 (22.63 t ha^{-1}) treatment. These results indicated that the maximum yield found from Vermicompost (2.50 t ha^{-1}) with inorganic fertilizer (Nitrogen 75.0 kg ha^{-1}, Phosphorus 25.0 kg ha^{-1}, Potassium 45.0 kg ha^{-1}, Sulphur 9.0 kg ha^{-1}, Zinc 1.0 kg ha^{-1} and Boric acid 0.5 kg ha^{-1}) whereas, the lowest number of leaves plant^{-1} was produced from no organic or chemical fertilizer application. Haque *et al.* (2021) showed that the highest yield was observed in 85% recommended chemical fertilizer with 3.00 t ha^{-1} organic fertilizer (50.59 t ha^{-1}) due to BARI Tomato-17. Afsun (2018) reported from the application of organic manures that the highest yield (50.78 t ha^{-1}) was obtained from cowdung 7.5 t ha^{-1} with poultry manure 5 t ha^{-1}. Shrestha *et al.* (2018) found that the treatment with compost dose of 12.5 t ha^{-1} with half amount of recommended dose of chemical fertilizers produced the highest yield. Saha *et al.* (2017) recorded that treatment Co-compost @ 2.00 t ha^{-1} with 50% recommended dose of chemical fertilizer (RDF) gave the highest yield of tomato fruit (45.94 t ha^{-1}). Kauser (2016) recorded that the maximum yield $hectare^{-1}$ (69.10 t ha^{-1}) were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Hyder *et al.* (2015) and Abafita *et al*. (2014) recorded that tomato fruit yield was the maximum (4.383 t ha^{-1}) at the application of 2.0 t vermicompost ha^{-1} and the vermicompost has a tremendous potential of plant nutrients supply for sustainable crop production. Parvin (2012) observed that the maximum yield per hectare (67.36 t ha^{-1}) was recorded from poultry manure. Chanda *et al.* (2011) mentioned that the treatment of vermicompost supplemented with chemical fertilizer showed 73% better yield of fruits than control. Harun-Or-Rashid (2011) recorded that the treatment receiving 2.5 t ha^{-1} poultry manure along with 107.50 kg N ha^{-1} performed the best recording yield of summer tomato. Prodhan (2011) recorded that the highest yield per hectare (68.99 ton) was obtained from Vermicompost (10 t ha^{-1}). Miah (2010) reported that the maximum yield at harvest (94.22 t ha^{-1}) was obtained from poultry manure. Manatad and Jaquias (2008) evaluated the study exposed that tomato yield was significantly enhanced by vermicompost application. Grigatti *et al.* (2007) and Edwards *et al.* (2004) reported that addition of vermicompost increased yield of tomato significantly. Solaiman *et al*. (2006) carried that the greatest fruit yield ha^{-1} were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K + 15 kg S ha^{-1}, but similar results were obtained from the treatment receiving 5.00 t cowdung ha^{-1} along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P + 40 kg K + 7.5 kg S ha^{-1}).

4.11 Soil organic carbon

There was a significant residual effect of cowdung, poultry manure and vermicompost along with chemical fertilizer (Table 4 and Appendix IX). The highest organic carbon (0.85%) was noted in treatment T_7. The effect of this treatment was statistically T_4 (0.85 %) and T_5 (0.85 %) treatment but superior to the rest of the treatments. Treatment T_3 (0.78 %) and T_6 (0.78 %) were statistically identical in recording organic carbon in soil and ranked second position. This might be due to higher amount of cowdung, poultry manure and vermicompost along with chemical fertilizer were applied resulting increased organic matter in soil due to organic manure treated plots than only chemical fertilizer and control treatments. The lowest organic carbon (0.60 %) was noted in T_0 treatment of the crop. Shrestha *et al.* (2018) found that the treatment with compost dose of 12.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest soil organic carbon. Harun-Or-Rashid (2011) reported that the maximum soil organic carbon (0.85%), was observed in treatments receiving 260 kg N ha^{-1} with 10.0 t ha^{-1} cowdung.

4.12 Soil pH

Soil pH was not significantly influenced by the residual effect of cowdung, poultry manure and vermicompost along with chemical fertilizer on the crop (Table 4 and Appendix IX). Each successive level of residual cowdung, poultry manure and vermicompost decreased the soil pH. The maximum soil pH (6.21) was recorded in T_7 treatment. The effect of T_7 (6.21) treatment was closely related to T_4 (6.17) and T_2 (6.13) treatment and ranked second in position. The minimum soil pH (5.89) was noted in T_0 treatment. Ibrahim and Fadni (2013) reported that organic manure fertilizers addition decreased soil pH values and increased the nutrients uptake by the plant. Increased in tomato yield between different types of organic fertilizer treatments compared with the control were as follows: 112% from compost, 90% from chicken plus cattle manure, 70% from chicken manure and 50% from the cattle manure compared to the untreated control. Harun-Or-Rashid (2011) recorded that soil pH (7.80) was observed in treatments receiving 260 kg ha^{-1} N with 10 t ha^{-1} cowdung application. Akande and Adediran (2004) found that poultry manure @ 5 t ha^{-1} significantly increased soil pH and nutrient uptakes.

4.13 Nitrogen content in soil

A remarkable variation of nitrogen content in soil was found among the different treatments receiving residual cowdung, poultry manure and vermicompost with the association of fertilizer as the source of chemical fertilizer (table 4 and Appendix IX). The maximum soil N content after harvest (0.11%) was noted in T_4 and T_7 treatment which was statistically identical to T_2 (0.10%) treatment and statistically similar with T_5 (0.08 %) and T_6 (0.08 %) treatment. On the other hand, the minimum soil N content after harvest (0.05 %) was noted in T_0 treatment.

Table 4. Effects of different organic and inorganic fertilizer on soil characteristics after harvest of BARI Tomato 15

Treatment	Organic carbon (%)	Soil pH	Nitrogen content in soil (%)	Phosphorus content in soil (ppm)	Potassium content in soil (meq. /100 g soil)
T_0	0.60 e	5.89	0.05 d	10.00 d	0.110
T_1	0.71 c	5.91	0.06 d	14.50 b	0.113
T_2	0.64 d	6.13	0.10 b	12.00 c	0.122
T_3	0.78 b	5.98	0.07 c	14.50 b	0.113
T_4	0.85 a	6.17	0.11 a	12.00 c	0.129
T_5	0.85 a	6.03	0.08 c	23.00 a	0.122
T_6	0.78 b	6.08	0.08 c	15.00 b	0.115
T_7	0.85 a	6.21	0.11 a	16.00 b	0.123
$LSD_{0.05}$	**0.03**	**NS**	**0.01**	**1.75**	**NS**
CV (%)	**5.45**	**0.25**	**16.07**	**7.54**	**7.42**

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability

Note: T_0 = Control,
T_1 = Cowdung @ 15.0 t ha^{-1},
T_2 = Poultry manure @ 12.0 t ha^{-1},
T_3 = Vermicompost @ 5.0 t ha^{-1},

T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1},

T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1},

T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and

T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}.

NS = Non-significant

4.14 Phosphorus content in soil

Post-harvest soils were influenced due to the applicant of organic manure along with chemical fertilizer (Table 4 and Appendix IX). Available P of the post-harvest soils ranged from 10.0 to 23.0 ppm against the P content of 11.0 ppm in initial soil. Available P of the post-harvest soils increased in all cases as compared to the initial soils except for the control. The highest available P content in soil (23.0 ppm) was recorded in T_5 treatment. Soil treated with organic manures along chemical fertilizer gave higher values of available P compared to other treatments. The release of available P from the decomposition of cowdung might be the cause of higher available P in soils treated with cowdung. The lowest available phosphorus (10.0 ppm) was noted in control treatment (T_0).

4.15 Potassium content in soil

Potassium content in soil was increased significantly due to the residual effect of organic manure along with chemical fertilizer (Table 4 and Appendix IX). The maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_4 receiving cowdung along with chemical fertilizer. The effects of this treatment were statistically superior to the rest of treatments of the crop. Treatment T_7 (0.123 meq. /100 g soil) receiving poultry manure along chemical fertilizer was statistically similar related to T_5 and T_2 treatment. The minimum potassium content in soil (0.110 meq. /100 g soil) was recorded from control (T_0) treatment.

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University during the period from from 05th November, 2019 to 10th March, 2020 for assessing the different organic and inorganic fertilizers on growth and yield of tomato. The experiment comprised of single factor comprising eight treatments viz. T_0 = Control, T_1 = Cowdung @ 15.0 t ha^{-1}, T_2 = Poultry manure @ 12.0 t ha^{-1}, T_3 = Vermicompost @ 5.0 t ha^{-1}, T_4 = N @ 150.0 kg ha^{-1} + P @ 50.0 kg ha^{-1} + K @ 90.0 kg ha^{-1} + S @ 18.0 kg ha^{-1} + Zn @ 2.0 kg ha^{-1} + B @ 1.0 kg ha^{-1}, T_5 = Cowdung @ 7.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}, T_6 = Poultry manure @ 6.0 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} and T_7 = Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}. Seeds of tomato cv. 'BARI Tomato-15' were used in the experiment. This experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. Data were collected on different aspects of growth, yield attributes, yield and harvest index of tomato including soil properties and nutrient contents.

The results revealed that treatment T_7 [Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}] exhibited its superiority compare to other organic and inorganic fertilizer treatments in terms of fruit yield of tomato. Treatment T_5 out-yielded over T_7 by 7.18%, T_4 by 11.24%, T_6 by 21.51%, T_3 by 31.62%, T_1 by 43.51% and T_2 by 53.02% higher fruit yield. Treatment T_7 also showed the tallest plant at harvest (125.00 cm), the maximum number of leaves plant^{-1} at harvest (89.15), the highest number of branches plant^{-1} at harvest (4.47), the highest number of flower clusters plant^{-1} (16.27), the maximum number of flowers cluster^{-1} (5.98), the highest number of fruits plant^{-1} (30.66), the maximum individual fruit weight (48.29 g), the highest yield of fruit plant^{-1} (0.83 kg) and the maximum yield of fruit plot^{-1} (13.85 kg) than other treatments in this experiment. On the other hand, the treatment T_0 (Control) returned with 67.37% lower yield than treatment T_7 which was significantly the lowest compare with other treatments under study.

In case of soil properties, the highest soil organic carbon (0.85%) and the maximum soil pH (6.21) was recorded from treatment T_7 in post-harvest soil. Considering the soil nutrients, the maximum soil N content after harvest (0.11%) was noted in T_7 treatment whereas the highest available P content in soil (23.0 ppm) and the maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_4 receiving chemical fertilizer.

CONCLUSION

From the above result it was revealed that T_7 [Vermicompost @ 2.50 t ha^{-1} + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1}] treatment gave higher yield along with higher values in all the growth and yield attributing parameters. It can be said that higher amount of vermicompost along with traditional chemical fertilizer improved soil properties along with increased availability of essential plant nutrients in soil solution. From the result of the experiment, it may be concluded that Vermicompost (2.50 t ha^{-1}) + N @ 75.0 kg ha^{-1} + P @ 25.0 kg ha^{-1} + K @ 45.0 kg ha^{-1} + S @ 9.0 kg ha^{-1} + Zn @ 1.0 kg ha^{-1} + B @ 0.5 kg ha^{-1} application seemed promising for producing higher fruit yield of tomato and maintaining soil productivity.

RECOMMENDATIONS

Considering the results of the present experiment, further studies in the following areas are suggested:

- Different levels of organic fertilizer may be used along with different levels of inorganic chemical fertilizer in tomato field for getting variety specific fertilizer recommendations.

- Studies of similar nature could be carried out in different agro-ecological zones (AEZ) of Bangladesh for the evaluation of zonal adaptability.

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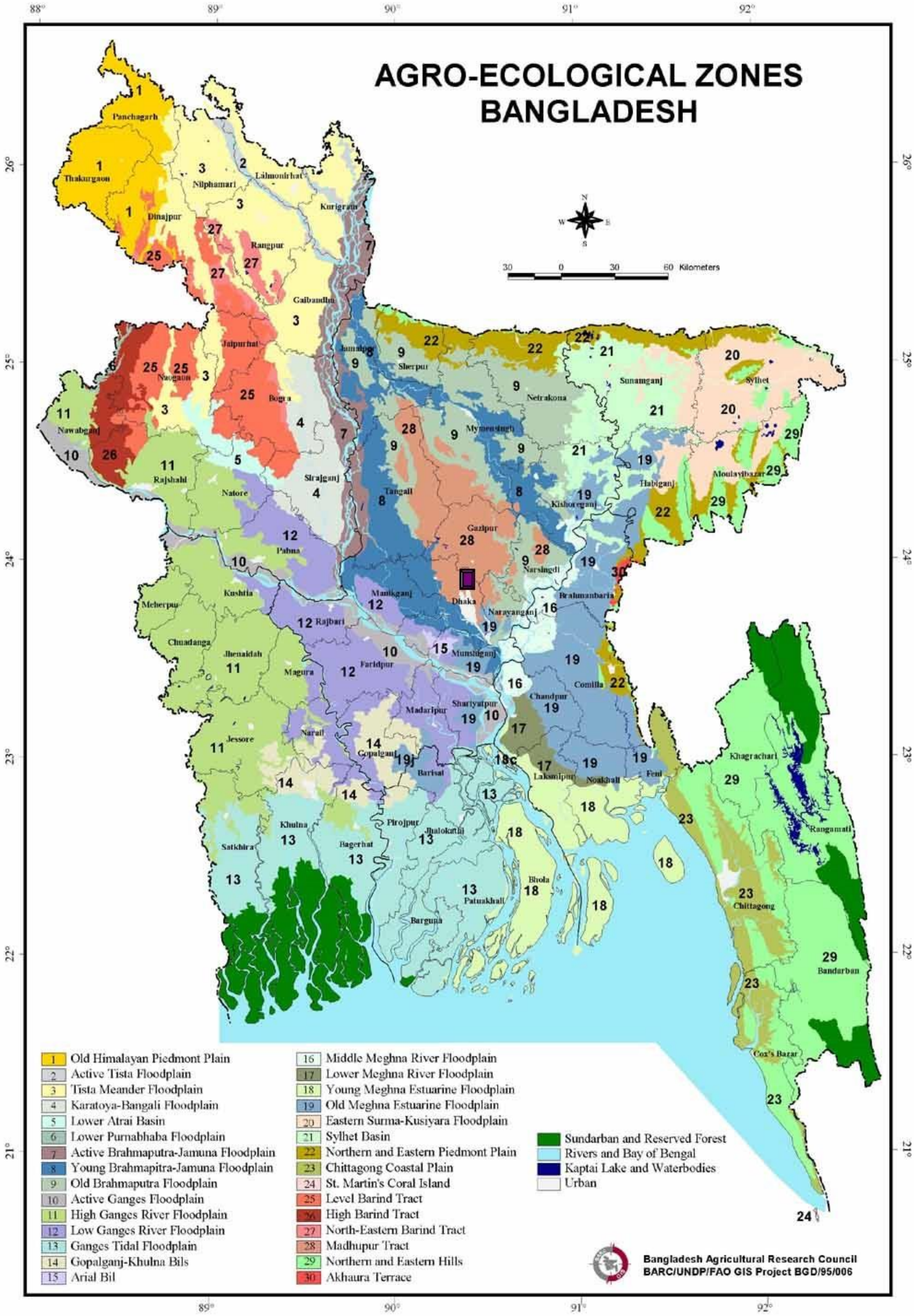
APPENDICES

Appendix I. Map showing the experimental sites under study



■ **The experimental site under study**

Appendix II: Characteristics of soil of experimental site analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly levelled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% clay	30
Textural class	Silty-clay
pH	6.0
Organic carbon (%)	0.69
Organic matter (%)	1.18
Total N (%)	0.06
Available P (ppm)	20.00
Exchangeable K (meq/100 g soil)	0.10
Available S (ppm)	22

Source: SRDI, 2019

Appendix III: Monthly average of Temperature, Relative humidity, total Rainfall and sunshine hour of the experiment site during the period from November 2019 to March 2020

Year	Month	Temperature			Relative Humidity (%)	Total Rainfall (mm)	Sunshine (Hour)
		Max (°C)	Min (°C)	Mean (°C)			
2019	November	32	24	29	65	42.8	349
	December	27	19	24	53	1.4	372
2020	January	25	14	23	50	3.9	364
	February	30	19	26	38	3.1	340
	March	35	24	31	38	19.6	353

Source: Bangladesh Meteorological Department (Climate & weather division), Agargoan. Dhaka – 1212

Appendix IV: Error mean square values for Plant height, number of leaves plant^{-1} and number of branches plant^{-1} of tomato

Source of variation	Degrees of freedom	Plant height	No. of leaves plant^{-1}	No. of branches plant^{-1}
Replication	2	0.034	0.459	0.219
Treatment	7	24.893*	8.828*	0.711**
Error	14	0.049	0.229	0.290

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix V: Error mean square values for number of flower clusters plant^{-1}, number of flowers cluster^{-1} and number of fruits plant^{-1} of tomato

Source of variation	Degrees of freedom	Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}	Number of fruits plant^{-1}
Replication	2	0.025	0.303	0.219
Treatment	7	0.277*	4.699**	1.315**
Error	14	0.021	0.167	0.076

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VI: Error mean square values for individual fruit weight and yield characteristics of tomato

Source of variation	Degrees of freedom	Individual fruit weight	Yield of fruit plant^{-1}	Yield of fruit plot^{-1}	Yield
Replication	2	0.022	0.026	0.096	0.204
Treatment	7	0.201*	0.883**	0.322**	451.839*
Error	14	0.009	0.007	0.028	2.498

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VII: Error mean square values for dry matter content of stem, leaves and fruit of tomato

Source of variation	Degrees of freedom	Dry matter content		
		Stem	**Leaves**	**Fruit**
Replication	2	0.025	0.080	0.509
Treatment	7	0.277*	2.032*	6.758**
Error	14	0.021	0.049	0.174

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VIII: Error mean square values for P^{H}, Organic matter, total N, available P and available K of the soil after harvest of tomato

Source of variation	Degrees of freedom	P^{H}	Organic matter	Total N	Available P	Available K
Replication	2	0.005	0.003	0.029	0.057	0.944
Treatment	7	0.001*	0.008**	0.006*	0.050*	0.503**
Error	14	0.002	0.058	0.007	0.008	1.447

*Significant at 5% level of probability ** Significant at 1% level of probability

PLATES

Plate 1. Harvesting of tomato from experiment plot

Plate 2. Fruit bearing tomato plant