EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF TOMATO

BOISHAKHI BISWAS

DEPARTMENT OF SOIL SCIENCE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

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BY

BOISHAKHI BISWAS
REGISTRATION NO.: 15-06390
Email: pujaboishakhi@gmail.com
Mobile: 01966783686

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Approved by:

Prof. Dr. Alok Kumar Paul
Supervisor
Department of Soil Science
Sher-e-bangla Agricultural University
Dhaka-1207

Prof. A. T. M. Shamsuddoha
Co-Supervisor
Department of Soil Science
Sher-e-bangla Agricultural University
Dhaka-1207

Prof. Dr. Mohammad Saiful Islam Bhuiyan
Chairman
Examination Committee
Department of Soil Science
Sher-e-bangla Agricultural University Dhaka-1207

Dedicated to
My

Loving Parents
and

Respected
professors,

whose hopes,
dreams, and
prayers have
guided me
through life.

DEPARTMENT OF SOIL SCIENCE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF TOMATO"*** *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*** *in* ***SOIL SCIENCE****, embodies the result of a piece of bona fide research work carried out by* ***BOISHAKHI BISWAS****, Registration number:* ***15-06390*** *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 during the course of this investigation has duly been acknowledged.

Dated: September 5, 2023
Dhaka, Bangladesh

Prof. Dr. Alok Kumar Paul
Supervisor

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-Author

EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF TOMATO

ABSTRACT

The experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University during the period from December 2020 to April 2021 under AEZ 28 (Madhupur tract), for assessing the effect of different vermicompost and inorganic fertilizers doses on growth and yield of tomato. The experiment comprised of single factor comprising eight treatments viz. T_1 = N_{140} P_{45} K_{60} $Zn_{2.0}$ $B_{1.0}$ kg ha^{-1}+ No organic kg ha^{-1}, T_2 = N_{120} P_{40} K_{55} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1}+ 1350 kg VC ha^{-1} , T_3 = N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1}+ 2700 kg VC ha^{-1} , T_4 = N_{80} P_{30} K_{45} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1}+ 4050 kg VC ha^{-1} , T_5 = N_{60} P_{25} K_{40} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1}+ 5400 kg VC ha^{-1} , T_6 = N_{40} P_{20} K_{35} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1}+ 6750 kg VC ha^{-1} , T_7 = Full VC 9350 kg ha^{-1} . 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_3 [N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1} + 2700 kg VC ha^{-1}] exhibited its superiority compare to other inorganic fertilizer with different doses of vermicompost treatments in terms of fruit yield of tomato. Treatment T_3 also showed the longest plant (126.00 cm), maximum number of leaves $plant^{-1}$ (90.30), highest number of branches $plant^{-1}$ (6.89), highest number of flower clusters $plant^{-1}$ (19.24), maximum number of flowers $cluster^{-1}$ (6.67), highest number of fruits $plant^{-1}$ (31.77), maximum fruit weight (48.29 g), maximum yield of fruit $plot^{-1}$ (37.23 kg), highest yield (60.86 t ha^{-1}) than other treatments in this experiment. On the other hand, the treatment T_7 [full dose VC] returned with 67.37% lower yield than treatment T_3 which was significantly the lowest compared with other treatments under study. In case of soil properties, the highest soil organic matter (0.85%) and the maximum soil pH (6.21) was recorded from treatment T_3 in post-harvest soil. Considering the soil nutrients, 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_2 receiving chemical fertilizer. Vermicompost (VC 2700 kg ha^{-1}) + (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1}) application seemed promising for producing higher fruit yield of tomato and maintaining soil productivity.

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ABBREVIATIONS

AEZ	Agro-Ecological Zone
BARI	Bangladesh Agricultural Research Institute
SAU	Sher-e-bangla Agricultural University
BBS	Bangladesh Bureau of Statistics
Co	Cobalt
CV%	Percentage of coefficient of variance
cv.	Cultivar
DAE	Department of Agricultural Extension
DAS	Days after sowing
^0C	Degree Celsius
et al	And others
FAO	Food and Agriculture Organization
g	gram(s)
ha^{-1}	Per hectare
HI	Harvest Index
kg	Kilogram
Max	Maximum
mg	Milligram
Min	Minimum
MoP	Muriate of Potash
N	Nitrogen
No.	Number
NS	Not significant
%	Percent
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
TSP	Triple Super Phosphate
UPOV	Union for the Protection of Plant Varieties
Wt.	Weight

CHAPTER I

INTRODUCTION

Tomatoes (*Lycopersicon esculentum* Miller) are one of the world's most important field and greenhouse-grown vegetable crops (Victoria *et al.*, 2011). In terms of human health, tomato is an essential source of minerals, vitamins, and antioxidants and a large part of the daily meals of many people in several nations (Kotkov *et al.*, 2011); (Vallverdu-Queralt *et al*., 2016). In terms of global vegetable production, it ranks third behind potato and sweet potato and first among canned vegetables (Ramakrishna *et al.*, 2009). In Bangladesh, however, it ranks second, behind the potato (Hossain and Abdulla, 2015). It has various raw applications, including salad and soup. Utilizing enough organic manure such as cow manure, compost, and vermicompost increased the soil's texture, structure, humus, color, aeration, water retention capacity, and microbial activity. In our country, most soils have less than 1.5% organic matter, and some have less than 1%. (BARC, 1997). Organic fertilizer has the most significant impact on tomato productivity and quality. Additionally, it enhances the tomato's vegetative development, flowering, and fruit set. Essential for tomato cultivation are calcium and the micronutrients boron, manganese, molybdenum, and iron. Singh and Kushwah (2006), found that these nutrients are usually present in enough amounts in biologically active soils with enough organic matter.

Using nitrogen fertilizer is essential for plant growth and fruits that can be harvested, and the right amount has been given to meet the needs of the plant. Due to its high nitrogen concentration (46% by weight), urea has surpassed other nitrogenous fertilizers as one of farmers' most popular nitrogenous fertilizers. When the amount of urea fertilizer put into the soil system is more than what the crop needs, up to 50% of the fertilizer may escape into the environment through leaching, surface runoff, decomposition, and ammonium volatilization in the soil, since plants can only use a small amount of the fertilizer. The slow-release method was used on urea fertilizer to slowly release the nutrients and match up with how well the plant could take them up. Mixed fertilizers could help increase crop yield stability, improve soil fertility, and speed up plant growth (Isbell *et al.*, 2017). There is evidence that combining organic and inorganic fertilizers enhances nutrient availability, optimizes the soil environment, and increases crop yield (Mubeen *et al.*, 2013); (Huang *et al.*, 2010). Integrated nutrient management, often known as the combined use of chemical and organic sources, is widely recognized as a way to boost crop output in a sustainable manner (Mubeen *et al.*, 2013); (Huang *et al.*, 2010). A combination of 3 t ha^{-1} vermicompost and 50% doses of NPK (60: 30: 30: kg ha^{-1}) fertilizer resulted in better tomato crop growth and output than NPK fertilizer alone. Singh *et al.* (2010); Ayeni *et al.*(2010) discovered that chickens at 20, 30, and 40 t ha^{-1} with NPK 15: 15: 15 fertilizers significantly boosted plant leaf area, leaf quantity, branch length, and tomato fruit output. Adnan *et al.* (2017) found that plant growth and tomato fruit yield were significantly improved when organic manures were mixed with the right amount of inorganic fertilizers. Prativa and Bhattarai (2011), looked at how integrated nutrition management affects tomato plant growth, yield, and soil nutrients. The study found that when organic manures were used with inorganic fertilizers, plant growth, yield, and soil macronutrient status were all better than when either nutrient was used alone. Mukta *et al.* (2015), discovered that utilizing 10 t ha^{-1} of vermicompost as an organic fertilizer and 50 % chemical fertilizer resulted in the highest tomato yield and quality.

Our farmers are more accustomed to using nitrogenous, phosphoric, and potassium fertilizers than compost. However, organic fertilizer is not always readily available. Moreover, farmers are not completely aware of the significance of using organic fertilizer. Therefore, the use of organic manure must be encouraged in our country. One of the most significant causes of environmental contamination is the use of chemical fertilizers in crop cultivation. Today, experts in various regions of the world are becoming increasingly aware of the environmental hazards caused by the use of chemicals in crop cultivation. As an alternative to chemicals, scientists in industrialized nations are attempting to create a variety of bio-fertilizers to reduce environmental contamination and obtain pollution-free crop production, particularly for vegetables. Organic manure has numerous advantages over chemical fertilizers in crop production. Organic fertilizer protects crop plants from adverse conditions.

Therefore, in order to improve the current condition of tomato production in Bangladesh, it is necessary to promote improved varieties to Bangladeshi growers. Current study was conducted to increase the growth, yield, and chemical content of tomato (*Lycopersicon esculentum* Miller) treated with mixed fertilizers with vermicompost at different rates.

OBJECTIVES

1. To investigate the effect of vermicompost and inorganic fertilizer on the growth and yield of Tomato

2. To find out the effective combination of vermicompost and inorganic fertilizer for the successful cultivation of Tomato

CHAPTER II

REVIEW OF LITERATURE

Environmental conditions, variety, and agronomic techniques highly control the yield and development of tomato. Among the several agronomic methods impacting crop production, the application of balanced fertilizer is particularly significant. Research on this crop is going on several elements to raise its potential yield and keep soil fertility and productivity in mind, which are responsible for optimum crop production. Using organic fertilizer plays a significant role in providing higher yields per unit area and maintaining soil health. In this chapter, an attempt was made to review the existing literature inside and outside the country that are connected to the influence of different organic manures on the growth and yield of tomato.

Wako and Muleta (2022) examined tomato performance, productivity, and quality with vermicompost. Tomato (*Solanum lycopersicum* L.) is a popular vegetable fruit worldwide. Tomatoes respond to organic and inorganic fertilizers. Unbalanced soil nutrients reduce tomato fruit output. Chemical fertilizers degrade soil fertility, nutrition, and fruit quality by accumulating heavy metals in plant tissues. Organic manures like vermicompost provide plant nutrients. It improves soil physical, chemical, and biological qualities. Thus, vermicompost is essential organic manure for tomato production and productivity, promoting growth, yield, yield components, fruit quality, and sustainable agriculture. Thus, vermicompost (alone or in combination) on tomato crops is essential for healthy output.

Carricondo-Martnez *et al.* (2022) studied the influence of organic amendments obtained from vegetal residues on tomato productivity and quality. Fresh vegetal residues, compost, and vermicompost at two different doses, all derived from previous tomato crop vegetal residues, were applied as fertilization treatments, along with an organic treatment with goat manure and a control mineral fertigation treatment. Tomatoes (*Solanum lycopersicum* L.) cv. 'Surcal' (Natursur S.C.A.) were transplanted after being grafted onto Beaufort (Monsanto) rootstock. The standard mineral fertigation management produced the maximum yield, followed by vermicompost treatments at two different doses, with no statistical differences. Organic treatments involving crop leftovers, compost, and goat dung resulted in a reduced yield. Regarding quality criteria, the lycopene concentration was greater in the mineral fertilization and vermicompost at treatments, but the other assessed antioxidants were more concentrated in tomatoes fertilized with vermicompost and goat dung. The plant nutrient management with vermicompost was the best circular solution since it allowed for the reintegration of wastes from past crop cycles into the soil, resulting in a yield comparable to chemical input management and nutritionally dense tomatoes.

Haque *et al.* (2021) conducted an experiment to find out the useful effects of organic fertilizer on the growth and yield of tomato. The highest yield was observed in 85% Recommended Chemical Fertilizer (RCF) + 3 t ha^{-1} organic Fertilizer (OF) due to higher number of fruit $plant^{-1}$ and weight of fruit $plant^{-1}$ and the lowest was in T5 70% CF + 1 t ha^{-1} OF These results may be due to the increased parameters of growth components with the increasing amount of organic and inorganic fertilizers applied. The combination of organic and inorganic fertilizer-treated plots produced a higher yield than plots without the combination of organic and inorganic fertilizer. The highest gross return was found in 85% Recommended Chemical Fertilizer (RCF) + 3 t ha^{-1} organic Fertilizer (OF) treatment, and the lowest gross return was recorded from 70% CF + 1 t ha^{-1}.

Sopha *et al*. (2020) conducted a study to determine the best formula of liquid organic fertilizer for organic tomato. The study consisted of two activities: formulating liquid organic fertilizer and evaluating liquid organic fertilizer on organic tomato growth and yield. The first activity was a material analysis that compared nine different organic materials. The organic materials were collected from other areas in West Java, Indonesia. The organic materials were collected and analyzed the chemical content, 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 rates 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 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 great potential as a nitrogen source, elephant grass and goat manure had a high amount of phosphorus and rabbit manure had the highest potassium content. The second activity found that the application 20 mL^{-1} of liquid organic fertilizer increased the tomato yield by up to 83% and improved vitamin C up to 66% more than the control. Liquid organic fertilizer made from manure (rabbit and goat manure) and green manure (white lead tree and elephant grass) doses of 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 the growth and yield of tomato. In the case of the application of organic manures, the highest yield was obtained from Cowdung 7.5 t ha^{-1} + Poultry manure 5 t ha^{-1}.

Shrestha *et al.* (2018) carried out a field experiment in the 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 a significant positive correlation between the plant height and the yield of tomato. The treatment with a compost dose of 12.5 t ha^{-1} with a 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 the increment in carbon content, nitrogen content, and potassium content of soil was observed in successive years. For commercial producers in the plastic tunnel, compost at the rate 12.5 t ha^{-1} with half dose of the recommended level of chemical fertilizer (100:90:40 kg N:P:K ha^{-1}) is recommended to apply in the field, while for organic producers, 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 $plant^{-1}$ (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 to be statistically significant. No significant difference was observed in tomato fruits' quality (total soluble solids) in both varieties' responses 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. It was found that treatment Co-compost @ 2 t ha^{-1} with 50% recommended dose of chemical fertilizer (RDF) gave the highest yield of tomato fruit followed by Vermicompost @ 2 t ha^{-1} with 50% RDF, 100% Chemical Fertilizer and Cow dung @ 5 t ha^{-1}. From the economic study, it was found that higher income obtained from using co-compost along with chemical fertilizer followed by Vermicompost @ 2 t ha^{-1} with 50% RDF. 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 histories. 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 more significant 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 more significant 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 the experiment in each type of soil. It was concluded that vermicompost could 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 determine the effect of different manures and potassium on the growth and yield of tomato. In case of manure, the tallest plant, maximum number of leaves plant^{-1}, maximum size of the canopy, the maximum size of stem diameter, the maximum number of clusters plant^{-1}, the maximum number of flowers cluster^{-1}, maximum number of fruits cluster^{-1}, the highest length of fruit, the highest diameter of fruit, maximum fresh weight of fruit, the maximum dry matter content of fruit, the highest TSS, the highest carbon assimilation rate, maximum yield of fruit plot^{-1} and the maximum yield ha^{-1} were recorded from the treatment of 3.75 t ha^{-1} vermicompost. The maximum number of branches plant^{-1} and maximum chlorophyll content in the leaf were recorded from the treatment of 15 t ha^{-1} cowdung.

Makinde *et al.* (2016) conducted a field experiment in which they compared the efficacy of organic and inorganic fertilizers on the growth, yield, and nutrient composition of tomato using four treatments, including sole application of NPK and Organic fertilizer, their complementary application, and a control that was replicated three times. Planting tomato prime (UC-82-B variety). Aleshinloye Compost (Grade B) organic fertilizer was administered two weeks prior to transplantation at a rate of 100 kg N ha 1. In comparison, NPK 15:15:15 was applied two weeks after transplanting at the same rate. The fertilizer sources didn't change how well the tomatoes grew, but they were better than the control plots. At eight weeks after transplantation (8 WAT), plants treated with NPK 15:15:15 had a higher rate of floral abortion (34.7) than control plots (24.67). The

NPK 15:15:15 at 100 kg N ha^{-1} produced the maximum fruit production of 18.60 t ha^{-1}, whereas the control plots produced the lowest yield of 4.07 t ha^{-1}. The plots given NPK had the highest amount of lycopene at 2.65%, which was the same as the control plot but a lot more than other sources. The NPK plots had the lowest potassium concentration (20.80%), while the control plots had the highest potassium buildup (23.20%); nonetheless, there was no statistical difference between the two. The plot that wasn't treated had the most sodium, at 0.43%, while the plot that was treated with NPK and organic matter had the least sodium, at 0.33%.

Salem *et al.* (2016) conducted a field experiment to determine the effect of organic fertilizers on the growth, yield, and flavor of four tomato varieties: Sadia F_1, Isabella F_1, Lelord, and Sun cherry. There were 64 elementary plots in all, and each plot got only the prescribed amounts of organic fertilizers: Cow Manure (AL BAQARA) at 18 kg $plot^{-1}$, Chicken+cow (AL MROOG) at 18 kg $plot^{-1}$, Chicken manure pellet at 18 kg $plot^{-1}$, Agro fish pellet at 18 $plot^{-1}$ The effects of chicken manure on the growth parameters of the tested tomato types were significant for plant height and root length of Isabella F_1, leaf area of sun cherry, root fresh and dry weight of Lelord, and leaf fresh and dry weight of Sadia F_1. When treated with mixed manure, the fresh and dry weight of Isabella tomato shoots increased. The treatment with agro fish pellets considerably improved the stem diameter of Isabella F_1 plants. The sun cherry tomato cultivar produced more blossoms and fruit when treated with agro fish pellets. In that order, agro fish also affected the number of fruits produced by Sadia F_1 and the fruit yield of Lelord and Isabella F_1. Based on how the fruits of the different types of tomatoes tasted, chicken manure made Sadia F_1 and Sun cherry tomatoes taste better overall. Agro fish pellet and mixed manure have affected the overall quality of tomato fruits of the Isabella F_1 and Lelord varieties.

Hyder *et al*. (2015) recorded that tomato fruit yield was the maximum 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, P, K in tomato fruit and plant were registered with soil application of vermicompost @ 2.0 t ha^{-1}. This study confirmed that vermicompost has tremendous potential for plant nutrient 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 treatments, 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 vegetative growth largely depends on the cultivars. Unlike the vegetative growth, the total fruit yield significantly increased with the application of PM and VC, irrespective of the cultivar. In contrast, the single fruit weight and number $plant^{-1}$ varied mainly 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 the 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 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 yield of tomato cultivars as compared to the 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) experimented to investigate the potential of vermicompost and mustard oil cake leachate as foliar organic fertilizer regarding the growth, yield, and TSS status of BARI hybrid tomato-8 and then examined their effects on different parameters. The experimental data revealed that significant increases in growth, yield, and TSS on BARI hybrid tomato-8 were observed due to the foliar application of vermicompost and mustard oil cake. All parameters performed better with the foliar application of the leachate from vermicompost, which was very close to the mustard oil cake. However, the maximum number of fruits, yield, and TSS were found from the foliar application of leachate from vermicompost, followed by mustard oil cake. In contrast, the minimum was observed in the control treatment.

Reshid *et al.* (2014) experimented with a 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 the effect of increasing the concentration of Vermicompost in target plant growth. The 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 yield of tomato cultivars compared to the 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). Soil samples were taken at the start and 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 changes in the soil chemical and physical properties and an 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 adding different sources of organic fertilizers. Organic manure fertilizers addition decreased soil pH values and increased the nutrients uptake by the plant. Increased 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 the growth and yield of tomato varieties and assess shelf life. The results revealed that at final harvest, the tallest plant, the maximum number of leaves plant^{-1}, the maximum number of flower clusters plant^{-1}, the maximum number of flower cluster^{-1}, the maximum number of flowers plant^{-1}, the maximum number of fruits plant^{-1}, the maximum length of individual fruit, the maximum diameter of individual fruit, the maximum weight of individual fruit, the maximum yield plant^{-1}, the maximum yield plot^{-1}, and the maximum yield ha^{-1} was recorded from 16 t ha^{-1} Poultry manure.

Chanda *et al.* (2011) conducted field trials using different fertilizers having an equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. The treatment Vermicompost supplemented with chemical fertilizer showed 73% better yield of fruits than the control. Besides, vermicompost supplemented with NPK treated plots Vermicompost supplemented with chemical fertilizer displayed better results regarding the fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches, and number of fruits plant^{-1} from other fertilizers treated plants.

Harun-Or-Rashid (2011) conducted a field experiment to assess the response of summer tomato to organic and inorganic fertilizers in respect of growth, yield, and yield contributing characteristics. The yield of summer tomato increased significantly due to the combined application of poultry manure and 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 than nitrogen alone or control treatment. Still, the effect of poultry manure was more pronounced than those of cow dung and nitrogen fertilizer or control treatments on the crop. Treatment 2.5 t ha^{-1} poultry manure and 107.50 kg N ha^{-1} performed the best in recording the crop's plant height. However, the optimum dose for the maximum length of the root was 2.5 t ha^{-1} poultry manure and 107.50 kg N ha^{-1}, and for the fruit diameter, fruit length, and fruit weight was 220 kg N ha^{-1}. Treatment receiving 2.5 t ha^{-1} poultry manure and 107.50 kg N ha^{-1} performed the best recording yield of summer tomato. The maximum particle density, organic carbon, electrical conductivity, and soil pH were observed in treatments receiving 260 kg N, 10 t cow dung with the association of 110 kg N, 5 t poultry manure, and 46.25 kg N, and control, respectively. The lowest particle density was recorded in 10 t cow dung + 110 kg N ha^{-1}. The minimum organic carbon, electrical conductivity, and pH were found in treatment 260 N ha^{-1} treatment on the crop.

Prodhan (2011) experimented to find out the effect of organic manure and spacing on the growth and yield of tomato. In the case of organic manures, the tallest plant, the maximum number of leaves plant^{-1}, and the maximum number of branches plant^{-1} were recorded from Vermicompost 10 t ha^{-1}. The minimum days required from transplanting to 1st flowering and the minimum days required from transplanting to 1st harvesting, the maximum number of fruits plant^{-1}, the maximum length of fruit, the widest diameter of fruit, the maximum dry matter content in plant, the maximum dry matter content in fruit, the maximum weight of individual fruit, and the highest yield ha^{-1} was obtained from Vermicompost 10 t ha^{-1}.

Yanar *et al.* (2011) evaluated the effects of different organic fertilizers on the yield and fruit qualities of indeterminate tomato. Influences of different organic and inorganic fertilizers on yields and fruit quality of tomato were compared during the 2006 and 2007 growing periods under field conditions. In the 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 1 t ha^{-1} before planting; 0.5 t ha^{-1} after first flowering and 0.5 t ha^{-1} after first harvest and composted cattle manure 60 t ha^{-1} before planting; 5 t ha^{-1} after first flowering and 5 t ha^{-1} after first harvest. Based on the first year results, organic fertilizers used during 2007 growing periods were F_1 (20 t ha^{-1} CCM before planting; 1 t ha^{-1} CPM before planting; 40 kg ha^{-1} Complex and 20 kg ha^{-1} Not every week and F_2 (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} Not 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, $Yank_1$ 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 F_1 fertilizer treatment was similar to the control application. The unmarketable yield was not affected by 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, the application of 20 to 40 t ha^{-1} composted cattle manure before planting, and the 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) experimented to find out the effect of organic manures and different varieties on the growth and yield of tomato. In case of organic manure, at final harvest, the tallest plant, the maximum number of leaves plant^{-1}, the maximum number of flower clusters plant^{-1}, the maximum number of flowers cluster^{-1} , the maximum number of flowers plant^{-1}, the maximum number of fruits plant^{-1}, the maximum length of individual fruit, the maximum diameter of individual fruit, the maximum weight of individual fruit, the maximum fresh weight of leaves, the maximum dry matter of leaves, the maximum dry matter of fruit, the maximum yield plant^{-1}, the maximum yield plot^{-1}, and the maximum yield ha^{-1} at harvest was obtained from OM_2 poultry manure.

Sinha and Valani (2009) reported an increase in plant height and yield in tomato plants treated with vermicompost alone or vermicompost with worms. Furthermore, the vermicompost with worms maintained outstanding growth from the start. Significantly more blooms and fruits were produced plant^{-1} compared to agrochemicals and normal compost. The presence of earthworms in the soil significantly affected tomato flowering and fruiting.

Chand *et al.* (2008) examined the impact of natural fertilizers on the productivity and quality of tomato plants by conducting experiments on tomato plants. Significantly higher tomato fruit yield was seen in the condition that received enhanced vermicompost and three sprays of liquid manure.

Ewulo *et al.* (2008) conducted an experiment to investigate the impact of poultry manure additions on nutrient availability, soil physical and chemical characteristics, and tomato output at five manure application rates: 0 t ha^{-1}, 10 t ha^{-1}, 25 t ha^{-1}, and 50 t ha^{-1}. The chicken dung boosted the soil's organic matter, nitrogen, and phosphorus concentrations. With increasing amounts of manure, the soil's bulk density and moisture content increase. The application of manure increased tomato leaf concentrations of nitrogen, phosphorus, potassium, calcium, and magnesium, plant height, number of branches, root length, and fruit number and weight. Compared to the control, the 25 t ha^{-1} poultry manure produced the highest leaf P, K, Ca, and Mg concentrations and yields. 10, 25, 40, and 50 t ha^{-1} of manure increased the average fruit weight by 58%, 102%, 37%, and 31%, respectively.

Manatad and Jaquias (2008) studied the effect of various vermicompost application rates on the growth and yield of vegetables. Vermicompost application considerably increased fruit length, diameter, weight of fruits plant^{-1}, and yield in watermelon, eggplant, sweet pepper, and tomato, according to their research.

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 plant height and the number of leaves showed increasing response as the amount of applied fertilizer increased. The combined application of the two 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 applying 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 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). Different doses of chemical fertilizer in combination with Lalon significantly increased the yield and yield components of tomato. The highest fruit yield was recorded with Lalon 200 kg ha^{-1} + 100% RD, which was statistically similar to 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 ha^{-1} 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 to be very close to 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 of poultry manure on selected soil physical properties, nutrient status, growth, and fruit yield of tomato (*Lycopersicon esculentum*). Soil bulk density and temperature were 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 the number and weight of fruits.

Grigatti *et al.* (2007) and Edwards *et al.* (2004) showed that compost enhanced the growth of a wide range of tomato species further than expected because of the supply of nutrients. They also reported that adding vermicompost increased plant heights and yield of tomato (*Lycopersicum esculentum*) significantly.

Monira (2007) investigated the effect of organic fertilizer treatment on tomato (Raton) nutrient uptake, growth, and yield. The treatments were T_1 (cow dung + urea), T_2 (cow dung + urea), T_3 (cow dung), and T_4 (urea), in that order. As fertilizers, urea, cow dung, triple superphosphate (TSP), muriate of potash (MP), gypsum, and sodium molybdate were administered at rates of 175 kg N, 63 kg P, 20 kg K, 30 kg S, and 1 kilogram Mo per hectare (ha^{-1}) in trials T_2, T_3, and T_4. The results suggested that the application rate of 21.34 t ha^{-1} of organic fertilizer had a good effect on tomato fruit yield. Organic fertilizer had the most significant fruit output of 75.67 t ha^{-1}. Based on the obtained tomato yield, it was concluded that cow dung application in tomato production at a rate of 21.34 t ha^{-1} could supplement N as an N-source.

Grimme and Stoffella *et al.* (2006) conducted a field trial taking well-decomposed cow dung 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 cow dung and vermicompost. Tomato grown in potting mixtures containing 40% decomposed cow dung along with vermicompost 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 greater. Still, they did not differ significantly from those of tomatoes grown in MM360. There were no positive correlations between the increase in tomato yields, 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) conducted 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 the Ratan variety of tomato. The plots were treated with three levels each of N (62, 100, and 200 kg ha^{-1}), P (11.7, 17.5, and 35 kg ha^{-1}), K (26.7, 40, and 80 kg ha^{-1}), S (5, 7.5 and 15 kg ha^{-1}) and cow dung (5, 10 and 15 t ha^{-1}). The tallest plant and dry matter weight of shoot, the maximum number of clusters of flowers and fruits $plant^{-1}$, the most significant fruit size, fruit yield $plant^{-1}$, 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 cow dung 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 that would offer the maximum benefit concerning cost ratio (4.38) for tomato production in the shallow red-brown terrace soil (AEZ 28) of Bangladesh.

Compost has been found to promote tomato plant development on multiple occasions, and these growth advantages have been linked to an improvement in the growing substrate's physical, chemical, and biological qualities, according to Papafotiou *et al.*, (2005). In general, replacing peat with moderate volumes of compost enhanced plant development due to an increase in the bulk density of the growing medium and a reduction in the overall porosity and amount of readily available water in the pots.

Akande and Adediran (2004) observed the impact of poultry manure on soil physical characteristics, nitrogen uptake, and the sustainability of tomato production systems, which is sparse. This experiment demonstrated the use of chicken manure in Nigerian tomato production. They discovered that poultry manure @ 5 t ha^{-1} greatly boosted tomato yields of fresh and dry matter, soil pH, N, P, K, Ca, and Mg, and nutrient uptakes.

Sangwoo *et al.* (2004) experimented with two cow dung-based, and two plant-residue-based organic amendments to a simple peat-based potting mix tested over two years to improve seedling biomass, out-planting success, and yield in an organic tomato production system. They concluded from their findings that excellent quality tomato transplants could be produced using plant-based cow dung-based organic amendments.

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

Chaoui *et al.* (2003) observed that the amount of nutrients in different compost amendments varies depending on the parent material from where they originated and concluded that both the compost from their study constitutes a slow-releasee 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 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 treated with vermicompost supplemented to recommended rates with inorganic fertilizers usually had greater amounts of total N, orthophosphates, dehydrogenase enzyme activity, and 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 was 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) showed that substituting 10% or 50% pig manure vermicompost for Metro-Mix 360 considerably enhanced the dry weights of tomato seedlings compared to those grown in 100% Metro-Mix 360. The most commercial fruit yields were produced by a mixture of 80% MetroMix 360 and 20% vermicompost. Lower concentrations of vermicompost (less than 50%) in the MM360 typically produced greater growth effects than high concentrations: 20% vermicompost substitution resulted in 12.4% more tomato fruit weights than those in MM360, and substitutions of 10%, 20%, and 40% vermicompost significantly reduced the proportions of non-marketable fruits and produced larger tomato fruits.

CHAPTER III

MATERIALS AND METHODS

The present investigation entitled "**EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF TOMATO"** was carried out during the period from December 2020 to April 2021 under AEZ 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207. The details of materials used, experimental procedures followed, and techniques adopted during the investigation are described in this chapter. Climatic and edaphic conditions prevailing during crop season, selection of site, cropping history of the field, and other experimental details are also presented.

3.1. Experimental period

This research work was carried out from December 2020 to April 2021.

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 at $23^{0}46^{/}$N latitude and $90^{0}22^{/}$E longitude (Anon., 2004). The location's altitude was 8.6 meters from the sea level (The meteorological department of Bangladesh, Agargaon, Dhaka).

3.3. Agro-Ecological Region

The land was Agro- ecological zone of Modhupur tract (AEZ no. 28). It was deep red brown terrace soil and belongs to "Noadda" cultivated series. The altitude of the location was 8 m above sea level as per the Bangladesh Metrological Department, Agargaon, Dhaka-1207. The amount of organic carbon, total N, available P and K were 1.25%, 0.08%, 20 ppm and 0.20 mg/l00g soil, respectively. The physical and chemical characteristics of the soil have been presented 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) were recorded for November 2019. In contrast, the minimum temperature (14.60°C), minimum relative humidity (64%), and no rainfall were recorded for January 2021. Details of the meteorological data of air temperature, relative humidity, rainfall, and sunshine hour during the study period have been presented in Appendix II.

3.5. Soil condition of the experimental area

Topsoil was silty clay in texture, olive-grey with standard fine to medium distinct dark yellowish-brown mottles. Soil pH was 6.0, and organic matter was 0.80. The experimental area was flat, with available irrigation and drainage systems and above flood levels. The soil data during the study period at the experimental site are shown in Appendix II.

3.6. Plant materials

25 days old tomato seedlings were used as planting material. Seedlings of tomato cv. 'BARI Tomato-15' were used in the experiment. The seedlings were collected from the Horticulture Center, Falabithi, Department of Agricultural Extension, Asadgate, Dhaka-1207.

3.7. 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 have 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), lifetime 100110 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

3.8. Experimental design

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

3.8.1. Treatment of the experiment

The experiment consisted of a single factor:

T_1 = N_{140} P_{45} K_{60} $Zn_{2.0}$ $B_{1.0}$ kg ha^{-1} + No organic kg ha^{-1}

T_2 = N_{120} P_{40} K_{55} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1} + VC 1350 kg ha^{-1}

T_3 = N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ kg ha^{-1} + VC 2700 kg ha^{-1}

T_4 = N_{80} P_{30} K_{45} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1} + VC 4050 kg ha^{-1}

T_5 = N_{60} P_{25} K_{40} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1} + VC 5400 kg ha^{-1}

T_6 = N_{40} P_{20} K_{35} $Zn_{1.0}$ $B_{1.0}$ kg ha^{-1} + VC 6750 kg ha^{-1}

T_7 = Full VC 9350 kg ha^{-1}

3.8.2. Experimental layout

An area of 200 m^2 was divided into three blocks. The experimental area was divided into three blocks, each representing a replication. The size of each unit plot was 2.00 m × 3.00 m (6.00 m^2). The space was kept at 0.75 m between the blocks and 0.75 m between the plots. The distance between row to row and plant to plant was 60 cm and 40 cm, respectively.

3.8.3. Layout of the experimental plots

Total number of plots	: 21
Individual plot size (2m×3m)	: 6 m^2
Space between block to block	: 0.75 m
Block to border (row)	: 0.75 m
Block to border (column)	: 0.50 m
Replication	: 3
Drainage size	: 0.5 m

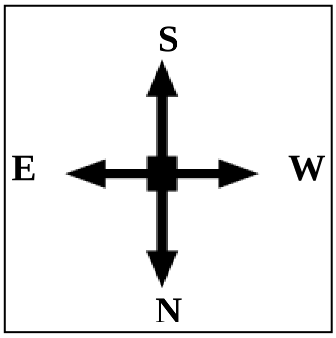


Figure 1. Compass

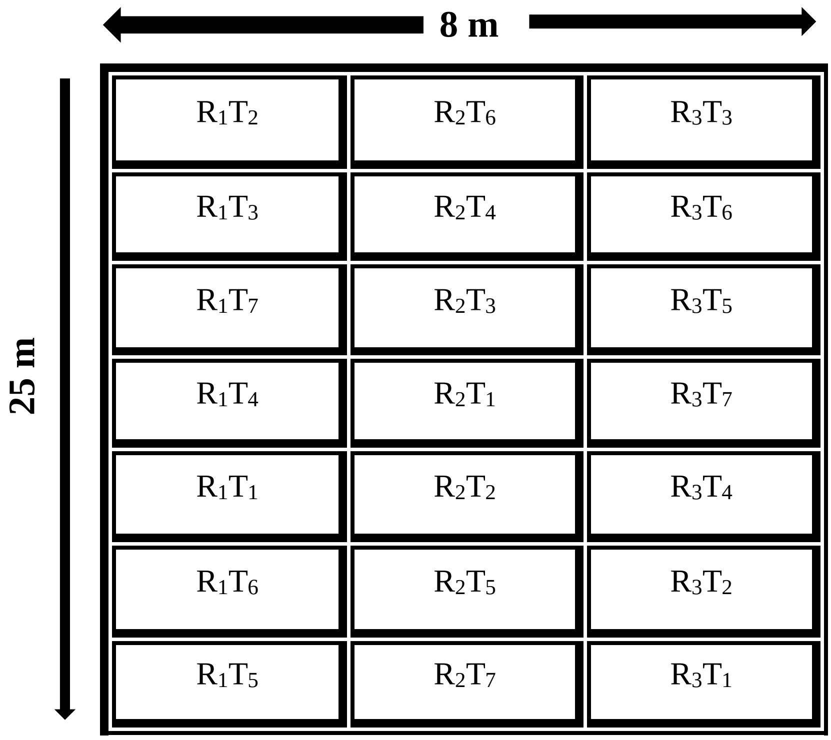


Figure 2. Field layout of the experimental plot

3.9. Collection of seedlings

25 days old tomato seedlings were collected from the Horticulture Center, Falabithi, Department of Agricultural Extension, Asadgate, Dhaka-1207. The seedlings were collected on 25th December 2020.

3.10. Plot preparation

Silty clay soil and the proper amount of fertilizer were mixed as per the plot recommendation. Then the field was filled with Furadan 5G (an insecticide) @ 15 kg ha^{-1} was also applied during final soil preparation to control cutworms and other soil insects. Then plots were placed on rooftops and arranged through experimental design. The plots were ready for transplanting seedlings.

3.11. Manures and fertilizers

The entire amounts of basal dose of fertilizer as per treatments and vermicompost were applied during the final land preparation. Vermicompost contains 2.0% Nitrogen, 1.5% P and 2% K respectively (www.organic manures nitrogen, phosphate, and potassium status.com).

According to Abd-Elzaher *et al.* (2022), Urea is a source of nitrogen, TSP is a source of phosphorus, MoP is a source of potassium, 90% Gypsum is a source of sulphur, Zinc sulphate heptahydrate ($ZnSO_4.7H_2O$) is a source of zinc and Boric acid as a source of boron. TSP, MoP, sulphur, zinc sulphate, and boric acid were applied as basal doses during final land preparation. Urea was applied as per treatment in three equal splits at 15, 35, and 55 days after transplanting as the 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 on the afternoon of 25th December 2020 maintaining the experimental design. In order to minimize the damage to the root system, the seedbed was watered before uprooting the seedlings. The seedlings were watered after transplanting. Shading was provided using a banana leaf sheath for three days to protect the seedling from the hot sun and removed after the 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. 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.

3.13.2. 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.

3.13.3. Irrigation

Irrigation was provided immediately after transplanting, and it continued until the seedlings were established in the plot. A high frequency of irrigation was demanded because it was a rooftop experiment. The 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.

3.13.4. 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.

3.13.5. Plant protection

3.13.5.1. 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 intervals 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 insect pests like leaf hopper, fruit borer, and others. The insecticide application was made fortnightly after transplanting and stopped before the second week of the first harvest.

3.13.5.2. Disease

During foggy weather precautionary measures 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.

3.13.6. Harvesting

Fruits were harvested at 3 days intervals during the early ripe stage when they developed a slightly red color. The harvesting of tomatoes was started on 20th March, 2021 and continued up to 7th April, 2021.

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

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

x. Post-harvest soil data

a) Soil organic matter (%),

b) Soil pH,

c) Phosphorus content in soil (ppm) and

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

3.13.8. Detailed procedures for data collection

3.13.8.1. Plant height

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

3.13.8.2. Number of leaves plant^{-1}

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

3.13.8.3. 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 chosen at random from the inner rows of each plot.

3.13.8.4. 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 plant^{-1} was calculated.

3.13.8.5. Number of flowers cluster^{-1}

The number of flowers per cluster was calculated as follows:

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

3.13.8.6. 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.

3.13.8.7. 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 to determine the individual fruit weight in grams. The weight was calculated from the total weight of fruits divided by the total number of fruits of every harvest and finally making the average was made from four times harvesting data.

3.13.8.8.Yield of fruit plot^{-1}

The yield of tomato plot^{-1} was calculated by converting the weight of plant yield into 4.00 m^2 and was expressed in kilogram (kg).

3.13.8.9. Yield

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

3.13.8.10. Collection of Samples

3.13.8.10.1. 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 on 07th May, 2021. The samples were air-dried, grounded, and sieved through a 2 mm sieve and preserved for analysis.

3.13.8.10.2. Soil Sample Analysis

The initial and postharvest soil sample were analyzed 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 following standard methods analyzed the soil:

3.13.8.10.3. 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 Cherie (2022).

3.13.8.10.4. Organic matter

The soil's organic matter was determined by the wet oxidation method described by Walkley and Black (1934) and Page Jr *et al.* (1982). To obtain organic matter content, the amount of organic matter was multiplied by the van Bemmelen factor of 1.73 (Chaikaew and Chavanich, 2017). The result was expressed in percentage.

3.13.8.10.5. 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 color using $SnCl_2$ reduction of phosphomolybdate complex. The absorbance of the molybdophosphate blue color was measured at 660 mm wavelength by spectrophotometer, and available P was calculated with the help of a standard curve.

3.13.8.10.6. 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 (Ullah *et al.*, 2022).

3.13.9. Statistical analysis

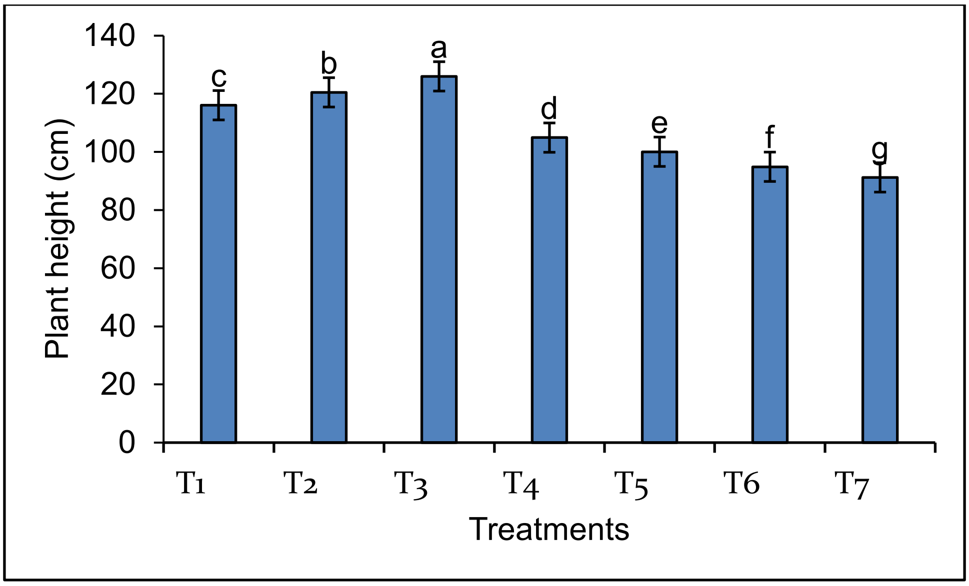
All the data were statistically analyzed by using statistix 10 computer package programs for different characters to find out the significance of the difference between the different doses of potassium on yield and yield contributing characteristics of onion. The mean values of all the treatments were calculated, and analyses of variance for all the characters were performed by the F-test (variance ratio). The significance of the difference among the treatment combinations of means was estimated by least significance difference (LSD) at a 5% level of probability.

CHAPTER IV
RESULTS AND DISCUSSION

The purpose of the experiment was to determine the effect of vermicompost and inorganic fertilizer on tomato growth and yield. In this chapter, the results of the study are given, discussed, and compared via table(s) and/or figure(s). In the appendices, the analysis of data variance for all parameters is displayed. The data have been presented and discussed with the aid of tables, graphs, and possible interpretations listed below. The following headings have been used to present the analytical results:

4.1 Plant height

Plant height is one of the important parameters, which is positively correlated with the yield of tomato. The application of vermicompost and inorganic fertilizer exhibited a significant influence on the height of tomato plants at the time of final harvest (Figure 3). Plant height ranged from 91.23 cm to 126.00 cm due to the different vermicompost and inorganic fertilizer applications. At the final harvest, the longest plant (126.00 cm) was recorded from the T_3 (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ + 2700 kg VC ha^{-1}) treatment whereas the shortest (91.23 cm) was from the T_7 (Full VC 9350 kg ha^{-1}) treatment. Vermicompost (2700 kg VC ha^{-1}), along with inorganic fertilizer (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$) performed best in recording plant height compared to other treatment(s) combinations. The lowest plant height was noted from the T_7 treatment having no inorganic fertilizer throughout the entire growth period of the crop. Vermicompost is rich in nitrogen and nutrient content. This favorable condition creates better nutrient absorption and favors vegetative growth. It is found 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, 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 the control. (Abafita, 2014).



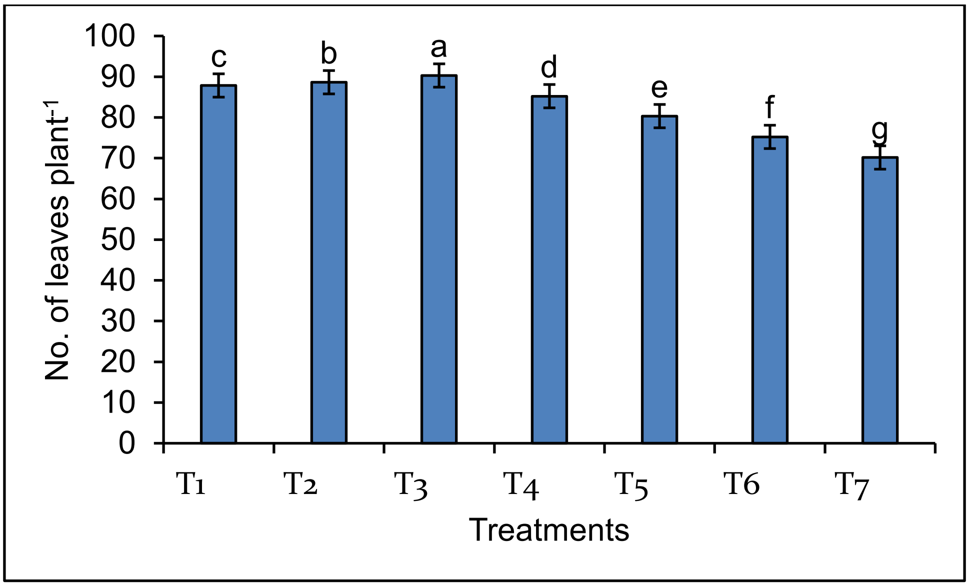
Here, $T_1 = N_{140} P_{45} K_{60} Zn_{2.0} B_{1.0}$ + No organic kg ha^{-1}; $T_2 = N_{120} P_{40} K_{55} Zn_{1.5} B_{1.0}$ + 1350 kg VC ha^{-1}; $T_3 = N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$ + 2700 kg VC ha^{-1}; $T_4 = N_{80} P_{30} K_{45} Zn_{1.0} B_{1.0}$+ 4050 kg VC ha^{-1}; $T_5 = N_{60} P_{25} K_{40} Zn_{1.0} B_{1.0}$+ 5400 kg VC ha^{-1}; $T_6 = N_{40} P_{20} K_{35} Zn_{1.0} B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};Values in a column with letters are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications

Figure 3. Effects of different vermicompost and inorganic fertilizers doses on plant height

Rashid *et al.* (2014) found that 85% of recommended chemical fertilizers with 3 t ha^{-1} vermicompost fertilizer gave the best result on plant height. Shrestha *et al.* (2018); Wako and Muleta (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest plant height over other treatments.

4.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} is a fundamental morphological character for plant growth and development as the leaf is the main photosynthetic organ. To investigate the effect of different vermicompost and inorganic fertilizer combinations, changes in the number of leaves plant^{-1} of tomato were counted. Different vermicompost and inorganic fertilizer combinations showed a significant influence on the formation of leaves plant^{-1} (Figure 4). At harvesting time, the maximum number of leaves plant^{-1} (90.30) was recorded from T_3 ($N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$ + 2700 kg VC ha^{-1}) treatment and the minimum (70.16) was recorded from T_7 (Full VC 9350 kg ha^{-1}) treatment. These results indicate that the highest number of leaves plant^{-1} was found from Vermicompost (2700 kg VC ha^{-1}) with inorganic fertilizer ($N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$) whereas, the lowest number of leaves plant^{-1} was produced from no chemical fertilizer application. So, the optimum level of vermicompos makes the availability of macro and micronutrients and the ultimate results were the maximum numbers of leaves plant^{-1}. Vermicompost contains an appreciable amount of nitrogen and other essential elements which encourage vegetative growth as well as the number of leaves.



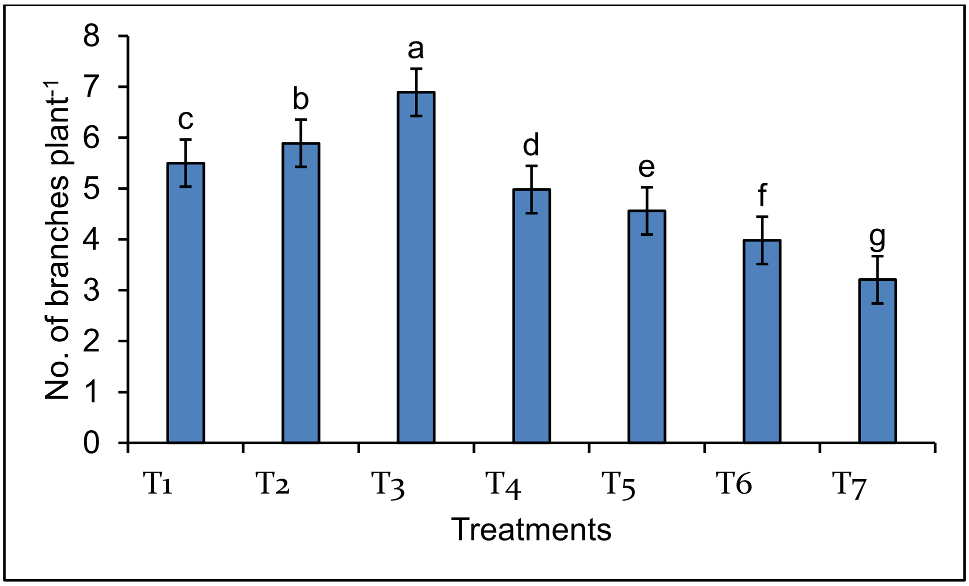
Here, T_1 = N_{140} P_{45} K_{60} $Zn_{2.0}$ $B_{1.0}$ + No organic kg ha^{-1}; T_2 = N_{120} P_{40} K_{55} $Zn_{1.5}$ $B_{1.0}$ + 1350 kg VC ha^{-1}; T_3 = N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ + 2700 kg VC ha^{-1}; T_4 = N_{80} P_{30} K_{45} $Zn_{1.0}$ $B_{1.0}$+ 4050 kg VC ha^{-1}; T_5 = N_{60} P_{25} K_{40} $Zn_{1.0}$ $B_{1.0}$+ 5400 kg VC ha^{-1}; T_6 = N_{40} P_{20} K_{35} $Zn_{1.0}$ $B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};Values in a column with letters are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications

Figure 4. Effects of different vermicompost and inorganic fertilizers doses on no. of leaves plant^{-1}

The present findings also supported the statement of Kauser (2016). Hyder *et al.* (2015) and Abafita *et al.* (2014) confirmed that vermicompost has a tremendous potential for 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). Rashid *et al.* (2014) found that 85% of recommended chemical fertilizers with 3 t ha^{-1} vermicompost manure gave the best result on the numbers of leaves plant^{-1}. Shrestha *et al.* (2018); Wako and Muleta (2022) recorded that the treatment with vermicompost dose of 2.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest numbers of leaves plant^{-1} over other treatments.

4.3 Number of branches plant^{-1}

Different vermicompost and inorganic fertilizer combinations showed a significant influence on the formation of branches plant^{-1} (Figure 5). At harvesting time, the highest number of branches plant^{-1} (6.89) was recorded from T_3 (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ + 2700 kg VC ha^{-1}) treatment. On the other hand, the lowest number of branches plant^{-1} (3.21) was recorded from T_7 treatment. These results indicate that the highest number of branches plant^{-1} found from Vermicompost (2700 kg VC ha^{-1}) with inorganic fertilizer (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$) whereas the lowest number of branches plant^{-1} was produced from no chemical fertilizer application.



Here, T_1 = N_{140} P_{45} K_{60} $Zn_{2.0}$ $B_{1.0}$ + No organic kg ha^{-1}; T_2 = N_{120} P_{40} K_{55} $Zn_{1.5}$ $B_{1.0}$ + 1350 kg VC ha^{-1}; T_3 = N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ + 2700 kg VC ha^{-1}; T_4 = N_{80} P_{30} K_{45} $Zn_{1.0}$ $B_{1.0}$+ 4050 kg VC ha^{-1}; T_5 = N_{60} P_{25} K_{40} $Zn_{1.0}$ $B_{1.0}$+ 5400 kg VC ha^{-1}; T_6 = N_{40} P_{20} K_{35} $Zn_{1.0}$ $B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};Values in a column with letters are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications

Figure 5. Effects of different vermicompost and inorganic fertilizers doses on no. of branches plant^{-1}

Chanda *et al.* (2011) and Prodhan (2011) observed that vermicompost supplemented with NPK treated plots displayed better results regarding 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 the number of flower clusters plant^{-1} at different vermicompost and inorganic fertilizers (Table 1). The highest number of flower clusters plant^{-1} (19.24) was found from T_3 treatment which was flowed by T_2 (18.22) and T_1 (17.19) treatment whereas, the lowest number of clusters (8.86) and (9.99) was recorded from T_7 and T_6 treatments respectively. These results indicate that vermicompost along with chemical fertilizer increased the formation of the number of flower clusters plant^{-1}.

Table 1. Effects of different vermicompost and inorganic fertilizers doses on Number of flower clusters plant^{-1}, Number of flowers cluster^{-1} of BARI Tomato 15

Treatment	Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}
T_1	17.19 b	5.87 a
T_2	18.22 ab	6.02 a
T_3	19.24 a	6.67 a
T_4	11.99 c	4.47 b
T_5	10.93 cd	4.01 b
T_6	9.99 de	3.75 bc
T_7	8.86 e	3.14 c
LSD $_{0.05}$	0.58	0.39
CV (%)	1.27	0.85

Here, dissimilar letter differs significantly at 0.05 percent level of probability. $T_1 = N_{140}\ P_{45}\ K_{60}\ Zn_{2.0}\ B_{1.0}$ + No organic kg ha^{-1}; $T_2 = N_{120}\ P_{40}\ K_{55}\ Zn_{1.5}\ B_{1.0}$ + 1350 kg VC ha^{-1}; $T_3 = N_{100}\ P_{35}\ K_{50}\ Zn_{1.5}\ B_{1.0}$ + 2700 kg VC ha^{-1}; $T_4 = N_{80}\ P_{30}\ K_{45}\ Zn_{1.0}\ B_{1.0}$+ 4050 kg VC ha^{-1}; $T_5 = N_{60}\ P_{25}\ K_{40}\ Zn_{1.0}\ B_{1.0}$+ 5400 kg VC ha^{-1}; $T_6 = N_{40}\ P_{20}\ K_{35}\ Zn_{1.0}\ B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};

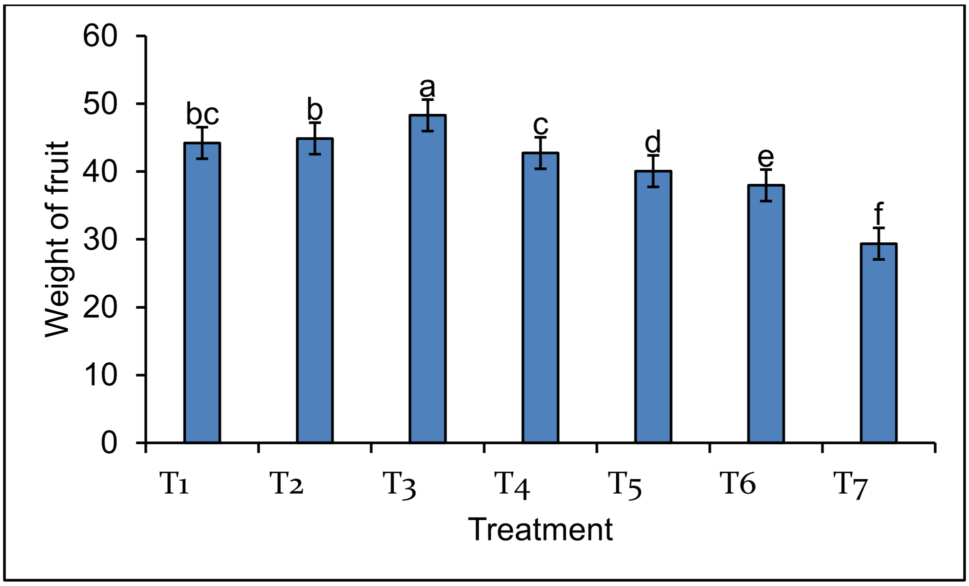
Kauser (2016) said that the maximum number of clusters plant^{-1} were recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) and Miah (2010) reported that the maximum number of flower clusters plant^{-1} (9.74) was recorded from vermicompost.

4.5 Number of flowers cluster^{-1}

Vermicompost and inorganic fertilizers had a significant effect on the number of flower cluster^{-1} of tomato (Table 1). The maximum number of flowers cluster^{-1} observed from T_3 treatment was (6.67), which is statistically similar to T_2 and T_1 treatments (6.02) and (5.87) respectively. On the other hand, the minimum number of flowers cluster^{-1} observed from T_7 treatment was (3.14) which is statistically similar to T_6 and T_5 treatments (3.75) and (4.01) respectively. From this result it was found that the vermicompost along with chemical fertilizer produce the maximum 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 cluster^{-1} (8.25) was recorded from vermicompost with the mixture of inorganic fertilizer.

4.6 Individual fruit weight

Individual fruit weight of tomato is highly influenced by different vermicompost and chemical fertilizer (Figure 6). The maximum fruit weight (48.29 g) was obtained from the T_3 treatment whereas, the minimum (29.37 g) was obtained from the T_7 treatment. Haque *et al.* (2021) recorded that the higher weight of fruit plant^{-1} was observed in 85% of recommended chemical fertilizer with 3.00 t ha^{-1} vermicompost. Kauser (2016) recorded that the maximum fresh weight of fruit (88.59 g) was 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 vermicompost.



Here, $T_1 = N_{140}\ P_{45}\ K_{60}\ Zn_{2.0}\ B_{1.0}$ + No organic kg ha^{-1}; $T_2 = N_{120}\ P_{40}\ K_{55}\ Zn_{1.5}\ B_{1.0}$ + 1350 kg VC ha^{-1}; $T_3 = N_{100}\ P_{35}\ K_{50}\ Zn_{1.5}\ B_{1.0}$ + 2700 kg VC ha^{-1}; $T_4 = N_{80}\ P_{30}\ K_{45}\ Zn_{1.0}\ B_{1.0}$+ 4050 kg VC ha^{-1}; $T_5 = N_{60}\ P_{25}\ K_{40}\ Zn_{1.0}\ B_{1.0}$+ 5400 kg VC ha^{-1}; $T_6 = N_{40}\ P_{20}\ K_{35}\ Zn_{1.0}\ B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};Values in a column with letters are significantly different at $p \leq 0.05$ applying Fisher's LSD test. Bars represent ±SD values of three biological replications

Figure 6. Effects of different vermicompost and inorganic fertilizers doses on weight of fruit

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 the same treatment combinations. Ewulo *et al.* (2008) stated that manure applications increased the 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} vermicompost 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 85% recommended dose of chemical fertilizers with 2.5 t ha^{-1} of vermicompost application.

4.7 Number of fruits plant^{-1}

Significant effect of vermicompost and inorganic fertilizer was found on the number of fruits plant^{-1} of tomato (Table 2). The highest number of fruits plant^{-1} (31.77) was obtained from T_3 treatment. On the other hand, the lowest number (19.09) of fruits plant^{-1} was obtained from the T_7 treatment. These results indicate that the highest number of fruits plant^{-1} found from Vermicompost (2700 kg VC ha^{-1}) with inorganic fertilizer (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$) whereas the lowest number of fruits plant^{-1} was produced from no 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} vermicompost. 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 plant^{-1} (42.07) was recorded from vermicompost. Chanda *et al.* (2011) and Prodhan (2011) concluded that vermicompost supplemented with NPK treated plots displayed better results regarding number of fruits plant^{-1} 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 plant^{-1} were also significantly higher as compared to those on agrochemicals and conventional compost.

4.8 Yield of fruit plot^{-1}

At different vermicompost and chemical fertilizer combination application significantly differ in the yield of fruit plot^{-1} was found (Table 2). The maximum yield of fruit plot^{-1} (37.23 kg) was obtained in T_3 treatment which was followed by T_2 treatment (35.56 kg) and the minimum yield (30.32 kg) was obtained in T_7 treatment which was statistically similar to the treatments of T_5 (31.16 kg) and T_6 (31.69 kg). Kauser (2016) recorded that the maximum yield of fruit plot^{-1} (25.24 kg) was recorded from the treatment of 3.75 t ha^{-1} vermicompost. Parvin (2012) recorded that the maximum yield plot^{-1} (44.08 kg) was recorded from the vermicompost application. Miah (2010) reported that the maximum yield (40.70 kg plot^{-1}) was obtained from vermicompost application. Integrated nutrient management (combination of organic and inorganic fertilizer) is the best option for higher tomato production in Bangladesh.

Table 2. Effects of different vermicompost and inorganic fertilizers doses on Number of fruits plant^{-1}, Yield of fruit plot^{-1} (kg) and yield (t ha^{-1}) of BARI Tomato 15

Treatment	Number of fruits plant^{-1}	Yield of fruit plot^{-1} (kg)	Yield (t ha^{-1})
T_1	28.20 b	34.22 bc	56.27 c
T_2	29.77 b	35.56 ab	58.23 b
T_3	31.77 a	37.23 a	60.86 a
T_4	25.13 c	33.17 cd	54.57 d
T_5	23.82 c	31.16 de	52.54 e
T_6	21.19 d	31.69 de	51.79 e
T_7	19.09 e	30.32 e	49.44 f
LSD $_{0.05}$	0.82	0.63	0.45
CV (%)	1.79	2.21	1.58

Here, dissimilar letter differs significantly at 0.05 percent level of probability. $T_1 = N_{140} P_{45} K_{60} Zn_{2.0} B_{1.0}$ + No organic kg ha^{-1}; $T_2 = N_{120} P_{40} K_{55} Zn_{1.5} B_{1.0}$ + 1350 kg VC ha^{-1}; $T_3 = N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$ + 2700 kg VC ha^{-1}; $T_4 = N_{80} P_{30} K_{45} Zn_{1.0} B_{1.0}$+ 4050 kg VC ha^{-1}; $T_5 = N_{60} P_{25} K_{40} Zn_{1.0} B_{1.0}$+ 5400 kg VC ha^{-1}; $T_6 = N_{40} P_{20} K_{35} Zn_{1.0} B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};

4.9 Yield

There was a significant difference in the yield of tomato in respect of vermicompost and chemical fertilizer of tomato (Table 2). The highest yield (60.86 t ha^{-1}) of tomato was found in the T_3 treatment, whereas the lowest yield (49.44 t ha^{-1}) of tomato was found in the T_7 (full dose VC) treatment. These results indicated that the maximum yield was found from Vermicompost (2700 kg VC ha^{-1}) with inorganic fertilizer ($N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$) whereas, the lowest number of yield plant^{-1} was produced from no chemical fertilizer application. Haque *et al.* (2021) showed that the highest yield was observed in 85% of recommended chemical fertilizers 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 vermicompost 2.5 t ha^{-1}. Shrestha *et al.* (2018) found that the treatment with a 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 of 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 ha^{-1} (69.10 t ha^{-1}) was 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 ha^{-1} (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 the 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 ha^{-1} (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 vermicompost. 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} was obtained from the application of the 85% recommended dose of nutrients, 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}).

4.10 Post-Harvest Soil Data

4.10.1 Soil organic matter

There was a significant residual effect of vermicompost and chemical fertilizer (Table 3). The highest organic matter (0.85%) was noted in treatment T_3. The effect of this treatment was statistically similar to T_5 (0.85 %) and T_6 (0.85 %) treatments but superior to the rest of the treatments. Treatment T_4 (0.78 %) and T_7 (0.78 %) were statistically identical in recording organic matter in soil and ranked in second position. This might be due to higher amounts of vermicompost along with chemical fertilizer applied, resulting in increased organic matter in soil due to organic manure treated plots than only chemical fertilizer and full dose vermicompost treatments. The lowest organic matter (0.60 %) was noted in T_1 treatment of the crop. Shrestha *et al.* (2018) found that the treatment with a compost dose of 12.5 t ha^{-1} with half dose of recommended dose of chemical fertilizers produced the highest soil organic matter. Harun-Or-Rashid (2011) reported that the maximum soil organic matter (0.85%), was observed in treatments receiving 260 kg N ha^{-1} with 10.0 t ha^{-1} cowdung.

Table 3. Effects of different vermicompost and inorganic fertilizers doses on soil characteristics after harvest of BARI Tomato 15

Treatment	Organic matter (%)	Soil pH	Phosphorus content in soil (ppm)	Potassium content in soil (meq. /100 g soil)
T_1	0.60 e	6.00	10.00 d	0.11
T_2	0.71 c	6.01	14.50 b	0.12
T_3	0.64 d	6.13	12.00 c	0.12
T_4	0.78 b	6.02	14.50 b	0.11
T_5	0.85 a	6.17	12.00 c	0.13
T_6	0.85 a	6.03	23.00 a	0.12
T_7	0.78 b	6.08	15.00 b	0.12
$LSD_{0.05}$	**0.03**	**NS**	**1.75**	**NS**
CV (%)	**5.45**	**0.25**	**7.54**	**7.42**

Here, dissimilar letter differs significantly at 0.05 percent level of probability. $T_1 = N_{140} P_{45} K_{60} Zn_{2.0} B_{1.0}$ + No organic kg ha^{-1}; $T_2 = N_{120} P_{40} K_{55} Zn_{1.5} B_{1.0}$ + 1350 kg VC ha^{-1}; $T_3 = N_{100} P_{35} K_{50} Zn_{1.5} B_{1.0}$ + 2700 kg VC ha^{-1}; $T_4 = N_{80} P_{30} K_{45} Zn_{1.0} B_{1.0}$+ 4050 kg VC ha^{-1}; $T_5 = N_{60} P_{25} K_{40} Zn_{1.0} B_{1.0}$+ 5400 kg VC ha^{-1}; $T_6 = N_{40} P_{20} K_{35} Zn_{1.0} B_{1.0}$+ 6750 kg VC ha^{-1}; T_7 = Full VC 9350 kg ha^{-1};

4.10.2 Soil pH

Soil pH was not significantly influenced by the residual effect of vermicompost along with chemical fertilizer on the crop (Table 3). Each successive level of residual vermicompost decreased the soil pH. The maximum soil pH (6.17) was recorded in T_5 treatment. The effect of T_5 (6.17) treatment was closely related to T_3 (6.13) and T_7 (6.08) treatment and ranked second in position. The minimum soil pH (6.00) was noted in T_1 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.

4.10.3 Phosphorus content in the soil

Post-harvest soils were influenced due to the application of vermicompost along with chemical fertilizer (Table 3). Available P of the postharvest soils ranged from 10.0 to 23.0 ppm against the P content of 11.0 ppm in the initial soil. Available P of the post-harvest soils increased in all cases compared to the initial soils except for the control. The highest available P content in soil (23.0 ppm) was recorded in the T_6 treatment. Soil treated with organic manures along with chemical fertilizer gave higher values of available P compared to other treatments. The release of available P from the decomposition of vermicompost might be cause of higher available P in soils treated with vermicompost. The lowest available phosphorus (10.0 ppm) was noted in full dose vermicompost treatment (T_1).

4.10.4 Potassium content in soil

Potassium content in soil was increased significantly due to the residual effect of vermicompost along with chemical fertilizer (Table 3). The maximum potassium content in soil (0.129 meq. /100 g soil) was recorded from the treatment T_3 receiving vermicompost along with chemical fertilizer. The effects of this treatment were statistically superior to the rest of treatments of the crop. Treatment T_1 (0.123 meq. /100 g soil) receiving vermicompost along chemical fertilizer was statistically similar related to T_4 and T_5 treatment. The minimum potassium content in soil (0.110 meq. /100 g soil) was recorded from full dose vermicompost (T_7) treatment.

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled "**EFFECT OF VERMICOMPOST AND INORGANIC FERTILIZER ON GROWTH AND YIELD OF TOMATO"** was carried out during the period from December 2020 to April 2021 under AEZ 28 (Madhupur tract), Sher-e-Bangla Nagar, Dhaka-1207. The experiment comprised of single factor comprising eight treatments viz. $T_1 = N_{140}\ P_{45}\ K_{60}\ Zn_{2.0}\ B_{1.0}$ + No organic kg ha^{-1}, $T_2 = N_{120}\ P_{40}\ K_{55}\ Zn_{1.5}\ B_{1.0}$ + 1350 kg VC ha^{-1} , $T_3 = N_{100}\ P_{35}\ K_{50}\ Zn_{1.5}\ B_{1.0}$ + 2700 kg VC ha^{-1} , $T_4 = N_{80}\ P_{30}\ K_{45}\ Zn_{1.0}\ B_{1.0}$+ 4050 kg VC ha^{-1} , $T_5 = N_{60}\ P_{25}\ K_{40}\ Zn_{1.0}\ B_{1.0}$+ 5400 kg VC ha^{-1} , $T_6 = N_{40}\ P_{20}\ K_{35}\ Zn_{1.0}\ B_{1.0}$+ 6750 kg VC ha^{-1} , T_7 = Full VC 9350 kg ha^{-1} . 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_3 [$N_{100}\ P_{35}\ K_{50}\ Zn_{1.5}\ B_{1.0}$ + 2700 kg VC ha^{-1}] exhibited its superiority compared to other inorganic fertilizer with different doses of vermicompost treatments in terms of fruit yield of tomato. Treatment T_3 also showed the longest plant (126.00 cm), the maximum number of leaves $plant^{-1}$ (90.30), the highest number of branches $plant^{-1}$ (6.89), the highest number of flower clusters $plant^{-1}$ (19.24), maximum number of flowers $cluster^{-1}$ (6.67), highest number of fruits $plant^{-1}$ (31.77), maximum fruit weight (48.29 g), maximum yield of fruit $plot^{-1}$ (37.23 kg), highest yield (60.86 t ha^{-1}) than other treatments in this experiment. On the other hand, the treatment T_7 [full dose VC] returned with 67.37% lower yield than treatment T_3 which was significantly the lowest compared with other treatments under study.

In case of soil properties, the highest soil organic matter (0.85%) and the maximum soil pH (6.21) was recorded from treatment T_3 in post-harvest soil. Considering the soil nutrients, 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_2 receiving chemical fertilizer.

CONCLUSION

From the above result, it was revealed that T_3 [N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$ + 2700 kg VC ha^{-1}] treatment gave a higher yield along with higher values in all the growth and yield attributing parameters. It can be said that a 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 (2700 kg VC ha^{-1}) + (N_{100} P_{35} K_{50} $Zn_{1.5}$ $B_{1.0}$) 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 vermicompost may be used along with different levels of inorganic chemical fertilizer in a tomato field for getting a variety of 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.

CHAPTER VI

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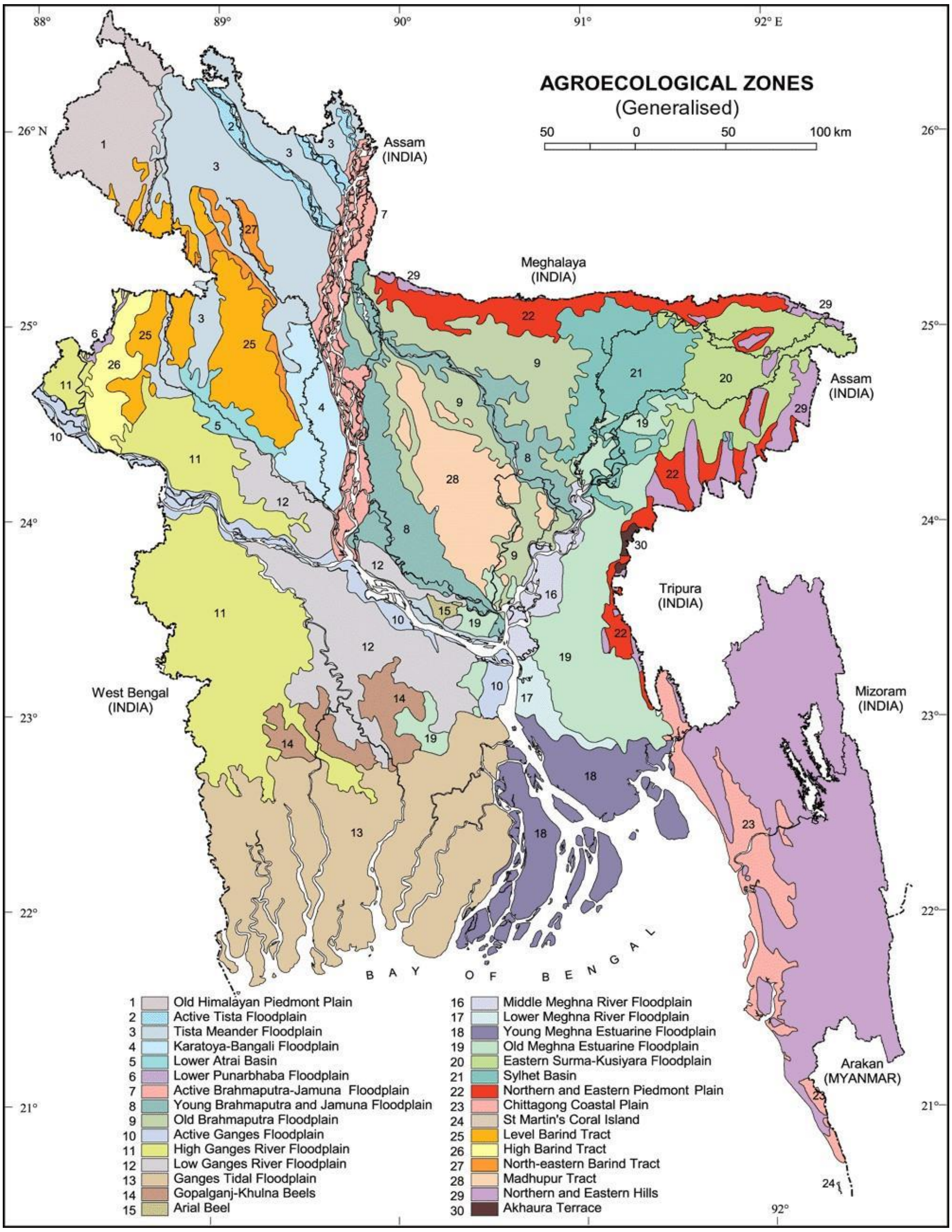
CHAPTER VII

APPENDICES

Appendix I. Map Showing the experimental site under study



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of experimental field

Morphological features	Characteristics
Location	Agronomy field, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. Physiological properties of the initial soil

Characteristics	Value
Particle size analysis	
Sand%	25
Silt%	45
Clay%	30
Textural Classes	Silty -Clay
pH	6.00
Particle density (g/cc)	2.68
Organic matter (%)	0.47
Organic matter (%)	0.80
Available P (ppm)	22.00
Exchangeable K (meq/100g soil)	0.121

Appendix III. Monthly average of relative humidity, air temperature, and total rainfall of the experimental site during the period from November 2020 to April 2021

Month	Average RH%	Average temperature (C^0)		Total Average Rainfall(mm)
		Min.	Max.	
November, 2020	50.45	8.56	24.87	00
December, 2020	52.41	6.04	23.35	00
January, 2021	59.13	12.45	21.32	00
February, 2021	53.66	16.34	24.12	4.34
March, 2021	46.37	19.41	28.54	1.22

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

Appendix IV. Schedule of cultural operation in the experiment

Serial No.	Cultural preparation	Date
1.	Transplanting of seedlings to the main field	25.12.2020
2.	Gap fillings	05.01.2021
3.	1st Irrigation	20.01.2021
4.	Tagging	23.01.2021
5.	1st Weeding with mulching	28.01.2021
6.	2nd Irrigation	15.02.2021
7.	Drainage	18.02.2021
8.	2nd Weeding	03.03.2021
9.	Fencing with Net	03.03.2021
10.	Data collection with different parameters	10.03.2021
11.	1st Harvesting	20.03.2021
12.	Final Harvesting	07.04.2021
13.	Collection post-harvest soil	07.05.2021
14.	Analysis of soil sample	25.05.2021

Appendix V. 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	1.51	2.01	6.69
Treatment	6	534.82	172.26	4.53
Error	12	0.32	0.08	0.01

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

Appendix VI. 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	6.58	2.63	20.47
Treatment	6	55.51	5.36	63.75
Error	12	0.51	0.23	1.015

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

Appendix VII. Error mean square values for fruit weight, yield of fruits plot^{-1} and yield of tomato

Source of variation	Degrees of freedom	Fruit weight	Yield of fruits plot^{-1}	Yield
Replication	2	12.33	0.3586	12.34
Treatment	6	113.39	18.7218	46.78
Error	12	1.17	0.6016	0.31

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

Some memories during my research

Plate 1. Land preparation

Plate 2. Data collection of seedlings

Plate 3. Flowering

Plate 4. Fruit setting

Plate 6. Collecting and processing soil samples for testing

Plate 5. sieving

Plate 7. filtering

Plate 8. filtration of a soil solution

A memory with my respected supervisor

The End

Thank You!