GROWTH, FRUIT SET AND YIELD OF SUMMER TOMATO INFLUENCED BY 4-CPA AND VERMICOMPOST

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*This is to certify that the thesis entitled "**GROWTH, FRUIT SET AND YIELD OF SUMMER TOMATO INFLUENCED BY 4-CPA AND VERMICOMPOST**" submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the results of a piece of bona fide research work carried out by **MOST.SHARMIN AKTER SHILPI**, Registration. No. **12-04752** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

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

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The Author

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ABSTRACT

A pot experiment was conducted during the period of April 2017 to October 2017. The research work was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment consisted of two factors. Factor A: Four levels of 4-CPA viz., H_0: Control, H_1: 15 ppm, H_2: 45 ppm, H_3: 75 ppm and Factor B: four levels of vermicompost i.e. VC_0: Control, VC_1: 500 g/pot, VC_2: 1 kg/pot, VC_3: 1.5 kg/pot respectively. The experiment was laid out in Completely Randomized Design method with three replications. 4-CPA and vermicompost showed significant variations with most of the parameters. In case of 4-CPA the highest amount of yield (3.23 kg/plant) was recorded from H_3 and lowest (2.37 kg/plant) from H_0. For vermicompost, the highest amount of yield (3.31 kg/plant) was from VC_3 and lowest (2.34 kg/plant) from VC_0. For combine effect the highest yield (3.66 kg/plant) was noted from H_3VC_3 and the lowest (0.95 kg/plant) from H_0VC_0. So, the use of 75 ppm 4-CPA with 1.5 kg vermicompost gave best result for growth and yield of summer tomato.

LIST OF ABBREVIATED TERMS

ABBREVIATION	FULL NAME
AEZ	Agro-Ecological Zone
^{0}C	Degree Celsius
Cm	Centimeter
DAT	Days After Transplanting
et al.	And others
G	gram(s)
H	Hormone
Kg	Kilogram
LSD	Least Significant Differences
No.	Numbers
NS	Not significant
Ppm	Parts per million
SAU	Sher-e-Bangla Agricultural University
SRDI	Soil Resources and Development Institute
VC	Vermicompost
4-CPA	4-Chlorophenoxyacetic Acid

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CHAPTER I

INTRODUCTION

Tomato (*Solanum Lycopersicum L.*) is one of the most important vegetable crops in Bangladesh. It belongs to the Solanaceae family. It was originated in tropical America (Salunkhe *et al.*, 1987), particularly in Peru, Ecuador and Bolivia of the Andes (Kalloo, 1989). The Nahuatl (Aztec language) word tomatl gave rise to the Spanish word tomate, from which the English word tomato-derived. Its use as a cultivated food may have originated with the indigenous peoples of Mexico. The Spanish encountered the tomato from their contact with the Aztec during the Spanish colonization of the Americas and brought it to Europe. From there, the tomato was introduced to other parts of the European-colonized world during the 16th century. Tomato plants are vines, initially decumbent, typically growing 180 cm (6 ft) or more above the ground if supported. Tomato plants are dicots and grow as a series of branching stems, with a terminal bud at the tip that does the actual growing.

The fruit is a familiar vegetable, but the fruit, leaf, and vine are used to make medicine. Tomato is used for preventing cancer of the breast, bladder, cervix, colon and rectum, stomach, lung, ovaries, pancreas, and prostate. It is also used to prevent diabetes, diseases of the heart and blood vessels (cardiovascular disease) and asthma. Tomato is an essential component of the human diet that supplies vitamins and minerals .Tomatoes are the major dietary source of the antioxidant lycopene, which has been linked to many health benefits, including reduced risk of heart disease and cancer. They are also a great source of vitamin C, potassium, folate, and vitamin K. An essential mineral, potassium is beneficial for blood pressure control and heart disease prevention, folate is important for normal tissue growth and cell function. It’s particularly important for pregnant women. Tomato is used as a fresh salad, sauce, juice, curry, etc. Tomato juice, because of its various phytonutrients, can reduce the risk of blood clots.

The hormone 4-CPA is a plant growth regulator. Plant growth regulators (PGRs) are used in horticultural crops to enhance plant growth and improve yield by increasing fruit number, fruit set, and size (Batlang, 2008). Application of plant growth regulators has been shown to improve fruit setting (AVRDC, 1990). Sprays of hormone especially 4-CPA (4-chlorophenoxy acetic acid) on flower cluster effectively increase the fruit set as well as fruit production, 4-chlorophenoxyacetic acid (4-CPA) is one of the plant growth regulators which increases fruit set during summer (Sasaki *et al.* 2005). Tomato fruit set is hampered at high temperature. As a consequence, efficient tomato production in Bangladesh is mainly confined during winter (November-March) season. At higher temperature, the probability of floral abscission is high after anthesis (Iwahori, 1967). Fruit set depends on the successful completion of pollination and fertilization (Gillaspy *et al.*, 1993). In summer, tomato fruit set can be increased by applying plant growth regulators (Batlang, 2008; Rahman *et al.* 2015). High day and night temperatures above 32°C and 21°C, respectively, were reported as limiting fruit-set due to an impaired complex of the physiological process in the pistil, which results in floral or fruit abscission (Picken and Ahmedi 1984). The high temperature associated with high night temperature during summer affects fruit-set of tomatoes in the country. In such high-temperature conditions, tomato flowers often fail to set fruits which leads to low productivity of summer tomato.

Vermicompost is an important organic manure. Use of organic manures to meet the nutrient requirements of a crop would be a valuable practice for sustainable agriculture. Organic manure improves physical, chemical and biological properties of soil along with conserving the moisture holding capacity and thus resulting in enhanced crop productivity and quality (Premsekhar and Rajashree, 2009). Thus, the successful application of manure to soil requires an understanding of the impact of manure addition on microbial characteristics of the soil (Pell, 1997). Due to the adverse effects of chemical fertilizers, interest has been stimulated for the use of organic manures (Follet *et al.*, 1981).

The use of plant growth regulator and vermicompost improved the production of tomato which attracts the researchers and growers for its commercial application for summer tomato production. But very limited research has been conducted on the effect of different levels of 4-CPA and vermicompost on fruit set and yield of heat-tolerant tomato varieties. Therefore, the study was undertaken to find the impact of 4-CPA and vermicompost on growth, fruit set and yield of summer tomato

The present investigation was, therefore, carried out with a view to achieving the following objectives:

1. To find out the optimum dose of 4-CPA on growth, fruit set and yield of summer tomato.

2. To estimate the appropriate amount of vermicompost on growth, fruit set and yield of summer tomato.

3. To determine the suitable combination of 4-CPA and vermicompost on growth, fruit set and yield of summer tomato.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important and nutritious vegetables and widely grown vegetables worldwide. Till the production level of summer, the tomato has not met the demand of Bangladesh. A large quantity was needed to import every year which may lead the process of losing foreign currency and reserve. Moreover, the country with high temperature and dry weather around the year lead the loss of production. Many researchers were conducted their research to find out the effect of plant hormone 4-CPA and vermicompost. However, in this chapter, the literature available in this aspect in the country and abroad were reviewed.

2.1 Literature on hormone

Salwa *et al.* (2018) was conducted an experiment to evaluate the yield performance of five new hybrid combinations of tomato (DCH_1, DCH_2, DCH_3, TCH_1 and TCH_2) along with BARI Hybrid Tomato-4 at the experimental field of Horticulture Department, Sylhet Agricultural University in Randomized Complete Block Design (RCBD) under with and without hormone application systems (4-para chlorophenoxy acetic acid) during the summer season from May to September 2015. Both hybrids and hormone application systems had a significant influence on growth and yield of tomato during summer. The hybrid, BARI Hybrid Tomato-4 produced the highest number of fruits plant^{-1} (22.67) and fruit yield plant^{-1} (0.89 kg) closely followed by TCH_1 (0.84 kg plant^{-1}). The hybrid DCH_3 produced the heaviest individual fruit weight (46.65 g), but its plant yield was only 0.63 kg. The number of fruits plant^{-1}, individual fruit weight, and fruit yield were largely affected due to hormone application. Fruit yield plant^{-1} was quite high in the hormone-treated plant (0.82 kg) compared to untreated plant (0.68 kg). In general, all the hybrids performed better when treated with the hormone in respect of yield compared to their corresponding untreated plants. Among the hybrids, BARI Hybrid Tomato-4 had the highest fruit yield (1.03 kg plant^{-1}) followed by TCH_1 (0.92 kg plant^{-1}) when the plants were treated with the hormone. These two hybrids again produced an appreciable amount of tomato under untreated condition (0.75 kg plant^{-1} and 0.77 kg plant^{-1}, respectively). This indicates that there is a possible scope of tomato production during the summer season in Sylhet region with and without hormone application, though hormone application had a benefit on fruit yield.

Karim *et al.* (2015) a field experiment was conducted at the Horticulture Farm in the Department of Horticulture, Bangladesh Agricultural University, Mymensingh to evaluate the influence of different levels of 4-chlorophenoxy acetic acid on growth and yield potential of tomato during summer. The two-factor experiment viz., Factor A: four different concentrations of 4-chlorophenoxy acetic acid (4-CPA) i.e., concentrations of 4-CPA were (i) 0 ppm (without 4-CPA), (ii) 20 ppm, (iii) 40 ppm and (iv) 60 ppm; and Factor B: two varieties of summer tomato namely, BARI Hybrid Tomato-4 and 8. The experiment was laid out in randomized complete block design with three replications. At harvest, the tallest plant (78.53 cm), number of flowers and fruits (35.11and 18.10, respectively) plant^{-1}, fruit yield plant^{-1} and ha^{-1} (1.12 kg and 21.98 tons, respectively) were found in BARI Hybrid Tomato-8. At harvest, the maximum plant height (85.57 cm), number of flowers and fruits (44.89 and 24.97, respectively) plant^{-1}, fruit yield plant^{-1} and fruit yield ha^{-1} (1.32 kg and 27.78 tons, respectively) were found when 4-CPA applied at 60 ppm, whereas the minimum for these characters was recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (88.90 cm), number of flowers and fruits (40.04 and 21.99, respectively), fruit yield plant^{-1} and fruit yield ha^{-1} (1.34 kg and 28.28 tons, respectively) were observed in BARI Hybrid Tomato-8 when treated with 4-CPA at 60 ppm, and the minimum for all these characters were found in control plants. The results of the present study suggest that 4-CPA at 60 ppm can be practiced for increasing summer tomato production for both the varieties.

Rahman *et al*. (2015) an experiment was conducted at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh to test the impact of plant growth regulators on growth and yield of summer tomato. The experiment consisted of two tomato varieties viz. BARI Hybrid Tomato-4 and BARI Hybrid Tomato-8 and four types of plant growth regulator (PGR)viz.,(i) control (without PGR), (ii) 4-CPA (4-chlorophenoxy acetic acid), GA_3 (gibberellic acid) and 4-CPA +GA_3. The two-factor experiment was laid out in randomized complete block design with three replications. The results of the experiment revealed that significant variations were observed for most of the characters studied. At 75 DAT, the tallest plant (79.35 cm), number of flowers and fruits (38.11 and 19.04, respectively) plant^{-1}, individual fruit weight (58.44 g) and fruit yield (22.75 t ha^{-1}) were found in BARI Hybrid Tomato-8. At 75 DAT the maximum plant height (87.90 cm), number of flowers and number of fruits (49.04 and 21.9, respectively) plant^{-1} , individual fruit weight (61.16 g), and fruit yield (27.28 t ha^{-1}) were found when 4-CPA + GA_3 applied together, whereas the minimum for these characters was recorded from control plants. In case of combined effect of variety and plant growth regulator, the maximum plant height (87.90 cm), number of flowers and fruits (49.04 and 21.91, respectively) plant^{-1}, individual fruit weight (61.16 g) and fruit yield (27.28 t ha-1) were observed in BARI Hybrid Tomato-8 when treated with 4-CPA + GA_3together, and the minimum for all these parameters were found in control plants. The results of the present study suggest that both 4-CAP and GA_3 together can be practiced for increasing summer tomato production for both the varieties.

Shemu *et al.* (2014) were conducted a field experiment in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, during the period from April 2012 to October 2012 to quantify the effect of Tomatotone on the yield of summer tomato. The experiment consisted of four levels of Tomatotone, viz. H_0: no Tomatotone (control), H_1: 1% Tomatotone, H_2: 2% Tomatotone and H_3: 3% Tomatotone. The experiment was laid out in Randomized Complete Block Design with three replications. Results revealed that the significant variation was observed for the different growth contributing characters of summer tomato due to Tomatotone. The longest plant (86.6 cm), maximum number of leaves (50.2), maximum number of flowers per plant (63.4), highest number of fruits per plant (41.0), highest length of fruit (5.2 cm), highest weight of individual fruit (41.9 g), highest yield per plant (4.4 kg) and highest yield (22.7 t/ha) was found from H_2. On the other hand, the lowest plant height, lowest yield, the lowest number of leaves, flower, and fruits was found from H_0 (control).

Choudhury *et al*. (2013) were carried out an investigation to assess the effect of different PGRs on tomato during the summer season at Horticulture Farm of Sher-e-Bangla Agriculture University, Dhaka-1207. They have exposed the plant in plant growth regulators (PGR) viz. PGR_0 = Control, PGR_1= 4-CPA (4-chloro-phenoxy acetic acid) @ 20 ppm, PGR_2 = GA_3 (gibberellic Acid) @ 20 ppm and PGR_3= 4-CPA + GA_3 @ 20 ppm through foliar application. They have concluded that the growth and yield contributing characters of tomato plants were significantly differed due to different plant growth regulators. They have found the maximum plant height at 60 DAT, number of flowers cluster per plant, number of flowers per plant, number of fruits per plant, maximum individual fruit weight and maximum yield in the treatment PGR_3, and the minimum for all parameters were found in control (PGR_0) treatment.

Baliyan *et al*. (2013) were conducted an experiment to know the effects of different concentrations of 4-chlorophenoxyacetic acid (4-CPA) plant growth regulator hormone on fruit set, yield and economic benefit of tomato (*Lycopersicon esculentum* Mill) growing in high temperatures in Botswana (Southern Africa). In a field experiment laid under complete randomized block design, tomatoes flowers were treated with four different concentrations of 00 ppm (control), 15ppm, 45ppm and 75ppm of 4-CPA growth regulator. Data collected an involved amount of fruit set, the weight of small tomato, the weight of cracked tomatoes, the weight of cat face tomatoes, the weight of rotten tomatoes, the weight of pest damaged and marketable tomatoes. A two-way analysis of variance (ANOVA) was performed using the SPSS software ver.19 to analyze the data. The application of 4-CPA hormone indicated a positive and significant effect on the fruit set and yields of tomato. A positive relationship between the hormone concentration and the fruit set as well as total yield of tomato was also established (higher the concentration, higher the fruit set and tomato yield). The 75 ppm concentration of4-CPA resulted not only the highest increase in fruit set but also increased the tomato yield and hence economic benefit in tomato production increased. It was concluded that use of 4-CPA hormone increased the fruit set, yield and economic benefit of summer tomato production. Suggested future research can be conducted to observe the effect of higher concentration of the 4-CPA hormone on fruit set, yield and fruit quality of tomatoes.

Hossain (2006) the experiment was conducted at the Research Farm of Olericulture Division under Horticulture Research Center of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur from May 2006 to August 2006. The experiment was laid out in an RCBD (factorial) with three replications. Two heat-tolerant tomato varieties BARI Tomato-4 and BARI Hybrid Tomato-8 with and without plant growth regulator applications were included in this experiment. The higher fruit set percentage (42.52%) was recorded from BARI Hybrid Tomato-4 which was also higher in case of pollen viability (42.75%), number of fruits per cluster (3.01), number of fruits per plant (12.70) and yield per plant (460 g). Better performance was observed in spraying of 4-CPA at 40 ppm concentration in respect of percent fruit set (45.38%), number of fruits per plant (16.45) and yield (39.39 t/ha) under high-temperature condition. In combined treatment, BARI Hybrid Tomato -4 with 40 ppm 4-CPA performed a significant role in the number of fruits per cluster (3.41), number of fruits per plant (22.48), number of fruits per plot (144.00), yield per plant (621.68 g), yield per plot (15.23 kg) and above all fruit yield (50.57 t/ha)

Sasaki *et al.* (2005) studied the effects of plant growth regulators on fruit set of tomato *(Lycopersicon esculentum* Mill.) under high temperature were examined in a controlled environment and a field under rain shelter. Tomato plants exposed to high temperature (34/20°C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially treatment with mixtures of 4-chlorophenoxyacetic acid (4-CPA) and gibberellins (GAs). In the field experiment, tomatoes treated with a mixture of 4-CPA and GAs showed increased fruit set and the numbers of normal fruits (excluding abnormal types such as puffy fruit) were more than the plants treated with 4-CPA alone during summer.

Sasaki *et al*. (2005) were conducted a field experiment on the reduction of high-temperature inhibition in tomato fruit set by plant growth regulators. They examined the effect of plant growth regulators on fruit set of tomato (*Lycopersicon esculentu*m Mill.) under high temperature and in a controlled environment in the field under rain shelter. Tomato plants exposed to high temperature (34/20 ^{0}C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially treatment with a mixture of 4-chlorophenoxy acetic acid (4-CPA) and gibberellins (GAs). They have found, in the field experiment, tomato treated with a mixture of 4-CPA and GAs showed increased fruit set and the number of normal fruits (excluding abnormal types such as puffy fruit) were more than the plants treated with 4-CPA alone during summer

Halder *et al*. (2003) were carried out a field study to know the performance of summer tomato and suitable time of planting for maximizing yield potential during 1997-1999. The results indicated that the plants planted in 15th April performed the best yield (26.78 t ha^{-1}) as compared to other planting times. It might be the cause of maximum vegetative growth as well as the cool night temperature. Similarly, spraying tomatotone hormone (2%) efficiently produced the highest fruit yield (22.16 t ha^{-1}) and maximum number of fruits (28.13 $plant^{-1}$) than that of untreated plants. The results showed that from interaction effects, it was evident that 15th April planting with efficient use of tomatotone hormone exhibited the best performance (31.37 t ha^{-1}) and declined yield with the change of planting time

Bhosle *et al.* (2002) was carried out an investigation to know the effects of NAA (25, 50 and 75 ppm), gibberellic acid (15, 30 and 45 ppm) and 4-CPA (25, 50 and 75 ppm) on the growth and yield of tomato cultivars Dhanashree and Rajashree through the field experiment conducted in Rahuri, Maharashtra, India during the summer of 1997. They have concluded that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Treatment with 30 ppm gibberellic acid resulted in the tallest plants, whereas treatment with 25 ppm 4-CPA and 45 ppm gibberellic acid resulted in the highest number of primary branches of Dhanashree (4.16) and Rajashree (5.38), respectively. The highest marketable yield of Dhanashree and Rajashree resulted from treatment with 75 ppm 4-CPA.

Karakurt (2000) was studied on the foliar application of 4-CPA in tomato hybrids under greenhouse conditions with the pruning of some flowers in the inflorescence. He has concluded that foliar application of 4-CPA and pruning had positive effects on crop yield, development and maturation.

Ravestijn (1983) through the weekly application of a spray mix consisting of 20 mg/1 active ingredient 4-CPA and 500 mg/l iprodione or 500 mg/l vinclozolin on the eggplant flower, the production becomes earlier and is increased. This occurs through an increasing amount of fruit and higher average fruit weight. The color of the fruit is sometimes favorably improved. The varieties used to the present (Adona, Berinda, Claresse, and Dobrix) all react positively to this treatment, but not to the same degree. The cultivation in Rockwool also results in an earlier production after application of this auxin-fungicide mix. It is possible that total production also can be improved.

2.2 Literature on vermicompost

Islam *et al.* (2017) field trials were conducted on the tomato for yield and quality of fruits using different types of organic and inorganic fertilizers at the horticulture farm of Bangladesh Agricultural University (BAU), Mymensingh. Fertilizer treatments were tested on two varieties of tomato ca. Roma VF and BARI Tomato-15. The fertilization treatments were T_1, vermicompost (12 t/ha); T_2, compost (10 t/ha); T_3, integrated plant nutrient system (IPNS) or mixed fertilizers (organic 2/3 part and inorganic 1/3 part); T_4, inorganic fertilizers; and a control (T_5). Results showed growth and yield (20.8 t/ha) in tomato were higher in the IPNS treatment. A higher number of fruits per plant (73.7) and plant height (73.5 cm) were obtained from mixed fertilizers (organic 2/3 + inorganic 1/3) or IPNS (integrated plant nutrient system) in Roma VF than other treatments. Fruit yield and diameter were found statistically significant. No significant difference was observed in the quality (total soluble solids) of tomato fruits in both varieties' response to the treatments. The electrical conductivity and pH of the soil were improved by the application of organic manure.

Wang *et al. (*2017) a greenhouse pot test was conducted to study the impacts of replacing mineral fertilizer with organic fertilizers for one full growing period on soil fertility, tomato yield and quality using soils with different tomato planting history. Four types of fertilization regimes were compared: (1) conventional fertilizer with urea, (2) chicken manure compost, (3) vermicompost, and (4) no fertilizer. The effects on plant growth, yield and fruit quality and soil properties (including microbial biomass carbon and nitrogen, NH+4NH4+-N, NO−3NO3--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 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 treatment; (3) vermicompost led to greater improvements in fruit yield (74%), vitamin C (47%), and soluble sugar (71%) in soils with no tomato planting history compared with those in soils with long tomato planting history; and (4) vermicompost led to greater improvements in soil quality than chicken manure compost, including higher pH (averaged 7.37 vs. averaged 7.23) and lower soil electrical conductivity (averaged 204.1 vs. averaged 234.6 μS/cm) at the end of experiment in each type of soil. We conclude that vermicompost can be recommended as a fertilizer to improve tomato fruit quality and yield and soil quality, particularly for soils with no tomato planting history.

Thuy *et al.* (2017) reported that experiments arranged in a Randomized Complete Block Design-RCBD included six vermicompost levels (10, 15, 20, 25, 30, 35 ton ha^{-1}) with three replications. The results showed that vermicompost dose had a significant effect on plant height, leaf number, and height and internode number from stump to the first flower cluster. When applying higher vermicompost levels, significantly higher in individual fruit weight and yield of tomato was supported. The highest yield was obtained at 35 ton ha^{-1} vermicompost (in autumn-winter season 2013) and at 30 ton ha^{-1} vermicompost (in autumn-winter season 2012, but the difference was not significant as compared to level 35 ton ha^{-1}). Vermicompost had beneficial effects not only on yield but also on fruit quality. By regression way, the regression equation that presents depended relation between yield of HT152 tomato variety and vermicompost dose was established as following: y = 0.0054x2 + 0.3596x + 34.602 with R^2 = 0.4745. The result of the optimal calculation indicated that the highest yield of HT152 tomato variety at optimal vermicompost dose of 33.3 ton ha^{-1}. The knowledge gained from this study provided an important link about organic production, and could further improve product quality not only in tomato but also in other plants.

Khan *et al.* (2017) find out the effect of compost and inorganic fertilizers on yield and quality of tomato was investigated in a field experiment carried out on silt loam soil at Nuclear Institute of Food and Agriculture (NIFA), Peshawar during summer 2016. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications and seven treatments. N, P and K fertilizers at 180, 100 and 60 kg ha^{-1} respectively were applied with or without compost, while compost was applied at 20 tons ha^{-1}. The sources of N, P and K were urea, triple superphosphate, and muriate of potash. The results of the study showed that yield and quality parameters of tomato fruit were significantly affected by the combined use of compost and inorganic fertilizers. Maximum tomato fruit and dry matter yields, fruit density, number of fruit kg^{-1}, N, P and K uptake by tomato plant were obtained from treatment where a full dose of N, P and K with10 tons of compost were applied. Maximum vitamin C content in tomato fruit was observed where full doses of compost and mineral fertilizers were applied. Soil organic matter and N, P, K contents were improved where full doses of mineral fertilizers with a full dose of compost were applied. It is concluded that a combination of plant residue compost and mineral fertilizers significantly improved the yield, quality of tomato fruit and sustained soil fertility status.

According to **Dasgan *et al.* (2017)** in the present study, greenhouse tomato ('Jaledo') was grown with organic nutrition by the inoculation of some biofertilizers under the soilless cultivation rules. The treatments were three different biofertilizers; 1) mycorrhiza, 2) vermicompost, 3) fermentation microorganisms (EM), and 4) control. The experiment was carried out in the glasshouse during the spring cultivation period under Mediterranean climate conditions. The growing medium was a mixture of peat: perlite in the ratio of 1:1. The constant nutrition in all treatments with the certified organic fertilizers was used to feed the plants beside the biofertilizers. Some plant growth parameters such as plant height and leaf number were similar in the treatments. The tomato yield was the highest in vermicompost, it was 8.3% higher than the control plants. Mychorriza treatment also increased the yield by 2.5%, however, the fermentation microorganisms (EM) decreased the yield by 12.4%. The fermentation bacteria (EM) may compete with the plant for available nutrients in the root medium. Mean fruit size and fruit volume were higher in vermicompost and mychorriza. Total soluble solids (Brix) and titratable acidity were higher in the EM. At the end of the experiment, EC inside the growing medium was measured and the biofertilizers, especially mychorriza, decreased the EC, that could be important to prevent salinization in root medium during growing. Leaf nutrient analysis showed that the tomato plants were adequately fed under the experimental conditions, in some cases, the advantages of biofertilizers were seen, for example, the leaf Na concentration was the lowest in mychorriza treatment. The results showed that as a sustainable approach, the greenhouse vegetables can be produced under the rules of soilless cultivation in the organic growing medium by the combination of organic nutrients and the biofertilizers like vermicompost and mycorrhiza.

Thakur and Tripathi (2015) reported that Organic agriculture in India can become a potent endeavor because 81% of small and marginal farmers dominate the major section of agriculture. The minor stream is directly benefitted from urban-oriented growth, while the majority section is still on the verge of the struggle for producing sufficient food and income for sustaining a livelihood. These farmers have a unique set of needs that the modern, chemically equipped agriculture paradigm has not been able to fulfill. The intensive, rather excessive use of chemical fertilizers has completely degraded the soil health, environmental and ecological parameters reflecting today's human health and security. Supporting a serious suitable option for small scale production system, organic agriculture holds another kind of promise in terms of overall productivity with ecological parameters. Keeping in view a vigorous demand for a sustainable source and value-added commercial tomato farming in terms of secured economic gains and returns, a study was conducted at farmer's field during 2012-13 on standardizing organic production package for commercially grown tomato (cv. Solan Salima). The experiment was laid out in a randomized block ANUM ASSOCIATION Meknes, Morocco 1- 2 May 2015 www.anuma.ma 2 design (RBD) with seven treatments and five replications each of organic manures (Farmyard manure and Vermicompost), biofertilizers (Azotobacter, Azospirillium, and PSB) and farmers practice (control). A tomato grown under both systems was analyzed for their quality attributes and nutritional composition. The results of the study indicated that the application of different microbial preparations in treatment T_3 (FYM@ 200q/ha + Azospirillum + PSB + Trichoderma herzianum (4kg/ha each) in comparison to control led to a balanced OC (0.99%), NPK status (413.1 Kg/ha, 26.33Kg/ha and 285.4 Kg/ha) crop quality attributes. The results of studies indicated that the maximum yield (665.0q/ha) was recorded with maximum net return (1,360,950/ha) and cost-benefit ratio of (1:2:29) under the organic system and the minimum (649.0q/ha) under chemical cultivation with (1:1:59).

According to **Najar *et al. (2015)*,** the study was conducted to investigate the effect of different rates (2, 4 and 6 t/ha) of macrophyte-based vermicompost on germination, growth, and yield of Solanum melongena under field conditions. The data revealed that different rates of vermicompost produced a varied and significant effect (P\0.05) as compared to the control on germination, growth and yield parameters with the maximum value recorded at 6 t/ha, followed by 4 t/ha and the least at 2 t/ha. The dose of 6 t/ha significantly (P\0.05) increased germination (22.56 ± 2.5 %), number of fruits per plant (3.55 ± 0.07) mean fruit weight (73 ± 5.0 g), yield per plant (1.48 ± 0.05 kg) and marketable fruits (28.66 ± 3.0 %) when compared with the control. The study suggests that macrophyte-based vermicompost as a potential source of plant nutrients for sustainable crop production.

Mukta *et al.* (2015), a pot experiment was conducted to investigate the yield and nutrient content of tomato (*Lycopersicon esculentum*) as influenced by the application of vermicompost and chemical fertilizers. The experiment was laid out in a completely randomized design (CRD) with 3 replications and comprised of 8 treatments viz., T1 - control, T2 - recommended dose of NPK fertilizers (CF), T3 - vermicompost @ 5 t ha-1 (VC1), T4 - vermicompost @

10 t ha-1 (VC2), T5 - VC1 + 50% CF, T6 - VC1 + 75% CF, T7 - VC2 + 50% CF and T8 - VC2 + 75% CF. Application of vermicompost @ 10 t ha-1 along with 50% chemical fertilizers showed the best performance for plant height, number of leaves plant^{-1}, number of flowers branch^{-1}, number of fruits branch^{-1} number of fruits plant^{-1}, fruit size, and yield of tomato. Vermicompost treated soils significantly contributed the highest contents of sugar, pH, N, P, K, Ca, Mg, S, Zn & B in tomato, influenced nutrient status of the postharvest soil and conserved more organic C, N, P, K, Ca, Mg, S, Zn & B contents over control. However, soluble solids and vitamin C content in tomato were not significantly influenced by the application of vermicompost and chemical fertilizers. Results of the study demonstrate that the combined application of vermicompost and chemical fertilizers would help to maintain the long-term soil productivity for sustainable tomato cultivation.

According to **Tiwari. (2015)** the twelve treatment combinations were replicated three times in a randomized block design. The NPK fertilizers were applied as urea, SSP and MOP/ha. The seedlings were transplanted on 17.08.2014 and the first picking was started from 2014. Treatments-12 T_1 FYM 20 t/ha, T_7 Vermicompost 5 t/ha +*Azotobacter* , T_2 Vermicompost 5 t/ha , T_8 FYM 10 t/ha + Vermicompost 2.5 t/ha+ *Azotobacter* , T_3 FYM 10 t/ha + Vermicompost 2.5 t/ha , T_9 FYM 15 t/ha + *Azotobacter* + 50% NPK, T_4 FYM 10 t/ha + 50% NPK + *Azotobacter,* T_{10} Vermicompost 5 t/ha + Biofertilizer(*Azotobacter*) + 50% NPK, T_5 Vermicompost 2.5 t/ha + 50% NPK + *Azotobacter,* T_{11} FYM 10 t/ha + Vermicompost 2.5 t/ha+ *Azotobacter*+ 50% NPK ,T_6 FYM 10 t/ha + *Azotobacter* T_{12} RFD of NPK (100:60:80) Undergrowth characters height of plant and number of branches were studied. Under reproductive characters, a number of flower clusters per plant, flowers per cluster and days to fruit-set per cluster were taken. In yield characters, a number of fruits per plant, average fruit weight and yield per hectare were studied. Nutritional quality of fruit, as well as the grading of fruits, were also determined. the combined application of organic-cum-inorganic nutrients, T11 having four sources of nutrients was continued to be the best with respect to quality also. Accordingly, the significantly higher dry matter of tomato fruit (8.17%), "A" grade tomato (54.59%), TSS to 10.84% Brix was obtained from the fertility treatment T11. The second best fertility treatment was T1 having 20 t FYM/ha (dry matter 7.80, "A" grade tomato 52.16%, TSS 10.50 oBrix. The "C" grade tomato was in the lowest range. This was followed by T8 and T9 treatments. On the other hand, the significantly lowest values (6.53-6.63% dry matter, 48.49-48.61% "A" grade tomato, 8.47-9.02% Brix TSS and was obtained from T6 and T7 treatments having half dose of FYM or vermicompost with *Azotobacter*.

According to **Uz *et al.* (2014),** this study was conducted to investigate the direct short-term impact of vermicompost on some soil biological properties by monitoring changes after addition of vermicompost as compared to farmyard manure in alkaline soil with high lime content from the semiarid Mediterranean region of Turkey. For this purpose, mixtures of soil and organic fertilizers in different doses were incubated under greenhouse condition. Soil samples collected at regular intervals were analyzed for biological parameters including dehydrogenase, β-glucosidase, urease, alkaline phosphatase activities, and a total number of aerobic mesophilic bacteria. Even though soil dehydrogenase activity appeared to be dose-independent based on the overall evaluation, organic amendments were found to elevate dehydrogenase activity when sampling periods are evaluated individually. β-glucosidase, urease, alkaline phosphatase activity, and aerobic mesophilic bacterial numbers in vermicompost treatments fluctuated but remained significantly above the control. A slight but statistically significant difference was detected between organic amendments in terms of urease activity. Vermicompost appeared to more significantly increase the bacterial number in soil. Clearly, vermicompost has the potential to be used as an alternative to farmyard manure to improve and maintain soil biological activity in alkaline calcareous soils from the Mediterranean region of Turkey. Further studies are needed to assess its full potential for these soils.

Joshi *et al.* (2014) showed in the present review, vermicompost is described as an excellent soil amendment and a biocontrol agent which make it the best organic fertilizer and more eco-friendly as compared to chemical fertilizers. Vermicompost is ideal organic manure for better growth and yield of many plants. It can increase the production of crops and prevent them from harmful pests without polluting the environment. Application of vermicompost increased seed germination, stem height, number of leaves, leaf area, leaf dry weight, root length, root number, total yield, number of fruits/plant, chlorophyll content, pH of juice, TSS of juice, micro and macronutrients, carbohydrate (%) and protein (%) content and improved the quality of the fruits and seeds. Studies suggested that treatments of humic acids, plant growth promoting bacteria and vermicomposts can be used for sustainable agriculture discouraging the use of chemical fertilizers.

Ali *et al.* (2014) revealed that this is in an environmentally friendly approach to increase the yield of summer tomato as an alternative to the application of hazardous chemical fertilizers. An experiment was carried out in the experimental field of the Olericulture Research field, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur, Dhaka, Bangladesh to investigate the potential of vermicompost and mustard oil cake leachate as foliar organic fertilizer with reference to the growth, yield and TSS status of BARI Hybrid Tomato-8 and then examined their effects on different parameters. Treatments of the experiment were: No foliar application (T); foliar application of leachate from vermicompost (T) and foliar application of leachate from 1 2 mustard oil cake (T). The experimental data revealed that significant increase in growth; yield and TSS on 3 BARI hybrid tomato 8 were observed due to foliar application of vermicompost and mustard oil cake. All parameters performed better results with the foliar application of the leachate from vermicompost which was very close to the mustard oil cake. However, a maximum amount of fruit (30.9 plants), yield (14.3 kg/ plot) and TSS 1 1 (4.7%) were found from the foliar application of leachate from vermicompost which was followed by mustard oil cake (28.4 plants, 12.7 kg plot and 4.2% respectively) whereas minimum found from control.

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

Singh *et al.* (2013) a field experiment was conducted for two years to investigate the effect of vermicompost, organic mulching and irrigation level on growth, yield and quality attributes of tomato (*Solanum lycopersicum* L.) with an ultimate aim of optimizing water and nutrient requirement of tomato in mild-tropical climate during the dry season. The vermicompost together with organic mulching increased plant height(106.5 cm), leaf area (40.6 cm2), leaf weight (1301 mg/ leaf), fruit weight (92.9 g), fruit yield (4.013kg/ plant), fruit density (0.972 g/ cc), post-harvest shelf-life (15.0 days) and TSS (5.2% Brix) of tomato significantly. Application of vermicompost alone too increased the shelf-life of fruits by 25-106 % and TSS beyond 4.5 %, both of which are traits highly desirable for the production of summer tomato and related processing industry. The application of vermicompost @ 5 tonnes/ ha, 5 cm thick mulching with dried crop residues, a two-thirds dose of NPK fertilizer (80:40:40 kg/ ha) and 30 % irrigation is optimum for obtaining better quality and productivity of field-grown tomatoes during the dry period of mild-tropical climate.

According to **Resendez *et al.* (2013),** different studies have suggested that the use of vermicompost as part of the plant growth media can provide nutrients and retain moisture while promoting the development of crops. To corroborate this assumption we tested the effects of vermicompost supplementation to tomato (saladette type) under greenhouse conditions. The evaluated treatments included four mixtures (T1, T2, T3, and T4) of vermicompost and river sand, with volume ratios 0:1, 1:1, 1:2 and 1:3, respectively. Physical and chemical tests were performed in each mixture to determine nutritional elements (N, P, K, Ca, Mg, Na, Fe, Cu, Zn, Mn, organic matter, pH, texture, cation exchange capacity, electric conductivity, and apparent density) and water holding capacity. Treatment with 0:1 volume ratio (T1) was used as a control, and it was fertilized with a nutrient solution [KNO3, Ca(NO3)2, Mg(NO3)2, phosphoric acid concentrate, and multi Maxiquel (Bioagro ®)]. Seeds were sown in polystyrene trays with 200 cavities, padded with peat moss; seedlings were transplanted 37 days after sowing in 20 L black plastic bags. Harvest, including up to the fifth cluster, was performed manually when the fruits reached a pink color. The treatment effects on tomato were evaluated considering the number of fruits, number of locules, equatorial and polar diameters, pulp thickness, soluble solids, fruit weight, and fruit yield. The four treatments were repeated eight times in a completely randomized design. Data were statistically analyzed by analysis of variance and means were separated by the $LSD_{.05}$ test. Five of the variables studied number of fruits, number of locules, soluble solids, pulp thickness, and yield showed a highly significant difference ($P \leq 0.01$) among treatments; the polar diameter showed significant differences ($P \leq 0.05$), and both equatorial diameter and weight of fruit were not significantly different among the substrates tested. The maximum yield (50.29 $t \cdot ha^{-1}$) was obtained in treatment T2 with a water volume of 40 L•pot-1, followed by T1 (49.93 $t \cdot ha^{-1}$), applying a water volume of 95.72 $L \cdot pot^{-1}$. Derived from the results of the best treatment (T2), and under conditions described, the productivity was estimated in 30.66 kg•m-3. Since no synthetic fertilizers were used during the crop production, the results indicate that the vermicompost was able to satisfy the nutrient demand of tomato plants and reduces the volume of water required by this crop.

Meenakumari and Shekhar (2012), an experiment was conducted to determine the effect of vermicompost and other fertilizers on growth, yield and fruit quality of tomato in the field condition. The field trials were conducted using different fertilizers having an equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared whereT1 was kept as control and five others were treated by different category of fertilizers (T2-Chemical fertilizers, T3-Farm Yard Manure (FYM), T4-Vermicompost, T5, and T6-FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively). The treatment plots (T6) showed 73% better yield of fruits, and dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant than control, followed by T5.

Joshi and Vig (2010) conducted a study on the effect of vermicompost on growth, yield, and quality of tomato (*Lycopersicon esculentum* Mill). The treatments (control), VC15 (Soil+15% VC), VC30 (Soil+30% VC), VC45 (Soil+45% VC) . Various growth and yield parameters like mean stem diameter, mean plant height, yield/plant, marketable yield/plant, mean leaf number and total plant biomass were recorded for each treatment. Various quality parameters like ascorbic acid, titrable acidity, soluble solids, and insoluble solids were recorded for tomatoes from each treatment. Almost all the growth, yield, and quality parameters increased significantly as compared to control.

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

Azarmi R *et al.* (2008) reported that an experiment was conducted to determine the effects of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum* var. Super Beta) in a field condition. The experiment was a randomized complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t ha^{-1}) was incorporated into the top 15 cm of soil. During the experiment period, fruits were harvested twice in a week and the total yield was recorded for two months. At the end of the experiment, growth characteristics such as leaf number, leaf area and shoot dry weights were determined. The results revealed that the addition of vermicompost at a rate of 15 t ha^{-1} significantly (at $p < 0.05$) increased growth and yield compared to control. Vermicompost with the rate of 15 tha^{-1} increased EC of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe, and Zn in the plant tissue increased 55, 73, 32 and 36% compared to untreated plots respectively. The result of our experiment showed the addition of vermicompost had significant ($p < 0.05$) positive effects on growth, yield and elemental content of plant as compared to control.

Patil *et al.* (2004), the effects of inorganic and organic fertilizers on the fruit yield and quality of tomato (cv. Parbhani Yashshri) was studied in Parbhani, Maharashtra, India, during rabi 2000/01. The treatments consisted of 100% recommended fertilizer rate (RFR; 100:50:50 kg NPK/ha), 75% RFR + 25% Celrich, Teracare, farmyard manure (FYM) or vermicompost; 50% RFR + 50% Celrich, Teracare, FYM or vermicompost; 25% RFR + 75% Celrich, Teracare, FYM or vermicompost; and 100% organic fertilizer (25% each of FYM, Teracare, Celrich and vermicompost). Celrich (2.0 t/ha), Teracare (2.5 t/ha), FYM (25.0 t/ha) and vermicompost (25.0 t/ha) were applied at 10 days before transplanting. Plant height, number of primary branches, and number of leaves were evaluated from 30 to 105 days after transplanting. The application of 50% RFR + 50% FYM resulted in the greatest plant height (120.70 cm), number of primary branches per plant (8.53), number of fruits per plant (52.0), average fruit weight (45.06 g), yield per plant (2.34 kg), and total soluble solid content (6.08%). The highest number of leaves per plant was obtained with 50% RFR + 50% FYM (118.10) and 50% RFR + 50% vermicompost (116.63). Ascorbic acid content (26.76, 26.53 and 25.97 mg/100 g) and shelf life (6.91, 7.00 and 6.22 days) were highest with 50% RFR + 50% FYM, 50% RFR + 50% vermicompost and 100% organic fertilizers.

Sendurkumaran *et al.* (1998) also observed an increased yield in tomato and brinjal, respectively when plots were fertilized with both organic and inorganic sources. The quality parameters such as TSS, ascorbic acid lycopene were comparatively higher in tomato when grown organically

CHAPTER III

MATERIALS AND METHODS

In this chapter, describes the materials and methods which were used in the field to conduct an experiment titled on "**GROWTH, FRUIT SET AND YIELD OF SUMMER TOMATO INFLUENCED BY 4-CPA AND VERMICOMPOST**" during the period from April 2017 to October 2017. A short description of experimental site, soil, and climate, variety, growing of the crops, experimental design and treatments and collection of data are presented under the following headings.

3.1 Experimental site

The experiment was conducted on the pot at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 Bangladesh during the period from April 2017 to October 2017.

3.2 Location of site

Geographically the experimental site is situated at the $23^0$74/N latitude and $90^0$35/ E longitudes at an elevation of 8.2 m from sea level (Anon., 1989)

3.3 Characteristics of Soil

The experimental soil was collected from the Horticulture Farm. The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected area was medium high land and the soil series was Tejgaon (FAO, 1988). The soil sample was collected from a depth of 0-30 cm before conducting the experiment and analyzed in the Soil Testing Laboratory, Soil Resources Development Institute (SRDI), Farmgate, Dhaka and details soil characteristics were presented in Appendix 1.

3.4 Climate and weather

The climate of the experimental site was subtropical in nature and characterized by three distinct seasons, winter season from November to February and the pre-monsoon or summer season from March to April and the monsoon period from May to October. The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the study period were collected from the Bangladesh Meteorological Department (climate division) .

3.5 Pot soil collection and preparation

The soil was collected 20 days prior to setting the experiment. The topsoil at a 15 cm depth was collected from the Horticulture Farm Area of Eastern-west corner, mixed thoroughly and makes it clean by removing stones, grass, roots and other debris.

3.6 Vermicompost mix with soil

Vermicompost was added in the soi according to the treatment prior 15 days of filling the pot and wrapped with a polyethylene sheet.

3.7 Collection of seeds (planting materials)

The seeds of BARI Hybrid Tomato-8 was collected from Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.8 Treatments of the experiment

The experiment consisted of two factors.

Factor A: Four levels of 4-CPA, viz.

a) $\mathbf{H_0}$**:** Control

b) $\mathbf{H_1}$**:** 15 ppm

c) $\mathbf{H_2}$**:** 45ppm

d) $\mathbf{H_3}$**:** 75 pm

Factor B: Different levels of vermicompost such as,

a) $\mathbf{VC_0}$**:** Control

b) $\mathbf{VC_1}$**:** 500 g/pot

c) $\mathbf{VC_2}$**:** 1 kg/pot

d) $\mathbf{VC_3}$**:** 1.5 kg/pot

Treatment combinations were 16 (4 × 4) such as H_0VC_0, H_0VC_1, H_0VC_2, H_0VC_3, H_1VC_0, H_1VC_1, H_1VC_2, H_1VC_3, H_2VC_0, H_2VC_1, H_2VC_2, H_2VC_3, H_3VC_3, H_3VC_1, H_3VC_2, H_3VC_3 .

3.9 Design and layout of the experiment

The experiment was laid out in **CRD (Completely Randomized Design)** method with three replications. Seedlings were planted in the middle of the potting soil and 16 pots were placed in each row. Pots were placed considering plants distanced between rows to row and plant to plant was 60 cm and 40 cm, respectively.

3.10 Raising of seedlings

Seeds of a tomato variety BARI Hybrid Tomato-8 were planted in seed trays. The soil of the seed trays was made loosen and friable as much as possible and organic matter mixed with soil. All weeds, stones and dead roots were removed. The seeds were sown on 11^{th} June 2017 in the trays. The seed tray was supported with a partial shed at 12:00-4:00 pm in the high hot under polythene shed. Proper care was taken to raise healthy seedlings.

3.11 Pot preparation

Plastic pots were used in this experiment. The height and width of each pot were 35 and 30 cm respectively. Two holes were made in the middle of the bottom of each pot and holes were covered by the broken pieces of the earthen pot. All the pots were washed with ash and tap water by rubbing and sun-dried. The vermicompost mixed soil was made well pulverized. The final check was made to remove plant propagates, inert materials, visible insect and pests. In the lower part of all the pots were filled with general sun-dried and clean soil; only upper 20 cm of the pot was filled with vermicompost mixed well-prepared soil and topmost upper 5 cm of the pot was blank for irrigation purpose.

3.12 Transplanting of seedlings in the pot

Thirty days old seedling was transplanted in the middle of each pot at 11^{th} July 2017. The seedling was transplanted in the late afternoon to overcome day temperature. Immediate after transplanting the plants were irrigated with tap water. The pots were arranged inside the polythene shed as per the design of the experiment.

3.13 Intercultural operations

3.13.1 Irrigation

After transplanting, immediate light watering to the individual seedling was provided to overcome water deficit. At two days interval, the plants were supported with water as a regular basis.

3.13.2 Supporting

Tomato plants were supported using strings suspended with bamboo stick and threads as to when needed.

3.13.3 Gap filling

Very few seedlings were damaged after transplanting and new seedlings from the same stock were replaced these.

3.13.4 Weeding

Weeding and soil loosening was done as and when required. During experimentations, it was done in three times.

3.13.5 Pruning

All shoots from the base of all plants were removed at a 7 cm distance from the ground. It was maintained to a single stem by removing all side shoots at least once a week. Remove the shoot early in the morning on sunny days when they are very small (one inch or smaller).

3.13.6 Use of pesticide

Admire was sprayed @ 1 ml per liter of water for 3 times at 10, 20 and 30 DAT of seedling in all plants.

3.13.7 Use of fungicide

Ridomil was sprayed @ 1 gm per liter of water for 3 times at 15, 25 and 35 DAT of seedling in the potting soil.

3.13.8 General observation

The field was frequently observed to notice any changes in plants, pest and disease attack and necessary action was taken for normal plant growth.

3.14 Application of 4-CPA

4-CPA hormone was applied in all plants considering the treatment of the experiment. The first application was made at 20 DAT in the day when first flower initiation was found in the experimental pot and second & third application was made at a 15 days interval which was 35 and 50 DAT. A specific concentration was made at a 0 ppm, 15 ppm (@15 mg/litre tap water), 45 ppm (@45 mg/litre tap water), 75 ppm (@75 mg/litre tap water) separately for each time of the application and it was applied in the flower and flowering stalk.

3.15 Data collection

3.15.1 Plant height

Plant height was measured from base to the tip of the longest leaf at 20, 40, 60 days after transplanting (DAT) and at harvest time. To measure plant height of the plant and expressed in centimeter (cm), a meter scale was used.

3.15.2 Number of branch per plant

The total number of a branch of the individual plant was counted and recorded. It was counted for the first time at 40 DAT. For the second time, the number of the branch were counted at 60 DAT and it was made an average.

3.15.3 Number of leaves per plant

A total number of leaves produced by each plant was counted at 20, 40, 60 days after transplanting (DAT).

3.15.4 Measurement of the length of leaves

The lengths of leaves of individual plants were measured at 20, 40 and 60 DAT. A meter scale used for estimating the length of leaves and expressed in centimeter and it was made an average.

3.15.5 Measurement of the breadth of leaves

The breadth of leaves of individual plants was measured at 20, 40 and 60 DAT. A meter scale used for estimating the breadth of leaves and expressed in centimeter and it was made an average.

3.15.6 Counts the number of clusters per plant

A total number of fruit cluster was counted at the final stage of harvesting for an individual plant.

3.15.7 Counts the number of flower per plant

A total number of the flower was counted for individual plant and treatment. Data were collected and it was made an average.

3.15.8 Counts the number of fruit per plant

Fruits were harvested considering commercial maturity stage of fruits. The maturity of the crop was determined on the basis of starting the reddish color of fruits. The fruits of each potted plant were harvested separately. In each of the harvesting, the number of fruits data was recorded.

3.15.9 Counts the days to first flower initiation

It was estimated by the visual observation for each of the treatment. The date was noted and day required for flower initiation was counted. First flower initiation was seen about 20 days after transplanting.

3.15.10 Counts the days to first fruiting

It was estimated by the visual observation for each of the treatment. The date was noted and day required for first fruiting was counted. Firstfruits were seen about 45 days after transplanting.

3.15.11 Counts the days to first fruit harvesting

It was estimated by the visual observation for each of the treatment. The date was noted and day required for first fruiting was counted. First fruit harvesting was started at about 70 days after transplanting.

3.15.12 Fruit weight of the individual plant

Fruits were harvested at the commercial maturity stage of the fruit. In each of harvesting, the weights of harvested fruits were recorded using the electric balance in the field. The final data was made at the final harvesting using the calculator and Microsoft Excel Software. Average results are used for statistical analysis purpose.

3.15.13 Measurement of fruit length

After harvesting of fruits of individual plants fruit length was measured and expressed in cm.

3.15.14 Measurement of fruit diameter

After harvesting of fruits of individual plants fruit diameter was measured and expressed in cm.

3.15.15 Measurement of Brix Percentage

Brix Refractometer was used to measure total soluble solids **(**TSS). Tomato sample was collected from each of the treatment. Tomato sample was cut with the sharp knife and inside was squeeze with the needle for sample juice. A drop of juice was placed on the transparent glass and it was covered by the upper glass. Brix Refractometer was directly showed the TSS as a percentage.

3.15.16 Harvesting of tomato

Tomatoes were harvested early in the morning when the fruits were developed red colors . Avoided full sunny and hot weather and after harvesting fruits were stored at room temperature. A fruit harvested at the red ripe stage will be subjected to more bruising without enhancing quality.

3.15.17 Measurement of yield per plant

After completing the harvest, the total yield of each individual plant was calculated by multiplying the number of fruits and fruit weight of each plant.

3.16 Statistical analysis

The data was collected on various parameters and statistically analyzed by using SPSS software (Version 20.00) to find out the statistical significance of the treatment effect. The mean values of all the treatments were calculated and analyses of variance for all the characters were performed by the F-test. The significance of the difference among the treatments and combinations of means was estimated by DMRT (Duncan's Multiple Range Test) at 5% level of significance.

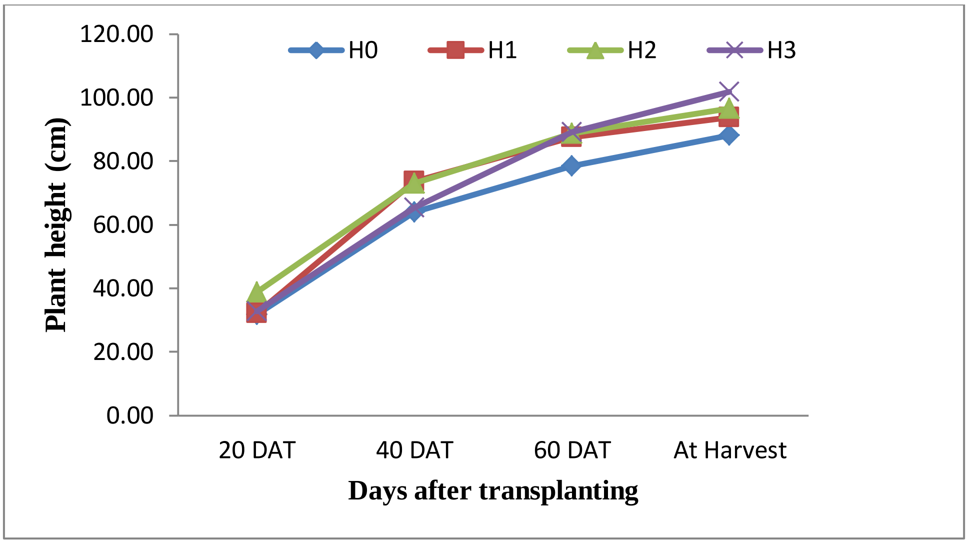
CHAPTER IV
RESULTS AND DISCUSSIONS

This chapter represents the result and discussion for the performance of vermicompost and application of 4-CPA hormone on the growth, yield and economic benefit of growing summer tomato. Data on different growth, yield contributing characters, and yield of tomato plants were recorded. The results have been presented and discussed with the help of graphs, tables and possible interpretations given under the following headings

4.1 Plant height

4.1.1 Effect of 4- CPA

The plant height is one of the most important factors which affect the growth and yield of tomato. Nutrient availability and 4–CPA hormone application are the important factors for desirable plant height. Different levels of 4-CPA showed a different variation on plant height at 20, 40, and 60 days after transplanting (DAT) and at harvest (Figure 1 and Appendix II-V). At 20 DAT, the plant height ranged from 31.8 cm to 38.8 cm. The tallest plant (38.83 cm) was found from (H_2) and the shortest plant (31.83 cm) was recorded from the control treatment (H_0). At 40 DAT, the highest plant height (73.5 cm) was recorded from H_1, while the lowest (63.9 cm) was recorded from H_0. At 60 DAT, the longest plant (89.1 cm) was recorded from H_3 and the shortest plant (78.5 cm) was recorded from H_0. At final harvest, the highest plant (101.9 cm) was obtained from H_3, while the lowest (88.0 cm) was obtained from H_0. This result agreed with the findings of Shemu *et al*. (2014), Choudhury *et al*. (2013).

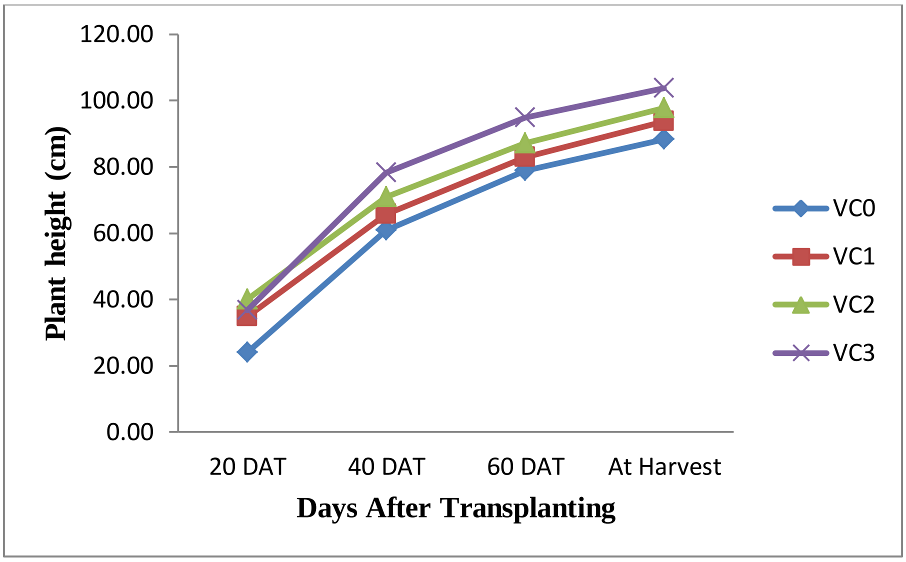


(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Figure 1: Effect of 4-CPA on plant height at different days after transplanting (DAT).

4.1.2 Effect of Vermicompost

After earthworms digest organic matter, they excrete a nutrient-rich waste product and enriching soil thus increasing vegetative growth like as plant height. Plant height was recorded at different days after transplanting (DAT) and at final harvest. Vermicompost exhibited a significant influence on the height of tomato plants at 20, 40, 60 days after transplanting (DAT) and at final harvest (Figure 2 and Appendix II-V). At 20 DAT, the plant height ranged from 24.08 cm to 40.08 cm. The tallest plant (40.08 cm) was found in the application of vermicompost (VC_2) and the shortest plant (24.08 cm) was recorded from the control treatment (VC_0). At 40 DAT, the highest plant height (78.33 cm) was recorded from VC_3, while the lowest (60.92 cm) was recorded from VC_0. At 60 DAT, the plant height ranged from 78.92 cm to 94.92 cm. The longest plant (94.92 cm) was recorded from VC_3 and the shortest plant (78.92 cm) was recorded from VC_0. At final harvest, plant height ranged from 88.25 cm to 103.83 cm. The highest plant (103.83 cm) was recorded from VC_3, while the lowest (88.25 cm) was recorded from VC_0. It was revealed that the plant height increased with the increased in days after transplanting (DAT) i.e., 20, 40, 60 DAT and the final harvest. The results revealed that the addition of vermicompost significantly increased growth and yield compared to control. The present finding is agreed with the findings of Singh *et al*. (2010), Abduli e*t al.* (2013).



(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

Figure 2: Effect of vermicompost on plant height at different days after transplanting (DAT).

4.1.3 Combined effect of 4-CPA and Vermicompost

Significant variation was found due to the combined effect of 4-CPA and vermicompost on plant height at different days after transplanting (Appendix II-V & Table 1). The maximum plant height (44.66 cm) was recorded from the treatment combination of H_3VC_3, while the treatment combination of H_0VC_0 gave the minimum plant height (21.33 cm) at 20 DAT. At 40 DAT significant differences in terms of plant height were observed among the treatment combinations. However, the largest plant (77.00 cm) was recorded from the treatment combination of H_3VC_3 whereas the minimum (52.66 cm) was recorded from a treatment combination of H_0VC_0. At 60 DAT, the tallest plant (99.33 cm) was recorded from the treatment combination of H_3VC_3, while the minimum plant height (73.66 cm) was recorded from treatment combination of H_0VC_0. At harvest, the maximum plant height (110.33 cm) was obtained from the treatment combination H_3VC_3 whereas the minimum (84.00 cm) was found from the treatment combination of H_0VC_0.

Table 1: Interaction effect of 4-CPA and vermicompost on plant height of tomato

Treatment	Plant height (cm)			
	20 DAT	40 DAT	60 DAT	At Harvest
H_0VC_0	21.33 f	52.66 e	73.66 d	84.00 c
H_0VC_1	29.00 d-f	55.66 de	74.66 cd	85.66 c
H_0VC_2	36.00 b-d	70.33 a-d	75.66 cd	84.33 c
H_0VC_3	32.33 cd	75.33 a-c	87.00 a-d	98.33 a-c
H_1VC_0	24.33 ef	71.00 a-d	82.33 a-d	94.33 a-c
H_1VC_1	31.00 c-e	70.66 a-d	87.33 a-d	93.33 a-c
H_1VC_2	38.00 a-c	70.66 a-d	91.66 a-c	100.33 a-c
H_1VC_3	35.33 b-d	82.00 a	95.33 ab	103.33 a-c
H_2VC_0	25.33 ef	60.00 c-e	76.66 cd	85.33 c
H_2VC_1	43.33 ab	70.66 a-d	88.00 a-d	96.00 a-c
H_2VC_2	43.66 ab	77.00 ab	90.66 a-d	98.00 a-c
H_2VC_3	43.00 ab	85.33 a	98.00 ab	103.33 ab
H_3VC_0	25.33 ef	60.00 c-e	83.00 a-d	89.33 bc
H_3VC_1	35.66 b-d	59.66 de	81.66 b-d	100.00 a-c
H_3VC_2	34.00 cd	65.33 b-e	90.66 a-d	108.00 a
H_3VC_3	44.66 a	77.00 ab	99.33 a	110.33 a
S.E	2.56	4.64	5.14	5.19
Significance level (0.05)	0.000	0.000	0.013	0.011

(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)

Here, Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm) and Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

4.2 Number of branch per plant

4.2.1 Effect of 4-CPA

Different levels of 4- CPA showed a significant source of variation on a number of branches per plant of tomato at 40, and 60 DAT (Table 2 and Appendix VI-VII). At 40 DAT the maximum number of branches per plant (3.58) was found from H_2 and a minimum number of branches per plant (2.25) was from H_0. At 60 DAT, the maximum number of branches per plant (5.75) was attained from H_3 (75 ppm) which was statistically identical (4.83) with H_2 (45 ppm) and closely followed (4.50) with H_1 (15 ppm). The minimum number (3.25) was observed from H_0 (0 ppm)

Table 2: Effect of 4-CPA on number of branch per plant on tomato

Treatment	No. of Branch/Plant	
	40 DAT	60 DAT
H_0	2.25b	3.25b
H_1	3.00b	4.50a
H_2	3.58a	4.83a
H_3	3.16a	5.75a
S.E	0.29	0.42
Significance level (0.05)	0.083	0.018

(**Ho:** Control, **H1**: 15 ppm, **H2**: 45 ppm, **H3:** 75 ppm)

4.2.2 Effect of Vermicompost

Application of vermicompost exhibited a significant influence on a number of branch per plants at 40 and 60 days after transplanting (DAT) (Table 3 & Appendix VI-VII). At 40 DAT, the maximum (3.917) number of branch per plant was recorded from VC_3, while the minimum (2.250) was obtained from VC_0. The maximum (6.167) number of leaves per plant was recorded from VC_3 and the minimum (3.00) was found from VC_0 at 60 DAT.

Table 3: Effect of Vermicompost on number of branch per plant on tomato plant

Treatment	No. of Branch/Plant	
	40 DAT	60 DAT
VC_0	2.25c	3.00c
VC_1	2.66bc	4.16bc
VC_2	3.16ab	5.00ab
VC_3	3.91a	6.16a
S.E	0.29	0.42
Significance level (0.05)	0.008	0.000

(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

4.2.3 Combined Effect of 4-CPA and Vermicompost

Interaction effect of hormone and vermicompost application of the treatments showed statistically significant differences in terms of a number of effective branches per plant at 40 and 60 days after transplanting (Appendix VI-VII). At 60 DAT maximum number of effective branches per plant (8.00) was recorded from H_3VC_3 which was statistically similar with H_2VC_3 (7.33) while the minimum number of effective branches per plant (2.66) was recorded from H_0VC_0 treatment combination (Table 4).

Table 4: Interaction effect of 4-CPA and vermicompost on number of a branch of the tomato plant

Treatment	Number of Branch/Plant	
	40 DAT	60 DAT
H_0VC_0	2.00 cd	2.66 e
H_0VC_1	3.00 b-d	3.33 de
H_0VC_2	2.33cd	3.66 c-e
H_0VC_3	1.66 d	3.33 de
H_1VC_0	2.33cd	3.00 e
H_1VC_1	2.66 cd	4.33 c-e
H_1VC_2	3.00 b-d	4.67 b-e
H_1VC_3	4.00 a-c	6.00 a-d
H_2VC_0	2.333 cd	3.00 e
H_2VC_1	2.67 cd	3.67 c-e
H_2VC_2	4.00a-c	5.33 a-e
H_2VC_3	5.33 a	7.33 ab
H_3VC_0	2.33 cd	3.33 de
H_3VC_1	2.33 cd	5.33 a-e
H_3VC_2	3.33 b-d	6.33 a-c
H_3VC_3	4.67 ab	8.00 a
S.E	0.58	0.84
Significance level (0.05)	0.005	0.001

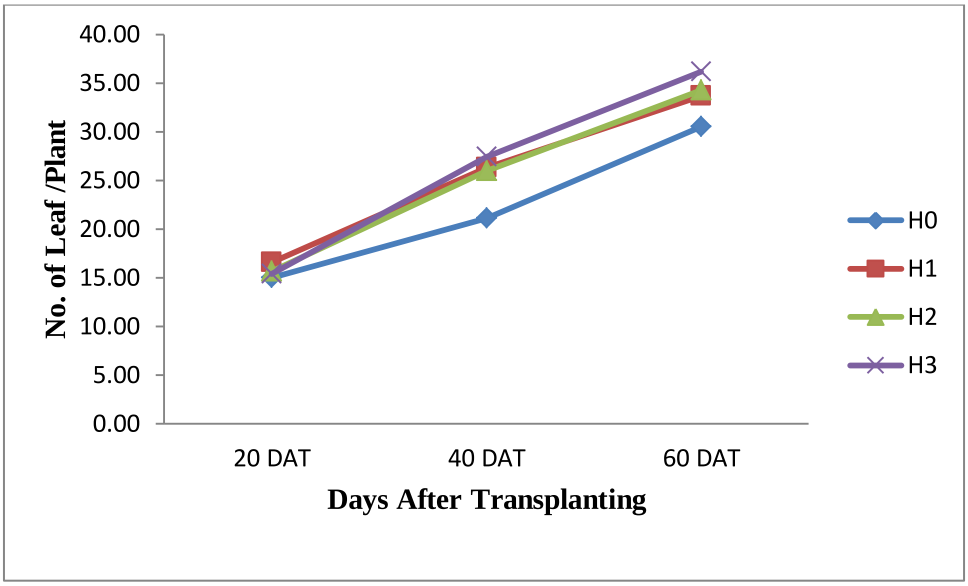
(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)
Here,Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

4.3 Number of leaves per plant

4.3.1 Effect of 4-CPA

Significant variation was recorded in terms of a number of leaves per plant of tomato at 20, 40, and 60 DAT for different levels of tomatotone (Appendices VIII-X). At 20 DAT, the maximum number of leaves per plant was recorded from H_1 (16.58) which was while the minimum number from H_0 (15.00) At 40 DAT, the maximum no. of leaves per plant was recorded from H_3 (27.41) which was while the minimum number from H_0 (21.08). At 60 DAT, the maximum number of leaves per plant was recorded from H_3 (36.167) which was statistically identical with H_1 (33.66) and H_2 (34.25), while the minimum number from H_0 (30.50) (Figure 3). A similar result was observed in tomato from Shemu *et al*. (2014).

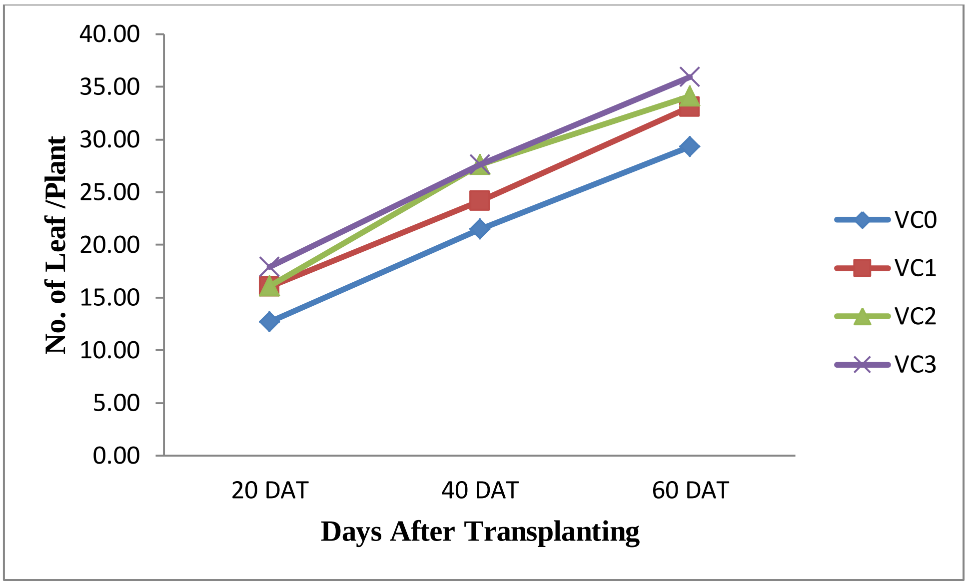


(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Figure 3: Effect of 4-CPA on number of leaf per plant at different days after transplanting (DAT). Vertical Bars indicate LSD value

4.3.1 Effect of vermicompost

A significant increase in leaf number of tomato plant was observed by the increasing of levels of vermicompost. Significant variation was recorded in terms of a number of leaves per plant of tomato at 20, 40, and 60 DAT for different levels of vermicompost (Appendices VIII-X). At 60 DAT, the maximum number of leaves per plant was recorded from VC_3 (35.92) which was statistically identical with VC_1 (35.25) and VC_2 (34.08), while the minimum number from H_0 (29.33) (Figure 4). Vermicompost has high microbial activity due to the presence of fungi, bacteria, and actinomycetes. They can produce plant growth regulators (PGRs) such as auxins, gibberellins, cytokinins, ethylene, and abscisic acid, then affected positively to the plant growth. This results agreed with the Azarmi R *et al*. (2008).



(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

Figure 4: Effect of vermicompost on a number of leaf per plant at different days after transplanting (DAT). Vertical Bars indicate LSD value

4.3.3 Combined effect of 4-CPA and Vermicompost

Interaction effect of 4-CPA and vermicompost application of the treatments showed statistically significant differences in terms of a number of leaves per plant at 20, 40 and 60 days after transplanting (Appendix VIII-X). A maximum number of leaves per plant (41.667) was recorded from H_3VC_3 which was statistically similar with H_2VC_3 (38.333) while the minimum number of leaves per plant (28.00) was recorded from H_0VC_0 treatment combination at 60 DAT (Table 5).

Table 5: Interaction effect of 4-CPA and vermicompost on number of leaves of the tomato plant

Treatment	No. of Leaf /Plant		
	20 DAT	40 DAT	60 DAT
H_0VC_0	11.66 bc	17.33 d	28.00 a
H_0VC_1	15.00 a-c	22.00b-d	32.00 a
H_0VC_2	17.33 ab	23.00 a-d	31.66 a
H_0VC_3	16.00 a-c	22.00 b-d	30.33 a
H_1VC_0	16.00 a-c	22.67 b-d	28.33 a
H_1VC_1	17.33 a	27.33 a-c	38.00 a
H_1VC_2	15.33a-c	28.67 a-c	35.00 a
H_1VC_3	17.67 a	26.67 a-d	33.33 a
H_2VC_0	11.33 c	20.67 cd	29.33 a
H_2VC_1	16.67 ab	26.67 a-d	35.66 a
H_2VC_2	15.67 a-c	27.33 a-c	33.67 a
H_2VC_3	19.00 a	29.33 a-c	38.33 a
H_3VC_0	11.67 bc	25.33 a-d	31.66 a
H_3VC_1	15.00 a-c	20.67 cd	35.33 a
H_3VC_2	16.00 a-c	31.33 ab	36.00 a
H_3VC_3	19.00 a	32.33 a	41.66 a
S.E	1.56	2.83	4.49
Significance level (0.05)	0.023	0.029	0.742

(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)

Here,Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot

4.4. Leaf Length

Significant variation was recorded for the length of leaves due to the effect of 4-CPA (Appendix XI). Results indicated that the longest leaves (31.99cm) were recorded from H_3 while the shortest leaves (27.66 cm) were recorded from H_0 (Table 6).

The length of leaves showed significant variation with different levels of vermicompost as treatment (Appendix XI). The length of leaves was highest (32.84 cm) in VC_3 treated plants which were statistically similar with VC_2

(30.73cm) and VC_1 (30.85) treated plants whereas lowest (26.66 cm) was observed in VC_0 treated plants (Table 7).

Significant variation was observed due to the interaction effect of 4-CPA and vermicompost treatments in terms of length of leaves of summer tomato (Appendix XI). It was remarked that longest leaves (38.00 cm) were found in H_3VC_3 treated plants which was statistically similar with H_2VC_1 (35.53cm) whereas the lowest leaves length (25.56 cm) was found in H_2VC_0 treated plants which were statistically similar to H_0VC_0 (26.56 cm) and H_0VC_1 (27.73 cm) treated plants (Table 8).

4.5. Leaf Breadth

Different levels of 4-CPA showed a significant source of variation on the breadth of leaves (Appendix XII). Results indicated that widest leaves (25.04 cm) were recorded from H_3 while the shortest leaves (18.56 cm) were recorded from H_0 which was statistically similar with H_1 (19.08 cm) (Table 6).

The breadth of leaves showed significant variation with different levels of vermicompost as treatment (Appendix XII). The breadth of leaves was highest (23.84cm) in VC_3 treated plants which were not statistically similar with VC_2 (22.03cm) and VC_1 (21.27 cm) treated plants whereas lowest (16.92 cm) was observed in VC_0 treated plants (Table 7).

Significant variation was observed due to the interaction effect of 4-CPA and vermicompost treatments in terms of breadth of leaves of summer tomato (Appendix XII). It was remarked that the highest result (30.70 cm) was found in H_3VC_3 treated plants which were statistically similar with H_3VC_2 (28.33 cm) whereas the lowest result (16.66 cm) was found in H_0VC_0 treated plants which were statistically similar to H_1VC_0 (16.66 cm) and H_2VC_0 (16.367 cm) treated plants (Table 8).

4.6. Number of Flower Cluster per Plant

Plants which were not treated with exogenous hormone showed very poor performance with respect to fruit-set in all the cluster order of flower (Table 1). On the other hand, the treated plants showed substantially higher fruit-set.

Significant variation was observed for a number of flower cluster per plant of tomato for different levels of 4-CPA (Table 6 and Appendix XIII). The highest number of flower cluster per plant (9.75) was found from H_2 which was closely followed (8.87and 8.60) by H_1 and H_2 respectively whereas the lowest number (7.75) was obtained from H_0 (no 4-CPA). This results agreed with the findings of Choudhury *et al*. (2013).

Different levels of vermicompost significantly influenced the number of flower cluster per plant (Table and Appendix XIII). VC_3 treated plants showed the maximum number of cluster per plant (10.30), while the minimum number of cluster per plant (7.25) was obtained from VC_0 treated plant (Table 7)

The combined effect of 4-CPA hormone and vermicompost treatments showed statistically significant variation in terms of a number of cluster per plant (Appendix XIII). The maximum number of flower cluster per plant (13.96) was recorded from H_3VC_3, while the minimum number per plant (6.33) was recorded from H_0VC_0 treated plants (Table 8).

4.7. Number of Flower per Plant

The number of flowers per plant is an important character which has the importance to determine the yield of tomato. Significant variation was observed in the case of a number of flowers per plant when applied different doses of 4-CPA (Appendix XIV). The maximum number of flowers (58.50) per plant was observed in H_1 which was statistically similar to H_3 (57.83) whereas the minimum number of flowers (55.58) per plant was found in H_2 (Table 6). This results agreed with the Shemu *et al.* (2014).

There was significant variation in respect of the number of flowers per plant due to the application of different levels of vermicompost (Appendix XIV). The maximum number of flowers (60.83) per plant was found in VC_3 treatment. The minimum number of flowers (53.33) per plant was found in the control treatment VC_0 (Table 7)

There was no significant difference among the treatments and variety combination in respect of a number of flowers per plant (Table 03). However, The highest number of flowers (61.33) per plant was observed in H_3VC_3 whereas the minimum number of flowers (51.66) per plant was found in H_2VC_0 which was statistically similar to H_0VC_0 (54.33) and H_2VC_1 (53.66) (Table 8)

4.8. Number of Fruit per Plant

The number of fruit set was recorded just before the commencement of harvest and was done for each treatment and spraying dates separately. Application of 75 ppm concentration of 4-CPA hormone produced the highest number of tomato fruit set (45.25) followed by 45.83 at 45 ppm concentration. The lowest number of tomato fruit set (21.25) was observed in control where no hormone was applied (Table 6). It also indicated that the number of fruit set has increased with the increase in the concentration of hormone applied. Choudhury *et al.* 2013 found similar results where a positive relationship between the fruit set and the concentration of hormone was observed. Similar results were also observed by Sasaki, H and others (2005), Salwa *et al.* (2018) in their field experiment where tomatoes treated with 4-CPA showed an increase in fruit set. It is therefore clear that the application of 4-CPA hormone has a significant effect on the tomato fruit set.

Significant variation was recorded for a number of fruits per plant at different levels of vermicompost (Appendix XV). The highest number of fruits per plant (44.33) was obtained from VC_3 while the lowest number (23.91) was found from VC_0 (Table 7).

The combined effect of 4-CPA and vermicompost treatments showed statistically significant variation in terms of a number of cluster per plant (Table and Appendix XV). The maximum number of fruits per plant (53.33) was recorded from H_3VC_3, while the minimum number per plant (18.33) was recorded from H_0VC_0 treated plants (Table 8).

Table 6: Effect of the hormone on leaf length, leaf breadth, number of cluster per plant, number of flower per plant, number of fruit per plant on tomato plant

Treatment	Leaf Length	Leaf Breadth	No. of cluster/Plant	No. of flower/Plant	No. of fruit/Plant
H_0	27.66b	18.56c	7.75c	56.66b	21.25b
H_1	29.30b	19.08c	8.87b	58.50a	40.83a
H_2	32.13a	21.38b	8.60b	55.58c	41.25a
H_3	31.92a	25.04a	9.75a	57.83a	45.25a
S.E	0.78	0.74	0.16	0.27	0.16
Significance level (0.05)	0.017	0.001	0.035	0.116	0.000

(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Table 7: Effect of vermicompost on leaf length, leaf breadth, number of cluster per plant, number of flower per plant, number of fruit per plant on tomato plant

Treatment	Leaf Length	Leaf Breadth	No. of cluster/Plant	No. of flower/Plant	No. of fruit/Plant
VC_0	26.66b	16.92c	7.25c	53.33d	23.91b
VC_1	30.85a	21.27b	8.62b	56.33c	39.33a
VC_2	30.73a	22.03ab	8.80b	58.08b	41.00a
VC_3	32.84a	23.84a	10.30a	60.83a	44.33a
S.E	0.78	0.74	0.16	0.27	0.16
Significance level (0.05)	0.002	0.001	0.000	0.000	0.000

(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot

Table 8: Interaction effect of 4-CPA and vermicompost on leaf length, leaf breadth, number of cluster per plant, number of flower per plant, number of fruit per plant

Treatment	Leaf Length	Leaf Breadth	No. of cluster/Plant	No. of flower/Plant	No. of fruit/Plant
H_0VC_0	26.56fg	16.66 e	6.33 h	54.33 f	18.33e
H_0VC_1	27.73e-g	18.60de	8.36ef	56.33 e	20.33de
H_0VC_2	27.26 e-g	19.36de	8.00fg	56.33 e	22.00de
H_0VC_3	29.10 c-g	19.63 de	8.30ef	59.66bc	24.33de
H_1VC_0	26.03fg	16.66 e	8.50 d-f	53.66 f	20.33de
H_1VC_1	31.30b-f	20.23 de	8.50 d-f	57.66 de	45.33b
H_1VC_2	28.90 d-g	19.40 de	8.90 c-f	61.00ab	48.33a
H_1VC_3	31.00 b-f	20.03 de	9.60bc	61.66 a	49.33a
H_2VC_0	25.56 g	16.36 e	7.26gh	51.66f	26.00cd
H_2VC_1	35.53ab	23.13 cd	9.43 b-d	53.66 f	43.33b
H_2VC_2	34.16 a-c	21.03 c-e	8.36ef	56.33 e	45.33b
H_2VC_3	33.26 a-d	25.00bc	9.33 b-e	60.66ab	50.33ab
H_3VC_0	28.50 d-g	18.00 de	6.90 h	53.66 f	31.00c
H_3VC_1	28.86 d-g	23.13 cd	8.20fg	57.66 de	48.33a
H_3VC_2	32.60 b-e	28.33ab	9.93 b	58.66 cd	48.333a
H_3VC_3	38.00 a	30.70 a	13.96 a	61.33 ab	53.33a
S.E	1.57	1.41	.32	.54	.32
Significance level (0.05)	0.000	0.000	0.000	0.000	0.000

(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)

Here, Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot

4.9 First Flowering

The effect of the hormone showed statistically significant variation for days from transplanting to first flowering (Appendix XVI). The minimum days after transplanting to first flowering (24.33) was found from H_3, while the maximum days to first flowering (27.33) was recorded from H_0 which has been notified in Table 9.

Days after transplanting to the first flowering of summer tomato varied significantly for different levels of vermicompost (Appendix XVI). The minimum days after transplanting to first flowering (23.16) was found from VC_3 treated plants while the maximum days (28.33) was recorded from VC_0 i.e. control condition (Table 10).

Significant variation was observed due to the interaction effect of 4-CPA and vermicompost application in terms of days after transplanting to first flowering (Appendix XVI). The minimum days after transplanting to first flowering (21.66) was recorded from H_3VC_3 combined treatments while the maximum days (30.00) were found from H_0VC_0 (Table 11).

4.10 First Fruiting

The effect of the hormone showed statistically significant variation for days from transplanting to first flowering (Appendix XVII). The minimum days after transplanting to first fruiting (54.16) was found from H_3 which was statistically similar with H_2 (54.75), while the maximum days to first fruiting (58.08) was recorded from H_0 which was statistically similar with H_1 (57.25) has been notified in Table 9.

Days after transplanting to first fruiting of summer tomato varied significantly for different levels of vermicompost (Appendix XVII). The minimum days after transplanting to first fruiting (52.00) was found from VC_3 treated plants while the maximum days (59.08) was recorded from VC_0 i.e. control condition (Table 10).

Significant variation was observed due to the interaction effect of 4-CPA and vermicompost application in terms of days after transplanting to first fruiting (Appendix XVII). The minimum days after transplanting to first fruiting (48.66) was recorded from H_3VC_3 combined treatments while the maximum days (61.00) was found from H_0VC_0 (Table 11).

4.11 First Harvesting

Hormone showed statistically significant variation for days from transplanting to first flowering (Appendix XVIII). The minimum days after transplanting to first fruiting (74.50) was found from H_3 which was statistically similar with H_2 (75.25), while the maximum days to first fruiting (78.33) was recorded from H_0 which was statistically similar with H_1 (77.33) has been notified in Table 9.

Days after transplanting to first fruiting of summer tomato varied significantly for different levels of vermicompost (Appendix XVIII). The minimum days after transplanting to first fruiting (72.83) was found from VC_3 treated plants while the maximum days (79.25) was recorded from VC_0 i.e. control condition (Table 10).

Significant variation was observed due to the interaction effect of 4-CPA and vermicompost application in terms of days after transplanting to first fruiting (Appendix XVIII). The minimum days after transplanting to first fruiting (70.33) was recorded from H_3VC_3 combined treatments while the maximum days (80.66) was found from H_0VC_0 (Table 11)

Table 9: Effect of 4-CPA on first flowering, first fruiting, first harvesting on tomato plant

Treatment	First Flowering(DAT)	First Fruiting(DAT)	First Harvesting(DAT)
H_0	27.33a	58.08a	78.33a
H_1	27.00a	57.25a	77.33a
H_2	25.41bc	54.75b	75.25b
H_3	24.33c	54.16b	74.50b
S.E	0.59	0.54	0.50
Significance level (0.05)	0.039	0.028	0.028

(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Table 10: Effect of vermicompost on first flowering, first fruiting, first harvesting on tomato plant

Treatment	First Flowering(DAT)	First Fruiting(DAT)	First Harvesting(DAT)
VC_0	28.33a	59.08a	79.25a
VC_1	26.50b	56.91b	77.08b
VC_2	26.08b	56.25b	76.25b
VC_3	23.16c	52.00c	72.83c
S.E	0.59	0.54	0.50
Significance level (0.05)	0.000	0.000	0.000

(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

Table 11: Interaction effect of 4-CPA and vermicompost on first flowering, first fruiting, first harvesting on tomato plant

Treatment	First Flowering(DAT)	First Fruiting(DAT)	First Harvesting(DAT)
H_0VC_0	30.00 a	61.00 a	80.66 a
H_0VC_1	27.66a-d	56.66 c-e	77.33a-c
H_0VC_2	28.33 a-c	60.33 ab	80.33 a
H_0VC_3	23.33 ef	54.33 e-g	75.00 a-d
H_1VC_0	29.33 ab	58.00 a-d	78.00 a
H_1VC_1	27.00 a-e	59.33 a-c	79.33 a
H_1VC_2	28.00 a-c	59.00 a-c	79.33 a
H_1VC_3	23.6 ef	52.66 fg	72.6 de
H_2VC_0	28.33 ab	57.66 a-e	78.6 ab
H_2VC_1	24.66 c-f	54.33 e-g	74.33 cd
H_2VC_2	24.66 c-f	54.66 d-f	74.66 cd
H_2VC_3	24.00 d-f	52.3 fg	73.33 de
H_3VC_0	25.66 b-e	59.66 a-c	79.66 a
H_3VC_1	26.66 a-e	57.33 b-e	77.33a-c
H_3VC_2	23.33 ef	51.00 gh	70.66 e
H_3VC_3	21.66 f	48.66 h	70.33 e
S.E	1.19	1.08	1.01
Significance level (0.05)	0.000	0.000	0.000

(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)
Here,Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

4.12 Length of Fruit

Application of different doses of 4- CPA showed a significant effect on the length of the fruit of tomato (Appendix XIX). The highest length of fruit (4.84 cm) was recorded from H_3. On the other hand, the lowest length (4.55 cm) was recorded from H_0 (Table 12). Cell division and cell elongation enhanced by hormone application. So, fruit length may be increased due to plant growth regulator (4-CPA) can be considered for increasing fruit size under high-temperature conditions (AVRDC, 1982). This results agreed with the Shemu et al. (2014)

Significant variation was found on the length of the fruit of tomato due to the application of different levels of vermicompost (Appendix XIX). The highest length of fruit (5.03 cm) was observed from VC_3 and the lowest length (4.37 cm) was observed from VC_0 (Table 13).

The combined effect of hormone and vermicompost showed significant differences in terms of fruit length (Appendix XIX). The highest length of fruit (5.26 cm) was recorded from H_3VC_3 and the lowest length (4.26 cm) was found from H_0VC_0 (Table 14).

4.13 Diameter of Fruit

The diameter of tomato fruit varied significantly for the application of hormone (Appendix XX). The highest diameter of fruit (4.83 cm) was recorded from H_3, whereas the lowest diameter (4.50cm) was recorded from H_0 (Table 12).

As fruit size increased by plant growth regulator, consequently individual fruit weight increased. Generally, average fruit weight increased 10 to 40% by the plant growth regulator treatment (AVRDC, 1982).

A significant difference was observed for the diameter of the fruit of tomato for the application of different levels of vermicompost (Appendix XX). The highest diameter of fruit (4.88 cm) was recorded from VC_3, while the lowest diameter (4.39 cm) was recorded from VC_0 (Table 13).

Hormone and vermicompost significantly influenced the diameter of fruit for their interaction effect (Appendix XX). The highest diameter of fruit (5.20 cm) was recorded from H_3VC_3. On the other hand, the lowest diameter (4.36 cm) was recorded from H_0VC_0 (Table 14).

4.14 Individual fruit weight

Individual fruit weight of summer tomato was influenced significantly with the effect of hormone (Appendix XXI). H_3 condition was given the maximum weight of individual fruit (66.55 g) and minimum individual fruit weight (57.40 g) was obtained from H_0 (Table 12). This results agreed with the findings of Choudhury *et al*. (2013)

Individual fruit weight varied significantly with the application of different levels of vermicompost treatments (Appendix XXI). Maximum individual fruit weight of tomato (67.04 g) was recorded from VC_3 treatment while the lowest individual fruit weight (57.46 g) was obtained from VC_0 i.e. controlled condition (Table 13). This results agreed with the findings of Thuy *et al.* (2017), Singh *et al.* (2010).

The combined effect of 4-CPA and vermicompost treatments showed a statistically significant variation in terms of individual fruits weight (Appendix XXI). The maximum individual fruits weight (68.76g) was recorded from H_3VC_3 which was statistically similar with H_3VC_2 (67.63 g), whereas the minimum Individual fruits weight (52.30 g) was recorded from H_0VC_0 which was statistically similar with H_0VC_1 (54.06 g) (Table 14).

4.15 Brix Percentage

Tomato fruit quality has been assessed by the content of chemical compounds such as dry matter, Brix degree, acidity, single sugars, citric acids, and volatile components. The brix percentage is expressed in a unit of total soluble solids (TSS) content.

This research work exhibited distinct variations in total soluble solids (TSS) of summer tomato by the effect of hormone (Appendix XXII). The maximum TSS in summer tomato (5.42 %) was found from H_3, while the minimum was (5.04 %) obtained from H_0 (Table 12).

In our study, under the effect of vermicompost, total sugar content in tomato fruits planted in summer season fluctuated significantly (Appendix XXII). The maximum TSS in summer tomato (5.45 %) was found from VC_3, while the minimum was (5.03 %) obtained from VC_0 (Table 13). This results agreed with the findings of Singh et al. (2013) and Ali et al. (2014).

The combined effect of 4-CPA and vermicompost application varied significantly on the TSS of summer tomato (Appendix XXII). It was observed that maximum TSS (5.5 %) was obtained from H_3VC_3 treated plants, which was statistically similar with H_3VC_2 (5.5 %) and H_3VC_1 (5.4 %), whereas the minimum (4.8 %) was recorded from H_0VC_0 (Table 14).

Table 12: Effect of 4-CPA on fruit length, fruit diameter, and individual fruit weight of tomato plant and brix percentage of tomato

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Weight of Individual Fruit (g)	Yield/Plant (kg)	Brix (%)
H_0	4.55c	4.50c	57.40c	2.37c	5.04c
H_1	4.75ab	4.67b	62.99b	2.85b	5.30b
H_2	4.68b	4.64b	63.79b	2.90b	5.28b
H_3	4.84a	4.83a	66.5a	3.23a	5.42a
S.E	0.03	0.04	0.30	15.60	0.01
Significance level (0.05)	0.088	0.015	0.000	0.000	0.000

(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Table 13: Effect of vermicompost on fruit length, fruit diameter, individual fruit weight of tomato plant and brix percentage of tomato

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Weight of Individual Fruit (g)	Yield/Plant (kg)	Brix(%)
VC_0	4.37d	4.39d	57.46d	2.34c	5.03d
VC_1	4.65c	4.62c	61.60c	2.74b	5.22c
VC_2	4.76b	4.75b	64.61b	2.98b	5.34b
VC_3	5.03a	4.88a	67.04a	3.31a	5.45a
S.E	0.03	0.04	0.30	15.60	0.01
Significance level (0.05)	0.000	0.000	0.000	0.000	0.000

(**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

Table 14: Interaction effect of 4-CPA and vermicompost on fruit length, fruit diameter, individual fruit weight, yield per plant of the tomato plant and brix percentage of tomato

Treatment	Fruit Length (cm)	Fruit Diameter (cm)	Weight of Individual Fruit (g)	Yield/Plant (kg)	Brix (%)
H_0VC_0	4.26 h	4.36 gh	52.30 h	.95f	4.80 e
H_0VC_1	4.53e-g	4.46 e-h	54.06 h	1.10f	4.96 d
H_0VC_2	4.60 d-f	4.53 d-g	58.06 g	1.27ef	5.10 c
H_0VC_3	4.80 cd	4.63 c-f	65.16 cd	1.58de	5.30 b
H_1VC_0	4.33 gh	4.26 h	53.50 h	1.09f	4.96 d
H_1VC_1	4.73 c-e	4.63 c-f	63.3 e	2.86bc	5.26 b
H_1VC_2	4.80 cd	4.86 bc	67.46 ab	3.26ab	5.46 a
H_1VC_3	5.13 ab	4.93 b	67.70 ab	3.34b	5.50 a
H_2VC_0	4.40 f-h	4.43 f-h	60.43 f	1.57de	5.1 c
H_2VC_1	4.66 de	4.70 b-e	62.90 e	2.72c	5.23 b
H_2VC_2	4.73 c-e	4.66 c-g	65.30 cd	2.96bc	5.30 b
H_2VC_3	4.93 bc	4.76 b-d	66.53 bc	3.35ab	5.50 a
H_3VC_0	4.50 e-h	4.50 f-h	63.63de	1.98d	5.26 b
H_3VC_1	4.66 de	4.70b-e	66.16 bc	3.19a-c	5.43 a
H_3VC_2	4.93 bc	4.93 b	67.63 ab	3.27ab	5.50 a
H_3VC_3	5.26 a	5.20 a	68.76 a	3.66a	5.50 a
S.E	0.07	0.07	0.59	31.21	0.03
Significance level (0.05)	0.000	0.000	0.000	0.000	0.000

(Means in the column followed by a different letter(s) differed significantly by DMRT at 5% level of significance)

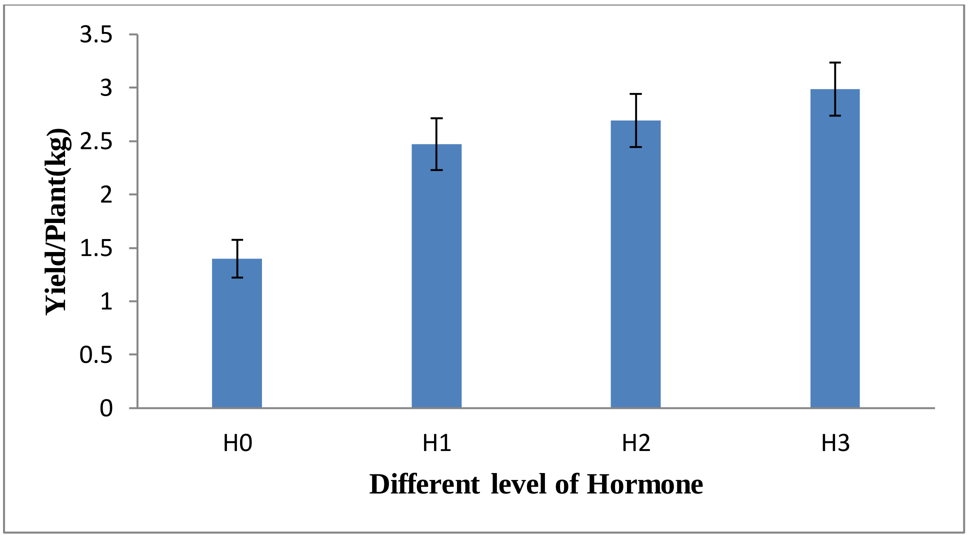
Here,Hormone (**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Vermicompost (**VC_0**: Control, **VC_1:** 500 g/pot, **VC_2**: 1 kg/pot, **VC_3:** 1.5 kg/pot)

4.1 Yield per plant

It can be seen that the treatment 75 ppm hormone concentration emerges as the best treatment to be replicated in the blocks to maximize the total tomato yield output, while the treatment 00ppm concentration corresponds to the lowest total yield among the four treatments (Appendix XXIII and Figure). The total yield of tomato was the highest of 3.23 kg and 2.90 kg at 75 ppm and 45ppm concentration of hormone application. The lowest number of tomato fruit (1.23kg) was observed in control where no hormone was applied (Figure 5). Salwa *et al.* (2018) Choudhury *et al.* (2013), Baliyan *et al.* (2013).

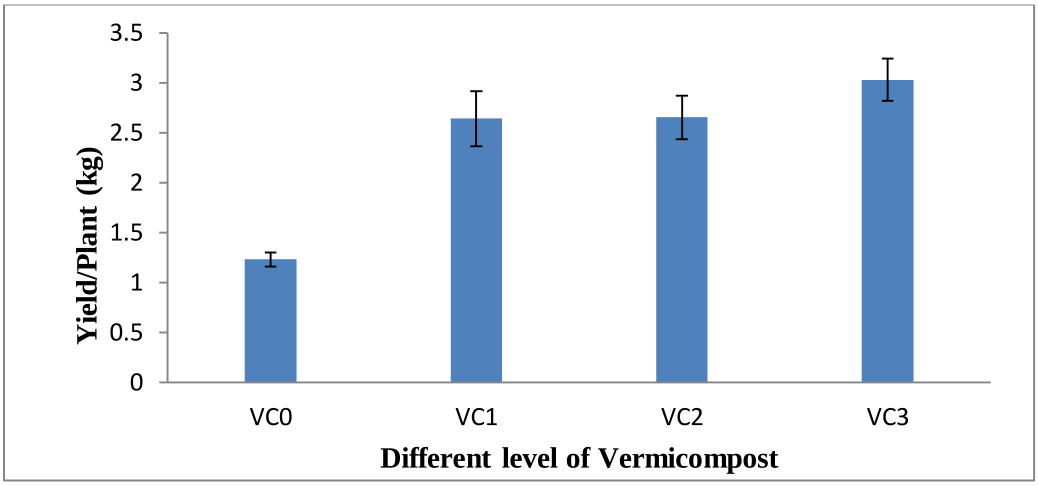
It indicated that the tomato yield has increased with the increase in the concentration of hormone applied. It therefore clearly indicates that the application of 4-CPA hormone has a positive effect on the yield of tomato growing in higher temperatures. Results also revealed that tomato yield has increased with the increase in the concentration of 4-CPA hormone.



(**H_0:** Control, **H_1**: 15 ppm, **H_2**: 45 ppm, **H_3:** 75 ppm)

Figure 5: Effect of 4-CPA on yield per plant of tomato. Vertical Bars indicate LSD value

Yield per plant varied significantly due to the application of different levels of vermicompost (Appendix XXIII and Figure 6). The maximum (3.31 kg/plant) yield was recorded from VC_3, while the minimum (2.34 kg/plant) was found from VC_0 (Control treatment). Vermicompost enhances the maximum size of fruits and weight. As a result, performed the higher yield. This results agreed with the findings of Thuy *et al.* (2017), Singh *et al.* (2010).



(**VC0**: Control, **VC1:** 500 g/pot, **VC2**: 1 kg/pot, **VC3:** 1.5 kg/pot)

Figure 6: Effect of vermicompost on yield per plant of tomato. Vertical Bars indicate LSD value.

Significant variation was found due to the interaction effect of hormone and vermicompost for yield per plant (Appendix XXIII and & Table 14). The maximum (3.66 kg/plant) yield was recorded from a treatment combination of H_3VC_3, while H_0VC_0 gave the minimum yield (0.95 kg/plant).

CHAPTER V

SUMMARY AND CONCLUSIONS

The experiment was carried out to determine the performance of summer tomato BARI Hybrid Tomto – 8 with the effect of 4-CPA and vermicompost. The research work was conducted on the pot at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh, during the period from April 2017 to October 2017.

The experiment consisted of two factors: Factor A**:** Four levels of 4-CPA, viz. H_0: control, H_1: 15 ppm 4-CPA (4-Chloro Phenoxy Acetic Acid), H_2:45 ppm 4-CPA, H_3: 75ppm 4-CPA and Factor B: Different levels of vermicompost such as, VC_0: Control, VC_1**:** 500 g/pot, VC_2: 1 kg/pot, VC_3**:** 2 kg/pot. There were 16 (4 × 4) treatment combinations. The two-factorial experiments were laid out in Complete Randomized Design (CRD) with three replications.

In case the use of 4-CPA, the highest plant height (101.91 cm) was recorded with 75 ppm hormone (H_3) treatment whereas the shortest plant height (88.08 cm) was recorded without hormone (H_0) treatment at final harvest. The maximum number of effective branches per plant (5.75) was observed from H_3 whereas the minimum number of effective branches per plant (3.25) was found from H_0 at 60 days after transplanting. The maximum number of leaves per plant (36.16) was recorded from H_3 whereas the minimum number (30.50) was recorded from H_0 at 60 days after transplanting. The longest leaves (31.99 cm) were recorded from H_3 while the shortest leaves (27.66 cm) were recorded from H_0. The highest result in terms of leaf breadth (25.04 cm) was observed from H_3 while the lowest result (18.56 cm) was observed from H_0. The higher number of cluster per plant (9.75) was obtained from H_3 while the lower number of cluster per plant (7.75) was obtained from H_0. The highest number of flower per plant (57.83) was obtained from H_3 while the lowest number of flower per plant (56.66) was obtained from H_0. The topmost result in terms of total number of fruits per plant (48.58) was obtained from H_3 while the lower number of fruits per plant (41.25) was obtained from H_0. The minimum days after transplanting to first flowering (24.33) was found from H_3, while the maximum days to first flowering (27.33) was found from H_0. The minimum days after transplanting to first fruiting (54.16) was found from H3, while the maximum days to first fruiting (58.08) were found from H_0. The minimum days after transplanting to first harvesting (74.50) was found from H3, while the maximum days to first harvesting (78.33) were found from H_0. In case of fruit length, the highest result (4.84 cm) was observed from H_3 and the lowest result (4.55 cm) was obtained from H_0. The highest fruit diameter (4.83 cm) was recorded from H_3 whereas the lowest fruit diameter (4.50 cm) was recorded from H_0. H_3 condition was given maximum individual fruit weight (66.55 g) and minimum individual fruit weight (57.40 g) was obtained from H_0. Total fruit weight of summer tomato per plant was observed the maximum (3.23 kg) from H_3, while the minimum fruit weight per plant (2.37 kg) obtained from H_0. H_3 scored the maximum brix percentage in summer tomato (5.42 %), while the minimum (5.04 %) obtained from H_0.

In case the use of vermicompost, the highest plant height (103.83 cm) was recorded with 2 kg/pot vermicompost (VC_3) treatment whereas the shortest plant height (88.25 cm) was recorded without vermicompost (VC_0) treatment at final harvest. The maximum number of effective branches per plant (6.16) was observed from VC_3 whereas the minimum number of effective branches per plant (3.00) was found from VC_0 at 60 days after transplanting. The maximum number of leaves per plant (35.91) was recorded from VC_3 whereas the minimum number (29.33) was recorded from VC_0 at 60 days after transplanting. The longest leaves (32.84 cm) were recorded from VC_3 while the shortest leaves (26.66 cm) were recorded from VC_0. The highest result in terms of leaf breadth (22.03 cm) was observed from VC_3 while the lowest result (16.92 cm) was observed from VC_0. The higher number of cluster per plant (10.30) was obtained from VC_3 while the lower number of cluster per plant (7.25) was obtained from VC_0. The highest number of flower per plant (60.83) was obtained from VC_3 while the lowest number of flower per plant (53.33) was obtained from VC_0. The topmost result in terms of total number of fruits per plant (49.33) was obtained from VC_3 while the lower number of fruits per plant (40.58) was obtained from VC_0. The minimum days after transplanting to first flowering (23.16) was found from VC_3, while the maximum days to first flowering (28.33) was found from VC_0. The minimum days after transplanting to first fruiting (52.00) was found from VC_3, while the maximum days to first fruiting (59.08) were found from VC_0. The minimum days after transplanting to first harvesting (72.83) was found from VC_3, while the maximum days to first harvesting (79.25) were found from VC_0. In case of fruit length, the highest result (5.03 cm) was observed from VC_3 and the lowest result (4.37 cm) was obtained from VC_0. The highest fruit diameter (4.88 cm) was recorded from VC_3 whereas the lowest fruit diameter (4.39 cm) was recorded from VC_0. VC_3 condition was given maximum individual fruit weight (67.04 g) and minimum individual fruit weight (57.46 g) was obtained from VC_0. Total fruit weight of summer tomato per plant was observed the maximum (3.31 kg) from VC_3, while the minimum fruit weight per plant (2.34 kg) obtained from VC_0. VC_3 scored the maximum brix percentage in summer tomato (5.45 %), while the minimum (5.03 %) obtained from VC_0.

In case of the interaction effect of hormone and vermicompost, the tallest plant was recorded from H_3VC_3 (110.33 cm) which is statistically similar with H_3VC_2 (108.00 cm) treatment whereas the shortest plant was recorded from control H_0VC_0 (84.00 cm) treatment at final harvest. The maximum number of effective branches per plant (8.00) was observed from H_3VC_3 whereas the minimum number of effective branches per plant (2.66) was found from H_0VC_0 at 60 days after transplanting. The maximum number of leaves per plant (41.66) was recorded from H_3VC_3 whereas the minimum number (28.00) was recorded from H_0VC_0 at 60 days after transplanting. The longest leaves (38.00 cm) were recorded from H_3VC_3 while the shortest leaves (26.56 cm) were recorded from H_0VC_0. The highest result in terms of leaf breadth (30.70 cm) was observed from H_3VC_3 while the lowest result (16.66 cm) was observed from H_0VC_0. The higher number of cluster per plant (13.96) was obtained from

H_3VC_3 while the lower number of cluster per plant (6.33) was obtained from H_0VC_0. The highest number of flower per plant (61.33) was obtained from H_3VC_3 while the lowest number of flower per plant (54.33) was obtained from H_0VC_0. The topmost result in terms of the amount of fruit per plant (53.33) was obtained from H_3VC_3 while the lower number of fruits per plant (38.33) was obtained from H_0VC_0. The minimum days after transplanting to first flowering (21.66) was found from H_3VC_3, while the maximum days to first flowering (30.00) was found from H_0VC_0. The minimum days after transplanting to first fruiting (48.66) was found from H_3VC_3, while the maximum days to first fruiting (61.00) were found from H_0VC_0. The minimum days after transplanting to first harvesting (70.33) was found from H_3VC3, while the maximum days to first harvesting (80.66) were found from H_0VC_0. In case of fruit length, the highest result (5.26 cm) was observed from H_3VC_3 and the lowest result (4.26 cm) was obtained from H_0VC_0. The highest fruit diameter (5.20 cm) was recorded from H_3VC_3 whereas the lowest fruit diameter (4.36 cm) was recorded from H_0VC_0. H_3VC_3 condition was given maximum individual fruit weight (68.76 g) and minimum individual fruit weight (52.30g) was obtained from H_0VC_0. Total fruit weight of summer tomato per plant was observed the maximum (3.66 kg) from H_3VC_3, while the minimum fruit weight per plant (2 kg) obtained from H_0VC_0. H_3VC_3 scored the maximum brix percentage in summer tomato (5.5 %), while the minimum (4.8 %) obtained from H_0VC_0 .

Conclusions

Considering the present study the following recommendation may be suggested:

I. The application of 4-CPA hormone has a positive and significant effect on the fruit set and total yield of summer tomato. A positive relationship between the concentration of hormone and the amount of fruit set as well as tomato yield. This study provides a strong possibility that higher concentration of 4-CPA (>75ppm) may have more positive effects on the yield of summer tomato and therefore it was suggested that similar study can be conducted to determine the effects of higher concentration of 4-CPA hormone on fruit set and yield of tomato.

II. From the study, it is concluded that vermicompost as organic fertilizer can show the best performance in terms of yield and quality of tomato as well as soil fertility management.

III. The combined application of 4-CPA and vermicompost would help to get a better result in summer tomato cultivation and may provide a higher return in terms of yield

IV. Further investigation is needed in different Agro-Ecological Zones (AEZ) of Bangladesh to justify the result for economic returns

V. After consecutive trial, best result could be proposed for commercial cultivation in all over the country.

CHAPTER VI

REFERENCES

AVRDC, (1990). Progress Report. Asian Vegetables Research and Development Center, Shanhua, Tainan, Taiwan. **p**. 352-358

Abduli, M.A., Amiri, L., Madadian, E., Gitipour, S. and Sedighian, S. (2013). Efficiency of Vermicompost on Quantitative and Qualitative Growth of Tomato Plants. Int. J. Environ. Res., **7**(2):467-472.

Ali, M.R., Mehraj, H. and Uddin, A.F.M. J. (2014). Foliar Application of the Leachate from Vermicompost and Mustard Oil Cake on the Growth and Yield of Summer Tomato. MEJSR., **22** (8): 1233-1235.

Azarmi, R ., Ziveh, PS. and Satari, MR. (2008). Effect of vermicompost on growth, yield and nutrition status of tomato (*Lycopersicum esculentum*). Pak J Biol Sci; **11**(14):179-802.

Baliyan, S.P., Madhava Rao, K. S. and Mahabile, M. (2013). The effects of 4-chlorophenoxyacetic acid plant growth regulator on the fruit set, yield and economic benefit of growing tomatoes in high temperatures. Int. J. Agric. Sci., **3**: 29-36.

Batlang, U. (2008). Benzyladenine plus gibberellins (GA4+7) increase fruit size and yield in greenhouse-grown hot pepper (*Capsicum annuum* L.). *Journal of Biological Science.* **8**(3): 659-662.

Bhosle, A. B., Khrbhade, S. B., Sanap, P. B. and Gorad, M. K. (2002). Effect of growth hormones on growth, yield of summer tomato. *Orissal of Hort*., **30**(2): 63-65.

Choudhury, S., Islam, N., Sarker, M.D. and Ali, M.A. (2013). Growth and yield of summer tomato as influenced by plant growth regulators. *Int. J. Sustain. Agric*., **5**(1):25-28.

Dasgan, H.Y., Cetinturk, T. and Altuntas, O. (2017). The effects of biofertilizers on soilless organically grown greenhouse tomato. Acta Hortic., **1164**: 555-561.

Follet, R., Donahue, R. and Murphy L.(1981) Soil and Soil Amendments. Prentice- hall; Inc., New Jersey.

Gillaspy, G., Ben-David, H., Gruissem, W.(1993). Fruits: a developmental perspective. The Plant Cell, **l 5**: 1439–1451

Halder, N.K., Shaha, M.K., Kabir, A.H.M.F., Sarker, J.U. and Rahman, M.J. (2003). Response of Summer Tomato to Hormone and Planting Time at Hill Slope. *Pak J Biol Sci.* ,**6**(2): 146-148.

Hossain, S.M. (2006). Effect of Plant Growth Regulator on the Growth and Yield of Heat Tolerant Tomato (Lycopersicon esculentum).MS Thesis. Department of Horticulture and Postharvest Technology. Sher-E-Bangla Agricultural University. **pp**. 1-94

Islam, M. A., Islam, S., Akter, A., Rahman, M.H. and Nandwani, D. (2017). Effect of Organic and Inorganic Fertilizers on Soil Properties and the Growth, Yield and Quality of Tomato in Mymensingh, Bangladesh. MDPI, agriculture; **7**(18):1-7

Iwahori, (1967). Auxin of tomato fruit set at different stages of its development with a special reference to high-temperature injuries. Plant and Cell Physiol. **8:** 15-22.

Joshi, R. and Vig, A.P. (2010). Effect of Vermicompost on Growth, Yield, and Quality of Tomato (*Lycopersicum esculentum L*). AJBAS.,**2** (3-4): 117-123.

Joshi, R., Singh, J., and Vig, A.P.(2014).Vermicompost as an effective organic fertilizer and biocontrol agent: Effect on Growth, Yield, and Quality of Plants. Reviews in Environmental Science and Biotechnology. **14**(1): 137 – 159.

Karim, M.R., Nahar, M.A. and Saharia, M.S. (2015). Improvement of summer tomato (*Lycopersicon esculentum Mill.*) production using 4-chlorophenoxy acetic acid. J. Biosci. Agric. Res. **04**(02): 86-91.

Karakurt, R. (2000). Effects of 4-CPA applications and inflorescence pruning on the yield of hybrid tomato in greenhouse conditions. *Bahce*., **29**(1/2): 45-48.

Kalloo. (1989). Tomato (*Lycopersicon esculentum* Mill). *Indian Hort.,* **33** (1): 12-15.

Khan, A.A., Bibi, H., Ali, Z., Sharif, M., Shah, S.A., Ibadullah, H., Khan, K., Azeem, I. and Ali, S.(2017). Effect of compost and inorganic fertilizers on yield and quality of tomato. Acad J **Agric** Res .,**5**(10): 287-293.

Meenakumari, T. And Shekhar, M. (2012). Vermicompost and Other Fertilizers Effect on Growth, Yield and Nutritional Status of Tomato (Lycopersicon esculentum) Plant. *World Res. J. Agric. Biotechnol*. ,**1**(1), pp. 14-16.

Mukta, S. Rahman, M. M. and Mortuza, M. G.(2015). Yield and Nutrient Content of Tomato as Influenced by the Application of Vermicompost and Chemical Fertilizers. J. Environ. Sci. & Natural Resources, **8**(2): 115-122.

Najar, I. A., Khan, A. B. and Hai, A.(2015). Effect of macrophyte vermicompost on growth and productivity of brinjal (*Solanum melongena)* under field conditions. Int J Recycl Org Waste Agriculture .,**4**:73–83

Patil, MB., Mohammed, RG. and Ghadge, PM. (2004). Effect of organic and inorganic fertilizers on growth, yield, and quality of tomato. J. Mahatma Phule Krishi Vidyapeet., **29**(2):124-127.

Pell, A. N. (1997). Manure and microbes: public and animal health problem. *J Dairy Sci.* ,**80:**2673-3734.

Picken, A.J.F.(1984). A Review of pollination and fruit set in the tomato (*Lycopersicon esculentum Mill*). *J. Hortic. Sci*., **55:** 1-13

Premsekhar, M., and Rajashree, V. (2009). Influence of organic manures on growth, yield, and quality of okra. *The American Journal of Sustainable Agriculture.* ,**3:**6-8.

Rahman, M., Nahar, M.A., Sahariar, M.S . and Karim, M.R.(2015). Plant growth regulators promote growth and yield of summer tomato (*Lycopersicon esculentum Mill.*). Progressive Agriculture .,**26:** 32-37.

Resendez, A. M., Saldivar, E. C., Dimas, N. R., Carrillo, J. L .R., Ríos, P. C, Arroyo, J. V . and Viramontes, U. F. (2013). Vermicompost management: An alternative to meet the water and nutritive demands of tomato under greenhouse conditions. Emir. J. Food Agric. **25** (5): 385-393.

Ravestijn, W. van. (1983). Improvement of fruit set in eggplants with 4-CPA (Tomatotone) . Acta Horticulturae. Issue :137

Salunkhe, D. K., Desai, B. B. and Bhat, N. R. (1987). Vegetables and Flower Seed Production. 1st. Edn., Agricola Publishing Academy., New Delhi, India. **pp**. 118-119.

Salwa, M., Islam, M. S. and Uddin, M. N. (2018).Yield Performance of Tomato Hybrids during the Summer Season in Sylhet. *Asian J. Agric. Res*., **8**(2): 1-8

Sasaki, H., Yano, T., and Yamasaki, A. (2005). Reduction of high-temperature inhibition in tomato fruit set by plant growth regulators. JARQ, **39**:135-138.

Sendurkumaran, S., Natarajan, S and Thambrai S. (1998). Effect of organic and inorganic fertilizer on growth, yield, and quality of tomato. *South Indian Horticulture,* **46**(3/4):205.

Shemu, S. A., Amin, M. R., Shiam, I. H., Mehraj, H. & Jamal Uddin, A. F. M. (2014). Effect of Tomatotone on Growth and Yield of Summer Tomato. J. sci. technol. environ. Inform . ,01(02): 54-59.

Singh, B.K., Pathak, K.A., BOOPATHI, T. and DEKA, B.C. (2010).Vermicompost and NPK Fertilizer Effects on Morpho-Physiological Traits of Plants, Yield and Quality of Tomato Fruits: (*Solanum lycopersicum* L.). Vegetable Crops Research Bulletin.,**73:** 77-86.

Singh, B.K., Pathak, K.A., Ramakrishna, Y., Verma, V.K. and Deka, B.C. (2013).Vermicompost, Mulching and Irrigation Level on Growth, Yield, and TSS of Tomato(*Solanum lycopersicum L*.). *Indian J. Hill Farming*., **26**(2):105-110.

Thakur, N and Tripathi A. (2015). Impact of Integrated Organic approaches compared to conventional practices on small scale tomato (cv. Solan lalima) production system in terms of sustainability and profitability under mid-hill conditions of Himachal Pradesh. Anum Association, 1-19.

Thuy, P .T ., Nghia, N.A. and Dung, P. T.(2017). Effects of Vermicompost Levels on the Growth and Yield of HT152 Tomato Variety Grown Organically. *IJAIR*., **5**(4): 2319-1473.

Tiwari, M. (2015). Effect of Organic, Inorganic, and Biofertilizers on Growth and Yield of Tomato (*Lycopersicon esculentum* Mill) under Protected Condition.MS Thesis. Department of Horticulture. Jawaharlal Nehru Krishi Vishwa Vidyalaya College of Agriculture. **pp**:1-116.

Uz, I. and Tavali, I E.(2014) Short-Term Effect of Vermicompost Application on Biological Properties of an Alkaline Soil with High Lime Content from the Mediterranean Region of Turkey. *ScientificWorldJournal*., **pp**. 11.

Wang X-X, Zhao F, Zhang G, Zhang Y and Yang L (2017) Vermicompost Improves Tomato Yield and Quality and the Biochemical Properties of Soils with Different Tomato Planting History in a Greenhouse Study. Front. Plant Sci**. 8**:1978.

APPENDICES

Appendix I: Characteristics of Sher-e-Bangla Agricultural University soil, analysed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Horticulture Garden, SAU, Dhaka
AEZ	Modhupur Tract (28)
General soil Type	Shallow red brown terrace soil
Land Type	Medium high land
Soil Series	Tejgaon
Topography	Fairly leveled
Flood Level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of initial soil

Soil characteristics	**Analytical results**
pH	6.00-6.63
Organic matter	0.84
Total N(%)	0.46
Available phosphorus	21 ppm
Exchangeable K	0.41 mcq/100g soil

Source: Soil Resources Development Institute (SRDI)

Appendix II: Analysis of variance of data on plant height at 20 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	395.22	3	131.74	2.10	0.11
Factor B (Vermicompost)	1715	3	571.91	17.49	0.00
Interaction A×B	2521.81	15	168.12	8.50	0.00

Appendix III: Analysis of variance of data on plant height at 40 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	915.41	3	305.13	2.61	0.06
Factor B (Vermicompost)	1996.41	3	665.47	7.23	0.00
Interaction A×B	3975.25	15	265.01	4.10	0.00

Appendix IV: Analysis of variance of data on plant height at 60 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	910.72	3	303.57	2.87	0.04
Factor B (Vermicompost)	1686.56	3	562.18	6.38	0.00
Interaction A×B	3020.97	15	201.39	2.53	0.01

Appendix V: Analysis of variance of data on plant height at harvest of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	1213.08	3	404.36	3.91	0.015
Factor B (Vermicompost)	1550.41	3	516.80	5.39	0.003
Interaction A×B	3167.91	15	211.19	2.60	0.011

Appendix VI: Analysis of variance of data on number of branch at 40 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	11.16	3	3.72	2.37	0.083
Factor B (Vermicompost)	18.50	3	6.16	4.41	0.008
Interaction A×B	46.66	15	3.11	2.98	0.005

Appendix VII: Analysis of variance of data on number of branch at 60 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	38.50	3	12.83	3.73	0.018
Factor B (Vermicompost)	64.33	3	21.44	7.52	0.000
Interaction A×B	121.66	15	8.11	3.81	0.001

Appendix VIII: Analysis of variance of data on number of leaves at 20 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	16.16	3	5.38	0.50	0.684
Factor B (Vermicompost)	172.16	3	57.38	7.92	0.000
Interaction A×B	254.66	15	16.97	2.30	0.023

Appendix IX: Analysis of variance of data on number of leaves at 40 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	285.41	3	95.13	3.26	0.03
Factor B (Vermicompost)	313.41	3	104.47	3.67	0.01
Interaction A×B	797.25	15	53.15	2.21	0.02

Appendix X: Analysis of variance of data on number of leaves at 60 DAT of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	199.39	3	66.46	1.21	0.31
Factor B (Vermicompost)	318.22	3	106.07	2.04	0.12
Interaction A×B	659.64	15	43.97	0.72	0.74

Appendix XI: Analysis of variance of data on leaf length of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	169.65	3	56.55	3.78	0.017
Factor B (Vermicompost)	241.89	3	80.63	6.06	0.002
Interaction A×B	588.69	15	39.24	5.27	0.000

Appendix XII: Analysis of variance of data on leaf breadth of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	312.90	3	104.30	6.88	0.001
Factor B (Vermicompost)	309.87	3	103.29	6.78	0.001
Interaction A×B	766.10	15	51.07	7.65	0.000

Appendix XIII: Analysis of variance of data on number of cluster per plant of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	24.45	3	8.15	3.12	0.035
Factor B (Vermicompost)	56.04	3	18.68	9.86	0.000
Interaction A×B	129.34	15	8.62	27.50	0.000

Appendix XIV: Analysis of variance of data on number of flower per plant of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	59.72	3	16.91	2.08	0.116
Factor B (Vermicompost)	356.06	3	118.68	42.14	0.000
Interaction A×B	451.97	15	30.13	34.43	0.000

Appendix XV: Analysis of variance of data on number of fruit per plant of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	4185.56	3	1395.18	14.78	0.000
Factor B (Vermicompost)	2955.72	3	985.24	8.05	0.000
Interaction A×B	7821.31	15	521.42	32.29	0.000

Appendix XVI: Analysis of variance of data on first flowering(DAT) of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	70.72	3	23.57	3.03	0.039
Factor B (Vermicompost)	164.72	3	54.91	9.73	0.000
Interaction A×B	276.97	15	18.46	4.34	0.000

Appendix XVII: Analysis of variance of data on first fruiting(DAT) of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	129.72	3	43.24	3.32	0.028
Factor B (Vermicompost)	316.72	3	105.57	12.03	0.000
Interaction A×B	590.81	15	39.38	11.25	0.000

Appendix XVIII: Analysis of variance of data on first harvesting(DAT) of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	114.39	3	38.13	3.32	0.028
Factor B (Vermicompost)	255.89	3	85.29	10.33	0.000
Interaction A×B	519.64	15	34.64	11.16	0.000

Appendix XIX: Analysis of variance of data on fruit length of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	0.54	3	0.18	2.32	0.088
Factor B (Vermicompost)	3.39	3	0.22	12.62	0.000
Interaction A×B	3.39	15	0.22	12.63	0.000

Appendix XX: Analysis of variance of data on fruit diameter of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	0.67	3	0.22	3.89	0.015
Factor B (Vermicompost)	1.57	3	0.52	14.09	0.000
Interaction A×B	2.61	15	0.17	9.28	0.000

Appendix XXI: Analysis of variance of data on individual fruit weight of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	530.25	3	176.75	9.31	0.000
Factor B (Vermicompost)	613.22	3	204.40	11.95	0.000
Interaction A×B	1330.88	15	88.72	82.42	0.000

Appendix XXII: Analysis of variance of data on yield of tomato plant

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	22.60	3	7.53	14.47	0.000
Factor B (Vermicompost)	17.19	3	5.73	8.91	0.000
Interaction A×B	43.29	15	2.88	41.74	0.000

Appendix XXIII: Analysis of variance of data on brix percentage of tomato

Source of variation	Sum of Squares	D.f	Mean Square	F-Value	Significance Level
Factor A (Hormone)	0.92	3	0.30	9.76	0.000
Factor B (Vermicompost)	1.14	3	0.38	14.36	0.000
Interaction A×B	2.22	15	0.14	54.79	0.000