EFFECT OF CHEMICAL AND ORGANIC FERTILIZER ON GROWTH, YIELD AND PHENOLIC CONTENT OF TOMATO

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF CHEMICAL AND ORGANIC FERTILIZER ON GROWTH, YIELD AND PHENOLIC CONTENT OF TOMATO"** submitted to the **DEPARTMENT OF AGRICULTURAL CHEMISTRY**, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of *bona fide* research work carried out by **MD. SK. SABIT**, Registration No. **13-05517** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

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ABSTRACT

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka from October 2018 to March 2019 to assess the effect of chemical and organic fertilizers on growth, yield and phenolic contents of tomato. The experiment consisted single factor: five fertilizer management practice with chemical and organic fertilizer (cowdung) viz. T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different fertilizer management practices influenced significantly on all of the studied parameters. Among the fertilizer management practices T_3 treatment (75% Chemical fertilizer +25% Organic fertilizer) performed best in case of all of the vegetative (Plant height, number of leaves, number of branches) and reproductive characteristics (days to flowering, number of clusters, number flowers and fruits per cluster, number of fruits per plant). Fruit length, fruit weight was also observed highest from T_3 treatment and lowest from T_1 treatment. Maximum yield was obtained from T_3 treatment (3.30 kg/plant and 93.2 t/ha) and lowest was found from T_1 treatment (2.10 kg/plant and 76.8 t/ha). Phenolic content of tomato pulp and seed was highest for T_5 treatment (49.87 mg GAE/100g and 24.76 mg GAE/100g) and the lowest phenolic content was found from T_1 33.30 mg GAE/100g and 14.31 mg GAE/100g).

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ABBREVIATIONS AND ACRONYMS

N	:	Nitrogen
P	:	Phosphorus
K	:	Potassium
DAT	:	Days after transplanting
ANOVA	:	Analysis of variance
LSD	:	Least significant difference
df	:	Degrees of Freedom
C.V.%	:	Percentage of Coefficient of Variation
t	:	Ton
h	:	Hectare
pH	:	Potential hydrogen
ppm	:	Parts per million
RCBD	:	Randomized completely blocked design
S	:	Sulfur
CEC	:	Cation exchange capacity
meq	:	Milliequivalents
TPC	:	Total phenolic content
EM	:	Effective Microorganisms
UV	:	Ultra Violet
HRC	:	Horticulture Research Centre
TSS	:	Total Soluble Sugar
µg	:	Microgram
mg	:	Milligram

Kg	:	Kilogram
LAI	:	Leaf Area Index
CRCF	:	Controlled-Release Compound Fertilizer
GEA	:	Gallic Acid Equivalent
FRAP	:	Ferric Reducing Antioxidant Power
TE	:	Trolox Equivalent
DPPH	:	2,2-Diphenyl-1-picrylhydrazyl

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum*) is a widely cultivated perennial plant, commonly red, sometimes yellow, used as vegetable in throughout the world including Bangladesh. In Bangladesh, the area of cultivation is about 68366 acres with the production of about 388725 metric tons. Tomato plants belongs to the family Solanaceae and are known as a good source of phenolic compounds, pigments, antioxidants, and other nutrients in the human diet (Taveira *et al.,* 2012). Phenolic contents are linked to many health benefits, includes reduced risk of heart disease and cancer (Devanand *et al.,*2006). For the achievement of high quality and quantity of tomato yield with availability of primary nutrients is prime target. Primary nutrient supplement for tomato cultivation are Nitrogen, Potassium and phosphorus usually needed at a higher dose. These are the most limiting factors for increasing the productivity of tomato in the tropical countries like Bangladesh. The presence of macronutrients is essential for plant growth and has a significant effect on the accumulation of polyphenols and antioxidants (Zhang *et al*., 2014). Nutrients are usually supplied as inorganic fertilizer in Bangladesh. However, the continuous use of chemical fertilization leads to deterioration of soil characteristics and fertility. These may lead to the accumulation of heavy metals in plant tissues which compromises fruit nutrition value and edible quality (Shimbo *et al.,* 2001). Therefore, farmers have started to use organic fertilizers beside the inorganic fertilizers in tomato production. Research comparing soils of organically and chemically managed farming systems have recognized the higher soil organic matter and total nitrogen (N) with the use of organic agriculture (Alvarez *et al.,* 1988; Drinkwater *et al*., 1995; Reganold, 1988). There is a good number of evidence that organic fertilizer promotes plant growth and have a favorable influence on yield parameters of crops like, tomato, brinjal, wheat, paddy, and sugarcane etc. (Ansari., 2007).

Phenolic compounds are a group of small molecules characterized by their structures having at least one phenol unit. Based on their chemical structures, phenolic compounds can be divided into different subgroups, such as phenolic acids, flavonoids, tannins, coumarins, lignans, quinones, stilbens, and curcuminoids. (Gan *et al*., 2010). Phenolic compounds (PCs) are ubiquitously distributed phytochemicals found in most plant tissues, including fruits and vegetables. They are secondary metabolites synthesized through the shikimic acid and phenylpropanoid pathways (La Rosa *et al*., 2019). Phenolic compounds have been extensively characterized in tomato varieties from different countries, including genetically modified tomatoes and by-products (Barros *et al*., 2012; C´etkovic´ *et al.,* 2012 and Valdez-Morales *et al*., 2014). However, the chemical composition of tomatoes can vary among tissues of a single fruit and type of tomatoes, according to the cultivar, cultivation conditions, and handling and storage methods (Barros *et al.,* 2012). Phenolic compounds in plants may exist in free, soluble conjugated (acid and alkaline hydrolysable) and insoluble-bound forms (Wang *et al*., 2015). Recently, analysis and evaluation of bioactivity of different fractions of phenolic compounds from vegetable sources and by-products have attracted the attention of researchers because it allows a more complete characterization (Ambigaipalan *et al*., 2016; Ayoub *et al.,* 2016). Some reports have shown that tomato fruit extracts exhibit antimicrobial and anticancer properties. The phenolic contents of tomato fruits have been correlated with their antioxidant capacity. These compounds also prevent oxidative changes in cells by reducing the levels of free radicals or reactive oxygen species (ROS). Epidemiological reports suggest a direct correlation between the antioxidant capacity of tomatoes and a reduced risk of developing cardiovascular disease and cancer (Acosta-Estrada *et al.,* 2014). There is a growing interest to develop simple methods to increase the concentration of polyphenols in foods in order to strengthen their overall nutritional value (Parr and Bolwell, 2000; Schreiner, 2005; Schreiner and Huyskens-Keil, 2006). Phenolic compounds can be increased by using different types of fertilizer managements practices. Using organic fertilizer solely or in combination with chemical fertilizer phenolic content can be increased (Beltrán et al., 2015). Research supports that organic manure supplemented crops are highly nutritious and tasty (Sable *et al*., 2007; Qingren *et al.,* 2008).

Essential nutrients are the major constituents of most of the enzymes, co-enzymes and different types of phenolic compounds. Beside that N and P and K requirement of tomato are quite high particularly at the letter part of plant life i.e. for fruit growth and development. Nitrogen is the most important and key nutrient for tomato production all over the world due to its huge requirements and instability in soil. The significant role of nitrogen nutrition in plant production is universally accepted. Moreover, N and K fertilizers are considered to be closely associated having well marked cumulative and individual effects on the quality and production of different vegetable crops. Nitrogen promotes growth providing sufficient photosynthetic area which in turn helps in flowering ad fruit setting. Nitrogen compound constitute 40 to 50 per cent of the dry matter of protoplasm. Hence N fertilizer is required in large amounts. Adequate supply of nutrient can increase the phenolic content, yield, fruit quality, fruit size, keeping quality, color and taste of tomato (Shukla and Naik. 1993). The literature suggested that that the levels of fertilization in nitrogen, phosphorus, potassium and calcium can affect the production of secondary metabolites in plants (Oloyede *et al.*, 2012; Sabrina *et al*., 2012; Omar *et al.*, 2012; Vignesh *et al*., 2012). Therefore, the presence of macronutrients in soil is essential for plant growth and developments which also has a significant effect on the accumulation of polyphenols and antioxidants (Zhang *et al*., 2014).

However chemical fertilizer is not the only solution for best quality and quality of tomato. Instead, continuous application of chemical fertilizers leads to deteriorate the soil characteristics and fertility, and stimulate the accumulation of heavy metals in soil. Chemical fertilizer also reduces the protein content and the carbohydrate quality of crops (Marzouk and Kassem, 2011). Excess potassium content on chemically overfertilized soil decreases Vitamin C, carotene content and antioxidant compounds in vegetables (Toor *et al*., 2006). Vegetables and fruits grown on chemically overfertilized soils are also more prone to attacks by insects and disease (Karungi *et al*., 2011). Although chemical fertilizers have been claimed as the most important contributor to the increase in world agricultural productivity over the past decades (Smil, 2001), the negative effects of chemical fertilizer on soil and environment limit its usage in sustainable agricultural systems (Peyvast *et al*., 2008). Substitution by organic fertilizers or simultaneous use with chemical fertilizer can be an effective alternative solution (Togun *et al*., 2004).

Organic agriculture is one among the broad spectrum of production methods that are supportive of the environment. The demand for organic food is gradually increasing both in developed and developing countries with an annual growth rate of 20–25 per cent (Ramesh et al., 2005). Organic fertilizer contains a large amount of total nutrients with larger percentage of available forms. Valuable is the higher number of microorganisms and also considerable level of growth regulators such as auxins, gibberellins, cytokinins. Organic fertilizer application accelerates the ripening process of the crop with improving the quality parameters of cultivated plants (Kovacik, 2014). It is eco-friendly, non-toxic, consumes low energy input for preparing and is a recycled biological product (Lourduraj and Yadav, 2005). They have a high and diverse microbial and enzymatic activity, fine particulate structure, good moisture-holding capacity, and contain nutrients such as N, P, K, Ca and Mg in forms readily taken up by plants (Lavelle and Martin, 1992; Prabha *et al.*, 2011; Arancon *et al.*, 2009). Organic fertilizers are slow releasing compare to chemical one as a result nutrient loss is minimum and nutrients are available for longer period of time. Organic fertilizers also improve soil structure texture, increases aeration, and improves water holding capacity. Hidlago *et al.*, (2006) reported that the incorporation of compost increased plant growth, leaf growth and root length. Some studies have shown that organically produced tomato fruits contain higher amounts of antioxidants, total phenolics and ascorbic acid (Toor *et al.*, 2006, Mendoza, 2004), and more total soluble solids (Chassy *et al*. 2006; Rickman Pieper and Barrett, 2008) compared to conventionally grown tomatoes.

It is necessary to investigate the effect of chemical and organic fertilizer on the growth yield and total phenolic content of tomato. Therefore, the study will help us to compare the effect of both of those modern fertilizer application tactics for searching the best strategy to get maximum output with minimum inputs. Hence the objectives of the study were as follows-

1. To determine the effect of chemical and organic fertilizer on growth and yield of tomato crops
2. To evaluate the effect of chemical and organic fertilizer on phenolic content of tomato fruits

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the major vegetable crops in of Bangladesh. Some of important and informative works have been done in home and abroad related to this experimentation have been presented in this chapter

2.1 Effect of chemical fertilizers on the growth and yield of tomato

Jayasinghe and Weerawansha, (2018) conducted a study to observe the effect of compost and different levels of NPK fertilizer on growth and yield performance of three different recommended tomato varieties. According to results, treatment consisted with 50% of compost with 50% of NPK fertilizer treated plants on days to attained 50% of flowering. There were no significant differences between treatments consisted with 100% of NPK fertilizer with 50% of compost and 50% of NPK fertilizer on days to attained 50% of flowering, number of fruits per plant and yield of varieties. Results showed that all treatments except chemical fertilizer application improved the soil organic C, total N, P and K status. Increase in microbial biomass C and N was observed in soils receiving organic manures only or with the combined application of organic and chemical fertilizers.

Kibria *et al*., (2016) conducted an experiment was conducted to study the effects of biogas plant residues (BPR) and NPK fertilizer on growth, yield and quality of tomato (*Lycopersicon esculentum.* The results showed that application of BPR and NPK fertilizers significantly influenced the growth and yield of tomato compared to control treatment. BPR @ 50 t/ha produced the highest shoot and root dry weight and plant height, number of fruits per plant, weight of fruits per plant and yield (t/ha).

Isah *et al.*, (2014) conducted an experiment to study growth rate and yield of tomato under green manure and NPK fertilizer rates. Application of NPK fertilizer significantly increased growth such as plant height, crop dry weight, crop growth rate, and yield. Application between 250 and 280 kg/ha NPK fertilizers was found efficient for total fruit yield.

Kisetu and Heri, (2014) published the result of a study to compare effects of poultry manure and NPK (23:10:5) fertilizer to the performance of tomato (*Lycopersicon* *esculentum* Mill). Results 40 kg NPK /ha recorded the highest shoot length (91 cm) and fruit size and yield. It was concluded that poultry manure at 8 t/ha and NPK (23:10:5) fertilizer at 40 kg/ha are sufficient for tomato plants but the former outweighs the latter.

Kochakinezhad *et al.*, (2012) assessed the effect of four different fertilizers (chemical, municipal solid waste compost, cattle manure, and spent mushroom compost) on four commercial tomato cultivars (Redstone, Flat, Peto Pride and Chief) was in this research. The highest yield was obtained with chemical fertilizer and the lowest value was obtained with Peto Pride fertilized with 20 tonnes per hectare (t/ha) of cow manure. The difference between the two classes of fertilizers (organic and chemical) was not very high so that organic fertilizers are competitive and may be a suitable replacement for chemical fertilizer.

Salam *et al.,* (2009) conducted an experiment at the vegetable research farm of the Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute, Joydebpur. Gazipur, during the period of 2006-2007 to investigate the effects of boron and zinc in presence of different levels of NPK fertilizers on quality of tomato. The highest pulp weight (88.14%), dry matter content (5.34%). TSS (4.50%). acidity (0.47%), ascorbic acid (10.95 mg/100g), lycopene content (112.0 µg/100g), chlorophyll-a (41.00 µg/100g), chlorophyll-h (56.00 µg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B+ 6kg Zn/ha and recommended dose of NPK fertilizers (N@ 253, @ 90, and K@ 125 kg/ha).

Shaymaa *et al.,* (2009) conducted a study to compare the effect of method and rate of fertilizer application under drip irrigation system were evaluated on growth, yield and nutrient uptake by tomato grown on sandy soil. Higher level of fertigation was found significantly concerning growth parameter and total fruit yields. Fertigation at 100% NPK recorded significantly higher total dry matter (4.85 t/ha) and LAI (3.65) 4 5 respectively, over drip irrigation. The fruit yield of tomato was 28% higher in drip irrigation (43.87 t/ha) over furrow irrigation (34.38 t/ha). Fertigation with 100% NPK water-soluble fertilizers increased tomato fruit yield significantly (58.76 t/ha) over furrow irrigated control, drip irrigation, 50% fertigation (48.18 t/ha) and 75% NPK fertigation (54.16 t/ha).

Oko-Ibom.and Asiegbu (2007) investigated the fruit quality characteristics of eight tomato (*Lycopersicon esculentun* Mill.) cultivars namely; UN-83, Nsukka Local, Roma VFN. Ronita, life-1, Rossol, NHIe 7-7-1 and Ace VF were assessed under seven fertilizer application schemes in two field experiments at Nsukka. Southeast Nigeria. The tomato cultivars, UN-83. Roma VFN and Ronita excelled in most of the fruit quality characteristics studied, especially, resistance to cracking, low seed content, firmness, percent titratable acidity and soluble solids and longer shelf life.

Zhang *et al.,* (2007) conducted field experiments with five rates (0, 75, 150, 225, and 450 kg P_20_5/h) of seedbed P fertilizer application to investigate the yield of tomato in response to fertilizer P rate on calcareous soils with widely different levels of Olsen P (13-142 mg/kg) at 15 sites in some suburban counties of Beijing (China) in 1999. Under the condition of no P fertilizer application, tomato yield generally increased with an increase in soil test P levels, and the agronomic level for soil testing P measured with Olsen method was 50 or 82 mg/kg soil to achieve 85% or 95% of maximum tomato yield, respectively. With regards to marketable yield, in the fields where Olsen P levels were <50 mg/kg, noticeable responses to applied P were observed.

Taiwo *et al.,* (2007) conducted field trials in Ibadan. Nigeria, during 2002 and 2004 to evaluate the effect of fertilizer types on the yield and quality of tomato (*Lycopersicon esculenium* cv. Ibadan Local). The application of CBF alone increased fruit yield by 145% over the controls, and was superior to the other treatments in 2002. The application of CBF + urea to tomato affected the growth and quality of the fruit. The titratable acidity in tomato grown with CBF alone slightly decreased in relation to tomato treated with 30 kg NPK ha/S, but the vitamin C increased by 13% and the Ca content increased by 44% than the controls.

Simonne *et al.,* (2007) conducted an experiment in Spring 2005, tomatoes were grown on a Lakeland and fine sand in North Florida using plasticulthre and N rates @ 0, 78, 1571235, 314, and 392 kg/ha. Soluble solid contents decreased as N rate decreased for the first harvest (8.1 to 5.6 for 0 to 392 kg/ha of N), but increased for the second harvest (6.9 to 10.1 for 0 to 314 kg/ha of N).

Segura *et al.,* (2007) reported that the effect of different NPK doses applied by fertigation and two types of irrigation water on tomato production under greenhouse conditions. An increase of the nutrient concentration from 100 to 200% produced a slight increase of yield (less than 10%), but lowered the nutrient uptake efficiency (27% for N 44% for P and 34% for K).

Qin and Li (2007) conducted a solar greenhouse trial with a cultivar Ershishiji Fenbao in 2003-04 to investigate the effects of different K applied amounts (300 as the control, 450 and 600) on its yield and quality during 2003-04. Adding K fertilizer 150 kg/ha was proper to increase the pollen viability, yield and quality of tomato based on custom fertilizer application pattern (45 m^3 chicken dung/ha., 600 kg N/ha. 300 kg P_20_5/ha, and 300 kg K_2O/ha).

Podsiado *et al.*, (2007) conducted field experiments during 1999-2001 in northwestern Poland, on sandy soil to assess the effect of drip irrigation and mineral fertilizer application on some features and yield of high bush and dwarf tomato (cvs. Kora and Betalux. respectively). NPK @ 340 kg/ha gave the largest fruit. Betalux yielded better than Kora by 41% of marketable fruit, and by 66% of the total crop. Fertilizer application significantly increased sclerenchyma width while other features changed only to some extent.

Elia *et al.*, (2007) carried out an experiment with four levels of N (0. 100, 200 and 300 kg/ha) were applied through fertigation to evaluate the growth. N uptake, NUE, and yield of tomato. At harvest, the total and marketable yields were assessed. By applying 300 kg/ha of N. Plants had higher dry mass yield (approximately 13.0 t/ha). Fresh matter, total, and marketable fruit yields increased from 0 to 100 and 200 kg/ha of N (6.6, 5.5 and 4.2 kg/plant, respectively), while with increasing levels, the same variables showed a decreasing trend. A greater number of total and marketable fruits per plant (160 and 109, respectively) were obtained upon supplying 200 kg/ha of N.

Deshmukh and Takte (2007) reported that the effects of fertigation on the performance of tomato (cv. Rajashree) were studied in Rahuri, Maharashtra, India. The application of 80% of the recommended rate through water-soluble fertilizers was superior to the other treatments. A 16% increase in yield (85.97 t/ha) was obtained with fertigation of 80% of the recommended fertilizer rates.

Jan *et al.*, (2006) carried out a field experiment during summer 2004, at Karma Farm Juglote, Northern Areas of Pakistan, to study the impact of NP application in light textured soil on growth and yield of tomatoes and to develop more sustainable fertilization strategies. Maximum plant height (18.58 inches). number of branches /plant (17.77), number of leaves /plant (129.0), number of fruits /plant (21.79), fruit weight (67.22 g), yield /plant (1465 g) and yield /ha (43.95 tons) were recorded in treatments receiving N and P @ 110 and 100 kg /ha.

Kadam and Karthikeyan (2006) conducted an experiment at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. India, during 1998-99 to study the yield, yield contributing characters and quality parameters of tomato cv. Dhanshree as affected by fertigation. The number of fruits and weight of fruits per plant were greatest in plants treated with 100% of the recommended NPK applied through drip (T_4). 100% of the recommended NPK applied to soil + drip irrigation (T_2). and 70% N 80% p and K fertigated through drip (T_5). Quality parameters, such as pH, TSS (total soluble solids) and lycopene content, under 100% of the recommended NPK applied. If

Parisi *et al.* (2006) conducted an experiment to study the influence of nitrogen supply (from 0 to 250 kg N/ha) on yield and quality components of processing tomato grown in 2002-03 in Sele valley (Campania, Italy). Nitrogen fertilizer application from 50 to 250 kg/ha increased total yield but not marketable yield, because of a strong increase of unmarketable yield. Rates higher than 150 kg/ha did not produce increase in total, ripe and unripe yield.

Chaurasia *et al.,* (2006) reported that the effects of the foliar application of Multi K and NPK (19:19:19, 19:9:19 or 17:10:27) in 3 or 5 times, in addition to the soil application of the recommended NPK rates, on the performance of tomato were studied in Varanasi, Uttar Pradesh. India. during 1999-2002. The greatest mean plant height (125.4 cm). number of branches per plant (4.2). fruit length (4.9 cm). fruit diameter (4.5 cm), number of fruits per plant (24.6), yield (745.12 quintal/ha) were obtained with spraying of 19:9:19 NPK 5 times. The highest TSS content (3.54%) was recorded for 17:10:27 NPK.

Tomar and Madhubala (2006) conducted a field experiment in Jhabua, Madhya Pradesh, hidia, during the rabi seasons of 2002-03 and 2003-04 to study the effects of planting date and N fertilizer (urea) @ (80, 100 or 120 kg/ha on the performance of tomato (*L. esculenium* cv. ACC-99). The highest fruit yields of 292.78 and 274.04 quintal/ha were obtained with planting during the last week of October and 2nd week of November in combination with the application of 116.82 and 132.41 kg N/ha, respectively.

Bharkad *et al.,* (2005) conducted a field trial in Maharashtra, India. during 2002-03 to study the effects of different levels of Rio-K (0, 0.5, 1.0 and 1.5 ml/liter of water) and/or inorganic fertilizers (100% recommended dose of NPK (RDF), 100% NP + 75% K. 100% NP + 50% K, 100% NP + 25% K) on tomato cv. Parbhani Yashshri. The number 41 of branches (9.66), number of flowers (83.93), fruit weight (47.01 g), total yield per plant equatorial diameter (4.40 cm), TSS (5%), were highest with treatment Bio-K @ 1.5 ml/liter of water + 100% NP + 75% K. The RDF recorded highest number of fruits (39.46) and fruit set (45.2%).

Yan and Zhang (2005) reported in a pot experiment with tomato, 4 controlled-release compound fertilizers (CRCFs) with a controlled-release duration of 90 days, differing in the ratio of NPK, were compared with common compound fertilizer (CCF) containing the same amount of nutrients. CRCFs significantly increased plant height, leaf area, leaf number and fresh fruit weight compared with the control and were favorable for the prevention of diseases and pests.

Ingole *et al.,* (2005) conducted a study in Akola, Maharashtra, India during kharif 2003 to evaluate the effect of NK fertilizers on the fruit yield and quality of tomato cv. Arkas 4 Vikas. Maximum yield was obtained from 100 kg N/ha (31.14 i/ha). N @ 125 kg/ha produced the highest soluble solids content in fruits. N @ 125 kg/ha ± K @ 25 kg/ha resulted in maximum titratable acidity. Singh A. K. (2005) conducted an experiment during 1997-98. in Bichpuri. Agra, Uttar Pradesh. India, to evaluate the effects of spacing (75x50. 75x75 and 75x 100 cm) and N level (0, 75. 150. 200 and 250 kg/ha) on tomato hybrid Naveen. The highest yield was obtained with the narrowest spacing and highest (250 kg/ha) nitrogen fertilizer level.

Singh *et al.,* (2005) reported that the effects of NPK @200:100:150, 350:200:250 and 500:300:350 kg/ha on the growth and yield of tomato hybrids Rakshita, Karnataka and Naveen were determined in an experiment conducted in New Delhi, India during the early winter of 2000-02. Plant height, number of leaves per plant, leaf length, stem thickness, number of flower clusters per plant and picking period were highest with the application of 500:300:350 kg NPK per hectare during both years. Fruit yield (30.2 and

3.48 kg/ha in 2000-01 and 2001-02, respectively) and number of pickings (14 during both years) were highest with the application of 350:200:250 kg NPK per hectare.

Yang *et al.,* (2005) conducted a pot experiment to determine the effects of potassium (K) fertilizer on yield, quality, and resistance of tomato to unfavorable environments in China. The results showed that the yield of tomato treated with K fertilizer increased by 15.71% more than that without K. Applying K promoted the absorption of N and increased the utilization ratio of NK fertilizer also improved the quality of tomatoes.

Bineeth *et al.,* (2004) conducted a field experiment in Kamataka. India, to investigate the effects of graded levels of NPK on the yield, quality and nutrient uptake of tomato cultivars resistant to tomato leaf curl virus (TLB 111, TLB 130 and TLB 182). Among the interactions. TLB 182 with 150% RDF recorded the highest fruit yield (87 t/ha). As far as the quality is concerned. TLB 182 with 150% RDF showed higher rind thickness (0.74 cm), fruit size (32.47 cm^2) and pH 4.40. TLB 130 with 150% RDF showed the highest total soluble solids content (4.40%), acidity (0.48%) and ascorbic acid (46.87 mg/100 g juice). TLB 182 showed the highest N (121.29 kg/ha), phosphorus (11.74 kg/ha) and K (109.97 kg/ha) uptake with 150% RDF.

Groote *et al.*, (2004) conducted an experiment to investigate the effects of NP rates on the growth of tomato (cv. Capita). The relative growth rate increased sharply with increasing plant P concentration, and then leveled off. The response of relative growth rate to increasing plant N concentration was gradual, leveling off at high N concentrations. This suggests that the highest N rates were high enough to gain maximum growth.

Singh and Parmar (2004) conducted a study in Uttar Pradesh, India during 1996-97 to investigate the effects of N (0. 100, 200 and 300 kg/ha) designated as N_I, N_2, N_3 and N_4 on the biochemical components of tomato hybrids Naveen and Rupali. Naveen showed higher total soluble solids (TSS) content, ascorbic acid and acidity than Rupali, but Rupali showed higher juice and seed contents. Ascorbic acid content increased with increasing spacing. N_2 produced the highest TSS, juice content and seed content (5.96, 62.46 and 180.83%, respectively) among the N rates.

Yagmur *et al.,* (2004) conducted a study in Turkey to examine the effect of K fertilization on greenhouse tomato yield and quality parameters. Results showed that the highest dose of K yielded the highest. Similarly, the highest K dose was also positively effective on some fruit parameters as average fruit weight, fruit width, ten fruit weight and acidity. On the other hand, 240 kg K_20 /ha dose had positive impacts on total soluble solids. Vitamin C and color of fruits.

Bineeth *et al.,* (2004) conducted an experiment during late summer season of 2000 at the Main Research Station, University of Agricultural Sciences, Bangalore on red sandy loam soil to study the effect of grade levels of fertilizers on growth of three tomato leaf curl resistant varieties. Among leaf curl resistant varieties TLB 182 recorded significantly higher plant height (81.83 cm), leaf area (117.51cm^2), leaf area index (2.17), total plant dry matter production (256.62 g/plant), and crop growth rate (4.71 g/plant per day, fruit yield (87 ton/h), net income (Rs. 181855/-) and cost benefit ratio (1:5.10) with 150% recommended dose of fertilizer.

Ashok *et al.,* (2003) conducted a study to determine the optimum nitrogen (N) and Is phosphorus (P) rates for tomato hybrid production in Uttar Pradesh. India, during the 1991-93 rabi seasons. P hastened the first fruit picking compared with the control. The highest P rate hastened the final picking. The highest N and P rates recorded the highest increases in TSS and ascorbic acid. The highest mean yields of 538.8 and 592.1 q/ha in Rupali and Naveen, respectively, were recorded from the combined application of 180 kg N/ha+ 120 kg P/ha.

Chandra *et al.,* (2003) reported that the effects of N: P: K @ (200:100:150. 350:200:250 or 500:300:350 kg/ha on the performance of 4 indeterminate tomato hybrids (Rakshita. Karnataka, Naveen and Sun 7611) were studied in a multi-span greenhouse during 2000- 2001 and 2001-2002. Among the fertilizer levels. N: P: K @ 350:200:250 kg/ha was superior in terms of fruit diameter, average fruit weight, yield, gross income and benefit: cost ratio. The number of fruits per plant increased with the increase in the rate of NPK.

Colla *et al.,* (2003) carried out two field experiments during summer 2000 at the University of Tuscia in Central Italy to evaluate the impact of nitrogen fertigation rate on the growth, yield and fruit quality of processing tomato hybrids. In both experiments, total aboveground dry weight of aerial biomass, leaf area index (LAI) and yield increased with an increase in nitrogen rate.

Harneet *et al.,* (2003) carry out an investigation in Punjab, India during 2000-01 to study the effect of NK application on the growth. yield and quality of spring crop of tomato cv. Punjab Upma. Significant increase in juice content, ascorbic acid content, N and K concentrations in leaves was observed when the N level increased from 100 to 140 kg/ha. There was also a significant increase in the concentration of K in leaves when K level 41 was increased from 40 to 60 kg/ha.

Guvenc and Badem (2002) conducted greenhouse experiments to study the response of tomato cv. Sakata Fl 178 to various sources and levels of N. The highest early yield (yield in 30 days) was obtained with urea (966.1 g per plant). The total yield was improved by ammonium nitrate and urea but not by potassium nitrate. Urea @ 0.6% gave the highest number of fruits per plant (76.5) and total yield (5196 g per plant).

Sahoo *et al.,* (2002) conducted an experiment in Orissa, India during 1999-2000 with different levels of NK were tested to standardize the nutrient levels for growth and yield of tomato fruit. All the observations recorded in relation to yield and yield attributing characters indicates the superiority of N (150 kg/ha) over other treatments except single 12 fruit weight (g). With each increase in levels of K from 75 to 150 kg/ha, a correspondingly significant decrease in the yield of tomato was observed.

Duraisanii and Mani (2002) reported that the optimum levels of Nit for yield maximization of rainfed tomato and for sustained soil fertility were determined. All treatments recorded higher crop yield compared to the control, with 80 kg N/ha±40 kg P205/ha+80 kg K_20/ha recording the highest yield (20.5 t/ha). TSS had an inverse relationship with N rates but increased with increasing P and K.

Khalil (2001) undertook a field study in Peshawar. Pakistan in the summer of 1995-96 to determine the appropriate nitrogen fertilizer for maximum tomato (cv. Peshawar Local) yield and its effects on various agronomic characters of tomato. The ammonium sulfate + P + K treatment was the best among all treatments with respect to days to flower initiation (57 days), days to first picking (94 days), weight of individual fruit (50.8 g), a weight of total fruits per plant (1990 g) and yield (21,865 kg/ha).

Sharma *et al.,* (2001) conducted a field experiment in Kullu. Ilimachal Pradesh, India. during 1996 and 997 to study the effect of N (0, 50. too, iso, and 200 kg/ha) and spacing on the growth and yield of tomato. Fruit and seed yields, number of fruits per plant.

plant height, fruit length, fruit diameter, and fruit weight increased with the increase in N rate. However, yields produced with 150 and 200 kg N/ha did not significantly vary. The increase in N rate delayed maturity.

Singh *et al.,* (2000) conducted an experiment in Uttar Pradesh. India, to determine the suitable rate and application of N fertilizers for obtaining optimum growth and yield of tomato cv. N at 80 kg/ha applied in 3 splits produced the highest yield and biomass. Increasing N rates resulted in increasing biomass and yield.

Turemi, N. and Darin, K. (2000) studied a research in the small fruits implementation area belonging to Cukurova University Agricultural Faculty Horticultural department, Turkey, during the 1999 vegetation period with Nessy. Chester Thomless, Oregon Thornless and Jumbo blackberry cvs. Pollen viability levels in these cultivars were determined by using TIC and FDA staining tests. In addition, the effects of 50. 100, 200 and 400 ppm concentrations of $Ca(NO_3)_2$, $MgSO_4$, KNO_3 and H_3BO_3on pollen germination were investigated. Pollen viability levels varied from 79.75% 13 (Oregon Thorniess) to 91.94% (Chester Thorniess) in FTC, and 82.17% (Oregon Thorniess) to 93.15% (Chester Thorniess) in FIDA. The effects of minerals on pollen germination were found to vary according to cultivars and dose.

Begum *et al.,* (2000) conducted a field experiment in the rabi season of 1998-99 on a day terrace soil in Salna, Gazipur. Bangladesh to study the effects of irrigation and P fertilizer application on the yield, total water use, and water use efficiency of tomato (cv. Roma VF). In the individual effects of irrigation and P application, the yield was significantly high in the three and four irrigations and @ 120 kg P had.

Gupta and Sengar (2000) reported that tomato cv. Pusa Gaurav treated with N @ 0. 40, 80 and 120 kg/ha and K Qi 0. 30 and 60 kg/ha in a field experiment conducted in Madhya Pradesh, India during rabi 1992-93 and 1993-94. N application resulted in increases in plant height, number of fruits per plant, fruit weight and fresh yield. Increasing N rate produced a corresponding increase in yield and yield components. except total soluble solids (TSS) content. K increased vegetative growth, yield and TSS (total soluble solid) content. Increasing K rate up to 60 kg/ha increased growth parameters like plant height, and also increased fruit weight and marketable yield.

Mehia *et al.,* (2000) reported that the response of 3 tomato cultivars to 3 levels of NP fertilizers (50 kg N/ha ± 30 kg P/ha. 100 kg N/ha + 60 kg P/ha and 150 kg N/ha + 90 kg P/ha) and 4 spacing (60 x 60, 60 x 45, 45 x 45 and 30 x 30 cm) was investigated during 1992 and 1993 in Haryana, India. An increase in the concentration of N and P fertilizers increased the yield and yield components of tomato. The highest values in most parameters were observed in 150 kg N/ha + 90 kg P/ha, including the highest total fruit yields of 384.5 and 360.6 q/ha during 1992 and 1993, respectively.

Ravinder *et al.,* (2000) conducted experiments at Solan in 1996 and 1997, eight tomato hybrids (Meenakashi, Manisha, Menka, Solan Sagun. FT5xEC-174023 EC1 74023xEC-1 74041, Rachna and Naveen) were treated with four NPK combinations (100:75:55; 150:112.5:82.5; 200:150:110; 250:187.5:137.5 kg NPK /ha). The number of marketable fruits per plant and yield per plant were highest in Menka followed by 'i Manisha. Of the fertilizer's treatments, 200:150:110 kg NPK /ha produced the highest yields.

Nanadal *et al.,* (1998) conducted field experiments from 1989 to 1991 in Ilaryana, India, using Four levels of each of P and K with tomato variety Ilisar Arun showed that increasing levels of phosphorus up to 50 kg P and potash up to 80 kg K /ha improved the height of plant, number of flowers, weight of fruit, early and total yield, ascorbic acid content, chlorophyll content, total soluble solids and reducing and non-reducing sugars in the fruit.

Rao, M. H. (1994) conducted in a field experiments on red sandy loam soil, the effects of K @ 0, 50, 100, 150, and 200 kg K_2O/ha as KCl or K_2SO_4 on growth, yield and quality of tomato cv. Arka Saurabh, carrot cv. Early Nantes and cauliflower cv. Aghani were examined. In tomato, mean fruit weight and total yield were significantly increased up to 100 kg K20/ha. However, there were no significant differences between K sources. The TSS, titratable acidity and ascorbic acid contents were increased as K increased.

2.2 Effect of organic fertilizer (Cowdung) on the growth and yield of tomato

Saha *et al.*, (2017) conducted an experiment to at ARS, BARI, Satkhira on three types of organic fertilizer (OF) like OF from Co-compost (Faecal Sludge and Municipal Solid Waste), OF from earthworm compost (Vermicompost) and OF from cowdung whereas chemical fertilizer was applied as control treatment. It was found that treatment T_2 gave the highest yield (45.94 t ha-1) followed by T_3 (42.16 t ha^{-1}), T1 (32.50 t ha^{-1}) and T_4 (32.50 t ha^{-1}). From the economic study, it was found that higher income obtained from using co-compost along with chemical fertilizer (198825 Tk. ha^{-1}) followed by T_3 (155025 Tk. ha^{-1}), T_1 (118025 Tk. ha^{-1}) and T_4 (190575 Tk. ha^{-1}). Now, it is clear that 2 ton co-compost with 50% inorganic fertilizer from Recommended Dose of Fertilizer (RDF) gave the highest yield with economic benefit.

Saliou *et al.*, (2009) investigated the study to compare the effects of organic manures on tomato (*Lycopersicon esculenium* var. Mongal) by analyzing their impact on the yield, dry-matter. and the susceptibility of tomato under pesticide free condition. The poultry and groundnut manures recorded the highest losses due to damages by *H. armigera* respectively 13.3 and 13.21 /ha. The horse and fish manures were the least affected by the pest (9.7 and 10.1t/ha) and therefore recorded the highest net yields respectively 20.7 and 4 17.7 t/ha. However, the cow and sheep manures showed more dry matter to tomato fruit conferring them a longer shelf life. The horse dung based-fertilizer is highly recommended in tomato farming in the sahelian agro-ecosystems.

Zhai *et al.*, (2009) evaluated against conventional hydroponic fertilizers in two experiments with greenhouse tomatoes grown in peat-based substrate with organic fertilizer regimens consisting of combinations of composts (yard waste, swine manure, or spent mushroom substrate) and liquid fertilizers (fish or plant based). In general, organic tomatoes had a lower postharvest decay index (better shelf life) than did the hydroponic controls, possibly as an indirect consequence of overall reduced yield in those treatments.

Periasamy (2009) carried out an experiment to assess the effect of egg lime mix with panchakavya on the growth and yield parameters of tomato plant (*Solanum lycopersicum*). Maximum height (34.6cm), leaf number (124.3/ plant), leaf area (10.6 cm^2). fruit number (17.8/ plant), fruit weight (34.2gm/ fruit) and total chlorophyll content (3.86 mg/ g fresh wt) were observed in the plants treated with T_4 formulations.

Qingren *et al.,* (2008) conducted a field experiment to evaluate the effects of summer cover crops and organic compost on winter fresh market tomato (*Lycopersicon esculentum*.) yields and quality. The tomato total marketable yields increased 49-82 and 71-85 t/ha, respectively, in 2 year. The application of OM @ 75 or 50 t/ha increased tomato yields compared with that 25 t/ha. Yields of extra-large tomato fruits. especially at the first harvest during the early winter, were improved by growing sun hemp or applying the composts.

Sable *et al.,* (2007) reported that the effects of various organic amendments on the performance of tomato (cv. Parhhani Yashshri) were studied in Parbhani, Maharashtra. india, during the rabi season of 2002-03. The organic manures were generally superior to the inorganic fertilizers in the enhancement of the pollen viability (%), the fruit yield and dry matter yield. The percentage of marketable fruits was higher when organic amendments were applied (83-93%) than when inorganic fertilizers were used (77.5%). The fresh fruit weight was lower when 100% of the N was supplied through vermicompost than when N was supplied through various combinations of neem cake 4 and vermicompost.

Togun *et al.,* (2004) reported that the potentials of different plant residue composts as organic fertilizer on the growth, nutrient uptake, yield and economic performance of tomato were studied in Nigeria, during 1998 and 1999. The plant residues used were maize (Ms). guinea grass (Gg) and cowpea stover (Cs). Compost rate had a significant effect on the growth, nutrient uptake and yield of tomato. In most cases, the application of 4 ton compost/ha produced the best results. The fruit yield of 18.5 t/ha produced from the use of 4 t/ha compost was significantly higher than 14.1 and 14.4 t/ha obtained with application of 6 ton compost/ha and conventional NPK fertilizer, respectively.

Krishna and Krishnappa (2002) reported that the effect of NPK fertilizer applied with or without organic manures (farmyard manure and Agrimagic) on the yield and quality of tomato cv. Avinash-2 was investigated during rabi 2000/01 in Bangalore, Karnataka, India. In general, NPK @ 250:250:250 kg/ha plus Agrimagic @ 16.87 t/ha or farmyard manure @ 38 t/ha recorded the highest values for the different yield (plant height, branches per plant, clusters per plant, fruits per cluster, fruits per plant, fruit weight, fruit weight per plant, estimated fruit yield and total chlorophyll) and quality (pericarp thickness, fruit firmness, total soluble solids and titratable acidity) parameters.

Kumaran *et al.,* (1998) reported that the effect of inorganic and organic fertilizers on growth. yield and quality of tomato was investigated at Coimbatore, india. Results showed that a combination of organic and inorganic fertilizers gave the best results in terms of growth and yield. Plant height, branches per plant, mean fruit weight and number of fruits per plant were best with organic + inorganic fertilizers and Azospirilliun and phospho bacteria. The quality parameters such as chlorophyll content, TSS, ascorbic acid and lycopene contents were comparatively higher in organically grown tomato plants.

2.3 **Combined effect of chemical and organic fertilizer on the growth and yield of tomato**

Hala and Nadia (2009) carried out a field experiment in the Research and production station of National Research Centre at F.l-Nobaria during the season 2008 to evaluate the vegetative growth. yield quantity and quality of tomatoes as affected by different organic fertilizers and Sulphur addition. Chicken manure and farmyard manure had a synergistic effect on both fresh and dry weights of tomato shoots and roots, yield quantity and quality as well as mineral composition of tomato fruits compared to control (mineral NPK).

Ayeni *et al* (2009) conducted field experiments in two locations at Owo in southwest Nigeria in early and late crop seasons (2007) to compare the effects of poultry manure 0, 10, 20, 30, 40 t/ha and 300 kg/ha NPK 15:15:15 fertilizer on nutrient uptake and yield of tomato in randomized complete block design. Poultry manure @ 20, 30 and 40 t/ha and NPK 15:15:15 fertilizer significantly ($P<0.05$) increased plant leaf, area height, number of leaves, branches, fruits and fruit yield.

Adekiya and Agbede (2009) conducted four field trials during the years 2006 and 2007 at Owo. the forest- savarma transition zone in southwest Nigeria, to study the effect of poultry manure (PM), NPK 15-15-15 fertilizer and NPK 15-15-I5 fertilizer + poultry manure on the growth and yield of tomato. All levels of poultry manure. NPK 15-15-15 fertilizer alone and NPK 15-15-15 fertilizer + poultry manure increased the number of leaves, plant height, leaf area, number of fruits and fruit weight significantly. Among poultry manure levels, 30 t/ha poultry manure gave the highest fruit yield. Among the seven treatments, NPK 15-15-15 fertilizer + poultry manure gave the highest yield.

Premsekhar. and Rajashree, (2009) conducted field experiments to study the effect of various biofertilizers on the growth, yield parameters, yield and quality of tomato var. CO_3. The results revealed that significantly taller plants, better yield parameters and higher yield was recorded with the application of Azospirillum + 75% N + 100% PK followed by Azospirillum + 100% NPK. The higher total soluble solids of 4.450 Brix were recorded with Azospirillum + 75% N + 100% PK.

Yoldas *et al.,* (2009) conducted the study to determine the effects of organic and inorganic fertilizer doses on yield and quality in processing tomato. Organic and inorganic fertilizer significantly increased total yield, fruit diameter and length, and average weight of tomato compare to control. The highest total yield, fruit diameter and length, average weight of tomato value were obtained at 6 t/ha organic manure and half of recommended rate of inorganic fertilizer.

Olaniyi and Ajibola (2008) conducted field experiments to determine the effects of inorganic and organic fertilizers application on the growth, yield and nutrient content of tomato at the Ladoke Akintola University of Technology, Nigeria in the cropping seasons of 2004 and 2005. The yield and quality of tomato fruits produced with poultry manure are comparable with those obtained using mineral N fertilizer. Poultry manure can therefore be a suitable replacement for inorganic fertilizer in tomato production.

Ojeniyi *et al.,* (2007) reported that combined use of crop and animals waste is necessary in order to obtain adequate amount of organic manure for use in crop production. Among eight treatments compared. CII and SG amended with PM gave height fruit yield, compared with control. NPKF, amended SO and CH increased fruit yield by 268, 342 and 397%, respectively.

Dhanasekaran and Bhuvaneswari (2007) conducted a field experiment in a silty clay loam soil, in Tamil Nadu, India, to study the response of tomato to different levels of NPK and foliar application of enriched humic substances. The results revealed that foliar application of micronutrients and NAA enriched PCA to the plants supplied with 125% NPK recorded the highest fruit yield at the same level without causing any nutrient depletion in postharvest soil quality.

Shukla *et al.,* (2006) conducted an experiment in farmers' fields of Solan district, Himachal Pradesh, India, during 2002-03 and 2003-04 to study the effects of inorganic and organic fertilizers on the performance of tomato. The application of recommended rates of NPK (100. 75 and 55 kg/ha, respectively) with farmyard manure and vermicompost (250 and 12.5 quintal/ha, respectively) was superior in terms of yield per plant, yield/ha, number of fruits per plant, average fruit weight, number of fruits per cluster, total chlorophyl content and TSS (total soluble solids) content.

Raut *et al.,* (2006) carried out a field study at the Vegetable Research Farm. Maharajpur, Madhya Pradesh. India. during 1998-99 to determine the microbial population and the yield of tomato variety Jawahar Tomato-99, as affected by different nutrient sources. The recommended NPK along with FYM gave the maximum plant height (95.67 cm). fruit weight (591.0 g/plant) and fruit yield (196.43 q/ha) which shows promise on inorganic fertilizers.

Solaiman and Rabbani (2006) carried out a field experiment at the Bangabandhu Sheikh Mujibur Rahman Agricultural University farm, in Bangladesh, to assess the effects of inorganic and organic fertilizers on vegetative, flowering and fruiting characteristics as well as yield attributes and yield of Ratan variety of tomato. The highest plant height and dry weight of shoot, the maximum number of clusters of flowers and fruits/plant as well as the greatest fruit size and fruit yield/plant, fruit yield/ha were obtained from the application of the recommended dose of nutrients viz. 200 kg N + 35 kg P + 80 kg K+15 kg S/ha, but similar results were obtained from the treatment receiving 5 ton cow dung/ha along with half of the recommended doses of nutrients (100 kg N + 17.5 kg P4 + 40 kg K + 7.5 kg S/ha).

Itoo and Manivannan (2004) conducted pot experiments to determine the effect of macro and micronutrients in different forms compared to humic acid on the growth, yield and quality of tomato. The treatments comprised: 10, I5 and 20 g Biogran/pot; 10, I5 and 20 tablets Biotab/pot; 20, 40 and 60 ppm NPK + humic acid/pot; and NPK fertilizer (control). Biotab @ 20 tablets/pot resulted in the maximum number of primary branches, number of flower clusters per plant and number of flowers per cluster, maximum number of fruits per plant, fruit yield per plant and single fruit weight, and ISS, ascorbic acid content and acidity.

Patil *et al.,* (2004) stated that the effects of inorganic and organic fertilizers on the fruit yield and quality of tomato (cv. Parbhani Yashshri) were studied in Parhhani, Maharashtra, India, during rahi 2000/01. 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 1 (2.34 kg), total chlorophyll content (0.132 mg) and total soluble solid content (6.08%).

Raut *et al.,* (2003) conducted studies with tomato in Jabalpur. Madhya Pradesh. India, during 1998/99, involving 12 treatments of organic fertilizers. The maximum plant height (45.67 cm), number of branches (12.52), number of flowers per cluster (5.56), number of flower cluster per plant (32.88), fruit weight per plant (591 g) and fruit yield (196.43 q/ha) were recorded with 100:50:50 kg NPK+20 ton farmyard manure (FYM). The maximum number of fruits per plant (20.96) was recorded with 20 ton PM +5 kg Azospirillum +5 kg phosphate solubilizing bacteria (PSB).

Togun *et al.,* (2003) reported that the influence of maize-stover compost and N fertilizer on the growth, nutrient uptake and fruit yield of tomato was studied during 1997/98 and 1998/99 in lbadan, Nigeria. Application of maize stover compost and N fertilizer enhanced plant growth. Plant height, number of flowers, dry matter yield and number of fruits per plant were significantly improved by the different levels of compost with or without N fertilizer.

Rafi *et al.,* (2002) conducted the study on the effect of organic and inorganic fertilizers on yield and quality of tomato (cv. Parbhani "Yashashri") conducted in Parhhani, Maharashtra, India, revealed that application of 50% recommended dose of farmyard manure (FYM) @ 12.5 t ha" along with reduced levels of recommended doses of fertilizers (50% of the recommended dose of fertilizers of 100:50:50 NPK kg/ha resulted in the highest yield with high quality.

Naidu *et al.,* (2001) conducted an experiment during the 1996/97 and 1998/99 rabi seasons in Jabalpur, Madhya Pradesh. India, the use of organic and inorganic fertilizers with and without biofertilizers. Application of 100 kg N, 1- 50 kg P_20_5 + 50 kg K_20+20 FYM/ha was significantly superior than the other combinations and gave maximum plant height (50.68 cm), number of leaves per plant (49.50), number of branches per plant (16.83), number of flower clusters per plant (19.25), number of fruits per plant

2.4 Effect of chemical and organic fertilizer on the phenolic content of tomato

Aryal *et al*., (2019) studied with eight selected wild vegetables from Nepal (*Alternanthera sessilis*, *Basella alba*, *Cassia tora*, *Digera muricata*, *Ipomoea aquatica*, *Leucas cephalotes*, *Portulaca oleracea* and *Solanum nigrum*). Among the selected plant extracts *C. tora* displayed the highest DPPH radical scavenging activity with an IC_{50} value 9.898 µg/mL, whereas *A. sessilis* had the maximum H_2O_2 scavenging activity with an IC_{50} value 16.25 µg/mL—very close to that of ascorbic acid (16.26 µg/mL). *C. tora* showed the highest absorbance in the FRAP assay and the lowest lipid peroxidation in the FTC assay. A methanol extract of *A. sessilis* resulted in the greatest phenolic content (292.65 ± 0.42 mg gallic acid equivalent (GAE)/g) measured by the Folin–Ciocalteu reagent method, while the smallest content was recorded for *B. alba* (72.66 ± 0.46 GAE/g). There was a strong correlation between antioxidant activity with total phenolic (DPPH, $R^2 = 0.75$; H_2O_2, $R^2 = 0.71$) and total flavonoid content (DPPH, $R^2 = 0.84$; H_2O_2, $R^2 = 0.66$).

Elias *et al.*, (2018) evaluated antioxidant of tomato (*Lycopersicon esculentum* Mill. cv MT1) that have been planted according to split plot experimental design and subjected to sixteen (n=16) treatments namely as T1 to T16. The antioxidant of tomato extracts was determined by three methods namely total phenolic content (TPC), free radical scavenging activity (DPPH) and Ferric Reducing Antioxidant Power (FRAP). The highest mean efficiency for TPC and DPPH values in tomato were from T7, 1163.6 mg Gallic acid equivalent (GAE)/100 g and 55.7 % (chemical pesticide, mixture of organic and chemical fertilizer; and growth medium in cow manure compost). Pearson coefficient correlation test showed positive correlation ($p<0.05$) between TPC and DPPH assay (r=0.933) and FRAP assay (r=0.874), respectively showed that the phenolic compounds was a contributor of the antioxidant activity in tomato. Thus, the finding of this study demonstrated that pesticide, fertilizer and growth medium in compost factor and their interaction did not show any specific patterns content toward TPC, DPPH and FRAP; while the TPC was the main contributor of antioxidant activity in tomato

Bilalis *et al.*, (2018) conducted a study was to evaluate the influence of organic and inorganic fertilization on agronomic and quality characteristics of the processing tomato. The results showed that the highest fruit number per plant (98.5), average fruit weight (63.6 g) and fruit yield (168.0 t ha^{-1}) were obtained under inorganic fertilization. The highest total soluble solids (4.39 °Brix) and total soluble solids to titratable acidity ratio (17.4), L* (43.4) and a* (35.4) values, as well as the highest lycopene content (88.5 mg kg^{-1} f. w). were achieved through the application of organic fertilizer. Significantly higher total soluble solids and total soluble solids to titratable acidity ratio in organically grown tomatoes are particularly important to the processing tomato industry. Finally, the highest lycopene content produced under organic fertilization as well as the non-significant difference between the organic and conventional tomatoes in terms of lycopene yield make organic processing tomatoes suitable for lycopene production.

Sidhu *et al.,* (2017) conducted a study is to investigate nutritional and antioxidant activity of four types of organic tomato cultivars. Total phenolic compounds (TPC), lycopene, -carotene, DPPH free radical scavenging activity, reducing power, and color parameters were investigated in the current study. The results showed that there was no significant difference in TPC among cultivars regardless of Stimplex treatment. Higher lycopene and -carotene were obtained in Stimplex treated tomatoes. Lycopene and -carotene contents were significantly different among cultivars. The study showed that the darker the tomato color, the higher the lycopene and -carotene contents and the stronger the reducing power.

Heimler *et al.,* (2017) prepared a review deals with polyphenol content of vegetables and fruits under different experimental conditions. The effect of fertilizers, mainly nitrogen containing fertilizers, on qualitative and especially quantitative content of the polyphenols mixture, was reviewed. Soil nitrogen affects both anthocyanins and flavonoids content, and generally, a higher polyphenolic content is observed when less nitrogen fertilizer is added to the soil. Also, the effect of different agricultural management (conventional, organic, biodynamic, integrate) is reviewed with respect to polyphenols. In this case, a major effect has pointed out in the case of vegetables, while agricultural practice affects in a minimal way fruits polyphenols content. The effect of different management is, however, hardly pointed out, since many environmental factors are involved and affect polyphenols biosynthetic pathway.

Jorge *et al.,* (2017) evaluated the physicochemical and microbiological characteristics, antioxidant capacity and phenolic compounds of organic cherry tomatoes grown under fertigation with organic dairy cattle wastewater (DCW) with different nitrogen rates. The total phenolic content (TPC) and the antioxidant capacity was determined by the DPPH and FRAP methods. The different nitrogen rates (%N) affected the pH, protein and soluble solids contents. The increase in %N increased the antioxidant capacities, according to the DPPH assay, and TPC. On the other hand, the tomatoes under fertigation with the highest %N presented lower antioxidant capacities according to the FRAP assay. The fertigation did not affect the microbiological characteristics of the tomatoes, which presented fecal coliforms count <3 NMP /g and absence of Salmonella in 25 g.

Sereme *et al.,* (2016) conducted a study was to determine the impact of organic and mineral fertilization on the content of phenolic compounds and antioxidant activity in fruit of the tomato Mongal F_1 variety. Results of study revealed that plant treated by organic fertilizers have 16.36± 0.07mg Trolox Equivalent (TE)/100g fresh tomato (ft) antioxidant activity and 6.96± 0.63mg Gallic Acid Equivalent (GAE)/100g ft total phenols content while the plant treated by mineral fertilizer have 15.57± 0.05 mg TE/100g ft for antioxidant activity and 6.09± 0.13mg GAE/100g ft for total phenols content. Furthermore, it was reported that, as compared to mineral fertilization, organic fertilization significantly increases the antioxidant activity and phenolic compounds production in Mongal F1 tomato variety. This increase is probably due to the availability of various major and minor elements in organic fertilizer contrary to mineral fertilizer which has only three major elements, nitrogen, phosphorus, and potassium. 79 days after transplanting, fruit ripping has no obvious effect on the accumulation of these compounds.

Zhang *et al.,* (2016) studied The effects of different N level in combination with organic fertilizer on carotenoids, phenols and flavonoids contents in tomato fruits. The N mixed with organic fertilizer treatment had higher the content of β-carotene, and AN_2 achieved 34.20 μg/g. At red ripening stage, the content of lycopene of BN_1 and BN_2 were very close to, respectively 180.79 μg/g and 182.50 μg/g. The content of lutein at red ripening stage was nearly three times than that at turning stage. At red ripening stage, content of lutein ranged from 2.85 μg/g to 8.87 μg/g. In the al lof phenolic acid, coffeic acid was the highest levels. The highest caffeic acid content (73.74 μg/g) was observed in the AN_2 (double N and organic fertilizer), and only organic fertilizer (AN_0) was no significant difference with BN_1(single N). Rutin content in tomato fruit had no difference in three N levels (N_0, N_1, N_2). AN0 had the highest quercetin content in tomato fruits in all treatment, by 66.39 µg/g.

Varma *et al.*, (2015) conducted a study deals with the evaluation of compost prepared using Effective Microorganisms (EM), on antioxidant and defense enzyme activities of Tomato (*Lycopersicon esculentum*). A field experiment with five treatments (control, chemical fertilizer and EM compost alone and in combination) was conducted in randomized block design. An increment of 31.83% in tomato yield was recorded with the combined use of EM compost and half recommended dose of chemical fertilizers (N50 P30 K25 + EM compost at the rate of 5 t ha^{-1}). Similarly, fruit quality was improved in terms of lycopene content (35.52%), antioxidant activity (24–63%) and defense enzymes activity (11–54%), in tomatoes in this treatment as compared to the application of recommended dose of fertilizers. Soil microbiological parameters also exhibited an increase of 7–31% in the enzyme activities in this treatment. Significant correlation among fruit quality parameters with soil microbiological activities reveals the positive impact of EM compost which may be adopted as an eco-friendly strategy for production of high-quality edible products.

Perea-Dominguez *et al.*, (2018) conducted a study to isolate, identify and quantify soluble free phenolics, conjugated acid-hydrolysable phenolics (AHP) and alkaline-hydrolysable phenolics, and bound phenolics (BP) fractions from two tomato varieties (saladette and grape) and an industrial tomato by-product, as well as, to determine their antioxidant capacity. Phenolic composition was determined using Folin–Ciocalteu's method and HPLC–DAD. AHP were predominant in grape and saladette tomato extracts (91.47 ± 17.28 mg gallic acid equivalents (GAE) per g dry extract (DE) and 57.41 ± 8.80 mg GAE per g DE, respectively), while BP form was predominant in tomato by-product (51.30 ± 10.91 GAE per g DE). AHP extract of grape tomato presented the highest antioxidant capacity by DPPH assay (252.35 ± 42.55 lmol trolox equiv (TE) per g DE). In the case of ORAC assay, AHP fractions from both grape (1005.19 ± 138.52 lmol TE per g DE) and saladette tomatoes (804.16 ± 131.45 lmol TE per g DE), and BP fraction from by-product (852.40 ± 71.46 lmol TE per g DE) showed the highest ORAC values. Caffeic acid was the most abundant phenolic acid and it was found mainly in its conjugated forms. Naringenin was the most abundant flavonoid and it was mainly detected in bound form. Our analysis allowed a better characterization of phenolic compounds in whole tomato and by-product, remarking the importance of the fractionation. The valorization of the industrial tomato by-product, through the use of its different fractions of phenolic antioxidant compounds, could generate additional income to the tomato industry and reduce the waste disposal problem.

Beltrán *et al.,* (2015) conducted a study to evaluate the antioxidant and antimicrobial properties of extracts of different fractions of two tomato plant cultivars. The stems, roots, leaves, and whole-plant fractions were evaluated. Tomatine and tomatidine were identified by HPLC-DAD. The leaf extracts from the two varieties showed the highest flavonoids, chlorophyll, carotenoids, and total phenolics contents and the highest antioxidant activity determined by DPPH, ABTS, and ORAC. A positive correlation was observed between the antioxidant capacities of the extracts and the total phenolic, flavonoid, and chlorophyll contents. The Pitenza variety extracts inhibited the growth of pathogens such as E. coli O157:H7, Salmonella Typhimurium, Staphylococcus aureus, and Listeria ivanovii, yielding inhibition halos of 8.0 to 12.9 mm in diameter and MIC values of 12.5 to 3.125 mg/ml. These results suggest that tomato plant shows well potential as sources of various bioactive compounds, antioxidants, and antimicrobials.

Maršić *et al.,* (2011) conducted a research to evaluate the color, firmness, and total phenolic (TP) content in tomatoes according to cultivar and growing conditions. Cultivars with oval, elongated, round, and cherry-shaped fruits of determinate tomato were grown in Mediterranean (Dragonja Valley) and continental regions. Variation in total phenol (TP) content was evaluated in regards to different microclimatic conditions of the Ljubljana locations, outdoors and under the low tunnel. TP content, expressed as chlorogenic acid, ranged from 1.89 mg/100g to 3.28 mg/100 g fresh weight (fw) in field-grown tomatoes and from 2.31 mg/100g to 4.90 mg/100g in tunnel-grown tomatoes. Cherry tomato had a significantly higher content of TP, ranging from 8.60 mg/100g fw in field-grown fruits to 10.39 mg/100g f. w. in tunnel-grown fruits. Although the differences between TP content in tomato fruits, regarding the microclimatic environment, were not statistically significant, the increase in TP content in tunnel-grown tomato fruits could be a plant response mechanism to thermal stress.

Peschel *et al.,* (2006) studied with eleven fruit and vegetable byproducts and two minor crops were screened for industrial polyphenol exploitation potential by determination of their extraction yield, total phenolic content (TPC, Folin–Ciocalteu), and antioxidant activity (NTZ/hypoxanthine superoxide assay, ferric thiocyanate method). Extracts with the highest activity, economic justification and phenolic content were obtained from apple (TPC maximum 48.6 ± 0.9 mg Gallic acid equivalents g1dry extract), pear (60.7 ± 0.9 mg GAE g1), tomato (61.0 ± 3.0 mg GAE /g), golden rod (251.4 ± 7.0 mg GAE /g) and artichoke (514.2 ± 14.9 mg GAE /g). This study demonstrates the possibility of recovering high amounts of phenolics with antioxidant properties from fruit and vegetable residuals not only for food but also cosmetic applications.

Rivero *et al*. (2003) conducted an experiment where grafted and non-grafted tomato plants were grown at 25 and 35 ◦C for 30 days. In tomato leaves were analyzed total phenols, o-diphenols, enzymatic activities (PAL, PPO and GPX) and dry weight. Results indicated that heat stress in both grafted and non-grafted tomato plants occurred at 35◦C and resulted in (1) increased PAL activity, (2) increased total phenols and o-diphenols, (3) decreased PPO and GPX activities and (4) decreased dry weight. These results show that high temperature induces the accumulation of phenolics in tomato plants by activating their biosynthesis as well as inhibiting their oxidation. However, it was found that the levels of phenols in tomatoes subjected to stress and reported total phenol values of 2.66 to 3.55 mg caffeic acid equivalents per g.

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, staking, after care, harvesting and collection of data.

3.1 Period and location and of the experiment field

The field experiment was conducted in the Sher-e-Bangla Agricultural University farm, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2018 to March 2019 to find out the effect of different doses of chemical and organic fertilizer on growth, yield and phenolic content of tomato. The location of the experimental site is at 23.75^o N latitude and 90.34^o E longitudes with an elevation of 4 meter from the sea level. Morphological characteristics of the site is presented in appendix II.

3.2 Climate

The climate of the experimental area was subtropical in nature. It is characterized by heavy and moderate rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short-day period during rabi season (October to March).

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture. The area represents the Agro-Ecological Zone 28 which is Madhupur tract (Appendix I) with pH 5.8-6.5, ECE 25.28 (Haider, 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka (Appendix III).

3.4 Plant materials used

The tomato variety BARI Tomato-14 was used in the experiment. This is high yielding, heat tolerant and semi-indeterminate type variety. The seeds of which was collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in three seedbeds situated on a relatively high land at Sher-e-Bangla Agricultural University farm. The size of the seedbed was 3 m x l m. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung per bed was applied during seedbed preparation. The seeds were sown on the seedbed on 30 December, 2018 to get 30 days old seedlings. Germination was visible 3 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha/1 around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun or unwanted rain.

3.6 Treatments of the experiment

The experiment consisted of single factor which is consisted of five different level of Organic and inorganic fertilizers which are mentioned below with alphabetic symbol.

Treatments are

- T_1: Local Control (No fertilization)
- T_2: 100% Chemical fertilizer
- T_3: 75% Chemical fertilizer +25% Organic fertilizer
- T_4: 50% Chemical fertilizer + 50% Organic fertilizer
- T_5: 100% Organic fertilizer

The experiment was laid out in Randomized complete Block Design (RCBD) having two factors with three replications. The treatment combinations were accommodated in the unit plots.

3.7 Layout of the experiment

An area of 25 m x 8 m was divided into three equal blocks. Each block consisted of 5 plots where 5 treatments were allotted randomly. There were 15 unit plots altogether in the experiment. The size of each plot was 4.4 m x 2 m. The distance between two blocks and two plots were l m and 0.5 m respectively. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing (Figure 1).

- Randomizes Complete Block Design
- three replications

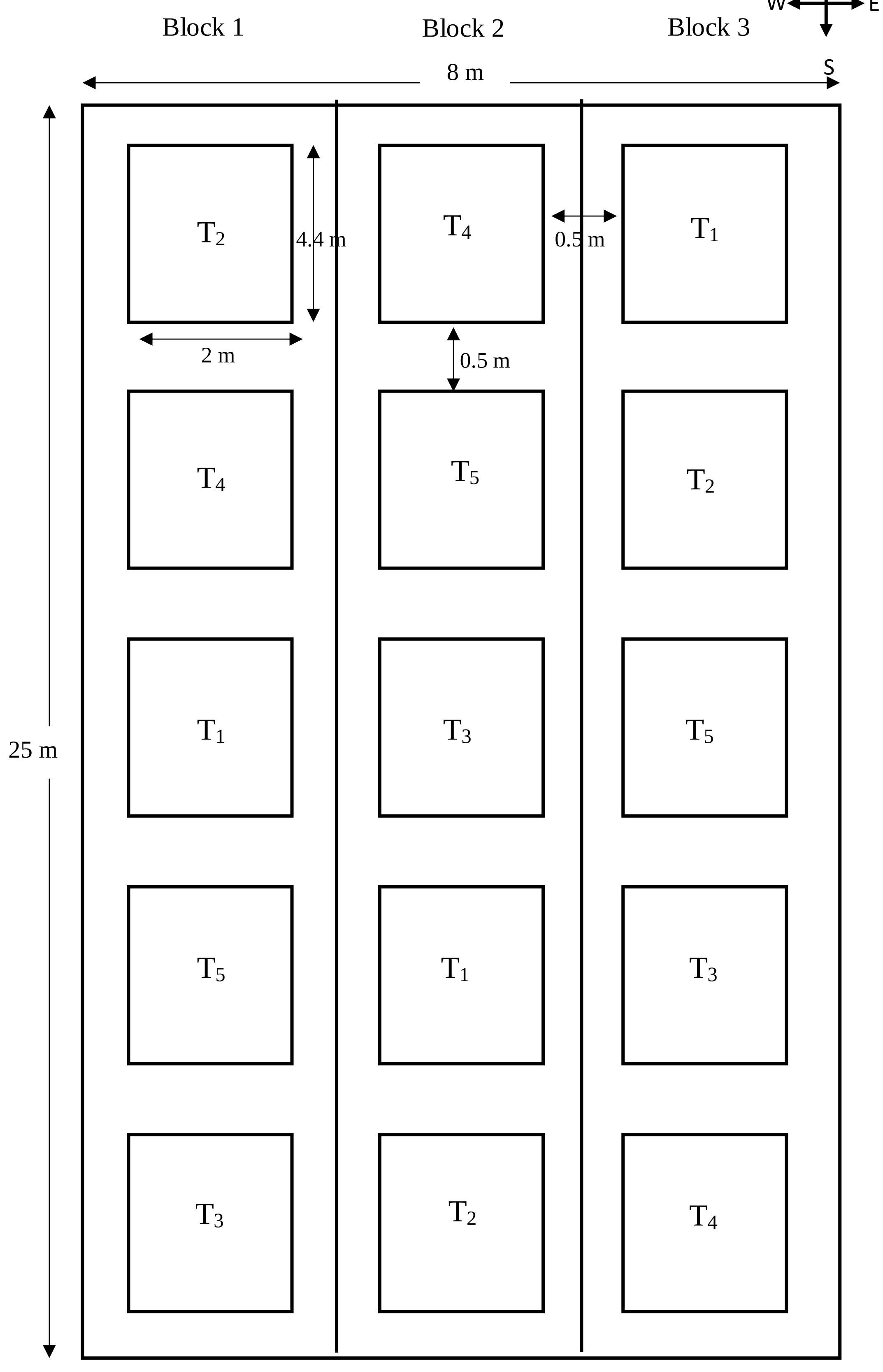

Figure 1: Showing the layout of the experiment

3.8 Cultivation procedure

3.8.1 Land preparation

The soil of the experiment field was first opened on 05 November, 2018 in order to get well prepare and good tilth for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later on, the land was ploughed three times followed by laddering to obtain untill desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally, the unit plots were prepared as 15 cm raised beds. Fifteen pits were made in each plot with in row-to-row and plant to plant spacing of 60 cm X 40 cm.

3.8.2 Manuring and Fertilizing

Fertilizer was applied as per treatments requirement:

For $\mathbf{T_1}$ no fertilizer was applied. For $\mathbf{T_2}$ 100% chemical fertilizer was applied as per BARI recommended dose 167 g urea, 100g TSP, 167 g MP, 33 g gypsum, 13 g zinc and 13 g boric acid to each pot. For $\mathbf{T_3}$ 75% of BARI recommended chemical fertilizer as 125 g urea, 75g TSP, 125 g MP, 25 g gypsum, 9.75 g zinc and 9.75 g boric acid with 25% organic fertilizer as 7 kg fermented cowdung for each plot. For $\mathbf{T_4}$ 50 % of BARI recommended chemical fertilizer as 85 g urea, 50 g TSP, 85 g MP, 16.5 g gypsum, 6.5 g zinc and 6.5 g boric acid with 25% organic fertilizer as 14 kg fermented cowdung to each plot. For $\mathbf{T_5}$ only 20 ton fermented cowdung was applied to each plot. Half of the cowdung. All the fertilizer was applied as basal dose at the time of land preparation except urea and MP was split into two and applied 15 and 35 days after transplanting.

3.8.3 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 25 November, 2018 maintaining a spacing of 60 cm x 40 cm between the rows and plants respectively. This allowed an accommodation of 15 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots. The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.4 Intercultural operations

After transplanting the seedlings, different intercultural operations were accomplished for better growth and development of the plants, which are as follows.

1. Gap filling: Very few seedlings have been damaged after transplanting and new seedlings from the same stock replaced these.

2. Weeding: The plants were kept under careful observation. Three times weeding were done during cropping period, viz. 1st December, 15th December and 1st January, for proper growth and development of the plants.

3. Spading: After each irrigation soils of each plot were pulverized by spade for easy aeration.

4. Irrigation: Irrigation was given by observing the soil moisture condition. Five times irrigation were done during crop period, viz. 4th December, 14th December, 24th December, 5th January and 15th January for proper growth and development of plants.

5. Earthing up: Earthing up was done by taking the soil from the space between the rows on 2nd Few plants were damaged by mole crickets and cut worms after the seedlings were transplanted in the experimental plots. Seven 80WP was dusted to the soil before irrigation to controlled mole crickets and cut worms on 1 December 2010.

3.8.5 Plant protection

Insect pests: Melathion 57 EC was applied @ 2 ml L-1 of water against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application 23 was made fortnightly after transplanting and stopped before second week of first harvest. Furadan l0G was also applied during final land preparation as soil insecticide.

Disease: During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 gm per litre of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g per litre of water against blight disease of tomato.

3.8.6 Harvesting

Fruits were harvested at 3-days interval during early ripe stage when they developed slightly red color. Harvesting was started from 19 April, 2019 and was continued up to May, 2019.

3.9. Data collection

Five plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the course of experiment.

- Plant height
- Number of leaves per plant
- Number of ranches per plant
- Number of cluster per plant
- Days to flowering
- Number of flowers per cluster
- Number of fruits per cluster
- Number of fruits per plant
- Fruit length
- Single fruit weight
- Degree of brix
- Yield per plant
- Yield per hectare
- Phenolic content of tomato

3.9.1 Plant height

Plant height at final harvest was measured from sample plants in centimeter from the ground level to the tip of the longest stem and the mean value for each treatment was calculated. Plant height was also recorded at 10 days interval starting from 20 days of transplanting up to 60 days after transplanting.

3.9.2 Number of leaves per plants

The number of leaves of the sample plant were recorded at 10 days interval starting from 20 days of transplanting up to 60 days after transplanting and the average number of leaves produced per plant was recorded.

3.9.3 Number of branches per plants

The numbers of branches of the sample plant were recorded at 10 days interval starting from 20 days of transplanting up to 60 days after transplanting and the average number of branches produced per plant was recorded.

3.9.4 Number of clusters per plant

The number of fruit clusters was counted from the sample plants and the average number of clusters borne per plant was recorded at the time of final harvest.

3.9.5 Day to flowering

The first date of first flowering was recorded for 5 plants. Then days from transplanting to flowering is calculated and averaged.

3.9.6 Number of flowers per cluster

Total number of flowers of 5 flower cluster from each of the five sample plant is counted, then average were recorded as flower per cluster.

3.9.7 Number of fruits per cluster

Total number of fruits of 5 cluster from each of the five sample plant is counted, then average were recorded as fruits per cluster.

3.9.8 Number of fruits per plant

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

3.9.9 Length of fruit (cm)

The length of fruit was measured with slide-calipers from the neck to the bottom of 5 selected marketable fruits and their average was taken in cm as the length of fruit.

3.9.10 Single fruit weight (cm)

Ten marketable size fruit was taken and then measured by measuring balance and then average was made to obtain single fruit weight

3.9.11 Brix (%)

Brix percentages were measured by Portable Refractometer (ERMA, Tokyo, Japan). Every single fruit was blend and juice was collected to measure brix percentage. Mean was calculated for each treatment. Brix percentage of fruits was measured at room temperature.

3.9.12 Fruits yield per plant

The fruits were harvested from 5 sample plants and measured with the help of measuring balance and average was taken as fruits yield per plant.

3.9.13 Yield per hectare

Yield per hectare was calculated using fruit yield per plant data

3.9.14 Measurement of phenolic content

In a dark bottle, 5 mL of 50% methanol was added to 100 mg of lyophilized sample of tomato fruit, and the bottle was then tightly closed. The extraction proceeded for 24 h at 60 °C with frequent stirring. After 24 h, the bottle was cooled to room temperature and opened, and the contents were centrifuged for 5 min at 13,000 rpm in an Eppendorf 5415C centrifuge machine. The clear supernatant was used for total phenolic determination.

The total phenolic content was determined for individual extracts using the Folin–Ciocalteu method (Lee *et al.,* 2015). Briefly, 1 mL of extract (100–500 µg/mL) solution was mixed with 2.5 mL of 10% (w/v) Folin–Ciocalteu reagent. After 5 min, 2.0 mL of Na_2CO_3 (75%) was subsequently added to the mixture and incubated at 50 °C for 10 min with intermittent agitation. Afterwards, the sample was cooled and the absorbance was measured utilizing a UV Spectrophotometer (Shimazu, UV-1800) at 765 nm against a blank without extract. The outcome data were expressed as mg/g of gallic acid equivalents in milligrams per gram (mg GAE/g) of dry extract.

3.10 Statistical analysis

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results was performed using Statistix 10 computer software. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to observe the effects of chemical and organic fertilizer on growth, yield and phenolic content of tomato. Tomato showed differences among the treatments in terms of different growth and yield related characters.

4.1 Plant Height

Plant height significantly differed within the different types of fertilizer combination at different days after transplanting (Appendix: IV). Finally, highest plant height was found with the treatment T_3 (95.7 cm) and the lowest plant height was found in treatment T_1 (78.4 cm) (Figure 2). It seems that 75% Chemical fertilizer with 25% Organic fertilizer produced the highest plant height of tomato. Whereas control plants produced the lowest plant height. Ayeni *et al* (2009); Adekiya and Agbede (2009) Premsekhar. and Rajashree, (2009) Yoldas *et al.*, (2009) also stated that chemical fertilizer with organic matter increases the plant height of Tomato.

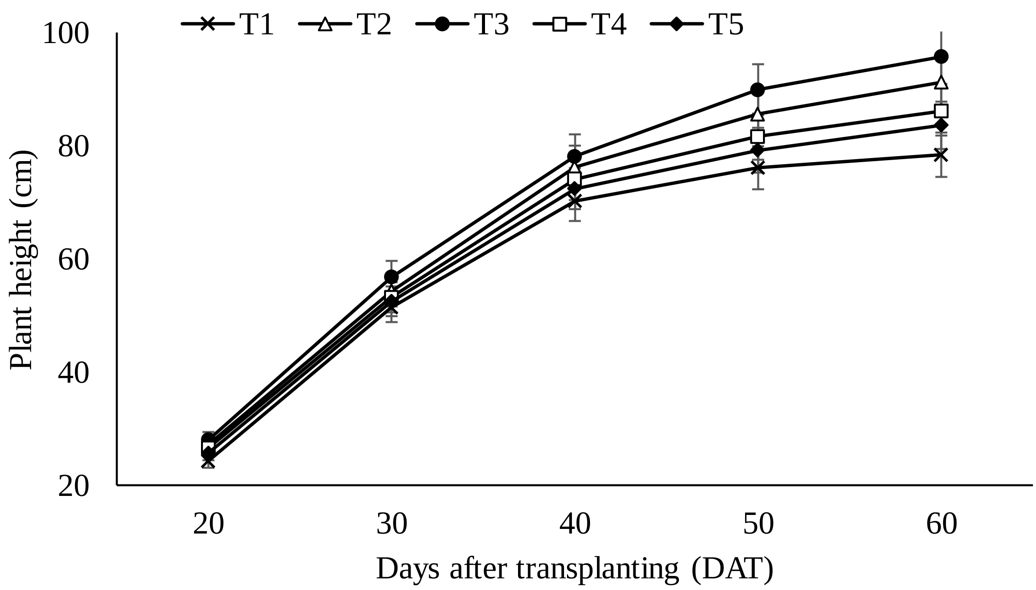

Figure 2. Effect of different types of fertilizer combination on plant height of tomato at different days after transplanting

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

4.2 Number of leaves per plant

Number of leaves per plant significantly differed within the different types of fertilizer combination at different days after transplanting (Appendix: IV). Finally, number of leaves per plant was the maximum with the treatment T_3 (85.7) and the minimum number of leaves per plant was found in treatment T_1 (70.9) (Figure 3). It can be stated as 75% Chemical fertilizer with 25% Organic fertilizer produced the maximum leaves. Premsekhar. and Rajashree, (2009); Yoldas *et al.*, (2009) Adekiya and Agbede (2009) stated the similar findings.

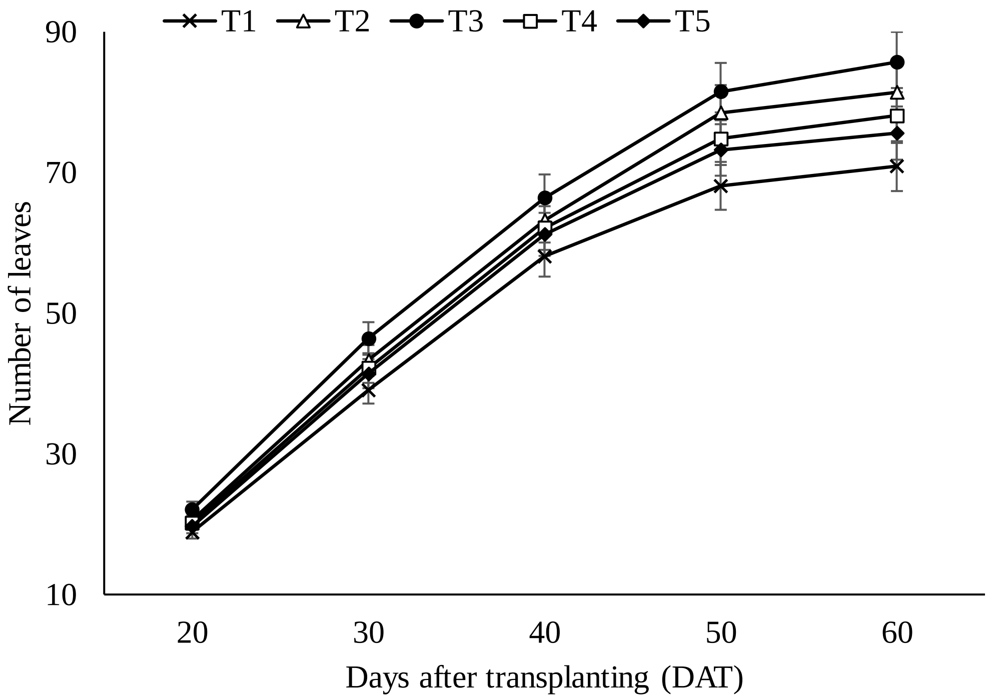

Figure 3. Effect of different types of fertilizer combination on Number of leaves per plant of tomato at different days after transplanting

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

4.3 Number of branches per plant

Number of branches per plant significantly differed within the different types of fertilizer combination at different days after transplanting (Appendix: IV). Finally, Number of branches per plant was the maximum with the treatment T_3 (28.6) and the minimum Number of branches per plant was found in treatment T_1 (20.2) (Figure 4). It shows that 75% Chemical fertilizer with 25% Organic fertilizer produced the maximum number of branches. Number of branches is an important result of better plant growth. Higher no of branches increases the possibility of higher yield. Premsekhar. and Rajashree, (2009), Yoldas *et al.,* (2009) with many other also reported that chemical fertilizer with organic matter increases the number branches of tomato.

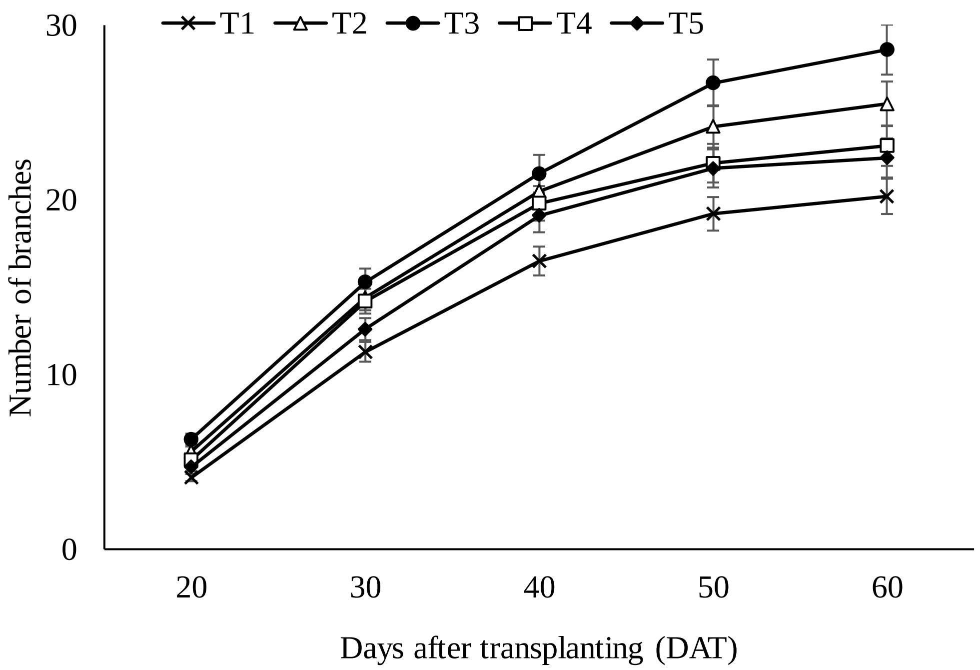

Figure 4. Effect of different types of fertilizer combination on Number of branches per plant of tomato at different days after transplanting

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

4.4 Number of clusters per plant

Number of clusters per plant of tomato plants significantly differed among the different types of treatments combination (Appendix: IV). Maximum number of clusters per plant was found with T_3 (9.6) treatment which is 75% Chemical fertilizer +25% Organic fertilizer and the minimum was found in T_1 (6.4) (Table 1) which is the control. Higher number of clusters per plant is an important parameter which shows the possibility of higher production. Flowers of tomato is produced in cluster which after fertilization becomes fruit. Higher no. of cluster represents better developmental growth. Nutrient supply is prerequisite for development of plant which may result in higher number of clusters. Olaniyi and Ajibola (2008); Dhanasekaran and Bhuvaneswari (2007) stated that chemical fertilizer and organic fertilizer combined application increases the number of clusters per plant

4.5 Days to flowering

Days to flowering significantly varied among the different fertilizer treatments (Appendix: IV). The earliest flowering was observed by treatment T_3 (51.1days). On the other hand, treatment T_1 took the longest period (59.9 days) for panicle initiation (Table 1). This study presented that tomato plant treated with 75% Chemical fertilizer +25% Organic fertilizer took the shortest time to produce flower. Whereas control plants took longer time to produce a flower. Days to flowering is an important indication of the crop duration. Earlier flowering helps in early harvesting which is very important for the farmer as it is related to crop market, climate etc. Early harvesting can help the farmer to accumulate a better market price. Chemical fertilizer with organic metter can reduced the time taken for flowering. Similar result was also found by Itoo and Manivannan (2004); Olaniyi and Ajibola (2008) Itoo and Manivannan (2004) and many others.

4.6 Number of flowers per cluster

Significant variation was found among the different types of fertilizer management treated plants in case of number flowers per cluster. (Appendix: V). Maximum number flowers per cluster was obtained from treatment T_3 (15.0) whereas treatment T_1 (9.3) showed minimum number flowers per cluster (Table 1). It can be stated that the treatment of 75% Chemical fertilizer with 25% Organic fertilizer produced higher number of flowers per cluster. Higher no of flower in an important sign which indicates better developmental growth. Higher the number of flowers means the possibility of increased fruiting. Chemical fertilizer provides the necessary nutrient to the plant as available state which accelerates the vegetative growth of plant. Better vegetative growth results in better reproductive parts development. On the other hand, organic manure contains various plant hormone which stimulates plant for to the floral part of the plant, which may induce the higher reproductive production. Thus, chemical and organic fertilizer combinedly may increased the number of flowers of the plant. Solaiman and Rabbani (2006); Itoo and Manivannan (2004) and Patil *et al.,* (2004) stated that chemical and organic fertilizer combinedly effective to increase the no of flower of tomato.

4.7 Number of fruits per cluster

Significant variation was found among the different types of fertilizer management treated plants in case of number of fruits per cluster. (Appendix: V). The maximum number of fruits per cluster was obtained from T_3 (3.85). On the other hand, treatment T_1 (3.18) produced the minimum number of fruits per cluster (Table 1) though, T_4 (3.49) and T_5 (3.38) was statistically similar with this. From the findings it can be concluded that 75% Chemical fertilizer +25% Organic fertilizer produced the maximum number fruits per cluster. Higher number of fruits per cluster indicates better fruit setting. Thus, converging from flower to fruit rate is higher. Plant with better vegetative growth produces stout and viable reproductive organs. Which helps in better fruit setting. Chemical fertilizers supply the required nutrient for reproductive development on the other hand organic matter improves the soil physical and chemical properties which improves better nutrient uptake. Organic manure also provides various micronutrients and hormone which altogether may help for the better reproductive growth, thus higher fruit setting for tomato. Similar finding was also observed by Ojeniyi *et al.,* (2007); Solaiman and Rabbani (2006); Shukla *et al.,* (2006) and may other researchers.

4.8 Total number of fruits per plant

Significant variation was found among the different types of fertilizer combination treated plants in case of total number of fruits per plant. (Appendix: V). Total number of fruits per plant obtained from T_3 (3.85) was the maximum. On the other hand, treatment T_1 (3.18) produced the minimum total number of fruits per plant (Table 1). From this result in can be said that tomato plants treated with 75% Chemical fertilizer + 25% Organic fertilizer produced the maximum number of fruits per plant. On the other hand, plant with no fertilizer produced the minimum number of fruits per plant. Production of higher number of clusters results in a higher number of flowers. Better fruit setting of flower produces higher number of fruits per cluster. Ultimately higher the number of fruits per cluster results in higher number of fruits per plant. Chemical fertilizer combinedly with organic fertilizer increases the number of fruits per plant. This result is in supportive with Solaiman and Rabbani (2006) Dhanasekaran and Bhuvaneswari (2007) Itoo and Manivannan (2004) Patil *et al.*, (2004).

Table 1. Effect of different fertilizer treatments on tomato related to different attributes

Treatments	No of cluster per plant	Days to flowering	Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant
T_1	**6.4 c**	**59.9 a**	**9.3 d**	**3.18 c**	**22.3 d**
T_2	8.1 b	54.1 c	13.2 b	3.54 b	30.1 b
T_3	**9.6 a**	**51.1 d**	**15.0 a**	**3.89 a**	**35.1 a**
T_4	7.9 b	54.7 bc	12.9 b	3.49 bc	28.0 bc
T_5	7.5 b	56.0 b	11.8 c	3.38 bc	26.1 c
LSD $_{(0.05)}$	**0.87**	**2.89**	**0.89**	**0.34**	**2.31**
C. V. (%)	**5.84**	**3.76**	**3.80**	**5.19**	**4.34**

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

4.9 Fruit length

Tomato plants expressed significant difference among the different types of fertilizer treatments in case of fruit length. (Appendix V) From this study it was observed that treatment T_3 (5.87 cm) produced the longest fruit. On the other hand, treatment T_1 (3.65 cm) produced the shortest fruit (Table 2). From this research it was observed that applying 75% Chemical fertilizer +25% Organic fertilizer plants produced lager fruit. Whereas plants treated with control produced smaller fruits. Larger the fruit, higher the yield. Larger fruit is an indication of better accumulation of photosynthesis product from leaves thus better metabolism. Plant produces food by photosynthesis process, which is than transport to the storage location. These chemical reactions depend on many enzyme, co-enzyme and many complex materials. Essential nutrients are constituent of these reagent. And these chemical reactions are indirectly dependent on the uptake of nutrient. So, the supply of nutrient as well as the soil environment is crucial. Chemical and organic fertilizer combinedly may fulfil that purpose that result in a better food production and storage within plant and ultimately bigger fruit.

4.10 Single fruit weight

Single fruit weight was significantly affected by different types of fertilizer treatments (Appendix: V). Among the five types of fertilizer treatments T_3 (94.3 g) produced the fruits having maximum weight and T_1 (83.1g) produced the fruits having minimum weight (Table 2). From this research it was observed that applying 75% Chemical fertilizer +25% Organic fertilizer plants produced fruit with maximum weight. N and P and K requirement of tomato are quite high particularly at the letter part of plant life i.e. for fruit growth and development (Shaymaa *et al.,* 2009). Chemical fertilizer provides essential nutrients in available forms (Taiwo *et al.,* 2007). On the other hand, organic fertilizers improve soil structure texture, increases aeration, and improves water holding capacity (Periasamy, 2009). Which leads to better uptake of nutrients for production of food materials within the plant. Organic matter supplies hormones and enzyme (Kovacik, 2014), which is responsible for transport of food material for production point to the storage location which ultimately results in larger fruit. Taiwo *et al.,* (2007) Itoo and Manivannan (2004); Solaiman and Rabbani (2006) also stated that application of chemical and organic fertilizer combinedly increased the fruit weight.

4.11 Degree of brix

Degree of brix was significantly affected by fertilizer management treatments (Appendix VI). Degree of tomato exposed statistically significant inequality among treatments. The maximum brix percentage was observed in T3 (3.7%) treated plants while minimum from control that is T1 (2.3%) (Table: 2). Above result indicates that 75% Chemical fertilizer +25% Organic fertilizer produced fruits with maximum brix (%). Whereas, fruits produced from control plot had minimum brix (%). Researcher suggested that organic matter produced fruits are with better post-harvest quality. Degree of brix indicates the better quality of tomato fruits. Organic production of crops is suggested by many researchers such as, Hidlago *et al*., (2006) and Rafi *et al.,* (2002).

4.12 Fruit yield per plant

Fruit yield per plant was significantly affected by different types of fertilizer management treatments (Appendix: VI). Among the all fertilizer treatments T_3 (3.30 Kg) produced the highest fruit yield per plant and whereas the lowest fruit yield per plant was produced by T_1 (2.1 Kg) (Table 2). Chemical fertilizer in combination of organic manure produces more cluster, fruits per cluster, and bigger size fruit, ultimately results in higher fruit yield per plant. Taiwo *et al.,* (2007) Itoo and Manivannan (2004); Solaiman and Rabbani (2006); Solaiman and Rabbani (2006) also presented similar kind of result.

4.13 Yield per hectare

Tomato plants expressed significant difference among the different types of fertilizer management treatments in case of calculated yield per hectare (Appendix VI). From this research it was observed that T_3 (93.2 t) showed highest calculated yield per hectare and T_1 (76.8 t) showed the calculated yield per hectare (Table 2). 75% Chemical fertilizer +25% Organic fertilizer produced the maximum yield. Adequate nutrient supply along with favorable soil environment induces proper root and shoot growth. Later proper reproductive growth results in better flower and fruit setting. Better nutrition transportation and stage of food material results in bigger and healthier fruit. Altogether results in a higher yield. Chemical and organic matter combinedly provides all these needs. Similar kind of result is found from many research studies (Taiwo *et al.,* 2007; Itoo and Manivannan, 2004; Solaiman and Rabbani, 2006; Solaiman and Rabbani, 2006; Dhanasekaran and Bhuvaneswari, 2007; Itoo and Manivannan, 2004; Patil *et al.,* 2004).

Table 2. Effect of different fertilizer treatments on tomato related to different attributes

Treatments	Fruit length (cm)	Single fruit weight (g)	Degree of brix (%)	Yield per plant (Kg)	Yield per hectare (t)
T_1	**3.65 d**	**83.1 d**	**2.3 d**	**2.10 c**	**76.8 c**
T_2	4.91 b	90.5 b	3.2 b	2.79 b	86.5 b
T_3	**5.87 a**	**94.3 a**	**3.7 a**	**3.30 a**	**93.2 a**
T_4	4.72 b	88.7 bc	2.9 c	2.55 b	83.1 b
T_5	4.30 c	86.8 c	2.7 c	2.50 b	81.4 bc
LSD $_{(0.05)}$	**0.39**	**3.49**	**0.25**	**0.30**	**5.32**
C. V. (%)	**4.39**	**4.71**	**4.55**	**5.94**	**4.36**

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

4.14 Total phenolic content

4.14.1 Total phenolic content of tomato pulp

Total phenolic content of tomato fruit pulp was significantly affected by different fertilizer treatments (Appendix VI). Total phenolic content exposed statistically significant inequality among treatments. The maximum total phenolic content was observed in treatment T_5 (48.871mg GAE/100g) while the minimum from control that is T_1 (33.30 mg GAE/100g) (Figure 5). It can be concluded that plants grown with use of organic fertilizer (cowdung) produced highest amount of phenolic compound. Organic fertilizers are recommended by many researchers to produce healthy and safe food (Kovacik, 2014; Marzouk and Kassem, 2011; Lourduraj and Yadav, 2005). Beltran *et al*., 2015 found phenolic content level 44.18 mg GAE/100g in tomato pulp. Zoran *et al.*, (2014) reported the amount of phenolic contents in their study on tomato they are in agreement with this result for the fertilization. They found 50.83 and 29.98 mg GAE/100g fresh tomato from organic and mineral fertilizations, respectively.

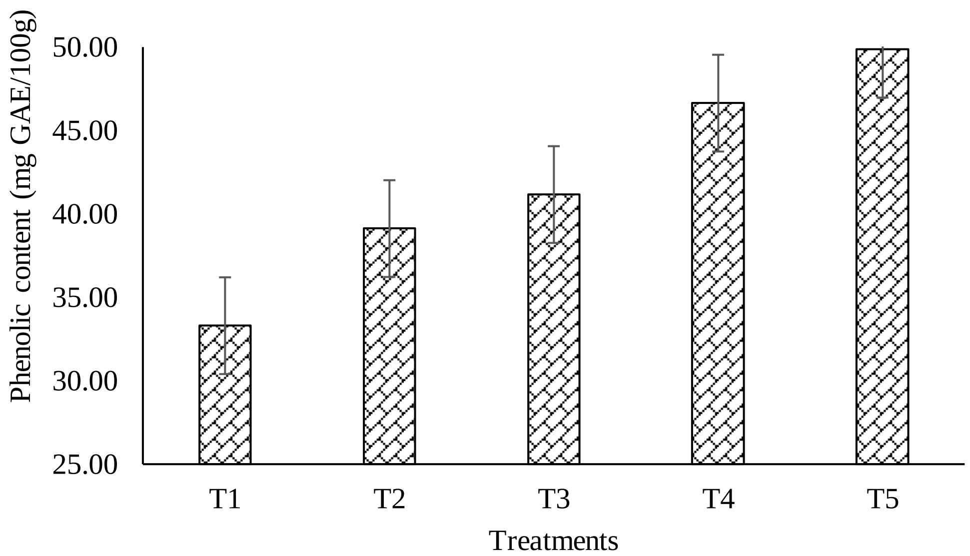

Figure 5. Effect of different types of fertilizer combination on phenolic content of tomato fruit flesh.

* T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

** Vertical bar represents the standard error.

4.14.2 Total phenolic content of tomato seed

Total phenolic content of tomato seed exposed statistically significant inequality among the fertilizer treatments (Appendix VI). The maximum total phenolic content was observed in treatment T_5 (24.76 mg GAE/100g). On the other hand, the minimum phenolic content was observed from control that is T_1 (14.31 mg GAE/100g) (Figure 6). Organic matter seemed to act well for higher amount of phenolic content. Many researchers suggested to organic tomato production for better phenolic content. Beltran *et al.*, (2015) reported phenol content on tomato seed 21.94 mg GAE/100g. Zoran *et al.*, (2014) and Seremi *et al.*, (2016) also stated that phenolic content increased due to organic fertilizer application.

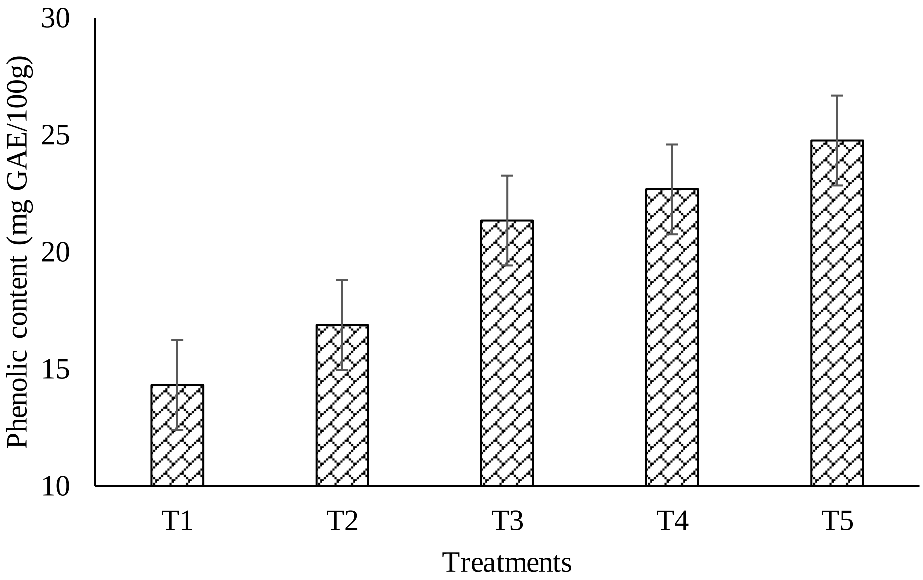

Figure 6. Effect of different types of fertilizer combination on phenolic content of tomato fruit seed.

T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer

** Vertical bar represents the standard error.

CHAPTER IV

SUMMERY AND CONCLUSION

Summery

Tomato is one of the major cultivated vegetables in Bangladesh. Based on its use as food and nutritional value it has become a very popular among people. It contains various types of phenolic compounds, anti-oxidants, vitamins which gives us protection from various major diseases.

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the rabi season of October 2018 to March 2019, with a view to observe the effect of different doses of chemical and organic fertilizer on growth, yield and phenolic content of tomato (*Lycocopersicon Esculentum*) showed differences in terms of different characters at robi season under the Modhupur Tract (AEZ-28).

There were altogether five treatment combinations consisting of different source of nutrition as, T_1: Local Control, T_2: 100% Chemical fertilizer, T_3: 75% Chemical fertilizer +25% Organic fertilizer, T_4: 50% Chemical fertilizer + 50% Organic fertilizer, T_5: 100% Organic fertilizer.

From this study highest plant height (95.7 cm) was found with the treatment T_3 and the lowest plant height (78.4 cm) was found in treatment T_1. The maximum number of leaves and branch was observed from the treatment T_3 (85.7 and 28.6) and the minimum was observed in treatment T_1 (70.9 and 20.2). Maximum number of clusters per plant was found with T_3 (9.6) treatment and the minimum was found in T_1 (6.4).

Maximum number flowers and fruits per cluster was obtained from treatment T_3 (15.0 and 3.85) whereas treatment T_1 (9.3 and 3.18) showed minimum number flowers per cluster (Table 3).

The earliest flowering was observed by treatment T_3 (53.2 days) and treatment T_1 took the longest period (57.8 days) for panicle initiation. Also, the maximum number of fruits per plant was produced T_3 (3.85) and treatment T_1 (3.18) produced the minimum

Treatment T_3 (5.87 cm and 94.0 g) produced the longest and heaviest fruit and treatment T_1 (3.65 cm and 84.3 g) produced the shortest and least heavy fruit.

The maximum brix percentage was observed in T_3 (3.7) treated plants while minimum from T_1 (2.3).

Among the five treatments T_3 and produced the highest fruit yield per plant (3.30 Kg) yield per hectare (93.2 t) whereas the lowest fruit yield per plant (2.1 Kg) and yield per hectare (76.8 t) was produced by T_1.

The phenolic content was maximum for treatment T_5 (48.871mg GAE/100g for skin and 24.76 mg GAE/100g for seed) and the minimum phenolic content was found for Treatment T_1 (33.30 mg GAE/100g for skin and 14.31 mg GAE/100g for seed).

Conclusion

Regarding as the above results it can be concluded that T_3 (75% chemical fertilizer and 25% organic fertilizer) performed best in case of all of the vegetative and yield characteristics like plant height, number of leaves, branches, cluster, flowers, fruits. It also produced flower in earliest time. fruit size and weight, degree of brix and yield was also better for T_3. On the other hand, T_5 which is 100% organic matter, performed superior in case of phenolic content. Although, treatment T_3 (75% chemical fertilizer and 25% organic fertilizer), produced slightly lesser phenolic compounds but considering the performance on every other aspects T_3 is recommended for successful cultivation of tomato.

Further recommendation

To reach a specific conclusion, more research work on other varieties and different fertilizer combinations should be done in different Agroecological zones of Bangladesh.

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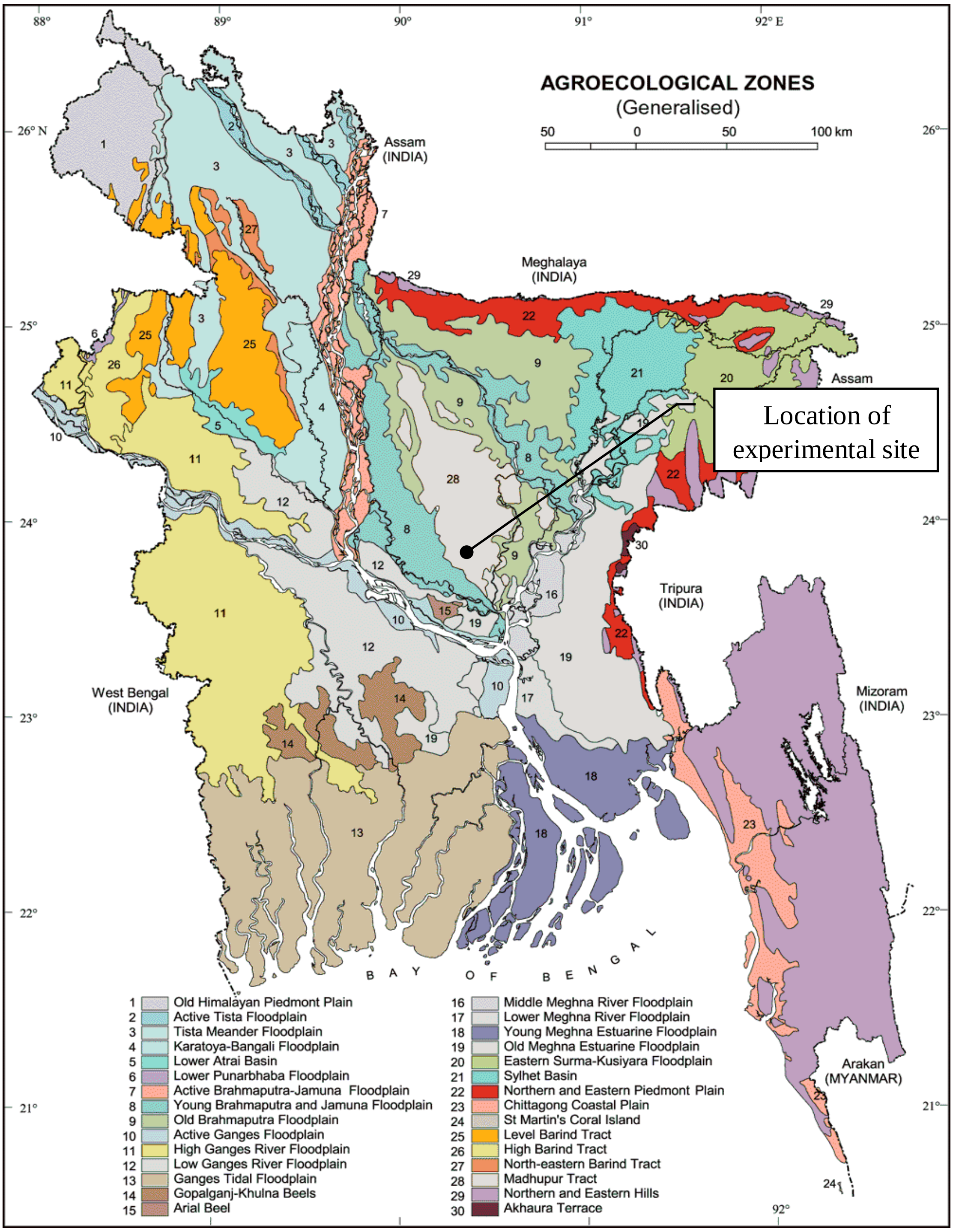
APPENDICES

Appendix I: Map showing the location of the site of the experiment.



Appendix II: Morphological characteristics of the experimental field.

Morphology	Characteristics
Location	SAU Farm. Dhaka
Agro-ecological zone	Madhupur Tract (AEZ 28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

Source: (FAO and UNDP, 1988)

Appendix III: Physical and chemical properties of the soil

Characteristics	Value
Particle size analysis	
% Sand	30
% Silt	40
% Clay	30
Textural class	Clay loam
Consistency	Granular and friable when dry
pH	5.6
Bulk Density (g/cc)	1.45
Particle Density (g/cc)	2.53
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.06
Available P (ppm)	20.0
Exchangeable K (meq/100g soil)	0.12

Source: SRDI, 2015

Appendix IV: Analysis of variances of the data on different attributes of tomato

Source of variation	Degrees of freedom	Mean squares				
		Plant height (Final)	Number of leaves per plant	Number of branches per plant	Number of clusters per plant	Days to flowering
Replication	2	2.738	2.45	0.128	0.21218	0.392
Treatment	4	163.245**	94.839**	30.909**	4.005*	8.865**
error	8	5.128	4.2	0.768	0.21308	2.352

Appendix V: Analysis of variances of the data on different attributes of tomato

Source of variation	Degrees of freedom (df)	Mean squares				
		Number of flowers per cluster	Number of fruits per cluster	Number of fruits per plant	Brix (%)	Single fruit weight
Replication	2	0.2205	0.03701	3.5227	0.018	4.802
Treatment	4	13.209**	0.18554**	67.3077**	0.834*	45.606**
error	8	0.223	0.03284	1.5077	0.0181	17.552

Appendix VI: Analysis of variances of the data on different attributes of tomato

Source of variation	Degrees of freedom	Mean squares				
		Fruit length	Fruit yield per plant	Fruit yield per hectare	Phenolic content of fruit skin	Phenolic content of seed
Replication	2	0.05624	0.0335	11.645	2.1082	1.0122
Treatment	4	2.00655*	0.58281*	113.026**	32.192**	18.596**
error	8	0.04244	0.02475	7.985	1.921	0.885