RESPONSE OFSUMMER TOMATO TO DIFFERENT PLANT GROWING STRUCTURESIN THE ROOFTOP GARDEN

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This is to certify that the thesis entitled "**RESPONSE OF SUMMER TOMATOTO DIFFERENT PLANT GROWING STRUCTURES IN THE ROOFTOP GARDEN"** submitted to the Department of,Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science**in**AGRICULTURAL BOTANY**, embodies the result of a piece of *bonafide* research work carried out by**MD. MOJAMMEL HAQUE,** Registration No. **11-04630**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.

Dated:

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Dedicated To

My Beloved Parents

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RESPONSE OF SUMMER TOMATO TO DIFFERENT PLANT GROWING STRUCTURES IN THE ROOFTOP GARDEN

ABSTRACT

The experiment was carried out at the rooftop garden of Department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to study the response of summer tomatoes to different plant growing structures in the rooftop garden during the period from July to November 2016. Two factors,Factor A - three varieties *viz*. V_1 (BINA tomato 6), V_2 (BINA tomato 7) and V_3 (Hybrid summer tomato variety) and Factor B - two plant growing structures *viz*. GS_1 (earthen pot) andGS_2 (plastic pot). The experiment was laid out in a Completely Randomized Design (CRD) with five replications. Data on different growth, yield contributing characters and yield of tomato were recorded and analyzed statistically. The recorded data on different morphological, yield and yield contributing characters were significantly influenced by different varieties and plant growing structures and by also their combinations.Considering varietal performance, V_3 (Hybrid summer tomato variety) gave the best performance on most of the studied parameters where number of flowercluster^{-1} was not significant with other varieties and in terms of plant growing structure GS_1 (earthen pot) gave the best resultswhere believe to keep lower temperature than plastic pots. In case of combination of different variety and plant growing structure, the highest number of leaves plant^{-1} (92.00), highest number of branches plant^{-1} (15.25), highest number of flowers plant^{-1} (42.50), highest number of fruits plant^{-1} (9.25) and highest yield plant^{-1} (109.60 g) were found from the V_3GS_1(Hybrid summer tomato variety along with earthen pot) treatment combination. Separatelythe highest plant height (71.52 cm) and maximum flowers cluster^{-1} (4.74) were found from the treatment interaction of V_2GS_1(BINA tomato 7 along with earthen pot).Therefore, this experimental results suggest that the variety V_3 (Hybrid summer tomato variety) incombination with growing structure GS_1 (earthen pot) increased the yield of summer tomato in the rooftop garden.

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
Ca	=	Calcium
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
e.g.	=	exempli gratia (L), for example
et al.,	=	And others
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
GM	=	Geometric mean
i.e.	=	id est (L), that is
K	=	Potassium
Kg	=	Kilogram (s)
L	=	Litre
LSD	=	Least Significant Difference
M.S.	=	Master of Science
m^2	=	Meter squares
mg	=	miligram
ml	=	mililitre
NaOH	=	Sodium hydroxide
No.	=	Number
^oC	=	Degree Celceous
P	=	Phosphorus
SAU	=	Sher-e-Bangla Agricultural University
UHI		Urban Heat Island
USA	=	United States of America
var.	=	Variety
WHO	=	World Health Organization
µg	=	Microgram

CHAPTER I

INTRODUCTION

In the urban area, the atmospheric temperature is high compared to the surrounding rural areas creating extreme influence (Arabi*et al*. 2015 and Sharma *et al*. 2016). The urban vegetation is an exceptionalalleviation strategy to keep the sound environment in the city. It has been reported that urban agriculture contributes to meet the food demand. Rooftop gardening is a part of urban agriculture to grow different vegetables and fruits on the building roof. In addition this garden conserve environment with changing climate. Different types of vegetables including tomato are producing in the central urban and peri-urban area in the kitchen and garden of city dwellers. Therefore rooftop gardening is gaining popularity day by day. The roof environment is unfriendly and it is difficult to grow crops there compared to land environment. The technologies relating to crop production on the building roof are scanty(Hossain*et al.*, 2004).

Tomato (*Solanumlycopersicum*L.) belongs to the family Solanaceae. It is one of the most important vegetable crops that can be consumed as both fresh and processed form. It is native of South America, but is now grown worldwide for itsedible fruits with many cultivars having been selected with varying fruit types and for optimum growth in differing growth conditions (Salunklie*et al*. 1987). Tomato is grown more extensively in USA, USSR, Italy, china, turkey and India. The tomato plant is herbaceous plant of usually 1-3 m height with weak stem and often sprawls over the ground and twines over other plants(Jang *et al.*, 1997).

Tomato has a significant role in human nutrition. It is a rich source of lycopene, minerals and vitamins such as ascorbic acid, carotene etc. which are anti-oxidants that promote good health.Lycopene is one of the most powerful antioxidant and vitamin C which are most beneficial to human beings (Wilcox*et al.*, 2003). It has several medicinal values as it improve blood purification, cures cancer and sour throat, apart from improving quality of the prepared foods. It is highly nutritious with good amount of vitamins. It is a good appetizer having pleasing taste (Ram, 1991).

Usually November-February is the cultivation period of tomato when suitable weather remains. There is a high demand of tomato in summer. But tomato cultivation during March to September (Kharif 2) in Bangladesh is constrained due to the adverse environments of summer along with lack of suitable heat tolerant varieties (Rahman*et al*. 2015). Varietal performance of tomato varies from place to place due to the varied climatic conditions. Performance of cultivars developed for conventional cropping systems differ in production system (Ahmed *et al*., 2007). The influence of variety on yield and quality has been documented (Stevens *et al*., 1977). Fruit number and weight (Balibrea*et al*., 1997) determine the yield of tomato. There is positive correlation between fruit number and yield. Adedeji*et al*. (2006) indicated that important quality parameters of tomato fruits varies with the types of cultivar including fruit size, volume, juice, specific gravity, maturity etc. The author also explained that factor such as specific gravity, juice, fruit size are specific to a variety which can be used to determine maturity stages and schedule harvest. In Bangladesh, a large number of tomato varieties are grown, which are of exotic origin and were developed long before. Most of them lost their potentiality due to genetic deterioration and disease infection(Tomalty and Komorowski, 2010).

Different plant growing structures including half drum cement bed, wooden bed, plastic pot, earthen pot affect the irrigation, fertilizer system, growth of root and shoot in container and finally affect the plant growth and yield. Knowledge and skill of different plant growing structures, water, fertilizer and pest management, root and shoot pruning are important for the long term success of rooftop garden in Bangladesh(Rahman*et al*., 2015).In addition, growing crops including tomato, chilli, pepper etc. in different plant growing structures have great concern in summer season (Nesmith and Duval, 1998 and Metwally, 2016). The concrete structureincluding building roofs (house, market, school, road etc.) occupies almost 60% area of the total area along with decreased vegetation which increases urban temperature in the Dhaka city (Ahmed *et al*., 2013).

As a part of urban vegetation, rooftop garden systems improve air quality and decrease urban temperature, extend roof life, reduce energy use, increase property value, pleasing work environment, increased biodiversity and source of crop production, etc (Hui, 2006; Tomalty and Komorowski, 2010). It is well known that rooftop garden is an old practice in abroad but recently it is gaining popularity in Bangladesh. There are numerous fruit, vegetables including, brinjal, chili, capsicum and tomato are easy to grow in the rooftop garden with suitable plant growing structures.

Sufficient study has not conducted about the suitability of plant growing structures including earthen potand plastic pot etc. Hence in order to improve the present situation of tomato production in rooftop garden, it is essential to promote better varieties to the growers of Bangladesh.

Considering the above-mentioned facts the present investigation was undertaken with the following objectives:

1. To investigate the performance of different summer tomato varieties during summer season (*Kharif 2*) in the rooftop garden
2. To evaluate the effect of different plant growing structures on the morphological and yield of summer tomato during summer season (*Kharif 2*) in the rooftop garden
3. To find the best variety and suitable plant growing structure either earthen pot or plastic pot for tomato cultivation in the rooftop garden to increaseurban agriculturearea in the Dhaka city

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and green house condition. It is also important vegetable crop in urban agriculture. Large number of researchers has studied the effect seasonal variation and variety on the morphological, yield attributes of tomato in different countries of the world, but their findings have little relevance to the agro-ecological situation of Bangladesh. New strategies should be devised to ensure the food security and rooftop gardens has already shown its potential as a source of urban food production site as well as prevent environmental pollution. Cultivation of summer tomato on rooftop garden can be a great source of nutrition also a unique procedure to improve urban environment especially in Bangladesh. However, the available research findings in this connection over the world have been reviewed in this chapter under the following headings.

2.1 Effect of variety on growth and reproduction of tomato

Bhati (2017) laid out this investigationwas to evaluation of tomato genotypes *viz.*,TODVAR-1, TODVAR-2, TODVAR-3, TODVAR-4, TODVAR-5, TODVAR-6, TODVAR-7, TODVAR-8 and H -86 (C) for their growth, yield and quality under foothills condition The results showed that there were significant differences in evaluated parameters among cultivars. Among the genotype, TODVAR-8 was found superior genotype and recorded maximum plant height (64.75 cm), number of branches plant^{-1} (14.22), number of leaves plant^{-1} (47.81), flowers number plant^{-1}, fruit length (4.24 cm), fruit diameter (5.28 cm), number of fruits plant^{-1} (34.01), fresh weight of fruit (37.00 g), yield ha (46.62 tones), ascorbic acid content (52.73 mg 100^{-1} g) and total soluble solids (5.13% Brix). The findings of this study may provide valuable information about nutritional value ofstudied cultivars for vegetable experts, researchers and growers under foothill condition of Nagaland and other hill or cool growing areas.

Sidhu and Nandwani (2017) conducted field research trials on yield performance from April to October in 2015 and 2016 growing seasons. Differences occurred in number of marketable fruit, fruit weight and total soluble solids. ‘Arbason F1’ (28.67 $Mt{\cdot}ha^{-1}$), ‘Gold Nugget’ (26.08 $Mt{\cdot}ha^{-1}$), ‘Roma’ (25.65 $Mt{\cdot}ha^{-1}$) were the high yielding and ‘Pink Bumblebee’ (2.61 $Mt{\cdot}ha^{-1}$), ‘Hillbilly’ (3.10 $Mt{\cdot}ha^{-1}$), ‘Cherokee Green’ (5.99 $Mt{\cdot}ha^{-1}$) had the lowest marketable yield. ‘Mountain Prince’ (57.68%), ‘Pink Brandywine’ (52.32%) and ‘Black Prince’ (44.74%) had the most culls and ‘Pink Bumblebee’ (1.80%), ‘Rutgers VF’ (4.98%), and ‘Hillbilly’ (5.02%) had the fewest cull fruit. ‘Bing Cheery’ and ‘Cheery Sweetie’ ranked highest in taste among cherry types. All twenty six cultivars did set fruits during the growing seasons in local climatic conditions.

Hamid *et al.* (2005) carried out an experiment to study the performance of five Russian varieties(RaickoiNaclazdenie, BelaiNalev, Ceberckoickorocpelai, Novichok, Patris) and one local variety of tomato. The results indicated that maximum plant height and size of fruit were observed in variety RaickoiNaclazdenie, whereas maximum number of flower clusters and fruits per plant were observed in Patris’. Minimum plant height, number of flower clusters and fruits were noted in Novichok, where minimum number of branches and fruit weight per plant noted in Local Kashmir. Varieties Ceberckoickorocepali and Patris gave maximum fruit weight of 4.96 and 4.85 kg $plant^{-1}$ compared to the minimum of 1.60 kg $plant^{-1}$ by local check and Novichok. Exotic varieties Patris and Ceberckoickorocpali are recommended for commercial Cultivation due to high production.

Rashid *et al.* (2000) carried out an experiment to evaluate thirty seven tomato varieties or lines for resistance to bacterial within the sick bed in replicated trial. Result found that, 26, 66, 33.33 and 30% incidence of wilt in BARI Tomato-4, BARI Tomato-10 respectively.

Khalid (1999) conducted an experiment with two winter (Ratan and Bahar) and three summer (BINA Tomato-2, BINA Tomato-3 and E-6) varieties of tomato during the winter season of 1998-99 at the Horticulture farm, BAU, Mymensingh. He observed that, the highest yield per plant was obtained from BINA Tomato-2 (1.74 kg), followed by BINA Tomato-3 (1.67 kg). But the yields of these varieties were statistically similar to each other.

The floral characteristics of heat-tolerant and heat sensitive tomato cultivars at high temperature was studied by Lohar and Peat (1998) in Nepal. They observed that, flowering was earliest in Pusa Ruby at 28-23° C (day/night) and latest in CL- 1131 at 15/10° C. They also indicated that, cv. CL- 1131 was suitable for cultivating at high temperature and producing an earlier crop. Cultivar Pusa Ruby produced fewer flowers and fruits at high temperature than CL-1131, but not in 15/10° C regime.

An experiment was conducted with two summer tomato varieties (BINA Tomato-2 and 3) to study the yield performance at 3 locations (Magura, Comilla and Khulna) during the summer season (BINA, 1998). It was observed that, BINA Tomato-2 produces higher fruit yield at Magura (38 t ha^{-1}) and Khulna (17 t ha^{-1}), while BINATomat-3 gave higher yield (29 t ha^{-1}) at Comilla. However, mean fruit yield from three locations showed that, the variety BFNA Tomato-2 produced higher fruit yield than BINA Tomato-3.

Singh and Sahu (1998) conducted a field experiment at Keonjhar, Orissa, India during *robi* 1991-92 and 1992-93 to evaluate 23 tomato cultivars to find out a suitable variety for winter season cultivation. They reported that, BT 12 produced the highest yield (34.09 t ha^{-1}) closely followed by BT 17, PED, BT14, Sel 120, BT 1 and Punjab Chhuhara. The variety Sel 120 had the highest weight and girth of fruit, whereas Punjab chhuhara produced the maximum number of fruit per plant and took less time to mature. The variety ArkaAlok was earliest and large fruits.

Ajlouni*et al.(*1996) conducted a field trial in Jordan 1993 to study the yield of 13 local and introduced open pollinated tomato cultivars, and to compare the yields to that of 3 common hybrids (Maisara F_1, 898 F_1 and$GS_{12}F_1$) inrelationto seasonal distribution of marketable and unmarketable yield and fruit number. The cultivars varied in their marketable yield during the harvested period (10 weeks from 22 June 1993). The results indicated that the cultivars Rio Grande, Nagina and T_2improved were superior to the hybrids.

Berry *et al.* (1995) conducted an experiment at Wooster, USA with the hybrid processing tomato Ohio Ox 38. It was observed that, the yields of this variety in 1992 and 1993 were higher (70.3 and 80.4 t ha^{-1}, respectively) compared to other cultivars.

Bhangu and Singh (1993) conducted a field trial with some tomato cultivars (Punjab Kesari, Punjab Chhuhara, Punjab Tropic, PNR-7, S-12, Pusa Ruby and the Hybrid THL-2312) in 1990 and 1992. Mean annual yield was highest in PunjaabKesari and lowest in Punjab Tropic. The number of fruits per plant was highest in Punjab Kesari (123). Punjab Tropic produced the largest fruits (66.69g).

Kallo (1989) worked with some tomato varieties (Pusa Early Dwarf, HS 102, HisarArun (Sel 7) And Punjab Chhuhara) in northern India. Result found that, HS 102 and Punjab Chhuhara were fit for summer cultivation, and Pusa Early Dwarf and HisaiArun were suitable for getting early fruits

Ahamed*et al.* (1986) assessed eight F-7 lines of tomato at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh. All the lines had shown indifference in plant height and fruit size. In contrast, fruit number had shown significant difference among the varieties. The line 0014-60-3-9-1-0 gave the highest yield of fruit (56.9 t ha^{-1}), followed by 0013-52-10-27-32-0 (50.0 t ha^{-1}).

Hossain and Haque (1984) carried out an experiment under a BARC financed project BVRD, at its Joydebpur Sub-Centre, Gazipur during the summer season of 1976 with three tomato varieties. It was found that, the variety Hope-1 was more adapted to our summer climate than the other two. Although Hope-1 produced smaller fruits, it produced the highest number of fruits (16) perlant, as well as the highest yield (9.24 t ha^{-1}), indicating that the variety could tolerate heat and high humidity of Bangladesh better than the other two varieties.

Sarker and Haque (1980) carried out an investigation to compare the yielding ability and to assess the distinguishing external morphological characters of seven varieties of tomato during the period from October 1977 to March 1978. The varieties were Master No. 2, Ramulas, Roma, Rambo, Marmande, Bigo and World Champion. They reported that, the Rambo produced the highest yield (28.28 t ha^{-1}) followed by Bigo (24.63 t ha^{-1}), World Champion (23.38 t ha^{-1}), Master No. 2 (21.98 t ha^{-1}), Roma(21.03 t ha^{-1}) and Ramuas (20.21 t ha^{-1}).

Thomas *et al.* (1979) conducted an experiment in India with some tomato varieties to study the yield and fruit characters. They reported that dwarf money maker was the highest yielder (50 t ha^{-1}) and having the longest fruiting period. The cultivar V. 687 and Parc-5 also gave higher yields than Gaamed, Punjab Chhuhara and Roma.

Prasad and Prasad (1977) carried out an experiment with 8 varieties tomato in India. The highest yield was obtained from KalyanpurAngurlate followed by KolyanpurT_1 and Sioux. The Kolyanpur T_1 had the highest fruit.

Hossain and Ahmad (1973) conducted a varietal trial at the Bangladesh Agricultural Research institute, Joydebpur. There were six tomato varieties namely, Roma, Bulgaria, USA, Anabik, Oxheart and Sanmarzano. They observed that, cv.Sanmarzano was the height yielder (28.98 t ha^{-1}), followed by Oxheart, Roma, Bulgaria, USA, Anabik.

In 1969-70, a yield trial was conducted with five varieties of tomato (Oxheart, Sinkurihara, L-7, Margiobe and Bulgaria) at the Vegetable Division of Agricultural Research Institute, Dhaka. The experiment was repeated in 1971-72. In both years, the varieties Qxjieart and Sinkriharawere found to be similar and significantly higher yielder than the other (Hoque*et al.*, 1975).

2.2 Effect of different plant growing structures

Metwally (2016) carried out an experiment with different substrate culture systems in relation to growth and production of hot pepper; beds system (100 liter of substrate/m^2, depth 10 cm), big pots system (60 liters of substrate/m^2, depth 15 cm), small pots system (30 liters of substrate/m^2, depth 13 cm) and horizontal bags system (90 liter of substrate/m^2, depth 10 cm). The author found that hot pepper plants grown in big pots system has the highest values regarding: plant height, number of leaves, branches, flowers and fruits per plant. Aerial parts fresh and dry weights, root fresh and dry weights, yield m^{-2} and highest nitrogen and phosphorus percentages in leaves and suggest that the big pots system could be recorded as the most suitable substrate culture system for producing hot pepper in rooftops gardens.

Bouzo and Favaro (2016) conducted trials to examine the effects of container size during spring-summer on tomato. The first experiment was conducted in a greenhouse to measure the effect on the initial yield. A second experiment was performed outdoors to incorporate the effect of plant age on the development and yield. Commercial hybrid tomato seeds of the cv. 'Tauro' were dry sown in containers of different volumes (20, 40, 70 and 350 mL) and with variable transplant times (14, 21, 28 and 35 days). The authors found that an increase in the container size results in plants of higher plant height, number of leaves and branches andhigher yield by number and weight.

Sharma *et al.* (2015) observed that green roof reduced the daytime roof temperature which varied linearly with increasing green roof fractions. Green roofs also reduced the horizontal and vertical wind speeds. The lowered wind speeds during daytime led to stagnation of air near the surface, potentially causing air quality issues. The selection of green and cool roofs for UHI mitigation should be considered.

Arabi*et al.* (2015) stated that green roofs are alleviating urban heat island (UHI). Rooftop garden as green roof mitigate the air pollution, improving management of run-off water, improving public health and enhancing the aesthetic value of the urban environment. They recommended that using green roofs as a main strategy for decreasing the harmful impacts of UHI especially the high air temperatures as well as their ability to add to the greening of cities.

Ouellette (2013) conducted an investigation aimed to fertility management for tomato production on an extensive green roof. This research project evaluated four fertilizer treatments on ‘Bush Champion II’ tomato *(Solanumlycopersicum)* growth and yield in a 7.62 cm green roof production system: (1) vermicompost tea, 2) Miracle-Gro fertilizer, 3) Organic Miracle-Gro fertilizer, 4) no fertilizer. Results indicated that Miracle-Gro provided the highest total tomato fruit yield, which was 30% and 50% more in 2011 and 2012, respectively, compared to the next highest treatment - Organic Miracle-Gro. Therefore, these results suggested that tomato can be successfully grown in a 7.62 cm green roof medium when given adequate fertilizer applications.

Kostopoulou*et al.* (2011) reported that container depth is considered an important variable influencing plant and root morphology as it is directly related to water holding capacity, humidity and air availability.

Carter and Rasmussen (2006) reported that rooftop garden reduces ambient air temperatures, extends the roof life, energy savings, increases bird and insect habitat, increase the beauty of the building or city, improve ecosystem, source of food and nutrition. Hui (2006) stated that green roof system showed a positive effect on mitigation of urban heat island and enhance the building thermal and environmental performance.

Celik (2010) performed a theoretical analysis of air-conditioning energy savings with different green roof applications. Thermal data was collected from a typical non-reflective (EPDM) roof membrane and model greenroof systems with three types of growth media (lava, arkalyte and hadite) matched with three sedum types *(Sedum kamtchaticum, S. spurium,* and *S. sexangulare).* Temperature readings underneath the growth media and from the non-reflective roof membrane were recorded for 32 months continuously. Results demonstrated that the right combination of growth media and vegetation can yield significant energy savings for air-conditioning.

Liu (2002) identified rooftop garden as an important component of any strategy to reduce greenhouse gas (GHG) emissions. He stated that Rooftop garden reduce energy demand on space conditioning, and hence GHG emissions, through direct shading of the roof, evapo-transpiration and improved insulation values. From his experiment, he indicated that rooftop gardens could reduce the airborne pollutants, UHI, heat stress, energy consumption and improve storm water management.

Keller (1985) stated that rooftop gardening can be an effective method in ensuring food supply and satisfying nutritional needs of the inhabitants. Rooftop gardening, although is being practiced in the city in many forms for years in the past, there have been hardly any concerted effort on part of the Government, community organizations and as well the general citizens to integrate it to urban agriculture. Proper understanding of the problems and prospects associated with the adoption of policies will contribute, to a great extent, to increased food supply in the city.

Eumorfopoulou and Aravantinos (1998) conducted an experiment and stated that in the summer, the heat flow through the reference roof created an average daily energy demand for space conditioning of 6.5-7.0 $kWhday^{-1}$. However, this energy demand was reduced to less than 1.0 $kWhday^{-1}$ in the garden roof- a reduction of over 75%, which can be attributed to the presence of the growing medium and the plants.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

This experiment was carried out at the rooftop garden of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. Location of the experimental site was 23°74′N latitude and 90°35′E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004), which have been shown in the Appendix I.

3.2 Experimental period

The experiment was carried out during the summer season from July to November 2016. Seedlings were sown on30 July and crops were harvested upto 10 November 2016.

3.3 Climatic conditions of the experimental site

The experimental site is situated in the subtropical monsoon climatic zone. Generally this zone is characterized by heavy rainfall during the months from April to November in kharif season. The overall weather condition at the experimental site during the cropping season July to November 2016 have been presented in Appendix II including minimum and maximum temperature, rainfall, relative humidity and sunshine hours etc.

3.4 Soil type

The soil for experiment was collected from an area that belongs to Modhupur Tract under AEZ No. 28 (Anon., 1988). The soil characteristics of experiment have been presented in Appendix III.

3.5 Planting materials

Three summer tomato varieties named BINA tomato 6, BINA tomato 7 and Hybrid summer tomato variety (Imported by Bejoshetol Seed Bd. Ltd.) were used as plant materials.

3.6 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Three varieties

1. V_1 = BINA tomato 6
2. V_2 = BINA tomato 7
3. V_3 = Hybrid summer tomato (Imported by Bejoshetol Seed Bd. Ltd.)

Factor B: Two growing structures in rooftop garden

1. GS_1 = Earthen pot
2. GS_2 = Plastic pot

3.7 Design and layout of the experiment

The factorial experiment was laid out in a Completely Randomized Design (CRD) with five replications. The 30 plants were planted in the earthen potand plastic pot. The earthen and plastic pot size was 40 cm in diameter and 30 cm in height with the depth of 25 cm.

3.8 Raising of the Seedling

In rising of seedlings, a common procedure was followed in the seedbed. Seeds were sown in the seed bed on 1^{st}July 2016. Seedlings were raised in one seedbed on a relatively high land. The size of the seedbed was 3 m × 1 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. During seedbed preparation 5 kg well rotten cowdung was applied. After 3 days sowing of seeds, germination was visible. 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. Emergence of the seedlings took place within 5 to 6 days after sowing. Shading was provided by banana leaves over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done as and when required.

3.9 Pot and bed preparation

Before transplanting the growing structures were prepared with silt loam soils. Well rotten cow dung and soil were mixed using the ratio of 1:3. Earthen pots as well as plastic pots were filled 10 days before transplanting. Soils were made completely stubbles and weed free.

3.10 Manure and fertilizer application

Urea, TSP and MP were applied as a source of N, P_2O_5 and K_2O. At the time of final preparation the entire amounts of TSP and MP were applied and Urea was applied in three equal installments. During bed preparation well-rotten cow dung was also applied.

3.11 Uprooting and Transplanting of seedlings

Seedlings of 30 days old on 30 July 2016 were uprooted separately from the seedbed and were transplanted.

3.12 Intercultural operations

Intercultural operations were done whenever needed for better growth and development. Intercultural operations followed in the experiment were irrigation, weeding, staking and top dressing etc.

3.12.1 Irrigation

Irrigation was provided once in a day either at morning or at evening at early stage of seedling. After that irrigation was provided to the plants twice a day except the rainy days.

3.12.2 Shading

To protect the plants from excess rainfall of monsoon a transparent polythene shade was provided. The shade was made just after the establishment of seedlings and was maintained up to final harvest.

3.12.3 Stalking

Staking was given to each plant by bamboo sticks for support, when the plants were well established.

3.12.4 Weeding

Weeding was done whenever it was necessary, mostly in vegetative stage for better growth and development.

3.12.5 Top dressing

After basal dose, the remaining doses of urea were used as top-dressed in 3 equal installments at 15, 30 and 45 DAT. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthening up operation was done immediately after top-dressing with nitrogen fertilizer.

3.13 Plant Protection Measures

Melathion 57 EC was applied @ 2 ml L^{-1} of water against the insect pests like cutworm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and was stopped before second week of first harvest. Furadan 10G was also applied during pot preparation as soil insecticide. Emitaf 20 SL @ 0.25 ml L^{-1} of water at 7 days interval for three weeks was also applied.

3.14 Harvesting

Harvesting was started during early ripe stage when the fruits attained slightly red color. Harvesting was done at 3 days interval starting from 20 Octoberand was continued up to 10November 2016.

3.15Data collection and recording

Experimental data were recorded from 30 days after transplanting and continued until last harvest. The following data were recorded during the experimental period.

1. Plant height
2. Number of leaves $plant^{-1}$
3. Number of branches $plant^{-1}$
4. Number of flower clusters $plant^{-1}$
5. Number of flowers $cluster^{-1}$
6. Number of flowers $plant^{-1}$
7. Number of fruits $plant^{-1}$
8. Yield $plant^{-1}$

3.16 Procedure of Recording Data

3.16.1 Plant height

Plant height was measured from the sample plants in centimeter from the ground level to the tip of the highest leaf and means value was calculated. To observe the growth rate plant height was recorded at 30, 50 and 70 days after planting.

3.16.2 Number of leaves $plant^{-1}$

Leaf number was counted from each plant at 30, 50 and 70 DAT.

3.16.3Number of branches $plant^{-1}$

The total number of branches $plant^{-1}$ was counted from each plant at 30 DAT, 50 DAT and 70 DAT.

3.16.4Number of flower clusters $plant^{-1}$

The number of flower clusters produced$plant^{-1}$ was counted and recorded.

3.16.5 Flowers plant^{-1}

The number of flower plant^{-1} was counted and recorded.

3.16.6Number of fruits plant^{-1}

The number of fruits plant^{-1} was counted and recorded.

3.16.7 Fruit yield per plant^{-1}

Fruit yield plant^{-1} was calculated by totaling fruit yield from first to final harvest and was recorded in gram (g).

3.17 Statistical Analysis

The data were statistically analyzed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean differences were adjudged by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSIN

The experiment was conducted to investigate the response of summer tomatoes to different plant growing structures in the rooftop garden. Data of the different parameters were analyzed statistically and the results were presented in the Figures and Tables. The results of the present study were presented and discussed in this chapter under the following headings.

4.1 Growth and morphological parameters

4.1.1 Plant height

Plant height is considered as the most important morphological parameter of plant. The plant height varied significantly due to different variety of summer tomatoes observed at different growth stages (Fig. 1 and Appendix IV). Results revealed that at 30 DAT, the highest plant height (18.30cm) was found from V_3 (Hybrid summer tomato variety) which was statistically identical with V_2 (BINA tomato 7)where the lowest plant height (15.18 cm) was found from V_1 (BINA tomato 6).At 50 DAT, the highest plant height (45.48 cm)was found from V_3 (Hybrid summer tomato variety) which was statistically identical with V_2 (BINA tomato 7)where the lowest plant height (38.29 cm) was found from V_1 (BINA tomato 6). At 70 DAT, the highest plant height (64.11 cm)was found from V_3 (Hybrid summer tomato variety) which was statistically identical with V_2 (BINA tomato 7)where the lowest plant height (60.73 cm) was found from V_1 (BINA tomato 6). Bhati (2017) and Hamid *et al.* (2005) also found significant variation on plant height due to different varieties which are supported with the results of this study.

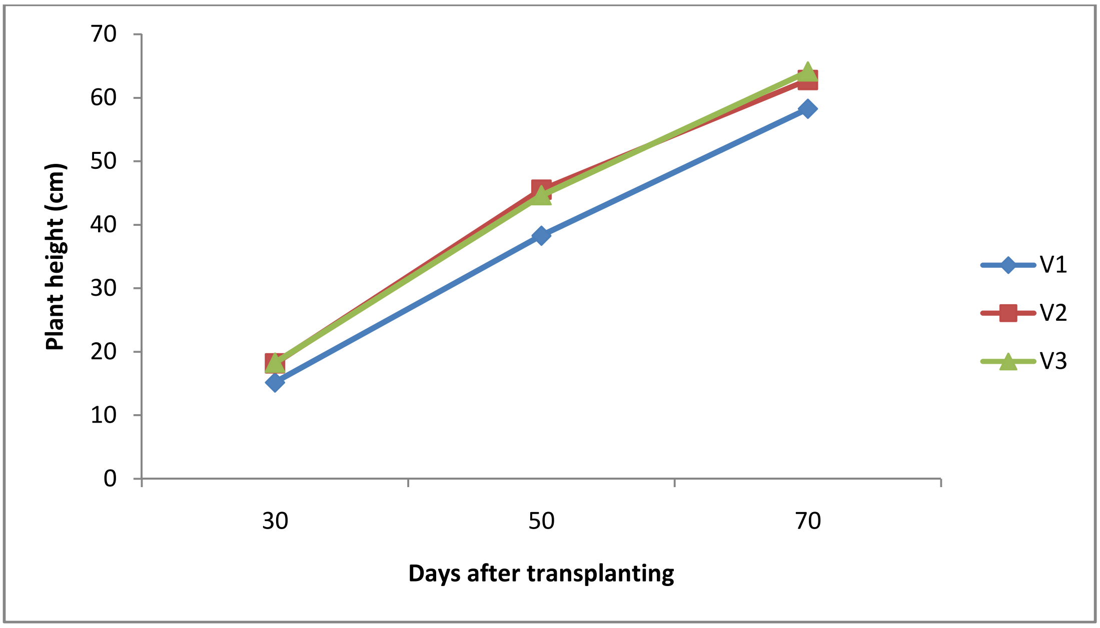

Fig.1. Plant height of tomato as influenced by different varieties in rooftop garden

V_1 = BINA tomato 6, V_2 = BINA tomato 7, V_3 = Hybrid summer tomato variety imported by Bejoshetol Seed Bd. Ltd.

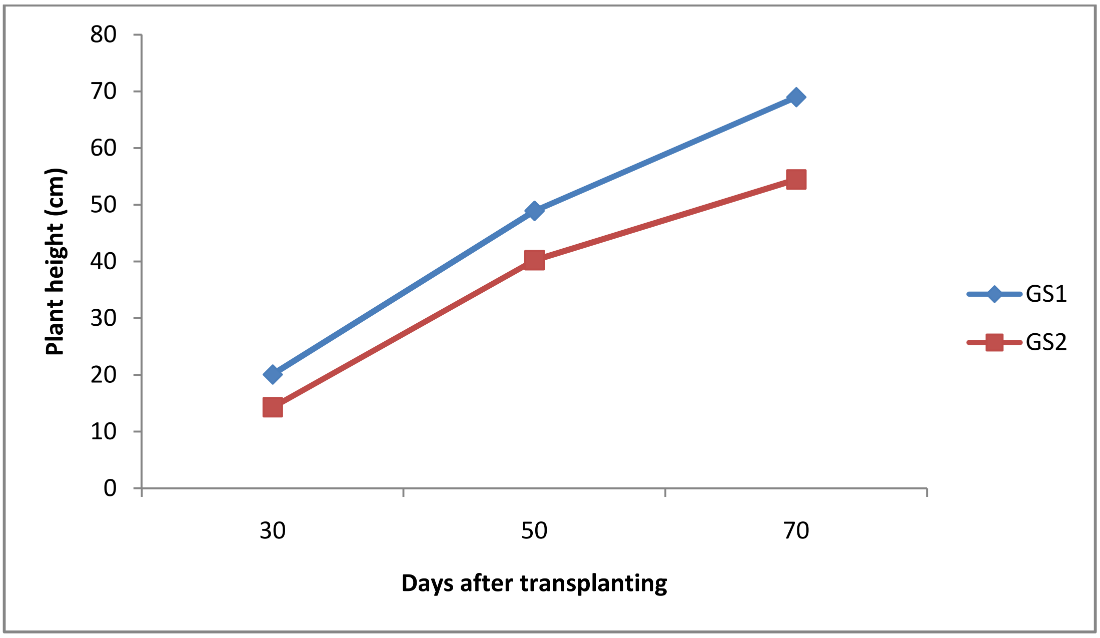

Fig. 2. Plant height of tomato as influenced by different plant growing structures in rooftop garden

GS_1 = Earthen pot, GS_2 = Plastic pot

Significant variation was found on plant height of tomato at different growth stages affected by different plant growing structures (Fig. 2 and Appendix IV). It was found that at 30 DAT, the highest plant height (20.09cm) was found from GS_1 (Earthen pot) where the lowest plant height (14.33 cm) was found from GS_2 (Plastic pot). At 50 DAT, the highest plant height (48.93cm) was found from GS_1 (Earthen pot) where the lowest plant height (40.22 cm) was found fromGS_2 (Plastic pot). At 70 DAT, the highest plant height (68.97cm) was found from GS_1 (Earthen pot) where the lowest plant height (54.45 cm) was found fromGS_2 (Plastic pot). Metwally (2016) also found similar result with the present study and they found that different growing structures showed significant variation on plant height. In addition they also reported that plants grown in big pots system has the highest values regarding plant height. Altogether these results suggest that earthen pot is more suitable to increase plant height of tomato than plastic pot.

Treatment combination of different varieties and plant growing structures showed signification variation on plant height at different growth stages (Table 1 and Appendix IV). Results indicated that at 30 DAT, the highest plant height (21.75cm) was found from the treatment combination of V_2GS_1which was statistically identical with $V_3GS_1$where the lowest plant height (13.24 cm) was found from the treatment combination of V_1GS_2. At 50 DAT, the highest plant height (50.20cm) was found from the treatment combination of V_2GS_1which was significantly different from all other treatment combinationswhere the lowest plant height (38.29 cm) was found from the treatment combination of V_1GS_2. At 70 DAT, the highest plant height (71.52cm) was found from the treatment combination of V_2GS_1which was significantly identical with V_3GS_1 where the lowest plant height (51.84 cm) was found from the treatment combination of V_1GS_2 which was statistically identical withV_2GS_2 treatment.

Table1. Plant height of tomato as influenced by different varieties and plant growing structures in rooftop garden

Treatment	Plant height (cm)		
	30 DAT	50 DAT	70 DAT
V_1GS_1	17.12 b	43.28 c	64.68 b
V_1GS_2	13.24 c	38.29 e	51.84 d
V_2GS_1	21.75 a	50.20 a	71.52 a
V_2GS_2	14.57 c	40.76 d	54.00 d
V_3GS_1	21.41 a	47.66 b	70.71 a
V_3GS_2	15.18 bc	41.62 cd	57.50 c
$LSD_{0.05}$	1.98	2.09	2.47
Significant level	*	*	*
CV (%)	9.53	11.61	12.31

V_1 = BINA tomato 6
V_2 = BINA tomato 7
V_3 = Hybrid summer tomato

GS_1 = Earthen pot
GS_2 = Plastic pot

CV=Co-efficient of Variance
LSD=Least Significant Difference
* = Significant at 5% level
NS = Non-significant

4.1.2 Number of leaves plant^{-1}

From the beginning leaf is the main photosynthetic part and it is very crucial part of plant, thus leaf number is very important character for plant growth and development.Significant variation was observed in terms of number of leaves plant^{-1} at all growth stages influenced by different variety of summer tomatoes (Fig. 3 and Appendix V). At 30 DAT, the highest number of leaves plant^{-1} (10.38) was found from V_3 (Hybrid summer tomato variety) where thelowest number of leaves plant^{-1} (7.50) was found from V_1 (BINA tomato 6) which was statistically identical with V_2 (BINA tomato 7). At 50 DAT, the highest number of leaves plant^{-1} (32.88) was found from V_3 (Hybrid summer tomato variety) where the lowest number of leaves plant^{-1} (25.63) was found from V_1 (BINA tomato 6). Similarly, at 70 DAT, the highest number of leaves plant^{-1} (72.38) was found from V_3 (Hybrid summer tomato variety) where the lowest number of leaves plant^{-1} (55.25) was found from V_1 (BINA tomato 6).Similar result was also observed by Bhati (2017) and found that variety showed significant variation on leaf number.

Different plant growing structures showed significant influence on number of leaves plant^{-1} at different growth stages (Fig. 4 and Appendix V). It was observed that at 30 DAT, the highest number of leaves plant^{-1} (11.25) was found from GS_1 (Earthen pot) where the lowest number of leaves plant^{-1} (8.00) was found from GS_2 (Plastic pot).At 50 DAT, the highest number of leaves plant^{-1} (33.42) was found from GS_1 (Earthen pot) where the lowest number of leaves plant^{-1} (25.00) was found from GS_2 (Plastic pot).At 70 DAT, the highest number of leaves plant^{-1}(77.92) was found from GS_1 (Earthen pot) where the lowest number of leaves plant^{-1}(48.67) was found from GS_2 (Plastic pot). These results are partially supported by Metwally (2016) who found that plants grown in big pots system has the highest values regarding number of leaves. Altogether these results suggest that earthen pot was more suitable to increase number of leaves per plant other than plastic pot.

Combined effect of different varieties and plant growing structures gave significant variation on number of leaves plant^{-1} at different growth stages of summer tomato (Table 2 and Appendix V). At 30 DAT, the highest number of leaves plant^{-1} (12.0) was found from the treatment combination of V_3GS_1 which was significantly different from all other combinations followed byV_2GS_1 where the lowest number of leaves plant^{-1} (7.50) was found from the treatment combination of V_1GS_2 which was statistically identical with V_2GS_2. At 50 DAT, the highest number of leaves plant^{-1} (38.75) was found from the treatment combination of V_3GS_1followed by V_2GS_1 where the lowest number of leaves plant^{-1} (22.50) was found from the treatment combination of V_1GS_2followed byV_2GS_2. At 70 DAT, the highest number of leaves plant^{-1} (92.00) was found from the treatment combination of V_3GS_1which was followed by V_2GS_1 where the lowest number of leaves plant^{-1} (44.50) was found from the treatment combination of V_1GS_2followed by $V_2GS_2$and V_3GS_2.

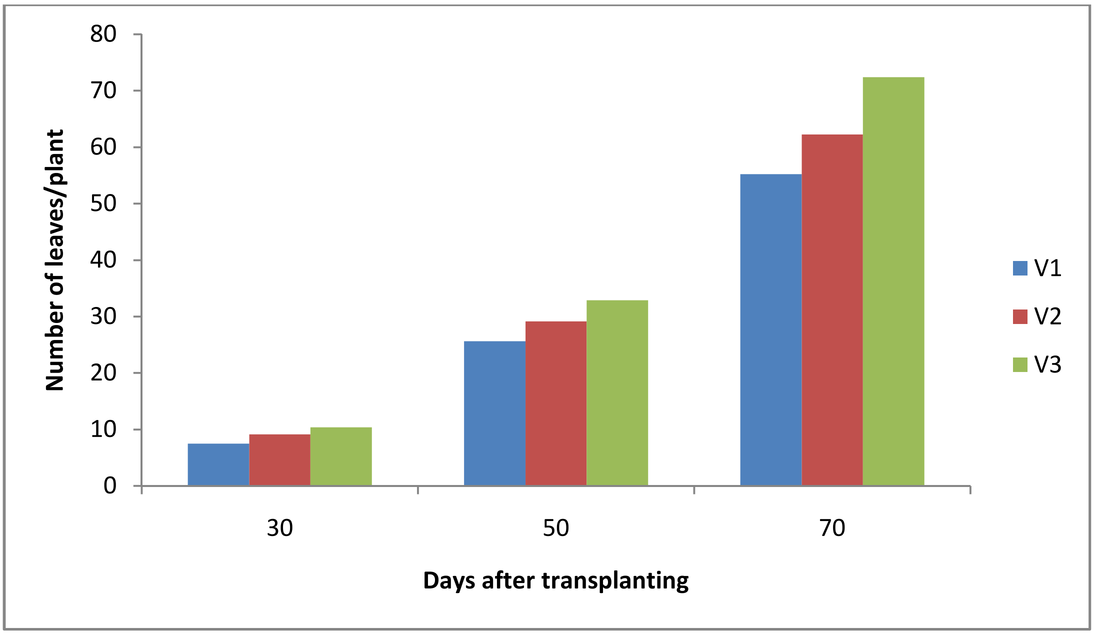

Fig.3. Number of leaves plant^{-1} of tomato as influenced by different varieties in rooftop garden

V_1 = BINA tomato 6, V_2 = BINA tomato 7, V_3 = Hybrid summer tomato variety imported by Bejoshetol Seed Bd. Ltd.

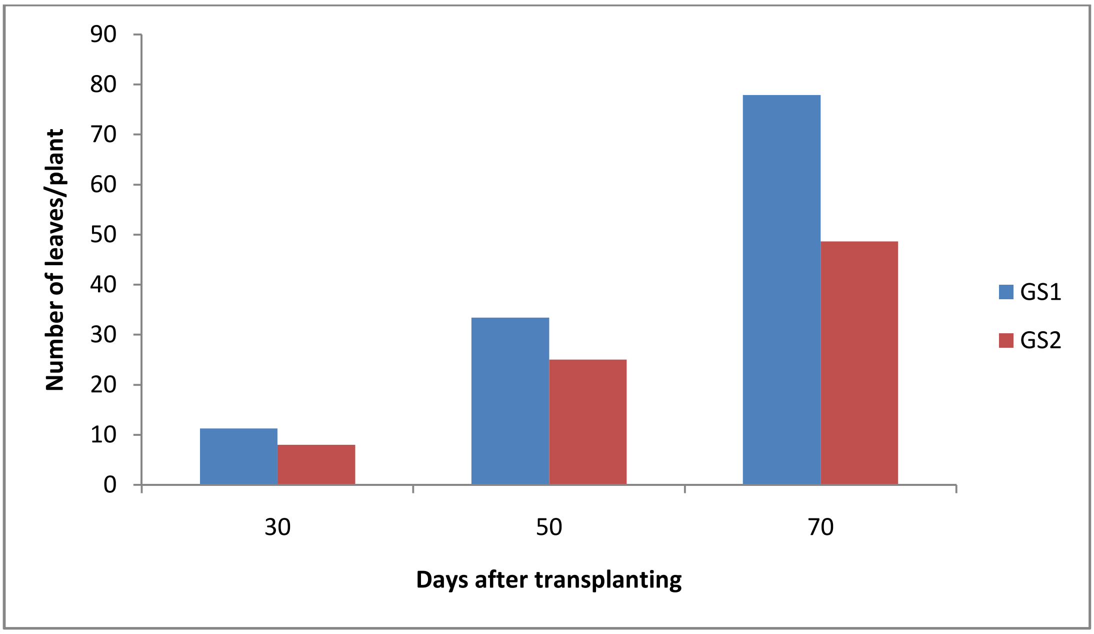

Fig.4. Number of leaves plant^{-1} of tomato as influenced by plant growing structures in rooftop garden

GS_1 = Earthen pot, GS_2 = Plastic pot

Table2. Number of leaves plant^{-1} of tomato as influenced by different varieties and plant growing structures in rooftop garden

Treatment	Number of leaves plant^{-1}		
	30 DAT	50 DAT	70DAT
V_1GS_1	9.75 bc	28.75 c	66.00 c
V_1GS_2	7.50 d	22.50 e	44.50 e
V_2GS_1	10.5 b	32.75 b	75.75 b
V_2GS_2	7.75 d	25.50 d	48.75 d
V_3GS_1	12.0 a	38.75 a	92.00 a
V_3GS_2	8.45 cd	27.00 cd	52.75 d
$LSD_{0.05}$	1.32	2.96	4.19
Significant level	*	*	*
CV (%)	8.15	10.39	12.71

V_1 = BINA tomato 6
V_2 = BINA tomato 7
V_3 = Hybrid summer tomato

GS_1 = Earthen pot
GS_2 = Plastic pot

CV=Co-efficient of Variance
LSD=Least Significant Difference
* = Significant at 5% level
NS = Non-significant

4.1.3 Number of branches plant^{-1}

Significant influence was recorded on number of branches plant^{-1} at 30, 50 and 70 DAT affected by different varieties of summer tomato (Fig. 5 and Appendix VI). At 30 DAT, the highest number of branches plant^{-1} (4.13) was found from V_3 (Hybrid summer tomato variety) where the lowest number of branches plant^{-1}(3.50) was found from V_1 (BINA tomato 6)which was statistically identical with V_2 (BINA tomato 7).At 50 DAT, the highest number of branches plant^{-1} (10.13) was found from V_3 (Hybrid summer tomato variety) where the lowest number of branches plant^{-1} (8.50) was found from V_1 (BINA tomato 6).At 70 DAT, the highest number of branches plant^{-1} (13.88) was found from V_3 (Hybrid summer tomato variety) which was statistically identical with V_2 (BINA tomato 7) where the lowest number of branches plant^{-1}(12.63) was found from V_1 (BINA tomato 6). Similar results were also observed by Bhati(2017) and Hamid *et al.* (2005) who found that variety had significant effect on number of branches plant^{-1}.

Significant influence was identified on number of branches plant^{-1} at 30, 50 and 70 DAT affected by different plant growing structures (Fig. 6 and Appendix VI). At 30 DAT, the highest number of branches plant^{-1} (4.33) was found from GS_1 (Earthen pot) where the lowest number of branches plant^{-1} (3.25) was found from GS_2 (Plastic pot). At 50 DAT, the highest number of branches plant^{-1} (10.92) was found from GS_1 (Earthen pot) where the lowest number of branches plant^{-1} (8.00) was found from GS_2 (Plastic pot). At 70 DAT, the highest number of branches plant^{-1} (14.67) was found from GS_1 (Earthen pot)where the lowest number of branches plant^{-1} (12.08) was found from GS_2 (Plastic pot). Altogether it can be said that earthen pot structure has significantly increased number of branches plant^{-1}.Similar result was also observed by Bouzo and Favaro (2016) and Metwally (2016). They found that increase in the container size results in plants of higher number of branches.

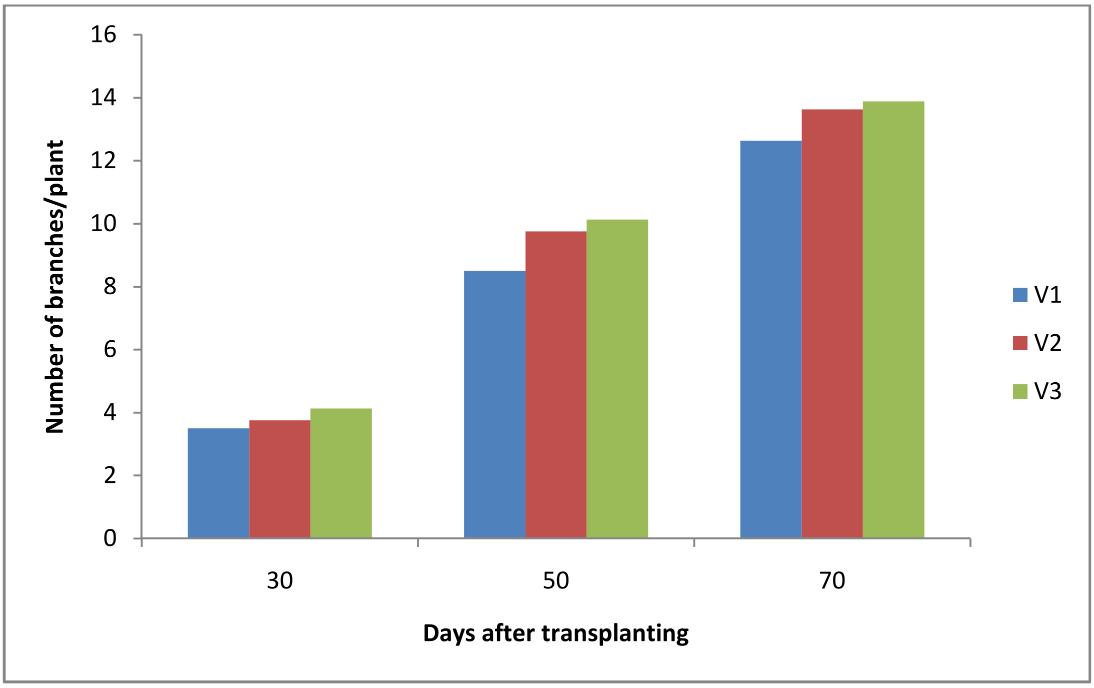

Fig.5. Number of branches plant^{-1} of tomato as influenced by different varieties in rooftop garden

V_1 = BINA tomato 6, V_2 = BINA tomato 7, V_3 = Hybrid summer tomato variety imported by Bejoshetol Seed Bd. Ltd.

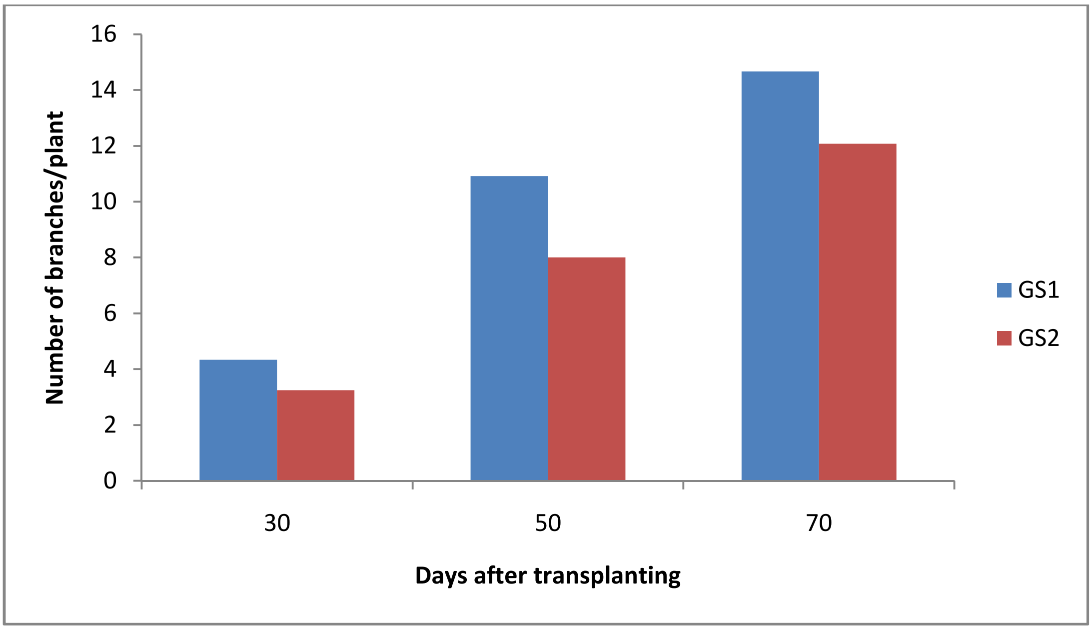

Fig.6.Number of branches plant^{-1} of tomato as influenced by different plant growing structures in rooftop garden

GS_1 = Earthen pot, GS_2 = Plastic pot

Thesignificant variation was remarked on number of branches plant^{-1}at 30, 50 and 70 DAT influenced by treatment combination of different varieties and plant growing structures (Table 3 and Appendix VI). At 30 DAT, the highest number of branches plant^{-1} (4.75) was found from the treatment combination of V_3GS_1which was significantly different from all other treatment combinations where the lowest number of branches plant^{-1} (3.00) was found from the treatment combination of V_1GS_2. At 50 DAT, the highest number of branches plant^{-1} (11.75) was found from the treatment combination of V_3GS_1which statistically identical with V_2GS_1 where the lowest number of branches plant^{-1} (7.25) was found from the treatment combination of V_1GS_2. At 70 DAT, the highest number of branches plant^{-1}(15.25) was found from the treatment combination of V_3GS_1which was statistically identical with V_2GS_1 and statistically similar with V_1GS_1 where the lowest number of branches plant^{-1}(11.50) was found from the treatment combination of V_1GS_2followed by V_3GS_2.

Table3. Number of branches plant^{-1} of tomato as influenced by different varieties and plant growing structures in rooftop garden

Treatment	Number of branches plant^{-1}		
	30 DAT	50 DAT	70 DAT
V_1GS_1	4.00 b	9.75 b	13.75 ab
V_1GS_2	3.00 d	7.25 d	11.50 c
V_2GS_1	4.25 b	11.25 a	15.00 a
V_2GS_2	3.25 cd	8.25 c	12.25 bc
V_3GS_1	4.75 a	11.75 a	15.25 a
V_3GS_2	3.50 c	8.50 c	12.50 bc
$LSD_{0.05}$	0.45	0.99	1.64
Significant level	*	*	*
*CV (%)	4.00	7.38	8.63

V_1 = BINA tomato 6
V_2 = BINA tomato 7
V_3 = Hybrid summer tomato

GS_1 = Earthen pot
GS_2 = Plastic pot

CV=Co-efficient of Variance
LSD=Least Significant Difference
* = Significant at 5% level
NS = Non-significant

4.2 Yield and yield contributing parameters

4.2.1 Number of flower clusters plant^{-1}

Significant influence was recorded on number of flower clusters plant^{-1} affected by different varieties of summer tomato (Table 4 and Appendix VII). Results signified that the highest number of flower clusters plant^{-1}(8.38) was found from V_3 (Hybrid summer tomato variety) which was statistically identical with V_2 (BINA tomato 7) where the lowest number of flower clusters plant^{-1}(7.75) was found from V_1 (BINA tomato 6). Hamid *et al.* (2005) also found similar result with the present study.

Significant influence was identified on number of flower clusters plant^{-1} affected by different plant growing structures (Table 4 and Appendix VII). Results showed that the highest number of flower clusters plant^{-1}(8.67) was found from GS_1 (Earthen pot)where the lowest number of flower clusters plant^{-1}(7.42) was found from GS_2 (Plastic pot).Metwally (2016) also observed higher number of flower clusters plant^{-1} with larger container size compared to lower sized container.

The significant variation was remarked on number of flower clusters plant^{-1} influenced by treatment combination of different varieties and plant growing structures (Table 5 and Appendix VII). It was observed that the highest number of flower clusters plant^{-1}(9.25) was found from the treatment combination of V_3GS_1followed by $V_2GS_1$and V_1GS_1. The lowest number of flower clusters plant^{-1}(7.25) was found from the treatment combination of V_1GS_2 which was statistically identical with $V_2GS_2$and V_3GS_2.

4.2.2 Number of flowers cluster^{-1}

Number of flowers cluster^{-1} was not significantly influenced by different varieties of tomato (Table 4 and Appendix VII). But it was observed that the highest number of flowers cluster^{-1} (4.29) was found from V_3 (Hybrid summer tomato variety) where the lowest number of flowers cluster^{-1} (3.69) was found from V_1 (BINA tomato 6).Hamid *et al.* (2005) also found similar result with the present study.

Different plant growing structures showed significant influence on number of flowers cluster^{-1} of tomato (Table 4 and Appendix VII). Results revealed that the highest number of flowers cluster^{-1} (4.40) was found from GS_1 (Earthen pot)where the lowest number of flowers cluster^{-1} (3.66) was found from GS_2 (Plastic pot).Similar result was also found from the findings of Metwally (2016) and he found that larger container gave higher number of flowers cluster^{-1}.

Interaction effect of different varieties and plant growing structures gave significant variation on number of flowers cluster^{-1} of summer tomato (Table 6 and AppendixVII). Results exposed that the highest number of flowers cluster^{-1} (4.74) was found from the treatment combination of V_2GS_1 which was statistically identical with V_3GS_1. The lowest number of flowers cluster^{-1} (3.50) was found from the treatment combination of V_2GS_2which was also statistically identical with $V_1GS_2$and V_2GS_2.

4.2.3 Number of flowers plant^{-1}

Significant variation was observed in terms of number of flowers plant^{-1} influenced by different variety of summer tomato (Table 4 and AppendixVII).Results indicated that the highest number of flowers plant^{-1} (36.13) was found from V_3 (Hybrid summer tomato variety)where the lowest number of flowers plant^{-1} (28.63) was found from V_1 (BINA tomato 6).Bhati (2017) and Hamid *et al.* (2005) also found similar results.

Different plant growing structures showed significant influence on number of flowers plant^{-1} at different growth stages (Table 4 and Appendix VII). It was noted that the highest number of flowers plant^{-1} (38.17) was found GS_1 (Earthen pot)where the lowest number of flowers plant^{-1} (27.25) was found from GS_2 (Plastic pot).Metwally (2016) also found similar result and he found that larger container gave higher number of flowers plant^{-1}.

Combined effect of different variety and plant growing structures gave significant variation on number of flowers plant^{-1} at different growth stages of summer tomato (Table 5 and Appendix VII). It was verified that the highest number of flowers plant^{-1} (42.50) was found from the treatment combination of V_3GS_1 followed by $V_2GS_1$where the lowest number of flowers plant^{-1} (25.50) was found from the treatment combination of V_1GS_2which was statistically identical with V_2GS_2.

4.2.4 Number of fruits plant^{-1}

Significant influence was found on number of fruits plant^{-1}affected by different variety of summer tomato (Table 4 and Appendix VII). It was noted that the highest number of fruits plant^{-1} (8.50) was found from V_3 (Hybrid summer tomato variety)followed by V_2 (BINA tomato 7) where the lowest number of fruits plant^{-1} (6.88) was found from V_1 (BINA tomato 6). The result obtained from the present study was similar with the findings of Hamid *et al.* (2005).

Significant influence was identified on number of fruits plant^{-1} affected by different plant growing structures (Table 4 and Appendix VII). It was indicated that the highest number of fruits plant^{-1} (8.75) was found from GS_1 (Earthen pot)where the lowest number of fruits plant^{-1} (6.42) was found from GS_2 (Plastic pot).Metwally (2016) and Bouzo and Favaro (2016) also found similar results with the present study. They found that increase in container size resulted higher number of fruits plant^{-1}.

Remarkable variation was noted on number of fruits plant^{-1} influenced by treatment combination of different varieties and plant growing structures (Table 5 and Appendix VII). Results verified that the highest number of fruits plant^{-1} (9.25) was found from the treatment combination of V_3GS_1 which was statistically similar with$V_1GS_1$and V_2GS_1.The lowest number of fruits plant^{-1} (5.50) was found from the treatment combination of V_1GS_2 which was statistically identical with V_2GS_2.

4.2.5 Yield plant^{-1}

Significant variation was observed in terms of yield plant^{-1} influenced by different varieties of summer tomatoes (Table 4 and Appendix VII). Results indicated that the highest yield plant^{-1} (96.50 g) was found from V_3 (Hybrid summer tomato variety) followed by V_2 (BINA tomato 7) where the lowest yield plant^{-1} (69.51 g) was found from V_1 (BINA tomato 6). The findings on yield plant^{-1} obtained by Bhati (2017), Hamid *et al.* (2005) and BINA, (1998) were similar with the findings of the present study.

Different plant growing structures showed significant influence on yield plant^{-1} (Table 4 and Appendix VII). It was found that the highest yield plant^{-1} (96.43 g) was found from GS_1 (Earthen pot)where the lowest yield plant^{-1} (65.08 g) was found from GS_2 (Plastic pot). Ouellette (2013) and Ahammed*et al.*

(2009)also obtained similar results on yield plant^{-1} with the present study.Metwally (2016) and Bouzo and Favaro (2016) also found similar results.

Remarkable variation was identified on yield plant^{-1} influenced by combined effect of different variety and plant growing structures (Table 5 and Appendix VII). Results revealed that the highest yield plant^{-1} (109.60 g) was found from the treatment combination of V_3GS_1 followed by $V_2GS_1$and V_2GS_1. The lowest yield plant^{-1} (50.51 g) was found from the treatment combination of V_1GS_2 followed by V_2GS_2.

Table4.Yield and yield contributing parameters of tomato as influenced by different varieties and plant growing structures in rooftop garden

Treatment	Yield contributing parameters				
	Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (g)
Effect of variety					
V_1	7.75 b	3.69	28.63 c	6.88 c	69.51c
V_2	8.00 a	4.12	33.38 b	7.38 b	76.27b
V_3	8.38 a	4.29	36.13 a	8.50 a	96.50a
$LSD_{0.05}$	0.41	0.63	1.25	0.52	6.84
Significant level	*	NS	*	*	*
CV (%)	5.80	4.23	8.93	6.34	10.59
Effect of plant growing structures in rooftop garden					
GS_1	8.67a	4.40 a	38.17 a	8.75 a	96.43 a
GS_2	7.42 b	3.66 b	27.25 b	6.42 b	65.08 b
$LSD_{0.05}$	0.57	0.38	1.67	0.48	2.65
Significant level	*	*	*	*	*
CV (%)	5.80	4.22	8.93	6.34	10.59

V_1 = BINA tomato 6
V_2 = BINA tomato 7
V_3 = Hybrid summer tomato

GS_1 = Earthen pot
GS_2 = Plastic pot

CV=Co-efficient of Variance
LSD=Least Significant Difference
* = Significant at 5% level
NS = Non-significant

Table5. Yield and yield contributing parameters of tomato as influenced by combined effect of varieties and plant growing structures in rooftop garden

Treatment	Yield contributing parameters				
	Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (g)
V_1GS_1	8.25 b	3.85 b	31.75 c	8.25 ab	88.50 b
V_1GS_2	7.25 c	3.52 c	25.50 e	5.50 c	50.51 e
V_2GS_1	8.50 b	4.74 a	40.25 b	8.75 ab	91.19 b
V_2GS_2	7.50 c	3.50 c	26.50 e	6.00 c	61.34 d
V_3GS_1	9.25 a	4.60 a	42.50 a	9.25 a	109.6 a
V_3GS_2	7.50 c	3.97 b	29.75 d	7.75 b	83.40 c
$LSD_{0.05}$	0.60	0.24	1.08	1.03	4.48
Significant level	*	*	*	*	*
CV (%)	5.80	4.22	8.93	6.34	10.59

V_1 = BINA tomato 6
V_2 = BINA tomato 7
V_3 = Hybrid summer tomato

GS_1 = Earthen pot
GS_2 = Plastic pot

CV=Co-efficient of Variance
LSD=Least Significant Difference
* = Significant at 5% level
NS = Non-significant

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the rooftop garden of Department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from July to November 2016 to investigate the response of different summer tomato varieties to different plant growing structures in rooftop garden. Two factors were used in the experiment, *viz.* three types of variety and two types of plant growing structures. Two factors as Factor A consisted of three varieties *viz.* V_1 (BINA tomato 6), V_2 (BINA tomato 7) and V_3 (Hybrid summer tomato variety imported by Bejoshetol Seed Bd. Ltd) and Factor B comprised of two plant growing structures *viz.* GS_1 (Earthen pot) and GS_2 (Plastic pot). The experiment was laid out in a Completely Randomized Design (CRD) with five replications. Data on different growth, yield contributing parameters and yield were recorded and analyzed significantly

The recorded data on different morphological, yield and yield contributing parameters were significantly influenced by different varieties and plant growing structures and also their combination.

In terms of varietal performance, considering morphological parameters, the highest plant height (18.30, 45.48 and 64.11 at 30, 50 and 70 DAT respectively), highest number of leaves plant^{-1} (12.00, 38.75 and 92.00 at 30, 50 and 70 DAT respectively) and highest number of branches plant^{-1} (4.13, 10.13 and 13.88 at 30, 50 and 70 DAT respectively) were found from V_3 (Hybrid summer tomato variety).

Considering yield and yield contributing parameters, the highest number of flower clusters plant^{-1} (8.38),Number of flowers cluster^{-1}(4.29),highest number of flowers plant^{-1} (36.13), highest number of fruits plant^{-1} (8.50) and highest yield plant^{-1} (96.50 g) were also found from V_3 (Hybrid summer tomato variety). On the other hand, the variety, V_1 (BINA tomato 6) gave the lowest plant height (15.18, 38.29 and 58.26 cm at 30, 50 and 70 DAT respectively), lowest number of leaves plant^{-1} (7.50, 25.63 and 55.25 at 30, 50 and 70 DAT respectively) and lowest number of branches plant^{-1} (3.50, 8.50 and 12.63 at 30, 50 and 70 DAT respectively). Again, the lowest number of flower clusters plant^{-1} (7.75), Number of flowers cluster^{-1}(3.69), lowest number of flowers plant^{-1} (28.63), lowest number of fruits plant^{-1} (6.88) and lowest yield plant^{-1} (69.51 g) were also found from V_1 (BINA tomato 6).

In terms of the studied parameters affected by different plant growing structures, the highest plant height (20.09, 48.93 and 68.97 cm at 30, 50 and 70 DAT respectively), highest number of leaves plant^{-1} (11.25, 33.42 and 77.92 at 30, 50 and 70 DAT respectively) and highest number of branches plant^{-1}(4.33, 10.92 and 14.67 at 50 and 70 DAT respectively) were found from GS_1 (Earthen pot). Similarly, the highest number of flower clusters plant^{-1} (8.67), highest number of flowers cluster^{-1} (4.40), highest number of flowers plant^{-1} (38.17), highest number of fruits plant^{-1} (8.75) and highest yield plant^{-1} (96.43 g) were also achieved from GS_1 (Earthen pot). Again, the lowest plant height (14.33, 40.22 and 54.45 cm at 30, 50 and 70 DAT respectively), lowest number of leaves plant^{-1} (8.00, 25.00 and 48.67 at 30, 50 and 70 DAT respectively), lowest number of branches plant^{-1} (3.25, 8.00 and 12.08 at 30, 50 and 70 DAT respectively)were found from GS_2 (Plastic pot). Accordingly, the lowest number of flower clusters plant^{-1} (7.42), lowest number of flowers cluster^{-1} (3.66), lowest number of flowers plant^{-1} (27.25), lowest number of fruits plant^{-1} (6.42) and lowest yield plant^{-1} (65.08 g) were also found from GS_2 (Plastic pot).

Regarding treatment combination of different varieties and plant growing structures, the highest plant height (21.75, 50.20 and 71.52 cm at 30, 50 and 70 DAT respectively) was observed from the treatment combination of V_2GS_1 whereas the highest number of leaves plant^{-1} (12.00, 38.75 and 92.00 at 30, 50 and 70 DAT respectively) and highest number of branches plant^{-1} (4.75, 11.75 and 15.25 at 50 and 70 DAT respectively) were found from the treatment combination of V_3GS_1. The highest number of flower clusters plant^{-1} (9.25), highest number of flowers plant^{-1} (42.50), highest number of fruits plant^{-1} (9.25) and highest yield plant^{-1} (109.60 g) were also found from the treatment combination of V_3GS_1. But the highest number of flowers cluster^{-1} (4.74) was found from the treatment combination of V_2GS_1.

On the contrary, the lowest plant height (13.24, 38.29 and 51.84 cm at 30, 50 and 70 DAT respectively), lowest number of leaves plant^{-1} (7.50, 22.50 and 44.50 at 30, 50 and 70 DAT respectively) and lowest number of branches plant^{-1}(3.00, 7.25 and 11.50 at 30, 50 and 70 DAT respectively) were found from the treatment combination of V_1GS_2. This treatment combination, V_1GS_2 also gave the lowest number of flower clusters plant^{-1} (7.25), lowest number of flowers plant^{-1} (25.50), lowest number of fruits plant^{-1} (5.50) and lowest yield plant^{-1} (50.51 g). But the lowest number of flowers cluster^{-1} (3.48) was found from the treatment combination of V_2GS_2.

From the above findings under the present study, it can be concluded that the most of the yield and yield contributing parameters of summer tomatoes on rooftop garden was increased while using the variety V_3 (Hybrid summer tomato variety) with plant growing structure GS_1 (Earthen pot) compared to GS_2 (Plastic pot).

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Further study is needed in the rooftop garden for definite results of the present experiment.
2. Other summer variety can be included to conduct related experiment.
3. Some other plant growing structure can be included for further experiment in the rooftop
4. Scope to conduct similar experiment for Rabi season in the rooftop

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

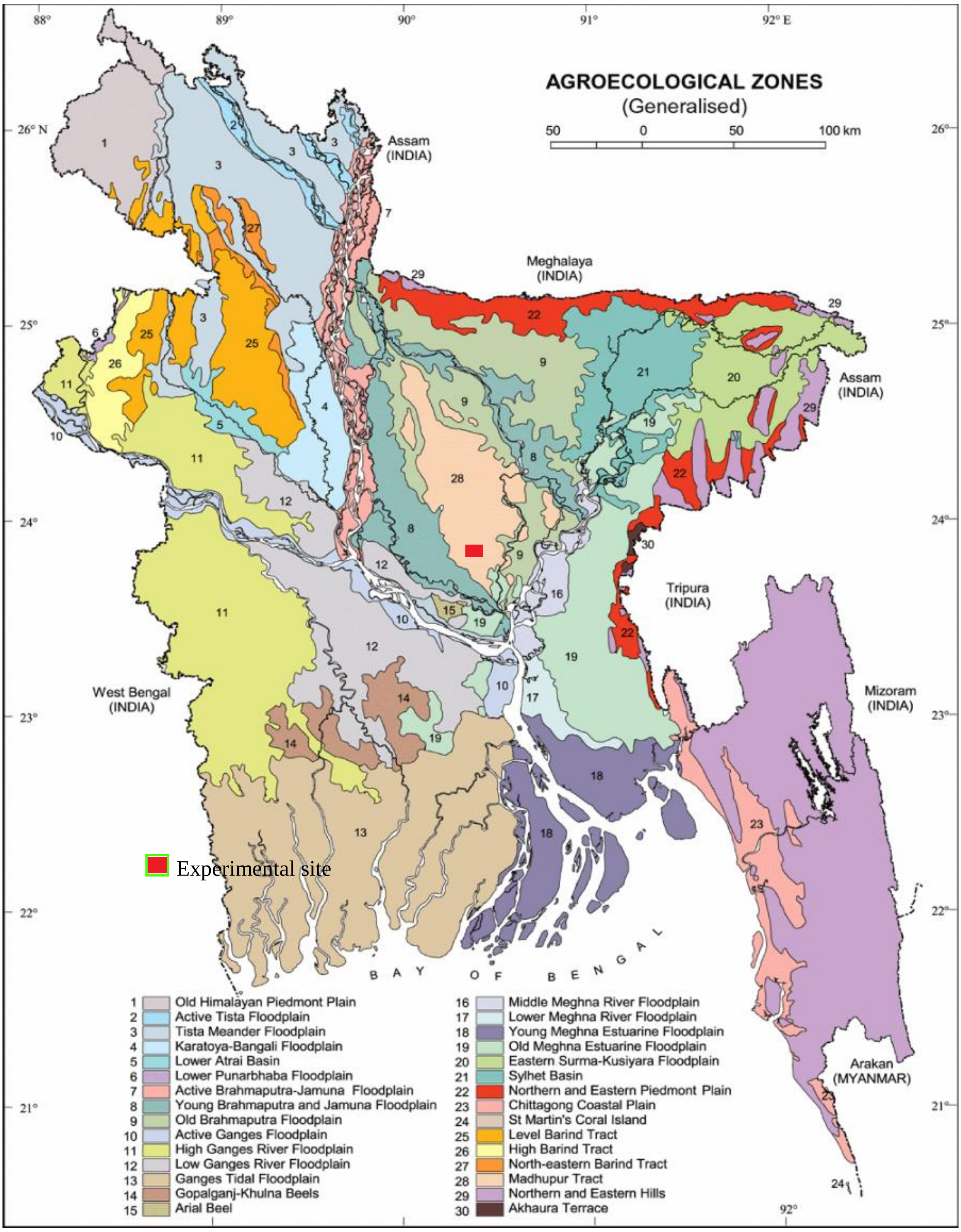

Fig.9. Experimental site

Appendix II. Monthly records of air temperature, relative humidityand rainfall during the period from July to November 2016

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
July	79.60	33.20	25.74	29.47	304.0
August	76.25	31.66	24.40	28.03	152.6
September	71.50	30.8	21.80	26.30	78.52
October	68.48	30.42	16.24	23.33	52.60
November	56.75	28.60	8.52	18.56	14.40

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III.Physical and chemical properties of soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Characteristics	Value
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Plant height of tomato influenced by different varieties and plant growing structures and also their combination at different growth stages

Sources of variation	Degrees of freedom	Mean square of plant height (cm) at		
		30 DAT	50 DAT	70 DAT
Replication	2	0.316	1.114	1.009
Factor A	2	12.21**	21.824*	26.418*
Factor B	3	18.58*	33.312*	37.124*
AB	6	10.62**	16.611**	18.244**
Error	22	1.304	2.056	3.117

Appendix V. Number of leaves plant^{-1} of tomato influenced by different varieties and plant growing structures and also their combination at different growth stages

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAT	50 DAT	70 DAT
Replication	2	0.317	1.214	1.086
Factor A	2	9.386*	21.287**	16.038*
Factor B	3	12.22*	28.304*	36.112*
AB	6	7.167**	11.490**	14.43**
Error	22	0.382	1.385	2.014

Appendix VI. Number of branches plant^{-1} of tomato influenced by different varieties and plant growing structures and also their combination at different growth stages

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}	
		50 DAT	70 DAT
Replication	2	0.128	0.132
Factor A	2	6.021**	5.385**
Factor B	3	9.118*	9.176**
AB	6	3.317**	2.028**
Error	22	0.109	0.136

Appendix VII. Yield contributing parameters and yield of tomato influenced by different varieties and plant growing structures and also their combination

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters				
		Number of flower clusters plant^{-1}	Number of flowers cluster^{-1}	Number of flowers plant^{-1}	Number of fruits plant^{-1}	Yield plant^{-1} (g)
Replication	2	0.024	0.046	0.258	0.042	3.217
Factor A	2	7.217*	NS	8.322*	5.346	23.814*
Factor B	3	10.114*	4.834**	18.715*	12.34*	45.529*
AB	6	6.329*	2.614**	8.386*	8.356*	12.426*
Error	22	1.045	1.376	1.739	1.017	3.186

Appendix VIII. Preview of rooftop gardening of tomato with earthen pot and plastic pot

Fig. 7.Rooftop gardening of tomato with earthen pot and plastic pot

Appendix IX. Preview of rooftop gardening of tomato with plastic potand earthen pot

Fig. 8.Rooftop gardening of tomato with plastic pot and earthen pot