RESPONSES OF TOMATO TO DIFFERENT PLANT GROWING STRUCTURES AND COMPOSITION OF GROWING MEDIA IN ROOFTOP GARDEN

THESIS

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CERTIFICATE

*This is to certify that the thesis entitled, **"RESPONSES OF TOMATO TO DIFFERENT PLANT GROWING STRUCTURES AND COMPOSITION OF GROWING MEDIA IN THE ROOFTOP GARDEN "** submitted to the Department of Agricultural Botany, Faculty of Agriculture, 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 **Most. Tania Akter** Registration No. **16-07540** under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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RESPONSE OF TOMATO TO DIFFERENT PLANT GROWING STRUCTURES AND COMPOSITION OF GROWING MEDIA IN ROOFTOP GARDEN

ABSTRACT

This experiment was carried out at the rooftop garden of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh from October 2017 to March 2018 to evaluate the response of tomato to different plant growing structures and composition of growing media in the rooftop garden. The experiment had two factors, factor A- two plant growing structures, *viz*., S_1= Plastic pot, S_2= Earthen pot and factor B- six different plant growing medium *viz*. M_0=Soil 100% (w/w) + inorganic fertilizer (IF)/(control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) + IF, M_2=Soil 70% (w/w) + 30% cowdung (w/w) + IF, M_3=Soil 90% (w/w) + 10% vermicompost (w/w) + IF, M_4=Soil 80% (w/w) + 20% vermicompost (w/w) + IF, M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) + IF. The factorial experiment was laid out in a Completely Randomized Design (CRD) with four replications. The experimental results such as morphological and yield contributing characters and yield of tomato significantly influenced by different plant growing structures and various composition of plant growing media and also their combination. Considering plant growing structures, the plastic pot (S_1) gave the higher plant height, number of leaves plant^{-1}**,** branch plant^{-1}**,** flower clusters plant^{-1}**,** flowers plant^{-1}**,** fruit length and fruit breadth. The maximum yield of fruits plant^{-1} (1.69 kg) was also obtained from plastic pot and the minimum yield of fruits plant^{-1} (1.46 kg) was obtained from earthen pot (S_2). The Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) + IF marked as **(**M_5) had the highest plant height, number of leaves plant^{-1}, branch plant^{-1}, flower clusters plant^{-1}, flowers plant^{-1}, fruit length and fruit diameter. The maximum yield of fruits plant^{-1} (2.17 kg) was recorded from the soil 80%(w/w) + 10% cowdung(w/w) + 10% vermicompost(w/w)) + IF noted as **(**M_5) whereas the minimum yield was found from control or M_0 (Soil 100% (w/w) + inorganic fertilizers conditions. The highest yield of fruits plant^{-1} (2.15 kg) was obtained from the treatment combination of S_1M_5 (plastic pot along with the soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) + IF), which is consistent of other parameters such as morphological and yield contributing characters of this study. The lowest yield of fruits plant^{-1} (0.99 kg) was obtained from the treatment combinations of S_2M_0 (earthen pot along with the soil 100% (w/w) + inorganic fertilizer /control) which is dependable to other characters of this study. This experimental results suggest that plastic pot along with soil 80%

(w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) + IF be able to increase the fruit yield of BARI tomato14 for *rabi* season in the rooftop garden under the climatic conditions of SAU.

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LIST OF ABBREVIATION AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BARI	=	Bangladesh Agricultural Research Institute
HRC	=	Horticulture Research Centre
BBS	=	Bangladesh Bureau of Statistics
FAO	=	Food and Agricultural Organization
N	=	Nitrogen
et al.	=	And others
TSP	=	Triple Super Phosphate
MOP	=	Muriate of Potash
RCBD	=	Randomized Complete Block Design
DAT	=	Days after Transplanting
ha^{-1}	=	Per hectare
g	=	gram (s)
kg	=	Kilogram
SAU	=	Sher-e-Bangla Agricultural University
SRDI	=	Soil Resources and Development Institute
wt	=	Weight
LSD	=	Least Significant Difference
^{0}C	=	Degree Celsius
NS	=	Not significant
Max	=	Maximum
Min	=	Minimum
%	=	Percent
NPK	=	Nitrogen, Phosphorus and Potassium
CV%	=	Percentage of Co-efficient of Variance

CHAPTER I

INTRODUCTION

The global population expansion increases the resource consumption, ultimately threatens the ecosystem, changes the environment and strains the humanity's ability to feed itself. It is well known that the following reasons have been contributing to change environment *viz*: over population, rising temperature, excess carbon-di-oxide (CO_2), methane (CH_4), nitrus oxide (N_2O) emission etc. In the urban area, the atmospheric temperature is high which creates urban heat island (UHI) compared to the suburban and rural areas. As a part of urban vegetation, rooftop garden systems improve air quality and decrease the UHI, 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). The augmentation of urban vegetation is an outstanding mitigation strategy to keep the sound environment in the city. The concrete structure including building roofs occupies almost 60% area of the total area along with decreased vegetation which increases urban temperature and create UHI in the Dhaka city (Ahmed et al. 2013). Although rooftop gardening is an old practice in Bangladesh but recently it is gaining popularity in urban area, especially Dhaka city. There are numerous fruits, vegetables such as brinjal, chili, capsicum and tomato are easy to grow in the rooftop garden.

Tomato (*Solanum lycopersicum*) is one of the most important popular vegetable crop under Solanaceae family which grown throughout the world including, Bangladesh. In terms of human health, tomato is a major component in the daily diet and constitutes of important sources including antioxidants- like lycopene which has anti-carcinogenic effect. It also contains vitamins A, B and C and minerals especially potassium (K^{+}), iron (Fe^{++}), calcium (Ca^{2+}) etc. In addition**,** total arable land of our country is decreasing at alarming rate due to over population, road construction, urbanization and changes of environment. Thus, it has nice scope to grow crops in the roof garden to minimize the total demand of agricultural crops especially in urban locations as a component of urban agriculture. As a high value crops tomato possible to cultivate in the rooftop garden as a part of climate smart agriculture in Bangladesh. It has been reported that urban agriculture provides one fifth of the total demand of the world food. Rooftop gardening as a part of urban agriculture influences ecology, health, and poverty in a city. The rooftop garden contributes to ensure local food security and safety and improve nutrition, community relations, education and research and urban agriculture.

It is well known to us that rooftop gardening has been practicing long before but the technologies related to tomato cultivation are not sufficient due to lack of researchers interest. The knowledge and skill about plant growing structures, fertilization, irrigation, mulching, pest management, shoot and root pruning are essential to ensure long term success of the rooftop garden. In the rooftop garden, plant growing structures such as earthen and plastic pot, wooden and concrete bed, half drums and their sizes are major concern to grow different crops including, pepper, tomato, chili etc. (Nesmith and Duval, 1998 and

Metwally, 2016). Morphological, physiological and yield responses of tomato, cauliflower and cabbage were uneven to container sizes (Bouzo and Favaro, 2016, Nesmith and Duval, 1998). In addition, recently our laboratory found that the water requirement also unequal to both *Rabi* and *kharif* season in different types of pots. However, limited study have been conducted on the selection of plant growing structures including earthen and plastic pot for growing tomato as *kharif* season crops in the rooftop garden in the Dhaka city.

As plant growing structures, plant growing media is also a major concern for sustainable rooftop gardening. Plant growing media including soil organic matter such as decomposed cowdung, vermicompost, cocopit and inorganic fertilizer play a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils. Organic manures such as cow dung, poultry manure and vermicompost improves the soil structure, aeration, slow release nutrient which support root development leading to higher growth and yield of tomato plants.

However to my knowledge little is known about the different components of cowdung and vermicompost as changes in the morpho-physiology, yield and quality of tomato under SAU environmental condition.

Therefore, the present study was undertaken keeping in mind the following objectives:

i. To investigate the independent effects of plant growing structures (earthen pot and plastic pot) on changes in morpho-physiology, yield and quality of tomato during *rabi* season in the rooftop garden.

ii. To examine the effects of different composition of soil, cowdung and vermicompost on changes in morpho-physiology, yield and quality in of tomato during *rabi* season for the rooftop garden.

iii. To study the interaction effects between plant growing structures and growing media on changes in morpho-physiological parameters, yield and quality of tomato during *rabi* season in the rooftop garden.

CHAPTER II

REVIEW OF LITERATURE

Over half the world's population now lives in urban as opposed to rural environments with this increasing rate of urbanization over time; it is a crucial need to increase food production sites near main consumption centers. 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 preventing 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 researches on rooftop garden in Bangladesh is still very limited.

This research was conducted to identify the effects of different plant growing structures on summer tomato in rooftop garden as well as to analyze the effect of gibberellins and silicon application on them with their best possible interaction. Different research work in this respect has been reviewed below.

2.1 Effect of different plant growing structures on morpho-physiological parameters and yield of various plants including tomato

Sharma *et al.* (2016) 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.

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 size and yield.

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 recommend that the 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.

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, 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.

An investigation aimed to fertility management for tomato production on an extensive green roof by Ouellette (2013). This research project evaluated four fertilizer treatments on 'Bush Champion II' tomato (*Solanum lycopersicum*) 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.

Ahmed *et al.* (2013) reported that the amount of built-up area of Dhaka city built-up area increased by 88.78% in the past 20 years (from 1989 to 2009) and is expected to increase three-fold and four-fold by 2019 and 2029, respectively. In 1989, a larger part of the Dhaka Metropolitan (DMP) area (74%) fell within the lower temperature zones (<18°C to < 21 °C). But in 1999, a majority of the area (91.40%) was found to fall into the mid-temperature zones (21 °C to < 27 °C). This trend continues, and a larger portion of the DMP area (44%) moved into the higher temperature zones (27 °C to <30 °C) in 2009. Therefore, it is suggesting that the temperature of Dhaka city is gradually increasing day by day with changing environment.

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 green roof 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.

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.

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 kWh day^{-1}. However, this energy demand was reduced to less than 1.0 kWh day^{-1} in the garden roof a reduction of over 75%, which can be attributed to the presence of the growing medium and the plants.

2.2 Effect of different plant growing medium on the growth and yield of tomato

Nileema, and Sreenivasa, (2011) was conducted an experiment at main Agricultural Research Station, University of Agricultural Sciences, Dharwad to study the influence of liquid organic manures, viz. panchagavya, jeevamruth and beejamruth on the growth, nutrient content and yield of tomato in the sterilized soil during *kharif* 2009. The various types of organic solutions prepared from plant and animal origin are effective in the promotion of growth and fruiting in tomato. The Panchagavya is an efficient plant growth stimulant that enhances the biological efficiency of crops. It is used to activate biological reactions in the soil and to protect the plants from disease incidence. Jeevamruth promotes immense biological activity in soil and enhance nutrient availability to crop. Beejamruth protect the crop from soil borne and seed borne pathogens and also improves seed germination. Significantly the highest plant growth and root length was recorded with the application of RDF + Beejamruth + Jeevamruth + Panchagavya and it was found to be significantly superior over other treatments. The application of Beejamruth + Jeevamruth + Panchagavya was next best treatment and resulted in significantly the highest yield as compared to RDF alone.

Jagadeesha, (2008) conducted a field experiment was conducted at the University of Agricultural Sciences, Dharwad during *kharif* season of 2007 to study the effect of organic manures and biofertilziers on plant growth, seed yield and quality parameters in tomato. Results of field experiment in *kharif* 2007 revealed that, application of RDF (60:50:30 kg NPK ha^{-1}) + biofertilzier (Azospirillum and P solubilizing bacteria 2.5 kg ha^{-1} each) records higher plant height (64.37, 109.50 and 162.33 cm), number of leaves (92.50, 153.33 and 146.50), leaf area (898.05, 4314.31 and 4310.94 cm^2) and leaf area index (898.05, 4314.31 and 4310.94 cm^2) at 30, 60 and 90 DAT respectively and records lesser days to 50 per cent flowering (38.00) followed by FYM (50%) + vermicompost (50%) + biofertilzier. The application of RDF + biofertilziers records higher seed yield (106.87 kg ha^{-1}) followed by FYM (50%) + vermicompost (50%) (101.94 kg ha^{-1}) over FYM alone. The seed yield was significantly higher with the application of RDF + biofertilziers was attributed to number of fruits per plant (45.22) number of seeds $fruit^{-1}$ (109.45) fruit weight $plant^{-1}$ (1280.98 g) and 1000 seed weight (2.84 g).

Sathish *et al*. (2009) Studies were carried out to evaluate biological activity of organic manures against tomato fruit borer, Helicoverpa armigera (Hub.) and safety of otanicals and biopesticides against egg parasitoid, richogramma chilonis Ishii and biochemical effects of Pseudomonas florescens on tomato under pot culture conditions. The feeding and infestation of the larvae of H. armigera were significantly low in farm yard manure (FYM) zospirillum + silicate solubilising bacteria (SSB) + Phosphobacteria+neem cake applied plants followed by FYM + Azospirillum + SSB + Phosphobacteria + mahua cake applied plants. Trichogramma parasitization on *H. armigera* eggs was adversely effected by neem oil 3% on treated plants followed by neem seed kernel extract (NSKE 5%) + spinosad 75 g a.i. ha^{-1}. Under laboratory condition among the microbial pesticide tested Spinosad (75 g a.i. ha^{-1}), HaNPV+Spinosad+Bt (1.5×1012 POBs ha^{-1} +75 g a.i. ha^{-1} +15000 IU/mg (2 lit/ha)), Spinosad+Bt (75 g a.i. ha^{-1} +15000 IU/mg-2 lit/ha) showed higher insecticidal toxicity (100 per cent mortality on 72 h) to all instars of H. armigera larvae. Biochemical parameters like phenol content, peroxidase and phenyl alanine ammonialyase (PAL) activity recorded higher levels in *Pseudomonas florescens* seed treatment @ 30 g/kg of seed and its foliar spray @ 1 gL^{-1} in treated tomato plants.

Goutam, *et al.* (2011) Field trials was conducted a field trials where using different fertilizers having equal concentration of nutrients to determine their impact on different growth parameters of tomato plants. Six types of experimental plots were prepared whereT1 was kept as control and five others were treated by different category of fertilizers (T2-Chemical fertilizers, T3-Farm Yard Manure (FYM), T4-Vermicompost, T5 and T6- FYM supplemented with chemical fertilizers and vermicompost supplemented with chemical fertilizer respectively).The treatment plots (T6) showed 73% better yield of fruits than control, Besides, vermicompost supplemented with N.P.K treated plots (T5

Fioreze and Ceretta (2006) conducted a study in Rio Grande do Sul, Brazil to determine the organic sources of nutrients in potato production systems. The treatments include hen and hog residue and mineral fertilizers. Results indicated that organic sources are economical and technical alternatives to chemical fertilizers. However, their efficiency is maximized when coupled with chemical fertilizers, mainly to maintain nitrogen supply along the crop cycle, displayed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits plant^{-1} from other fertilizers treated plants. Especially in the case of using hog residues. Hen residue is better than hog residue because it has higher amount of nutrients.

Singh and Kushwah (2006) was conducted a field experiment at Central Potato Research Station, Gwalior, Madhya Pradesh, India, during the winter seasons (rabi) of 2001-02 and 2002-03 to study the effect of organic and inorganic sources of nutrients on potato production. The treatments included 25, 50, 75 and 100% doses of NPK with and without organic manures (farmyard manure (FYM) and Nadep compost at 30 t ha^{-1}). Application of 100% NPK+30 t FYM/ha resulted in significantly higher tuber yield of 456 q ha^{-1} compared with that of other treatments except 100% NPK+30 t Nadepha^{-1} and 75% NPK+30 t FYMha^{-1}. The effect of organic manures (FYM and Nadep compost) in combination with inorganic fertilizers was more pronounced compared with that of organic manures alone. However, FYM was more effective than Nadep compost in producing higher tuber yield. Maximum net return of Rs 63 627/ha was also obtained from 100% NPK+30 t FYM ha^{-1}. However, benefit: cost ratio was almost same under 75% NPK with 30 t ha^{-1} FYM or Nadep compost and 100% NPK with 30 t ha^{-1} FYM or Nadep compost.

Klikocka *et al.* (2006) were conducted two experiments in Poland. In experiment 1 (1996-2001), the treatments consisted of: conventional soil tillage (ploughing at 20 cm depth, and pre-winter ploughing at 25 cm depth), autumn ridge tillage (ploughing at 20cm depth, and establishment of 20 to 25 cm deep ridges with a furrow plough ridger), and spring ridge soil tillage (ploughing at 20-cm depth with planting of spring potato, and establishment of 25 cm deep ridges with a planting machine). For all treatments, cattle manure was applied at 30 tha^{-1}. In experiment 2 (2001-03), the treatments were: summer ridge soil tillage (plough skimming at 10 cm depth, establishment of 25 cm deep ridges, and sowing of white mustard or *Sinapis alba* as a catch crop), autumn ridge soil tillage (plough skimming at 10 cm depth, sowing of white mustard, cultivation at 15 cm depth, and establishment of ridges), and spring ridge soil tillage (plough skimming at 10 cm depth, sowing of white mustard during the planting of spring potato, and establishment of 20 to 25 cm deep ridges with a planting machine). For all treatments, 5 t triticale straw/ha and 1.0 kg N in the form of urea per 200 kg of straw were applied. Tillage with ridge establishment in the autumn resulted in the highest total and commercial tuber yields. The tillage treatments had no significant effects on the N content at the 0 to 25 cm soil layer. The formation of ridges in the autumn reduced the N content at the 25 to 40 cm soil layer. The use of straw as fertilizer and mulch, along with the planting of white mustard, reduced N leaching and prevented soil erosion.

El-Fakhrani (1999) conducted an experiment on the effects of N fertilizer (0, 300 or 600 kg ha^{-1} as urea) and poultry manure (0 or 10 t ha^{-1}) on the performance of potato (cv. Monaliza) irrigated with saline water (EC of 0.42, 1.56 or 2.85 dS m^{-1}). N application significantly increased shoot dry weight per plant, and tuber fresh and dry weights over the control. N at 300 kg ha^{-1} resulted in the greatest tuber volume (241.2 cm^3), tuber fresh weight (257.9 g), tuber dry weight (48.8

g), and shoot dry weight (9.02 g) plant^{-1}. Poultry manure at 10 t ha^{-1} enhanced tuber volume (224.4 cm^3), tuber fresh weight (239.9 g), tuber dry weight (45.2 g), and shoot dry weight (8.12 g) plant^{-1}. The values of these parameters decreased with the increase in the salinity level. N at 300 kg ha^{-1} also registered the greatest P (12.37 mg plant^{-1}) and K (652.9 mg plant^{-1}) uptake, and total carbohydrate content (36.8 g plant^{-1}). Poultry manure also increased N (209.7 mg plant^{-1}), P (13.47 mg plant^{-1}) and K (602.3 mg plan^{-1} t) uptake, and total carbohydrate content (34.6 g plant^{-1}). The interaction between 300 kg N and 10 t poultry manure ha^{-1} was optimum for all parameters.

Kushwah, *et al.* (2005) was conducted an experiment during *rabi* 2004/05 on silty clay loam soil at Gwalior, Madhya Pradesh, India to study the effect of farmyard manure (FYM), Nadep compost, vermicompost and inorganic NPK fertilizers on yield and economics of potato. Application of FYM, Nadep compost and vermicompost alone or in combination did not influence tuber yield significantly. However, organic manures at 7.5 t ha^{-1} in combination with 50% recommended dose of NPK significantly increased tuber yield. The highest tuber yield (321 q ha^{-1}) was recorded with 100% recommended dose of NPK fertilizers. The highest incremental benefit cost ratio (7.5) was obtained with 50% recommended dose of NPK.

In an experiment, Gomes, et al. (1970) in Brazil found that the variety Floradel was slightly superior to the other varieties, namely, Maca, Caqui and Manalucie as regards to yield and number of fruits.

In a performance trial of six varieties of tomato conducted at the Bangladesh Agricultural Institute, Joydebpur, Hossain and Ahmed (1973) observed that cv. Sanmarzano was the highest yielder (28.98 t ha^{-1}), followed by 'Oxheart', 'Roma', Bulgaria, USA and Anabik. They also observed that 'Oxheart'produce the longest fruits with the average weight of 87 g followed by the Bulgaria, Roma, USA, Anabik and Sanmarzano.

Ali and Siddique (1974) found that the plants of Oxheart variety were 190.8 cmin height and yield 26.6 t ha^{-1}. In the above study they observed that the plants took 23.1 DAT for flowering.

Norman (1974) carried out an experiment to observe the performance of 13 varieties of tomato in Ghana. He found significant differences between cultivars in plant height, fruit maturity, yield and quality. He also stated that in the dry season, 'Floradel', 'Ace VF', 'Floralon', 'Piacenza 0164', 'Red colour' and No. 1 were found to be high yielders and appeared promising.

A yield trial was conducted at the vegetable Division of Agricultural Research Institute, Dhaka in 1969-70, with five varieties of tomato ('Oxheart', 'Sinkurihara', 'L-7', 'Marglobe' and 'Bulgaria'). The experiment was repeated in 1971-72. In both years, the varieties 'Oxheart' and 'Sinkurihara' were found to be similar and significantly higher yielder than the others (Hoque et al. 1975).

Prasad and Prasad (1977) carried out an experiment with 8 varieties tomato in India. The highest yield was obtained from 'Kalyanpur Angurlate' followed by 'Kolyanpur T1'and 'Sioux'. The 'Kolyanpur T1' had the largest fruit.

To compare the yielding ability and to assess the distinguishing external morphological characters of seven varieties of tomato an investigation work carried out by Sarker and Hoque (1980) during the period from 19 October 1977 to March1978. Thevarieties 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 'Ramulas' (20.21 t ha^{-1}).

Ahmed *et al*. (1986) assessed eight F-7 lines of tomato at the Horticulture farm, Bangladesh Agricultural University, Mymensingh. They observed that all the lines had shown indifferences 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 fruits (56.9 t ha^{-1}), followed by 0013-52-10-27-32-0 (50.0 t ha^{-1}).

Kalloo (1989) worked with some tomato varieties (Pusa Early Dwarf, HS 102, Hisar Arun and Punjab Chhuhara) in northern India. The 'HS 102' and 'Punjab Chhuhara' were fit for summer cultivation and 'Pusa Early Dwarf' and 'Hisar Arun' were suitable for getting early fruits.

A field experiment was carried out in 1990 and 1992 with some tomato cultivars, namely, 'Punjab Kesari', 'Punjab Chhuhara', 'Punjab Tropic', 'PNR-7', 'S-12' 'Pusa Ruby' and the 'Hybrid THL- 2312' (Bhangu and Singh, 1993). They observed mean annual yield was highest in 'Punjab Tropic'. Punjab Tropic produced the largest fruits (66.69 g) and the highest number of fruits per plant was obtained ‘Punjab Kesari’ (123).

Singh *et al*. (1994) conducted an experiment to evaluate the performance of tomato varieties (Arka Vikas, LE 79, BT 14, Punjab Chhuhara, BWRI and Pusa Ruby). They observed that BT 12 produced the tallest plant and BT 14 the shortest plant (mean values of 75.09 cm and 62.52 cm respectively).They also reported that Arka Vikas Had the heaviest fruits (54.87 g) and Punjab Chhuhara the smallest (21.93 g). Arka Vikas gave the highest mean yield (157.55 q ha^{-1}) and BT 14 the lowest (119.79 q ha^{-1}).

Berry *et al.* (1995) conducted an experiment at Wooster, USA with Hybrid processing tomato ‘Ohio Ox 38’. It was observed that, the yield of variety in 1992 and 1993 were higher (70.3 and 80.4 t ha^{-1}, respectively) compared to other cultivars.

A field trial was conducted by Ajlouni *et al*. (1996) in Jordan 1993 to study the yield of 13 local and introduced open pollinated tomato cultivars, to compare the yields to that of 3 common hybrids (Maisara F1, 898 F1and GS 12 F1) in relation to seasonal distribution of marketable and unmarketable yield and fruit number. The cultivars varied in their marketable yield during the harvesting period (10 weeks from 22 June 1993). The results indicated that the cultivars ‘Rio Grande,’ ‘Nagina’ and ‘T_2’

An experiment was conducted with two summer tomato varieties (BINA Tomato 2 and BINA Tomato 3) to study the yield performance at 3 locations of

Bangladesh (Magura, Comilla and Khulna) during the summer season (BINA1998). It was observed that ‘BINA Tomato 2’ produced higher fruit yield at Magura (38 t ha^{-1}) and Khulna (17 t ha^{-1}), while ‘BINA Tomato 3’ gave higher yield (29 t ha^{-1}) at Comilla. However mean fruit yield from three locations improved were superior to the hybrids showed that, the variety ‘BINA Tomato 2’ produced higher fruit yield than ‘BINA Tomato 3’.

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 experimental plot, characteristics of soil, climate and materials used for the experiment. The details of the experiment are described below.

3.1 Location of the experiment field

This experiment was carried out at the rooftop garden of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh from October 2017 to March 2018 to evaluate morpho-physiology and yield of tomato is influenced by different kinds of plant growing structures and plant growing media during *rabi* season in the rooftop garden.

3.2 Climate of the experimental area

The area is characterized by hot and humid climate. The average rainfall of the locality of the experimental area is 209.06 mm, the minimum and maximum temperature is 11.10 °C and 34.80 ºC, respectively. The average relative humidity was 75.8 % during October 2017 to March 2018.

3.3 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 I.

3.4 Plant materials used

In this research work, the seed of one tomato variety was used as planting materials. The tomato varieties used in the experiments were BARI Tomato 14. This variety is semi-indeterminate type. BARI Tomato-14 was collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI) at Joydebpur, Gazipur.

3.5. Raising of seedlings

In raising of seedlings, a common procedure was followed in the seedbed. Seeds were sown in the seedbed on 1st November 2017. Tomato seedlings were raised in seedbed of 2 m x 1m size. A distance of 50 cm was maintained between the beds. The soil was well prepared and converted into loose friable and dried mass by spading. All weeds and stubbles were removed. Four gram of seeds was sown on each seedbed. 50gm furadan was applied around each seedbed as precautionary measure against fungus, ants, worm and other harmful insects. The emergence of the seedlings took place with 6 to 8 days after sowing. Diathane M-45 was sprayed in the seedbeds @ 2 g/l, to protect the seedlings from damping off and other diseases. Weeding, Mulching and Irrigation were done as and when required.

3.6 Treatments and layout of the experiment

The experiment consisted of two factors; (A) Different types of plant growing structures and (B) Different plant growing medium. The levels of the two factors were as follows:

Factor (A) Different types of plant growing structures

i. S_1= Plastic pot

ii. S_2= Earthen pot

Factor (B) Different plant growing medium

I. M_0= Soil 100% (w/w)+ Inorganic Fertilizers (IF)/ (control),

II. M_1= Soil 80% (w/w)+ 20% cowdung (w/w) and Inorganic Fertilizers (IF),

III. M_2= Soil 70% (w/w)+ 30% cowdung (w/w) and Inorganic Fertilizers (IF),

IV. M_3= Soil 90% (w/w)+ 10% vermicompost (w/w) and Inorganic Fertilizers (IF),

V. M_4= Soil 80% (w/w) + 20% vermicompost (w/w)and Inorganic Fertilizers (IF),

VI. M_5= Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost(w/w) and required calculative amount of Inorganic Fertilizers (IF).

3.7 Design and layout of the experiment

The factorial experiment was laid out in a Complete Randomized Design (CRD) with four replications. The 48 plants were planted in the earthen pot and Plastic pot. The earthen and plastic pot size were 40 cm in diameter and 30 cm in height with the depth of 25 cm.

3.8 Pot preparation

Earthen pots, plastic pot were filled 10 days before transplanting. Soils were made completely stubbles and weed free.

3.9 Manure and fertilizer application

Urea, TSP and MP were applied as a source of N, P_2O_5 and K_2O. Throughly, in addition required amount of Zn, B, Mg were also applied in the pot. Total amount of TSP and half of MOP were applied. Urea and MOP were applied in splits. At the time of final preparation the entire amounts of TSP and MOP were applied and Urea was applied in three equal installments. During bed preparation well-rotten cow dung was also applied.

3.10 Uprooting and Transplanting of seedlings

Seedlings of 30 days old were uprooted separately from the seedbed and were transplanted in the pots in the afternoon of 4th December 2017 maintaining one seedling in each pot.

Before uprooting the seedlings, seedbed was watered to minimize damage to roots. After transplanting, seedlings were watered and also shading was provided for three days to protect the seedlings from the hot sun. Shading was kept after till the establishment of seedlings.

3.11.4 Intercultural operations

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

a) **Weeding and Mulching**

Weeding and Mulching were accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the crust. It also helped in soil moisture conservation.

b) **Staking and Pruning**

When the plants were well established, staking was given to each plant by Daincha (*Sesbania* sp.) and bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were given a uniform moderate pruning.

c) **Irrigation**

Light irrigation was provided immediately after transplanting the seedlings and it was continued till the seedlings established in the pot. Thereafter irrigation was provided.

d) **Top dressing**

After basal dose, the remaining doses of urea were used as top-dressed in 3 equal installments at 20, 40 and 50 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.

Plant protection

Insect pests: Malathion 57 EC was applied & 2 ml 1^{-1} against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide.

Diseases: During foggy weather precautionary measured against disease infection of Winter tomato was taken by spraying Diathane M-45 fortnightly & 2 g l^{-1}, at the early vegetative stage. Ridomil gold was also applied @ 2 g 1^{-1} against early blight disease of tomato.

3.12 Harvesting

Fruits were harvested at 5-day intervals during early ripe stage when they attained slightly red color. Harvesting was done at 3 days interval starting from 27th February and was continued up to 20th March 2018.

3.13 Data collection

Ten plants were selected randomly from each pot 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.

3.13.1 Plant height

Plant height at 40 and 60 days after transplanting (DAT) was taken from sample plants from the ground level to the tip of the plant and mean value was calculated in centimeter (cm).

3.13.2 Leaves plant^{-1}

Number of leaves per plant was counted at 40 and 60 days after transplanting (DAT).

3.13.3 Branches plant^{-1}

Number of primary branches was counted at 40 and 60 days after transplanting (DAT).

3.13.4 SPAD values of leaf

SPAD values of leaf were measured by SPAD meter.

3.11.5 Flowers cluster plant^{-1}

Total number of flower clusters was counted from selected flowers cluster of sample plant and was calculated

3.11.6 **Flowers plant^{-1}**

Total number of flowers was counted from ten selected sample plant and was calculated

3.13.7 Fruit length

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 10 randomly selected fruits from each plot and their average was taken in centimeter (cm) as the length fruit.

3.13.8 Fruit diameter

Diameter of fruit was measured at the middle portion of 10 randomly selected fruits from each plot with a slide calipers and their average was taken in centimeter (cm) as the diameter of fruit.

3.13.9 Weight of fruits per plant

A per scale balance was used to take the weight of fruits per plant. It was measured by total fruit of plant separately during the period from fruit to final harvest and was recorded in kilogram (kg).

4.14 Statistical analysis

The recorded data on various parameters were statistically analyzed by using MSTAT statistical package programmed. The mean for all the treatments was calculated and analysis of variance for all the characters was performed by F-test. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT) according to Gomez and Gomes, (1984).

CHAPTER IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results from the experiment. The experiment was conducted to determine the effects of morpho-physiology yield and quality of tomato as influenced by different kinds of plant growing structures and plant growing media during *rabi* season in the rooftop garden. The data of this study have been presented and expressed in table (s) and figures for discussion, comparison and understanding of the experimental findings. A summary of all the parameters have been shown in possible interpretation wherever necessary have given under the following headings.

4.1 Plant height

Plant height is one of the important parameter, which is positively correlated with the yield of tomato (Taleb, 1994). Plant height was recorded at 40 and 60 days after transplanting (DAT) which showed significant differences to different plant growing structures. At 40 DAT, plastic pot (S_1) had the highest plant height (68.34 cm). The lowest plant height (54.67 cm) was obtained from the earthen pot (S_2) (Table 1, Appendix IV). The plant growing structure of plastic pot (S_1) had the highest plant height (87.93 cm) at 60 DAT. The lowest plant height (77.08 cm) was obtained from the earthen pot (S_2). An increase in the container size results in plants of higher size and yield also plants grown in big pots system has the highest values regarding plant height (Bouzo and Favaro, Metwally 2016). Although these results indicate that both type and size of container is the most important factor for the development of sustainable roof garden.

As plant growing structures, plant growing media i.e. different composition of inorganic and organic materials also showed significant difference on plant height at both 40 and 60 date after transplanting (DAT) of tomato (Table 1 Appendix IV).

At 40 DAT, the composition of Soil and organic matter (soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w)) M_5 produced the tallest plant (72.38cm) while the shortest plant (48.33 cm) was produced by controlM_0 condition. The composition of Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) M_5 produced the tallest plant (88.96 cm) at 60 DAT and the shortest plant (77.29 cm) was obtained from control condition.

Application of cowdung + biofertilzier records higher plant height, number of leaves, leaf area and leaf area index (Jagadeesha, 2008). Although these results are also consistence with the previous findings. Altogether this experimental results suggest that the height of the tomato plant increase with the addition of organic matter either sole or together use of cowdung or vermicompost. The effect of plant growing structures and different plant growing media showed a significant variation in plant height at both 40 and 60 DAT (Table 3, Appendix IV). At 40 DAT, the tallest plant height (77.42 cm) was found in S_1M_5 plastic pottreatment combination with Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and the smallest plant height.

Table. 1. Effect of plant growing structures on the plant height and leaf number of tomato

Plant growing structures (S)	Plant height (cm)				Leaf number			
	40 DAT		60 DAT		40 DAT		60 DAT	
S_1	68.34	a	87.93	a	12.59	a	28.23	a
S_2	54.67	b	77.08	b	10.22	b	21.28	b
$LSD_{(0.05)}$	3.10		1.04		0.87		1.07	
Level of sig.	*		*		*		*	
CV (%)	5.5		6.41		8.25		7.3	

S_1= Plastic pot, S_2= Earthen pot

Table. 2. Effect of different plant growing medium on the plant height, leaf number of tomato

Plant growing media (M)	Plant height (cm)				Leaf number			
	40 DAT		60 DAT		40 DAT		60 DAT	
M_0	48.33	d	77.29	e	8.50	d	19.63	e
M_1	59.67	c	79.45	d	9.76	cd	22.45	d
M_2	61.86	bc	81.80	c	10.86	bc	24.25	cd
M_3	63.07	bc	83.10	bc	11.93	b	25.94	bc
M_4	63.72	b	84.45	b	12.67	b	27.16	ab
M_5	72.38	a	88.96	a	14.71	a	29.13	a
$LSD_{(0.05)}$	3.33		1.92		1.12		2.58	
Level of sig.	*		*		*		*	
CV (%)	5.5		6.41		8.25		7.3	

M_0=Soil 100% (w/w)+ Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w)and Inorganic Fertilizers (IF).

Table 3. Interaction of different plant growing medium and plant growing structures on plant height and Leaf number of tomato

Interaction		Plant height (cm)				Leaf number			
(S× M)		40 DAT		60 DAT		40 DAT		60 DAT	
S_1	**M_0**	54.33	e	82.58	e	9.58	de	23.42	ef
	M_1	68.33	bc	85.56	d	11.11	cd	26.67	c
	M_2	69.22	bc	88.5	bc	12.22	bc	27	c
	M_3	70.89	b	89.44	ab	13.78	ab	29.55	bc
	M_4	69.85	bc	90.19	ab	14.18	a	30.33	ab
	M_5	77.42	a	91.33	a	14.67	a	32.42	a
S_2	**M_0**	42.33	g	72	i	7.42	f	15.83	h
	M_1	51	d	73.33	hi	8.42	ef	18.22	g
	M_2	54.5	e	75.1	gh	9.5	de	21.5	f
	M_3	55.25	de	76.75	fg	10.08	de	22.33	ef
	M_4	57.58	f	78.7	f	11.15	cd	23.98	de
	M_5	67.33	cd	86.58	cd	14.75	a	25.83	cd
$LSD_{(0.05)}$		2.72		2.07		1.74		2.17	
Level of sig.		*		*		*		*	
CV (%)		5.5		6.41		8.25		7.3	

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

S_1= Plastic pot, S_2= Earthen pot

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

(42.33cm) was found in S_2M_0 earthen pot with control treatment combination. The tallest plant height (91.33) was obtained from in S_1M_5 at 60 DAT. The smallest plant height (72.00 cm) was found in S_2M_0. These results suggest that plastic pot along with together use of cowdung and vermicompost gave the heighest plant height compared to earthen pot along with together or sole application of cowdung and vermicompost

4.2 Leaves plant^{-1}

The effect of different plant growing structures was influenced on number of leaves per plant at 40 and 60 DAT (Table 1 Appendix IV). At 40 DAT, the plant growing structures, plastic pot had the highest number of leaves per plant (12.59) and the lowest number of branches per plant (10.22) was obtained from the earthen pot (S_2). The plastic pot S_1 had the highest number of leaves per plant (28.23) at 60 DAT and the lowest number of leaves per plant (21.28) was obtained from S_2, earthen pot. These results showed that plastic pot has given highest number of leaves per plant whereas from earthen pot show the lower number of leaves plant^{-1}.

As plant growing structures, plant growing media i.e. different composition of inorganic and organic materials also showed significant difference on leaves plant^{-1} at both 40 and 60 date after transplanting (DAT) of tomato (Table 1 Appendix IV).

At 40 DAT, the maximum number of leaves per plant (14.71) was produced by M_5 treatment. The control condition M_0 produced the minimum number of leaves per plant (8.50).The maximum number of leaves per plant (29.13) was observed in M_5 condition at 60 DAT. The control condition M_0 produced the minimum number of leaves plant^{-1} (19.63).

These results also consistent with the plant height of tomato (Table 1). Therefore, now it indicates that higher composition of organic substance creates a favorable environment by supplying required amount of nutrients along with increasing water holding capacity increase the number of leaves of tomato plants.

The interaction between different plant growing structures and different plant growing medium was found significant on the number of leaves per plant at 40 and 60 DAT (Table 3 Appendix IV). At 40 DAT, the maximum number of leaves per plant (14.67) was found in S_1M_5 treatment combination, which was statistically similar with$S_1M_4$and S_1M_5treatmentcombination.Whereas the lowest number of leaves per plant (7.42) was found in S_2M_0treatment combination. The maximum number of leaves per plant (32.42) was observed in S_1M_5treatment combination at 60 DAT. The lowest number of leaves plant^{-1} (15.83) was found in S_2M_0treatment combination. These findings also similar with my previous data of plant height of tomato (Table 3). These results suggest that plastic pot along with together use of cowdung and vermicompost gave the heighest leaves per plant compared to earthen pot along with together or sole application of cowdung and vermicompost.

4.3 Branch plant^{-1}

It is established that proper vegetative growth is an important factor for increasing the fruit yields of different crops including tomato. The formation of branches of a plant is the character of vegetative growth. In this study I counted number of branches of tomato with reference to different plant growing structures. The data of number of branches per plant showed significant differences at 40 days after transplanting (DAT) and 60 days after transplanting. (Table 4, Appendix V).

Number of branch per plant was influenced by plant growing structures. The plant growing structures of plastic pot had the highest number of branch per plant (10.69) and the lowest number of branch per plant (9.88) was obtained from earthen pot.

The different plant growing medium showed significant variation in the length of branch (Table. 5, Appendix V). The maximum number of branch (11.08) was produced by M_5 treatment. The control (M_0) produced the minimum number of branch (9.36).

The combined effect of plant growing structures and different plant growing medium was found significant on the number of branch per plant. The maximum number of branches plant^{-1} (11.33) was found in S_1M_5 treatment, whereas the lowest length of branch (8.83) was found in S_2M_0 treatment (Table 6, Appendix V).

4.4 SPAD Value of leaf

SPAD Value of leaf was influenced by plant growing structures. However, the S_1 treatment had the highest SPAD Value of leaf (43.94) and the lowest SPAD Value of leaf (42.72) was obtained from the S_2 treatment (Table 4, Appendix V).

The different plant growing medium was significant influenced on the SPAD Value of leaf (Table 5, Appendix V). The maximum SPAD Value of leaf (46.75) was produced by hormones M_5 treatment, which was statistically similar with M_3 and M_4. The treatment M_0 produced the minimum SPAD Value of leaf (39.07).

The interaction between different plant growing structures and plant growing medium significant effect on the SPAD Value of leaf (Table 6, Appendix V). The maximum SPAD Value of leaf (47.25) was found in S_1M_5 treatment. The lowest SPAD Value of leaf (38.60) was found in S_2M_0 treatment.

Table 4. Effect of plant growing structures on SPAD value, number of primary branches, flower clusters, total flowers of tomato

Plant growing structures (S)	Different data at 60 DAT			
	Primary branches	SPAD value	Flower clusters	Total flowers
S_1	10.69 a	43.94 a	9.05 a	62.62 a
S_2	9.88 b	42.72 b	8.15 b	55.95 b
$LSD_{(0.05)}$	0.26	1.25	0.22	0.69
Level of sig.	*	*	*	*
CV (%)	6.4	5.68	8.31	8.44

S_1= Plastic pot, S_2= Earthen pot

Table 5. Effect of plant growing media on SPAD value, number of primary branches, flower clusters, total flowers of tomato

Plant growing media (M)	Different data at 60 DAT			
	Primary branches	SPAD value	Flower clusters	Total flowers
M_0	9.36 b	39.07 c	8.08 bcd	50.62 f
M_1	10.11 ab	39.96 c	8.28 bc	57.45 c
M_2	10.09 ab	43.38 b	8.39 d	59.65 e
M_3	10.45 ab	45.08 ab	8.68 ab	60.63 b
M_4	10.63 ab	45.74 ab	8.78 cd	60.8 d
M_5	11.08 a	46.75 a	9.41 a	66.59 a
$LSD_{(0.05)}$	1.119	4.89	1.119	1.119
Level of sig.	*	*	*	*
CV (%)	6.4	5.71	8.31	8.44

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

Table 6. Interaction of different plant growing medium and plant growing structures on SPAD value, number of primary branches, flower clusters, total flowers of tomato

Interaction (S× M)		Different data at 60 DAT			
		Primary branches	SPAD value	Flower clusters	Total flowers
S_1	M_0	9.89 b-e	39.53 d	8.4 def	51.11 g
	M_1	10.55 a-d	39.72 d	8.6 cde	60.65 d
	M_2	10.62 a-d	45.35 b	8.78 cd	63.8 c
	M_3	10.8 a-c	45.5 b	9.36 ab	64.9 b
	M_4	10.95 ab	46.26 ab	9.45 ab	65.1 b
	M_5	11.33 a	47.25 a	9.71 ab	70.21 a
S_2	M_0	8.83 e	38.6 d	7.76 g	50.13 g
	M_1	9.67 c-e	40.2 cd	7.96 fg	54.24 f
	M_2	9.55 de	41.4 c	7.99 efg	55.5 e
	M_3	10.1 b-d	44.65 b	8 fg	56.36 e
	M_4	10.3 a-d	45.22 b	8.1 efg	56.5 e
	M_5	10.82 a-c	46.25 ab	9.1 bc	62.96 c
$LSD_{(0.05)}$		1.04	4.891	0.45	1.05
Level of sig.		*	*	*	*
CV (%)		**6.4**	571	**8.31**	**8.44**

In column, means containing same letter indicate significantly similar under DMRT at 5% level of significance. Values are the means of three replications

S_1= Plastic pot, S_2= Earthen pot

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

4.5 Flower clusters plant^{-1}

There was a significant difference among the plant growing structures in the number of flower clusters per plant. As evident from table-4, the maximum number of flower cluster (9.05) was produced in S_1 treatment. The minimum number of flower cluster per plant (8.15) was produced in S_2 treatment. Plants from plastic pot have given more flower cluster than the plants from earthen pot.

The different plant growing media showed significant variation in the number of flowers cluster per plant. The maximum number of flower cluster per plant (9.41) was produced from M_5 treatment and treatment M_0treatment produced the minimum number of flowers per cluster (8.08) (Table 4, Appendix V). The number of flowers per cluster decreased gradually as the temperature increased later. Similar result was reported by Hossain (2001).

A significant variation among the treatment combinations in number of flowers cluster per plant. The maximum number of flowers cluster per (9.71) was found in S_1M_5. Whereas the minimum number of flowers cluster per plant (7.76) was found in S_2M_5 (Table 5, Appendix V).

4.6 Flowers plant^{-1}

There was a difference among the plant growing structures in the number of flowers per plant. The maximum number of flower (62.60) was produced in S_1 treatment. The minimum number of flower plant^{-1} (55.95) was produced in S_2 treatment (Table-4, Appendix V)

The different plant growing medium showed significant variation in the number of flower per plant. The maximum number of flower per plant (66.60) was produced from M_5 treatment and treatment M_0treatment produced the minimum number of flower (50.60) (table 5, Appendix V).

A significant variation was observed among the treatment combinations in number of flowers per plant. The maximum number of flower per plant (70.21) was found in S_1M_5 treatment combination, whereas the minimum number of flower per plant (50.13) was found in S_2M_0 (Table 6, Appendix V).

4.7 Fruit Length

The plant growing structures was exhibited variation in the length of fruit. However, the longest fruit length (3.78 cm) was produced by S_1 and S_2 produced the shortest fruit length (3.28 cm), (Table 7, Appendix VI).

A significant variation in the length of fruit was found among the plant growing media. The longest fruit length (3.66 cm) was obtained from M_5, which was statistically similar with M_4 and M_3. The shortest fruit length (3.39 cm) was obtained from M_0, (Table 7, Appendix VI).

The variation in fruit length due to combined effect of plant growing structures and plant growing medium was found statistically significant (Table 7, Appendix VI). The longest fruit length (3.90 cm) was found in S_1M_5, whereas the shortest fruit length (3.13 cm) was found from S_2M_0, which was statistically similar with S_2M_1 and S_2M_2.

4.8 Breadth of fruit

The breadth of fruit was influenced by plant growing structures. The largest fruit breadth (4.96 cm) was produced by S_1 and S_2produced the shortest fruit breadth (4.68cm), (Table 7, Appendix VI).

A significant variation in the breadth of fruit was found among the plant growing medium. The largest fruit breadth (5.11 cm) was obtained from M_5 and the shortest fruit breadth (4.48 cm) was obtained from M_0, (Table 7, Appendix VI).

The variation in fruit breadth due to combined effect of plant growing structures and plant growing media was found statistically significant. The largest fruit breadth (5.25 cm) was found in S_1M_5, which was statistically similar with S_1M_4. The shortest fruit breadth (4.35 cm) was found in S_2M_0 treatment (Table 7, Appendix V).

Table 7. Interaction of different plant growing medium and plant growing structures on fruit length, fruit diameter, fruit brix of tomato

Treatment	Fruit length (cm)	Fruit diameter (cm)	Fruit brix (%)
Plant growing structures (S)			
S_1	3.78 a	4.96 a	4.72 a
S_2	3.28 b	4.68 b	4.25 b
CV (%)	5.78	5.61	7.15
Plant growing media (M)			
M_0	3.39 b	4.48 d	3.85 d
M_1	3.44 ab	4.68 cd	4.21 cd
M_2	3.49 ab	4.74 bcd	4.41 bc
M_3	3.61 a	4.84 abc	4.55 bc
M_4	3.63 a	5.06 ab	4.69 b
M_5	3.66 a	5.11 a	5.19 a
$LSD_{(0.05)}$	0.19	0.30	0.31
CV (%)	5.78	5.61	7.15
Interaction (S× M)			
S_1M_0	3.55 abcd	4.60 bc	4.10 de
S_1M_1	3.73 abc	4.85 abc	4.43 bcde
S_1M_2	3.75 abc	4.90 abc	4.53 bcd
S_1M_3	3.85 ab	4.93 abc	4.73 bc
S_1M_4	3.86 ab	5.23 a	4.90 b
S_1M_5	3.90 a	5.25 a	5.63 a
S_2M_0	3.13 d	4.35 c	3.60 f
S_2M_1	3.15 d	4.50 bc	4.00 ef
S_2M_2	3.23 d	4.58 bc	4.30 cde
S_2M_3	3.38 cd	4.75 abc	4.38 cde
S_2M_4	3.40 bcd	4.90 abc	4.48 bcde
S_2M_5	3.43 bcd	4.98 ab	4.75 bc
$LSD_{(0.05)}$	0.41	0.51	0.43
Level of sig.	*	*	*
CV (%)	5.78	5.61	7.15

S_1= Plastic pot, S_2= Earthen pot

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

4.9 Fruit brix

The variation in fruit brix was found among the plant growing structures. The maximum fruit brix reading (4.72%) was obtained from S_1andthe minimum fruit brix reading (4.25 %) was obtained from S_2 (Table 7, Appendix VI).

The variation in the fruit brix reading different plant growing medium was exhibited significant variation. The maximum fruit brix reading (5.19 %) was produced by M_5 treatment and control treatment produced the minimum fruit brix reading (3.85%), (Table 8, Appendix VI).

The variation in fruit brix reading due to combined effect of plant growing structures and plant growing medium was found statistically significant. The maximum fruit brix reading (5.63%) was found in S_1M_5. The minimum fruit brix reading (3.6%) was found in S_1M_0 (Table 9, Appendix VI).

4.10 Fruit yield (kg) plant^{-1}

The different plant growing structures of tomato influenced on the yield of fruits per plant. The maximum yield of fruits plant^{-1} (1.69 kg) was obtained from plastic pot and the minimum yield of fruits plant^{-1} (1.46 kg) was obtained from earthen pot (Fig1, Appendix VI). This is partially supported by Bouzo and Favaro (2016) who reported an increase in the container size results in plants of higher size and yield. These findings were also partially supported by Metwally (2016) who found that plants grown in big pots system has the highest values regarding yield.

The different time of different plant growing medium had significant effect on the yield of fruits per plant. The maximum yield of fruits plant^{-1} (2.17 kg) was produced by M_5 treatment and control treatment produced the minimum yield of fruits plant^{-1} (1.28 kg), (Fig 2, Appendix VI).

The combined effect of plant growing structures and different plant growing medium was significant on yield of fruit per plant. The highest yield of fruits per plant (2.15 kg) was obtained from Plastic pot with soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) S_1M_5, which was statistically identical with other. The lowest yield of fruits per plant (0.99 kg) was obtained from earthen pot with control (Fig 3, Appendix VI).

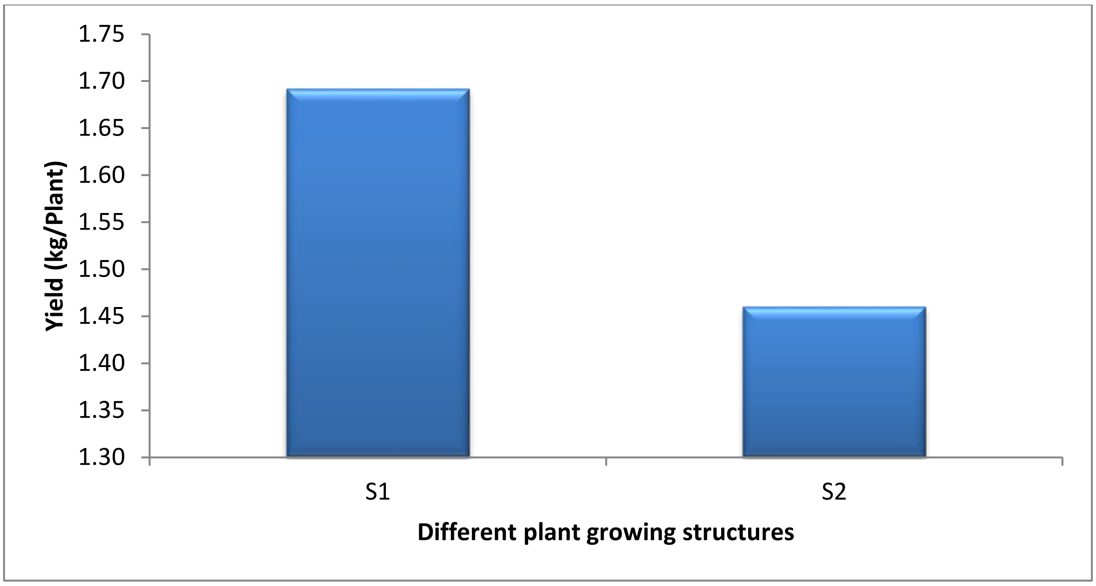

Fig. 1. Effect of plant growing structures on fruit yield of tomato

S_1= Plastic pot, S_2= Earthen pot

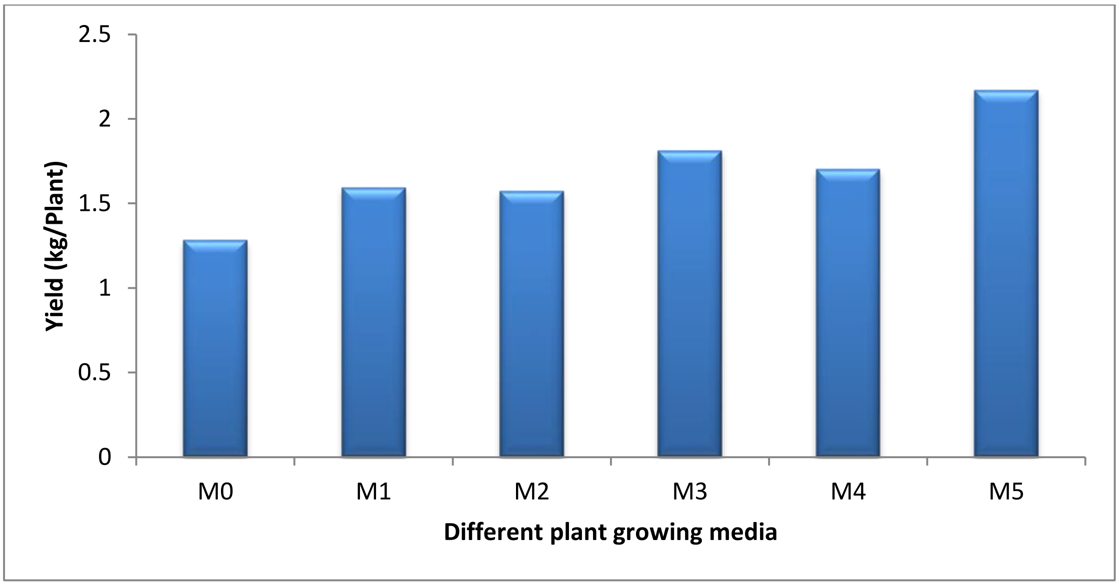

Fig. 2. Effect of plant growing media on fruit yield of tomato

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

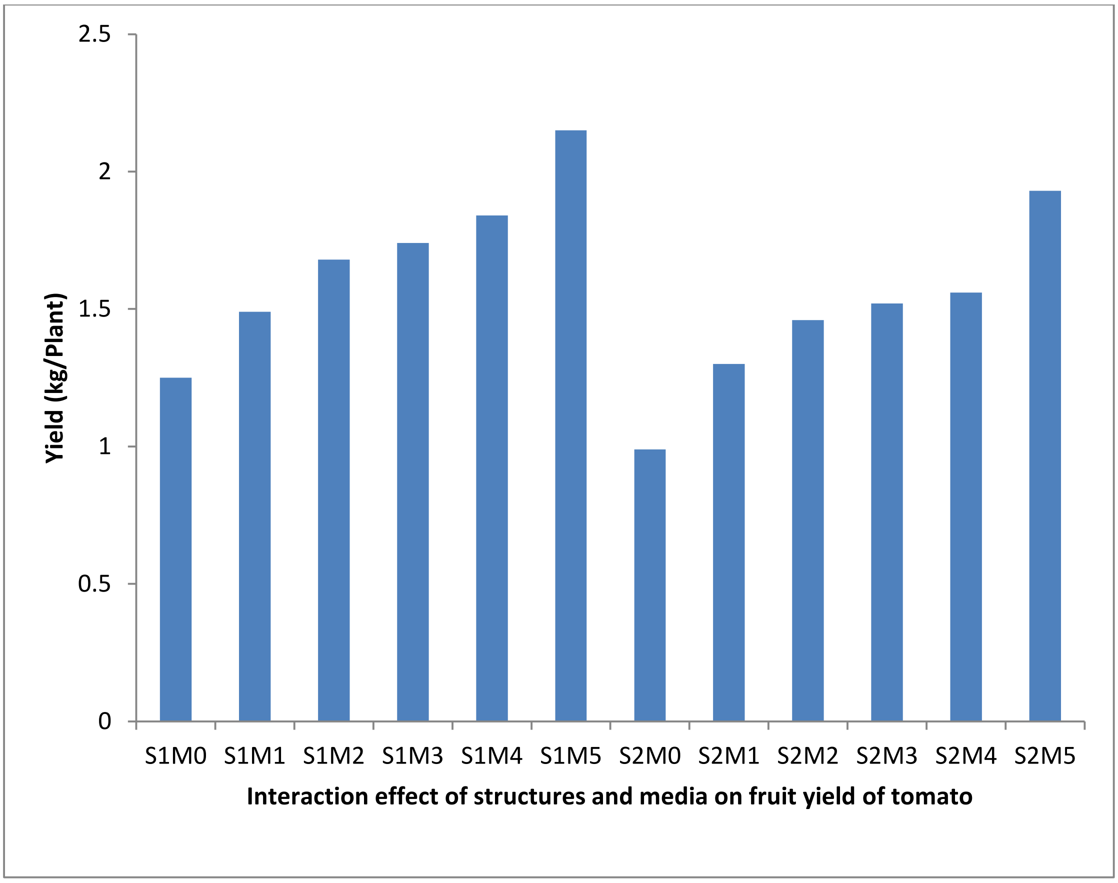

Fig. 3 Interaction effect of plant growing structures and media on fruit yield of tomato

S_1= Plastic pot, S_2= Earthen pot

M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF)/ (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung(w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was carried out at the rooftop garden of the Department of Agricultural Botany, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh from October 2017 to March, 2018 to evaluate responses of tomato to different plant growing structures and composition of growing media in the rooftop garden. The experiment consisted of two plant growing structures, *viz*., S_1= Plastic pot, S_2= Earthen pot and six different plant growing medium*viz*.M_0=Soil 100% (w/w) + Inorganic Fertilizers (IF) / (control), M_1=Soil 80% (w/w) + 20% cowdung (w/w) and Inorganic Fertilizers (IF), M_2=Soil 70% (w/w) + 30% cowdung (w/w) and Inorganic Fertilizers (IF), M_3=Soil 90% (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF), M_4=Soil 80%(w/w) + 20% vermicompost (w/w) and Inorganic Fertilizers (IF), M_5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) and Inorganic Fertilizers (IF).The factorial experiment was laid out in a Completely Randomized Design (CRD) with four replications. The 48 plants were planted in the earthen pot and Plastic pot. Data on growth and yield parameters were recorded and analyzed statistically. The recorded data on various parameters were statistically analyzed. Using MSTAT statistical package programmed. Difference between treatment means were determined by Duncan`s new Multiple Range Test (DMRT).

Data were taken on growth and yield contributing characters and the collected data were statistically analyzed for evaluation of the treatment effects. The summary of the results has been described in this chapter.

Plant height was recorded at 40 and 60 DAT (days after transplanting). The Plastic pot (S_1) had the highest plant height (68.34, 87.93 cm at 40 and 60 DAT, respectively). The effect of different plant growing structures was influenced on number of branch plant^{-1} at 40 and 60 DAT. The plant growing structures of Plastic pot had the highest number of leaves plant^{-1} (12.59, 28.23at 40 and 60 DAT, respectively). Number of branch per plant was influenced by plant growing structures. The plant growing structures of plastic pot had the highest number of branch per plant (10.69). There was a significant difference among the plant growing structures in the number of flower cluster per plant. The maximum number of flower cluster (9.05) was produced in S_1 treatment. There was a difference among the plant growing structures in the number of flower per plant. The maximum number of flower (62.62) was produced in S_1 treatment. SPAD Value of leaf was influenced by plant growing structures. The S_1 treatment had the highest SPAD Value of leaf (43.94). The plant growing structures was exhibited variation in the length of fruit. However, the longest fruit length (3.78 cm) was produced by S_1. The breadth of fruit was influenced by plant growing structures. The largest fruit breadth (4.96 cm) was produced by S_1. The different plant growing structures of tomato influenced on the yield of fruits per plant. The maximum yield of fruits plant^{-1} (1.69 kg) was obtained from plastic pot and the minimum yield of fruits plant^{-1} (1.46 kg) was obtained from earthen pot. The variation in fruit brix was found among the plant growing structures. The maximum fruit brix reading (4.72%) was obtained from S_1.

The effect of different plant growing medium on plant height at 40 and 60 DAT was significant. The doses of soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) M_5 produced the tallest plant (72.38, 88.96 cm at 40 and 60 DAT, respectively). The different plant growing media showed significant variation in the number of leaves per plant at 40 and 60 DAT. the maximum number of leaves per plant (14.71, 29.13 at 40 and 60 DAT, respectively) was produced by M_5 treatment. The different plant growing medium showed significant variation in the length of branch. The maximum number of branch (11.08) was produced by M_5 treatment. The different plant growing medium showed significant variation in the number of flowers cluster per plant. The maximum number of flower cluster per plant (9.41) was produced from M_5 treatment. The different plant growing medium showed significant variation in the number of flower per plant. The maximum number of flower per plant (66.59) was produced from M_5 treatment. The different plant growing medium was significant influenced on the SPAD Value of leaf. The maximum SPAD Value of leaf (46.75) was produced by hormones M_5 treatment. A significant variation in the length of fruit was found among the plant growing medium. The longest fruit length (3.66 cm) was obtained from M_5. A significant variation in the breadth of fruit was found among the plant growing medium. The largest fruit breadth (5.11 cm) was obtained from M_5. The different time of different plant growing medium had significant effect on the yield of fruits per plant. The maximum yield of fruits per plant (2.17 kg) was produced by M_5 treatment and control treatment produced the minimum yield of fruits plant^{-1} (1.28 kg). The variation in the fruit brix reading different plant growing media was exhibited significant variation. The maximum fruit brix reading (5.19 %) was produced by M_5 treatment

The combined effect of plant growing structures and different plant growing media indicated a significant variation in all parameter. The tallest plant height (77.42 and 91.33 cm at 40 and 60 DAT, respectively) was found in S_1M_5 (Plastic pot with soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w)). The maximum number of leaves per plant (14.67 and 32.42at 40 and 60 DAT, respectively) was found in S_1M_5 treatment combination. The maximum number of branch per plant (11.33) was found in S_1M_5 treatment combination. The maximum number of flowers cluster plant^{-1} (9.71) was found in S_1M_5. The maximum number of flower per (70.21) was found in S_1M_5 treatment combination. The maximum SPAD Value of leaf (47.25) was found in S_1M_5 treatment combination. The longest fruit length (3.90 cm) was found in S_1M_5. The largest fruit breadth (5.25 cm) was found in S_1M_5. The highest yield of fruits per plant (2.15 kg) was obtained from Plastic pot with soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w), which was statistically identical with other. The lowest yield of fruits per plant (0.99 kg) was obtained from earthen pot with control. The maximum fruit brix reading (5.63%) was found in S_1M_5.

Conclusion

Considering the stated findings, it may be concluded that yield and yield contributing parameters and quality are positively correlated with plant growing structures and plant growing medium. However, BARI Tomato-14 planted with plastic pot and soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost (w/w) would be beneficial for the farmers.

Considering the situation of the present experiment, the following recommendations may be suggested:

1. Repeated trial is needed in the rooftop garden for analogy the accuracy of the experiment.
2. It needs to conduct related experiment with other summer varieties.
3. It needs to conduct similar experiment for *Rabi* season in the rooftop.
4. Advance research on physiological reasons influencing yield of tomato by plant growing structures and medium should be conducted.

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APPENDIXES

Appendix I. Analytical results of soil

Soil
pH: 6.0
Organic matter: 1.21 %
Total nitrogen:0.061 %
Potassium: 0.19 meq/100 g
Phosphorus: 1.31 ppm
Sulphur: 42.13 ppm
Zinc: 0.95

Appendix II. Analytical results of cowdung

Cowdung
Moisture: 44.5 %
pH: 6.7
Organic carbon: 10.2 %
Total nitrogen: 0.65 %
Phosphorus: 0.39 %
Potassium: 0.40 %
Sulphur: 0.02 %
Boron: 0.02 %
Iron: 0.003 %
Manganese: 0.006 %
Zinc: 0.01 %
Copper: 0.002 %
Chromium: 10.12 ppm
Cadmium: 0.19 ppm
Lead: 5.76 ppm

Appendix III. Analytical results of vermicompost

Vermicompost
Moisture: 53.80 %
pH: 7.1
Organic carbon: 10.7 %
Total nitrogen: 1.12 %
Phosphorus: 0.67 %
Potassium: 0.95 %
Sulphur: 0.01 %
Boron: 0.007 %
Iron: 0.01 %
Manganese: 0.004 %
Zinc: 0.01 %
Copper: 0.003 %
Chromium: 22.43 ppm
Cadmium: 0.44 ppm
Lead: 2.97 ppm

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Analysis of variance of the data on plant height and Leaf number of tomato as influenced by plant growing structures and different plant growing medium

Sources of Variation	Degrees of freedom	Mean Square			
		Plant height			
		40 DAT	60 DAT	40 DAT	60 DAT
Replication	3	47.277	8.552	4.671	28.855
Factor A	1	116.88*	265.55*	3.307*	61.527*
Factor B	5	44.397*	122.06*	66.756*	41.541*
AB	5	8.222*	77.018*	15.691*	1.413*
Error	33	31.1	30.57	6.306	2.092

*significant at 5% level of probability

Appendix V. Analysis of variance of the data on SPAD value, number of primary branches, flower clusters, total flowers of tomato as influenced by plant growing structures and different plant growing medium

Sources of Variation	Degrees of freedom	Mean Square			
		Primary branches	SPAD	Flower clusters	Total flowers
Replication	3	1.075	21.097	17.817	48.521
Factor A	1	2.692*	10.453*	22.69*	7.244*
Factor B	5	0.45*	33.422*	6.803*	2.188*
AB	5	0.174*	9.47*	0.769*	0.624*
Error	33	0.458	11.56	2.23	0.93

*significant at 5% level of probability

Appendix VI. Analysis of variance of the data on fruit length, fruit diameter, Fruit weight fruit brix of tomato as influenced by plant growing structures and different plant growing medium

Sources of Variation	Degrees of freedom	Mean Square			
		Fruit length (cm)	Fruit diameter (cm)	Fruit weight(gm)	Fruit brix
Replication	3	0.129	0.582	9677.8	0.349
Factor A	1	2.95*	0.963*	372018*	2.613*
Factor B	5	0.061*	0.128*	331285*	0.88*
AB	5	0.082*	0.347*	92463*	0.852*
Error	33	0.237	0.43	191585	0.591

*significant at 5% level of probability