MORPHOLOGY AND YIELD OF TOMATO AS INFLUENCED BY VARIETIES AND PLANT GROWING MEDIA IN THE ROOFTOP GARDEN

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CERTIFICATE

This is to certify that the thesis entitled "**Morphology and Yield of Tomato as Influenced by Varieties and Plant Growing Media 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 **AFRIN AHMED ANNA, Registration No. 12-04829** 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.

June, 2020

Dhaka, Bangladesh

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Dedicated To

My Beloved Parents

& Husband

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The Author

Morphology and Yield of Tomato as Influenced by Varieties and Plant Growing Media in the Rooftop Garden

ABSTRACT

This experiment was carried out at the rooftop garden of the Department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find the independent effects of varieties and plant growing media and the interaction effects between varieties and plant growing media on morphology and yield of tomato grown in the rooftop garden during the period from November 2018 to March 2019. The two factorial experiment was laid out in a Randomized Complete Block Design with three replications. Two factors are, Factor A - three varieties *viz*. V_1 (BARI Tomato 14), V_2 (BARI Tomato 15) and V_3 (BARI Tomato 2) and Factor B – four plant growing media *viz*. M_1 (Soil 95% + Cow dung 5% + Inorganic Fertilizer), M_2 (Soil 80% + Cowdung 15% + Vermicompost 5% + Inorganic Fertilizer), M_3 (Cocodust 60% +Vermicompost 40% + Inorganic Fertilizer + Perlite), M_4 (Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite). Data on different morphological and 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 media independently and by also their interactions. Considering varietal performance, V_1 (BARI Tomato 14), V_2 (BARI Tomato 15) gave the best performance than V_3 (BARI Tomato 2) most of the studied parameters. As variety, the plant growing media also showed significant variations to morphological characters and fruit yield of tomato. In case of interaction between different variety and plant growing media, plant height, number of leaves plant ^{1}, number of branches plant^{-1}, number of flowers plant^{-1} and number of fruits plant^{-1} were found the best result from V_2M_2 treatment combination, though V_2M_3 combination were very close to the best. This experimental results highlighted that the number of flowers plant^{-1} were highest in soil media than the soil less media and the rate of flower drop were also more in soil less than the soil media, But the fruit weight were significantly higher in soil less media than the soil media. The experimental results suggest that tomato fruit yield increased in all varieties with the application of organic fertilizers (cow dung & vermicompost) in the rooftop garden.

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

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	=	Milligram
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

Total land of our country is decreasing at alarming rate due to over population, road construction, urbanization and changes of environment. To support growing food demand of increasing population food supply should be secure and sustainable. On the other hand, with the rate of urbanization build up areas are increasing; hence source of food production is decreasing. Roof top gardening can provide solution to increase food demand and also can promote a sustainable city. It was resulted that rooftop farming can support environment by improving air quality, reducing carbon in the atmosphere and can benefit society by reducing storm water management. In the urban area, the atmospheric temperature is so high compared to the surrounding sub urban and rural areas (Arabi *et al.* 2015). The urban vegetation is an anomalous abatement strategy to keep the environment sound of the city. It has been reported that urban agriculture contributes to meet the food demand. Rooftop gardening is a part of urban agriculture which can contribute to meet the demand of urban food specially fruits and vegetables and conserve the urban environment with changing climate as well as stimulate the economy of the country as a specialized agriculture in the world including Bangladesh.

Tomato (*Solanum lycopersicum* L.) is herbaceous annually cultivated crop which belongs to the family Solanaceae. It is native of South America, but is now grown worldwide for its edible fruits with many cultivars having been selected with varying fruit types and for optimum growth in differing growth conditions (Desai *et.al.*2014).

Tomatoes rank fourth among the leading world vegetables. It is one of the most popular vegetables and grouped as fruit as well as easy to grow and produce a lot of fruits. The requirement of tomato is enhancing successively due to its nutritional quality. Tomato is a key component ‚so-called "Mediterranean diet", which is strongly associated with a reduced risk of chronic degenerative diseases (Agarwal and Rao 1998, Agarwal and Rao 2000). It is a large source of minerals, lycopene, and vitamins such as ascorbic acid, carotene etc. which are antioxidants that promote good health. Lycopene is one of the most drastic antioxidant and vitamin C which are most beneficial to human beings (Willcox *et al*. 2003).

It has diverse medicinal values as it improves blood purification, cures cancer and sour throat, apart from improving quality of the prepared foods. It is a good appetizer having pleasing taste (Ram 1991).

Tomato is one of the most popular fruit vegetable which is grown commercially in rooftop garden. The diverse variation of agro climatic condition in different region of Bangladesh and the effect of global climate change can affect the growing condition, thus the performance of different tomato varieties also varies greatly. Besides these, the roof environment is unfriendly or hostile and it is difficult to grow crops there compared to land environment (Hossain 2004). BARI has also developed several modern varieties and released for commercial cultivation. However, the growth characters and nutritional quality of tomato varied significantly among different hybrid selection of high yield and nutritious hybrid tomato is important under existing agro climatic condition of Bangladesh for commercial purpose. In this aspect BARI Tomato 15, BARI Tomato 14 and BARI Tomato 2 provide high yield in winter (Siddiky et al. 2012). However, to my knowledge, little is known about performance of this variety grown in the rooftop garden under the climatic condition of Sher-e-Bangla Agricultural University. Commercial growing media were evaluated for their effect on tomato seedling emergence, growth and development in 80% roof garden.

Growing media have three main functions: 1) provide nutrition, aeration and water 2) allow for maximum root growth and 3) physically support the plant. Appropriate particle size selection or combination is critical for a light and fluffy (well-aerated) medium that promotes fast seed germination, strong root growth and adequate water drainage. Raw materials can be Inorganic or organic, but growing media are often formulated from a blend of different raw materials in order to achieve the correct balance of air and water holding capacity for the plants to be grown as well as for the long-term stability of the medium (Bilderback et al. 2005, Nair *et al*. 2011).

Plant growing media are materials, other than soils *in situ*, in which plants are grown. These can include organic materials such as peat, compost, tree bark, coconut (*Cocos nucifera* L.) coir, poultry feathers, or Inorganic materials such as clay, perlite, vermiculite, and mineral wool (Grunert et al. 2008, Vaughn *et al*. 2011) or mixes such as peat and perlite; coir and clay, peat and compost (Nair *et al*. 2011).

As the genotype of crop, plant growing media are the major concern for the sustainable development of urban agriculture in the form of rooftop garden. Urban gardeners have been using both soil and soilless media for growing crops in the rooftop garden. In the soil media different proportion of soil, cow dung, vermicompost, compost and Inorganic fertilizers are used to prepare an effective soil media. However, to my knowledge, no study has conducted to find out the suitable soil media with the composition soil, cow dung vermicompost and Inorganic fertilizers for tomato cultivation during robi season in the rooftop garden.

Skill and knowledge of diverse plant growing structures, water, pest management and fertilizer, root and shoot pruning are important for the long term attainment of rooftop garden in Bangladesh (Rahman *et al*. 2015).In addition, growing crops including tomato, chili, pepper etc. in different plant growing structures and media have great concern in different season (NeSmith and Duval 1998, Metwally 2016).

Limited study has conducted about the suitability of plant growing media including soil, coco dust, vermicompost, and Inorganic fertilizer for tomato production in rooftop garden using suitable varieties.

OBJECTIVES

1. To evaluate the independent effect of varieties on changes of morphology and yield of tomato in rooftop garden.
2. To find the effects of plant growing media between soil and soilless media on changes of morphology and yield of tomato in the rooftop garden.
3. To find the interaction effects between variety and plant growing media on morphology and yield of tomato 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.

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 incorpor

ate 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 liters of substrate/m2, depth 10 cm), big pots system (60 liters of substrate/m2, depth 15 cm), small pots system (30 liters of substrate/m2, depth 13 cm) and horizontal bags system (90 liters of substrate/m2, 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 per m2 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 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.

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 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.

Effects of different plant growing media 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) + biofertilzier (Azospirillum and P solubilizing bacteria 2.5 kg/ha 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 cm2) and leaf area index (898.05, 4314.31 and 4310.94 cm2) 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) followed by FYM (50%) + vermicompost (50%) (101.94 kg/ha) 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 per fruit (109.45) fruit weight per plant (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 botanicals 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. Under laboratory condition among the microbial pesticide tested Spinosad (75 g a.i./ha), HaNPV+Spinosad+Bt (1.5×1012 POBs/ha+75 g a.i./ha+15000 IU/mg (2 lit/ha)), Spinosad+Bt (75 g a.i./ha+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 g/litre 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 per plant 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). Application of 100% NPK+30 t FYM/ha resulted in significantly higher tuber yield of 456 q/ha compared with that of other treatments except 100% NPK+30 t Nadep/ha and 75% NPK+30 t FYM/ha. 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. However, benefit: cost ratio was almost same under 75% NPK with 30 t/ha FYM or Nadep compost and 100% NPK with 30 t/ha 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 20-cm 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 t/ha. 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 as urea) and poultry manure (0 or 10 t/ha) on the performance of potato (cv. Monaliza) irrigated with saline water (EC of 0.42, 1.56 or 2.85 dS/m). N application significantly increased shoot dry weight per plant, and tuber fresh and dry weights over the control. N at 300 kg/ha resulted in the greatest tuber volume (241.2 cm3), tuber fresh weight (257.9 g), tuber dry weight (48.8 g), and shoot dry weight (9.02 g) per plant. Poultry manure at 10 t/ha enhanced tuber volume (224.4 cm3), tuber fresh weight (239.9 g), tuber dry weight (45.2 g), and shoot dry weight (8.12 g) per plant. The values of these parameters decreased with the increase in the salinity level. N at 300 kg/ha also registered the greatest P (12.37 mg per plant) and K (652.9 mg per plant) uptake, and total carbohydrate content (36.8 g per plant). Poultry manure also increased N (209.7 mg per plant), P (13.47 mg per plant) and K (602.3 mg per plant) uptake, and total carbohydrate content (34.6 g per plant). The interaction between 300 kg N and 10 t poultry manure/ha 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 in combination with 50% recommended dose of NPK significantly increased tuber yield. The highest tuber yield (321 q/ha) 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), 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. 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 investigationwork carried out by Sarker and Hoque (1980) during the period from 19October 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) followed by

‘Bigo’ (24.63 t/ha), ‘World Champion’ (23.38 t/ha), ‘Master No.2’ (21.98 t/ha), ‘Roma’ (21.03 t/ha) and ‘Ramulas’ (20.21 t/ha).

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), followed by 0013-52-10-27-32-0 (50.0 t/ha).

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) and BT 14 the lowest (119.79 q/ha).

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, 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) and Khulna (17 t/ha), while ‘BINA Tomato 3’ gave higher yield (29 t/ha) 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

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 *Robi* season from November 2018 to March 2019. Seedlings were sown on November 2018 and were harvested up to March 2019.

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 November to March in *Rabi* season. The overall weather condition at the experimental site during the cropping season have been presented in Appendix II including minimum and maximum temperature, rainfall, relative humidity and sunshine hours etc.

3.4 Collection of soil, vermicompost and coco dust

The sandy loam soil collected for this pot experiment from Amin Bazar, Dhaka. The vermicompost and coco dust was collected from Ayub Agro Limited, Dhaka.

3.5 Chemical analysis of soil and vermicompost

The Chemical analysis of both soil and vermicompost were analyzed in the Laboratory of Soil Resource Development Institute, Dhaka and the result are shown in Appendix III.

3.6 Planting materials

Three tomato varieties named BARI Tomato 14, BARI Tomato 15 and BARI Tomato 2 (Ratan) were used in this experiment as planting materials.

3.7 Treatments of the experiment

The experiment was consisted of two factors; (A) Different varieties of tomato and (B) Different plant growing media. The factors were as follows:

Factor (A) Different Tomato varieties

i. V_1= BARI Tomato 14

ii. V2= BARI Tomato 15

iii. V_3= BARI Tomato 2 (Ratan)

Factor (B) Different plant growing media

i. M_1= Soil 95% +Cow dung 5% + Inorganic Fertilizer

ii. M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer

iii. M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite

iv. M_4= Coco dust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

The following (3*4=12); twelve treatment combinations are:

V_1M_1	V_2M_1	V_3M_1
V_1M_2	V_2M_2	V_3M_2
V_1M_3	V_2M_3	V_3M_3
V_1M_4	V_2M_4	V_3M_4

3.8 Design and layout of the experiment

The factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The 36 plants were planted in the earthen pot. The earthen pot size was 40 cm in diameter and 30 cm in height with the depth of 25 cm.

3.9 Raising of the Seedling

In rising of seedlings, a common procedure was followed in the seedbed. Seeds were sown in the seed bed on 8 November, 2018. 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. After 5 days seeds were sowing and 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 6 to 8 days after sowing. Shading was provided by polythene over the seedbed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done as and when required.

3.10 Preparation of plant growing media

The soil, coco dust and vermicompost were used according to treatment. According to the fertilizer recommendation guide-2012, the following Inorganic fertilizers such as Urea, TSP, MOP, Gypsum, Boric acid and Zinc oxide were applied as a source of N, P_2O_5, K_2O, S, B and Zn respectively. All Inorganic fertilizer and 1/3 Urea and 1/2 MOP were mixed in the soil during plant growing media preparation. The rest Urea and MOP were applied into three equal splits as required.

3.11 Pot preparation

According to the treatments earthen pots were filled 4 days before transplanting. Plant growing media were made completely stubbles and weed free.

3.12 Uprooting and transplanting of seedlings

Seedlings of 32 days old were uprooted separately from the seedbed and were transplanted in the beds in the afternoon of 10 December, 2018 maintaining one seedling in each pot. Before uprooting the seedlings, seedbed was watered to minimize damage of 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.

3.13 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.

3.14 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.

3.15 Weeding

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

3.16 Stalking

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

3.17 Top dressing

After basal dose, the remaining doses of urea were used as top-dressed in 3 equal installments at 15, 30 and 45 days after transplanting (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.

3.18 Plant Protection Measures

Melathion 57 EC was applied @ 2 ml/1L 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 10 G 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.

3.19 Harvesting

Harvesting was started during early ripe stage when the fruits attained slightly red color. Harvesting was done at 3 days' interval starting from 2 March and was continued up to 24 March 2019.

3.20 Data collection and recording

Experimental data were recorded from 30 DAT and continued until last harvest. The following data were recorded during the experimental period:

Plant height, Number of leaves per plant, Number of branches per plant, Number of flower per cluster, Number of flower per plant, Number of fruit per plant, Fruit number per plant, Fruit weight per plant

3.21 Procedure of Recording Data

Plant height

Plant height was measured from the sample plants in centimeter (cm) 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 20, 40 and 60 DAT.

Branches per plant

The total number of branches per plant was counted from each plant at 20 DAT, 40 DAT and 60 DAT.

Leaf per plant

Leaf number was counted from each plant at 20, 40 and 60 DAT.

Flower clusters per plant

The number of flower clusters produced per plant was counted and recorded.

Flowers per plant

The number of flower per plant was counted and recorded.

Fruits per plant

The number of fruits per plant was counted and recorded.

Fruit clusters per plant

The number of fruit clusters produced per plant was counted and recorded.

Individual fruit weight

Among the total number of fruits during the period from first to final harvest, fruit was considered for determining the individual fruit weight by the following formula:

Weight of individual fruit gram (g) = Total weight of fruits ÷ Total number of fruits

Fruit yield per plant

Fruit yield per plant was calculated by totaling fruit yield from first to final harvest and was recorded in (g).

. **CHAPTER IV**

RESULTS AND DISCUSSION

The experiment was conducted to determine the effects of morphology and yield of tomato as influenced by different varieties and different growing media during *robi* 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 (cm)

Plant height is one of the important parameter, which is positively correlated with the yield of tomato (Taleb, 1994). Plant height was recorded at 30, 45 and 60 days after transplanting (DAT) which showed significant differences to different varieties of tomato (Fig. 1 and Appendix IV). Result showed that, At 30 DAT, the highest plant height (15.14cm) was found from V_2 (BARI Tomato 15) on the other hand, the lowest plant height (14.30cm) was found from V_3 (BARI Tomato 2). At 45 DAT, the highest plant height (34.24cm) was found from V_2 (BARI Tomato 15) on the other hand the lowest plant height (28.53cm) was found from V_3 (BARI Tomato 2) and they are significantly different from one another. At 60 DAT, the highest plant height (75.28cm) was found from V_2 (BARI Tomato 15) on the other hand, the lowest height was found from V_3 (BARI Tomato 2) and they are significantly different from one another.

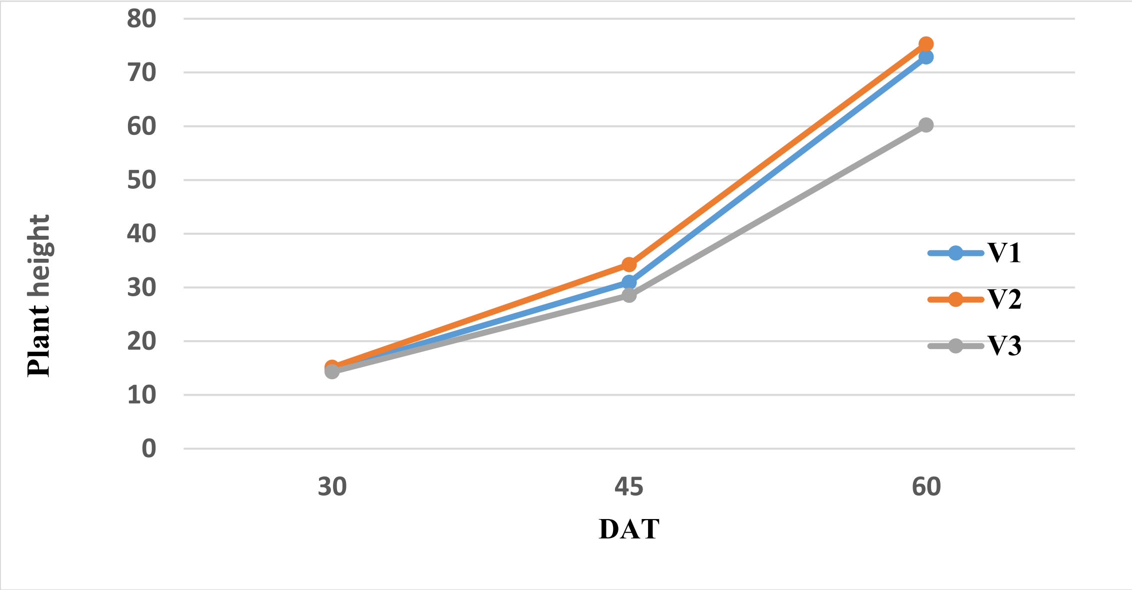

Fig.1. Plant height of tomato as influenced by different varieties at different days after transplanting in the rooftop garden

V_1 =BARI Tomato 14, V_2 = BARI Tomao 15, V_3 =BARI Tomato 2 (Ratan)

DAT=Days after transplanting

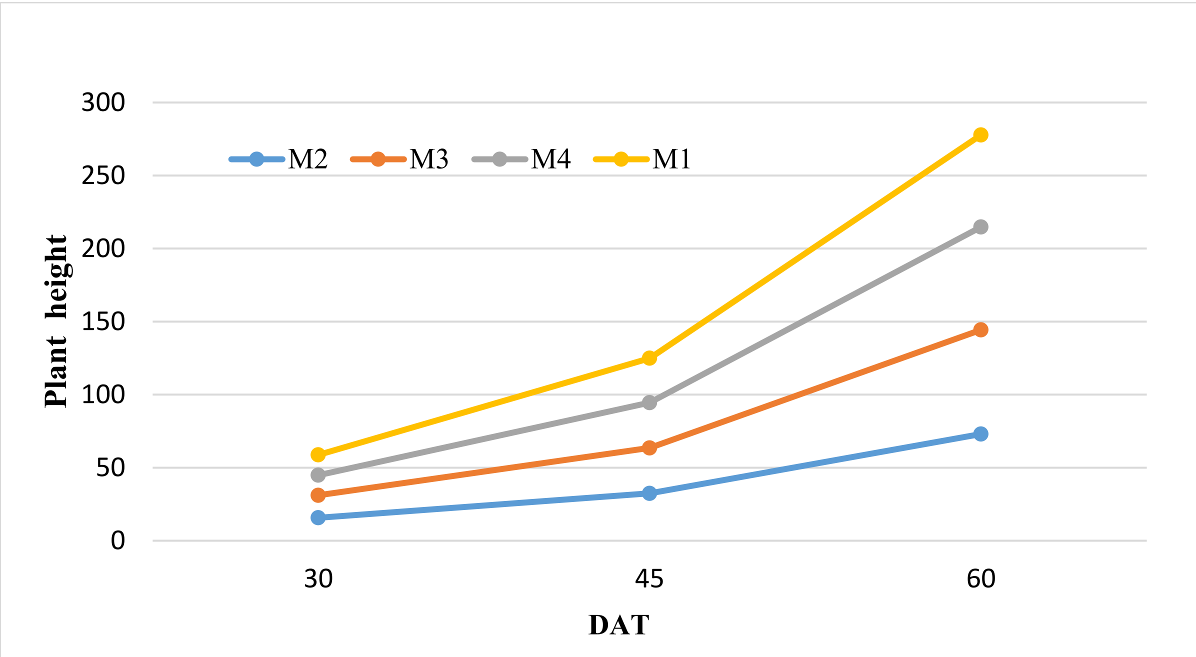

Fig.2. Plant height of tomato as influenced by different plant growing media at different days after transplanting in the rooftop garden

M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Cocodust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

Hamid *et al.* (2005) also examined significant variation on plant height due to different varieties which are supported with the present result.

Significant variation was found on plant height of tomato at different growth stages affected by different growing media (Fig. 2 and Appendix IV). It was found that at 30 DAT, the highest plant height (15.69cm) was found from M_2 where the lowest plant height (13.72cm) was found from M_1 and they are not significantly different from one another. At 45 DAT, the highest plant height (32.43cm) was found from M_2 where the lowest plant height (30.38cm) was found from M_1 and they are not significantly different from one another. At 60 DAT, the highest plant height (73.03cm) was found from M_2 where the lowest plant height (63.014cm) was found from M_1 and they are significantly different from one another. Metwally (2016) also found similar result with the present study and they found that different growing structures showed significant variation on plant height.

Treatment combination of different varieties and growing media showed significant variation on plant height (Table 1 and Appendix IV). Results indicated that at 30 DAT, the highest plant height (16.52cm) was found from the treatment combination of V_2M_2, where the lowest plant height (13.07cm) was found from the treatment combination of V_2M_1. At 45DAT, the highest plant height (34.65cm) was found from the treatment combination of V_2M_2 which was significantly identical where the lowest plant height (27.15cm) was found from the treatment combination of V_3M_1. At 60 DAT, the highest plant height (79.37cm) was found from the treatment combination of V_2M_2 which was significantly identical with V_2M_3 where the lowest plant height (54.33cm) was found from the treatment combination of V_3M_1. Metwally (2016) also found similar result with the present study and they found that different growing media showed significant variation on plant height.

Table 1. Plant height of tomato as influenced by different varieties and plant growing media at different days after transplanting in the rooftop garden

Treatment	Plant height (cm)		
	30 DAT	45 DAT	60 DAT
V_1M_1	13.75 ef	30.41 d	70.74 d
V_1M_2	15.27 c	32.22 c	74.48 b
V_1M_3	15.26 c	30.67 d	73.41 bc
V_1M_4	14.18 de	30.67 d	72.90 c
V_2M_1	13.57 ef	33.56 b	63.96 e
V_2M_2	16.52 a	34.65 a	79.37 a
V_2M_3	16.11 ab	34.59 a	79.21 a
V_2M_4	14.33 de	34.15 ab	78.60 a
V_3M_1	13.07 f	27.15 f	54.33 h
V_3M_2	15.30 bc	30.41 d	65.41 e
V_3M_3	14.89 cd	28.43 e	62.48 f
V_3M_4	13.93 e	28.07 e	58.55 g
LSD	0.83	0.75	1.45
CV(%)	3.36	1.43	1.24

V_1 =BARI Tomato 14, V_2 = BARI Tomato 15, V_3 =BARI Tomato 2(Ratan)
M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Coco dust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

4.2 Number of leaves per plant

The formation of number of leaves per plant was influenced by tomato varieties at 30, 45 and 60 DAT (Fig 3 and Appendix V). Leaf is the main photosynthetic part and it is very crucial part of plant. So 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 tomatoes (Fig. 3 and Appendix V). At 30 DAT, the highest number of leaves plant^{-1} (9.91) was found from V_1 (BARI Tomato 14) where the lowest number of leaves plant^{-1} (8.58) was found fromV_3 (BARI Tomato 2) and they are not significantly different from one another. At 45DAT, the highest number of leaves plant^{-1} (30.92) was found from V_1 (BARI Tomato14) where the lowest number of leaves plant^{-1} (26.58) was found from V_3 (BARI Tomato 2) Similarly, at 60DAT, the highest number of leaves plant^{-1} (69.75) was found from V_2 (BARI Tomato 15) where the lowest number of leaves plant^{-1} (63) was found from V_3 (BARI Tomato 2) which are significantly different from one another. Similar results was also observed by Bhati (2017) and found that variety showed significant variation on leaf number.

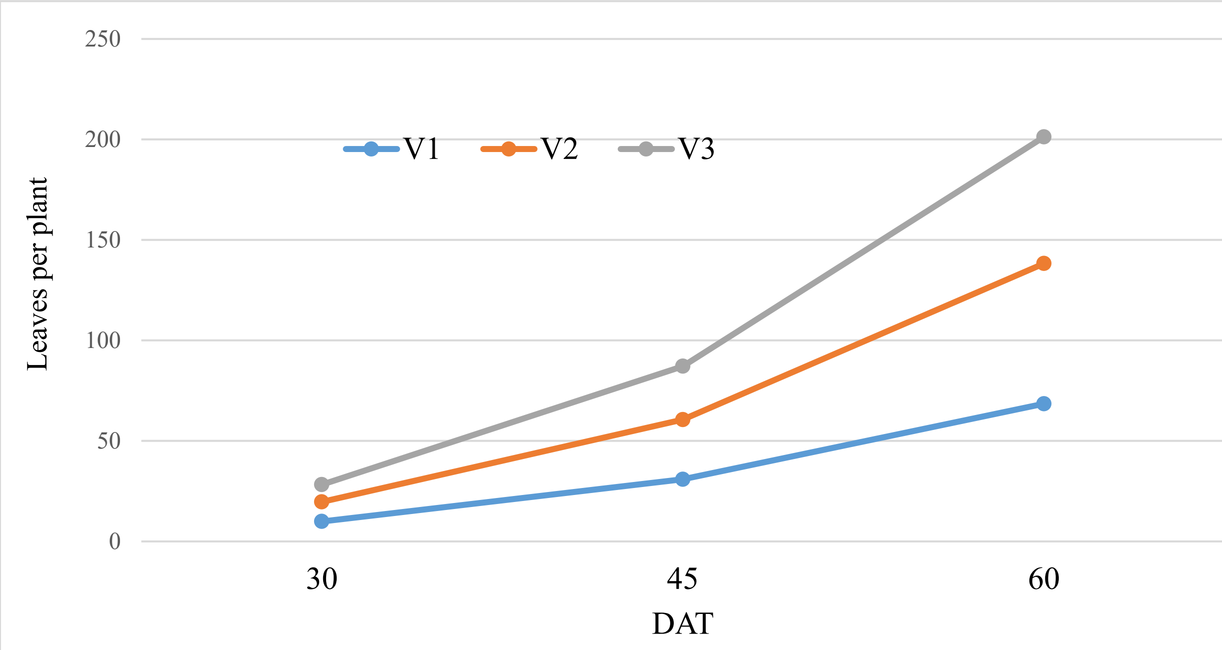

Fig.3. Leaves per plant of tomato as influenced by different varieties at different days after transplanting in the rooftop garden

V_1 =BARI Tomato 14, V_2 = BARI Tomao 15, V_3 =BARI Tomato 2 (Ratan)

DAT=Days after transplanting

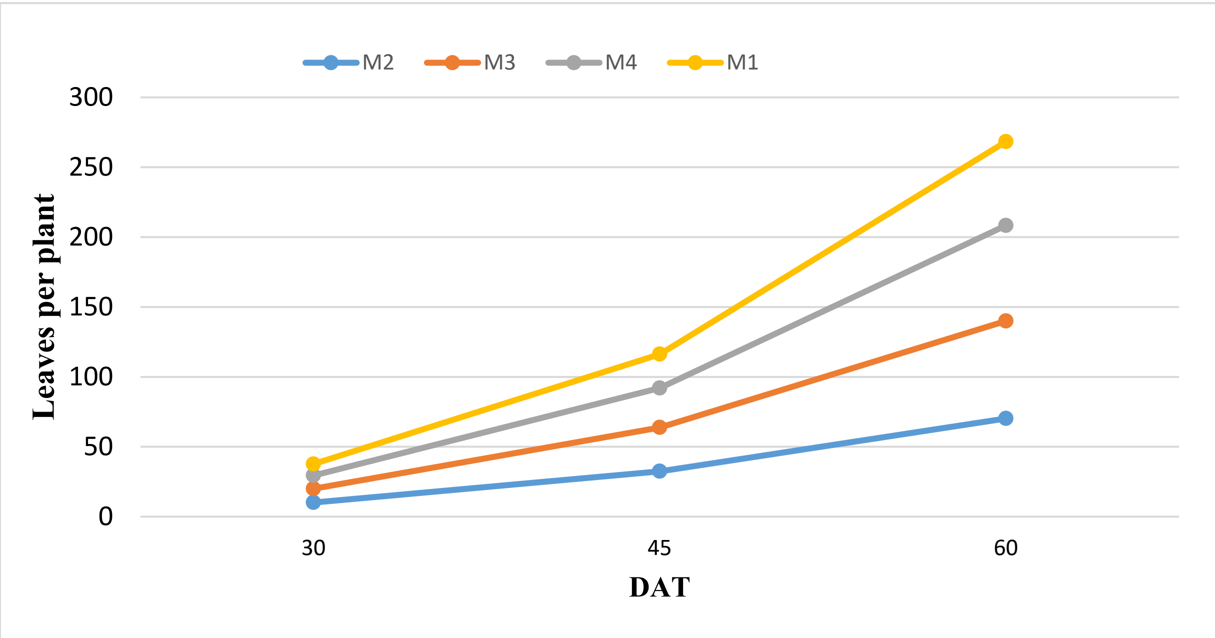

Fig.4. Leaves per plant of tomato as influenced by different plant growing media at different days after transplanting in the rooftop garden

M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

Different plant growing media 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} (10.11) was found from M_2 where the lowest number of leaves plant^{-1} (8.22) was found from M_1 and they are not significantly different from one another. At 45DAT, the highest number of leaves plant^{-1} (32.44) was found from M_2 where the lowest number of leaves plant^{-1} (24.22) was found from M_1, and they are significantly different from one another. At 60 DAT, the highest number of leaves plant^{-1}(70.22) was found from M_2, where the lowest number of leaves plant^{-1} (60) was found from M_1.

Interaction effect of different varieties and plant growing media gave significant variation on number of leaves plant^{-1} at different growth stages of tomato (Table 2 and Appendix V). At 30 DAT, the highest number of leaves plant^{-1} (11) was found from the treatment combination of V_2M_2 where the lowest number of leaves plant^{-1} (8) was found from the treatment combination of V_3M_1. At 45DAT, the highest number of leaves plant^{-1} (34.33) was found from the treatment combination of V_2M_2, where the lowest number of leaves plant^{-1} (23.33) was found from the treatment combination of V_3M_1. At 60 DAT, the highest number of leaves plant^{-1} (72) was found from the treatment combination of V_1M_2 where the lowest number of leaves plant^{-1}(55) was found from the treatment combination of V_3M_1.

Table 2. Number of leaves per plant of tomato as influenced by different varieties and plant growing media at different days after transplanting in the rooftop garden

Treatment	Number of leaves $plant^{-1}$		
	30 DAT	**45 DAT**	**60 DAT**
V_1M_1	8.66 de	24.66 gh	60.23 g
V_1M_2	10.66 ab	34.33 a	72.12 a
V_1M_3	10.33 bc	32.66 bc	71.12 b
V_1M_4	10.33 c	32.12 c	71.12 b
V_2M_1	8.12 f	24.66 gh	65.45 e
V_2M_2	11.34 a	34.45 ab	72.55 a
V_2M_3	10.56 c	33.33 abc	72.11 a
V_2M_4	10.12 c	26.66 ef	70.11 c
V_3M_1	8.67 f	23.33 h	55.54 h
V_3M_2	9.27 d	29.71 b	67.66 d
V_3M_3	9.12 d	28.11 de	67.33 d
V_3M_4	8.33 ef	26.22 fg	62.12 f
LSD	0.57	1.50	0.94
CV(%)	3.58	3.05	0.83

V_1 =BARI Tomato 14, V_2 = BARI Tomato 15, V_3 =BARI Tomato 2(Ratan)
M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

4.3 Number of branch per plant

It is found 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.

Significant influence was recorded on number of branches $plant^{-1}$ at 30, 45 and 60 DAT affected by different varieties of tomato (Fig. 5 and Appendix VI). At 30 DAT, the highest number of branches $plant^{-1}$ (3.91) was found from V_2 (BARI Tomato 15) where the lowest number of branches $plant^{-1}$ (3.66) was found from V_1 (BARI Tomato 14). At 45DAT, the highest number of branches $plant^{-1}$ (9.75) was found from V_2 (BARI Tomato 15) where the lowest number of branches $plant^{-1}$ (7.91) was found from V_3 (BARI Tomato 2). At 60 DAT, the highest number of branches $plant^{-1}$ (13) was found from V_1 (BARI Tomato 14) where the lowest number of branches $plant^{-1}$(11) was found from V_3 (BARI Tomato 2). Similar results were also observed by Bhati (2017) and Hamid *et al.* (2005) who found that variety had significant effect on number of branches per plant of tomato. Therefore altogether it suggest that number of branch of tomato is influenced by genotype of tomato.

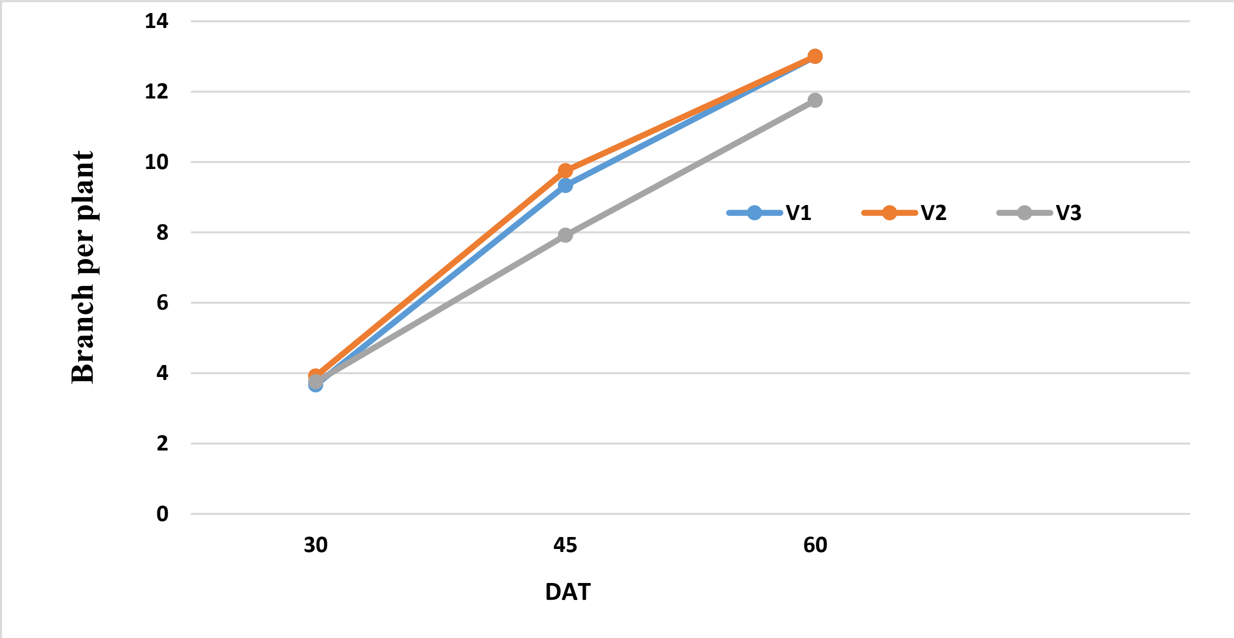

Fig.5. Branch per plant of tomato as influenced by different varieties at different days after transplanting in the rooftop garden

V_1 =BARI Tomato 14, V_2 = BARI Tomao 15, V_3 =BARI Tomato 2 (Ratan)

DAT=Days after transplanting

Significant influence was identified on number of branches plant^{-1} at 30, 45 and 60 DAT affected by different plant growing media (Fig. 6 and Appendix VI). At 30DAT, the highest number of branches plant^{-1} (4.11) was found from M_2 where the lowest number of branches plant^{-1} (3.11) was found from M1 and they are not significantly different from one another. At 45DAT, the highest number of branches plant^{-1} (9.77) was found from M_2 where the lowest number of branches plant^{-1} (7.88) was found from M_1 and they are not significantly different from one another. At 60 DAT, the highest number of branches plant^{-1} (13.22) was found from M_2 where the lowest number of branches plant^{-1} (11.61) was found from M_1 and they are not significantly different from one another.

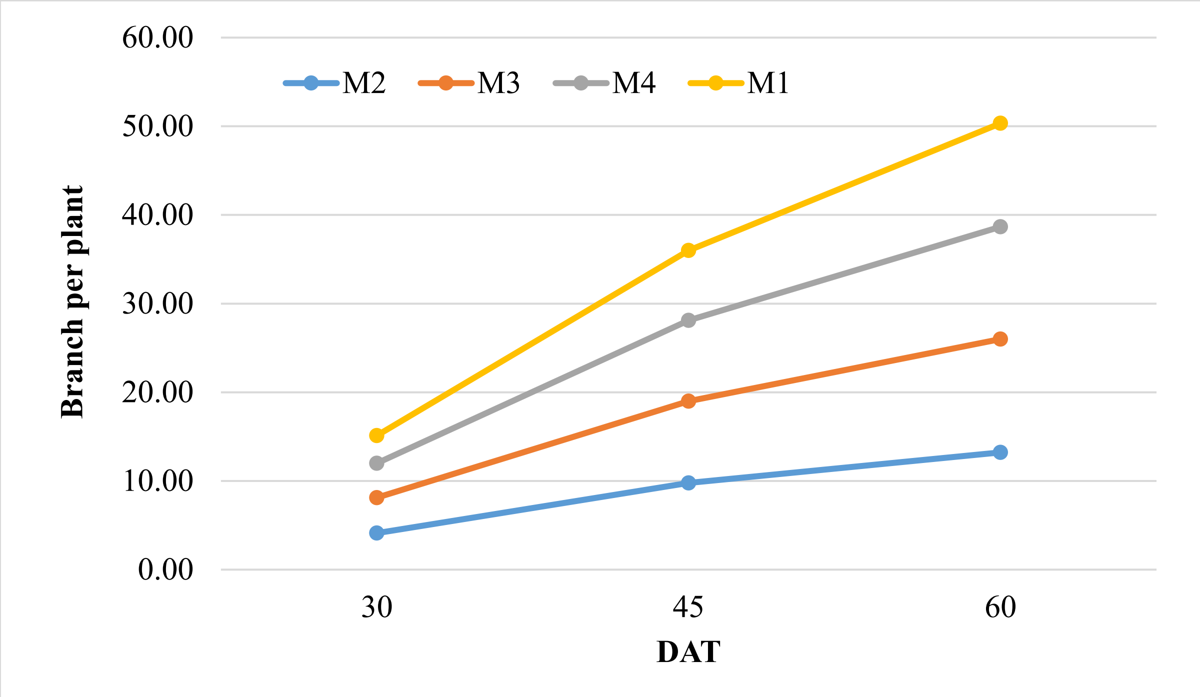

Fig.6. Branch per plant of tomato as influenced by different plant growing media at different days after transplanting in the rooftop garden

M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

The significant variation was remarked on number of branches plant^{-1}at 30, 45 and 60 DAT influenced by treatment combination of different varieties and growing media (Table 3 and Appendix VI). At 30 DAT, the highest number of branches plant^{-1}(4.34) was found from the treatment combination of V_2M_2 which was not 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_3M_1. At 45 DAT, the highest number of branches plant^{-1} (11.00) was found from the treatment combination of V_2 M_2 which was not statistically different from one another where the lowest number of branches plant^{-1} (7.00) was found from the treatment combination of V_3M_1. At 60 DAT, the highest number of branches plant^{-1}(14) was found from the treatment combination of V_1M_2 and they are not significantly different from one another where the lowest number of branches plant^{-1}(11.0) was found from the treatment combination of V_3M_1.

Table 3. Number of branches per plant of tomato as influenced by different varieties and plant growing media at different days after transplanting in the rooftop garden

Treatment	Number of branches plant^{-1}		
	30DAT	45DAT	60DAT
V_1M_1	3.00 d	8.66 cd	12.11 d
V_1M_2	4.12 ab	10.00 b	14.12 a
V_1M_3	4.23 ab	9.66 b	13.43 c
V_1M_4	3.66 bc	9.00 c	13.15 c
$V2M_1$	3.00 d	8.00 e	12.56 d
$V2M_2$	4.33 a	11.00 a	13.66 ab
$V2M_3$	4.33 a	10.11 b	13.33 bc
$V2M_4$	4.00 ab	10.04 b	13.00 c
V_3M_1	3.33 cd	7.05 f	11.00 e
V_3M_2	4.00 ab	8.33 de	12.11 d
V_3M_3	4.00 ab	8.33 de	12.44 d
V_3M_4	3.66 bc	8.00 e	12.23 d
LSD	0.6536z	0.5314	0.4169
CV(%)	10.22	3.49	1.96

V_1 =BARI Tomato 14, V_2 = BARI Tomato 15, V_3 =BARI Tomato 2(Ratan)
M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

4.4 Number of flower clusters per plant

There was a significant difference among the growing media and varieties in the number of flower clusters per plant (Table. 4 and Appendix VII). , the maximum number of flower cluster (7.33) was produced in V_1 (BARI Tomato 14). The minimum number of flower cluster per plant (6.42) was produced in V_3 (BARI Tomato 2). These result are consistent with the morphological data with this present study including plant height (Fig.1), leaf number (Fig.3) and branches per plant (Fig.5). Therefore it suggest that genotype character is one of the key factor for the development of reproductive parameter - Number of flower cluster per plant of tomato.

The different growing media showed significant variation in the number of flower cluster per plant (Table. 4 and Appendix VII). The result showed that, the maximum number of flower cluster per plant (7.55) was produced from M_2 whereas M_1

produced the minimum number of flowers per cluster (5.88) .This result are also consistent with the finding of different morphological characters of tomato such as plant height (Fig. 2), leaf number (Fig. 4) and branches per plant (Fig. 6) of this study. These results indicate that proper composition of organic fertilizer along with Inorganic fertilizer both in soil and soilless media provide better vegetative and reproductive growth of tomato in the rooftop garden.

A significant variation among the treatment combinations in number of flowers cluster per plant (Table. 4 and Appendix VII). The maximum number of flowers cluster per (8.0) was found in V_1M_2 treatment combination and the minimum number of flowers cluster per plant (5.34) was found in V_3M_1 treatment combination. This result are also consistent with the finding of different morphological characters of tomato such as plant height (Table. 1), leaf number (Table. 2) and branches per plant (Table. 3) of this study. These results indicate that proper composition of organic fertilizer along with Inorganic fertilizer both in soil and soilless media provide better vegetative and reproductive growth of tomato in the rooftop garden.

4.5 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} (3.66) was found from V_1 (BARI Tomato 14) where the lowest number of flowers cluster^{-1} (2.08) was found from V_3 (BARI Tomato 2).Hamid *et al.* (2005) also found similar result with the present study.

Different growing media 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} (3.34) was found from M_2 where the lowest number of flowers cluster^{-1} (2.34) was found from M_1.

Interaction effect of different varieties and plant growing structures gave significant variation on number of flowers cluster^{-1} of tomato (Table 6 and Appendix VII). Results exposed that the highest number of flowers cluster^{-1} (4.0) was found from the treatment combination of V_1M_2 where the lowest number of flowers cluster^{-1} (1.33) was found from $V_3 M_1$ and they are not significantly different from other.

4.6 Number of flowers per plant

There was a difference among the growing media in the number of flowers per plant. The maximum number of flower (27.16) was produced in V_1 (BARI Tomato 14) The minimum number of flower per plant (13.58) was produced in V_3 (BARI Tomato 2).

The different plant growing medium showed significant variation in the number of flower per plant. The maximum number of flower per plant (32.00) was produced from M_2 and M_1 treatment produced the minimum number of flower (24.00) (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 (32) was found in V_1M_2 treatment combination, whereas the minimum number of flower per plant (7) was found in V_3M_1.

4.7 Number of fruits plant^{-1}

Significant influence was found on number of fruits plant^{-} affected by different variety of tomato (Table 4 and Appendix VII). It was noted that the highest number of fruits plant^{-1} (19.55) was found from V_1 (BARI Tomato 14) where the lowest number of fruits plant^{-1} (15.33) was found from V_3 (BARI Tomato 2). 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 media (Table 4 and Appendix VII). It was indicated that the highest number of fruits plant^{-1} (19.56) was found from M_2 where the lowest number of fruits plant^{-1} (14.77) was found from M_1. Metwally (2016) and Bouzo and Favaro (2016) also found similar results with the present study.

Remarkable variation was noted on number of fruits plant^{-1} influenced by treatment combination of different varieties and plant growing media (Table 5 and Appendix VII). Results verified that the highest number of fruits plant^{-1} (19.00) was found from the treatment combination of V_1M_2.The lowest number of fruits plant^{-1} (15.33) was found from the treatment combination of V_3M_1.

4.8 Yield of fruits (gm) per plant

The different plant growing structures of tomato influenced on the yield of fruits per plant. The maximum yield of fruits per plant (1007.0) was obtained from V_2 and the minimum yield of fruits per plant (998.3) was obtained from V_3.
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 (1168.9) was produced by M_2 and M_1 produced the minimum yield of fruits per plant (838.9).

The combined effect of different varieties and different plant growing medium was significant on yield of fruit per plant. The highest yield of fruits per plant (1110.00) was obtained from V_1 M_2 which was statistically identical with other. The lowest yield of fruits per plant (650.7) was obtained from V_3M_1.

Table. 4. Yield and yield contributing parameters of tomato as influenced by different varieties and plant growing media at different days after transplanting in the 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	7.33 a	3.66 a	27.16 a	19.16 a	1007.20 b
V_2	7.16 a	3.41 a	24.75 a	18.16 a	1012.5 a
V_3	6.41 b	2.08 b	18.87 b	15.33 b	998.3 c
$LSD_{0.05}$	0.41	0.32	2.45	0.27	1.45
CV (%)	7.02	12.63	13.26	4.67	0.28
Effect of plant growing media in rooftop garden					
M_1	5.88 c	2.33 b	24.00 b	14.55 c	838.9 d
M_2	7.55 a	3.33 a	32.44 a	19.55 a	1108.9 a
M_3	7.45 ab	3.33 a	29.00 a	11.44 a	1030.6 b
M_4	7.00	3.22 a	26.88 b	10.78 b	910.4 c
$LSD_{0.05}$	0.47	0.37	2.83	0.32	1.68
CV (%)	7.02	12.63	13.26	4.67	0.28

V_1 =BARI Tomato 14, V_2 = BARI Tomato 15, V_3 =BARI Tomato 2(Ratan)
M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

Table. 5. Yield and yield contributing parameters of tomato as influenced by combined effect of varieties and plant growing media at different days after transplanting in the 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_1M_1	6.33 cd	3.00 b	24.00 c	16.00 d	840.0 i
V_1M_2	8.00 a	4.00 a	32.00 a	19.00 a	1110.0 a
V_1M_3	7.66 ab	4.00 a	30.67 ab	17.67 a	1100.0 c
V_1M_4	7.33 ab	3.67 a	27.00 b	17.00 b	913.0 f
V_2M_1	6.00 de	2.67 bc	26.00 c	16.00 d	845.0 h
V_2M_2	7.66 ab	3.67 a	28 00 ab	18.00 a	1105.0 b
V_2M_3	7.66 ab	3.67 a	28 00 ab	17.67 a	1070.0 d
V_2M_4	7.33 ab	3.67 a	27.00 b	17.00 b	920.0 e
V_3M_1	5.33 e	1.33 d	20.00 d	15.33 e	650.7 l
V_3M_2	7.00 bc	2.33 c	26.33 c	17.00 b	880.7 g
V_3M_3	7.00 bc	2.33 c	26.33 c	16.67 bc	749.7 j
V_3M_4	6.33 cd	2.33 c	24.67 c	16.33 cd	718.63 k
$LSD_{0.05}$	0.82	0.65	4.90	0.54	2.91
CV (%)	7.02	12.63	13.26	4.67	0.28

V_1 =BARI Tomato 14, V_2 = BARI Tomato 15, V_3 =BARI Tomato 2(Ratan)
M_1= Soil 95% + Cow dung 5% + Inorganic Fertilizer
M_2= Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer
M_3= Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite
M_4= Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted at the rooftop garden of Department of Agricultural Botany of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2018 to March 2019 to investigate the response of different tomato varieties to different plant growing media in the rooftop garden. Two factors were used in the experiment, *viz.* three types of variety and four types of plant growing media. Two factors as Factor A consisted of three varieties *viz*. V_1 (BARI Tomato 14), V_2 (BARI Tomato 15) and V_3 (BARI Tomato 2) and Factor B comprised of four plant growing media *viz*. M_1 (Soil 95% +Cow dung 5% + Inorganic Fertilizer), M_2 (Soil 80% + Cowdung 15%+ Vermicompost 5% + Inorganic Fertilizer), M_3 (Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite), M_4 (Cocodust 70% + Vermicompost 30% + Inorganic Fertilizer + Perlite) .The experiment was laid out in a Randomized Complete Block Design (RCBD) with three 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 media and also their combination.

In terms of varietal performance, considering morphological parameters, the highest plant height (15.14, 34.24 and 75.28 cm) at 30, 45 and 60 DAT respectively were found from V_2, highest number of leaves plant^{-1} (9.91, 30.92, and 69.75) at 30, 45 and 60 DAT respectively were found from V_1 and highest number of branches plant^{-1} (3.91, 9.75, and 13) at 30, 45 and 60 DAT respectively were found from V_2 (BARI Tomato 15).

Considering yield and yield contributing parameters, the highest number of flower clusters plant^{-1} (7.33), Number of flowers cluster^{-1}(3.66), highest number of flowers plant^{-1} (27.16), highest number of fruits plant^{-1} (19.55) and highest yield plant^{-1} (1007.20 g) were also found from V_2 (BARI Tomato 15). On the other hand, V_3 (BARI Tomato 2) gave the lowest plant height (14.30, 28.53, 14.30cm at 30, 45 and

60 DAT respectively), lowest number of leaves plant^{-1} (8.53, 26.58, and 63 at 30, 45 and 60 DAT respectively) and lowest number of branches plant^{-1} (3.66, 7.91 and 11 at 30, 45 and 60 DAT respectively). Again, the lowest number of flower clusters plant^{-1} (6.42), Number of flowers cluster^{-1}(2.08), lowest number of flowers plant^{-1} (13.58), lowest number of fruits plant^{-1} (13.33) and lowest yield plant^{-1} (998g) were also found from V_3 (BARI Tomato 2).

In terms of the studied parameters affected by different plant growing media, the highest plant height (15.69, 32.43 and 73.63 cm at 30, 45 and 60 DAT respectively), highest number of leaves plant^{-1} (10.11, 32.44 and 70.22 at 30, 45 and 60 DAT respectively) and highest number of branches plant^{-1}(4.11, 9.77 and 13.22 at 30, 45 and 60 DAT respectively) were found from M_3. Similarly, the highest number of flower clusters plant^{-1} (7.55), highest number of flowers cluster^{-1} (3.34), highest number of flowers plant^{-1} (32.17), highest number of fruits plant^{-1} (15.33) and highest yield plant^{-1} (1108.9 g) were also achieved from M_2. Meanwhile, the lowest plant height (13.72, 30.38 and 63.14 cm at 30, 45 and 60 DAT respectively), lowest number of leaves plant^{-1} (8.23, 24.22 and 60.00 at 30, 45 and 60 DAT respectively), lowest number of branches plant^{-1} (3.11, 7.88 and 11.61 at 30, 45 and 60 DAT respectively) were found from $M_{1.}$ Accordingly, the lowest number of flower clusters plant^{-1} (5.88), lowest number of flowers cluster^{-1} (2.34), lowest number of flowers plant^{-1} (24.12), lowest number of fruits plant^{-1} (14.77) and lowest yield plant^{-1} (838.9g) were also found from M_1.

Regarding treatment combination of different varieties and plant growing structures, the highest plant height (16.52, 34.65 and 79.37 cm at 30, 45 and 60 DAT respectively) was observed from the treatment combination of V_2M_2 whereas the highest number of leaves plant^{-1} (11.00, 34.33 and 72.00 at 30, 45 and 60 DAT respectively) and highest number of branches plant^{-1} (4.34, 11.75 and 14.25 at 30, 45 and 60 DAT respectively) were found from the treatment combination of V_1M_2 and V_2M_2. The highest number of flower clusters plant^{-1} (8.00), highest number of flowers plant^{-1} (32.12), highest number of fruits plant^{-1} (19.25) and highest yield plant^{-1} (1110.00 g) were also found from the treatment combination of V_1M_2.

On the contrary, the lowest plant height (13.07, 27.15 and 54.33 cm at 30, 45 and 60 DAT respectively), lowest number of leaves plant^{-1} (8.00, 23.50 and 55.50 at 30, 45 and 60 DAT respectively) and lowest number of branches plant^{-1}(3.00, 7.25 and 11.50 at 30,45 and 60 DAT respectively) were found from the treatment combination of V_3M_1. This treatment combination, V_3M_1 also gave the lowest number of flower clusters plant^{-1} (5.34), lowest number of flowers plant^{-1} (17.50), lowest number of fruits plant^{-1} (15.50) and lowest yield plant^{-1} (650g).

From the above findings under the present study, it can be concluded that the most of the yield and yield contributing parameters of tomato on rooftop garden was increased while using the variety V_1 (BARI Tomato 14) and V_2 (BARI Tomato 15) with combination of plant growing media M_2 (Soil 80% + Cow dung 15%+ Vermicompost 5% + Inorganic Fertilizer) and M_3 (Coco dust 60% + Vermicompost 40% + Inorganic Fertilizer + Perlite). It was found that number of fruits per plant were highest in M_2 but fruit weight per plant were highest in M_3, ultimately the yield was about same on that two media.

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 variety can be included to conduct related experiment.
3. Some other plant growing media can be included for further experiment in the rooftop garden.
4. Scope to conduct similar experiment for *kharif* season in the rooftop garden.

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APPENDICES

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

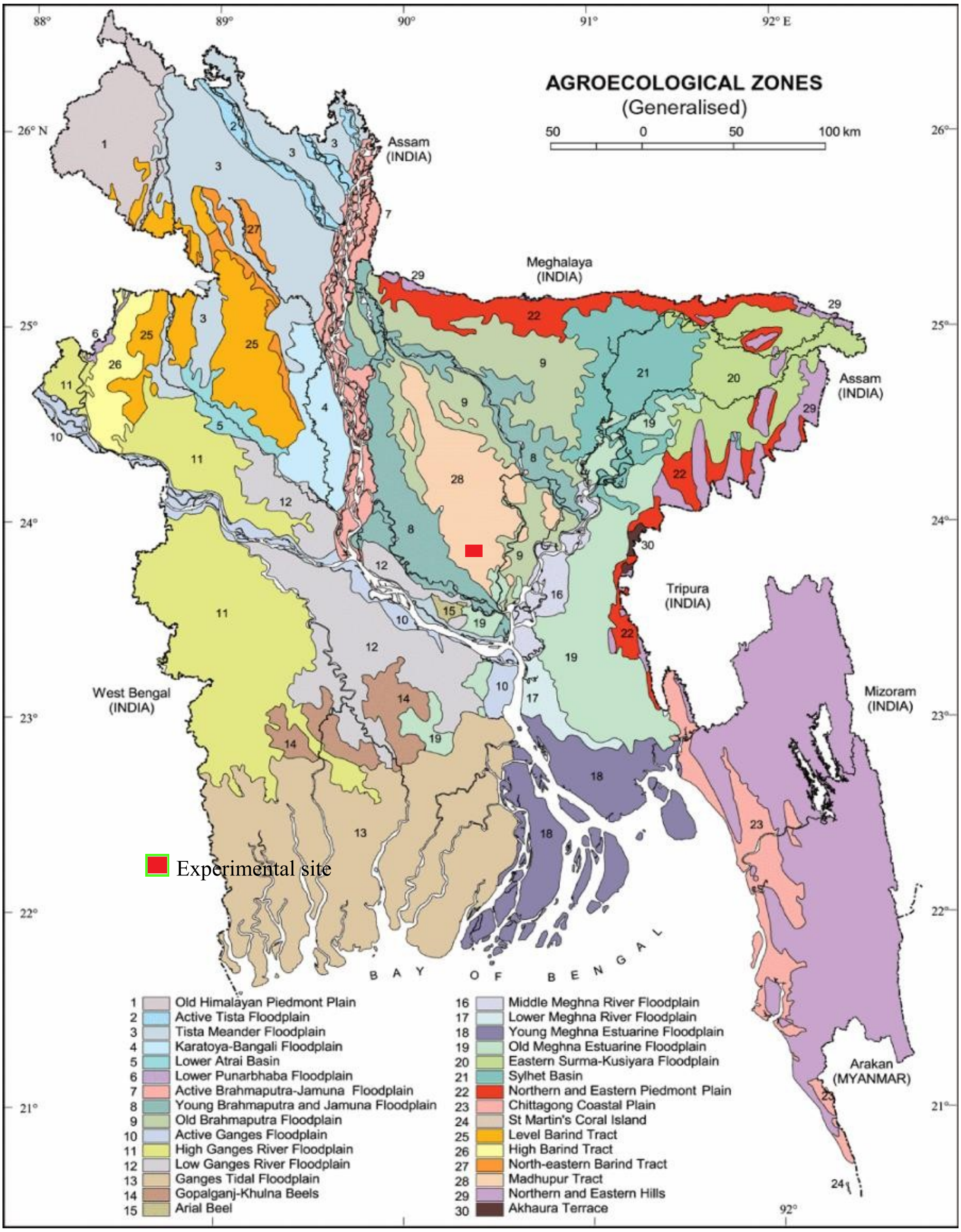

Fig.7. Experimental site

Appendix II: Monthly record of air temperature, rainfall, relative humidity and sunshine hours of the experimental site during the period from November to March (2018-2019)

Year	Month	Average Air temperature (°F)			Total rainfall (mm)	Average RH (%)	Average sunshine hours
		Maximum	Minimum	Average			
2018-2019	November	85.3	66.6	85.3	34.4	53	8
	December	79.5	57.4	79.5	12.8	50	9
	January	77.7	54.9	70.5	7.7	47	9
	February	82.6	59.9	57.6	28.9	38	8.1
	March	90.5	68.7	60.7	65.8	37	7

Appendix III: Chemical properties of soil, cow dung and vermicompost analyzed at Soil Resources Development Institute (SRDI), Farmgate,Dhaka.

Soil	Cowdung	Vermicompost
pH: 6.0	Moisture: 44.5 %	Moisture: 53.80 %
Organic matter: 1.21 %	pH: 6.7	pH: 7.1
Total nitrogen:0.061 %	Organic carbon: 10.2%	Organic carbon: 10.7 %
Potassium: 0.19 meq/100 g	Total nitrogen: 0.65 %	Total nitrogen: 1.12 %
Phosphorus: 1.31 ppm	Phosphorus: 0.39 %	Phosphorus: 0.67 %
Sulphur: 42.13 ppm	Potassium: 0.40 %	Potassium: 0.95 %
Zinc: 0.95	Sulphur: 0.02 %	Sulphur: 0.01 %
	Boron: 0.02 %	Boron: 0.007 %
	Iron: 0.003 %	Iron: 0.01 %
	Manganese: 0.006 %	Manganese: 0.004 %
	Zinc: 0.01 %	Zinc: 0.01 %
	Copper: 0.002 %	Copper: 0.003 %
	Chromium: 10.12 ppm	Chromium: 22.43 ppm
	Cadmium: 0.19 ppm	Cadmium: 0.44 ppm
	Lead: 5.76 ppm	Lead: 2.97 ppm

Source: Soil Resource Development Institute (SRDI)

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

Sources of variation	Degrees of freedom	Mean square of plant height (cm) at		
		30 DAT	45 DAT	60 DAT
Replication	2	0.04	0.00059	1.27
Factor A	2	2.13^{ns}	98.99*	789.118*
Factor B	3	9.37*	6.67*	176.37**
AB	6	0.67^{ns}	1.00*	35.87^{ns}
Error	22	0.24	0.20	0.74

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

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

Sources of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAT	45DAT	60 DAT
Replication	2	0.08	2.69	0.25
Factor A	2	6.33*	59.69**	154.75*
Factor B	3	6.39*	122.18^{ns}	206.54^{ns}
AB	6	0.70*	8.88*	14.38*
Error	22	0.11	0.78	0.311

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

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

Sources of variation	Degrees of freedom	Mean square of number of Branches plant^{-1}		
		30 DAT	45DAT	60 DAT
Replication	2	0.02	0.25	4.39
Factor A	2	0.19^{ns}	11.08*	6.25*
Factor B	3	1.85*	5.70**	3.87*
AB	6	0.15*	0.67*	0.21^{ns}
Error	22	0.14	0.09	0.06

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII: Yield contributing parameters and yield of tomato influenced by different varieties and plant growing media and also their combination at different growth stages

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	0.02	1.36	71.08	0.52	120.80*
Factor A	2	2.86**	8.69*	630.08*	2.78*	612.7*
Factor B	3	5.21*	2.11^{ns}	256.63^{ns}	6.00**	2205.0^{ns}
AB	6	0.04^{ns}	0.02*	4.04*	0.11*	80.87*
Error	22	0.23	0.14	8.38	0.10	10.70

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII: Preview of rooftop gardening of tomato with three different varieties in four different plant growing media.

Fig. 8. Growing plant in soil media

Fig. 9. Growing plant in soilless media

Appendix IX: Preview number and size of tomato of rooftop gardening with three different varieties in four different plant growing media.

Fig. 10. M_2 media having number of fruits

Fig. 11. M_3 media having large size fruits