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Effect of Plant growing Structures and Media on Yield of Tomato in the Rooftop Garden

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Authors' contributions

This work was carried out in collaboration among all authors. Author MMI designed the study. Author MTA performed the statistical analysis and wrote the protocol. Author PAB wrote the first draft of the manuscript. Authors SP and MEB managed the analyses of the study. Author MTA managed the literature searches. All authors read and approved the final manuscript.

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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 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

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plant growing structures, the S_1 gave the highest flower clusters per plant, flowers per plant, fruit length and fruit breadth. The maximum yield of fruits per plant (1.69 kg) was also obtained from plastic pot. The M_5 had the highest flower clusters per plant, flowers per plant, fruit length and fruit diameter. The maximum yield of fruits per plant (2.17 kg) was recorded from the M_5. The highest yield of fruits per plant (2.15 kg) was obtained from the treatment combination of S_1M_5. This experimental results suggest that S_1M_5 be able to increase the fruit yield of BARI tomato14 for rabi season in the rooftop garden.

Keywords: Solanum lycopersicum; production; plastic pot; earthen pot; vermicompost; cowdung; soil.

1. INTRODUCTION

The continuously increasing world population is predicted to rise to almost 10 billion people by 2050 [1]. This situation will lead to a higher food demand and, consequently, increased pressure on many ecosystem services [2]. Moreover, the population living in urban areas is also expected to increase from 54% (in 2015) to 66% by 2050 [3]. It is well known that the following reasons have been contributing to change environment viz: over population, rising temperature, excess carbon-di-oxide (CO2), methane (CH4), nitrus oxide (N2O) 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 [4,5].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 [6]. 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 (Ca2+) 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 gardens 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 gardens 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. [7,8]. Morphological, physiological and yield responses of tomato, cauliflower and cabbage were uneven to container sizes [9,7]. In addition, recently our laboratory found that the water requirement also unequal to both Rabi and kharif season in different types of pots. However, to my knowledge 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 yield and quality of tomato under.

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

i. To investigate the independent effects of earthen pot and plastic pot on changes in 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 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 yield and quality of tomato during rabi season in the rooftop garden.

2. MATERIALS AND METHODS

2.1 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.

2.2 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 34.80ºC respectively. The average relative humidity was 75.8% during October 2017 to March 2018.

2.3 Soil Type

The soil for experiment was collected from an area that belongs to Modhupur Tract under AEZ No. 28 (Anon., 1988). Analytical result of soil was 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.

2.4 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.

2.5 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.

2.6 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. S1= Plastic pot
ii. S2= Earthen pot

Factor (B) Different plant growing medium:

i. M0=Soil 100% (w/w)+ Inorganic Fertilizers (IF)/ (control),
ii. M1=Soil 80% (w/w)+ 20% cowdung (w/w) and Inorganic Fertilizers (IF),
iii. M2=70% (w/w)+ 30% cowdung (w/w) and Inorganic Fertilizers (IF),
iv. M3=Soil 90% (w/w)+ 10% vermicompost (w/w) and Inorganic Fertilizers (IF),
v. M4=Soil 80% (w/w) + 20% vermicompost (w/w)and Inorganic Fertilizers (IF),
vi. M5=Soil 80% (w/w) + 10% cowdung (w/w) + 10% vermicompost(w/w) and required calculative amount of Inorganic Fertilizers (IF).

2.7 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.

2.8 Pot Preparation

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

2.9 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.

2.10 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.

2.11 Intercultural Operations

After transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants such as weeding and mulching, staking and pruning, irrigation, top dressing and different plant protection measures.

2.12 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.

2.13 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.

2.14 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 [10].

3. RESULTS AND DISCUSSION

3.1 Number of Flower Clusters per Plant

There was a significant difference among the plant growing structures in the number of flower clusters per plant. As evident from Table 1, 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_0 treatment produced the minimum number of flowers per cluster (8.08) (Table 2).

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 3).

3.2 Number of Flowers per Plant

There was a difference among the plant growing structures in the number of flowers per plant. The maximum number of flowers (62.60) was produced in S1 treatment. The minimum number of flowers per plant (55.95) was produced in S2 treatment (Table 1).

The different plant growing medium showed significant variation in the number of flowers per plant. The maximum number of flowers per plant (66.60) was produced from M_5 treatment and M_0 treatment produced the minimum number of flower (50.60) (Table 2).

A significant variation was observed among the treatment combinations in number of flowers per plant. The maximum number of flowers 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 S2M0 (Table 3).

3.3 Length of Fruit (cm)

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 4).

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 4).

Table 1. Effect of plant growing structures on flower clusters, total flowers of tomato

Plant growing structures (S)	Numbers of different flower /plant at 60 DAT			
	Flower clusters		Total flowers	
S_1	9.05	a	62.62	a
S_2	8.15	b	55.95	b
$LSD_{(0.05)}$	0.22		0.69	
Level of sig.	*		*	
CV (%)	8.31		8.44	

*S_1= Plastic pot, S_2= Earthen pot, *significant at 5% level of probability*

Table 2. Effect of plant growing media on flower clusters, total flowers of tomato

Plant growing media (M)	Numbers of different flower / plant at 60 DAT			
	Flower clusters		Total flowers	
M_0	8.08	bcd	50.62	f
M_1	8.28	bc	57.45	c
M_2	8.39	d	59.65	e
M_3	8.68	ab	60.63	b
M_4	8.78	cd	60.8	d
M_5	9.41	a	66.59	a
$LSD_{(0.05)}$	1.119		1.119	
Level of sig.	*		*	
CV (%)	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). *significant at 5% level of probability*

Table 3. Interaction of different plant growing medium and plant growing structures on flower clusters, total flowers of tomato

Interaction (S× M)		Numbers of different flower/plant at 60 DAT			
		Flower clusters		Total flowers	
S_1	M_0	8.4	def	51.11	g
	M_1	8.6	cde	60.65	d
	M_2	8.78	cd	63.8	c
	M_3	9.36	ab	64.9	b
	M_4	9.45	ab	65.1	b
	M_5	9.71	ab	70.21	a
S_2	M_0	7.76	g	50.13	g
	M_1	7.96	fg	54.24	f
	M_2	7.99	efg	55.5	e
	M_3	8	fg	56.36	e
	M_4	8.1	efg	56.5	e
	M_5	9.1	bc	62.96	c
$LSD_{(0.05)}$		0.45		1.05	
Level of sig.		*		*	
CV (%)		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)

The variation in fruit length due to combined effect of plant growing structures and plant growing medium was found statistically significant (Table 4). 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.

3.4 Breadth of Fruit (cm)

The breadth of fruit was influenced by plant growing structures. The largest fruit breadth (4.96 cm) was produced by S_1 and S_2 produced the shortest fruit breadth (4.68cm), (Table 4).

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 4).

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 4).

3.5 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_1 and the minimum fruit brix reading (4.25 %) was obtained from S_2 (Table 4).

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 4).

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 4).

3.6 Yield of Fruits (kg) per Plant

The different plant growing structures of tomato influenced on the yield of fruits per plant. The maximum yield of fruits per plant (1.69 kg) was obtained from plastic pot and the minimum yield of fruits per plant (1.46 kg) was obtained from earthen pot (Fig. 1). This is partially supported by Bouzo and Favaro [9] who reported an increase in the container size results in plants of higher size and yield. These findings were also partially supported by Metwally [8] 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 per plant (2.17 kg) was produced by M_5 treatment and control treatment produced the minimum yield of fruits per plant (1.28 kg), (Fig. 2).

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).

The urban expansion that widens the distances between production and consumption areas, increasing the dependence of cities on external resources [11]. In this context, the necessity of rethinking our food systems is rising to achieve urban sustainability and avoid intensive agricultural techniques that have critical environmental costs. As a result, urban agriculture (UA) is gaining importance to facilitate

Table 4. 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)

access to healthy, reliable and fresh food, which is usually difficult in cities (e.g., “food deserts”) [3] along with many other social and ecological related services. Specifically, urban rooftop farming, which includes gardens, greenhouses or farms placed on building rooftops, can offer new landscape opportunities while restraining the burden on agricultural land and achieving more sustainable and resilient cities [12]. Such is the case in which urban planners in northern global cities already include UA in their agendas and policy planning [13]. Although soil-based agriculture is the most common urban agricultural practice [12], soilless systems are gaining importance as the lightest operation system. Therefore, UA can be performed in unused urban spaces, such as rooftops or terraces [14], which are already built spaces that are usually empty [12]. Moreover, one of the major risks in UA is contamination, mainly caused by heavy metals present in soils [15]. In this sense, soilless practices help avoid this risk by using inert and non-contaminated substrates [15]. Notwithstanding that soilless systems can be perceived as “unnatural” or artificial [16], it should be considered that this practice is already highly consolidated in conventional agriculture [17]. For instance, intensive greenhouse soilless food production is performed in Almeria (Spain), the major vegetable producer in southern Europe. According to Specht and Sanyé-Mengual [16], many of the vegetables for sale in the market are already produced using soilless techniques [16]. This wide use of soilless systems is due to the substantial water savings that it allows [12]. Although irrigation management is crucial for the performance of soilless systems, easy access to nutrients and water allows plants to grow faster and produce higher yields at higher densities because there is no competition for nutrients [14]. Apart from community, commercial or industrial UA initiatives, private home gardens have been always present and still discreetly sprouting in cities [18]. According to Calvet-Mir et al. [19], there are many reasons to cultivate home gardens. The main goal is to obtain better quality and safer food, which will consequently enhance healthier diets by increasing the intake of abundant and diverse vegetables [20]. Another important reason is that home gardens increase self-reliance and self-sufficiency, allowing certain economic independence and resilience to external dynamics (Calvet-Mir et al., 2012). Therefore, food sovereignty can be seen as a form of empowerment [20]. In terms of production, Sanyé-Mengual et al. [21] quantified that 150 tones of tomatoes could be produced in the roof area of Barcelona. Although concerns about community and industrial UA are gaining interest worldwide, home urban gardens are overlooked and understudied [22]. In addition, the existing literature concerning home urban gardens is mainly qualitative and focused on their ecosystem and social services provisions (Calvet-Mir et al., 2012, [23]) or their contribution to food security [18] rather than on their agronomic and environmental performance. From an environmental impact perspective, urban food production has been assessed for rooftop greenhouses [24] and community rooftop gardens [25] by applying the Life Cycle Assessment methodology [26]. Nevertheless, there is still a gap in the literature regarding agronomic and environmental studies on open-air, urban, soilless and polyculture gardens. As stated by Specht and Sanyé-Mengual [16], the available literature is insufficient, and new

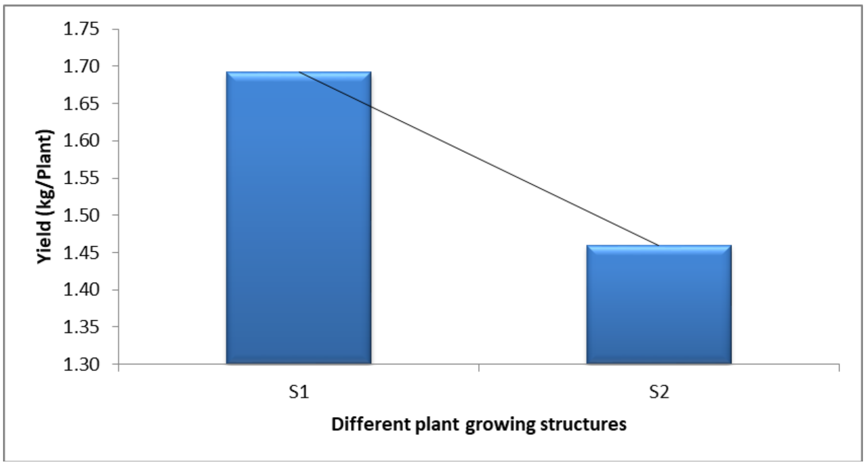

Fig. 1. Effect of plant growing structures on fruit yield of tomato
S_1= Plastic pot, S_2= Earthen pot

quantitative data are needed to "increase awareness and knowledge" about urban rooftop agriculture. In addition, this paper will provide useful specific indicators for policy making and design planning in cities that seek to enhance UA. This lack of data implies uncertainty in urban management and hinders the inclusion of a food policy dimension in urban plans. This study seeks to shed some light by providing new quantitative data to assure the best performance of urban gardens in the future.

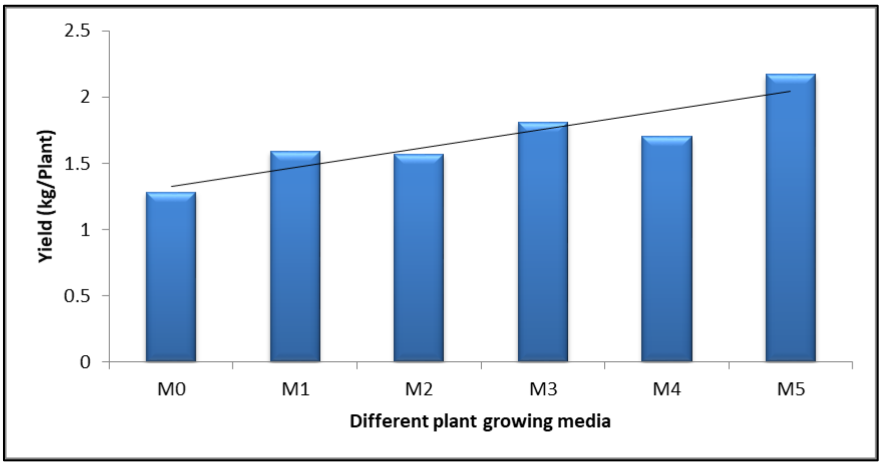

Fig. 2. Effect of plant growing media on fruit yield of tomato

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)

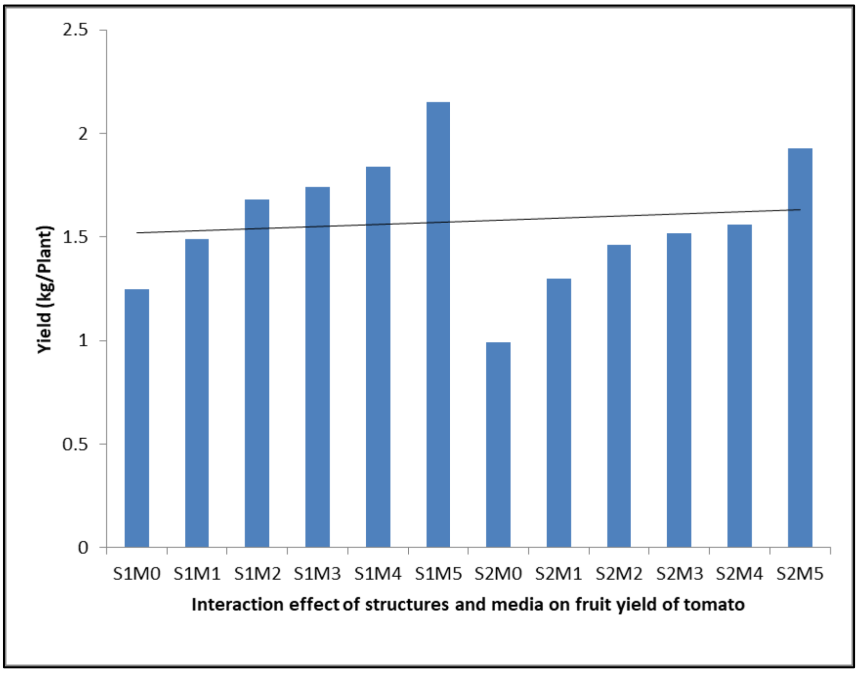

Fig. 3. Interaction effect of plant growing structures and media on fruit yield of tomato

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)

4. 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, further studies in the following areas 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.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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