Pure Appl. Biol., 9(1): 884-896, March, 2020
http://dx.doi.org/10.19045/bspab.2020.90093

Research Article

Effect of growing media on rooting response of tomato (*Lycopersicum esculentum* L.) stem cuttings

Mehboob Alam[1], Zawar Hussain[1*], Izhar Ullah[1], Samiullah[1], Imran Ahmad[1], Muhammad Asif[1], Muhammad Azhar Shah[1], Syed Qaisar Ali Shah[1] and Johar Raza Khan[2]

1. Department of Horticulture, The University of Agriculture Peshawar-Pakistan
2. Department of Plant Breeding and Genetics, The University of Agriculture Peshawar-Pakistan

**Corresponding author's email: saidzawar61@gmail.com*

Citation

Mehboob Alam, Zawar Hussain, Izhar Ullah, Samiullah, Imran Ahmad, Muhammad Asif, Muhammad Azhar Shah, Syed Qaisar Ali Shah and Johar Raza Khan. Effect of growing media on rooting response of tomato (*Lycopersicum esculentum* L.) stem cuttings. Pure and Applied Biology. Vol. 9, Issue 1, pp884-896.
http://dx.doi.org/10.19045/bspab.2020.90093

Received: 20/09/2019 Revised: 01/12/2019 Accepted: 16/12/2019 Online First: 01/01/2020

Abstract

A greenhouse study was conducted to determine the effect of growing media on root development of stem cuttings of tomato hybrids. Axillary cuttings from various tomato hybrids (Anna, Saandal, Salar and Sahil) were planted on different organic media (T_1: Control (garden soil + FYM + silt (1:1:1), silt + compost of spent mushroom (1:1), T_2: Moss peat compost (1:1) and T_3: Pure peat moss). Pure peat moss had a highly significant effect ($P<0.001$) on plant height, stem diameter, single leaf area, weight of fresh shoot, weight of dry shoot, length of root, weight of fresh root, dry weight of root with better survival percentage and number of roots per plant. Similarly maximum value of plant height, stem diameter, single leaf area, weight of fresh shoot, weight of dry shoot, length of root, number of roots plant^{-1} , weight of fresh root, weight of dry root and survival percentage were recorded in Sahil hybrid. Regarding interaction between growing media and tomato hybrids, significant differences (($P<0.01$) were observed in plant height, shoot fresh weight, stem diameter and survival percentage. The results of this study suggest that vegetative propagation of Sahil hybrids could be successfully achieved in pure peat moss for better growth and rooting.

Keywords: Antioxidants; Growing media; Growth habit; Hybrids; Peat Moss

Introduction

The term growing media is amongst other used to describe the material used in a container to grow a plant. Various growing media are available including peat moss, spent mushroom compost etc. Peat moss is dried sphagnum moss that has the capacity to gained and release nutrients and moisture to the growing media. It accelerates vegetative growth of tomato, when used with normal manure. Different media like organic media (spent mushroom compost) are less caustic and can cause less burning of plants than inorganic fertilizers if used in large quantity. Growing media is an important factor that influences growth of

herbaceous cuttings and quality of cuttings [1]. [2] evaluated the effect of culture media on growth indexes and absorption of some nutrients in greenhouse tomato. Growing media based on peat and peat with cocoas derivatives were tested against mineral wool for tomato. Results showed that plants grown in the pure peat rooted more easily than those grown in the peat-coco or mineral wool but the total yield was similar for all media [3]. [4] investıgated the use of different growing media for zinnia and suggested physical and chemical properties of media, like, structure, texture, pH, as well as, nitrogen, phosphorus and potassium, as a dominant factor for the growth and development of plant. Advances in modern agriculture allows today's farmers to grow in ways that are measurably more sustainable. These practices help farmers retain topsoil and reduce erosion, conserve water in multiple ways, reduce emissions, protect pollinators and protect natural resources by using farmland more efficiently sustainable agriculture is an integrated system of plant and animal production practices having a site-specific application that will satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends, make the most efficient use of non renewable resources, sustain the economic viability of farm operations and enhance the quality of life for farmers and society as a whole [5].

Organic food is increasingly attracting the interest of consumers, as it is perceived to be healthier than the food produced by conventional agriculture, and more sustainable for the environment [6]. [7] reported that the nutritional properties of organic produce have never been inferior to conventional produce. [8] reported that there is no evidence for a difference in nutrient quality between organically and conventionally produced foodstuffs. In their meta-analysis on the content of secondary metabolites and vitamins in organically and conventionally produced fruits and vegetables. Organic production may be considered a possible solution to the health and environmental problems that results from synthetic chemical inputs, such as fertilizers and pesticides [9]. Many people believe that organic products are healthier than conventionally produced ones and that they are produced in a more environmentally compatible manner [10].Tomato (*Lycopersicon esculentum* L.) One of an important member of Solanaceae family which is the second largest vegetable after potato in vegetables production all over the world. It is hot season crop and optimum temperature required for its cultivation is 25-29°C [11]. Tomato was originated in the Andes mountain region of South America. Tomato is an important source of minerals and antioxidants such as carotenoids, lycopene, vitamins C, E and phenolic compounds [12]. Tomato plants are mainly propagated by two ways i.e. through seed and by cutting. Tomato hybrid is an important source to get higher production because tomato hybrid has high yield per area used as cash crop. Tomato hybrids are mostly indeterminate and give several pickings throughout the growing season and it is estimated that single plant of tomato hybrid gives 10-12 kg yield plant^{-1} [13]. The success of rooting of stem cuttings has been attributed amongst other factors to the rooting medium as well as the presence of rooting hormone and its concentration [14-17].Growing hybrid tomatoes are expensive and poor farmers cannot afford buying seeds/seedlings, therefore vegetative propagation of tomato is one of an important way to multiply the true to type tomato hybrids. It is an easy, cheap and practical experience to use tomatoes cuttings for starting new tomato plants and to extent its production for hybrid plants [18]. The

present study was performed to achieve the best and most appropriate culture medium to produce healthy, strong and homogeneous transplant and reduction of production costs and seed waste and to reach the best mixture for rooting of greenhouse tomato hybrids.

Materials and methods

Experimental site and plant material collection

The experiment was carried out at the Agriculture Research Institute (ARI) Tarnab, Peshawar, Pakistan in spring season 2016. Four growing media comprised of T_1: Silt+ garden soil+ FYM (1:1:1), T_2: Spent mushroom compost+ silt (1:1), peat moss compost+ silt (1:1) and T_3: Pure peat moss were prepared. All ingredients were mixed well in above proportion in equal volume. After mixing in specific proportions each medium was poured in the polythene bags of size (6×9 inches) for planting tomato cuttings.

Selection of auxiliary branch cuttings

The auxillary branches of size (4-5 inches) with stem diameter (0.22 cm) at three leaves stage were randomly selected from various hybrids of tomato including Anna, Saandal, Salar and Sahil. Healthy branches were selected and cutted from the stem using pruning shear. One cutting per bag was planted in the selected medium. Each medium contain 32 cuttings replicated three times, while the whole experiment comprised of 384 cuttings that were transplanted to polythene bags.

Physico-Chemical analysis of soil

Once the media was prepared in specific proportion, the physico-chemical analysis of each growing media was performed in the Soil Science division at ARI, Tarnab Peshawar. Results of the physico-chemical analysis of the growing media are given in (Table 1).

Data collection

The following growth attributes were studied during the experiment.

Plant height (cm)

Five plants were selected randomly from each experimental unit and its height from base to tip was measured with measuring tape.

Stem diameter (mm)

Five plants were selected randomly from each experimental unit and their diameter was calculated using digital vernier caliper (Kincrome, K2313) and then its average was find out.

Single leaf area (cm^2)

In each treatment and in each replication three leaves (bottom, middle and top) of five plants were selected randomly for single leaf area by using leaf area meter (CID, Inc. CI-202) and then its averaged was find out.

Shoot fresh weight (g)

To determine the shoot fresh weight, the shoot portion of the plant was placed on electric balance (Citizen, CY 510C) and its average was calculated.

Shoot dry weight (g)

After taking shoot fresh weight, they were kept in oven at 70 ^{0}C for 24 hour to dry out. Using electric balance (Citizen, CY 510C) dry weight was determined.

Length of root (cm)

Roots were separated from shoot with the help of scissor and length of root was calculated using measuring tape and its average was determined.

Number of roots $plant^{-1}$

Number of roots $plant^{-1}$ were measured by counting number of roots per plant manually and their average were calculated.

Weight of fresh root (g)

Fresh root weight of randomly selected plants in each replication were measured with the help of electric balance (Citizen, CY 510C) and their means were calculated.

Root dry weight (g)

After taking root fresh weight, they were kept in oven 70 ^{0}C for 16 hour to dry out and then collected from the oven. Using

electric balance (Citizen, CY 510C) dry weight was determined.

Survival Percentage

Survival percentage was calculated by using following formula

$$\text{Survival percentage} = \frac{\text{No. of plants survived}}{\text{Total number of plants}} \times 100$$

Statistical Analysis

Analysis of variance was calculated using statistical software Statistix version 8.1, when F-value was significant. Means values were compared by using LSD test at 5% level of significance [19].

Results and discussion

Plant height (cm)

The analysis of variance revealed highly significant differences among the treatments and their interaction (Table 2). The highest value of plant height (28.18cm) was recorded in cutting planted in pure peat moss medium, while lowest value of plant height (17.21 cm) was observed in control (garden soil + FYM + silt) medium. Regarding tomato hybrid, Sahil showed maximum plant height (23.35 cm), whereas minimum plant height (20.67cm), (Figure 1).The interaction between growing media and hybrids revealed that maximum value of plant height (26.78) was observed in Sahil tomato hybrid when their cutting were planted in pure peat moss medium as compared to plant height of Anna hybrid cuttings grown in control medium (garden soil + FYM + silt) (Figure 2). The peat moss media is the rich source of the nitrogen, potassium and organic matter which contribute positively in plant height. [20] reported significant difference for plant height in peat moss media as compared to the sheep manure media. Growth and development of the plant depend on balance rooting media that supply all essential nutrients for attaining maximum height of plant. [21] who observed significant differences for plant height and showed that Phosphorus plays a vital role in photosynthesis and respiration. The present studies are similar with the results obtained by [20].

Stem diameter (mm)

It is obvious from (Table 2) that tomato hybrid cuttings, growing media and their interaction significantly influenced stem diameter. The highest value of stem diameter (0.65 mm) was recorded in cutting planted in pure peat moss medium, while lowest value of stem diameter (0.47mm) was observed in control (garden soil + FYM + silt) medium. Regarding tomato hybrid, Sahil showed maximum stem diameter (0.58 mm**),** whereas minimum stem diameter (0.51 mm) was recorded in Anna hybrid (Figure 1). Regarding interaction of stem diameter between growing media and hybrids, maximum shoot diameter (0.67mm) was observed for Sahil hybrid grown on pure peat moss, while minimum shoot diameter (0.36 cm) was observed for Anna hybrid grown on control medium (garden soil+ FYM + silt) (Figure 2). The availability of nutrients in growing substrate greatly affects the vegetative growth. [22] reported that peat moss media comprised of important elements due to which elongation of cell and rapid division of cell takes place. As a result thickness of the stem occurs. Stem with thickest diameter are stronger and show resistance against different abiotic stresses. The stem thickness of cutting plays a vital role in enhancing the water and nutrients transportation. It was reported that peat moss medium increased the soil porosity, infiltration rate, water retention and aggregate stability and also not only reducing the bulk density but also maintained the temperature of the soil. Sahil hybrid exhibited maximum stem diameter and minimum stem diameter was found for both Anna and Sandal. Maximum increase in stem diameter revealed vigorous vegetative plant growth. [13] investigated that Sahil tomato hybrid grown from cutting

gives one or more extra crops as compared to other hybrids.

Single leaf area (cm^2)

The statistical analysis of data revealed that single leaf area was significantly influenced by hybrid cuttings and growing media, whereas their interaction of hybrid cuttings and growing media was found non-significant (Table 2). The highest leaf area (3.07 cm^2) was recorded in cutting planted in pure peat moss medium, while lowest value of leaf area (1.97 cm^2) ın control medıum. Similarly maximum leaf area (2.62 cm^2) was noticed in Sahil hybrid which was statistically at par with Salar hybrid having leaf area (2.59 cm^2), while minimum leaf area (2.32 cm^2) and (2.31 cm^2) were found in Sandal and Anna, respectively (Fıgure 1). Leaf area of the plant depends upon the availability of the nutrients as reported by **[23]**. Their results revealed that high leaf area in top soil + peat moss (1:1) media might be due to the ability of the plant to retain nutrients and water for translocation to shoot system. **[24]** observed larger leaf area in that media where all three nutrients such as N, P and K are present. **[25]** recorded that nitrogen increase leaf area and vegetative growth due to the increase of cell size and leaf cell number. Similarly phosphorus is one of the main components of chlorophyll and protoplasm. It converts photosynthetic into phospholipids as a result vegetative growth increased adequately. **[26]** found that cutting of tomato hybrids showed maximum vegetative growth for leaf area due to high content of auxin.

Shoot fresh weight (g)

The data for shoot fresh weight showed that shoot fresh weight was significantly influenced by hybrid cuttings, growing media and their interaction (Table 2). The highest shoot fresh weight (6.61 g) was observed in plants grown in pure peat moss and lowest (4.32 g) shoot fresh weight was noticed in plants grown in control treatment. Regarding tomato hybrid, Sahil showed maximum shoot fresh weight (5.88 g), whereas minimum shoot fresh weight (5.00 g) was recorded in Anna hybrid (Figure 1). Similarly maximum shoot fresh weight (7.04 g) was noted in pure peat moss when Sahil hybrid was grown on it and minimum (3.76 g) were noted in cutting of Sandal grown in control medium (garden soil + FYM + silt) (Figure 2). **[27]** observed that peat moss media gave highest shoot fresh weight as compared to other media which mıght be due to the fact that peat moss growing media provide sufficient amount of nutrients and well balanced minerals. It has also been reported that peat moss media improved the vegetative growth parameter of the plant including plant height, shoot fresh weight and dry weight. Similar finding was reported by **[28]** that vermicompost significantly increased the fresh weight of tomato shoot. **[29]** recorded variability in shoot fresh weight in tomato for hybrid productions. **[30]** studied that tomato hybrids contain different type of regulatory hormones which stimulate the shoot fresh weight and that hormones plays a vital role in cell division, cell elongation, early differentiation of xylem and phloem tissues and initiation of cambium in tomato

Dry shoot weight (g)

Dry shoot weight of tomato significantly influenced by hybrid cutting and growing media, whereas the interaction of hybrid cuttings and growing media had non-significant influence on dry shoot weight of tomato (Table 2). The highest value of dry shoot (0.79 g) was recorded in cutting planted in pure peat moss medium, while lowest value of dry weight (0.41 g) was observed in control (garden soil + FYM + silt) medium. Regarding tomato hybrid, Sahil showed maximum shoot dry weight (1.03 g), whereas minimum shoot dry weight (0.25 g) was recorded in Anna hybrid (Figure 1). **[31]** observed highest shoot dry

weight in peat moss media, which may be due to the reason that peat moss medium is the rich source of all the basic nutrient i.e. nitrogen, phosphorus and potassium which helps in increasing the fertility of the growing media. They also stated that shoot dry weight was totally dependent on the vegetative growth of the plants. [32] observed that tomato plant produces certain type of hormones which regulates the cell elongation, cell division as well as promote vegetative growth.

Root length (cm)

The analysis of data showed that root length was significantly influenced by hybrid cutting and growing media, whereas their interaction had no significant influence on root length of tomato (Table 2). Among the different growing media, longer root length was observed for pure peat moss, while minimum root length (12.25cm) was noticed in control medium (garden soil + FYM + silt). Regarding hybrids, maximum root length (15.05 cm) was observed for Sahil tomato hybrid, while minimum root length (10.75 cm) was recorded for Anna tomato hybrid (Figure 1). [33] studied the effect of various growing media on the geranium cuttings, who observed significant differences for root length in different media. Their results revealed that peat moss medıum gave the highest root length for geranium cutting, whereas the garden soil had lowest length of root (3.7cm). It was noted that peat moss media had almost double root length as compared to garden soil. They also observed that peat moss media having longest root length due to their efficiency of high uptake of nutrients and water holding capacity compared to garden soil. [34] reported that, the downward movement of water and nutrients is one of the best performances of silt. Length of the root is increased because root absorbs water and nutrient in sufficient quantity. [13] reported that Sahil hybrid had a significant effect on root length as compared to Sandal and Salar due to acceleration of endogenous hormone like auxin. **Numbers of roots plant^{-1}**

It is obvious from data presented in (Table 2) that number of roots plant^{-1} were significantly influenced by growing media and hybrids cutting, while their interaction was found non-significant. Maximum numbers of roots plant^{-1} (20.00) were noted in pure peat moss compared to number of roots plant^{-1} (14.92) in control treatment. Among the different tomato hybrids, maximum number of roots plant^{-1} (20.17) was recorded for Sahil hybrid and minimum number of roots plant^{-1} (16.42) observed for Anna hybrid (Figure 1). Significant differences were found for number of roots plant^{-1} by [34]. Numbers of roots plant^{-1} depend on plant height and vegetative growth of the plant. Number of roots plant^{-1} increased the water holding capacity, aeration and nutrients uptake for the plants. [35] observed highly significant variations for number of roots plant^{-1} among the hybrids at different media. Peat moss media contains essential nutrients which are readily available to the plant and acts as a soil conditioners to hold water. Peat moss growing media is the rich source of magnesium and potassium which enhances the growth and development of the plant. Maximum number of root cutting^{-1} might be due to availability of fundamental nutrient provided by peat moss medium. The present studies are in line with [36] who also observed significant differences among the media. Among the tomato hybrid Sahil showed maximum response to produced highest number of roots as compared to other hybrid through cuttings because it has capability of early root formation, resistance against diseases and pest [13].

Root fresh weight (g)

Different growing media and hybrids cutting significantly affected root fresh weight,

while their interaction for leaf area was found non-significant (Table 2). The data for growing media showed that maximum root fresh weight (3.03g) of tomato was recorded in pure peat moss media. While minimum root fresh weight (1.73g) was observed in control treatment. Regarding hybrids, Sahid had maximum root fresh weight (2.67g) as compared to other hybrids (2.32, 2.18 and 1.94) (Figure 1). Root fresh weight revealed significant differences among tomato hybrids and growing media. Auxiliary branches depend upon the availability of nutrients in the media, while media should be free from pathogen, weeds, insect pest and nematodes. Significant variations were observed for root fresh weight by **[34]**. **[37]** observed that organic matter of the media had profound effects on its biological, physical and chemical properties. **[38]** reported that longer root penetrate deeply and have the ability to absorb high amount of water and nutrients as a result heavier weight of fresh root was recorded. It was also reported that adequate aeration and drainage was obtained through fine sand medium, which lead to increase porosity and better initiation of roots. **[39]** also reported that growing media had a significant effect on the growth of the cutting. **[40]** investigated that various media for growing, generate new roots and to promote root formation in tomato cloning through cuttings, the important thing is to activate plant hormone like IAA which plays a vital role in the formation of adventitious roots in tomato cuttings.

Root dry weight (g)

It is obvious from (Table 2) that tomato hybrids and different growing media significantly influenced the dry root weight of tomato plant, whereas their interaction was found non-significant for root dry weight. Among the different growing media, maximum dry root weight (0.42 g) was recorded in pure peat moss, while lowest dry root weight (0.28 g) was resulted in control treatment. Similarly hybrids, highest dry root weight (0.40 g) was recorded for Sahil hybrid which was at par with root dry weight of Sandal (0.36), while minimum dry root weight (0.27 g) were observed for Anna hybrid. Root dry weight of tomato cuttings depend upon the vegetative growth of tomato plants. Among all organic media, peat moss media showed maximum root dry weight. Similar results were also reported by **[34]** for (*Ficus binnendijkii*) root dry weight.

Table 1. Physico-chemical characterization of the growing media used for growing tomato cuttings

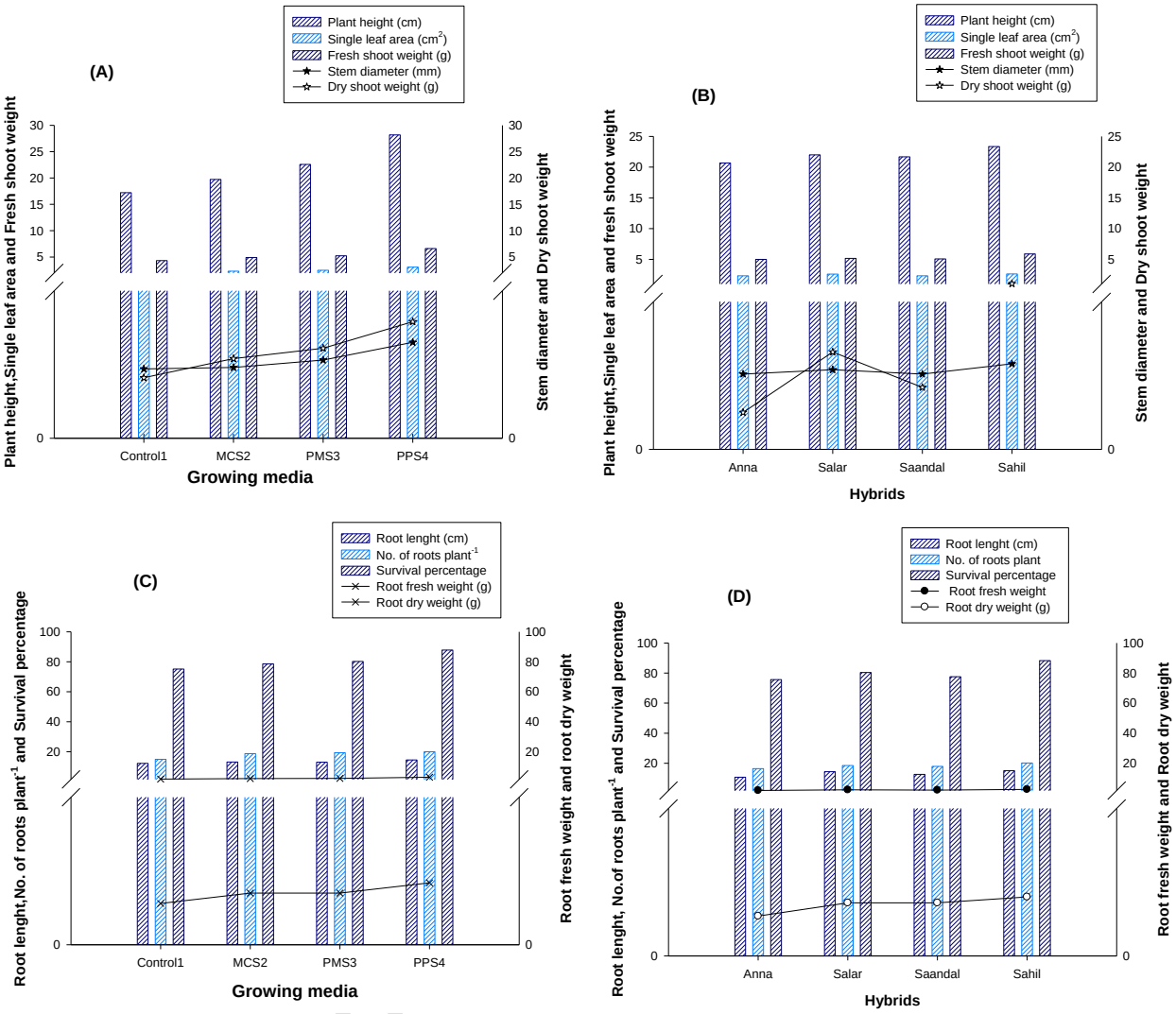
Growing media	pH	Organic matter (%)	N (%)	P (%)	K (%)
Control[1]	7.5	5.28	0.13	0.004	0.037
MCS[2]	7.3	4.9	0.09	0.005	0.006
PMS[3]	6.5	6.01	0.51	0.0032	0.115
PPS[4]	6.1	7.65	0.76	0.0045	0.135

[1]Control: Garden soil+ silt+ FYM; [2]MCS: Mushroom compost +silt; [3]PMS: Peat moss +silt; [4]PPS: Pure peat moss

Table 2. Mean Square value of growth and quality characteristics of tomato as influenced by different growing media and tomato hybrids

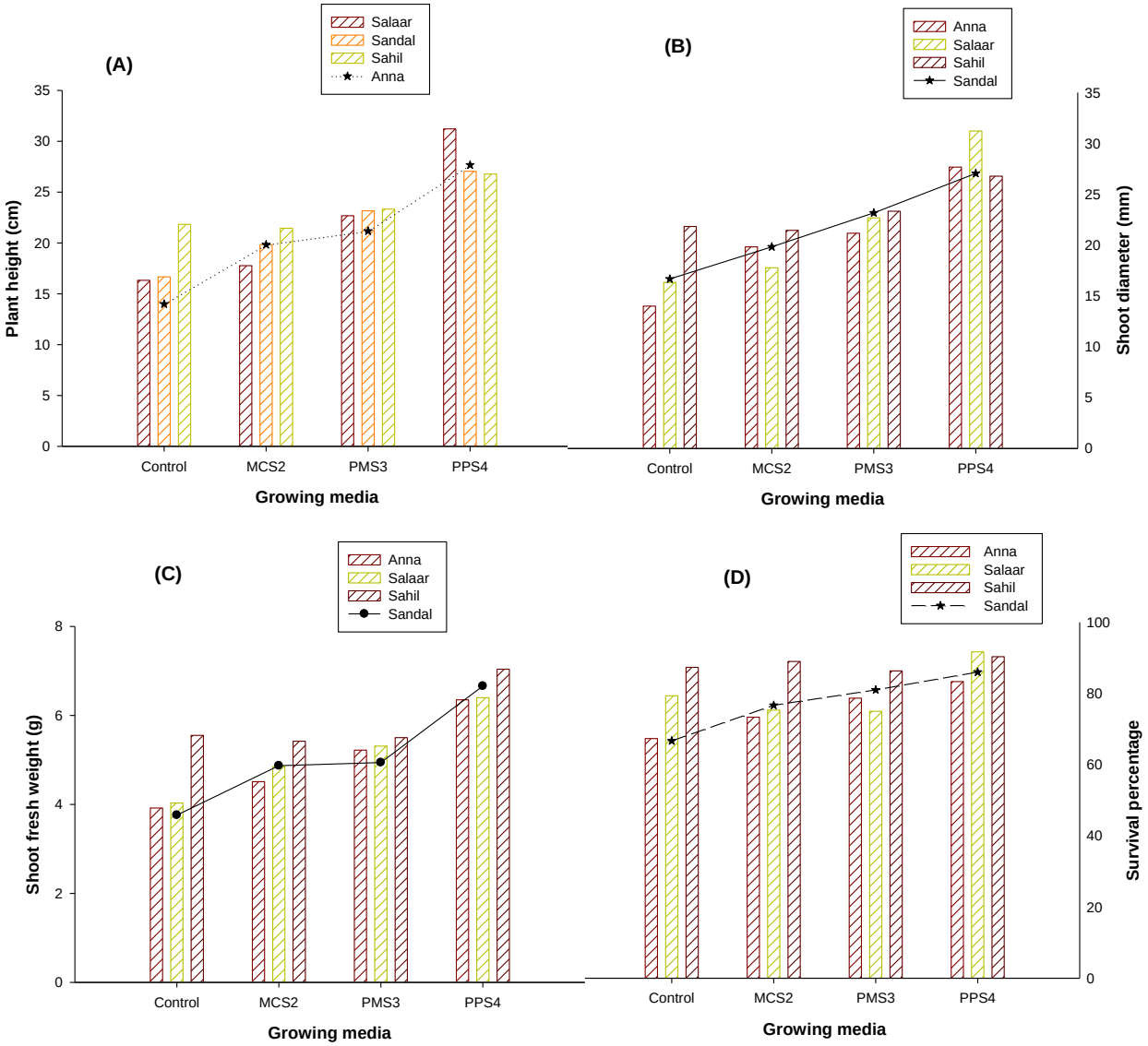
SOV	DF	Mean Square (MS)									
		PH	SP	SLA	FSW	SDW	LOR	NORPP	RFW	RDW	SP
Rep	2	3.711^{ns}	0.004^{ns}	0.051^{ns}	0.143^{ns}	0.024^{ns}	4.673^{ns}	19.75^{ns}	0.282^{ns}	0.006^{ns}	18.396^{ns}
Media (M)	3	266.7***	0.082***	2.543***	11.38***	0.297***	10.46**	62.389***	3.541***	0.039***	343.8***
Hybrids (H)	3	14.678***	0.011***	0.349***	2.004***	1.378***	44.98***	28.833**	1.108***	0.034***	367.81***
M×H	9	13.507***	0.007***	0.101^{ns}	0.319^{ns}	0.065***	2.771^{ns}	19.704^{ns}	0.188^{ns}	0.014^{ns}	64.565***
Error	30	3.958	0.002	0.119	0.065	0.015	2.43	14.15	0.175	0.009	19.045
Total	47										

PH: Plant height; SD: Shoot diameter; SLA: Single leaf area; FSW: Fresh shoot weight; SDW: Soot dry weight; LOR: Length of root; NORPP: Number of root per plant; RFW: Root fresh weight, RDW: Root dry weight, and SP: Survival percentage,***:$p \leq 0.0001$; ***:$p \leq 0.001$; ns: Non-significant



[1]Control: Garden soil+ silt+ FYM; [2]MCS: Mushroom compost +silt; [3]PMS: Peat moss +silt; [4]PPS: Pure peat moss

Figure 1. Growth and quality attributes of tomato as influenced by various hybrids (A, C) and growing media (B, D)



[1]Control: Garden soil+ silt+ FYM; [2]MCS: Mushroom compost +silt; [3]PMS: Peat moss +silt; [4]PPS: Pure peat moss

Figure 2. Plant height (A), Shoot diameter (B), Shoot fresh weight (C) and Survival percentage (D) of tomato as influenced by interaction between tomato hybrids and various growing media

Survival Percentage (cm)

The analysis of data revealed that survival percentage for growing media, hybrids cutting and their interaction was found significant (Table 2).The highest survival percentage was observed in pure peat moss (87.83%) followed by survival percentage in peat moss+silt (80.25%), while plants grown on control treatment had lowest survival percentage (75.17%). Regarding hybrids, Sahil had maximum survival percentage (88.25%) as compared to other hybrids (80.33, 77.53 and 77.67%) (Figure 1). The interaction between growing media and tomato hybrids revealed that maximum survival percentage (91.67%) was recorded by Salar hybrid followed by Sahil hybrid (90.33%) in peat moss, while the minimum survival percentage was obtained by Saandal hybrid (66.67%) in control treatment (Figure 2). Favorable environmental factors are usually required for the survival of the plant;

the most important factor required for the survival and production is growing media. It was concluded that more number of plants survive in growing media, when supplemented with peat moss medium in comparison to those media having (Canal silt + Garden soil). Peat moss growing media is the rich source of organic matter which is readily available for plant growth. The highest survival percentage of cutting in these media provide the better environment (physical) and sufficient elements to the cutting which are required to activate biochemical and enzymatic processes. **[40]** observed highly significant differences for potting media, while studying the effect of growing media on jojoba cuttings. They observed high value of (76.80%) survival in field (soil+ peat moss) followed by that of (field soil +leaf mold) (75.00%). **[41]** investigated the response of different growing media on tomato hybrid and reported that tomato hybrid produced more roots per cutting with less mortality percentage and diseased free plants production.

Conclusion

It was concluded from the results of the present experiment that amongst various growing medium, tomato plants grown on pure peat moss gave better vegetative growth as compared to other growing media. Sahil axillary cuttings showed good performance amongst other tomato hybrids. It could be recommended that pure peat moss growing media should be used for growing tomato hybrid cuttings and Sahil tomato hybrid for better vegetative propagation.

Authors' contributions

Conceived and designed the experiments: M Alam, Performed the experiments: Samiullah, Analyzed the data: Z Hussain & M Asif, Contributed materials/ analysis/ tools: I Ahmad, SQA Shah, MA Shah & JR Khan, Wrote the paper:I Ullah & Z Hussain.

References

1. Unal M (2013). Effect of organic media on growth of vegetable seedlings. *Pak J Agri Sci* 50(3): 517-522.
2. Mohammadi-ghahsare A, Alifar N & Honarjoo N (2010). Effect of culture medium type on yield and absorption of some nutrient elements in greenhouse cucumber. *Season J of Sci and Tech of Greenhouse Cultures* 1(1): 19.
3. Grunert O, Perneel M & Vandaele S (2008) Peat-based organic grow bags as a solution to the mineral wool waste problem// Mires and Peat 3 :1–5
4. Riaz A, Arshad M, Younis A, Raza & Hameed (2008). Effects of different growing media on growth and flowering of *zinnia elegans* cv. blue point. *Pak J Bot* 40: 1579-1585.
5. Anonymous. Modern Agriculture is Sustainable Agriculture Retrieved from (http://www.faircolorado.org/modern-agriculture-is-sustainable-agriculture/).
6. Hughner RS, McDonagh P, Prothero A, Shultz II CJ & Stanto J (2007). Who are organic food consumers? A compilation and review of why people purchase organic food. *J Consum. Behav* 6: 94–110.
7. Lairon D (2009). Nutritional quality and safety of organic food. A review. *Agron Sustain Dev* 30: 33–41.
8. Dangour AD, Dodhia SK, Hayter A, Allen E, Lock K, Uauy R (2009) Nutritional quality of organic foods: a systematic review. *Am J Clin Nutr* 90: 680-685.
9. Aksoy U (2001). Ecological agriculture: a general view. pp 3-10. In: Ozturk, A; Akkaya, F, ed. 2001. Proceedings of the Symposium on Ecological Agriculture. The Turkish Agricultural Society, Antalya, Turkey.
10. Baade E (1985). Einstellungen und Verhaltensweisen bei Verbrauchern von

"Bio'-Produkten. AID-Verbrauch 30: 245-253.
11. Ejaz M, Rehman SU, Waqas R, Manan A, Imran M & Bukhari MA (2011). Combined efficiency of macro-nutrients and micro-nutrients as a foliar application on growth and yield of tomato grown by vegetable forcing. *Inter J for Agro Vet Med Sci* 5(3): 327-335.
12. Adalid AM, Rosello S & Nuez F (2004). Breeding tomatoes for their high nutritional values. *Rec Res Dev Plant Sci* 2: 33-52.
13. Waheed A, Hamid FS, Abbasi FM, Alam S, Shah AH, Ahmad N, Naheed Z, Ali H & Khan N (2015). Effect of Indole Buteric Acid (IBA) on early root formation (Tomato "Sahil" hybrid) cuttings. *J Material Environ Sci* 6(1): 272-279.
14. Al-Saqri F &Alderson PG (1996). Effects of IBA, cutting type and rooting media on rooting of Rosa centifolia. *J Hort Sci* 71: 729-737.
15. Hartmann HT, Kester DE, Davies FT & Geneve LR Jr (1997). Plant propagation: Principles and Practices (6th Edn), Prentice Hall International Edition, Englewood Cliffs, New Jersey, USA, pp 880.
16. Afzal M, Khan MA, Pervez MA & Ahmed R (2011). Root induction in the aerial offshoots of date palm (*Phoenix dactylifera* L.) cultivar, Hillawi. *Pak J Agri Sci* 48:11-17.
17. Ullah E, Awan AA, Abbas SJ, Masroor FS & Khan (2012). Growth response of various olive cultivars to different cutting lengths. *Pak J Bot* 44(2): 683-686.
18. Khan NT, Ghulam J, Tariq S, Mehmood T, Hussain S (2011). Effect of different concentration hormones on growth of tomato cuttings (*Solonum esculantus* L.) *J Agric Res* 49(2): 417-423.
19. Steel R, Torrie JH & Dickey D (1997). Principles and procedures of statistics. A biometrical approach, 3rd ed. McGraw hill publishers, New York.
20. Rahman Z, Aboutalibi A & Hassanzadeh H (2013). Effect of various culture media on tomato transplant production. *Inter Res J Appl Basic Sci* 4(2): 326-328.
21. Sagervanshi A, Kumari P, Nagee A & Kumar A (2012). Isolation and characterization of phosphate solubilizing bacteria from Anand Agriculture Soil. *Inter J Life Sci Pharm Res* 23: 256-266.
22. Mehmood TM, Ahmad W, Ahmad KS, Shafi J, Shehzad MA & Sarwar MA (2013). Comparative effect of different potting media on vegetative and reproductive growth of floral shower (*Antirrhinum majus* L.). *J Plant Sci* 1(3):104-11
23. Omovbude S, Oni OO & Azghb E (2016). Growth responses of two varieties of heliconia flowers to selected growth media in port horticulture south Nigeria. *Afric J Plt Sci* 10(3): 68-76.
24. Sajid M & Amin NU (2014). Effect of various combinations of nitrogen, phosphorus and potash on enhancing the flowering time in Chrysanthemum (*Chrysanthemum morifolium*). *Inter J Biol Sci* 4(10): 99-108.
25. Meyer BS, Banderson D, Bohning DH & Fratianne DG (1973). Introduction to plant physiology. D Van Nostrand Company Newyork. pp 193-322.
26. Costa CT, Almeida MR, Ruedell CM, Schwambach J, Maraschin FS & Fett-Neto AG (2013). Harmonal control of adventitious rooting in cuttings. *Plant Cell Biol* 4(133):1-19.
27. Aghdak P, Mobli M & Khoshgoftarmanesh AH (2016). Effect of different growing media on

vegetative and reproductive growth of bell pepper. *J Plant Nutr* 39(7): 967-973.
28. Samavatipour P, Slehi R & Abdossi V (2015). Vermicompost as a soil supplement to improve growth of tomato (*Lycopersicum esculantum*). *Inter Res J Appl Basic Sci* 9(8): 1345-1347.
29. Sardoei AS & Shahdadneghad (2015). Effect of different growing media on the growth and development of zinnia (*Zennia elanga* L) under the agro climatic condtions of Jarup. *Res J Environ Sci* 9(6): 302-306.
30. Chao L, Limingchen C & Zinhuang L (2001). Effect of Indole-3-Buteric Acid on the endogenous hypocotyls during adventitious root formation. *J Plant cell Physiol* 1(4): 1257-1262.
31. Mousa GT, Abdul-Hafeez EY & Ibrahim OHM (2015). Response of gardenia plants grown under various growth media and ferrous sulfate application. *Pak J Agri Sci* 52(3): 651-658.
32. Najma YC, & Saima (2003). Study of external and internal morphology of *Pisum sativum* L. with growth hormones. *Pak J Biol Sci* 6(4): 407-412.
33. Mamba B & Wahome PK (2010). Propagation of Geranium (*Perlagonium hortorum*) using different rooting medium components. *American-Eurasian J Agric Environ Sci* 7(5): 497-500.
34. Shah M, Khatak AM & Amin NU (2006). Effect of different growing media on the rooting of ficus binnendijkii 'amstel queen' cuttings. *J Agri Biol Sci* 1(3): 15-17.
35. Kiran M, Baloch JUD & Waseem K (2007). Effect of different growing media on growth and development of Dahlia (*Dahlia hybrida* L.) under the agro climatic conditions of Dera Ismail Khan. *Pak J Biol Sci* 10(22): 4140-4143.
36. Irshad M, Rab A, Rahman J, Sajid M, Khan I, Ali S, Razzaq M & Sallahuddin (2014). Influence of different planting dates and media on growth of kiwi (*Cv Hayward*) cuttings. *Sarhad J Agric* 30(4): 419-424.
37. Kambooh CMS (1984). Desi Khadein. Zarat Nama 23(9): 26-28.
38. Adugna M, Belew D & Tilahun (2015). Influence of rooting media and number of nodes per stem cutting on nursery performance of vanilla (*Vanilla planifolia syn. fragrans*). *J Horti Forest* 7(3):48-56.
39. Odongo T, Isutsa DK, Aguyoh JK (2008). Effect of integrated nutrient sources on growth and yield of strawberry grown under tropical high altitude conditions. *Afr J of Hort Sci* 1: 53-69.
40. Rao VK, Kasula K, Umate P, Sree T, Rao AV & Abbaganisadanandam (2004). Introduction of multiple shoots from leaf segments invitro flowering and fruiting of dwarf tomato. *J Plant Physiol* 162(8): 959-962.
41. Bashir AM, Ahmad M & Anjum MA (2007). Effect of various potting media on growth of rooted jojoba (*Simmondsia chinensis*) cutting. *Int J Agri Biol* 9(1): 147-152.