Pure Appl. Biol., 11(3):704-708, September, 2022
http://dx.doi.org/10.19045/bspab.2022.110071

Research Article

Pre and postharvest evaluation of hydroponically grown tomato at different maturity stages

Hafiz Nazar Faried[1*], Zeeshan Haider[1], Ishtiaq Ahmed Rajwana[1], Ali Asad Bahar[1], Shahzad Ahmed[2], Sami Ullah[1], Kashif Razzaq[1], Gulzar Akhtar[1], Muhammad Amin[1], Ambreen Naz[3], Arslan Mehmood[1], Abdul Manan Athar[1] and Muhammad Shahzad Zafar[4]

1. Department of Horticulture, MNS University of Agriculture, Multan, Pakistan
2. Department of Agri-engineering, MNS University of Agriculture, Multan, Pakistan
3. Department of Food Science and Technology, MNS University of Agriculture, Multan, Pakistan
4. Mango Research Station, Shujabad, Pakistan

**Corresponding author's email: nazar.farid@mnsuam.edu.pk*

Citation
Hafiz Nazar Faried, Zeeshan Haider, Ishtiaq Ahmed Rajwana, Ali Asad Bahar, Shahzad Ahmed, Sami Ullah, Kashif Razzaq, Gulzar Akhtar, Muhammad Amin, Ambreen Naz, Arslan Mehmood, Abdul Manan Athar and Muhammad Shahzad Zafar. Pre and postharvest evaluation of hydroponically grown tomato at different maturity stages. Pure and Applied Biology. Vol. 11, Issue 3, pp704-708. http://dx.doi.org/10.19045/bspab.2022.110071

Received: 30/07/2021 Revised: 20/09/2021 Accepted: 23/09/2021 Online First: 07/10/2021

Abstract

Tomato is a valuable crop preferably grown in greenhouse under soil and soilless cultivation system. Tomato demand in the country has been increasing at 7.3% annually while the yield is 9.5 tons ha^{-1} that is not only stagnant but also the only 25% of the global average (38-ton per ha). Therefore, one needs to find the alternate high production technologies like soilless greenhouse farming. In this regard, a pre- and post-harvest studies were planned to evaluate the performance of beefsteak (cv Badia) and plum (cv Sahil) tomatoes grown in soilless cultivation system under partially controlled greenhouse. Additionally, the fruits were harvested at three maturity stages (M_1: Mature green, M_2: Turning and M_3: Ripped tomatoes) for its shelf-life testing. Different morpho-physio-biochemical attributes were recorded as per the requirement. Pre-harvest results indicated that the cultivar Badia performed better than Sahil in number of leaves, inter-nodal distance and fruit size, photosynthetic rate, transpiration rate, stomatal conductance, sub-stomatal CO_2, and water use efficiency. However, cultivar Sahil performed better in total soluble solids (TSS°), ascorbic acid and total acidity.

Keywords: *Lycopersicon esculentum*; Photosynthesis; Soilless; Vitamin C

Introduction

Tomato is a popular vegetable in Pakistan and widely utilizes for salads and cooking. It's a rich source of minerals and vitamins **[1]**. However, antioxidant activity depends on variety, growing conditions, and ripening stages **[2]**. In Pakistan, tomato is cultivated on an area of 55,260 ha with an annual production of 0.56 million tons during kharif and rabi seasons (protected off season). Additionally, Pakistan exported 29,160 tons worth 1161 million PKR while imported 182153 tons worth 3676 million PKR during 2019 **[3]**. Being tender, tomato crop is more prone to soil and air borne biotic and abiotic (temperature, drought, salinity etc.) stresses, thereby negatively affecting its growth, development, yield, and quality. Besides, market demand couldn't be

fulfilled mostly due to poor cultivation techniques, inappropriate cultivar selection, insufficient plant nutrition, adverse climatic conditions, pest, and disease infestation. Moreover, the demand for tomato and its products has been increasing at a rate of 7.3% per annum, much higher than the current production. Pakistan earns only 28% of the world average export price suggesting great challenges in improving tomato value chain. The country exports less than 1% of its production while the world average export-production ratio is 4.7%. Pakistan has great potential to improve its export-production ratio because of its lower farm gate prices than the world average. In this connection, Pakistan may become an exporter of tomato by adopting new techniques to improve the existing practices and move towards the protected cultivations and production [4].

Hydroponic technology has been adopted widely as an industrial agriculture and NASA declares it a cultivation system for space stations [5]. Hydroponic systems have different supporting medium for growing the plant roots like coconut coir, peat moss, vermiculite and rock wool. Aggregate systems have a solid medium of support. Hydroponic growing media are designed porous for excellent retention of air and water. Healthy plant-roots are developed by good breath [6]. It does not harm our environment as runoff fertilizer enriched water is reutilized. It is useful technology particularly for drought and salinity affected areas. Water and nutrients are used efficiently with an appropriate regulation of electrical conductivity (EC) and pH of the nutrient solution along-with optimum growing temperature. Therefore, soilless production system provides an optimum environment for growth and progress of plants which results in higher yield and value as compared to traditional production methods [7]. Mostly, high value vegetables (e.g. tomato, pepper, cucumber, greens) ate grown under hydroponic cultivation system. Most of the vegetables are perishable. Poor handling and transport system affects produce quality, thereby higher postharvest losses which are 24-40% in developing countries while 2-20% in advanced countries [8]. Tomato crop have a short life spam due to higher water contents and respiration during its ripening period [9]. Therefore, reduction in post-harvest losses of tomato crop is required for improved food security particularly in emerging countries [10]. In developing countries like Pakistan, a unified and comprehensive approach is required for pre- and post-harvest studies of high value crops like tomato (beefsteak and plum) particularly under soilless greenhouse cultivation system for higher and quality production per unit area to fulfill indigenous sustainable requirement and foreign exchange earnings. In this regard, a soilless tomato cultivation study was planned to compare yield and shelf quality of beefsteak and plum tomato under semi-arid climate of the South Punjab.

Materials and Methods

The study was conducted at Latitude of 30° 8'26.93"N and longitude of 71°26'35.43"E in a hydroponic unit located at University Research Farm, MNS-University of Agriculture, Multan. The study was aimed to evaluate the performance of hydroponically grown tomato cultivars (CV_1: Badia and CV_2: Sahil) at three maturity stages (T_1 Mature green, T_2 Turning and T_3 Ripped) with factorial arrangement under complete randomized design (CRD) replicated thrice. An economical nutrient recipe with a defined fertigation schedule was developed to ensure the appropriate provision of water and nutrient as per growth stages. Following temperature and relative humidity were observed during the entire study (Table 1).

Pre-harvest data includes germination percentage, number of leaves, number of clusters, inter nodal distance (cm), shoot fresh and dry weight (g), number of fruits per cluster, and fruit size (cm). Moreover, gaseous exchange parameter includes photosynthesis rate (*Pn*), transpiration rate

(*E*), stomatal conductance (*gs*) and sub-stomatal (*Ci*) were assessed from top 3rd- 4th intact tomato plant's leaf from 11:30 am to 2:30 pm with the help of CIRAS-3 Portable Photosynthetic System SW Version 2.00 Console Serial Number, C3F0255 by PP System, Amesbury, MA, USA. Besides this, post-harvest analysis includes titratable acidity (TA %), total soluble solids (TSS), and vitamin C (mg 100 g^{-1} of juice) which were carried out in postharvest science and technology lab, central lab system. Collected data was subjected to analysis of variance (ANOVA) by using Statistix 8.1.

Table No 1. Average Maximum and Minimum Temperature (˚C) and Relative humidity (%) of the Greenhouse during the Crop Season

	Temperature (˚C)		Relative Humidity (%)	
Month	**Min**	**Max**	**Min**	**Max**
January	22.6	27.8	60.1	64.6
February	26.3	31.7	61.8	65.1
March	29.4	30.8	64.2	67.4
April	32.7	34	63.6	68.3
May	33.2	36.1	66.7	71.2

Results and Discussion

Pre-harvest results showed that germination percentage was found 100% in both cultivars. The cultivar Badia attained maximum number of leaves (43) and inter-nodal distance (2.67 cm). However, the cultivar Sahil attained maximum number of clusters (13), number of fruits per cluster (6.86), thereby the total number of fruits per plant (66). However, maximum fruit size was attained by cultivar Badia (82.13 mm) followed by Sahil (37.88 mm) (Table 2). Additionally, the cultivar Badia showed maximum fruits size. The results are in line to the findings of other studies **[11]** which might be associated that reduced internodal distance and number of clusters promotes fruit size. Similarly, in this connection, gaseous exchange attributes demonstrated that cultivar Badia attained maximum photosynthetic rate (10.03), transpiration rate (18.98), stomatal conductance (163.71), sub stomatal conductance (256.71), water use efficiency (5.97) and vapor pressure deficit (3.05) as compared to cultivar Sahil (Table 3). Irrespective to all this, post-harvest analysis results showed a significant difference among three maturity stages (Green, Turning and Red) of the tomato cultivars. The cultivar Badia showed that the titratable acidity (TA) showed a decreasing trend from green stage to red. Maximum range of TA was observed at green maturity stage (0.35) and minimum was observed at red maturity stage (0.26). Total soluble solids (TSS) and vitamin C were also influenced at different maturity stages (Table 4). Vitamin C showed an increasing trend from green to red maturity stage. The maximum increase of vitamin C was in red maturity stage (120 mg/100ml). The amount of Vitamin C ranged from 60 to 120 among three maturity stages (Green, Turning and Red) of Badia cultivar (Table 4). Similarly, the cultivar Sahil also depicted a decreasing trend in titratable acidity (TA) from green to red stage. Moreover, the total soluble solids (TSS) and vitamin C of cultivar Sahil were also influenced at different maturity stages (Table 4). TSS contents were found higher at red maturity stage (3.53) while lower at turning stage (3.13). Our results are in lined to the findings of **[12]** they reported that TSS content in fruits of tomatoes ranged between 3.6 to 5.7 °Brix, respectively. Similarly, vitamin C contents were found higher at red maturity stage (134), followed by turning stage (108) whereas lowest reading was recorded at green stage (103) (Table 4).

Table 2. Morphological Attributes

Cultivars	Emergence %	No of leaves	No of cluster	*IND (cm)	No of fruit/cluster	Fruit size (mm)	No of Fruit / plant
Badia	100a	43.5a	10.5b	2.67a	4.28b	82.13a	38b
Sahil	100a	38.5b	13a	2.53b	6.86a	37.88b	66a

*IND Internodal distance

Table 3. Physiological attributes of tomato leave of top third leave

Varieties	*Pn* (µmol CO_2 m^{-2} s^{-1})	*E* (mmol H_2O m^{-2} s^{-1})	*gs* (mmol H_2O m^{-2} s^{-1})	*Ci* (µmol mol^{-1})	WUE (mmol CO_2 mol^{-1} H_2O)	VPD (kPa)
Badia	10.03a	18.98a	163.71a	256.17a	5.97a	3.05a
Sahil	8.88b	12.69b	123.38b	231.71b	3.97b	2.65b

*Photosynthesis Rate (*A*), Transpiration Rate (*E*), Stomatal Conductance (*gs*), Sub-Stomatal CO_2 (*Ci*), Water use efficiency (*WUE*), Vapor Pressure Deficit (*VPD*)

Table 4. Biochemical Parameters

CVs	Observation	Green	Turning	Red
Badia	Titrable Acidity (TA) (%)	0.35	0.27	0.26
	Total Soluble Solids (TSS) (°Brix)	2.3	3.2	4.5
	Vitamin C (mg/100g)	62	82	120
Sahil	Titrable Acidity (TA) (%)	0.25	0.21	0.23
	Total Soluble Solids (TSS) (°Brix)	3.46	3.13	3.53
	Vitamin C (mg/100g)	103	108	134

Conclusion

Pre- and post-harvest analysis of hydroponically grown tomato cultivars (Badia and Sahil) elaborating that cultivar Badia performed well in improving the physiological attributes, number of leaves and fruit size. However, the cultivar Sahil performed better in increasing the number of clusters, number of fruits per cluster, and post-harvest attributes (TSS and ascorbic acid).

Authors' contributions

Conceived and designed the experiments: HN Faried, IA Rajwana, S Ahmed, K Razzaq & M Amin, Performed the experiments: Z Haider, A Mehmood, AM Athar & A Naz, Analysed the data: G Akhtar & S Ullah, Contributed reagents/ materials/ analysis tools: A Naz & MS Zafar, Wrote the paper: HN Faried, Zeeshan Ahmad & AA Bahar.

References

1. Frusciante LB, Barone D, Carputo MR, Ercolano F, Della R & Esposito S (2000). Evaluation and use of plant biodiversity for food and pharmaceuticals. *Fitoterapia* 71: 66-72.
2. Leonardi CP, Ambrosino F, Esposito & Fogliano V (2000). Antioxidant activity and carotenoid and tomatine contents in different typologies of fresh consumption tomatoes. *J Agric Food Chem* 48: 4723–4727.
3. MNFSR. (2017). Fruit, Vegetables and Condiments Statistics of Pakistan 2013-2014. Govt. of Pakistan, Ministry of National Food Security and Research, Islamabad.
4. Tahir A, Shah H, Sharif M, Akhtar W & Akmal N (2012). An overview of tomato economy of Pakistan: comparative analysis. *Pak J Agric Res* 25: 288-295.

5. Plooy Du, Maboko CP, Van den Heever MM & Chiloane S (2012). Research and technology transfer by Agricultural Research Council to sustain South African hydroponic industry. *Acta Hortic* 947: 147-151.
6. Lakkireddy K & Kondapalli K (2012). Role of Hydroponics and Aeroponics in Soilless Culture in Commercial Food Production.
7. Maboko MM, du Plooy CP & Bertling I (2009). Comparative performance of tomato on soilless vs in-soil production systems. *Acta Hortic* 843: 319-326.
8. Rosa S (2006). Postharvest management of fruit and vegetables in the Asia-Pacific region/Asian Productivity Organization. Food and Agricultural Organization (FAO).
9. Ullah J (2009). Storage of fresh tomatoes to determine the level of (CaCl2) coating and optimum temperature for extended shelf life, Asian Institute of Technology Bangkok, Thailand.
10. Kader AA (2005). Increasing food availability by reducing postharvest losses of fresh produce. *Inter Postharvest Symposium* 682: 2169-2176.
11. Saleem MY, Asghar M, Haq MA, Rafique T, Kamran A & Khan AA (2009). Genetic analysis to identify suitable parents for hybrid seed production in tomato (Lycopersicon esculentumL.). *Pak J Bot* 41(3): 1107-1116.
12. Dar RA, Sharma JP, Nabi A & Chopra S (2012). Germplasm evaluation for yield and fruit quality traits in tomato (*Solanum lycopersicon* L.). *Afr J Agri Res* 7: 6143-6149.