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Optimizing Tomato Grafts for Improved Growth, Yield and Fruit Quality

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Abstract

Low tomato production and yield in the country can be attributed to various biotic and abiotic stresses. To mitigate the impact of these challenges, vegetable grafting is gaining popularity worldwide. Furthermore, tomato growers are adopting hybrid varieties, but the majority of them face challenges affording the cost of hybrid seeds. This study was conducted in 2018 to investigate successful tomato grafting techniques aimed at enhancing growth, yield, and fruit quality. This study examined three distinct rootstocks (AS-2565, Bush beefsteak, and Roma vf), three high-yielding scion varieties (Super tomato, Rio-grande, and T-1359), and employed two grafting methods (splice and cleft). Non-grafted plants were maintained as check plants. The grafting methods showed non-significant differences in all studied parameters except grafting success, whereas the scion-rootstock combinations exhibited highly significant differences. The highest grafting success, number of fruits per plant, fruit length, fruit diameter, fruit weight, and yield per plant were observed in the T-1359 scion grafted onto the Bush beefsteak (BBS) rootstock. Regarding quality characteristics, higher levels of total soluble solids (TSS) and pH were observed in non-grafted Super tomato plants. In terms of vitamin C, titratable acidity (TA), and lycopene content, the T-1359 scion performed better across various rootstocks. In conclusion, T-1359 grafted onto the BBS rootstock proved to be a superior scion-rootstock combination in terms of growth, yield, and quality.

Key words: stionic establishment, production, quality characteristics,

Introduction

The demand of vegetables throughout the world is increasing in response to the growth of population, living standards and active encouragement to consume vegetables by the government health agencies (Yahia *et al.*, 2019). The tomato is commercially important worldwide both for fresh fruit market and processed food industries. The lack of good quality seed and poor knowledge about the varieties leading production issues. The production of seed is very technical and highly specialized expert activity. Growers are unable to produce their own seeds and are forced to purchase seeds from unknown resources. Despite the availability of a number of hybrid seeds growers find it difficult to grow tomatoes, one of the reasons being that they are suitable locally but require careful management. Majority of tomato growers are also finding difficulty in affording the cost of the hybrid seeds. The existing biotic and abiotic stresses and low soil fertility issues may also encounter to the low production of tomato plant (Shao *et al*., 2015). Besides, soil-borne diseases are also one of the main contributors to the low production of tomato. The tomato seedlings are usually destroyed by damping off and adult plants are getting damaged due to wilt and leaf minor diseases (Zhang *et al*., 2022). To overcome all these problems in the direction to enhance tomato production, vegetable grafting may be a better solution to the mentioned issues related to the cultivation of tomato. Vegetable grafting started in Japan at the end of 1920s when watermelon plants were grafted onto squash rootstock (Kubota *et al.*, 2008). Grafting is usually applied on number of vegetable crops, but due to intensive labour requirement, it is mostly practiced on cucurbits and solanaceous crops. Different grafting techniques such as hole insertion, splice (top or tube), cleft, approach are applied and results vary from crop to crop. Commonly splice (top or tube), tongue and cleft grafting are applied. Splice grafting is the most widely used grafting method for tomatoes and brinjal (Johnson *et al*., 2011). However, proper selection of the technique is based on the crop, growth stage, size and compatibility of the two plants. Given the rising demand for tomatoes, it is imperative to investigate grafting techniques using improved rootstock and scion varieties, with a focus on enhancing tomato growth, quality, and yield.

Material and Methods

The present experiment was conducted during the year 2018 to explore grafts of tomato for better growth, yield and fruit quality. In this regard, three different rootstocks (AS-2565, Bush beefsteak and Roma vf) and three high yielding scion varieties (Super tomato, Rio-grande and T-1359) were selected for the present study. On the basis of these selected scion and rootstock varieties following combinations were made. Non-grafted plants were maintained as check plants.

Scion-rootstock combinations

A. Non-grafted varieties (Check)

1) Super tomato
2) Rio-grande
3) T-1359

B. Cross grafted

4) Super tomato on AS-2565
5) Super tomato on Bush beefsteak
6) Super tomato on Roma vf
7) Rio-grande on AS-2565
8) Rio-grande on Bush beefsteak
9) Rio-grande on Roma vf
10) T-1359 on AS-2565
11) T-1359 on Bush beefsteak
12) T-1359 on Roma vf

The experiment was conducted in Split plot design, with three replications Two methods of grafting viz. Cleft and splice (tube) grafting were applied to explore better grafts.

Sowing of the seeds for grafting: The seeds of scion varieties were sown few days earlier than seeds of the rootstocks in order to ensure similar diameter at the grafting time because of the differences in growth vigor. The seeds of scion varieties were grown on 15th of August while rootstock seeds on 25th of August in seedling trays capacity of 72 seedlings contained coco peat. On attaining the diameter of approx. 1.5 to 2.5 mm with two to four leaves (Bumgarner and Kleinhenz, 2014; Rivard and Louws, 2011) seedlings were grafted on 17th of September, 2018.

Grafting: The cleft and splice techniques were applied for grafting. In cleft grafting technique a horizontal cut of 5 mm below cotyledon and 4 mm vertical insertion made on rootstock. The scion is prepared in the form of wedge and enters the sharp scion area into the vertical cut of rootstock. This method is also used in cucurbits and some other Solanaceous crops (Lee *et al.*, 2010). In splice grafting, a slanting deep angle cut was given on the rootstock to create more surface area on the cut. Same angle cut of 45° was given on the scion. Both cut areas of the stem were joined and covered with the silicon grafting clip. This technique is commonly used in grafting of tomato seedling on commercial scale in the world (Oda, 1998). It is comparatively speedy process of grafting with an average of 300 to 500 seedlings grafted per hour by one worker (Kubota *et al.*, 2008). The cut parts of scion and rootstock were covered with silicon grafting clips (Plate 1 and 2). After grafting seedlings were placed in the same shade house for few days required for healing and survival of the plants. Grafts were kept in controlled condition in by maintaining an average temperature of 24$\pm$3degree Celsius and relative humidity more than 80% as mentioned by Marsic and Osvald (2004). After two weeks of grafting, grafted and non-grafted seedlings were shifted into the container (pot of 3L) containing a mixture of garden soil and compost (1:1) and shifted in green house maintained at average temperature 24°C. Stalking of the seedlings was followed in the pots The humidity was lowered down slowly, and also increasing the light intensity step by step and bring out from growing chamber gradually expose to outer atmosphere. Successful grafts were shifted to the main field and explored for the growth performance, quality and yield of tomato. Successful grafts were shifted to the main field and explore for the growth performance, quality and yield of tomato.

Land preparation: The land was prepared and ploughed to fine tilth by giving five ploughings. Raised beds of 1.5 feet wide were prepared with furrow ploughs by adjusting the plough width and irrigation channel of 0.5 m between the two raised beds. The prepared beds were irrigated two days' prior the seedling transplantation. The seedlings were transplanted in evening on both sides of the raised beds at a distance of 0.5 meter. In tomato, a balanced fertilizer and compost are essential for proper plant growth. During the preparation of the land, the decomposed manure was added and turned upside down at a rate of 25 tons per hectare. Chemical fertilizers were also applied at a rate of 75 kg of nitrogen, 60 kg of phosphorus and 60 kg of potassium per hectare. Half of all the fertilizer and the full amount of manure was applied during soil preparation. The remaining part of the fertilizer was divided into two equal volumes.

Soil analysis: The soil samples at 0-15 and 15-30 cm depth were collected for the analysis of soil texture, electrical conductivity, pH and organic matter of the soil. The collected soil samples were analyzed for particle size distribution by Hydrometer method, EC and pH were determined by digital EC and pH meters. The organic matter was determined by Walkley and Black method.

Seed germination and vegetative growth observations: Seeds of all tomato varieties were sown in a plastic tray capacity of 50 seedlings in each tray with three replication and data were recorded on emergence of radical size 2 mm (Mohammad *et al.*, 2014). Seed germination was checked on daily basis for upto ten days of sowing and percentage were calculated by the equation of Larsen and Andreasen (2004).

$$GP = \sum n / N \times 100$$

Where n is a number of sprouted seeds at each check and N is all out seeds in every treatment.

Seedling vigor index was determined by using the following formula of Abdul-Baki and Anderson (1973).

Seedling Vigor index (SVI) = [seedling length (cm)× germination percentage. Grafting success will be monitored daily for up to 20 to 25 days and percentage was calculated by the equation of Larsen and Andreasen (2004).

Grafting success = (Number of grafted plants/total number of grafted plants) × 100%

When the plants reached a certain height and then the plant stopped growing, the plants were randomly selected to be measured. The plant height was measured from 50% random plants of each treatment. The height was measured from the base to the tip of the plant with the help of measuring scale and average values were calculated in centimeters.

Flowering and fruit related observations: The flowering and fruiting related observations were recorded from tagged random plants of 50% from each treatment. The days taken to flowering and fruiting were counted from plantation up to flowering and fruit initiation respectively. For number of fruits per plant, harvested fruits at the fully ripened stage were counted and averages were calculated. Fruit length by using measuring scale, fruit diameter by digital vernier caliper, fruit weight by using an electronic weighing balance were recorded at random. The yield per plant was calculated by weighing the total number of fruits harvested from one plant and weighed and yield per plant was expressed in Kilograms.

Quality related observations of tomato fruit: In quality related observations, total soluble solids, pH, vitamin C, titratable acidity, and lycopene content of tomato fruits were analyzed. To determine total soluble solids, juice was extracted from fruits of each treatment and drop of juice was placed on the slab of digital refractometer (Model-HI-96813) and reading was noted. The pH of fruit juice was determined with the help of pH meter (SCT-pH-PEN-5). Vitamin C (mg 100 g^{-1}) of tomato juice was determined in the manner described by Ruck (1961). The titratable acidity of the tomato fruit juice was determined by the method described by Hortwiz (1960). Lycopene content of tomato fruits was determined from fully ripened tomatoes by a method described by Davis *et al.* (2003). The recorded data was statistically analyzed by using Statistix-8.1 computer software (Statistix, 2006). The least significant difference was used to compare the means of the treatment at $P \leq 0.05$.

Results

The soil samples of 0-15 cm and 15-30 cm were analyzed for soil texture, electrical conductivity (EC), pH and organic matter of the soil. The results showed that soil was clay loam in texture, non-saline in nature and EC ranges from 0.32 to 0.58 dS m^{-1} and pH 7.3 to 7.5. The organic matter was less than 1% and ranges from 0.45 to 0.68%.

The data in Table 1 shows significant effect of scion-rootstock combinations and grafting methods on the grafted success (%). The data reveals that each scion-rootstock combination went well and responded more than 50% grafting success. The highest success (88.33%) was observed from the scion-rootstock combination where scion of T13559 was grafted on Bush beefsteak rootstock. The lowest grafting success (54.83%) was observed from scion-rootstock combination of Super tomato and AS2565. These results are at par with the results (55.17%) obtained from Rio-grande when grafted on the same rootstock AS2565. To compare means of the grafting methods, cleft grafting had more success (74.52%) as compared to splice (65.59%).

The data in Table 2 shows results for plant height, days to flower and fruit initiation. All these parameters were significantly affected by the scion-rootstock combinations only. However, grafting methods as an independent factor or in interaction with scion-rootstock combination had no significant differences. The data shows that among three different scion varieties whether grafted or non-grafted, T-1359 had more plant height. The maximum plant height (116.50 cm) was recorded from the grafted plant when T-1359 was grafted on BBS rootstock. However, these results are at par with the results (108.50 cm) when T-1359 was grafted on Roma-vf rootstock or planted as non-grafted (109.00 cm) plant. The Super tomato with BBS rootstock (110.50 cm) had also non-significant results with above mentioned results. The data in Table 2 reveals that among three different scion varieties, non-grafted scions produced early flowering and fruiting than the grafted ones. Non-grafted T-1359 took minimum days (27.67) to start flowering, which is statistically at par with real rooted Super tomato (29.50 dyas) and Rio-grande (31.33 days). Out of self and cross grafted combinations of scion and rootstock, only T-1359 scion with BBS rootstock produced early flowering (31.33 days). While, Rio-grande scion with BBS and AS2565 rootstocks took maximum days (43.17; 42.83) to flowering. The similar trend of the results was observed for fruit setting. The Super tomato non-grafted took minimum days to start fruiting (36.50), which is statistically similar with non-grafted T-1359 (37.00 days), Rio-grande (39.67 days) and grafted combination of T-1359 scion on BBS rootstock (40.00 days. In grafted plants, Rio-grande scion with AS2565 and BBS rootstocks had late fruiting and took 53.50 and 53.33 days respectively to fruiting.

The data in Table 3 shows that among three different scion varieties, T-1359 with BBS rootstock produced maximum number of fruits (35.33), fruit length (7.45 cm), fruit diameter (5.40 cm), fruit weight (101.67 g) and fruit yield per plant (3.58 kg). The similar

Table 1. Effect of different scion-rootstock combinations and grafting methods on the grafting success of the tomato grafts.

Scion-Rootstock combinations	Method of grafting		Grafting success (%)
	Splice	Cleft	
Super tomato/AS-2565	52.00	57.7	54.83 e
Super tomato/BBS	73.33	83.3	78.33 b
Super tomato/Roma-VF	63.33	80.3	71.83 bcd
Rio-grande/AS-2565	46.67	63.7	55.17 e
Rio-grande/BBS	66.67	74.0	70.33 cd
Rio-grande/Roma-VF	66.67	75.0	70.83 bcd
T-1359/AS-2565	67.33	65.0	66.17 d
T-1359/BBS	83.00	93.7	88.33 a
T-1359/Roma-VF	71.33	78.0	78.33 b
	65.59 b	**74.52 a**	

Table 2. Effect of scion-rootstock combinations on plant height, flower and fruit initiation of tomato.

Scion-Rootstock combinations	Plant height (cm)	Flower initiation (Days)	Fruit initiation (Days)
Super tomato-AS2565	94.00 c	33.67 cd	42.83 bcd
Super tomato –BBS	110.50 ab	35.83 bc	44.17 bc
Super tomato-Roma-VF	90.83 c	34.50 bcd	41.50 bcd
Super tomato (Non-grafted)	92.00 c	29.50 e	36.50 e
Rio-grande – AS2565	85.33 c	42.833 a	53.50 a
Rio-grande – BBS	92.00 c	43.17 a	53.33 a
Rio-grande – Roma-VF	68.00 d	34.00 bcd	42.00 bcd
Rio-grande (Non-grafted)	86.00 c	31.33 de	39.67 de
T-1359 – AS2565	104.33 b	37.67 b	45.67 b
T-1359 – BBS	116.50 a	31.33 de	40.00 cde
T-1359 – Roma-VF	108.50 ab	35.33 bc	43.83 bcd
T-1359 (Non-grafted)	109.00 ab	27.67 e	37.00 e

number of fruits per plant (32.67) were also observed when Super tomato was grafted on the same BBS rootstock. The Rio-grande as non-grafted produced minimum fruits per plant (15.0), had minimum fruit length (5.05 cm), fruit weight (52.65 g) and fruit yield per plant (0.79 kg). The data in Table 4 shows that T-1359 grafted or non-grafted had maximum TSS, vitamin C, titratable acidity and lycopene content. Total soluble solids (TSS) of various scion-rootstock combinations whether grafted or non-grafted ranges from 4.42 to 5.67°Brix. The fruits of each non-grafted variety had maximum TSS as compared to the grafted ones producing maximum from Super tomato (5.67°Brix) and T-1359 (5.50 °Brix) However, when T-1359 was grafted on BBS rootstock had also similar TSS (5.15°Brix) as recorded from non-grafted T-1359 (5.50°Brix). The minimum TSS (4.42°Brix) was recorded in Rio-grande scion grafted with Roma-vf. The fruit pH of grafted and non-grafted plants ranges from 4.13 to 4.71. The maximum pH (4.71) was recorded from the grafted plant when Rio-grande was grafted on BBS rootstock. However, these results are statistically non-significant with the results (4.67) while Rio-grande was grafted on Roma-vf rootstock and Super tomato non-grafted (4.55). The maximum vitamin C content (15.67 mg 100 g^{-1}) was recorded from the grafted plant where T-1359 was grafted on BBS rootstock, which was statistically at par with T-1359 non grafted had vitamin C value (15.30 mg 100 g^{-1}). The varietyT-1359 with each rootstock had fruits with maximum TA value ranges from 0.48 to 0.52%. These results are also at par with Super tomato grafted on BBS rootstock results (0.48%). The lycopene content was also recorded higher in non-grafted plants of T-1359 (4.13 mg 100 g^{-1}). These results are at par with the results when T-1359 grafted on BBS and AS2565 rootstocks had lycopene content of 3.98 and 3.90 mg 100 g^{-1}, respectively.

Table 3. Effect of scion-rootstock combinations on fruit yield traits of tomato.

Scion-Rootstock combinations	Fruits per plant	Fruit length	Fruit diameter (cm)	Fruit weight (g)	Fruit yield per plant
Super tomato-AS2565	20.67 cd	5.23 de	4.20 ef	58.17 ef	1.19 ef
Super tomato –BBS	32.67 a	6.53 b	4.63 bcd	94.33 ab	3.09 b
Super tomato-Roma-VF	26.33 b	5.87 c	4.38 cdef	71.83 c	1.92 cd
Super tomato (Non-grafted)	24.00 bc	5.52 cde	4.48 cde	63.00 cde	1.53 de
Rio-grande – AS2565	23.83 bcd	5.62 cd	3.73 g	62.00 cdef	1.48 e
Rio-grande – BBS	21.17 cd	5.52 cde	4.37 cdef	61.67 def	1.30 e
Rio-grande – Roma-VF	20.33 cd	5.43 cde	4.13 f	61.83 cdef	1.25 ef

Rio-grande (Non-grafted)	15.00 e	5.05 e	4.67 bc	52.65 f	0.79 f
T-1359 – AS2565	23.67 bcd	6.40 b	4.50 cde	85.17 b	2.04 c
T-1359 – BBS	35.33 a	7.45 a	5.40 a	101.67 a	3.58 a
T-1359 – Roma-VF	25.67 b	6.52 b	4.92 b	87.33 b	2.26 c
T-1359 (Non-grafted)	20.00 d	5.28 de	4.33 def	68.67 cd	1.37 e

Table 4. Effect of scion-rootstock combinations on quality traits of tomato fruit.

Scion-Rootstock combinations	**Total soluble solids (ºBrix)**	**Fruit pH**	**Vitamin C (mg 100 g^{-1})**	**Titratable acidity (%)**	**Lycopene content (mg 100 g^{-1})**
Super tomato-AS2565	5.12 bc	4.38 bcd	14.23 de	0.47 bc	3.50 cd
Super tomato –BBS	4.83 cd	4.56 ab	14.60 bcd	0.48 ab	3.58 cd
Super tomato-Roma-VF	4.92 cd	4.14 d	14.65 bcd	0.45 bcd	3.48 cd
Super tomato (Non-grafted)	5.67 a	4.55 ab	14.70 bcd	0.40 e	3.73 bc
Rio-grande – AS2565	4.63 cd	4.25 cd	14.23 de	0.42 de	2.97 e
Rio-grande – BBS	4.98 bc	4.71 a	14.42 cde	0.43 cde	3.05 e
Rio-grande – Roma-VF	4.42 d	4.67 a	14.37 de	0.40 e	2.75 e
Rio-grande (Non-grafted)	5.00 bc	4.13 d	13.70 e	0.35 f	3.36 d
T-1359 – AS2565	4.73 cd	4.49 abc	14.38 cde	0.52 a	3.90 ab
T-1359 – BBS	5.15 abc	4.24 cd	15.67 a	0.49 ab	3.98 ab
T-1359 – Roma-VF	4.92 cd	4.29 cd	15.13 abc	0.48 abc	3.02 e
T-1359 (Non-grafted)	5.50 ab	4.38 bcd	15.30ab	0.46 bcd	4.13 a

Discussion

Consumption of tomatoes has the highest potential for growth in demand. Therefore, there is a greater demand for tomatoes in terms of population, economic growth and urbanization (Mari, 2009). Considering the diverse use of vegetable grafts around the world, this technique has the potential to solve the tomato industry's problems and can help increase a farmer's income by improving crop yields and reducing costs by purchasing large quantities of fertilizer and pesticide products. With ever increasing demand of tomatoes, it has become imperative to explore grafting using better rootstock and scion varieties on the basis of growth, quality and yield of tomatoes. Findings from the current study are discussed here under the following section. The grafting success is one of the basic parameters for the assessment of the successful grafting. It is determined by the factors such as seedling performance during grafting, scion and rootstock compatibility (Bumgarner and Kleinhenz, 2014). In the present study, most of the scion and rootstock combinations had more than 70% grafting success and had the highest grafting success from T-1359 with BBS. This indicates that type of rootstock had greater influence on the success of grafting. The compatibility of scion may vary from rootstock to rootstock. Bisognin *et al.* (2005) reported number of factors are involved in the success of grafting such as plant vigor, growing conditions, carbohydrate content and proper match of vascular bundles. Soe *et al.* (2018) grafted scion of “Plantinum 701” a tomato variety on three local rootstocks of tomato, eggplant and hot pepper. They observed grafting success from 70.7 to 87.3% and had the highest success from egg-plant rootstock by using tomato scion.

The method of grafting has also major role in the success of grafting. In the present study more grafting success was observed in cleft grafting over splice. The higher grafting success in cleft grafting may be due to a strong joint of rootstock and scion where as in splice pressure of grafting tube may push the scion upward direction resulting in grafting failure. These results are in line with the results of Draie (2017) who observed more than 98% grafting success through cleft grafting method. Marsic and Osvald (2004) recorded the high percentage of successful grafting 79 to 100% for both tomato scions and rootstocks, using cleft and tube grafting methods. They also reported that both grafting methods (cleft and tube) are suitable for grafting.

The plant height of the grafted and non-grafted plants had significant differences. The taller plants were obtained from the grafted plants where T 1359 was grafted on BBS rootstock. These results are in line with Khah *et al.* (2006) who reported significant differences between grafted and non-grafted plants of tomato cultivars in open field conditions. They obtained taller plants of 75 cm from grafted combination of Big Red and Heman. Waiganjo *et al.* (2011) observed taller plants from the grafts as compared to the non-grafted by using MT56 as rootstock and Onyx as scion for grafting.

Delayed flowering, fruit setting and fruit maturity is a common phenomenon due to grafting of the scion. Each grafted plant took more days as compared to non-grafted. This delay in flowering may be due to shock/stress of graft wound in seedling at the time of rootstock and scion union. Khah *et al.* (2006) reported that when graft union is successful after some time period, then the flow of nutrients is started and physiological processes occurs, therefore it takes more days to flowering as compared to normal flowering of these cultivars. Ibrahim *et al.* (2001) reported that grafted plants took maximum days to flowering as compared to non-grafted plants. The delay in fruiting was also observed from non-grafted plants as compared to the grafted plants. This delay in fruiting is directly related with the fruiting. Rashid *et al.* (2004) also reported grafted tomato plants on *Solanum torvum* rootstock took more days for fruit maturity (115 days) than the non-grafted tomato plants (98 days). The delayed in maturity might be due to the stress faced by the plant in the grafting operation (Ibrahim *et al*., 2001) and (Khah *et al*., 2006).

Researchers reported the better performance in yield of grafted under both stress and non-stress conditions, depends on the rootstock genotype (Chetelat and Petersen, 2003, Khah *et al*., 2006; Pogonyi *et al.*, 2005). The total yield is based on the number, size and weight of the fruits produce by the plant. In the present study the increase in number of fruits, fruit weight and yield were observed in few scion and rootstock combinations. The T-1359 and Super tomato both gave a greater number of fruits, weight and yield per plant on BBS rootstock as compared to the non-grafted plants. This increase in number of fruits, weight and yield in grafted plants may be due to the effect of vigorous rootstock. Ceballos and Rioja (2019) said that the rootstock is the most considering factor in grafting. It affects survival of the grafting, growth indexes, physiological traits and flowering order. Kacjan Marsic and Osvald (2004) observed more number of fruits per plant in the grafted plants as compared to the non-grafted plants. Increased yield due to grafting was also reported by several researchers (Di Gioia *et al*., 2010; Gisbert *et al*., 2011; Turhan *et al*., 2011). This yield increase in grafted tomato was mainly due to higher fruit biomass and greater number of fruits per plant than nongrafted plants.

Quality characteristics of the fruit are not in consistency in response to the grafted and non-grafted plants. There are several conflicting reports about quality parameters. Among the fruit quality related components, vitamin C and lycopene content are reported lower from grafted plants as compared to non-grafted plants (Milenković *et al*., 2018). Increase in lycopene content in fruit of grafted tomato was reported by Fernandez Garcia *et al*. (2004). The quality characteristics such as Total soluble solids (TSS) and titratable acidity (TA) are positively affected by the rootstock as reported by Kumar *et al*. (2015). Whereas Turhan *et al*. (2011) reported that pH and lycopene content of the tomato did not change with grafting. They also observed decreased levels of TA, vitamin C content and TSS in grafted plants. Variation in quality aspects of the fruits harvested from grafted plants is sometimes caused by the type of rootstock and scion used, degree of maturity at harvest, environmental conditions, and the management during the production (Lee *et al*., 2010).

Conclusion

Variety T-1359 demonstrated superior performance when grafted onto the Bush beefsteak (BBS) rootstock, resulting in higher tomato yields and improved fruit quality. This suggests that vegetable growers can benefit from using BBS rootstock for grafting various high-yielding tomato varieties, including T-1359.

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