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Grafting Influence on Physio-chemical Characters of Tomato on Brinjal Root Stock

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Abstract

The field experiment was conducted in research farm at Lovely Professional University, Punjab, India during 2018–2019 under protected cultivation. The objective of the study was to assess the influence of tomato grafting on rootstock of Brinjal cv. Navkiran. Tomato growers' farmers who wants to earn supplementary from tomato harvested during rains, may find this knowledge valuable. Even the hobbyist growers may find this tomato grafting technology, enjoyable, as they continuously plant tomatoes for easy and accessible fresh tomato yields during year. The tomato cultivars used as scions were Punjab Varkha Bahar-4, Sona NTH-2829 and Heemshikhar. For tomato scion variety taken was of an indeterminate type wherein trellis was provided for favorable development. Cleft grafting technique was practised during grafting of research field work. Obtained fruits were evaluated on the basis of physio-chemical characteristics of grafted and non-grafted plants viz. fruit weight, average fruit weight, firmness, TSS, Vitamin C and titrable acidity. A positive and significant influence of grafting practice was recorded in fruits of tomato with brinjal as a rootstock. Results of this experiment confirmed that grafting of tomatoes on eggplant rootstock performed better in comparison to non-grafting ones in terms of physico-chemical traits of the produced fruit. Grafting operation could be a valuable alternative in tomato production.

Keywords: Grafting, tomato, rootstock, brinjal, physio-chemical

1. Introduction

India is the second largest producer of horticultural crops especially vegetables in the World followed by China country. Area under vegetables 10.29 mha and total production of vegetables is 176.17 mt (Anonymous, 2017–18). Tomato (*Solanum lycopersicom* L.) is the major vegetable crop, grown in many parts of the World and has high economic importance. It belongs to family solanaceae. Cultivation practices of tomato vary from region to region depending on soil conditions, altitude, agro-climate, source availability, skills of farmers, and finance availability. It consists of 95% of water, 4% carbohydrate per 100-gram, crude tomatoes supply 18 calories of energy and 17% vitamin C. The overall production of tomato is 177 mt; China is the major producer, sharing 32% of the total production, followed by the European Union, India, USA and Turkey. In India; Andhra Pradesh, Madhya Pradesh and Karnataka are the major producing state contributing approximately 30% to the total production. The production of tomato in Punjab is 226t

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with share rate 1.16% (Anonymous, 2017–18).

Grafting is a method of propagation in which anticipated rootstocks are obtained to induce vigor, improved yield and quality of the produce, better survival rate under biotic and abiotic stress situations. Grafting has also been a common practice in fruit trees since ages, vegetable grafting is of recent popularization on large scale (Sakata et al., 2007). This technique reduces the dependence upon chemicals mandatory to treat the soil borne diseases and has opened new view in organic farming particularly vegetables (Tirupathamma et al., 2019). In vegetables, grafting is mainly successful in solanaceae and Cucurbitaceae family. The production technology of grafted plants was first started in Japan and Korea in 1920s with watermelon grafted onto gourd rootstock. In World, grafting technique has gained more popularity especially in case of cucurbits, eggplant and tomato, by using vigorous rootstocks to ensure adequate yields (Buller et al., 2013). In solanaceae vegetables, 60–65% tomatoes and eggplants along with 10-14% of peppers are produced through grafting technique. While in country like Netherlands all the tomato under soilless conditions utilize grafted tomato seedlings (Bie et al., 2017).

An area where the land use is intensive, vegetable grafting is considered an innovative technique. High cost, soil-born pests' aspect and diseases management, and adaptation of the grafted seedlings to local conditions or abiotic stresses are the foremost constraints that can be overcome by grafting. In soil less tomato cultivation, grafted plants had higher marketable yield, fruit quality (Gebologlu et al., 2011). According to one survey data concerning the Mediterranean area, it was reported that Spain playeda vital role spreading vegetable grafting mainly in tomato and watermelon vegetables, at rate of 40% and 52% (Leonardi and Romano, 2004). Grafting can be characterized as a natural or deliberate combination of plant parts with the goal that vascular connectivity is built between them (Pina and Errea, 2005) and the subsequent genetically composite organism may function as a single plant (Mudge et al., 2009). The wide utilization of protected cultivation including greenhouse technology for the production of vegetables in the late 1950s resulted in higher production along with quality. In recent period of organic and sustainable agriculture, liberal utilization of synthetic pesticides and inorganic chemical fertilizers should be minimized for eco-friendly agri-production (Davis et al., 2008). Ofori (2015) stated that grafting tomatoes onto 'Black Beauty' are having more plant growth, yield and quality as compared to the non-grafted plants A large portion of the greenhouse tomato growers are using grafting techniques to decrease susceptibility to various root diseases and to increase fruit production (Vrcek et al., 2011). In tomato, grafting resulted in the formation of more number of internodes and flowers in outdoor cultivation and number and the total weight of fruits in indoor cultivation (Voutsela et al., 2012). The study by (Khah et al., 2006) showed that tomato grafting on suitable rootstocks has positive effects or shows results in cultivation performance, mainly in greenhouse conditions. Researchers have perceived variable effects of grafting operation on fruit quality particularly in case of tomato crop. Kumar et al. (2015) demonstrated that fruit quality traits such as skin colour, fruit shape index, titrable acidity, soluble solids content, and dry matter content are affected by the rootstock in case of vegetable grafting. As healing chambers, plastic tunnels are used with success rate 95% on commercial scale (Dong et al., 2015).

2. Materials and Methods

2.1. Grafting

In this experiment tomato varieties, Punjab Varkha Bahar-4 (V_1), Sona NTH-2829 (V_2), Heemshikhar (V_3) cultivars were used as scion material and brinjal variety, Navkiran (B) was used as rootstock. Some combinations were made in the experiment viz., Punjab Varkha Bahar-4+Navkiran (V_1+B), Sona NTH 2829+Navkiran (V_2+B) and Heemshikhar +Navkiran (V_3+B).The average temperature of the polyhouse ranged between 20-25 °C and relative humidity was 65–75%. Complete Randomized design was laid out with two replicates and twenty plants in each replicate. The significance of difference among treatment means were tested by F-test. Wherever, the F-test was found to be significant, critical difference (CD) at 5 % level of significance was calculated. All the collected data on various parameters were subjected to analyze statically following by using ANOVA technique explained by Gomez et al. (1984).

The successful grafted plants and non-grafted plants were transplanted to the beds on September 2018 in the protected structure. The grafted union remained at least 2.5 cm above the soil surface. Grafting clip was not removed until the graft union joined firmly and properly. Various type of cultural practices was followed such as irrigation, fertilization, trilling, weed control, training and pruning, etc., as recommended by package of practices by Punjab Agricultural University, Ludhiana. Grafting success (%) was calculating by dividing the number of successful grafting plants and the total number of plants grafted and following formulae was used-

Grafting success (%)=(No. of successful grafted plant/total no. of grafted plant)×100

On maturity various parameters of the tomato fruit like fruit length, diameter, weight firmness and quality parameters such as total soluble solids, vitamin c and titrable acidity were determined from all the replication and average was calculated.

2.2. Preparation of seedlings

Coco peat, vermiculite and perlite were mixed in the ratio of 3:1:1 to fill pro trays. Individual seed was sown in each cell of tray and placed under high-tech polyhouse structure with controlled temperature ranging from 25°-30 °C and RH of 60 to 65%. The nursery of brinjal was prepared 6-7 days earlier

than to tomato. So, that brinjal could attain more growth e.g. diameter for successful graft union. Grafting was done when the seedlings had the 3-4 leaf stage and the diameter of rootstock and scion was 0.5 cm, 0.3 cm respectively. Cleft grafting technique was used. The scion was cut with the help of grafting knife at a right angle, each plant remained with 2-3 leaves, and then the taper end was fitted into a cleft cut in the rootstock. After the grafting, plants were kept in healing chamber for 4-5 days. It was mainly done for the purpose of declining transpiration rate and increases the chances of grafting success per centage (%). The successful grafted and non-grafted plants were transplanted to the beds in the polyhouse. The beds were raised up to a height of 15 cm with a width of 1m. Row to row and plant to plant distance was kept 60 cm and 45 cm, respectively. The full length of the bed was 45m. The grafted plants remained at least 2.5 cm above the soil surface and the clip that was used to combine the graft union and was not removed until the graft union joined properly.

3. Results and Discussion

3.1. Grafting success (%)

Before taking the observations grafting success (%) between different scion and rootstock was recorded as under-

Data pertaining to graft success (%) has been presented in Table 1 showed maximum success rate (96.33%) in treatment V_2+B followed by V_3+B 95.00%. Minimum grafting success (93.66%) was recorded in V_1+B treatment.

Table 1: Effect of grafting operation on grafting success (%) in case of tomato grafted on brinjal

Treatment Details	Graft success (%)
V1+B (Punjab Varkha Bahar-4+Navkiran)	93.66
V2+B (Sona NTH 2829+Navkiran)	96.33
V3+B (Heemshikhar+Navkiran)	95.00

Success of grafting operation depends on several factors like, grafting technique adapted, seedling age, post-grafting management, environmental conditions and rootstock-scion compatibility. Besides this, many factors like compatibility of rootstocks and scions in grafting operation also influence grafting success. Vegetable grafting also induce vigour and improved survival rate. High seedling survival rate can also be achieved by beginners through tongue approach or approach grafting methods, but it is mandatory for high rate of success, relative humidity should be sustained at 95%. The optimum temperature should retain at 21-36 °C for better transplanting (Kumar, 2017). Ofori (2015) and Msogoya and Mamiro (2016) reported similar types of result in their study while grafting tomato on brinjal rootstock.

3.2. Yield Parameters

3.2.1. No. of fruits plant^{-1}

It is clear from the data, presented in Table 2, pertaining to number of fruits in grafted and non- grafted plants confirms that highest number of fruits per plant (140.66) was recorded in V_2+B (Sona NTH 2829+Navkiran) followed by (129.40) in V_3+B (Heemshikhar+Navkiran) whereas, lowest number of fruits per plant (91.93) was found in V_1+B (Punjab Varkha Bahar-4+Navkiran). This clearly reflects that number of fruits per plant was affected highly significant by grafting. Grafted plants tolerated better the out of optimum range temperatures; therefore, they were able to produce more fruits due to less dropping of flower. This result was supported by the study of Khah et al. (2006) and Gisbert et al. (2011) which found significant result in grafted tomato.

3.2.2. Average fruit weight (g)

It is evident from Table 2 that average fruit weight of tomato was maximum (57.30 g) in V_2+B treatment followed by (49.24 g) in V_3+B treatment while minimum fruit weight (41.15 g) was reported in V_1 treatment combination. In this study, highest average tomato weight (57.30 g) was observed in grafted plants of V_2+B treatment. Lee and Oda (2003) suggested that higher yield of fruits from grafted plants might be due to the influence of the vigorous root system of the used rootstock, which enhanced the uptake of water and minerals. Schwarz et al. (2013) and Turhan et al. (2011) also reported similar increasing trend in fruit weight by using grafting.

3.2.3. Fruit diameter (cm)

Significant variations were found in case of fruit diameter among all the grafted and non- grafted combination as presented in Table 2. The highest fruit diameter was recorded in grafting combination V_2+B treatment, 5.15 cm trailed by V_1+B treatment combination as 4.71 cm and (4.34 cm) in V_3+B treatment. It was interesting to note that non- grafted variety V_2 treatment resulted in the lowest fruit diameter (3.93 cm) of tomato fruit.

Increased fruit diameter in case of grafted plants could be attributed to enhanced water and nutrient uptake when vigorous rootstock was used. Increase in fruit diameter is also supported by the findings of Yetisir et al. (2007). He recorded that grafting of watermelon onto interspecific squash hybrid resulted in increased fruit size by 52%.

3.2.4. Fruit length (cm)

Data pertaining to length of fruit have been exhibited in Table 1, reveals that fruit length was affected by the grafting operation. Highest value of fruit length (4.15 cm) was recorded in grafting combination V_3+B treatmentwhich is at par with grafting combination V_1+B treatment (3.94 cm). The next largest fruit length (3.70 cm) was noted in non-grafted V_3 treatmentand lowest fruit length (3.09 cm) was found in V_1 treatment. The increase in fruit length might be due to the compatibility of the rootstock and scion resulting in appropriate nutrient and water uptake. Turhan et al. (2011)

Table 2: Grafting influence on physical traits and bio-chemical of tomato fruit on brinjal root stock

Treat-ments	Treat-ments Details	No. of fruits plant^{-1}	Fruit weight (g)	Fruit diameter (cm)	Fruit length (cm)	Fruit firmness (kg cm^{-2})	Vitamin C (mg 100 g)	Total solu-ble solids (°brix)	Titrable Acidity (%)
Non-grafted Plants	V_1	91.93	41.15	4.13	3.09	1.99	7.37	5.53	0.5
	V_2	101.06	44.77	3.93	3.57	2.93	7.43	4.15	0.47
	V_3	116.93	47.66	4.11	3.7	3.18	8.25	3.88	0.44
Grafted Plants	V_1+B	83.06	44.62	4.71	3.94	2.46	8.39	5.9	0.42
	V_2+B	140.66	57.3	5.15	3.23	4.05	10.83	4.72	0.35
	V_3+B	129.40	49.24	4.34	4.15	3.36	9.31	4.16	0.39
SEm±		6.28	2.21	0.1	0.11	0.15	0.29	0.12	0.008
CD (*p*=0.05)		1.96	7.08	0.33	0.37	0.48	0.93	0.39	0.02

proved in tomato crop, grafted on other tomato cultivars that the fruit index (diameter/length) and fruit weight were considerably inclined by grafting operation.

3.2.5. Fruit firmness (kg/cm²)

From the perusal of data on fruit firmness of table 1, it may be concluded that fruit firmness (4.05 kg cm^{-2}) was maximum in V_2+B treatmentfollowed by (3.36 kg cm^{-2}) in V_3+B treatmentand (3.18 kg cm^{-2}) in V_3 treatmentwhile minimum (1.99 kg cm^{-2}) tomato firmness was observed in V_1 treatment.

The influence of rootstock on fruit firmness of grafted tomatoes may be related to alterations in cell turgidity and chemical and mechanical properties of the cell wall as a consequence increasing synthesis of endogenous hormones and changing water relationsalong with nutritional status of the scion as described by Rouphael et al. (2010). High firmness which is good for postharvest storage, prevents injury during handling and transportation of fruits. This can prolong the postharvest quality of the fruit; especially the shelf life and may be due to the effect of grafting. The result of current study agrees with El-Wanis et al. (2014) who found that grafting improves the firmness of grafted tomato fruit significantly.

3.3. Effect of grafting on biochemical parameters

However, to get encouraging influence of grafting on vegetable quality, combinations of rootstock/scion should be selected with care and specific for specific climatic and geographic situations (Davis *et al.,* 2008).

3.3.1. Vitamin C (mg 100 g^{-1})

The data regarding vitamin C content of tomato fruits of grafted plants/ non- grafted plants presented in table 1 confirms that maximum vitamin C content (10.83 mg 100 g^{-1}) was recorded in V_2+B treatment followed by (9.31 mg 100 g^{-1}) inV_3+B treatment and (8.39 mg mg 100 g^{-1}) in V_1+Btreatment. Treatment V_1 treatment shows minimum value (7.37 mg 100 g^{-1}) of vitamin C. It clearly reflects that ascorbic acid in tomato fruit was significantly affected by grafting operation. These results might be due to better growth of plants which helps in better accumulation of nutrients and water uptake from soil. Similar results were recorded by Balliu et al. (2008) in tomato.

3. 3.2. Total soluble solids (°Brix)

Data presented in Table 2 clearly specifies the TSS value of the tomato fruit was affected by the grafting. Maximum total soluble solids (5.90 °brix) was recorded in V_1+B treatment followed by (5.53 °Brix) in V_1 treatmentand (4.72 °Brix) in V_2+B treatment. Minimum values of total soluble solids (3.88°Brix) in fruit were observed in V_3treatment. This clearly reflects that total soluble solids content in tomato fruit was significantly influenced by grafting operation. Higher TSS content may be attributed to better light intensity during crop growing conditions, better uptake of water and nutrients and greater photosynthetic activity. Gioia et al. (2010) verified that there are no significant differences in TSS of tomato "Oxheart" grafted onto 2 inter-specific hybrids *S. lycopersicum × S. habrochaites.*

3. 3.3. Titrable acidity (%)

Titrable acidity (%) for grafted and non-grafted tomato plants displayed in Table 2, lowest titrable acidity (0.35%) was evaluated in V_2+B treatment trailed by (0.39%) in V_3+B treatment and (0.44%) in V_1+B treatment. It may be concluded the titrable acidity was significantly affected by grafting whereas, highest (0.50%) titrable acidity was noted in V_1treatment. Low value of titrable acidity in non- grafted plants could be attributed to enhanced water supply to the plants causing a dilution effect. Grafting between *C. maxima*×*C. moschata* has been resulted in increasing the acidity and reduction in the pH of the pulp (Soteriou *et al*., 2014).

4. Conclusion

Graft combination of tomato scion variety, Sona NTH-2829 onto brinjal rootstock, Navkiran (V_2+B) proved the best combination regarding physical (Average fruit weight 57.30 g, diameter 5.15 cm and length 3.23 cm) and biochemical parameters (vitamin C 10.83 (mg 100 g^{-1}), TSS 4.72 (°brix) and

titrable acidity 0.35%) of tomato fruit.

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