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# Impact of grafting on biochemical traits of tomato grown in root-knot nematode (*Meloidogyne incognita*) infested soils under polytunnel cultivation

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## Abstract

The experiment aimed to assess grafting effects on the tomato fruit quality in root-knot nematode-infested conditions in polytunnel cultivation. Three screened resistant brinjal rootstocks against nematode were used as rootstock for tomato grafting with three different scions *viz.* Hisar Arun, Arka Rakshak and Pusa Rohini. Different biochemical parameters were evaluated using the ripened fruits of tomato and the grafted plants had significantly increased T.S.S. content by 9.84 to 13.5 % and ascorbic acid content by 6.03 to 23.2 %. In contrast, the acidity of tomatoes decreased by 8.6 to 18.8 % as compared to non-grafted tomato plants. Among all treatments, R19 and R20 rootstocks grafted with Arka Rakshak performed best for fruit quality characters.

**Key words:** Tomato grafting, fruit quality, rootstocks, root-knot nematode

## Introduction

In the horticultural sector, the main aim has traditionally been yield, but in recent years, consumers' interest in the quality of products has increased worldwide. Tomato (*Lycopersicon esculentum.* L) is the major vegetable crop grown in many parts of the country and is highly economically significant. It is a rich source of lycopene content (an antioxidant), ascorbic acid, beta-carotene, and dietary fibres (Wilcox *et al.*, 2003). Tomato in India's second most common vegetable in terms of area and production (2024). During 2024, tomato covered an area of 853.99 million hectares with 21323.22 million tonnes of production and an average yield of 24.97 tonnes per hectare (Anon, 2024). Several biotic factors seriously threaten the global vegetable growing system (Lee *et al.,*2021). Among these are the plant parasitic nematodes, specifically root-knot nematodes (*Meloidogyne* spp.), one of the most important pests that restrict crop output and quality (Sasser and Carter, 1985*;* Seid *et al.*, 2015). Kumar *et al.* (2020) reported 23 % losses in tomato crops where sequential planting of sensitive crops is followed year after year.

Grafting is a successful, proven technology widely followed in horticultural crops and provides resistance against many biotic and abiotic stresses (Tamilselvi, 2019). It is carried out between compatible species and genera (Edelstein *et al.*, 2017). Grafted plants have vigorous root systems that help to absorb water and nutrients more efficiently than non-grafted plants (Arora *et al.*, 2022). It improves both yield and quality of fruits and reduces infestation of diseases.

Fruit quality is one of the major aspects of production that is affected by nematode infestation. Many researchers have shown improved results of grafting on fruit quality. According to Fernandez-Garci *et al.* (2010), grafting could be an effective tool for improving tomato fruit quality in terms of shape and size, sugar content, and acidity. Some brinjal or tomato rootstocks significantly affect sugar and acid content (Schwarz *et al.*, 2013). Studies have examined the physiological mechanisms by which rootstocks affect scion performance and the impact of grafting on the physicochemical quality and nutritional value of vegetable fruits (Kyriacou *et al.*, 2017*;* Aloni *et al.*, 2010). The biochemical parameters are the primary parameters to be evaluated in grafted plants for biotic and abiotic stress resistance.

Similarly, rootstocks' effect on the fruits' quality parameters is essential for consumer preference and nutritional security (Pugalendhi *et al.*, 2021). Grafting enhances water nutrient uptake and nutrient use efficiency (Santa-Cruz *et al.,* 2002) to extend the duration of harvest time and to improve fruit quality (Colla *et al.,* 2006*;* Fernandez-Garcia *et al.*, 2004). This study aimed to find the effect of tomato grafting on fruit quality on the resistant rootstock of brinjal against root-knot nematode.

## Materials and methods

The present study was conducted at Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, during the rabi season of 2021-2022. Three resistant brinjal rootstocks were selected for tomato grafting with three tomato scions, Hisar Arun, Arka Rakshak and Pusa Rohini, that were primarily grown in polytunnels and greenhouse conditions in India. The grafted tomato seedlings were transplanted in sick plots of root-knot nematode in randomized block design. The grafted plants were transplanted with a spacing of 60 ×60 cm. The following treatments were:

T1- Rootstock 1 (R20) + Scion 1 (Hisar Arun/Selection -7),T2 - Rootstock 1 (R20) + Scion 2 (Arka Rakshak)*;* T3 - Rootstock 1

(R20) + Scion 3 (Pusa Rohini)*;* T4 - Rootstock 2 (R19) + Scion 1 (Hisar Arun/Selection-7)*,*T5 - Rootstock 2 (R19) + Scion 2 (Arka Rakshak)*;* T6 - Rootstock 2 (R19) + Scion 3 (Pusa Rohini)*;* T7 - Rootstock 3 (R6) + Scion 1 (Hisar Arun/Selection- 7)*,*T8 - Rootstock 3 (R6) + Scion 2 (Arka Rakshak)*;* T9 - Rootstock 3 (R6) + Scion 3 (Pusa Rohini)*;* T10 - Non-grafted Scion 1(Hisar Arun /Selection- 7)*,*T11 - Non-grafted Scion 2 (Arka Rakshak)*;* T12 - Non-grafted Scion 3 (Pusa Rohini)

**Preparation of grafts and transplanting:** The seeds of resistant rootstocks and scions were initially sown in protrays filled with cocopeat, providing a conducive environment for seedling growth. Once the seedlings reached an appropriate stage of growth, the grafting process was performed. The grafting was conducted with precision to ensure successful union and growth, ensuring that the scion would receive adequate nutrients and water through the brinjal's root system. Grafted seedlings were placed in a healing chamber with a relative humidity of 85-90 % for good graft union. Regular irrigation was provided to the protrays for proper growth of grafted seedlings. After proper healing, seedlings were kept in the hardening chamber to establish them in field conditions easily. Grafted seedlings, after hardening, were transplanted to the root-knot nematode-infested microplots. The observations for quality parameters, *viz.,* T.S.S., titrable acidity and ascorbic acid were undertaken.

**Determinations of different quality parameters and statistical analysis:** Well-developed ten red ripe tomato fruits were selected for different fruit quality parameters. The result was statistically analyzed using the method of Panse and Sukhatame (1987).

**T.S.S. content (°Brix)**: Well-developed red ripe tomato fruits were selected. Tomato juice was extracted from the selected fruits. A drop of juice was placed over the prism present in the hand refractometer. A digital A.T.A.G.O., Sanco pocket refractometer with a reading range of 0 to 50 ◦Brix was used for T.S.S. analysis. Total soluble solids were recorded for the four fruits for each grafted plant separately and the T.S.S. content of the fruit was worked out by averaging these values.

**Acidity**: Titratable Acidity was measured according to A.O.A.C. (1985) and it is measured in %. Acidity was measured by taking 5 mL of juice after filtration with the help of filter paper and making the final volume of 25 mL by adding distilled water. Titration was done with the help of 0.1 N sodium hydroxide (NaOH) by using 1-2 drops of phenolphthalein as an indicator. Sodium hydroxide was added drop by drop to the sample and pink colour,which was for a minute or longer, was taken as the end-point of titration.

**Ascorbic acid content of fruits (mg/100g)**: The ascorbic acid content of tomato fruits was determined by the 2, 6 dichlorophenol indophenols titration method (A.O.A.C., 1975) and it was expressed in mg per 100 g of the fresh fruit weight.

## Result and discussion

**T.S.S. content (ºBrix):** T.S.S. content plays an important role in assessing fruit quality. T.S.S. content was higher under the rootstock R-6 (5.16 ºBrix). Among the scion treatments, the highest T.S.S. (5.19 ºB) was obtained in Arka Rakshak and it was significantly superior to Pusa Rohini (4.91 ºB) and Hisar Arun (4.72 ºB).

It is revealed that all grafted combinations improved the T.S.S. content over the non-grafted scions and, thus, improved the quality of tomato fruits. The T.S.S. content increased by 13 % in Hisar Arun, 13.5 % in Arka Rakshak, and 9.84 % in Pusa Rohini in grafted plants compared to non-grafted plants.

Rootstocks and scion interactions played a significant role in increasing the T.S.S. of the harvested tomato fruits. Grafting alters T.S.S. value as per interactions between scions when grafted on different rootstocks, which may alter plant hormonal production levels. According to Gioia *et al.* (2010), higher T.S.S. content may be increased due to better light intensity during crop growing conditions, improved uptake of water and nutrients, and more photosynthetic activity. Similar findings were reported by Flores *et al.* (2010), Ibrahim *et al.* (2014), Kumar *et al.* (2017)*;* Rahmatian *et al.* (2014), Rathod (2017) and Singh *et al.* (2019).

Table 1. Effect of different rootstocks and scions on T.S.S. content (ºBrix) in tomato

| Rootstock (A) | Hisar Arun (S-1) | Arka Rakshak (S-2) | Pusa Rohini (S-3) | Mean |
|---|---|---|---|---|
| R-20 | 4.57 | 5.07 | 4.80 | 4.81 |
| R-19 | 4.63 | 5.00 | 4.93 | 4.86 |
| R-6 | 4.97 | 5.50 | 5.00 | 5.16 |
| Mean | 4.72 | 5.19 | 4.91 | |
| C.D at 5% | Factor A-0.16, Factor B-0.16, Factor A×B -NS | | | |
| Non-grafted scion | | | | |
| | Hisar Arun- | 4.17 | | |
| | Arka Rakshak- | 4.57 | | |
| | Pusa Rohini- | 4.47 | | |
| C.D at 5% | | 0.27 | | |
| Percentage increase/decrease over non-grafted plants | | | | |
| | +13 | +13.5 | +9.84 | |

**Acidity (%)**: The perusal of the data indicated that different rootstocks had no significant effect on acidity while different scions used over the rootstocks significantly affected the acidity. The highest acidity was obtained in scion Arka Rakshak (0.308 %) and it was at par with Pusa Rohini (0.284 %) but significantly higher than Hisar Arun (0.267 %). However, the interactions among different treatments, *viz.*, rootstocks and scions for acidity, was found nonsignificant.

It is revealed that grafted combinations decreased the acidity content over non-grafted scions by 16.5 % in Hisar Arun, 8.6

Table 2. Effect of different rootstocks and scions on acidity (%) in tomato

| Rootstock (A) | Hisar Arun (S-1) | Arka Rakshak (S-2) | Pusa Rohini (S-3) | Mean |
|---|---|---|---|---|
| R-20 | 0.286 | 0.320 | 0.307 | 0.304 |
| R-19 | 0.260 | 0.307 | 0.290 | 0.285 |
| R-6 | 0.256 | 0.298 | 0.256 | 0.270 |
| Mean | 0.267 | 0.308 | 0.284 | |
| C.D at 5% | Factor A-NS, Factor B-0.028, Factor A×B -NS | | | |
| Non-grafted scion | | | | |
| | Hisar Arun- | 0.320 | | |
| | Arka Rakshak- | 0.337 | | |
| | Pusa Rohini- | 0.50 | | |
| C.D at 5% | | NS | | |
| Percentage increase/decrease over non-grafted plants | | | | |
| | -16.5 | -8.6 | -18.8 | |

% in Arka Rakshak and 18.8 % in Pusa Rohini. On comparison between grafted and non-grafted plants, there was a decrease in acidity content by 8.6 to 18.8%. The low value of titrable acidity in grafted plants could be attributed to enhanced water supply to the plants, causing a dilution effect as per Singh *et al.* (2019).

**Ascorbic acid (mg/100g):** Different grafted combinations increased the ascorbic acid content over the non-grafted tomato plants. Ascorbic acid content increased by 6.03 % in Hisar Arun, 11.0 % in Arka Rakshak and 23.2 % in Pusa Rohini in grafted plants over non-grafted scions. No significant effect variation due to rootstock and scion was observed on the ascorbic acid content in tomato fruits.

The grafting significantly affected the ascorbic acid content in tomato fruits. According to Singh *et al.* (2019), the results could be attributed to better plant growth, which aids in accumulating nutrients and water uptake from soil. Zhang *et al.* (2019) revealed that grafting with suitable rootstock increased the ascorbic acid content. In addition, a 10.59 % increase in ascorbic acid content was noticed in grafted brinjal than in non-grafted brinjal (Na *et al.,* 2012). Similar results were reported by Kumar *et al.* (2017)*;* Ibrahim *et al.* (2014) and Pugalendhi *et al.* (2021).

Table 3. Effect of different rootstocks and scions on ascorbic acid (mg/100g) in tomato

| Rootstock (A) | HisarArun (S-1) | Arka Rakshak(S-2) | Pusa Rohini (S-3) | Mean |
|---|---|---|---|---|
| R-20 | 21.73 | 17.73 | 19.40 | 19.62 |
| R-19 | 19.07 | 18.40 | 18.73 | 18.73 |
| R-6 | 17.73 | 18.27 | 17.07 | 17.69 |
| Mean | 19.51 | 18.13 | 18.40 | |
| C.D at 5% | Factor A-NS, Factor B-NS, Factor A×B -NS | | | |
| Non-grafted scion | | | | |
| | Hisar Arun- | 18.40 | | |
| | Arka Rakshak- | 16.33 | | |
| | Pusa Rohini- | 14.93 | | |
| C.D at 5% | | NS | | |
| Percentage increase/decrease over non-grafted plants | | | | |
| | +6.03 | +11.0 | +23.2 | |

The most important factor in vegetable production is its nutritional quality. The pH, T.S.S., titrable acidity, and ascorbic acid are highly considered for value addition. Grafting helps to manage biotic stresses such as pests and diseases, which can significantly impact plant biochemical parameters. This improves plant health and survival and reduces the need for chemical inputs, promoting more sustainable agricultural practices. The use of grafted tomato plants with brinjal rootstock in graft combinations improved the T.S.S. by 9.84 to 13.5 % and ascorbic acid by 6.03 to 23.2 %, while acidity decreased by 8.6 to18.8 % when compared to non-grafted plants in root-knot nematode infested conditions.

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