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Interactive effects of scion-rootstock combinations on biochemical and quality parameters of tomato

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Abstract
In this study, we examine about how tomatoes behave when grafted on different rootstocks by measuring the amount of change in the qualitative composition of tomato grafts using various rootstocks, scions, and grafting methods. Two tomato hybrids (Yuvraj and Suraj) were used as scions, and five different cultivars (Pant T3, *Solanum lycopersicum var. cerasiforme*, *Solanum torvum*, VNR Solmel Brinjal and VNR Garcia chilli) were used as rootstocks and they were grafted using Splice grafting methods. Analyses were performed for reducing sugar percent, non-reducing sugar percent, total sugar percent, TSS, ascorbic acid content, titrable acidity, lycopene content, firmness and pH value. The biochemical compositions were significantly affected by different rootstock and tomato scions. Pant T3 had the highest reducing sugar percent, non-reducing sugar percent and total sugar percent whereas *Solanum lycopersicon var. cerasiforme* had the highest TSS, ascorbic acid content, titrable acidity, lycopene content, firmness and pH value. Yuvraj was performed best among both scions. Among all the combinations, Yuvraj grafted onto Pant T3 had highest reducing sugar percent, non-reducing sugar percent, total sugar percent; Yuvraj grafted onto *Solanum torvum* had maximum firmness; Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* had highest TSS, ascorbic acid content, titrable acidity, lycopene content and pH value. The interactive effect of scion-rootstock combinations of tomato was found more effective than control for all growth parameters under study. The results of this study suggest that the grafting of tomato on tomato and brinjal rootstock may be a good strategy for enhancing the biochemical composition of tomato.

Keywords: Ascorbic acid, brinjal, firmness, grafting, lycopene, pH, quality, tomato, TSS, rootstock, scion, Yuvraj

Introduction
Tomato (*Solanum lycopersicum* L.) is the major vegetable crop, belongs to family solanaceae with a chromosome number of 2n= 24. It consists of 95% of water, 4% carbohydrate per 100-gram, crude tomatoes supply 18 calories of energy and 17% vitamin C. In addition to the above, Tomato is rich in lycopene, which acts as an antioxidant by quenching out the freely available toxic reactive oxygen species (ROS), thereby avoiding cell injury (Pugalendhi, 2021) [11]. Brinjal (*Solanum melongena* L.), also known as eggplant is an important Solanaceous vegetable crop of tropical and sub-tropical regions belongs to family solanaceae. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It has been reported that on an average, the oblong-fruited eggplant cultivars are rich in total soluble sugars, whereas the long-fruited cultivars contain a higher content of free reducing sugars, anthocyanin, phenols, Glycoalkaloids (such as Solasodine), dry matter and amide proteins.
Chilli (*Capsicum annum*) belongs to the family solanaceae having diploid species with 2n=2x=24 chromosomes. It is also a richest source of vitamin C. Capsaicin is a pungent principle and Capsanthin is a colouring agent present in Chilli. It is used as an analgesic in tropical ointments and dermal patches to relieve pain.
Grafting tomatoes on resistant varieties from the solanaceous crops controls the problem with soil-borne diseases and gives good yield as well as quality fruit was therefore adopted as a strategy to cure the nuisance without harming the ecosystem. Vegetable grafting has been improved over the last decade, thanks to the introduction of new techniques and materials. Grafted seedlings are being progressively adopted by the Vegetable industry as propagates of choice for crop establishment. However, despite this recent advance, the percentage of grafted plants in the overall Vegetable production is still relatively low due to the high cost of grafting; problems with soil-borne pests and diseases control, and adaptation of the grafted

seedlings to abiotic stresses are the major constraints. The combination of this technique with other techniques could be a strategy to enhance the ability of plants to tolerate stressing conditions. Researchers have perceived variable effects of grafting operations on fruit quality particularly in the case of tomato crop. Kumar *et al.*, 2015 [6] demonstrated that fruit quality traits such as skin colour, fruit shape index, titrable acidity, soluble solid 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. In this study we investigated the interactive effects of scion-rootstocks combinations on quality parameters of tomato.

Material and Methods

The proposed experiment will be carried out in the field of Centre of Excellence and PCPF, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2020-21 and 2021-2022. Raipur district is located in the central part of the Chhattisgarh Plains, at an altitude of 289.56 meters above mean sea level (MSL) between 21 ° 16 'N latitude and 81 ° 26' E longitude.

The experimental materials for the present investigation comprised of five solanaceous rootstocks and two tomato hybrids were used as scion. Out of all the five rootstocks included in the study, two were wild *solanum* species i.e., *Solanum torvum* and *Solanum lycopersicon* var. *cerasiforme* and other three were the cultivated *Solanum* species. The rootstocks and scion combination are mentioned in the Table 1. Twelve treatments in total comprising of five rootstocks and two scions including two controls (non-grafted treatments) were planted in Factorial Randomized Block Design having 3 replications.

Table 1: Rootstocks and Scion Combinations

Factor A	Level
Yuvraj(Y)	*Solanum torvum* (T_1)
	Solmel Brinjal (T_2)
	Solanum lycopersicon var. cerasiforme (T_3)
	Pant T3 (T_4)
	Garcia chilli (T_5)
Control	Without grafting (T_6)
Factor B	
Suraj(S)	*Solanum torvum* (T_1)
	Solmel Brinjal (T_2)
	Solanum lycopersicon var. cerasiforme (T_3)
	Pant T3 (T_4)
	Garcia chilli (T_5)
Control	Without grafting (T_6)

Table 2: Treatment combinations between rootstock and scion

Treatments	Treatment details
YT_1	Yuvraj grafted on *Solanum torvum*
YT_2	Yuvraj grafted on VNR Solmel
YT_3	Yuvraj grafted on *Solanum lycopersicon var. cerasiforme*
YT_4	Yuvraj grafted on Pant T3
YT_5	Yuvraj grafted on VNR Garcia
YT_6	Yuvraj (Control without grafting)
ST_1	Suraj grafted on *Solanum torvum*
ST_2	Suraj grafted on VNR Solmel
ST_3	Suraj grafted on *Solanum lycopersicon var. cerasiforme*
ST_4	Suraj grafted on Pant T3
ST_5	Suraj grafted on VNR Garcia
ST_6	Suraj (Control without grafting)

The experimental material comprising of commercial cultivars, varieties and wild relatives displayed the presence of variability in terms of morphological characteristics. The two scion cultivars *viz*., Yuvraj (Y) and Suraj (S) produce round, flat round and square oblong fruits, respectively contributing to the substantial amount of variability in terms of fruit characterstics. Furthermore, inclusion of non-edible wild brinjal species '*Solanum torvum'* and also hybrid cultivars of tomato 'Pant T3', '*Solanum lycopersicum var. cerasiforme'*, 'Solmel' hybrid brinjal and 'Garcia' hybrid chilli were added to the variability regarding the plant growth and quality characteristics. Both the scion cultivars represent consumer accepted characteristics of tomato fruits along with good quality and therefore are preferred for cultivation by farmers.

Result

Reducing sugar (%)

Reducing sugar was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.11) Among all the rootstocks, maximum reducing sugar was recorded in T4 - Pant T3 (1.88 and 1.88) followed by T3 - *Solanum lycopersicon var. cerasiforme* (1.69 and 1.82), T1- *Solanum torvum* (1.34 and 1.65) whereas, minimum was recorded (1.22 and 1.54) in T5- VNR Garcia. Between both the scions, maximum reducing sugar was recorded (1.55 and 1.76) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum reducing sugar was recorded (1.93 and 1.99) in YT4 –Yuvraj grafted onto Pant T3 followed by YT3 (1.87 and 1.89), ST1 (1.83 and 1.78) in year 2020-21 and 2021-22, respectively. Under these combinations, minimum reducing sugar was recorded (1.17 and 1.52) in ST6 during 2020-21 and 2021-22, respectively. Minimum reducing sugar (1.49 and 1.70) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively. Similar results were reported by other researchers (Ibrahim *et al.* 2017; Tadesse *et al.* 2012; Diwan *et al.* 2021) [5, 15, 1]. When using the splice grafting method, maximum reducing sugar content in tomato fruit was recorded in Yuvraj observed by Diwan (2021) [1]. Minerals commonly found in tomato fruits and have buffering capacity as well, therefore they influence the taste of tomatoes.

Non-reducing sugar (%)

Non-reducing sugar was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.11) Among all the rootstocks, maximum non-reducing sugar was recorded in T4 - Pant T3 (2.81 and 2.75) followed by T3 - *Solanum lycopersicon var. cerasiforme* (2.74 and 2.58), T1- *Solanum torvum* (2.19and 2.38) whereas, minimum was recorded (2.08 and 2.20) in T5- VNR Garcia. Between both the scions, maximum non-reducing sugar was recorded (2.44 and 2.53) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum non-reducing sugar was recorded (2.88 and 2.92) in YT4 –Yuvraj grafted onto Pant T3 followed by YT3 (2.78 and 2.68), ST1 (2.75 and 2.63) in year 2020-21 and 2021-22, respectively. Under these

combinations, minimum non-reducing sugar was recorded (2.03 and 2.15) in ST6 during 2020-21 and 2021-22, respectively. Minimum non-reducing sugar (2.40 and 2.46) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively. Similar results were reported by other researchers (Ibrahim *et al.* 2017; Tadesse *et al.* 2012; Diwan *et al.* 2021) [5, 15, 1].

Total sugar content (%)

Total sugar content was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.11) Among all the rootstocks, maximum total sugar content was recorded in T3 - *Solanum lycopersicon var. cerasiforme* (4.10 and 4.49) followed by T4 - Pant T3 (4.06 and 4.43), T1- *Solanum torvum* (3.94 and 3.99) whereas, minimum was recorded in T5- VNR Garcia. Between both the scions, maximum total sugar content was recorded (3.96 and 4.24) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum total sugar content was recorded (4.15 and 4.63) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by YT4 (4.08 and 4.62), ST1 (4.07 and 4.46) in 2020-21 and 2021-22, respectively. Under these combinations, minimum total sugar content was recorded (3.58 and 3.92) in ST6 during 2020-21 and 2021-22, respectively. Minimum total sugar content (3.90 and 4.16) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

Similar results were reported by other researchers (Ibrahim *et al.* 2017; Tadesse *et al.* 2012; Milenkovic 2020; Mavlyanova 2020; Diwan *et al.* 2021) [5, 15, 20, 7, 1]. The high contents of sugar and acid are signs of good taste and flavour. The results show that fruit TS content was significantly influenced by grafting. TS content of non-grafted plants was significantly higher than that of grafted ones. Diwan *et al.* 2021 [1] reported that Maximum total sugar content in tomato fruit was recorded in scion Yuvraj.

Total soluble solids (°Brix)

Total soluble solids were not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.12. Among all the rootstocks, maximum TSS was recorded (5.20% and 5.45%) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (5.15% and 5.15%), T1- *Solanum torvum* (5.02% and 4.99%) whereas, minimum was recorded (4.68% and 4.63%) in T5- VNR Garcia. Between both the scions, maximum TSS was recorded (5.04% and 5.08%) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum TSS was recorded (5.23% and 5.47%) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by ST4 (5.17% and 5.43%), YT4 (5.15% and 5.25%) in 2019-20 and 2020-21, respectively. Under these combinations, minimum TSS was recorded (4.39% and 4.32%) in ST6 during 2020-21 and 2021-22, respectively. Minimum TSS (4.48% and 4.44%) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively. Similar results were reported by other researchers (Kumar *et al.* 2015; Hossain *et al.* 2019; Sharma *et al.* 2019; Singh *et al.* 2019; Ha *et al.* 2021; Pugalendhi *et al.* 2021) [6, 5, 13, 14, 2, 11].

Lycopene content (mg/100g)

Lycopene content was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.12) Among all the rootstocks, maximum lycopene content was recorded (5.72 and 5.69) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (5.69 and 5.63), T1- *Solanum torvum* (5.65 and 5.44) whereas, minimum was recorded (5.57 and 5.27) in T5- VNR Garcia. Between both the scions, maximum lycopene content was recorded (5.67 and 5.53) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum lycopene content was recorded (34.83 and 37.90) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by ST4 (31.50 and 33.53), YT4 (31.23 and 32.40) in 2019-20 and 2020-21, respectively. Under these combinations, minimum lycopene content was recorded (24.10 and 28.93) in ST6 during 2020-21 and 2021-22, respectively. Minimum lycopene content (25.48 and 28.98) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

Lycopene content is the most important factor that determines the colour of the fruit, which plays a major role in market value of the commodity. Total carotenoid content of the tomato fruit contains mostly lycopene and β carotene. In most of the cases the lycopene content remains the same in grafted and non-grafted plants. Walubengo *et al.* (2022) [18] reported that lycopene content increases with ripening because chloroplasts are transformed into chromoplasts. Temperature influences the biosynthesis of lycopene and the fact that in the present study, the grafted and controlled tomatoes were grown in the same greenhouse with same temperature and light conditions, could have led to similar lycopene content observed in all the fruits at each of the maturity stages. However, with progress in maturity, the lycopene content increased. In agreement with this result, Turhan *et al.* (2011) [16] also found no significant differences among the grafted and non-grafted plants for lycopene content. Decrease in lycopene content was also found in grafted plants by (Mohammed *et al.*, 2012) [9] Scion has highly influenced the lycopene content of grafted plants as all the graft combinations showed results on par to that of scion. Highest lycopene content was recorded in Shivam grafted onto Solanum sisymbrifolium rootstock.

Ascorbic acid content (%)

Ascorbic acid was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.12) Among all the rootstocks, maximum ascorbic acid was recorded (33.17 and 35.72) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (30.58 and 32.13), T1- *Solanum torvum* (28.87 and 31.48) whereas, minimum was recorded (27.67 and 29.62) in T5- VNR Garcia. Between both the scions, maximum ascorbic acid was recorded (30.29 and 32.57) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum ascorbic acid was recorded (34.83 and 37.90) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by ST4

(31.50 and 33.53), YT4 (31.23 and 32.40) in 2019-20 and 2020-21, respectively. Under these combinations, minimum ascorbic acid was recorded (24.10 and 28.93) in ST6 during 2020-21 and 2021-22, respectively. Minimum ascorbic acid (25.48 and 28.98) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

Vitamin C (ascorbic acid) is an oxidant. Tomato is very rich in vitamin C and contains significant amounts of this vitamin (Sablani *et al.* 2006). The fruit vitamin C content was strongly reduced by grafting. Compared with the non-grafted plants, the grafted plants accumulated less vitamin C in their fruit tissue. This finding agrees with those reported by Qaryouti *et al.* (2007) [12], who found that vitamin C content was reduced in soil cultivation in Cecilia grafted on He-Man and Spirit. However, the effects on vitamin C content of grafting onto various rootstocks may be either positive or negative. For example, vitamin C content differed significantly between plants grafted onto Beaufort and Arnold rootstocks. Beaufort exhibited better vitamin C content performance than did Arnold. In addition, 10.59% increase in ascorbic acid content was noticed in grafted brinjal than non-grafted brinjal. But, it was reduced by grafting as per the study conducted by Turhan *et al.* (2011) [16] in tomato. In this study, a mild increase in ascorbic acid content was noticed in tomato plants grafted with all the three rootstocks than the non-grafted plants.

Firmness

Firmness was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.13) Among all the rootstocks, maximum firmness was recorded (2.92 and 2.83) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (2.87 and 2.68), T1- *Solanum torvum* (3.81 and 3.47) whereas, minimum was recorded (2.02 and 2.35) in T5- VNR Garcia. Between both the scions, maximum firmness was recorded (3.20 and 3.01) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively.

Among different graft combinations, maximum firmness was recorded (4.02 and 3.53) in YT1 –Yuvraj grafted onto *Solanum torvum* followed by YT2 (3.95 and 3.46) ST2 (3.60 and 3.40), in year 2019-20 and 2020-21, respectively. Under these combinations, minimum firmness was recorded (1.94 and 2.33) in ST6 during 2020-21 and 2021-22, respectively. Maximum firmness (3.05 and 2.93) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

Milenkovic *et al.* (2020) [20] studied the influence of grafting on firmness and reported that firmness is one of the typical attributes used to describe the fruit texture. Fruits of the cultivars 'Classy' and 'ASVEG10', obtained from plants grafted onto 'Brigeor' or 'Maxifort' and grown under potassium deficiency, but also fruits from plants grafted onto eggplant rootstock were less firm with higher deformation than fruits from self-grafted tomatoes. While Riga23 did not find differences in fruit firmness between ungrafted and self-grafted 'Jack' tomatoes.

Titrable acidity (%)

Titrable acidity was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.13) Among all the rootstocks, maximum titrable acidity was recorded (6.87 and 7.39) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (7.67 and 7.50), T1- *Solanum torvum* (6.87 and 7.39) whereas, minimum was recorded (6.20 and 6.95) in T5- VNR Garcia. Between both the scions, maximum titrable acidity was recorded (7.05 and 7.43) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively. Among different graft combinations, maximum titrable acidity was recorded (7.74 and 7.88) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by ST4 (7.72 and 7.74), YT4 (7.67 and 7.55) in 2019-20 and 2020-21, respectively. Under these combinations, minimum titrable acidity was recorded (4.68 and 6.31) in ST6 during 2020-21 and 2021-22, respectively. Maximum ascorbic acid (6.95 and 7.37) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

Zhang and Guo (2019) [19] studied the effects of tomato on potato hetero-grafting on physiological parameters, quality and yield of tomato fruits and potato tubers and reported that titrable acidity in the grafted tomato fruit significantly decreased compared to the self-rooted tomato fruit. Vieira and Hanada (2019) [17] reported that a significant difference in titrable acidity was detected between treatments and between harvests. All treatments showed a titrable acidity average between the harvests higher than the control, including that the rootstocks significantly increased the titrable acidity of the tomato fruit. It has been observed in all treatments that titrable acidity tends to increase with the advancement of culture age. Pugalendhi *et al.* (2021) [11] reported that tomato grafted with suitable rootstocks improved the titrable acidity. This is in accordance with the results observed by (Turhan *et al.*, 2011) [16]. Similar results are in agreement with Diwan *et al.* 2021 [1].

pH value

The data on pH value was not significantly affected due to different rootstocks, scion and combinations of rootstock and scion treatments during the year 2020-21 and 2021-22. (Table 4.13) Among all the rootstocks, maximum pH was recorded (3.96 and 4.44) in T3 - *Solanum lycopersicon var. cerasiforme* followed by T4 - Pant T3 (3.91 and 4.37), T1- *Solanum torvum* (3.84 and 4.12) whereas, minimum was recorded (3.62 and 3.59) in T5- VNR Garcia. Between both the scions, maximum pH was recorded (3.86 and 4.20) in Yuvraj (Y) followed by Suraj (S) during 2020-21 and 2021-22, respectively. Among different graft combinations, maximum pH was recorded (4.00 and 4.54) in YT3 –Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme* followed by ST4 (3.91 and 4.21), YT4 (3.92 and 4.52) in 2019-20 and 2020-21, respectively. Under these combinations, minimum pH was recorded (3.71 and 3.68) in ST6 during 2020-21 and 2021-22, respectively. Maximum pH (3.83 and 4.12) was recorded in control treatment (non-grafted) as compared to other treatments 2020-21 and 2021-22, respectively.

The pH value also plays an important role in determining fruit quality characteristics. Many studies focused on pH as a key element in tomato selection. In this study, pH values differed slightly among tomato plants. Moreover, pH values did not differ significantly between the grafted and non-grafted plants. In addition, different rootstocks had no positive effects on fruit pH values. Our findings generally agree with other researchers who found that fruit pH values were not affected by grafting. Pugalendhi *et al.* (2021) [11] reported that the

values of pH were significantly different among all the treatments. Comparing non-grafted plants, Shivam recorded a higher level of pH. Slight difference in pH value was found among the grafted plants. This was in contrast to the results given by Turhan *et al.* (2011) [16] where no difference in pH was identified in grafted plants.

Table 3: Effect of grafting on Reducing Sugar, Non-Reducing Sugar and Total Sugar

	Reducing Sugar			Non-Reducing Sugar			Total sugar		
Treatments	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
Rootstock									
T1	1.34	1.65	1.49	2.19	2.38	2.29	3.94	3.99	3.97
T2	1.30	1.62	1.46	2.17	2.37	2.27	3.82	3.97	3.89
T3	1.69	1.82	1.75	2.74	2.58	2.66	4.10	4.49	4.30
T4	1.88	1.88	1.88	2.81	2.75	2.78	4.06	4.43	4.24
T5	1.22	1.54	1.38	2.08	2.20	2.14	3.60	3.92	3.76
S.Em ±	0.04	0.27	0.05	0.03	0.21	0.04	0.04	0.27	0.04
CD (0.05)	0.32	0.57	0.46	0.25	0.44	0.36	0.29	0.57	0.45
Scion									
Y	1.55	1.76	1.66	2.44	2.53	2.48	3.96	4.24	4.10
S	1.42	1.64	1.53	2.36	2.38	2.37	3.85	4.07	3.96
Sem ±	0.02	0.17	0.02	0.01	0.14	0.01	0.02	0.17	0.02
CD (0.05)	0.20	0.36	0.41	0.16	0.28	0.32	0.19	0.36	0.41
Control vs Other									
Control	1.64	1.76	1.70	2.50	2.55	2.52	4.03	4.30	4.17
Other	1.49	1.70	1.59	2.40	2.46	2.43	3.90	4.16	4.03
S.Em ±	0.01	0.17	0.01	0.01	0.14	0.01	0.01	0.17	0.01
CD (0.05)	0.20	0.36	0.40	0.16	0.28	0.31	0.19	0.36	0.39
Interaction									
YT1	1.37	1.71	1.54	2.22	2.40	2.31	3.98	4.04	4.01
YT2	1.33	1.66	1.50	2.18	2.39	2.29	3.97	4.01	3.99
YT3	1.87	1.89	1.88	2.78	2.68	2.73	4.15	4.63	4.39
YT4	1.93	1.99	1.96	2.88	2.92	2.90	4.08	4.62	4.35
YT5	1.27	1.56	1.41	2.12	2.26	2.19	3.62	3.92	3.77
ST1	1.83	1.78	1.81	2.75	2.63	2.69	4.07	4.46	4.26
ST2	1.32	1.58	1.45	2.17	2.36	2.26	3.90	3.94	3.92
ST3	1.82	1.77	1.80	2.73	2.57	2.65	4.03	4.23	4.13
ST4	1.52	1.75	1.63	2.70	2.48	2.59	4.05	4.35	4.20
ST5	1.27	1.58	1.42	2.15	2.35	2.25	3.67	3.93	3.80
YT6	1.17	1.52	1.34	2.03	2.15	2.09	3.58	3.92	3.75
ST6	1.45	1.74	1.60	2.25	2.47	2.36	4.00	4.13	4.07
S.Em ±	0.09	0.39	0.09	0.07	0.30	0.07	0.08	0.39	0.09
CD (0.05)	0.45	0.81	0.65	0.35	0.63	0.51	0.41	0.81	0.64

Treatments detail: YT_1 – Yuvraj + *Solanum torvum*; YT_2 – Yuvraj + VNR Solmel; YT_3 – Yuvraj + *Solanum lycopersicon* var *cerasiformie*; YT_4 – Yuvraj + Pant T3; YT_5 – Yuvraj + VNR Garcia; YT_6 – Yuvraj; ST_1 – Suraj + *Solanum torvum*; ST_2 – Suraj + VNR Solmel; ST_3 – Suraj + *Solanum lycopersicon* var *cerasiformie*; ST_4 – Suraj + Pant T3; ST_5 – Suraj + VNR Garcia; ST_6 – Suraj

Table 4: Effect of grafting on TSS, Lycopene Content and Ascorbic Acid

	TSS			Lycopene Content			Ascorbic Acid		
Treatments	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
Rootstock									
T1	5.02	4.99	5.01	5.65	5.44	5.54	28.87	31.48	30.18
T2	4.95	4.89	4.92	5.63	5.35	5.49	27.82	31.10	29.46
T3	5.20	5.45	5.33	5.72	5.69	5.71	33.17	35.72	34.44
T4	5.15	5.15	5.15	5.69	5.63	5.66	30.58	32.13	31.36
T5	4.68	4.63	4.65	5.57	5.27	5.42	27.67	29.62	28.64
S.Em ±	0.09	0.40	0.07	0.02	0.19	0.03	1.04	2.97	0.67
CD (0.05)	0.65	0.83	0.74	0.11	0.40	0.29	7.48	6.15	6.85
Scion									
Y	5.04	5.08	5.06	5.67	5.53	5.60	30.29	32.57	31.43
S	4.96	4.97	4.96	5.63	5.42	5.52	28.95	31.45	30.20
S.Em ±	0.04	0.25	0.03	0.01	0.12	0.01	0.42	1.88	0.27
CD (0.05)	0.41	0.52	0.66	0.07	0.25	0.26	4.73	3.89	6.13
Control vs Other									
Control	4.48	4.44	4.46	5.69	5.56	5.63	25.48	28.98	27.23
Other	5.00	5.02	5.01	5.65	5.48	5.56	29.62	32.01	30.82
S.Em ±	0.02	0.25	0.01	0.00	0.12	0.01	0.21	1.88	0.13
CD (0.05)	0.41	0.53	0.64	0.07	0.25	0.25	4.75	3.91	5.87
Interaction									

YT1	5.03	5.01	5.02	5.66	5.47	5.56	29.80	31.57	30.68
YT2	5.00	4.96	4.98	5.65	5.41	5.53	27.83	31.13	29.48
YT3	5.23	5.47	5.35	5.75	5.76	5.75	34.83	37.90	36.37
YT4	5.15	5.25	5.20	5.70	5.75	5.72	31.23	32.40	31.82
YT5	4.79	4.69	4.74	5.60	5.28	5.44	27.73	29.87	28.80
ST1	5.02	4.97	4.99	5.63	5.40	5.52	27.93	31.40	29.67
ST2	4.90	4.82	4.86	5.60	5.29	5.45	27.80	31.07	29.43
ST3	5.17	5.43	5.30	5.70	5.62	5.66	31.50	33.53	32.52
ST4	5.15	5.05	5.10	5.69	5.51	5.60	29.93	31.87	30.90
ST5	4.57	4.57	4.57	5.54	5.26	5.40	27.60	29.37	28.48
YT6	4.56	4.55	4.56	5.70	5.65	5.68	26.87	29.03	27.95
ST6	4.39	4.32	4.36	5.69	5.47	5.58	24.10	28.93	26.52
S.Em ±	0.18	0.56	0.15	0.03	0.27	0.06	2.08	4.20	1.35
CD (0.05)	0.92	1.17	1.05	0.15	0.56	0.41	10.58	8.70	9.69

Treatments detail: YT_1 – Yuvraj + *Solanum torvum*; YT_2 – Yuvraj + VNR Solmel; YT_3 – Yuvraj + *Solanum lycopersicon* var *cerasiformie*; YT_4 – Yuvraj + Pant T3; YT_5 – Yuvraj + VNR Garcia; YT_6 – Yuvraj; ST_1 – Suraj + *Solanum torvum*; ST_2 – Suraj + VNR Solmel; ST_3 – Suraj + *Solanum lycopersicon* Var *cerasiformie*; ST_4 – Suraj + Pant T3; ST_5 – Suraj + VNR Garcia; ST_6 – Suraj

Table 5: Effect of grafting on Firmness, Titrable Acidity and pH value

	Firmness			Titrable Acidity			pH		
Treatments	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**	**2020-21**	**2021-22**	**Pooled**
Rootstock									
T1	3.81	3.47	3.64	6.87	7.39	7.13	3.84	4.12	3.98
T2	3.62	3.33	3.47	6.29	7.21	6.75	3.83	4.07	3.95
T3	2.92	2.83	2.87	7.73	7.81	7.77	3.96	4.44	4.20
T4	2.87	2.68	2.77	7.67	7.50	7.58	3.91	4.37	4.14
T5	2.02	2.35	2.18	6.20	6.95	6.57	3.62	3.59	3.60
S.Em ±	0.08	0.47	0.08	0.30	0.77	0.19	0.09	0.36	0.07
CD (0.05)	0.54	0.97	0.78	2.15	1.60	1.89	0.63	0.74	0.69
Scion									
Y	3.20	3.01	3.11	7.05	7.43	7.24	3.86	4.20	4.03
S	2.89	2.85	2.87	6.85	7.31	7.08	3.80	4.03	3.92
S.Em ±	0.03	0.29	0.03	0.12	0.49	0.07	0.03	0.23	0.03
CD (0.05)	0.34	0.61	0.70	1.36	1.01	1.69	0.40	0.47	0.61
Control vs Other									
Control	3.05	2.93	2.99	6.95	7.37	7.16	3.83	4.12	3.97
Other	2.41	2.47	2.44	5.22	6.57	5.89	3.74	3.74	3.74
S.Em ±	0.02	0.30	0.02	0.06	0.49	0.04	0.02	0.23	0.01
CD (0.05)	0.34	0.61	0.67	1.36	1.02	1.62	0.40	0.47	0.59
Interaction									
YT1	4.02	3.53	3.78	7.33	7.40	7.37	3.86	4.17	4.02
YT2	3.95	3.46	3.70	6.29	7.27	6.78	3.85	4.14	4.00
YT3	2.99	2.87	2.93	7.74	7.88	7.81	4.00	4.54	4.27
YT4	2.96	2.83	2.89	7.67	7.55	7.61	3.92	4.52	4.22
YT5	2.09	2.38	2.24	6.21	7.04	6.63	3.67	3.62	3.65
ST1	3.60	3.40	3.50	6.41	7.37	6.89	3.82	4.06	3.94
ST2	3.29	3.20	3.25	6.28	7.14	6.71	3.80	3.99	3.89
ST3	2.85	2.79	2.82	7.72	7.74	7.73	3.91	4.34	4.13
ST4	2.77	2.53	2.65	7.67	7.44	7.55	3.90	4.21	4.06
ST5	1.94	2.33	2.13	6.18	6.85	6.51	3.57	3.55	3.56
YT6	2.42	2.50	2.46	5.76	6.82	6.29	3.78	3.80	3.79
ST6	2.40	2.45	2.43	4.68	6.31	5.50	3.71	3.68	3.69
S.Em ±	0.15	0.66	0.15	0.60	1.09	0.37	0.17	0.51	0.14
CD (0.05)	0.76	1.37	1.11	3.04	2.26	2.68	0.89	1.05	0.97

Treatments detail: YT_1 – Yuvraj + *Solanum torvum*; YT_2 – Yuvraj + VNR Solmel; YT_3 – Yuvraj + *Solanum lycopersicon* var *cerasiformie*; YT_4 – Yuvraj + Pant T3; YT_5 – Yuvraj + VNR Garcia; YT_6 – Yuvraj; ST_1 – Suraj + *Solanum torvum*; ST_2 – Suraj + VNR Solmel; ST_3 – Suraj + *Solanum lycopersicon* var *cerasiformie*; ST_4 – Suraj + Pant T3; ST_5 – Suraj + VNR Garcia; ST_6 – Suraj

Conclusion

Effect of scion -rootstock combinations on quality parameters of tomato were found non-significant. Maximum reducing sugar and non-reducing sugar was recorded in Yuvraj grafted onto Pant T3. Total sugar content, lycopene content, TSS and ascorbic acid were recorded in Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme*. Maximum firmness was recorded in Yuvraj grafted onto *Solanum torvum.* Maximum titrable acidity was recorded in Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme*. Maximum pH was recorded in Yuvraj grafted onto *Solanum lycopersicon var. cerasiforme*.

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