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Performance of the tomato scions in wild rootstock of Brinjal (*Solanum melongena* L.) for quality parameter

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Abstract
Therefore, the present study was conducted to investigate the effects of tomato grafting on wild rootstocks on brinjal and tomato variety as a scion in yield, quality, of tomato production. During the *Kharif* season of 2022 and 2023, the study was carried out at the Departmental Research Farm of the Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and Sciences (SHUATS) in Prayagraj. The experimental design employed was a Randomized Block Design (RBD) with 15 treatments and 3 replication. From above experimental findings on effect of grafting in tomato, it is concluded that treatment T_1 (*S. torvum* + Kashi Anupam) performed best for quality parameter like TSS in the year 2022 & 2023 and pooled for the T_1 (*Solanum torvum* + Kashi Anupam) had the highest TSS among the treatments at (3.26,3.23, 3.25°Brix) and minimum was found in the treatment T_{15} Kashi Vishesh (non grafted) (2.46, 2.21, 2.33^{0}Brix) . Titrable acidity (%) in the year 2022 & 2023 and pooled for the T_1 (*Solanum torvum* + Kashi Anupam) had the highest titrable acidity (%) among the treatments at (0.19,0.23,0.21%) and minimum was found to (0.12,0.13,0.13%) Kashi Sharad (Non-Grafted).

Keywords: Acidity, quality, radial, tomato, TSS

1. Introduction
Tomato (*Solanum lycopersicum* L.) is the major vegetable crop, grown in many parts of the world and has high economic importance in many countries. It belongs to family solanaceae with a chromosome number of 2n= 24. It is a good source of carotenoids, vitamin C and pro-vitamin A with a good antioxidant potential including lycopene, ascorbic acid, phenolics, flavonoids and vitamin E. it is considered as protective food. In India, 46.72 thousand hectares are used for tomato production, and in 2020–21, 34.29 million tonnes were produced. In terms of area and tomato production in 2020–21, Andhra Pradesh leads, followed by Madhya Pradesh and Karnataka. Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh, and West Bengal are the main tomato-producing states.

Grafted commercial cultivars (scions) onto selected tolerant rootstocks could be a promising method for producing tomato at suboptimal conditions (Krumbein A. and Schwarz D.2013) [9]. Grafting is the union of two or more pieces of living plant tissue (Edelstein *et al*.,2017 and Fallic E. & Ilic Z.2014) [6], which are forced to develop vascular connection and grow as a single plant (Rivero *et al*.,2003) [17]. The root system of grafted plants is stronger and more efficient in uptake of water and nutrients which indirectly improves yield (Edelstein *et al*., 2017, Savvas *et al.*, 2010, Miskovic *et al.*, 2016) [4, 18, 12]. In this context, the use of adequate rootstocks through grafting provides an alternative strategy to reduce the losses in production caused by environmental stresses, such as the excess of radiation and temperature in the late cropping season (Pugalendhi *et al.*,2005) [16]. Grafting is becoming a common practice in several European countries, such as Spain, Italy, Turkey, Greece and Israel (Edelstein *et al*., 2017) [4]. Regarding the changes in fruit quality by grafting, there are several conflicting reports whether grafting effects are advantageous or disadvantageous (Davis *et al.*,2008) [2]. A negative effect of tomato grafting was observed regarding fruit yield per plant, number of fruits per plant and total yield (Miskovic *et al.*,2016) [12], but organic acid and lycopene content was significantly higher when the eggplant was used as a rootstock.

The overall results showed that tomato grafting on suitable rootstocks elicited positive effects on cultivation performance, but decreased tomato nutritional quality (Nicoletto *et al.*,2013) [13].
Obtained similar results with respect to vitamin C reduction because of grafting.
The effect of rootstocks on the amount of TSS was found not statistically significant, although some researchers have observed that soluble solid content was lower in grafted compared to non-grafted plants. (Al harbi *et al*.,2017) [1].

2. Materials and Methods

The trial took place at Sam Higginbottom University of Agriculture Science & Technology, Prayagraj (U.P.), stretching across the kharif season of 2021 and spanning two years, concluding in 2022-23. The experimental setup employed a Randomized Block Design (RBD) consisting of 15 treatments and three replications (see Table No.1). Among the four rootstocks investigated in this study—*Solanum torvum, Solanum violaceum, Solanum xanthocarpum, and Solanum incanum*—three served as scions, specifically the tomato varieties Kashi Anupam, Kashi Sharad, and Kashi Vishesh. The materials used in the experiment, which included cultivated varieties for commercial purposes and their wild relatives exhibited notable variability in morphological characteristics.

Table 1: Scion Rootstock combination as treatments

Sl. No.	Treatment No.	Treatment combination
1.	T_1	*Solanum torvum* + Kashi Anupam
2.	T_2	*Solanum torvum* + Kashi sharad
3.	T_3	*Solanum torvum* + Kashi vishesh
4.	T_4	*Solanum violaceum*+ Kashi Anupam
5.	T_5	*Solanum violaceum*+ Kashi sharad
6.	T_6	*S Solanum Sola Solanum violaceum* + Kashi Vishesh
7.	T_7	*Solanum xanthocarpum* + Kashi Anupa
8.	T_8	*Solanum xanthocarpum* + Kashi sharad
9.	T_9	*Solanum xanthocarpum* + Kashi vishesh
10.	T_{10}	*Solanum incanum*+ Kashi Anupam
11.	T_{11}	*Solanum incanum*+ Kashi sharad
12.	T_{12}	*Solanum incanum*+ Kashi vishesh
13.	$T1_3$	Kashi Anupam (Non –Grafted)
14.	T_{14}	Kashi Sharad (Non – Grafted)
15.	T_{15}	Kashi Vishesh (Non- Grafted)

The experimental field was well prepared and standard cultural and plant protection measures were followed to raise a healthy crop. Analysis of variance was carried out as per the procedure given by [14].

The total soluble solids (TSS) contents of the fruits were measured with the help of hand refract meter. Tomato juice was collected from red ripen fruits. A drop of juice was placed over the prism of digital refractometer and was noted in per cent.

Titrable acidity (%):- Acid content of the extracted juice was determined by titrating 5 ml of juice against N/10 NaOH using Phenolphthalein as an indicator. Acidity was expressed in term interaction effect is small compared to the average effect and has been found to be significant, of anhydrous citric acid (A.O.A.C.1960) per 100 ml of tomato juice.

3. Results and Discussions

1) Total soluble solids (^{0} Brix)

Total soluble solids or TSS data from the 2022–23 *Kharif* season showed significant differences between grafted and non-grafted tomato treatments. The highest TSS of T_1 (*Solanum torvum* + Kashi Anupam) was 3.26°Brix, while T_{10} (*Solanum incanum* + Kashi Anupam) was slightly less than T_1 at 2.98°Brix. With a TSS of 2.46°Brix, T_{15} (Kashi Vishesh, non-grafted) had the lowest of all the treatments.
There were notable variations in the TSS of the treatments, which included both grafted and non-grafted tomatoes, during the 2023-24 kharif season. The highest TSS was recorded by T_1 (*Solanum torvum* + Kashi Anupam) was 3.23°Brix, while T_{10} (*Solanum incanum* + Kashi Anupam) was slightly less than T_1 at 2.98°Brix. T_{15} (Kashi Vishesh, non-grafted) showed the lowest level of 2.21°Brix.
Pooled mean analysis also showed comparable trends. The treatment ranking should not change from year to year because the interaction effect is significant even though it is smaller than the average effect. It is therefore excludable. There were significant differences in the data for the pooled mean analysis when comparing for TSS within a treatment. T_1 (*Solanum torvum* + Kashi Anupam) was 3.25°Brix, while T_{10} (*Solanum incanum* + Kashi Anupam) was slightly less than T_1 at 2.98°Brix. T_{15} (Kashi Vishesh, non-grafted) displayed lowest level of 2.33 °Brix. Data regarding TSS are shown in Table 2 and Figure 1.
When grafted with the Kashi Anupam variety of tomato, *Solanum torvum*'s maximum Total Soluble Solids (TSS) content is likely the result of both physiological synergy and genetic compatibility when compared to other wild species and varieties. Genetic characteristics that encourage the accumulation of sugars and other soluble solids are shared by Kashi Anupam and *Solanum torvum*. Increased TSS content results from the rootstock and scion's physiological interaction, which maximises nutrient uptake. Furthermore, the resilience and adaptability of *Solanum torvum* may aid in the effective transformation of nutrients into soluble solids. Because of these combined advantages, grafting *Solanum torvum* with Kashi Anupam is the best way to increase TSS content while improving flavour and nutritional value.
Similar result were reported by Pugalendhi *et al.*, 2021 [16], Sharma *et al.*, 2019 [20], Singh *et al.*, 2019 and Walubengo *et al.*, 2022 [23].

Table 2: Performance of grafted and Non grafted tomato on different quality parameter in the year 2022 -23& 2023-24

Treatment Notation	Treatments details	TSS (°Brix)			Titrable Acidity (%)		
		2022	2023	POOLED	2022	2023	POOLED
T_1	*Solanum torvum* + Kashi Anupam	3.26	3.23	3.25	0.19	0.23	0.21
T_2	*Solanum torvum* + Kashi Sharad	2.68	2.61	2.65	0.17	0.15	0.16
T_3	*Solanum torvum* + Kashi Vishesh	2.86	2.83	2.85	0.13	0.18	0.15
T_4	*Solanum violaceum* + Kashi Anupam	2.9	2.9	2.90	0.20	0.17	0.18
T_5	*Solanum violaceum* + Kashi Sharad	2.76	2.73	2.75	0.13	0.19	0.16
T_6	*Solanum violaceum* + Kashi Vishesh	2.71	2.66	2.69	0.12	0.16	0.14
T_7	*Solanum xanthocarpum* + Kashi Anupam	2.93	2.93	2.93	0.16	0.18	0.17
T_8	*Solanum xanthocarpum* + Kashi Sharad	2.60	2.63	2.62	0.13	0.20	0.16
T_9	*Solanum xanthocarpum* + Kashi Vishesh	2.70	2.58	2.64	0.11	0.19	0.15
T_{10}	*Solanum incanum* + Kashi Anupam	2.98	2.98	2.98	0.21	0.18	0.19
T_{11}	*Solanum incanum* +Kashi Sharad	2.70	2.7	2.70	0.19	0.15	0.17
T_{12}	*Solanum incanum* + Kashi Vishesh	2.90	2.75	2.83	0.14	0.21	0.16
T_{13}	Kashi Anupam (Non-Grafted)	3.00	2.83	2.91	0.17	0.20	0.18
T_{14}	Kashi Sharad (Non-Grafted)	2.63	2.50	2.57	0.12	0.13	0.13
T_{15}	Kashi Vishesh (Non - Grafted)	2.46	2.21	2.33	0.16	0.12	0.14
	'F' Test	S	S	S	S	S	S
	SE. m (±)	0.15	0.15	0.09	0.01	0.01	0.01
	$CD_{0.05}$	0.34	0.22	0.34	0.02	0.02	0.01

2) Titrable acidity (%)

Titrable acidity data from the 2022–23 Kharif season showed significant differences between grafted and non-grafted tomato treatments. The highest titrable acidity of T_1 (*Solanum torvum* + Kashi Anupam) was 0.21%, while T_{10} (*Solanum incanum* + Kashi Anupam) was at par with T_1 at 0.19%. With a Titrable acidity of 0.12%, T_{14} (Kashi Sharad, non-grafted) had the lowest of Titrable acidity all the treatments.

There were notable variations in the Titrable acidity of the treatments, which included both grafted and non-grafted tomatoes, during the 2023-24 Kharif season. The highest titrable acidity of T_1 (*Solanum torvum* + Kashi Anupam) was 0.23%, while T_{10} (*Solanum incanum* + Kashi Anupam) was at par with T_1 at 0.18%. With a Titrable acidity of 0.13%, T_{14} (Kashi Sharad, non-grafted) had the lowest of Titrable acidity all the treatments.

Pooled mean analysis also showed comparable trends. The treatment ranking should not change from year to year because the interaction effect is significant even though it is smaller than the average effect. It is therefore excludable. There were significant differences in the data for the pooled mean analysis when comparing for titrable acidity within a treatment. The highest titrable acidity of T_1 (*Solanum torvum* + Kashi Anupam) was 0.21%, while T_{10} (*Solanum incanum* + Kashi Anupam) was at par with T_1 at 0.19%. With a Titrable acidity of 0.13%, T_{14} (Kashi Sharad, non-grafted) had the lowest of Titrable acidity all the treatments. Data regarding Titrable acidity are shown in Table 2 and Figure 1.

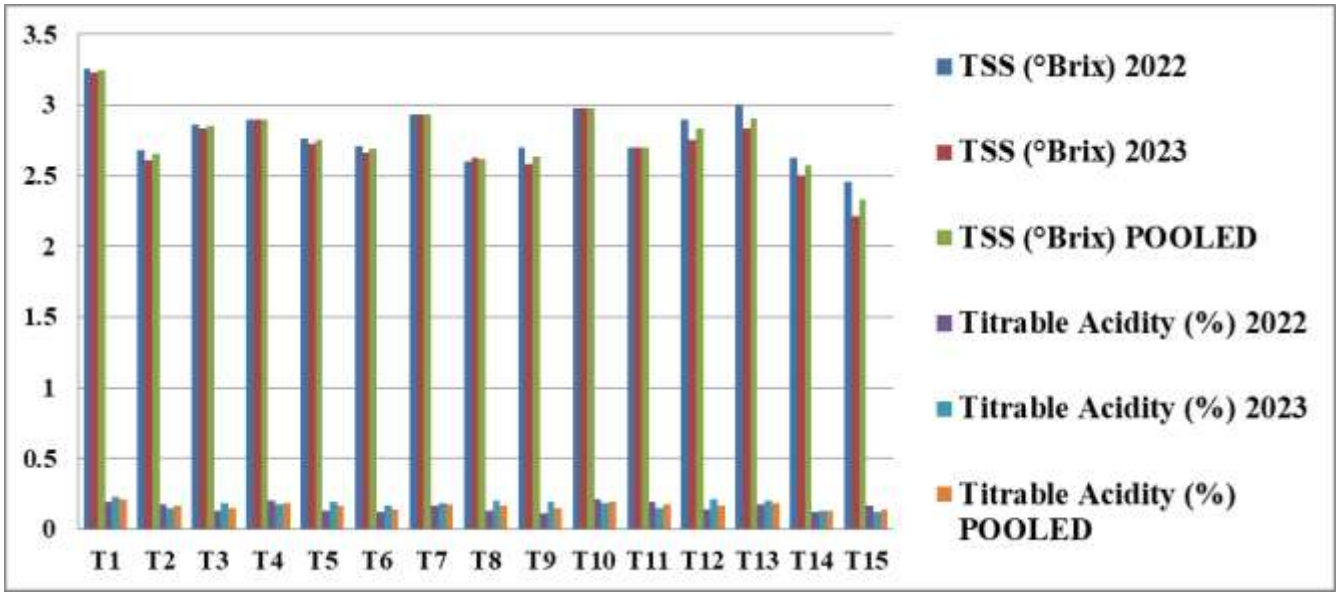

Fig 1: Performance of grafted and Non grafted tomato on different quality parameter in the year 2022 -23& 2023-24

The highest titrable acidity observed in *Solanum torvum* grafted with Kashi Anupam tomato is probably the result of a synergistic interaction between genes and physiological factors. Kashi Anupam and *Solanum torvum* both possess genetic characteristics that encourage the build-up of acid. Increased acid production results from the physiological interaction between the scion and rootstock, which maximises nutrient uptake and metabolic processes. Furthermore, the adaptability and resilience of *Solanum torvum* might facilitate the effective conversion of organic

acids even more. Through adjustments to nutrient transport and hormonal balance, the grafting process may also increase acidity. Titratable acidity levels are raised as a result of these factors taken together. Grafted Kashi Anupam on *Solanum torvum* yields improved flavour and culinary versatility, making it a great option for optimising titrable acidity. Similar result were reported by Pugalendhi *et al.*, 2021 [16], Sharma *et al.*, 2019 [20], Singh *et al.*, 2019 and Walubengo *et al.*, 2022 [23].

4. Conclusion

Based on the experimental findings regarding the compatibility of tomato scions in wild brinjal rootstocks (*Solanum melongena* L.), it is concluded that grafting treatment T_1 (*Solanum torvum* + Kashi Anupam) exhibited strong performance under field conditions post-transplantation.

5. Competing interests

Author have declared that no competing interests Exist.

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