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STANDARDIZATION OF APPROPRIATE GRAFTING AND GRAFT HEALING METHOD IN TOMATO

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ABSTRACT

This study investigated the effects of different healing environments and grafting methods on growth performance, grafting success and the healing response of grafted seedlings. The results showed that both factors significantly influenced rootstock and scion development, graft union success and callus initiation. Among healing conditions, the use of a polypropylene container placed in a polyhouse proved most effective, achieving the highest graft success (90.32%) and the quickest callus formation period (5.83 days), along with marked improvements in rootstock and scion diameters. In terms of grafting methods, cleft grafting was surpassed slice grafting by recording greater increases in growth parameters, higher success (81.87%) and a quicker healing duration (5.88 days). The interaction effect revealed that the combination of polypropylene containers in polyhouse conditions with cleft grafting was found most efficient, producing the maximum graft success (92.63%) with the rapid healing (5.69 days). These findings suggest that cleft grafting under polypropylene container conditions within a polyhouse is the most effective strategy for promoting successful graft establishment, rapid healing and enhanced growth performance.

***Key words*: Tomato, grafting, healing, method**

Introduction

Vegetables, though rich in nutrients, are often contaminated with pesticides in India. As alternatives like genetically modified (GM) crops face limitations. Grafting emerges as a simple, eco-friendly technique to improve disease resistance, stress tolerance, yield and quality. With growing demand for organic produce, grafting holds great promise for sustainable vegetable cultivation in India (Sen *et al*., 2018).

Grafted vegetable seedlings, developed for commercial use in the late 20^{th} century, involve joining a vegetable seedling with a hardy rootstock like wild brinjal or pumpkin. This technique improves resistance to pests, diseases and stresses while enhancing crop growth, yield and quality (Maurya *et al.*, 2019). The descriptive and qualitative features of the fruit remained unaffected by additional grafting (Leoni *et al*., 1989; Romano and Paratore, 2000). Adopting resistant rootstocks for grafting tomato scions with valuable traits promotes sustainable and environmentally safe control of biotic and abiotic stress (Louws *et al*., 2010).

Mortality percentage provides insight into grafting success, as lower rates correspond to well-executed grafting and improved plant survival (Shipepe and Msogoya, 2018). Selection of healthy rootstock and scion, proper grafting technique, hygienic conditions, healing and hardening conditions, gradual acclimatization and post-grafting care (Bogoescu *et al.*, 2014). Though multiple options are available in vegetable grafting, cleft or wedge grafting and splice grafting are the common approaches followed in tomato grafting.

Healing conditions promote callus formation and union, reduce scion mortality, enhance graft success rate and prevent pathogen infection (Lee *et al.*, 2010; Savvas *et al.*, 2013). The mortality rate can be reduced by selecting appropriate grafting methods in combination with optimal environmental conditions. The present investigation is designed to identify the most suitable healing microclimate conditions for tomato seedlings grafted onto *Solanum torvum*, to assess how different grafting techniques interact with healing environments in influencing graft success and anatomical union and test cost-effective healing chamber.

Materials and Methods

The study was conducted during 2025 at the Hi-tech nursery, Centre of Excellence (Fruits), Mulugu, Telangana, India. A Factorial Completely Randomized Design (FCRD) was employed, consisting of two factors, first factor is healing conditions (H) with three different levels (Fig. 1) (H_1: Healing chamber conditions; H_2: Automated polyhouse conditions and H_3: Polypropylene containers in polyhouse conditions) and second factor is grafting method (G) with two levels (Fig. 2) (G_1: Splice grafting and G_2: Cleft grafting) together making six treatments with four replications. The experimental material comprised rootstocks of brinjal (*Solanum torvum* Sw.) and tomato scion cultivar 'Saaho'.

Fig. 1: Creation of different healing conditions for grafting of tomato on brinjal (*Solanum torvum* Sw) rootstock.

Scion and rootstock seeds were germinated in 98-celled portrays, maintaining an early sowing interval of 25–30 days for *Solanum torvum*, so that stem diameters matched at grafting. Seeds of brinjal (*Solanum torvum* Sw.) were subjected to pre-sowing treatment with 2000ppm gibberellic acid for 24 hours (Sindhuja *et al.*, 2023). The rootstock seedlings were then transplanted into 50-cell portrays containing a 1:1 ratio of coco-peat and vermicompost prior to reaching the graftable girth.

The plants were raised under shaded nursery conditions with regular watering. Brinjal seedlings of 3–4 mm girth (55 days old), and scion (tomato) seedlings having 2–3 true leaves with 3–4 mm stem thickness was used for grafting.

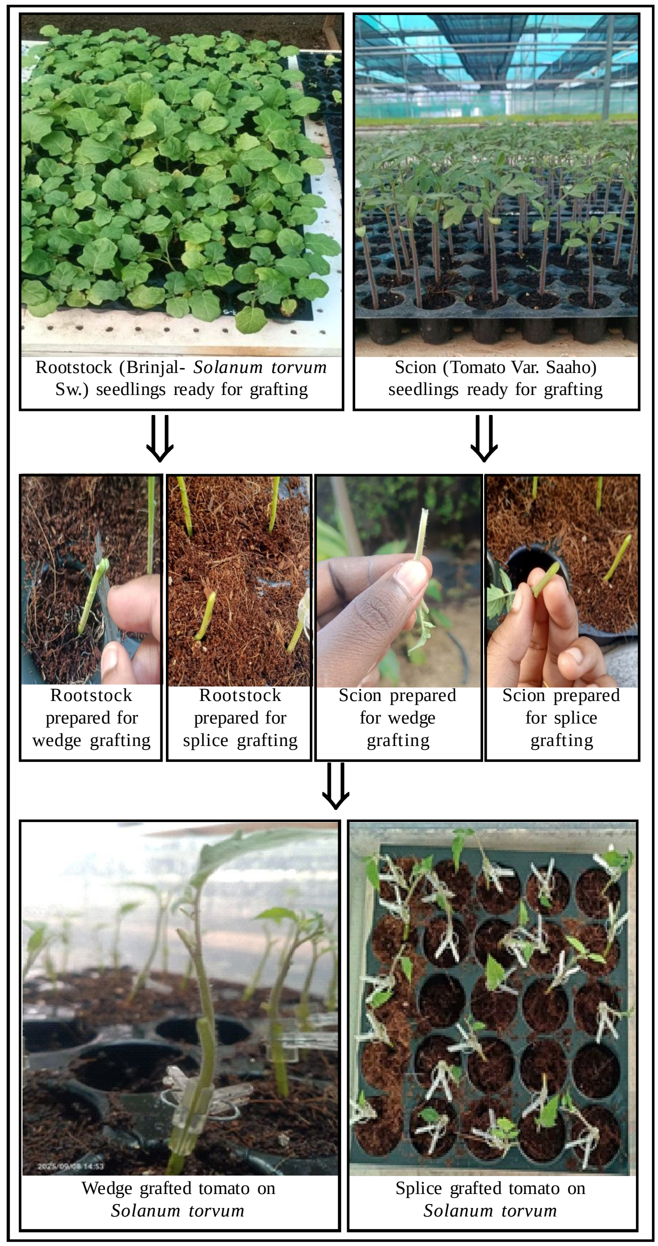

Fig. 2: Steps involved in wedge and splice grafting of tomato on Brinjal (*Solanum torvum* Sw) rootstock.

Table 1: Effect of different grating methods and healing conditions on diameter of rootstock, scion and scion to rootstock ratio of tomato grafted on *Solanum torvum*.

Factors	Treatment Details	Diameter of the rootstock			Diameter of the scion			Scion to rootstock ratio on diameter basis	
		0 DAG	15 DAG	% increase from 0 to 15 DAG	0 DAG	15 DAG	% increase from 0 to 15 DAG	0 DAG	15 DAG
Factor-I (Healing conditions-H)									
H_1	Healing chamber	2.87	2.93	2.08	2.49	2.53	1.82	0.87	0.87
H_2	Automated polyhouse	3.21	3.31	3.056	2.71	2.78	2.83	0.84	0.84
H_3	Polypropylene container in polyhouse	2.79	2.91	4.11	2.49	2.56	2.87	0.89	0.88
SE (m) ±		**0.156**	**0.162**	**0.055**	**0.150**	**0.154**	**0.045**	**0.036**	**0.035**
C.D at 5 %		**NS**	**NS**	**0.168**	**NS**	**NS**	**0.135**	**NS**	**NS**
Factor-II (Grafting method-G)									
G_1	Slice grafting	2.79	2.86	2.53	2.40	2.46	2.43	0.87	0.87
G_2	Cleft grafting	3.12	3.24	3.64	2.72	2.79	2.59	0.87	0.87
SE (m) ±		**0.128**	**0.132**	**0.045**	**0.122**	**0.126**	**0.036**	**0.029**	**0.029**
C.D at 5 %		**NS**	**NS**	**0.137**	**NS**	**NS**	**0.111**	**NS**	**NS**
Interaction (H×G)									
T_1	$H_1 \times G_1$	2.79	2.83	1.43	2.39	2.44	2.18	0.860	0.86
T_2	$H_1 \times G_2$	2.95	3.03	2.73	2.59	2.63	1.54	0.887	0.88
T_3	$H_2 \times G_1$	2.89	2.97	2.51	2.39	2.45	2.61	0.83	0.83
T_4	$H_2 \times G_2$	3.53	3.66	3.60	3.03	3.12	3.06	0.86	0.85
T_5	$H_3 \times G_1$	2.69	2.79	3.64	2.44	2.50	2.57	0.91	0.90
T_6	$H_3 \times G_2$	2.90	3.03	4.58	2.54	2.62	3.16	0.88	0.87
SE (m) ±		**0.221**	**0.229**	**0.078**	**0.212**	**0.218**	**0.063**	**0.051**	**0.050**
C.D at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**0.191**	**NS**	**NS**

NS: Non significant at 5% level of significance; DAG: Days after grafting

Grafting was performed by selecting rootstocks and scions of compatible stem diameter. The operation was carried out under shade conditions using a sterilized grafting blade, disinfected with alcohol. In cleft grafting (Fig. 2), the rootstock was given a horizontal cut, followed by a 0.5 cm vertical slit at its centre to form a "V" notch. The scion was shaped into a 0.5 cm wedge and inserted into this slit, after which the graft union was secured with spring clips. For splice grafting (Fig. 2), the rootstock was cut at a 35–45° angle, 0.8–1.0 cm below the cotyledon, and a scion of similar length cut at the same angle was aligned and fixed using a grafting clip or tube. To minimize transpiration, the grafted plants were gently misted, and subsequently transferred to a healing chamber maintained at 27 ± 2 °C with 80–90% relative humidity. The chamber environment was regularly checked using a hygrometer. The related parameters were recorded *viz.*, diameter of the rootstock, diameter of the scion, scion to rootstock ratio on diameter basis, height of scion, height of rootstock, grafting success and days taken for callus formation to assess the performance of different combinations.

The statistical analysis was performed using OPSTAT, an open-source agricultural data analysis software developed by CCSHAU, Hissar. Data recorded for all traits in both experiments were analyzed following the procedures outlined by Panse and Sukhatme (1985) for Factorial Completely Randomized Design (FCRD). Treatment effects were evaluated through an 'F' test of significance under the null hypothesis. Wherever significant differences were observed, critical difference (CD) was computed; otherwise, only standard error of means was reported. All data were analyzed and the results interpreted at a 5% probability level.

Result and Discussion

The data on rootstock and scion diameter and its ratio on diameter basis are presented in Table 1. As per the data presented in Table 1 on rootstock and scion diameter indicated that, the initial measures were not depicted the uniformity due to differences in the scion and rootstock diameter while grafting, due to which it may not be so appropriate to discuss on direct recorded data. Hence, the per cent (%) increases over initial diameters over 15 days after grafting were taken into account for drawing appropriate decisions on the

Table 2: Effect of different grating methods and healing conditions on height of the scion and rootstock, grafting success and days taken for callus formation in tomato grafted on Solanum torvum.

Factors	Treatment Details	Height of scion success			Height of rootstock			Grafting success	Days taken for callus formation
		0 DAG	15 DAG	% increase from 0 to 15 DAG	0 DAG	15 DAG	% increase from 0 to 15 DAG		
Factor-I (Healing conditions-H)									
H_1	Healing chamber	3.46	3.51	1.45	3.62	3.63	0.35	80.25	6.09
H_2	Automated polyhouse	4.88	4.98	2.05	3.09	3.10	0.42	68.31	6.34
H_3	Polypropylene container in polyhouse	4.49	4.61	2.69	3.08	3.09	0.47	90.32	5.83
SE (m) ±		**0.161**	**0.164**	**0.036**	**0.231**	**0.232**	**0.014**	**0.383**	**0.032**
C.D at 5 %		**0.491**	**0.500**	**0.110**	**NS**	**NS**	**0.042**	**1.164**	**0.096**
Factor-II (Grafting method-G)									
G_1	Slice grafting	4.43	4.52	1.89	3.11	3.12	0.41	77.39	6.29
G_2	Cleft grafting	4.12	4.20	2.24	3.41	3.42	0.42	81.87	5.88
SE (m) ±		**0.132**	**0.134**	**0.030**	**0.189**	**0.190**	**0.011**	**0.312**	**0.026**
C.D at 5 %		**NS**	**NS**	**0.090**	**NS**	**NS**	**NS**	**0.950**	**0.079**
Interaction (H×G)									
T_1	$H_1 \times G_1$	3.28	3.33	1.54	3.61	3.62	0.29	77.25	6.39
T_2	$H_1 \times G_2$	3.65	3.70	1.37	3.63	3.65	0.41	83.25	5.79
T_3	$H_2 \times G_1$	5.00	5.10	2.00	2.67	2.69	0.49	66.89	6.53
T_4	$H_2 \times G_2$	4.75	4.85	2.11	3.50	3.51	0.36	69.73	6.16
T_5	$H_3 \times G_1$	5.03	5.13	2.14	3.05	3.06	0.46	88.01	5.97
T_6	$H_3 \times G_2$	3.950	4.08	3.25	3.10	3.12	0.48	92.63	5.69
SE (m) ±		**0.228**	**0.232**	**0.051**	**0.327**	**0.328**	**0.019**	**0.541**	**0.045**
C.D at 5 %		**0.694**	**0.707**	**0.156**	**NS**	**NS**	**0.059**	**1.646**	**0.136**

NS: Non significant at 5% level of significance; DAG: Days after grafting

experiment. The combination of Saaho grafted onto *Solanum torvum* Sw. in polypropylene containers in polyhouse recorded the significantly highest increase in rootstock diameter (4.11%). In case of grafting methods, cleft grafting recorded significantly more increase (3.64%) in diameter as compared with splice method (2.53%). Interaction effect was found non-significant. Whereas, diameter of the scion was found significantly better increase in polypropylene containers in polyhouse (2.87%), which was on par with automated polyhouse conditions (2.83). Cleft grafting recorded more increase (2.59%) than splice grafting (2.43%). Interaction effect was also recorded significant differences, polypropylene containers in polyhouse with cleft grafting recorded maximum increase (3.16%) along with automated polyhouse conditions with cleft grafting method (3.06%). While scion to root ratio on diameter basis was found non-significant direct as well as interaction effects. Rivard (2007) also reported that rootstock diameter generally exceeds that of the scion used for grafting. These observations are in close agreement with the findings of Naik *et al.*, (2021) and Rajesh *et al.*, (2024).

The data on height of rootstock and scion are presented in Table 2. As per the data presented in Table 2 on rootstock and scion height indicated that, the initial measures were not depicted the uniformity due to differences in the scion and rootstock height while grafting, due to which it may not be so appropriate to discuss on direct recorded data. Hence, the per cent (%) increases over initial height over 15 days after grafting were taken into account for drawing appropriate decisions on the experiment. The combination of Saaho grafted onto *Solanum torvum* Sw. in polypropylene containers in polyhouse recorded the significantly highest increase in rootstock height (2.69%). In case of grafting methods, cleft grafting recorded significantly more increase (2.24%) in height of scion as compared with splice method (1.89%). Interaction effect was also recorded significant differences. Whereas, height of the scion was found significantly better in polypropylene containers in polyhouse with cleft grafting recorded maximum increase (3.25%).

The data on graft success and days taken for callus formation are presented in Table 2. The combination of Saaho grafted onto *Solanum torvum* Sw. polypropylene containers in polyhouse recorded the significantly highest increase grafting success (90.32%). In case of grafting methods, cleft grafting recorded significantly more increase (81.87%) in graft success as compared with splice method (77.39%). Interaction effect was found significant in polypropylene containers in polyhouse conditions with cleft grafting treatment was the most efficient, producing the maximum graft success (92.63%). Whereas, lowest in healing was found in Automated polyhouse (6.34) and fastest healing was found in polypropylene containers in polyhouse conditions (5.83). Cleft grafting has been recorded quickest healing (5.88) than splice grafting (6.29). Interaction effect was also recorded significant differences, polypropylene containers in polyhouse with cleft grafting recorded quickest healing (5.69) along with healing chamber conditions with cleft grafting method (5.79). The above results are in similar with Shipepe and Msogoya 2018; Surve *et al.*, 2019; Jain *et al.*, 2024; Sabatino *et al.*, 2019. In previous studies on brinjal and tomato grafted onto *Solanum torvum* rootstock, proliferation layers were evident by the 15th day and a callus bridge was formed by the 30th day after grafting (Dhivya, 2014). Similarly, anatomical studies of bitter gourd grafted onto pumpkin rootstock showed the appearance of proliferation layers by the 7th day, with callus bridge development by the 15th day. Vascular differentiation within the cambial region was observed by the 30th day, reaching complete differentiation by the 45th day post-grafting (Tamilselvi, 2014).

Conclusion

These findings demonstrated that both healing environments and grafting techniques had a considerable impact on growth attributes, graft success and the healing process of grafted seedlings. Among the healing conditions, the polypropylene container maintained inside a polyhouse (H_3) proved superior, as it achieved the highest graft success rate (90.32%) and the quickest callus formation (5.83 days), along with notable improvements in rootstock and scion diameter. Regarding grafting techniques, cleft grafting (G_2) outperformed slice grafting by recording greater increases in growth parameters, a higher success rate (81.87%) and shorter healing period (5.88 days). The combined effect highlighted that the polypropylene containers in polyhouse conditions with cleft grafting treatment was the most efficient, producing the maximum graft success (92.63%) and the fastest healing (5.69 days). In conclusion, employing cleft grafting under polypropylene container conditions within a polyhouse emerges as the most effective strategy for enhancing graft union establishment, promoting callus development, and improving overall growth performance.

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