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Standardization of Grafting Techniques: Unlocking the Potential of Pomegranate (*Punica granatum* Linn.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An Experiment was conducted at Department of Agriculture, School of Agriculture and Veterinary Science, Shridhar University, Pilani, Rajasthan, India during 2023-2024. Softwood grafting and (T_1 on June 15; T_2 on June 30; T_3 on July 15; T_4; on July 30; T_5 on August 15; T_6 on August 30), tongue grafting (T_7 on June 15; T_8 on June 30; and T_9 on July 15, T_{10} on 30th July, T_{11} on August15, T_{12} on August 30) these were the 12 grafting techniques that used as treatments in the study. For this study, one-year-old Ganesh seedlings were utilized as the rootstock. Experiment T_3, which entailed grafting softwood on July 15th, had the highest outcomes in terms of early bud break (15.16 days), improved sprouting percentage (57.32%) at 150 DAG, and grafting success (74%), at 60 DAG. When softwood and whip & tongue grafting methods were compared, softwood grafting produced better results in terms of bud break, sprouting percentage, and grafting success.

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Keywords: Pomegranate; grafting methods; graft success; grafting time; softwood grafting; tongue grafting.

1. INRODUCTION

The pomegranate, *Punica granatum* (L.), commonly referred to as the Chinese apple, is a plant belonging to the Punicaceae family with chromosomes no. 2n=18. One of the most revered and ancient beloved fruits. A common term for it is "friendship fruit." Customers all across the world seek for this well-known commercial fruit because of its exceptional combination, high dessert quality, and sweet-acid flavor. Due to its robust nature, pomegranates may thrive in a broad range of climates, including tropical, subtropical, desert, and temperate ones. The world's largest producer of pomegranates is India. There are over 760 varieties of pomegranate. Each pomegranate has about 840 seeds. It is grown commercially in the state of Maharashtra, Gujrat, Karnataka, Andhra Pradesh, Tamil Nadu, Madhya Pradesh and Rajasthan. Out of India's total production only 1.79% is exported. Pomegranate fruit has enormous medicinal and nutritional value due to the fact that is one of the richest sources of antioxidants. Currently, 275,500 hectares are planted with this fruit crop, with annual production of 3 million metric tons (MT) o (NHB statistics 2021-22). The state of Maharashtra with 75% of the total production leads the field, followed by Andhra Pradesh and Karnataka. The most common pomegranate propagation method is air layering. Our goal was to evaluate an alternative method of pomegranate propagation by whip/tongue and wedge grafting techniques using the softwood.

2. MATERIALS AND METHODS

The current study was conducted in 2023–24 at the Department of Agriculture (experimental field), School of Agriculture and Veterinary Science, Shridhar University, Pilani, Rajasthan, India. The study took place in the IV agro-climatic zones of Rajasthan (Transitional Plain of Inland Drainage), which are located at an altitude of 533 meters above sea level and at 28^0 to 27^0 N latitude and 75^0 to 63^0 E longitude. In the current study, 12 treatment combinations with 2 grafting methods, tongue grafting and wedge grafting, were included at two-week intervals throughout the months of June, July, and August. The treatments were set up in a randomized design with three replications. For grafting, we used about 15 cm long 'Bhagawa' scionwood. Rootstocks were one-year-old seedlings of Ganesh. Rootstocks were pencil-thick (0.6-0.8 cm diameter) and had uniform growth. Upon selecting a scion, the rootstock was headed back to 15-17 cm above the bag. We cut into the beheaded rootstock with the grafting knife to the depth of 2.5 to 5 cm. The scion was prepared by making a slanted cut on both sides approximately 5 cm long, creating a wedge-shaped end to be inserted into the prepared rootstock making sure that the cambium on both, rootstock and scion components are aligned and pressed together. The next step was to tie the graft, scion and rootstock combination, with a 150-gauge polythene strip, 1.5 cm wide and 30-40 cm long. Immediately after grafting, the graft was covered with a 2.5×16 cm long white polythene cap that was tied with thread at the lower end. We collected the sprouting data after 30 days, 60 days, 90 days, 120 days, and 150 days. The percentage of success was measured at 60 days after grafting, and the length of the scion was measured at 30 days, 60 days, 90 days, 120 days, and 150 days. For statistical analysis, we followed the Panse and Sukhatme (1978) protocol.

3. RESULTS AND DISCUSSION

At 150 DAG across all treatments, T_3 (softwood grafting) had the highest sprouting percentage (57.32%) whereas T_9 (whip and tongue grafting) had the lowest sprouting percentage (11.4%) (Table 1). The highest percentage of successful grafting (74%) was in (T_3) on July 15th, 60 days after grafting (Table 2). On July 15, whip and tongue grafting in T_9 had the lowest grafting success rate (11.49%) (Table 2). At 150 DAG, T_3 had maximum shoot height of 56 cm. The longest shoot length (24.64 cm) was on T_5 on August 15, at 60 DAG. In treatments including whip and tongue grafting, the minimum shoot length was noted. According to your tables, after 150 DAG, the largest diameter of 5.9 mm was in T_{12} and for the same period, the smallest shoot diameter of 5.22 was in T_6 (Table 4).

Notably, T_3 showed the highest percentage of pomegranate graft sprouting (57.32%), whereas tongue and whip grafting showed lower percentages of sprouting (11.4%) at 150 DAG (Dubey et al., 2022; Das et al., 2024). The results

show that the percentage of pomegranate grafts that sprouted was significantly influenced by the procedure and season. The extreme humidity and temperatures that were present at the time might account for this. Graft uptake was significantly impacted by the high humidity and warmth (Hartman and Kester, 1986). The results indicate that the percentage of pomegranate grafts that sprouted was significantly influenced by the procedure and season (Raj et al., 2024). The extreme humidity and temperatures that were present at the time might account for this. The high humidity and warmth had a major effect on graft absorption (Hartman and Kester, 1986; Patil et al., 2010; Sonawane et al., 2012) have confirmed the results of this study. It is plausible that incorrect interlocking of the scion and stocks causes less intimate contact between the two, preventing callus formation and reducing the sprouting percentage in tongue and whip grafting. A parallel result was defined by Hussain et al. (2016). The percentage of graft success (%) was highly impacted by the grafting method.

In contrast, T_9 had the lowest grafting success (%) of any species when whip and tongue grafting were used. The two primary factors that have a greater influence on the formation of graft unions are the optimal temperature and relative humidity, and they are to blame. In July, higher humidity helps to keep the scion from desiccating, which keeps the cells turgid and facilitates the creation of a callus between the scion and stock quickly. Similar to what Ghosh et al. (2010) observed, Nitish et al. (2019) saw increased graft success rates in July (72%) for softwood grafting in sapota. The highest grafting success (63.33%) in softwood grafted plants in sapota was reported by (Patil et al., 2010; Patil, 2019) also observed that the month of July (80.00%) had a higher grafting success percentage for softwood grafting. At 150 DAG, T_3 had a significant increase in shoot length (cm) of 56.00, whereas T_{11} had the lowest shoot length (44.15). Table 3 makes it clear that, in contrast to whip/tongue grafted plants, softwood grafted plants produced the longest shoots. It might be the result of increased warmth and humidity within the shade net, which raises cell metabolism and causes the scion's development to extend. Nitish et al. (2019) in sapota found the highest growth of scion in softwood grafting method performed in July month (Dubey et al., 2021; Sunil et al., 2023). There is a correlation between those research' findings and ours. Softwood grafting unquestionably provided the highest scion diameter (5.82 cm), as compared to whip and tongue grafting (5.9 cm) (Table 4). It occurred because softwood grafted plants have more leaves and early development, which leads to a larger accumulation of carbohydrates. Additionally, the humidity and temperature in July were favorable for the grafts to flourish. The results of this study are in line with those of Patel et al. (2010), who examined the highest scion diameter of softwood grafted plants in July while doing research in Mandarin.

Table 1. Sprouting percentage at various days of grafting

Treatments	Sprouting percentage (%) at DAG				
	30	**60**	**90**	**120**	**150**
T_1	24.00 (29.00)	32.32 (34.16)	28.16 (31.58)	28.15 (31.58)	24.00 (28.48)
T_2	32.32 (34.16)	32.32 (34.16)	32.32 (34.16)	32.32 (34.16)	32.32 (34.16)
T_3	53.16 (46.40)	74.00 (59.53)	61.49 (51.23)	57.32 (48.81)	57.32 (48.82)
T_4	11.49 (19.69)	24.00 (29.00)	24.00 (29.00)	24.00 (29.00)	24.00 (29.00)
T_5	36.49 (36.75)	36.49 (36.75)	36.49 (36.75)	36.49 (36.75)	36.49 (36.75)
T_6	49.00 (44.00)	53.16 (46.40)	49.00 (44.00)	44.82 (41.57)	44.82 (41.58)
T_7	0.00	0.00	0.00	0.00	0.00
T_8	0.00	0.00	0.00	0.00	0.00
T_{10}	0.00	0.00	0.00	0.00	0.00
T_{11}	40.67 (39.16)	53.16 (46.40)	53.16 (46.40)	53.16 (46.40)	53.16 (46.46)
T_{12}	40.66 (39.16)	36.49 (36.75)	32.32 (34.16)	32.32 (34.16)	32.32 (34.16)
S. E±	**1.42**	**2.11**	**1.83**	**1.79**	**2.12**
C.D 5%	**4.17**	**6.21**	**5.38**	**5.26**	**6.24**

Table 2. Graft success percentage at 60 days after grafting

Treatments	Percentage of graft success
T_1	32.32 (34.16)
T_2	32.32 (34.16)
T_3	74.00 (59.53)
T_4	24.00 (29.00)
T_5	36.49 (36.75)
T_6	53.16 (46.40)
T_7	0.00 (0.00)
T_8	0.00 (0.00)
T_9	11.49 (19.69)
T_{10}	0.00 (0.00)
T_{11}	53.16 (46.40)
T_{12}	36.49 (36.75)
S. E±	**2.11**
C.D 5%	**5.21**

Table 3. Impact of grafting on length of shoot at various days of grafting

Treatment	Shoot length (cm) at DAG				
	30	**60**	**90**	**120**	**150**
T_1	15.61	20.00	32.42	38.33	47.14
T_2	14.35	18.80	29.72	38.65	48.14
T_3	16.57	20.49	40.19	44.19	56.00
T_4	16.29	20.24	28.84	35.17	51.52
T_5	11.77	24.65	27.08	33.15	44.21
T_6	14.75	21.41	27.58	43.61	49.75
T_7	0.00	0.00	0.00	0.00	0.00
T_8	0.00	0.00	0.00	0.00	0.00
T_9	11.72	17.52	26.00	30.79	42.06
T_{10}	0.00	0.00	0.00	0.00	0.00
T_{11}	8.92	19.81	28.86	35.23	44.15
T_{12}	14.72	19.74	24.65	34.22	47.84
S. E±	**0.69**	**1.00**	**1.27**	**2.15**	**2.24**
C.D 5%	**2.06**	**2.92**	**3.75**	**6.33**	**6.59**

Table 4. Impact of grafting on scion diameter at various Days After Grafting (DAG)

Treatment	Scion diameter (mm) at DAG				
	30	**60**	**90**	**120**	**150**
T_1	4.62	4.82	5.06	5.32	5.44
T_2	4.71	5.08	5.32	5.45	5.76
T_3	5.17	5.21	5.28	5.46	5.55
T_4	5.73	5.37	5.44	5.81	5.82
T_5	4.65	4.92	5.28	5.43	5.65
T_6	4.68	4.77	4.97	5.15	5.22
T_7	0.00	0.00	0.00	0.00	0.00
T_8	0.00	0.00	0.00	0.00	0.00
T_9	5.07	5.18	5.26	5.37	5.46
T_{10}	0.00	0.00	0.00	0.00	0.00
T_{11}	4.53	4.73	4.79	5.01	5.41
T_{12}	4.57	4.47	5.05	5.02	5.9
S. E±	**0.12**	**0.18**	**0.06**	**0.9**	**0.10**
C.D 5%	**0.37**	**0.54**	**0.18**	**0.29**	**0.31**

DAG - Days After Grafting

4. CONCLUSION

In summary, our data suggest that grafting might be used to propagate pomegranates. Based on all the parameters examined, the cleft or wedge grafting that was done on July 15th produced the best results under shade net conditions. As a result, softwood grafting may be employed commercially by employing rootstocks resistant to different serious diseases, such as pomegranate wilt.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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