



Standardization of Time and Method of Grafting in Custard Apple (*Annona squamosa* L.) cv. Balanagar in Bundelkhand Region

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Abstract

The present study focused on the “Standardization of grafting time and method in custard apple (*Annona squamosa* L.) cv. Balanagar in the Bundelkhand region” and was conducted at Rani Lakshmi Bai Central Agricultural University, Jhansi, between January to June 2022. The experiment followed a Completely Randomized Design with a factorial arrangement, including twelve treatment combinations, and was replicated three times. The results regarding different grafting time and methods indicated that grafting performed in 3rd week of February and among different grafting methods, wedge grafting was found to be most favourable in terms of significantly higher number of graft sprouted, graft success percentage, number of shoots at 30, 60 and 90 DAG, shoot length at 30, 60 and 90 DAG, number of leaves at 30, 60 and 90 DAG, survival percentage of graft at 90 DAG, maximum leaf area at 60 and 90 DAG, scion girth at 60 and 90 DAG, internodal length at 30 and 60 DAG, fresh shoot biomass, fresh root biomass, dried shoot biomass and dried root biomass. Among interaction, 3rd week of February with wedge grafting found significantly higher number of graft sprout, graft success percentage, number of shoots 60 and 90 DAG, shoot length at 30, 60 and 90 DAG and number of leaves at 90 DAG maximum leaf area at 60 and 90 DAG, scion girth, internodal length, fresh shoot biomass, fresh root biomass, dried shoot biomass at 90 DAG.

Received: Sep 15, 2025

Accepted: Oct 10, 2025

Published Online: Oct 17, 2025

Journal: Journal of Plant Biology and Crop Research

Publisher: MedDocs Publishers LLC

Online edition: <http://meddocsonline.org/>

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Keywords: Custard apple; Days After Grafting (DAG); grafting time; grafting method.

Introduction

Custard apple (*Annona squamosa* L.), a key dryland fruit crop in India, belongs to the Annonaceae family. Though its primary origin is tropical America, it was historically cultivated from Central America to Southern Mexico. Commonly referred to as “Sugar apple,” “Sweet sop,” and “Sitaphal” or “Sarifa” in Hindi,

it thrives in forests, wastelands, rocky terrains, and other uncultivated areas, often regarded as a semi-wild fruit [1]. With its sweet and delicate flesh, custard apple is a prized fruit in arid regions and can be grown in arid and semi-arid conditions which are characterized by low and variable rainfall, high an-



Cite this article: Shreenidhi, Sharma G, Sharma S, Pal R, Abrol GS. Standardization of time and method of grafting in custard apple (*Annona squamosa* L.) cv. Balanagar in Bundelkhand region. J Plant Biol Crop Res. 2025; 9(2): 1112.

nual evaporation and high summer temperatures. Its xerophytic traits—such as deep roots, water retention capabilities, and adaptive leaf shedding—enable it to thrive in such challenging environments [2]. The optimal temperature range for custard apple growth is between 15°C and 25°C, although it can tolerate temperatures below freezing and above 40°C, with the latter causing significant floral drop in northern India. In India, custard apple is cultivated in states such as Andhra Pradesh, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Tamil Nadu, and Odisha. According to the National Horticulture Board [3], it covers approximately 46,000 hectares, yielding around 407,000 metric tons.

The Balanagar variety of custard apple is widely cultivated in the Bundelkhand region and is highly valued for its adaptability and superior yield compared to other custard apple varieties. The fruit is medium-sized, green in colour, and has a sweet taste. This hardy variety requires less water and thrives in arid regions. Custard apple can be propagated through both vegetative methods and seeds. However, seed propagation often results in significant variability in growth, productivity, and fruit quality. Vegetative propagation methods, such as wedge grafting, are simple, cost-effective, and capable of producing a large number of grafts in a short time [4]. The timing of grafting varies depending on local climatic conditions, as these greatly influence grafting success. Environmental factors significantly impact healing, callus formation, graft uptake, and the overall growth of the grafted plant [5].

Materials and methods

Location

The experiment was carried out in Horticulture Nursery, Department of Fruit Science, COH&F, Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh during January to June 2022.

Climate

The climate of the Bundelkhand region is semi-arid and subtropical, marked by hot, dry winds during the summer, warm, humid conditions during the monsoon, and cold, dry weather in the winter. The average annual temperature ranges from 7.4°C to 42.2°C, with April and May being the hottest months. The region receives an average annual rainfall of approximately 714.2 mm. Relative humidity typically fluctuates between 80-95% (maximum) and 48-68% (minimum). The monsoon in this region is often unpredictable, both in terms of total rainfall and its distribution. Historical climate data (Figure 1) for the Jhansi district (1991-2021) shows that the highest temperatures and rainfall occur from April to June and July to September, while the period from December to February is cooler.

Treatment details

The experiment was laid out in Completely Randomized Design with Factorial Concept (FCRD) with twelve treatment combinations and replicated thrice. Twelve treatment combination comprising of six different grafting times (S) viz., S1- 1st week of January, S2- 3rd week of January, S3- 1st week of February, S4- 3rd week of February, S5- 1st week of March, S6- 3rd week of March with two different grafting methods (M) viz., M1- wedge grafting, M2- side grafting.

Method of grafting

Wedge grafting:

One-year-old rootstocks with pencil-sized thickness were collected from the Horticulture Nursery in Baruasagar, and scions of the Balanagar variety were collected from mother plants in the Fruit Orchard at the College of Horticulture and Forestry, RLBCAU, Jhansi. The scions were carefully selected to match the girth of the rootstock. The rootstocks were cut at a height of 15-20 cm above ground level, and a vertical “V”-shaped wedge incision, approximately 2 to 4 cm in length, was made on the rootstock using a sharp knife. A matching shallow incision was made on the lower portion of the scion, ensuring some bark was left on the remaining two sides of the scion. The scion was then inserted into the rootstock and secured with 2 to 2.5 cm wide transparent polythene strips of 300 gauge. A total of 20 grafts per treatment were prepared for further studies.

Side grafting:

The rootstock is given a shallow downward side cut about 2 cm to 2.5 cm long at the base of the stem on the rootstock to expose a flap of bark with some wood still attached by using sharp knife. An inward cut at the base was made so that the flap of bark and wood can be removed from the rootstock. The scion of 10-15 cm was selected with a diameter the same as or slightly smaller than the rootstock. Sloping cut 2 cm to 2.5 cm long at the base of the scion was made. The scion was inserted and wrapped with transparent, 300 gauge of polythene strips. The aerial head of the stock permitted to grow until union is established between stock and scion. Total 20 grafts per treatment were prepared and used for further studies.

Observation recorded

The observations were recorded on various parameters viz., number of graft sprouts, days taken for first graft sprouting, graft success percentage (%) were at 30 DAG, number of shoots, shoot length (cm), number of leaves were at 30, 60 and 90 DAG and survival percentage of grafted plant (%) at 90 DAG, leaf area (cm²), scion girth (mm), inter nodal length (cm) were at 60 and 90 DAG and fresh shoot biomass (g), fresh root biomass (g), dried shoot biomass (g) and dried root biomass (g) at 90 DAG. Graft success percentage, survival percentage were calculated by following formula.

$$\text{Graft success percent} = \frac{\text{No. of sprouted grafts}}{\text{Total no. of grafts prepared}} \times 100$$

$$\text{Survival percent} = \frac{\text{Number of survived grafts}}{\text{Total number of grafts}} \times 100$$

Statistical analysis

Various characters under study were statistically analyzed by using analysis of variance technique for Completely Randomized Design (CRD) with Factorial concept as described by Steel and Torrie (6) and significant differences between means were evaluated against the Critical Difference (C.D.) at a 5% probability level.

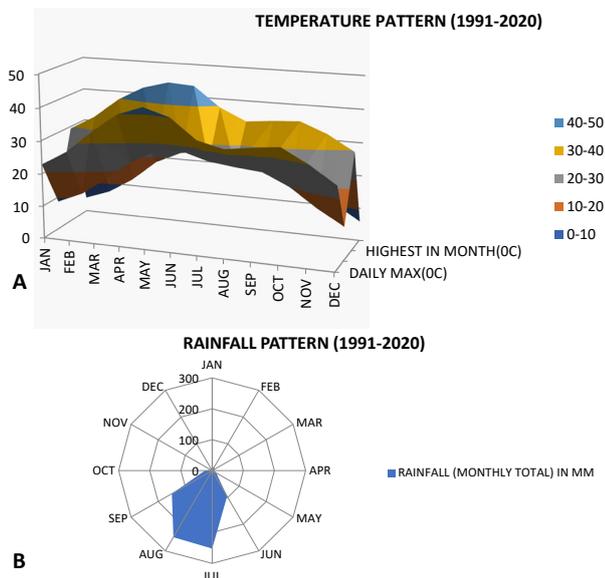


Figure 1: The average temperature (a) and rainfall (b) pattern in the Jhansi district of Bundelkhand region, Central India (1991-2020).

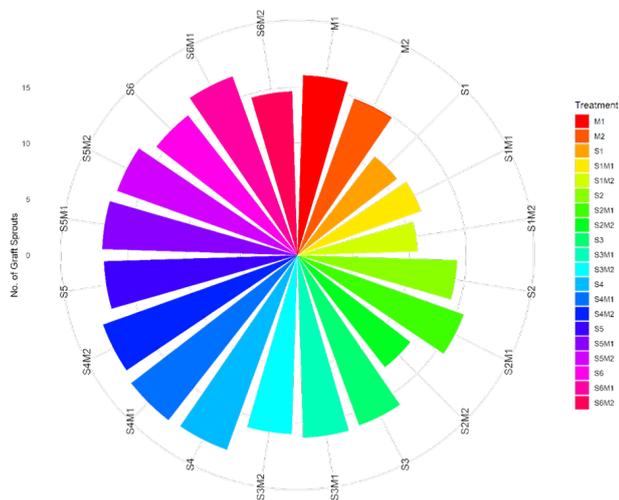


Figure 2: Effect of grafting time and method on number of graft sprouts.

Table 1: Effect of grafting time and method on days taken for first graft sprout.

Treatments	Days take for first graft sprout
Grafting time (S)	
S ₁ (1 st week of January)	27.67
S ₂ (3 rd week of January)	24.17
S ₃ (1 st week of February)	16.5
S ₄ (3 rd week of February)	9.5
S ₅ (1 st week of March)	7.67
S ₆ (3 rd week of March)	10.67
S.E(m)±	0.3
CD ≤ 5%	0.89
Method of grafting (M)	
M ₁ (Wedge grafting)	15.61
M ₂ (Side grafting)	16.44
S.E(m)±	0.17
CD ≤ 5%	0.5
Interaction (S X M)	
S ₁ M ₁	27.33
S ₂ M ₁	23.67
S ₃ M ₁	15.33
S ₄ M ₁	9
S ₅ M ₁	7.33
S ₆ M ₁	11
S ₁ M ₂	28
S ₂ M ₂	24.67
S ₃ M ₂	17.67
S ₄ M ₂	10
S ₅ M ₂	8
S ₆ M ₂	10.33
S.E(m)±	0.42
CD ≤ 5%	1.24

Table 1: Effect of grafting time and method on number of shoots (cm), shoot length and number of leaves.

Treatments	No. of shoots / grafted plant			Shoot length (cm)			No. of leaves / grafted plant		
	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG
Grafting time (S)									
S ₁ (1 st week of January)	2.73	3.33	4.43	3.06	5.46	6.40	2.87	6.63	7.93
S ₂ (3 rd week of January)	3.47	4.10	4.70	3.15	5.77	7.29	3.47	6.97	8.97
S ₃ (1 st week of February)	3.73	4.30	4.90	3.43	5.71	8.78	3.73	7.63	10.93
S ₄ (3 rd week of February)	4.23	4.83	6.10	3.87	6.08	11.97	4.63	8.33	12.57
S ₅ (1 st week of March)	3.83	4.53	5.37	3.53	5.89	11.02	3.97	8.00	11.73
S ₆ (3 rd week of March)	2.83	3.97	4.90	3.23	5.56	8.50	3.17	7.13	9.13
S.E(m)±	0.10	0.07	0.06	0.05	0.07	0.07	0.09	0.10	0.08
CD ≤ 5%	0.29	0.20	0.18	0.15	0.20	0.21	0.27	0.29	0.23
Method of grafting (M)									
M ₁ (Wedge grafting)	3.66	4.34	5.21	3.46	5.93	9.16	3.84	7.79	10.53
M ₂ (Side grafting)	3.29	4.01	4.92	3.29	5.56	8.83	3.43	7.11	9.89
S.E(m)±	0.06	0.04	0.04	0.03	0.04	0.04	0.05	0.06	0.05
CD ≤ 5%	0.17	0.11	0.11	0.09	0.11	0.12	0.16	0.17	0.14

Interaction (S X M)									
S ₁ M ₁	2.80	3.33	4.67	3.12	5.55	6.47	3.00	6.73	8.07
S ₂ M ₁	3.73	4.13	4.73	3.19	5.87	7.31	3.73	7.27	9.27
S ₃ M ₁	3.80	4.40	4.93	3.49	6.02	9.01	3.87	8.00	11.20
S ₄ M ₁	4.67	5.13	6.20	4.05	6.21	12.11	4.93	8.67	12.67
S ₅ M ₁	4.07	4.87	5.67	3.72	6.05	11.23	4.00	8.33	12.40
S ₆ M ₁	2.87	4.20	5.07	3.21	5.89	8.82	3.53	7.73	9.60
S ₁ M ₂	2.67	3.33	4.20	3.00	5.37	6.34	2.73	6.53	7.80
S ₂ M ₂	3.20	4.07	4.67	3.10	5.67	7.26	3.20	6.67	8.67
S ₃ M ₂	3.67	4.20	4.87	3.36	5.40	8.54	3.60	7.27	10.67
S ₄ M ₂	3.80	4.53	6.00	3.69	5.95	11.84	4.33	8.00	12.47
S ₅ M ₂	3.60	4.20	5.07	3.33	5.73	10.81	3.93	7.67	11.07
S ₆ M ₂	2.80	3.73	4.73	3.25	5.22	8.17	2.80	6.53	8.67
S.E(m)±	0.14	0.09	0.09	0.07	0.09	0.10	0.13	0.14	0.11
CD ≤ 5%	NS	0.27	0.26	0.21	0.28	0.30	NS	NS	0.33

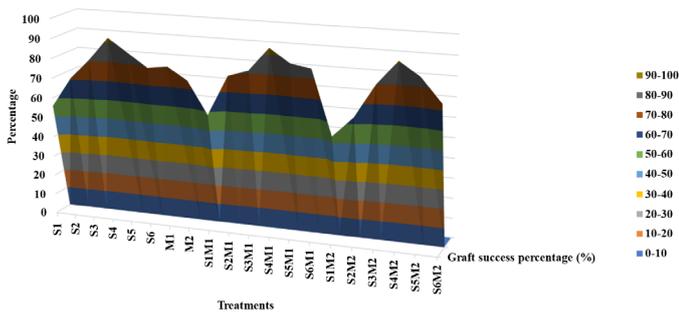


Figure 3: Effect of grafting time and method on graft success percentage.

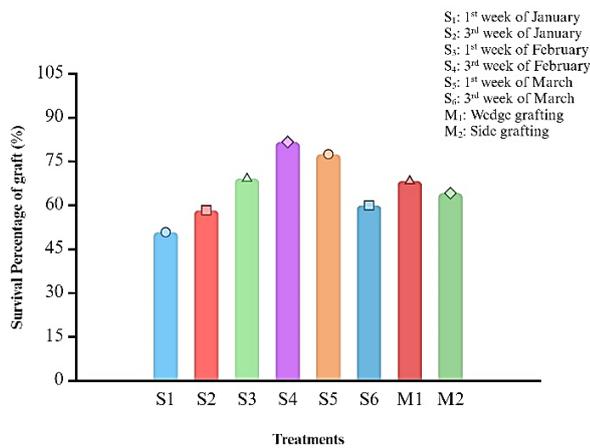


Figure 5: Effect of grafting time and method on survival percentage (%).

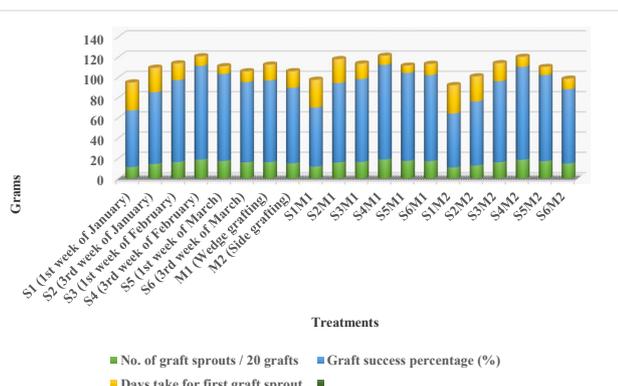


Figure 6: Effect of grafting time and method on fresh shoot biomass (g), fresh root biomass (g), dried shoot biomass (g) and dried root biomass (g).

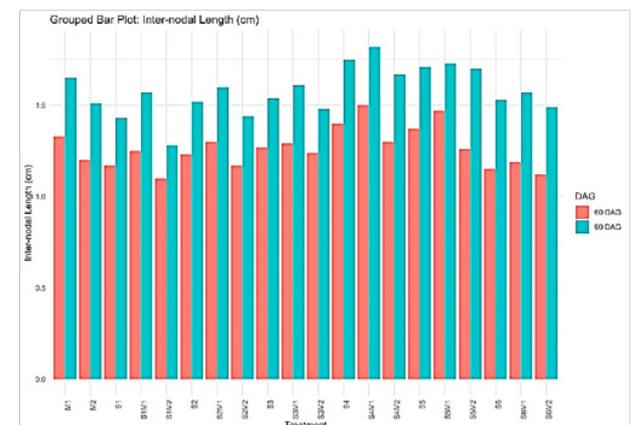
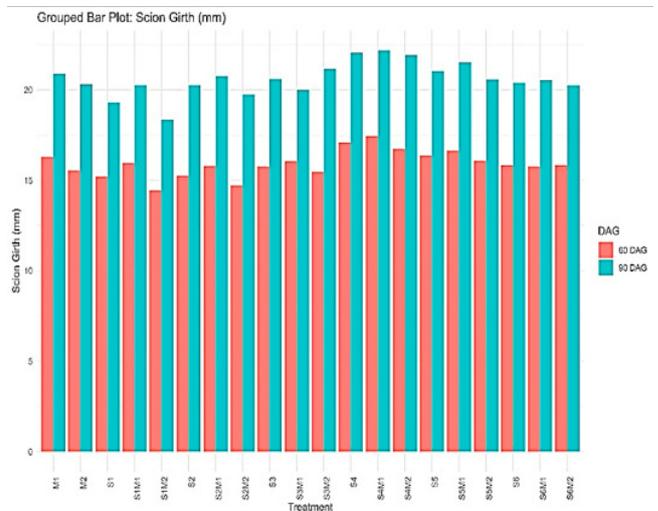
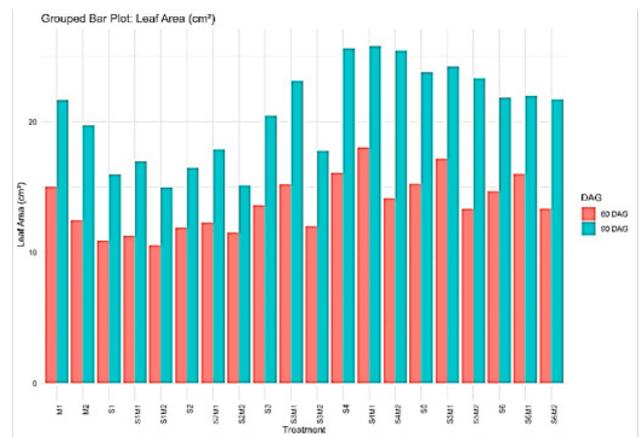


Figure 4: Effect of grafting time and method on leaf area (cm²) (A), scion girth (mm) (B) and inter nodal length (cm) (C).

Results and discussion

Number of grafts sprouted per treatment

The data presented in Figure 2 indicates that the timing of grafting had a significant impact on the number of grafts that sprouted per treatment. The highest number of grafts sprouted (18.50) occurred when grafting was performed in the third week of February (S4), followed by grafting in the first week of March (S5). The lowest number of sprouted grafts (11.17) was recorded for grafting conducted in the first week of January (S1). This variation may be attributed to favourable climatic conditions during the third week of February. Similar findings have been reported by 1 in custard apple, 7 and 8 in guava.

Among the grafting methods, wedge grafting (M1) produced the highest number of sprouted grafts (16.11). This may be due to the early formation of the graft union, as wedge grafting provides a larger surface area for contact between the cut sections of the scion and rootstock, promoting better callus formation and faster union compared to side grafting [9].

The interaction between grafting time and method was also significant in terms of the number of grafts sprouted per treatment. The highest number of grafts sprouted (18.67) was observed in the S4M1 combination (third week of February + wedge grafting), which was statistically similar to the combinations S4M2 (third week of February + side grafting) and S5M1 (first week of March + wedge grafting).

Graft success percentage (%)

The data on graft success percentage (Figure 3) showed that the highest success rate (92.50%) was achieved with grafting performed in the third week of February (S4). This can be attributed to favourable climatic conditions and the increased levels of auxin and carbohydrates in the scions collected during this period, which enhance graft-take [10]. Additionally, the graft success rate was significantly affected by the grafting methods, with wedge grafting (M1) showing the highest success rate of 80.56%. These findings align with previous studies by 4 and 11 in custard apple.

When examining the interaction between grafting time and methods, the highest graft success percentage (93.33%) was noted in S4M1 (third week of February + wedge grafting), surpassing all other combinations. Similar observations were reported by 1 in custard apple.

Days taken for first graft sprouting

The shortest time (Table 1) to the first sprouting (7.67 days) was observed when grafting was performed in the first week of March (S5), followed by grafting in the third week of February (S4). The longest time to sprouting (27.67 days) occurred with grafting in the first week of January (S1). This could be attributed to the higher temperatures in March, when custard apple plants resume growth after dormancy, with scions containing higher carbohydrate levels and improved sap flow, promoting earlier sprouting [12].

Regarding grafting methods, wedge grafting (M1) led to the shortest time for sprouting (15.61 days), which aligns with the findings of 13 in custard apple and 14 in guava.

The interaction between grafting time and methods also showed significant results, with the shortest sprouting time (7.33 days) recorded in S5M1 (first week of March + wedge

grafting). Similar results were reported by 15 in custard apple.

Number of shoots per grafted plant

The data in Table 2 indicated that grafting time significantly affected the number of shoots per grafted plant. The highest number of shoots per plant (4.23, 4.83, and 6.10 at 30, 60, and 90 days after grafting, respectively) was observed with grafting in the third week of February (S4). This can be attributed to favourable climatic conditions during February and March, as the gradual increase in temperature during this period positively impacted callus formation and cell activity, leading to improved graft union [16].

Grafting methods also had a notable effect on shoot production, with wedge grafting (M1) resulting in the highest number of shoots per plant (3.66, 4.34, and 5.21 at 30, 60, and 90 days after grafting, respectively). This may be due to the favourable conditions in February and March, which likely enhanced photosynthesis and physiological processes like respiration [17].

While the interaction between grafting time and methods was not significant at 30 days after grafting, it became significant at 60 and 90 days. The highest number of shoots per grafted plant (5.13 and 6.20 at 60 and 90 days, respectively) was recorded for S4M1 (third week of February + wedge grafting).

Shoot length per grafted plant (cm)

The longest shoot length per plant (3.87, 6.08, and 11.97 cm at 30, 60, and 90 days after grafting, respectively) was observed (Table 2) for grafts made in the third week of February (S4), followed by those grafted in the first week of March (S5). This increase in shoot length may be attributed to rising temperatures, which promote callus tissue formation and high cell activity necessary for better graft union [16], ultimately leading to faster shoot growth and enhanced photosynthesis.

Wedge grafting (M1) also resulted in significantly longer shoot lengths (3.46, 5.93, and 9.16 cm at 30, 60, and 90 days after grafting, respectively). These findings are in line with those reported by 17 in jamun and 18 in guava.

The interaction between grafting time and method was significant, with the longest shoot lengths (4.05, 6.21, and 12.11 cm at 30, 60, and 90 days after grafting) observed in S4M1 (third week of February + wedge grafting).

Number of leaves per grafted plant

The data on the number of leaves per grafted plant at 30, 60, and 90 days after grafting (Table 2) showed that grafting time significantly affected leaf production. The highest number of leaves (4.63, 8.33, and 12.57 at 30, 60, and 90 days, respectively) was recorded for grafts performed in the third week of February (S4). This period coincides with the resumption of growth in custard apple plants after dormancy, and the improved sap flow likely supported the healing process, enhancing the connection of cambial and vascular tissues, which facilitated early sprouting and an increased number of leaves compared to grafts made in later months [19].

Wedge grafting (M1) also resulted in a significantly higher number of leaves (3.84, 7.79, and 10.53 at 30, 60, and 90 days, respectively). These results are consistent with the findings of 1, 4, 11 and 12 in custard apple, as well as 20 in mango.

While the interaction between grafting time and method was not significant at 30 and 60 days after grafting, it became

significant at 90 days. The highest number of leaves (12.67 at 90 days after grafting) was observed in the combination of S4M1 (third week of February + wedge grafting).

Survival percentage of grafted plant (%)

The data on the survival percentage of grafted plants at 90 days after grafting (Figure 4) showed that grafting time had a significant impact. The highest survival rate (81.67%) at 90 days was observed when grafting was performed in the third week of February (S4), followed by 79.17% for grafting in the first week of March (S5). Similar findings have been reported by 21 in guava, 10 in sapota, 19 in walnut, and 22 in jamun.

In terms of grafting methods, wedge grafting (M1) showed the highest survival percentage (68.89% at 90 days). These results align with those of 4, who found wedge grafting to be superior to side grafting, and 14, who noted that wedge grafting had a higher survival rate compared to side and approach grafting in guava.

The interaction between grafting time and methods was found to be non-significant for the survival percentage of grafted plants at 90 days after grafting.

Leaf area (cm²)

The largest leaf area (16.09 cm² at 60 days and 25.62 cm² at 90 days after grafting) was recorded (Figure 5) for grafts performed in the third week of February (S4), followed by grafting in the first week of March (S5). Similar findings were reported by 22 in jamun and 23 in custard apple.

Wedge grafting (M1) also resulted in significantly larger leaf areas (15.01 cm² and 21.68 cm² at 60 and 90 days after grafting, respectively). These results are consistent with those of 4, and 11 in custard apple, and 18 in jamun.

The interaction between grafting time and methods showed the largest leaf area (18.02 cm² at 60 days and 25.79 cm² at 90 days) in the S4M1 combination (third week of February + wedge grafting). However, this was statistically on par with S5M1 (first week of March + wedge grafting) at 60 days and S4M2 (third week of February + side grafting) at 90 days.

Scion girth (mm)

The perusal of collected data (Figure 5) showed that different grafting time had significant effect on scion girth. Significantly highest scion girth (17.10 and 22.05 mm at 60 and 90 days after grafting, respectively) was observed when grafting was done in 3rd week of February (S4) followed by grafting in 1st week of March (S5). Similar results were also observed by 1 and 24 in custard apple and 19 in walnut.

Different grafting methods significantly affected the scion girth with highest scion girth of 16.29 and 20.88 mm at 60 and 90 DAG, respectively with wedge grafting (M1). Similar results were obtained by 4, in custard apple.

The interaction effects between the different grafting time and grafting methods was found to be non-significant on scion girth at 60 days after grafting but found to be significant at 90 days after grafting. Highest scion girth (22.19 mm at 90 DAG) was observed in S4M1 (3rd week of February + wedge grafting). This may be due to the higher quantity of stored food materials present in scions during the months of February-March, which enhances the growth of the grafts and more cambium

contact between the cut portion of stock and the scion with wedge grafting, resulting in a faster rate of growth in terms of scion girth. Similar results have also been reported earlier by 1 and 24 in custard apple.

Inter-nodal length (cm)

The longest inter-nodal length (1.40 cm at 60 days and 1.75 cm at 90 days) was observed (Figure 5) with grafting performed in the third week of February (S4), followed by grafting in the first week of March (S5). This is likely due to the enhanced growth of the grafts, which leads to increased inter-nodal length. These findings are consistent with those reported by 24 and 25 in custard apple.

Among grafting methods, wedge grafting (M1) resulted in the longest inter-nodal length (1.33 cm at 60 days and 1.65 cm at 90 days). This may be attributed to the quicker formation of a union between rootstock and scion, promoting faster growth in inter-nodal length compared to side grafting. Similar results were found by 25 in custard apple.

The interaction effects between grafting time and grafting methods on sprouting percentage of grafts were found to be significantly higher for inter-nodal length (1.82 cm at 90 days after grafting) in S4M1 (3rd week of February + wedge grafting).

Fresh shoot biomass of grafted plant (g)

The data presented in Figure 6, indicates that different grafting time had significant influence on fresh shoot weight and significantly highest fresh shoot biomass (10.97g at 90 days after grafting) noted when grafting was done in 3rd week of February (S4) followed by grafting in 1st week of March (S5). The different grafting methods also showed significantly highest fresh shoot biomass (9.82g) with wedge grafting (M1). The increase in the shoot biomass may be due to a greater number of leaves, which might have increased the production of carbohydrates resulting in higher number of shoots thereby increasing the vegetative growth of the plant. Similar observation was recorded by 26 and 20 in mango and 27 in custard apple.

The interaction effects between the different grafting time and methods were found significant on fresh shoot biomass. The highest fresh shoot biomass (11.07g) was observed in S4M1 (3rd week of February + wedge grafting), which was at par with S4M2 (3rd week of February + side grafting) and S5M1 (1st week of March + wedge grafting).

Fresh root biomass of grafted plant (g)

The data on fresh root biomass at 90 days after grafting (Figure 6) showed significant variations depending on the grafting time and method. The highest fresh root weight (6.01 g) was observed when grafting was performed in the third week of February (S4), followed by grafting in the first week of March (S5). Among the grafting methods, wedge grafting (M1) resulted in the highest fresh root weight (5.52 g). These findings are consistent with those reported by 28 and 29, 20 in mango, and 27 in custard apple.

The interaction between grafting time and method showed significant effects on fresh root biomass. The highest fresh root weight (6.05 g) was recorded for the combination of S4M1 (third week of February + wedge grafting), which was statistically similar to S4M2 (third week of February + side grafting) and S5M1 (first week of March + wedge grafting).

Dried shoot biomass of grafted plant (g)

The data regarding to the dried shoot weight recorded at 90 DAG is presented in Figure 6, which indicates that different grafting time had significant influence on dried shoot biomass with significantly highest dried shoot biomass (4.56 g at 90 days after grafting) noted when grafting was done in 3rd week of February (S4) followed by grafting in 1st week of March (S5). Among different grafting methods, the wedge grafting (M1) was found to be significantly highest with respect to dried shoot biomass (4.73 g). These findings are similar with the observation reported by 26 and 20 in mango, 27 in custard apple.

The interaction effect between the different grafting time and methods was found significant on dried shoot biomass. The highest dried shoot biomass (4.73 g) was observed in S4M1 (3rd week of February + wedge grafting).

Dried root biomass of grafted plant (g)

The data on dried root biomass at 90 days after grafting (Figure 6) revealed significant differences based on the timing and method of grafting. The highest dried root biomass (2.08 g at 90 days after grafting) was observed when grafting was done in the third week of February (S4), followed by grafting in the first week of March (S5). Among grafting methods, wedge grafting (M1) produced the maximum dried root biomass (1.57 g). This may be attributed to the increased plant vigour when wedge grafting is performed during the favourable conditions of late February and early March, leading to better root system development. Additionally, dry root weight correlates directly with fresh root weight, both following a similar pattern. These results are in agreement with findings by 28 and 29 in aonla, 20 in mango, and 27 in custard apple.

The interaction between grafting time and method was found to be non-significant in terms of dried root biomass at 90 days after grafting.

Conclusion

On the basis of the results obtained from the research experiment, it can be concluded that the grafting performed in 3rd week of February with wedge grafting in custard apple cv. Balanagar recorded maximum number of graft sprouts, success percentage, number of shoots, shoot length (cm), number of leaves and survival percentage (%) leaf area (cm²), scion girth (mm), inter-nodal length (cm), fresh shoot biomass (g), fresh root biomass (g) and dried shoot biomass (g), and the grafting performed in 1st week of March with wedge grafting recorded minimum number of days for first graft sprouting in a low cost 75% shade net house under Bundelkhand region.

Author declarations

Acknowledgement: The authors sincerely acknowledge the support and facilities provided by Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh, India, for carrying out this research work.

Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this manuscript.

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