



ISSN Print: 2618-060X
 ISSN Online: 2618-0618
 NAAS Rating (2026): 5.20
 IJRA 2026; 9(9): 997-1004
www.agronomyjournals.com
 Received: 17-07-2026
 Accepted: 21-08-2026
 Published: 23-09-2026

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Standardization of grafting technique in *Annona cherimoya* Mill. (Lakshamanphal)

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DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9n.6632>

ABSTRACT

The present study entitled “Standardization of Grafting Technique in *Annona cherimoya* Mill. (Lakshamanphal)” was undertaken at the Custard Apple Research Station, Ambajogai, during 2025–2026. The study was conducted to develop a suitable and reliable grafting technique for these two important *Annona* species under the local conditions. The investigation was carried out with twenty treatment combination comprising five different time of grafting (15th December, 1st January, 15th January, 1st February and 15th February) and four length (6, 8, 10 and 12 cm) of scion sticks were tried in Randomized Block Design with Factorial concept (FRBD) with 4 replications for *Annona cherimoya*. Minimum days required for sprouting (12.50), days taken for first leaf opening (13.50) at initial days and mortality percentages after 30 and 90 days (5.31 and 9.94 00%), maximum number of sprouts (2.88), leaf area (44.31, 50.56 and 56.44 cm²) at 30, 60 and 90 DAG respectively. Maximum success rate (94.69 and 90.00%) at 30 and 90 days. Maximum fresh weight of shoot (27.50 g), Dry weight of shoot (14.36 g), length of root (26.42 cm), fresh and dry weight of root (25.06 and 9.28 g) after 90 days results indicated that successful grafting was recorded when grafting was carried out on 15th February (G₅) using 10 cm long scion sticks (L₃).

Keywords: Leaf area, Success, Mortality, Percentage, Scion

Introduction

Lakshamanphal (*Annona cherimoya* Mill.) is an important fruit crop belonging to the family Annonaceae and is cultivated in tropical and subtropical regions of the world. Among these, the genera *Annona* and *Asimina* are important fruit-producing groups. *Annona cherimoya* Mill. is native to Central America and is a diploid species with a chromosome number of $2n = 14$. It is cultivated in Southeast Asia, the West Indies and other regions for its delicious fruits (Jansen *et al.*, 1991) [1]. The crop performs well under mild climatic conditions, with annual rainfall of about 600–1000 mm, mean temperatures of 15–25 °C and relative humidity of 60–70 per cent. It grows on a wide range of soils, although sandy loam to loam soils with moderate fertility and a pH of 6.5–7.6 are considered suitable.

Flowering generally occurs during April to May, while fruits require approximately eight months to mature. The main harvesting period extends from August to November, although fruits may be available throughout the year under favourable tropical conditions. A mature tree generally bears about 25 fruits annually, with individual fruits weighing approximately 150–500 g. The ripe fruit is sweet and aromatic and is commonly consumed fresh. It is also used in fruit salads, sherbets, ice creams and beverages.

Increasing demand for Lakshamanphal has created a need for improved propagation technologies. The crop is commonly propagated through seeds; however, seedlings are heterozygous and do not retain desirable characteristics of superior mother plants. Therefore, vegetative propagation is highly essential for producing uniform and true-to-type planting material. Budding, grafting and air layering have been attempted in *Annona*. Chovatia *et al.* (2000) [2] reported successful air layering using shoot ringing and suitable auxin concentrations. Hence, standardization of efficient grafting techniques, particularly grafting time and scion length, is important for rapid multiplication and successful establishment of superior Lakshamanphal plants.

Materials and Methods

At the Custard Apple Research Station in Ambajogai, the experiment was carried out in a green shed net house. Geographically, it is located in latitude 18°44' North, longitude 76°23', and an elevation of 1500 feet above mean sea level.

A part of the Marathwada region and the district, which is located in the center west of Sambhajinagar, are often more than 1500 feet above mean sea level. Eight months of the year usually dry, but the southwest monsoon season bringing rain. The warmest month has a maximum temperature of 40 °C. Beginning in mid-November, the low temperature drops to 12 °C. The region typically receives 950–1000 mm of rain annually between June and September.

The experiment was laid out in Factorial Randomized Block Design with twenty treatment combination and each treatment was replicated four times. Treatment involved date of grafting (15th December, 1st January, 15th January, 1st February and 15th February) were combined with length of scion (6, 8, 10 and 12 cm). Observations were recorded on various growth and grafting parameters including Days required for sprouting, Days for first leaf opening, Number of sprouts recorded at initial days, Leaf area (cm²) recorded at 30, 60 and 90 DAG. Success rate (%) and Mortality (%)

at 30 and 90 DAG. Fresh weight of shoot (g), Dry weight of shoot (g), Length of root (cm), Fresh weight of root (g), Dry weight of shoot (g) at 90 DAG.

The statistical analysis of data was done according to standard procedure given by Panse and Sukhatme (1996). Following treatment combination were employed. Leaf area (cm²) correction factor for *Annona* species is (0.75), Success rate (%) and Mortality recorded by following formula.

Table 1. Treatment combinations

Sr. No.	Treatment combination
1	G1L1
2	G1L2
3	G1L3
4	G1L4
5	G2L1
6	G2L2
7	G2L3
8	G2L4
9	G3L1
10	G3L2
11	G3L3
12	G3L4
13	G4L1
14	G4L2
15	G4L3
16	G4L4
17	G5L1
18	G5L2
19	G5L3
20	G5L4

$$\text{Leaf Area} = \text{Length} \times \text{Width} \times K \text{ (Correction factor)}$$

$$\text{Graft success} = \frac{\text{Number grafts of survived}}{\text{Total number of grafts}} \times 100$$

$$\text{Mortality percentage} = \frac{\text{Total number of grafts survived}}{\text{Total number of grafts sprouted}} \times 100$$

Results and Discussion

Days required for sprouting Effect of time

The data presented in Table 4.2 showed that the time of grafting had a significant effect on the number of days required for sprouting of the grafts.

Among the different grafting dates, grafts prepared on 15th February (G₅) sprouted earliest, taking only (12.50) days, followed by G₄ (12.69 days), G₃ (13.94 days) and G₂ (14.00 days). In comparison, grafts prepared on 15th December (G₁) took the longest period of 15.00 days to sprout.

The differences in sprouting time may be due to the prevailing conditions at the time of grafting, which can influence the physiological activity of the scion and the formation of the graft union. When conditions are favourable, faster cell activity and better healing at the graft union may help the scion to sprout earlier. Similar findings were reported by Kudmulwar *et al.* (2008) [3] in custard apple. Khopade *et al.* (2013) [4] also observed variation in the number of days required for sprouting in custard apple grafts, with values ranging from 12.66

to 22.40 days. The present findings are in agreement with these earlier observations.

Effect of length on scion stick

The results presented in Table 4.2 showed that the length of scion sticks had a significant effect on the time taken for sprouting. Among the different scion lengths, grafts prepared using 10 cm long scion sticks L₃ sprouted earliest, taking (13.25) days was at par with (13.35) L₂ and (13.75) L₄. Grafts prepared with 6 cm long scion sticks L₁ took the maximum time of (14.15) days to sprout. Similar results were reported by Purbiati *et al.* (1991) [5] and Gurudutta *et al.* (2004) [6], which are in agreement with the present findings.

Interaction effect

The data presented in Table 2 showed that the combined effect of time of grafting and length of scion sticks had a significant influence on the time required for sprouting. Among the different treatment combinations, G₅L₃ recorded the earliest sprouting, taking only (11.50) days was at par with G₄L₄ (12.25), G₅L₁ (12.50) and G₅L₂ (12.75). Grafts made on 15th December using 12 cm long scion sticks took the long

est time, with (15.75) days required for sprouting. The differences observed among the treatment combinations may be due to the combined

influence of grafting time and scion length, which affected the establishment and growth of the graft union.

Days required for first leaf opening

The results presented in Table 2 showed that the time of grafting significantly affected the number of days required for the first leaf to open. Grafts made on 15th February (G_5) showed the earliest leaf opening, taking only (13.50) days, was at par with G_3 (13.63 days) followed by G_4 (14.50 days) and G_2 (14.69 days). Grafts made on 15th December (G_1) took the longest time of (15.38) days for the first leaf to open. The earlier opening of the first leaf in grafts performed on 15th February (G_5) may be attributed to the favourable temperature and environmental conditions, which enhanced cambial activity, callus formation and graft union development. Similar observations were also reported by Usare (2016) [7], which support the findings of the present study.

Effect of length of scion stick

The data in Table 2 showed that scion length significantly affected the days required for first leaf opening. The minimum period (13.85 days) was recorded with 10 cm scions (L_3) was at par with L_2 (14.05), followed by L_4 (14.60). While maximum (14.85 days) was observed with 6 cm scions L_1 . The early leaf opening with L_3 may be attributed to adequate carbohydrate reserves, which supported rapid bud growth and leaf emergence. Similar findings were reported by Purbiati *et al.* (1991) [5] and Gurudutta *et al.* (2004) [6].

Interaction effect

The interaction between time of grafting and scion length significantly influenced the days required for first leaf opening. G_{5L3} recorded the earliest leaf opening (12.00 days), followed by G_{3L4} (13.25), G_{5L2} (13.50) and G_{3L1} (13.75). While G_{1L1} took the longest period (16.50 days). The early leaf opening in G_{5L3} may be attributed to favourable temperature and adequate carbohydrate reserves, which promoted faster graft establishment and bud break.

Table 2. Effect of time and length of scion on days required for sprouting

Treatment	Days required for sprouting	No. of days required for 1st leaf opening	Number of sprouts
Time of grafting (G)			
G_1	15.00	15.38	2.38
G_2	14.00	14.69	2.69
G_3	13.94	13.63	2.56
G_4	12.69	14.50	2.69
G_5	12.50	13.50	2.88
SEm $\pm$	0.26	0.16	0.15
C.D.at5%	0.74	0.46	0.44
Length of scion (L)			
L_1	14.15	14.85	1.50
L_2	13.35	14.05	2.25
L_3	13.25	13.85	3.50
L_4	13.75	14.60	3.30
SEm $\pm$	0.23	0.14	0.14
C.D.at5%	0.66	0.41	0.39
Interaction effect (G x L)			
G_{1L1}	14.75	16.50	1.50
G_{1L2}	14.00	14.50	2.00
G_{1L3}	15.50	15.50	3.25
G_{1L4}	15.75	15.00	2.75
G_{2L1}	15.00	15.50	1.50
G_{2L2}	13.50	14.50	2.25
G_{2L3}	13.25	13.75	3.50
G_{2L4}	14.25	15.00	3.25
G_{3L1}	15.25	13.75	1.50
G_{3L2}	15.00	13.00	2.25
G_{3L3}	12.50	14.50	3.00
G_{3L4}	13.00	13.25	3.50
G_{4L1}	13.25	14.00	1.50
G_{4L2}	12.75	14.75	2.00
G_{4L3}	12.50	13.50	3.75
G_{4L4}	12.25	15.75	3.50
G_{5L1}	12.50	14.50	1.50
G_{5L2}	12.75	13.50	2.25
G_{5L3}	11.50	12.00	4.00
G_{5L4}	13.50	14.00	3.50
General Mean	13.63	14.34	2.64

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Treatment	Days required for sprouting	No. of days required for 1st leaf opening	Number of sprouts
SEm ±	0.52	0.32	0.31
C.D.at5%	1.48	0.93	0.88

Number of sprouts effect of time of grafting

Grafts prepared on 15th February (G_5) recorded the maximum number of sprouts (2.88), which was at par with G_4 , G_2 and G_3 (2.69, 2.69 and 2.56, respectively). The minimum number of sprouts (2.38) was recorded in G_1 (15th December). This may be attributed to favourable environmental conditions and better physiological activity of the scion. Similar findings were reported by [Ghojage et al. \(2011\)](#) [8] in jamun.

Effect of scion-stick length

The maximum number of sprouts (3.50) was recorded with 10 cm scion sticks (L_3), which was at par with L_4 (3.30), while the minimum (1.50) was recorded with 6 cm scion sticks (L_1).

Interaction effect

The interaction between grafting time and scion-stick length was significant. The highest number of sprouts (4.00) was recorded in G_5L_3 , which was at par with G_4L_3 (3.75), G_4L_4 (3.50) and G_5L_4 (3.50). The lowest number of sprouts (1.50) was recorded in G_{1L1} .

Leaf area (cm²)

At 30 DAG, the data presented in [Table 3](#) showed clear differences in leaf area per graft among the different times of grafting. The highest leaf area was recorded in G_5 (44.31) followed by G_4 (40.56), G_3 (38.38) and G_2 (35.50), while the lowest leaf area was observed in G_1 (34.00).

At 60 DAG, G_5 continued to record the highest leaf area (50.56), followed by G_4 (46.56), G_3 (44.25) and G_2 (42.19). The minimum leaf area was recorded in G_1 (40.13).

At 90 DAG, the highest leaf area was recorded in G_5 (56.44), followed by G_4 (52.56), G_3 (50.88) and G_2 (48.19) whereas G_1 recorded the lowest leaf area (46.13).

Similar findings were reported by [Gadekar et al. \(2010\)](#) [9], who recorded a maximum leaf area of 43.29 cm² in jamun. [Alam et al. \(2006a\)](#) [10] and [Ram et al. \(2012\)](#) [11] also observed significant differences in leaf area among grafts of different mango varieties.

Effect of length of scion stick

Leaf area was significantly affected by the length of scion sticks used for grafting. Among the different scion lengths, L_3 recorded the highest leaf area of (40.56), (47.10) and (53.50) at 30, 60 and 90 days after grafting, respectively. Lowest leaf area was recorded in L_1 , (36.95), (43.00) and (49.00) at 30, 60 and 90 DAG. Maximum leaf area observed in L_3 might have been associated with better leaf growth and development of the grafts. Similar results were also reported by [Nalage et al. \(2010\)](#) [12].

Interaction effect

The interaction between time of grafting (G) and length of scion stick (L) did not show a significant effect on leaf area at 30, 60 and 90 days after grafting. However, the highest leaf area was recorded in G_5L_3 (47.25), (54.25) and (59.25) at 30, 60 and 90 DAG, respectively. Lowest leaf area was recorded in G_{1L1} (32.75), (38.75) and (44.75) at 30, 60 and 90 DAG respectively.

Success rate (%)

The data in [Table 4](#) showed that grafting time significantly affected graft success in Lakshamanphal. The highest success was recorded in G_5 (94.69 and 90.00) at 30 and 90 DAG respectively followed by G_4 (92.50 and 88.00) whereas lowest was observed in G_1 (82.65 and 77.63). Higher success in G_5 may be attributed to faster callus formation and graft healing, resulting in better leaf development, photosynthesis and carbohydrate production. Similar findings were reported by

[Kumar et al. \(2012\)](#) [13], who recorded 96.4 graft success in custard apple.

Effect of length of scion stick

The results presented in [Table 4.8](#) indicated that the length of scion had a significant effect on graft success at both 30 and 90 days after grafting (DAG). Among the scion lengths used in the study, highest success was recorded with 10 cm long scions (L_3), which gave (92.55) and (89.10) success at 30 and 90 DAG respectively. Lowest success was observed with 6 cm long scions (L_1), recording (85.40) at 30 DAG and (79.15) at 90 DAG. The higher graft success with 10 cm scions (L_3) may be due to adequate food reserves and viable tissue, which promoted rapid callus formation, better cambial union and improved graft survival. Similar results were reported by [Ratan et al. \(1987\)](#) [14], [Radhamony et al. \(1989\)](#) [15] and [Radha et al. \(1998\)](#) [16], who also observed better graft success with suitable scion length in their studies.

Interaction effect

The interaction between time of grafting (G) and scion stick length (L) was not significant effect on graft success at either 30 or 90 days after grafting (DAG). However, the highest success rate was observed in the G_5L_3 treatment combination, recording (97.75) and (94.50) success at 30 and 90 DAG respectively. In contrast, lowest success rate was recorded in G_{1L1} , with (78.00) at 30 DAG and (71.00) at 90 DAG. The results indicated that the combination of a suitable grafting time with an appropriate scion length favoured higher graft success, although the interaction effect was statistically non-significant.

Table 3. Effect of time and length of scion on leaf area (cm²) at 30, 60 and 90 DAG

Treatment	30DAG	60DAG	90DAG
Time of grafting (G)			
G_1	34.00	40.13	46.13
G_2	35.50	42.19	48.19
G_3	38.38	44.25	50.88
G_4	40.56	46.56	52.56
G_5	44.31	50.56	56.44
SEm ±	0.47	0.47	0.54
C.D.at5%	1.34	1.35	1.55
Length of scion (L)			
L_1	36.95	43.00	49.00
L_2	37.80	43.80	49.80
L_3	40.56	47.10	53.50
L_4	38.80	45.05	51.05
SEm ±	0.42	0.42	0.49
C.D.at5%	1.19	1.20	1.39
Interaction effect (G x L)			
G_{1L1}	32.75	38.75	44.75
G_{1L2}	33.75	39.75	45.75
G_{1L3}	35.00	41.50	47.50
G_{1L4}	34.50	40.50	46.50
G_{2L1}	35.00	41.00	47.00
G_{2L2}	35.25	41.50	47.50
G_{2L3}	35.75	43.50	49.50
G_{2L4}	35.00	42.75	48.75
G_{3L1}	36.50	42.50	48.50

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Treatment	30DAG	60DAG	90DAG	Treatment	30DAG	60DAG	90DAG
G_{3L2}	37.00	43.00	49.00	G_{5L1}	42.50	48.50	54.50
G_{3L3}	40.75	46.75	55.25	G_{5L2}	43.75	49.75	55.75
G_{3L4}	39.25	44.75	50.75	G_{5L3}	47.25	54.25	59.25
G_{4L1}	38.00	44.25	50.25	G_{5L4}	43.75	49.75	55.75
G_{4L2}	39.25	45.00	51.00	General Mean	38.55	44.74	50.84
G_{4L3}	43.50	49.50	55.50	SEm $\pm$	0.94	0.95	1.09
G_{4L4}	41.50	47.50	53.50	C.D.at5%	NS	NS	NS

Table 4. Effect of time and length of scion on success rate of grafting at 30 and 90 DAG (%)

Treatment	Success Rate		Mortality	
	30 DAG	90 DAG	30 DAG	90 DAG
Time of grafting (G)				
G_1	82.65	77.63	17.44	22.75
G_2	86.56	81.81	13.69	18.56
G_3	89.63	84.38	10.69	15.88
G_4	92.50	88.00	7.50	12.06
G_5	94.69	90.00	5.31	9.94
SEm $\pm$	0.23	0.27	0.18	0.24
C.D.at5%	0.66	0.76	0.52	0.69
Length of scion (L)				
L_1	85.40	79.15	14.60	20.85
L_2	88.55	83.40	12.00	17.35
L_3	92.55	89.10	7.45	10.05
L_4	90.40	86.05	10.00	14.40
SEm $\pm$	0.20	0.24	0.16	0.21
C.D.at5%	0.59	0.68	0.47	0.62
Interaction effect (G x L)				
G_{1L1}	78.00	71.00	21.55	28.50
G_{1L2}	81.75	76.25	18.75	24.25
G_{1L3}	87.50	83.50	13.50	17.50
G_{1L4}	84.00	80.50	16.50	20.50
G_{2L1}	82.75	76.75	17.50	23.75
G_{2L2}	85.75	81.00	15.00	20.00
G_{2L3}	90.00	86.75	10.50	13.25
G_{2L4}	87.75	82.75	13.00	17.75
G_{3L1}	86.00	79.50	14.50	20.75
G_{3L2}	89.00	83.25	11.50	17.50
G_{3L3}	93.00	88.75	7.50	11.75
G_{3L4}	90.50	86.00	10.00	14.50
G_{4L1}	89.25	83.00	11.50	17.50
G_{4L2}	91.75	87.25	8.75	13.50
G_{4L3}	96.25	92.50	4.50	7.75
G_{4L4}	94.25	90.00	6.75	10.75
G_{5L1}	92.00	86.25	8.50	14.75
G_{5L2}	94.50	89.25	6.00	11.50
G_{5L3}	97.75	94.50	2.25	5.50
G_{5L4}	95.50	91.00	3.75	8.50
General Mean	89.36	84.53	11.09	16.01
SEm $\pm$	0.46	0.54	0.37	0.49
C.D.at5%	NS	NS	NS	NS

Mortality (%) effect of time

The data presented in Table 4 showed that the mortality of Lakshmanphal grafts varied with the time of grafting. Minimum mortality was observed in G_5 , recording (5.31) and (9.94) at 30 and 90 days after grafting (DAG) respectively. It was followed by G_4

(7.50 and 12.06), G_3 (10.69 and 15.88) and G_2 (13.69 and 18.56) at 30 and 90 DAG respectively. Maximum mortality was recorded in G_1 , with (17.44 at 30 DAG and 22.75) at 90 DAG. Minimum mortality in G_5 may be due to favourable temperature and humidity, promoting rapid callus formation and better graft union. Similar observations were reported by Mulla *et al.* (2011) [17] in jamun which are in agree

ment with the findings of the present study.

Effect of length of scion stick

The results presented in Table 4 showed that the length of the scion had a significant effect on graft mortality at both 30 and 90 days after grafting (DAG). The minimum mortality was observed when 10 cm long scions (L_3) were used, with mortality of (7.45) and (10.05) at 30 and 90 DAG respectively. In comparison, maximum mortality was recorded with 6 cm long scions (L_1), which showed (14.60) and (20.85) mortality at 30 and 90 DAG respectively. Lower mortality in L_3 may be attributed to adequate food reserves and better physiological vigour, resulting in successful graft establishment. Similar results were also reported by Ratan *et al.* (1987) [14] and Radhamony *et al.*, (1989) [15], which support the findings of the present study.

Interaction effect

The results presented in Table 4 showed that the interaction between time of grafting

(G) and scion stick length (L) was not significantly influence graft mortality at either 30 or 90 days after grafting (DAG). The lowest mortality was observed in the G_5L_3 treatment combination, with (2.25) and (5.50) mortality at 30 and 90 DAG, respectively. Highest mortality was recorded in G_{1L_1} , which showed (21.55) and (28.50) mortality at 30 and 90 DAG, respectively. Thus, the G_5L_3 combination performed better in terms of reducing graft mortality, while G_{1L_1} recorded comparatively higher mortality under the conditions of the study.

Fresh weight of shoot (g) effect of time

The data showed in Table 5 in regards to time of grafting revealed that maximum fresh weight of shoot (27.50) was recorded in the G_5 which was followed by G_4 (25.69), G_3 (25.44) and G_2 (25.06) at 90 DAG. Minimum fresh weight of shoot (22.69) was recorded in G_1 .

Effect of length of scion stick

The data showed in Table 5 in regards to different length of scion revealed that maximum fresh weight of shoot (28.05) was recorded in L_3 which was followed by L_4 (25.60) and L_2 (24.45) at 90 DAG. Minimum fresh weight of shoot (23.00) was recorded in L_1 . This might be attributed to the maximum scion height, number of leaves and leaf area resulting in a greater accumulation of glucose necessary for vegetative development of the plant and a higher shoot weight. Roshan *et al.* (2013) [18] in anola) and Pawar *et al.* (2018) [19] in custard apple observed a similar result regarding the fresh weight of shoots in custard apple grafts.

Interaction effect

Interaction effect between time of grafting (G) and length of scion stick (L) with regards to fresh weight of root was non-significant. Maximum fresh weight of shoot (29.50) was recorded in G_5L_3 , was at par with G_4L_3 (28.25), G_2L_3 (27.75), G_{1L_3} (27.50), G_{3L_3} (27.25) and G_5L_4 (27.25). However minimum fresh weight of root (18.25) was recorded in G_{1L_1} . The higher fresh shoot weight recorded in G_5L_3 may be attributed to better graft establishment and stronger vegetative growth, which promoted greater photosynthetic activity and accumulation of assimilates in the developing shoots. Similar observations were reported by Pawar *et al.* (2018) [19] in custard apple.

Dry weight of shoot (g) effect of time

The results presented in Table 5 indicated that the time of grafting influenced the dry weight of the shoot. Highest shoot dry weight was recorded in G_5 (14.36) followed by G_4 (13.06), G_3 (12.42) and G_2 (11.20). Lowest shoot dry weight was observed in G_1 , (10.48). The higher shoot dry weight in G_5 may be due to favourable environmental conditions that enhanced graft establishment, photosynthesis and dry matter accumulation.

Effect of length of scion stick

The results presented in Table 5 indicated that the length of the scion had a noticeable influence on shoot dry weight. The highest shoot dry weight was recorded with 10 cm long scions L_3 which was (13.19) followed by L_4 (12.55) and L_2 (12.01). Lowest shoot dry weight was recorded with 6 cm long scions L_1 , at (11.46). The higher dry weight with 10 cm scions L_3 may be attributed to adequate stored carbohydrates and better physiological vigour, resulting in stronger shoot growth and greater dry matter accumulation. Similar findings were reported by Pawar *et al.* (2018) [19] in custard apple, who observed higher shoot dry weight along with better graft survival and vigorous shoot growth under successful softwood grafting conditions.

Interaction effect

Interaction effect between time of grafting (G) and length of scion stick (L) with regards to dry weight of shoot was non-significant. Maximum dry weight of shoot (15.28) was recorded in G_5L_3 followed by G_5L_2 (14.47), G_5L_4 (14.29) and G_4L_3 (13.94). However minimum dry weight of shoot (9.57) was recorded in G_{1L_1} . The maximum value in G_5L_3 may be due to the combined effect of favourable grafting conditions and optimum scion length, promoting better growth and assimilate accumulation.

Root character

The data showed in Table 6 in regards to time of grafting revealed that maximum length of root (26.42) was recorded in the G_5 which was followed by G_4 (24.56), G_3 (22.63) and G_2 (20.31) respectively. Minimum length of root (18.90) was recorded in G_1 . The higher root length recorded in G_5 may be attributed to favourable environmental conditions that promoted better graft establishment, nutrient uptake and root activity, resulting in enhanced root growth. The variation in length of root in cashew grafts has been also reported by Sardar *et al.* (1991) [20] and Roshan *et al.* (2013) [18] in anola, which supports the present findings.

Effect of length of scion

The data showed in Table 6 in regards to different length of scion revealed that maximum length of root (23.50) was recorded in the L_3 which was followed by L_2 (22.70) and L_4 (22.55) respectively. Minimum length of root (21.95) was recorded in L_1 . The superior performance of L_3 may be due to adequate carbohydrate reserves and vigorous scion growth, which increased photosynthate supply to the developing roots. Similar result was reported by Amrita *et al.* (2019) [21].

Interaction effect

Interaction effect between time of grafting (G) and length of scion stick (L) with regards to length of root was non-significant. Maximum length of root (27.95) was recorded in G_5L_3 followed by G_5L_4 (27.60), G_5L_2 (27.00) and G_5L_1 (26.00). However minimum length of root (18.24) was recorded in G_{1L_1} . The maximum root length in G_5L_3 may therefore be associated with the combined effect of favourable grafting conditions and optimum scion length.

Table 5. Effect of time and length of scion on fresh weight of shoot and dry weight of shoot at 90 DAG (g)

Treatment	Fresh weight	Dry weight
Time of grafting (G)		
G_1	22.69	10.48
G_2	25.06	11.20
G_3	25.44	12.42
G_4	25.69	13.06
G_5	27.50	14.36
SEM $\pm$	0.62	0.21
C.D. at 5%	1.77	0.61
Length of scion (L)		

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Treatment	Fresh weight	Dry weight
L_1	23.00	11.46
L_2	24.45	12.01
L_3	28.05	13.19
L_4	25.60	12.55
SEm $\pm$	0.55	0.19
C.D.at 5%	1.58	0.54
Interaction effect (G x L)		
$G_1 L_1$	18.25	9.57
$G_1 L_2$	21.25	10.45
$G_1 L_3$	27.50	11.45
$G_1 L_4$	23.75	10.43
$G_2 L_1$	22.50	10.59
$G_2 L_2$	24.25	10.80
$G_2 L_3$	27.75	11.71
$G_2 L_4$	25.75	11.67
$G_3 L_1$	24.25	11.35
$G_3 L_2$	24.75	11.74
$G_3 L_3$	27.25	13.54
$G_3 L_4$	25.50	13.02
$G_4 L_1$	23.75	12.37
$G_4 L_2$	25.00	12.58
$G_4 L_3$	28.25	13.94
$G_4 L_4$	25.75	13.33
$G_5 L_1$	26.25	13.38
$G_5 L_2$	27.00	14.47
$G_5 L_3$	29.50	15.28
$G_5 L_4$	27.25	14.29
General Mean	25.28	12.30
SEm $\pm$	1.25	0.43
C.D.at 5%	NS	NS

Fresh weight of root (g) effect of time

The data showed in Table 4.14 in regards to time of grafting revealed that maximum fresh weight of root (25.06) was recorded in the G_5 which was followed by G_4 (24.00), G_3 (23.41) and G_2 (22.91) respectively. Minimum fresh weight of root (22.25) was recorded in G_1 . The higher fresh root weight in G_5 may be attributed to favourable growing conditions that promoted better root development and fresh biomass accumulation. Hussain *et al.* (1997) [22] observed significant difference in fresh weight of roots in sapota grafts. Roshan *et al.* (2013) [18] also observed such difference in sapota grafts, which confirms present finding.

Effect of scion stick

The data showed in Table 4.14 in regards to different length of scion revealed that maximum fresh weight of root (24.63) was recorded in L_3 which was followed by L_4 (23.63) and L_2 (23.15) respectively. Minimum fresh weight of root (22.70) was recorded in L_1 . The superior performance of L_3 may be due to better graft establishment and vigorous plant growth, which supported greater root development. Similar result was reported by Amrita *et al.* (2019) [21] and Ashok *et al.* (2020) [23].

Interaction effect

Interaction effect between time of grafting (G) and length of scion stick (L) with regards to fresh weight of root was non-significant. Maximum fresh weight of root (26.25) was recorded in $G_5 L_3$ followed by $G_4 L_3$ (25.25), $G_5 L_2$ (25.00) and $G_5 L_4$ (24.75). However minimum fresh weight of root (21.62) was recorded in $G_1 L_1$. The

maximum value in $G_5 L_3$ may therefore be associated with favourable grafting conditions and optimum scion length.

Dry weight of root (g) effect of time

The data showed in Table 6 in regards to time of grafting revealed that maximum dry weight of root (9.28) was recorded in the G_5 which was followed by G_4 (8.53), G_3 (8.13) and G_2 (7.25) respectively. Minimum dry weight of root (6.06) was recorded in G_1 . The higher root dry weight in G_5 may be attributed to enhanced root activity and better utilization of available nutrients, resulting in greater dry matter deposition. The similar result regarding dry weight of roots in aonla grafts has been reported by Roshan *et al.* (2013) [18] which support the present finding.

Table 6. Effect of time and length of scion on length of root, fresh weight and dry weight of root at 90 DAG

Treatment	Length of root (cm)	Fresh weight of root (g)	Dry weight of root (g)
Time of grafting (G)			
G_1	18.90	22.25	6.06
G_2	20.31	22.91	7.25
G_3	22.63	23.41	8.13
G_4	24.56	24.00	8.53
G_5	26.42	25.06	9.28
SEm $\pm$	0.26	0.14	0.10
C.D.at 5%	0.75	0.41	0.31
Length of scion (L)			
L_1	21.95	22.70	7.08
L_2	22.70	23.15	7.68
L_3	23.50	24.63	8.65
L_4	22.55	23.63	8.00
SEm $\pm$	0.23	0.13	0.09
C.D.at 5%	0.67	0.37	0.27
Interaction effect (G x L)			
$G_1 L_1$	18.24	21.62	5.25
$G_1 L_2$	18.50	22.12	6.00
$G_1 L_3$	20.25	22.62	7.00
$G_1 L_4$	19.00	22.62	6.00
$G_2 L_1$	19.50	21.62	6.50
$G_2 L_2$	20.75	22.62	7.50
$G_2 L_3$	21.25	24.25	8.00
$G_2 L_4$	19.75	23.12	7.00
$G_3 L_1$	22.75	22.50	7.37
$G_3 L_2$	22.75	22.75	7.75
$G_3 L_3$	23.00	24.75	8.62
$G_3 L_4$	22.00	23.62	8.75
$G_4 L_1$	23.25	23.50	7.87
$G_4 L_2$	24.50	23.25	8.00
$G_4 L_3$	25.75	25.25	9.37
$G_4 L_4$	25.00	24.00	8.87
$G_5 L_1$	26.00	24.25	8.37
$G_5 L_2$	27.00	25.00	9.12
$G_5 L_3$	27.95	26.25	10.25
$G_5 L_4$	27.60	24.75	9.37
General Mean	22.70	23.53	7.85
SEm $\pm$	0.53	0.29	0.21
C.D.at 5%	NS	NS	NS

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Effect of scion stick

The data showed in Table 6 in regards to different length of scion revealed that maximum dry weight of root (8.65) was recorded in L_3 which was followed by L_4 (8.00) and L_2 (7.68) respectively. Minimum dry weight of root (7.08) was recorded in L_1 . The superior root dry weight with L_3 may be due to stronger root development and efficient assimilate partitioning towards the underground portion of the grafted plant. Similar result was reported by Amrita *et al.* (2019) [21] and Ashok *et al.* (2020) [23].

Interaction effect

Interaction effect between time of grafting (G) and length of scion stick (L) with regards to dry weight of root was non-significant. Maximum dry weight of root (10.25) was recorded in G_{5L3} followed by G_{5L4} (9.37), G_{4L3} (9.37) and G_{5L2} (9.12). However minimum dry weight of root (5.25) was recorded in G_{1L1} . The maximum value in G_{5L3} may be associated with better physiological balance between scion growth and root development, favouring greater accumulation of dry matter in the roots.

Conclusion

Based on present investigation entitled “Standardization of grafting technique in *Annona cherimoya* Mill. (Lakshamanphal)”, it can be concluded that minimum days required for sprouting, days taken for first leaf opening and mortality percentages, maximum number of sprouts, leaf area, success rate, fresh weight of shoot, dry weight of shoot, length of root, fresh and dry weight of root can be made successfully on 15th December (G_5) and 10 cm (L_3) long scion sticks. Whereas, maximum days required for sprouting, days taken for first leaf opening and mortality percentages, minimum number of sprouts, leaf area, success rate, fresh weight of shoot, dry weight of shoot, length of root, fresh and dry weight of root were recorded when graft made on 15th December (G_1) and 6 cm (L_1) long scion sticks. :975.43.

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How to cite this article: Jadhav M, Munde G, Ovhal S, Magar M, Bhujbal R. Standardization of grafting technique in *Annona cherimoya* Mill. (Lakshamanphal). *International Journal of Research in Agronomy*. 2026;9(9):997-1004. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i9n.6632>