emergent
Life Sciences Research

Research Article

Grafting month and environmental condition influences on the success of softwood grafting in Cashew under Bastar region of Chhattisgarh

Soumya Dewangan, Vikas Ramteke, G. L. Sharma, Tejpal Chandrakar, D. P. Singh, R. S. Netam, J. D. Adiga, Hemant Kumar Panigrahi

Received: 22 June 2023
Accepted: 22 August 2023
Online: 25 August 2023

Authors:
S. Dewangan, G. L. Sharma, H. K. Panigrahi
Department of Fruit Science, College of Agriculture (IGKV), Krishak Nagar, Raipur, Chhattisgarh, India

V. Ramteke ✉, T. Chandrakar, D. P. Singh, R. S. Netam,
Shaheed Gundadhoor College of Agriculture and Research Station (IGKV), Jagdalpur, Chhattisgarh, India

J. D. Adiga
ICAR- Directorate of Cashew Research, Puttur, Karnataka, India

✉ ramtekeviks@gmail.com

Emer Life Sci Res (2023) 9(2): 83-92

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2023.928392

Abstract

An experiment was conducted at Horticulture Nursery, Shaheed Gundadhur College of Agriculture and Research Station, Jagdalpur, Chhattisgarh during 2021-22 to identify the suitable month for grafting under different environmental conditions in cashew. Grafting was performed in five different months i.e., June, July, August, September, and October and grafts are placed in three conditions i.e., open condition, shade net, and mist chamber. Thus, in total, there were 15 treatment combinations that were replicated thrice under a factorial randomized complete block design. Among the individual effect of the month of grafting, July recorded the least days taken to sprouting (15.50) whereas August recorded the highest graft success (88.33 %), shoot height (25.88 cm), graft height (44.10 cm), graft diameter (0.661 cm), number of leaves (7.43), leaf area (29.71 cm^2), graft fresh weight (25.90 g), graft dry weight (7.71 g), root volume (7.17 cm^3), root to shoot ratio (0.306) and graft survival (92.38 %). Among the environmental conditions, mist chamber showed superiority over open and shade net conditions. Among the interactions between the treatments, the minimum days taken to sprouting was recorded when grafting was done in July under a mist chamber (13.83). The highest graft survival was recorded in July grafting under mist chamber (100.00 %) whereas grafting in the month of August under the mist chamber recorded the highest graft success (95.00 %), shoot height (28.50 cm), graft height (48.63 cm), graft diameter (0.689 cm), number of leaves (9.54), leaf area (41.50 cm^2), graft fresh weight (26.46 g), graft dry weight (7.98 g), root volume (8.03 cm^3) and root to shoot ratio (0.343). It can be concluded that grafting in the month of August under the mist chamber could be followed for the commercial propagation of cashew under Bastar region of Chhattisgarh.

Keywords cashew, environmental conditions, grafting, mist chamber

Introduction

Cashew is considered as the most significant tree nut crop next to almond and walnut. The crop is versatile and possesses different medicinal properties. The cholesterol free cashew kernel is known for its richness in fat content (38-44%) and protein (18-20%) whereas apples are used for fresh consumption, pickles, preserves, chutneys, and fermented and non- fermented beverages, as well as for creating pickles, preserves, chutneys, and fermented and non-fermented beverages [1-2]. In India, it is cultivated in Kerala, Karnataka, Goa, and Maharashtra along the west-coast and Tamil Nadu, Andhra Pradesh, Orissa, and West Bengal along the East-coast.

Maharashtra leads the country in terms of cashew nut area, production, and productivity among the major states. The area under cashew in Chhattisgarh was 30,313 ha in 2022-23, with a yield of 23,511 MT [3]. Cashew is easily crossed-pollinated and as a result, variability between trees is wide with respect to the vigour of growth, time of flowering, yields, and quality of nuts. The vegetative propagation approach may therefore be a viable option to improve the quality of cashew planting materials. The higher extent of cross-pollination in cashew results in seeds incorporated with wider heterozygosity and sometimes low productivity. The establishment of new cashew orchards through vegetative propagation is crucial because it enhances the preservation of the genotypes' genetic integrity and reduces the tree's juvenile stage [4]. Hence, vegetative propagation is preferred over seed propagation to the wholesome import of quality and yield traits from the mother plant to progenies. Among all the methods, grafting especially softwood grafting was reported as the best suitable method for the commercial production of cashew with a success percentage of 85 to 91 in India [2]. Softwood grafting has distinct advantages over other techniques of propagation, including being an efficient, cost-effective, and quick process, with grafts available in as little as a year. Due to the increasing demand for quality planting material of cashew, there is a need to develop a technique to improve the success of grafts by utilizing various factors. Cashews can be multiplied successfully by softwood grafting, but the time of grafting, proper maturity of scion, and growing environment for raising rootstock have to be standardized under local agro-climatic conditions [5]. The genotype of the scion and rootstock, as well as climatic conditions, were the most important factors impacting the quality, mortality, and establishment of softwood grafting. Light, temperature, rainfall, and humidity are examples of climatic elements, with light assisting in the activation of photosynthetic activity and the nutrition of graft growth [6]. The propagation environment is one of the most crucial aspects that determine grafting success. Because of the year-round variations in temperature, relative humidity, and sunlight, softwood grafting has varying degrees of success. Identification of the appropriate type of propagation structure, as well as perfect microclimate conditions for softwood grafting, can aid in quick multiplication and the development of healthy planting material [7]. Identification and performance of grafting in the proper season under congenial environmental conditions were necessary for achieving high grafting success. The main aim of this study was to standardize the individual effect of month of grafting, environmental conditions and interaction effect of month of grafting, and environmental conditions for better growth and success of cashew grafts under Bastar plateau region of Chhattisgarh.

Methodology

The experiment was carried out during the year 2021-22 at Horticulture Nursery, Shaheed Gundadhur College of Agriculture and Research Station, Kumhrawand, Jagdalpur, Chhattisgarh. The experimental site is located at 19.07° N and 82.03° E with an average elevation of 552 m. The average maximum temperature (31.1°C), average minimum temperature (18.4°C), rainfall (1017.5 mm), average morning relative humidity (88 %), and average evening relative humidity (51 %) was recorded during the study period. About six-month-old rootstocks of Vengurle-4 were selected for softwood grafting, which were raised in polybags at Horticulture Nursery, SGCARS, Jagdalpur. Fully matured scion sticks which are free from pests and disease were chosen from healthy and uniformly bearing 4-5 year or older plants of cashew variety Vengurle-4. Grafting was performed in five different months i.e., June (M_1), July, (M_2) August (M_3), September (M_4), and October (M_5), and grafts are placed in three conditions i.e., Open condition (C_1), Shade net (C_2) and Mist chamber (C_3). There were 15 treatment combinations that were replicated thrice under Factorial Randomized Block Design. Shade net houses with the shading percentage of 50 percent with a height 3.0 m was constructed using GI pipes. Mist chamber provided with pneumatic atomizing nozzles for misting having sensors for light, temperature, and humidity with high precision accuracy by the control panel was used for the experiment. Grafting was done on twenty rootstocks for each treatment combination in each replication. Days taken to sprouting were calculated as the average of days for initiation of sprout and days for final sprouting. The number of successful grafts in each treatment combination was counted at 30 DAG (days after grafting). The terminal bud consisting of fully opened leaves were considered as successful grafts. The shoot height was measured by measuring tape from

the middle of the graft joint to the tip of the leaf. The shoot height of the grafted plants was recorded on 30 DAG, 60 DAG, and 90 DAG. The total height of the grafted plants was recorded on 30 DAG, 60 DAG, and 90 DAG. It was measured by measuring tape from the base of the plant to the tip of leaf. The diameter of the graft was measured 1 cm above the graft joint. Graft diameter was calculated by using vernier calipers. The total number of leaves per graft was counted on 30 DAG, 60 DAG, and 90 DAG. Leaf area is calculated by tracing one representable leaf per replication through graph paper. Data was recorded on 30 DAG, 60 DAG, and 90 DAG. The fresh weight of the graft was measured after 90 days after grafting. The graft dry weight is recorded after completely drying the graft in a hot air oven at 70°C for 3 days until constant weight is obtained. It is calculated at 90 days after grafting. The root volume is measured at 90 days after grafting by the water displacement method. The root to shoot ratio is calculated at 90 days after grafting. It is calculated as ratio of dry weight of root to the fresh weight of the root. The graft survival percent is calculated at 90 DAG. The graft success percent and survival percent were calculated as per the following formula:

$$\text{Graft success percent} = \frac{\text{Total number of sprouted grafts}}{\text{Total number of grafted plants}} \times 100$$

$$\text{Graft survival percent} = \frac{\text{Total number of grafts survived}}{\text{Total number of sprouted grafts}} \times 100$$

Data recorded for various parameters was statistically analyzed using OPSTAT software for the interpretations of results [8].

Results and Discussion

The results with respect to days taken to sprouting were significant for the month of grafting (Table 1). Minimum days taken to sprouting were observed in July (15.50) while it was delayed in October (19.67). The congenial weather conditions during July, like optimum temperature (25.6-29.8°C) and high relative humidity (89-98 %) helped in early sprouting. Optimum temperature and water availability plays an important role in photosynthetic activity and also in early bud sprouting [9]. With respect to environmental conditions, significant variation was observed for days taken to sprouting in which the lowest was observed in the mist chamber (16.20) while it was delayed in open condition. The mist chamber has high relative humidity and slightly inclined temperature resulting in early bud sprouting [9]. A similar result was also observed by Raghavendra et al., [10] in wood apple. Among the interaction effects, the least number of days taken to sprouting was recorded in grafting in the month of July under a mist chamber (13.83). This might be due to high humidity and optimum temperature prevailing inside the mist chamber during July month [9]. This result was in close conformity with Parmar et al., [11] in mulberry. Observations with respect to graft success percent, shoot height, and graft height was found to be significant for the month of grafting (Table 1). Highest graft success (88.33 %), shoot height (22.06 cm, 23.88 cm, and 25.88 cm at 30, 60, and 90 DAG respectively), and graft height (39.51 cm, 42.03 cm, and 44.10 cm at 30, 60 and 90 DAG respectively) were recorded in the month of August. The graft diameter showed no statistically significant difference at 90 DAG, but the highest graft diameter was also recorded in August in all observational periods (Table 1). The maximum graft success is related to the prevailing optimum temperature coupled with higher humidity. Grafting carried out in a favorable month having congenial condition causes higher cellular activity, early healing of grafts, and higher photosynthetic activity which leads to an increase in height and girth of grafts [9]. In September month less graft success might be due to, higher diurnal temperature with low humidity which is not congenial for graft union. Apparently, scions grafted after peak monsoon did not have sufficient cambial activity for the 3 to 4 weeks necessary to form a successful graft union. Water stress due to less rainfall during September also affects graft success.

Table 1. . Individual effect of month of grafting and environmental conditions on days taken to sprouting, graft success percent, shoot height, graft height and graft diameter

Treatment	Days taken to sprouting	Graft success (%)	Shoot height (cm)			Graft height (cm)			Graft diameter (cm)		
Month of Grafting			**30 DAG**	**60 DAG**	**90 DAG**	**30 DAG**	**60 DAG**	**90 DAG**	**30 DAG**	**60 DAG**	**90 DAG**
June	16.67	67.22 (55.43)	20.56	22.32	23.86	35.90	37.81	39.40	0.53	0.58	0.63
July	15.50	76.67 (62.10)	21.41	23.29	25.28	34.68	37.00	38.92	0.58	0.61	0.63
August	17.78	88.33 (71.84)	22.06	23.88	25.88	39.51	42.03	44.10	0.60	0.63	0.66
September	18.11	70.56 (57.40)	20.33	22.24	23.52	33.92	35.80	37.31	0.58	0.63	0.64
October	19.67	82.22 (65.28)	21.07	23.13	24.29	34.20	35.89	37.83	0.57	0.60	0.61
Mean	17.54	77.00	21.08	22.97	24.56	35.64	37.70	39.51	0.57	0.61	0.63
SE m ±	0.36	1.92	0.41	0.41	0.42	0.62	0.66	0.67	0.01	0.01	0.02
SE (d)	0.51	2.72	0.58	0.58	0.59	0.88	0.94	0.95	0.02	0.02	0.02
C.D. (p=0.05)	1.05	5.59	1.20	1.19	1.21	1.81	1.93	1.96	0.04	0.04	NS
Environmental conditions											
Open condition	18.33	75.00 (60.66)	20.60	22.80	24.27	33.64	35.72	37.20	0.56	0.60	0.63
Shade net	18.10	72.00 (58.79)	19.91	21.43	22.94	34.66	36.07	37.79	0.57	0.61	0.63
Mist chamber	16.20	84.00 (67.78)	22.75	24.69	26.48	38.63	41.32	43.54	0.59	0.62	0.64
Mean	17.54	77.00	21.08	22.97	24.56	35.64	37.70	39.51	0.57	0.61	0.63
SE m ±	0.28	1.49	0.32	0.32	0.32	0.48	0.51	0.52	0.01	0.01	0.01
SE (d)	0.39	2.10	0.45	0.45	0.46	0.68	0.73	0.74	0.02	0.01	0.02
C.D. (p=0.05)	0.81	4.33	0.93	0.92	0.94	1.40	1.49	1.52	NS	NS	NS

Figures in parenthesis shows arc sign transformation

The result was in agreement with the findings of Gotur et al., [12] in guava. Among the environmental conditions, the mist chamber recorded the highest graft success (84.00 %), shoot height (22.75 cm, 24.69 cm, and 26.48 cm at 30, 60, and 90 DAG respectively), graft height (38.63 cm, 41.32 cm and 43.54 cm at 30, 60 and 90 DAG respectively) and graft diameter (0.589 cm, 0.624 cm and 0.637 cm at 30, 60 and 90 DAG respectively). This might be due to favourable environmental conditions prevailing inside the mist chamber resulting in better growth and success of grafts [9]. These results were in close conformity with Sivudu et al., [13] in mango and Kumar [14] in guava. Among the interaction effects, significant variation was observed for graft success percent, shoot height, and graft height (Table 2). Highest graft success (95.00 %), shoot height (23.57 cm, 25.83 cm, and 28.50 cm at 30, 60, and 90 DAG respectively), and graft height (41.32 cm, 45.70 cm, and 48.63 cm at 30, 60 and 90 DAG respectively) was recorded when grafting was done in August under mist chamber. Graft diameter was found to be non-significant however highest graft diameter (0.628 cm, 0.669 cm, and 0.689 cm at 30, 60, and 90 DAG respectively) was also recorded when grafting was done on August under a mist chamber. This might be due to the combined effect of optimum weather factors and congenial conditions like high humidity and optimum temperature inside the mist chamber with little or no hindrance being maintained which is a prerequisite for early union formation during a particular month, resulting in better growth of grafts [15]. These results were in close conformity with the findings of Gotur et al., [12] in guava. Observations with respect to a number of leaves per graft and leaf area for the month of grafting were found to be significant. The highest number of leaves per graft (5.69, 6.62, and 7.43 at 30, 60, and 90 DAG respectively) and leaf area (11.27 cm^2, 19.72 cm^2, and 29.71 cm^2 at 30, 60, and 90 DAG respectively) were found when grafting was done in August (Table 3). Due to graft exposure to varying relative humidity and temperature, the quantity of leaves and leaf area varies from month to month. Higher cell activity and active growth of both stock and scion leads to better graft growth during a given month [16]. These results were in agreement with the findings of Bhilare et al., [17] in Lemon grafts and Baghel et al., [18] in guava air layers.

Table 2. Interaction effect of month of grafting and environmental conditions on days taken to sprouting, graft success percent, shoot height, graft height and graft diameter

Month of Grafting × Environmental conditions	Days taken to sprouting	Graft success (%)	Shoot height (cm)			Graft height (cm)			Graft diameter (cm)		
			30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG
Grafting in the month of June + Open condition	17.33	66.67 (55.00)	21.03	22.60	23.87	35.64	37.22	38.55	0.531	0.564	0.625
Grafting in the month of June + Shade net	18.67	58.33 (49.82)	17.63	19.03	20.57	33.43	34.81	36.32	0.522	0.543	0.594
Grafting in the month of June + Mist chamber	14.00	76.67 (61.46)	23.00	25.33	27.13	38.62	41.40	43.33	0.549	0.627	0.657
Grafting in the month of July + Open condition	15.67	83.33 (65.95)	21.50	23.43	25.33	31.86	33.70	35.51	0.556	0.578	0.623
Grafting in the month of July + Shade net	17.00	58.33 (49.83)	19.57	20.87	22.63	31.49	32.86	34.55	0.572	0.633	0.649
Grafting in the month of July + Mist chamber	13.83	88.33 (70.50)	23.17	25.57	27.87	40.69	44.43	46.69	0.598	0.612	0.627
Grafting in the month of August + Open condition	18.50	86.67 (69.24)	22.43	24.30	26.07	39.13	40.93	42.57	0.602	0.625	0.672
Grafting in the month of August + Shade net	18.50	86.33 (66.84)	20.17	21.50	23.07	38.07	39.45	41.08	0.577	0.600	0.621
Grafting in the month of August + Mist chamber	16.33	95.00 (79.45)	23.57	25.83	28.50	41.32	45.70	48.63	0.628	0.669	0.689
Grafting in the month of September + Open condition	19.33	60.00 (50.79)	19.57	22.27	23.47	33.97	36.70	37.94	0.556	0.620	0.645
Grafting in the month of September + Shade net	16.50	75.00 (60.08)	20.23	22.00	23.63	33.33	34.93	36.56	0.589	0.637	0.666
Grafting in the month of September + Mist chamber	18.50	76.67 (61.33)	21.20	22.47	23.47	34.47	35.77	37.43	0.605	0.622	0.609
Grafting in the month of October + Open condition	20.83	78.33 (62.29)	18.47	21.40	22.63	27.59	30.05	31.42	0.549	0.598	0.576
Grafting in the month of October + Shade net	19.83	85.00 (67.41)	21.93	23.73	24.80	36.95	38.30	40.42	0.604	0.624	0.634
Grafting in the month of October + Mist chamber	18.33	83.33 (66.15)	22.80	24.27	25.43	38.05	39.32	41.64	0.564	0.592	0.605
Mean	**17.49**	**77.00**	**21.08**	**22.97**	**24.56**	**35.64**	**37.70**	**39.51**	**0.573**	**0.610**	**0.633**
SE m ±	**0.62**	**3.33**	**0.71**	**0.71**	**0.72**	**1.08**	**1.15**	**1.17**	**0.02**	**0.02**	**0.03**
SE (d)	**0.88**	**4.70**	**1.01**	**1.00**	**1.02**	**1.53**	**1.62**	**1.65**	**0.03**	**0.03**	**0.04**
C.D. (p=0.05)	**1.82**	**9.68**	**2.08**	**2.06**	**2.10**	**3.14**	**3.34**	**3.40**	**NS**	**NS**	**NS**
C.V. (%)	**6.15**	**9.20**	**5.87**	**5.33**	**5.08**	**5.24**	**5.27**	**5.11**	**7.03**	**6.11**	**7.06**

Figures in parenthesis shows arc sign transformation, DAG - Days after grafting

Among different environmental conditions, the mist chamber recorded significantly more number of leaves per graft (6.00, 7.04, and 7.96 at 30, 60, and 90 DAG respectively) and leaf area (12.66 cm^2, 23.50 cm^2, and 32.25 cm^2 at 30, 60 and 90 DAG respectively). Significant maximum leaf area per plant was reported in August month during the whole experimental period. This is probably due to timely grafted plants may enjoy favorable climatic conditions in terms of temperature, relative humidity, and other climatic parameter during various growth stages, which is reflected into better growth [19]. The favorable environment inside the structure promotes rapid callus formation and early cambial layer contact, allowing the graft to heal quickly and form a strong union, resulting in improved strength and faster growth [9]. Angadi and Karadi [20] also recorded a higher number of leaves and leaf areas in jamun under mist chamber.

Table 3. . Individual effect of month of grafting and environmental conditions on number of leaves per graft, leaf area, graft fresh weight, graft dry weight, root volume, root to shoot ratio and graft survival percent

Treatment	Number of leaves per graft			Leaf area (cm^2)			Graft fresh weight (g)	Graft dry weight (g)	Root volume (cm^3)	Root to shoot ratio	Graft survival (%)
Month of Grafting	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG					
June	4.43	5.32	6.12	7.86	15.98	25.00	14.51	5.18	6.56	0.27	86.47 (74.02)
July	5.21	5.87	6.61	9.85	16.19	26.96	18.06	5.28	6.16	0.24	88.92 (74.48)
August	5.69	6.62	7.43	11.27	19.72	29.71	25.90	7.71	7.17	0.31	92.38 (75.32)
September	4.38	5.06	5.80	7.53	14.09	22.07	19.11	6.26	5.94	0.23	84.51 (67.36)
October	4.20	4.77	5.53	6.42	12.85	23.11	16.95	5.85	5.36	0.26	84.67 (67.85)
Mean	4.78	5.53	6.30	9.13	15.77	25.94	18.90	6.06	6.24	0.26	87.39
SE m ±	0.18	0.16	0.19	0.23	0.24	0.43	0.91	0.33	0.32	0.02	1.88
SE (d)	0.25	0.23	0.27	0.32	0.34	0.61	1.29	0.47	0.45	0.03	2.66
C.D. (p=0.05)	0.52	0.23	0.55	0.66	0.70	1.25	2.65	0.96	0.92	NS	5.48
Environmental conditions											
Open condition	4.47	5.05	5.82	7.39	13.24	21.43	18.01	5.74	5.79	0.27	92.04 (74.92)
Shade net	3.88	4.51	5.11	5.70	10.56	19.43	17.54	5.33	5.60	0.22	75.17 (60.55)
Mist chamber	6.00	7.04	7.96	12.66	23.50	35.25	21.17	7.11	7.32	0.29	94.96 (79.95)
Mean	4.78	5.53	6.30	8.58	15.77	20.43	18.90	6.06	6.24	0.26	87.39
SE m ±	0.14	0.13	0.15	0.17	0.19	0.33	0.71	0.26	0.24	0.02	1.46
SE (d)	0.19	0.18	0.21	0.25	0.26	0.47	1.00	0.36	0.35	0.02	2.06
C.D. (p=0.05)	0.40	0.37	0.43	0.51	0.54	0.96	2.05	0.75	0.71	0.04	4.24

Figures in parenthesis shows arc sign transformation

Among the interaction effects, the highest number of leaves (6.97, 8.47, and 9.54 at 30, 60, and 90 DAG respectively) and leaf area (15.82 cm^2, 28.29 cm^2, and 41.50 cm^2 at 30, 60, and 90 DAG respectively) were observed in grafting in the month of August under mist chamber (Table 4). This might be due to favorable environmental conditions resulting in higher photosynthetic activity during a particular month which helps in increasing the number of leaves and leaf area [21]. The results were in agreement with the findings of Vanaja et al., [15] in guava and Giri and Lenka [16] in Bael. The significant difference was observed in the case of month for graft fresh weight, graft dry weight, and root volume (Table 3). The highest graft fresh weight (25.90 g), graft dry weight (7.71 g), and root volume (7.17 cm^3) were observed in August. The non-significant difference was recorded for root to shoot ratio in the case of the month of grafting. However, a higher root to shoot ratio was also recorded in the month of August. This could be due to increased graft height and diameter, increased leaf number and area during a favorable month, and increased photosynthetic rates, which result in increased root and shoot growth. When there is a comparison between different environmental conditions, significant variation was observed for graft fresh weight, graft dry weight, root volume, and root to shoot ratio (Table 4). The highest graft fresh weight (21.17 g), graft dry weight (7.11 g), root volume (7.32 cm3), and root to shoot ratio (0.287) were observed under the mist chamber. This might be due to prevailing favorable conditions inside the mist chamber resulting in higher growth of grafts which leads to more root and shoot growth parameters. Anant [21] observed the highest fresh and dry weight of the root and shoot of guava under polytunnel. The interaction effect between the month and environmental conditions was found to be non-significant for fresh weight, dry weight, root volume, and root to shoot ratio. However, the highest graft fresh weight (26.46 g), graft dry weight (7.98 g), root volume (8.03 cm^3), and root to shoot ratio (0.343) were observed in the month of August under mist chamber. This may be due to favourable weather conditions during a particular month under optimum controlled conditions resulting in more sap flow and higher photosynthetic activity leading to a more

Table 4. . Interaction effect of month of grafting and environmental conditions on number of leaves per graft, leaf area, graft fresh weight, graft dry weight, root volume, root to shoot ratio and graft survival percent

Month of Grafting × Environmental conditions	Number of leaves per graft			Leaf area (cm^2)			Graft fresh weight (g)	Graft dry weight (g)	Root volume (cm^3)	Root to Shoot ratio	Graft survival (%)
	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG					
Grafting in the month of June + Open condition	4.05	4.57	5.44	8.07	15.57	23.42	13.47	3.95	5.87	0.300	95.57 (82.68)
Grafting in the month of June + Shade net	3.20	4.10	4.69	3.75	7.79	16.58	13.88	4.55	6.13	0.265	66.40 (54.94)
Grafting in the month of June + Mist chamber	6.03	7.30	8.23	11.75	24.58	35.00	16.17	7.05	7.67	0.237	97.43 (84.44)
Grafting in the month of July + Open condition	5.24	5.77	6.47	9.74	15.26	24.33	19.10	5.80	6.37	0.241	92.03 (73.81)
Grafting in the month of July + Shade net	3.73	4.17	4.77	5.49	9.25	18.11	14.14	3.95	4.90	0.177	74.73 (59.91)
Grafting in the month of July + Mist chamber	6.66	7.67	8.60	14.32	24.05	38.43	20.93	6.08	7.20	0.292	100.00 (89.71)
Grafting in the month of August + Open condition	5.63	6.19	6.97	10.64	18.56	26.54	25.33	7.58	6.97	0.325	94.20 (76.07)
Grafting in the month of August + Shade net	4.47	5.20	5.78	7.33	12.32	21.10	25.90	7.56	6.50	0.252	86.57 (68.98)
Grafting in the month of August + Mist chamber	6.97	8.47	9.54	15.82	28.29	41.50	26.46	7.98	8.03	0.343	96.37 (80.91)
Grafting in the month of September + Open condition	4.03	4.63	5.23	4.16	8.20	15.47	17.17	6.16	5.33	0.231	89.07 (70.86)
Grafting in the month of September + Shade net	4.35	4.93	5.57	6.85	12.61	21.01	18.59	5.62	5.60	0.199	75.63 (60.44)
Grafting in the month of September + Mist chamber	4.76	5.63	6.59	11.58	21.44	29.73	21.58	7.01	6.90	0.250	88.83 (70.78)
Grafting in the month of October + Open condition	3.38	4.07	5.01	4.35	8.59	17.36	14.96	5.19	4.40	0.259	89.33 (71.16)
Grafting in the month of October + Shade net	3.65	4.13	4.75	5.09	10.82	20.36	15.17	4.95	4.87	0.195	72.50 (54.48)
Grafting in the month of October + Mist chamber	5.58	6.12	6.85	9.81	19.14	31.60	20.72	7.41	6.80	0.314	92.17 (73.90)
Mean	**4.78**	**5.53**	**6.30**	**8.58**	**15.76**	**25.37**	**18.90**	**6.06**	**6.20**	**0.259**	**87.39**
SE m ±	**0.31**	**0.28**	**0.33**	**0.39**	**0.42**	**0.74**	**1.58**	**0.57**	**0.55**	**0.03**	**3.26**
SE (d)	**0.43**	**0.40**	**0.47**	**0.55**	**0.59**	**1.05**	**2.23**	**0.81**	**0.77**	**0.05**	**4.61**
C.D.(p=0.05)	**0.89**	**0.83**	**0.96**	**1.14**	**1.21**	**2.16**	**NS**	**NS**	**NS**	**NS**	**9.48**
C.V. (%)	**11.09**	**8.87**	**9.03**	**7.87**	**4.56**	**5.05**	**14.43**	**16.36**	**15.14**	**22.75**	**7.79**

Figures in parenthesis shows arc sign transformation, DAG - Days after grafting

fresh and dry weight of grafts, root volume, and root to shoot ratio. Graft survival percentage was significantly influenced by the month of grafting (Table 3). The highest graft survival was recorded in the month of August (92.38 %). This might be due to favourable weather conditions resulting in less mortality and higher survival of grafts [7]. Kalabandi et al., [22] also recorded higher graft survival in sapota when grafting was performed during August. Significant variation was observed in graft survival percent with respect to environmental conditions. The result revealed that grafts kept under mist chamber recorded the highest survival (94.96 %). This may be due to congenial conditions inside the mist chamber or poly house which prevent desiccation of scion and stock [9]. The results were in agreement with the findings of Angadi and Karadi [20] in Jamun. The interaction effect of months of grafting and environmental conditions on graft survival % was found to be significant. Highest graft survival was observed in grafting in the month of July under mist chamber (100.00 %). Because of the differences in temperature and relative humidity that

exist over different months, graft success and survivability varies [6]. This result was in agreement with the findings of Gotur et al., [12] in guava. The correlation studies revealed that, there was a noticeable correlation among few characters under the study. Close perusal of the Table 5 revealed that, there was a significant and highly positive correlation between graft survival with number of leaves per graft (r=0.749**), leaf area (r=0.687**) and root to shoot ratio (r=0.659**).

Table 5. Correlation coefficients among vegetative growth parameters and graft survivability in cashew grafts

Variable	2	3	4	5	6	7	8	9	10	11
1. Days taken to sprouting	-0.153NS	-0.481*	-0.421*	-0.655**	-0.634**	-0.114NS	-0.109NS	-0.613**	-0.085NS	-0.415*
2. Grafting success		0.639**	0.241NS	0.661**	0.655**	0.743**	0.698**	0.510**	0.511**	0.513**
3. Graft height			0.563**	0.841**	0.826**	0.639**	0.658**	0.816**	0.613**	0.533**
4. Graft diameter				0.483**	0.383NS	0.446*	0.381NS	0.434*	0.112NS	0.206NS
5. Number of leaves					0.954**	0.635**	0.704**	0.896**	0.634**	0.749**
6. Leaf area						0.542**	0.617**	0.858**	0.605**	0.687**
7. Graft fresh weight							0.884**	0.649**	0.550**	0.454*
8. Graft dry weight								0.726**	0.549**	0.547**
9. Root volume									0.655**	0.606**
10. Root to shoot ratio										0.659**
11. Graft survival										1.000

*, **Correlation coefficient is significant at p< 0.05 and p< 0.0001, respectively

Root volume showed prohibitive significantly positive association with the number of leaves (r=0.896**), leaf area (r=0.858**) and graft height (r=0.816**). There was a significant and highly positive correlation between graft height and number of leaves (r=0.954**). The parameter days taken to the sprouting of graft had a highly adverse significant effect on the number of leaves (r=-0.655**), leaf area (r= -0.634**), and root volume (r=-0.613**). Similarly, days taken to sprouting of graft had a negative significant correlation with graft survival (r= -0.415*). The results are in conformity with Chipojola et al., [4] in cashew.

Conclusion

Based on the results obtained, grafting in the month of August under mist chamber conditions have registered higher success percentage, good growth and the highest survival percentage. Therefore, softwood grafting in August under mist chamber was found suitable for the successful propagation of cashew under agroclimatic conditions of the Bastar region.

Acknowledgments

We thank Dean, SGCARS, Jagdalpur for his guidance during the experiment. We also thank the Professor and Head, the Department of Fruit Science, College of Agriculture, Raipur, for his help and support during the investigation.

References

[1] S. Dewangan, V. Ramteke and S. Poyam **(2021)**. Cashewnut and cashew apple- a potential drug and medicine. Chronicle Bioresource Manag., **5:** 156-160.

[2] P. Preethi, S. Savadi, K. Vanitha, V. Ramteke, S. Mangalassery and M. S. Sandesh **(2021)**. Cashew (*Anacardium occidentale* L.). *In*: S. N. Ghosh and R. R. Sharma (eds). Tropical Fruit Crops: Theory to Practical. Jaya Publishing House, New Delhi, India. pp136-183.

[3] Anonymous **(2023)**. Area, Production & Productivity of Horticulture Crops in Chhattisgarh. Government of Chhattisgarh, Accessed from: https://agriportal.cg.nic.in/horticulture/HortiEn/Default.aspx.

[4] F. Chipojola, W. F. Mwase, M. B. Kwapata, J. P. Njoloma, J. M. Bokosi and M. F. Maliro **(2013)**. Effect of tree age, scion source and grafting period on the grafting success of cashew nut (*Anacardium occidentale* L.). Afr. J. Agric. Res., **8:** 5785-5790. doi:10.5897/AJAR10.879.

[5]D. Vaghela and D. K. Sharma **(2015)**. Effect of season and growing environment on success of soft wood grafting in cashew nut (*Anacardium occidentale*) under south Gujarat agroclimatic conditions. Current Hort., 3: 58-60.

[6] S. S. S. Narina, C.R. Sankar, G. V. H. Rao and M. L. N. Reddy **(2020)**. Potential shade structures to improve graft-take and the growth of softwood grafts in cashew (*Anacardium occidentale* L.). Acta Sci. Nutr. Health, **4:** 161-178. doi: 10.31080/ASNH.2020.04.0629.

[7] B. Manga, P. Jholgiker, G. S. K. Swamy, G. Prabhuling and N. Sandhyarani **(2017)**. Studies on effect of propagation environment for softwood grafting in guava (*Psidium guajava* L.) cv. Sardar. Int. J. Current Microbiol. App. Sci., **6:** 2779-2783.

[8] O. P. Sheron, D. S. Tonk, L. S. Kaushik, R. C. Hasija and R. S. Pannu **(1998)**. Statistical software package for agricultural research workers. Recent advances in information theory, statistics and computer applications by Hooda, DS and Hasija, RC, Department of Mathematics Statistics, CCS HAU, Hisar. pp139-143.

[9] S. Chander, S. Kumari, P. K. Nimbolkar and L. Bora **(2016)**. Seasonal variability and environmental condition to grafting success in fruit crops- A review. Adv. Life Sci., **5:** 5812-5816.

[10] V. N. Raghavendra, S. G. Angadi, A. N. Mokashi, T. B. Allolli, C. K. Venugopal and U. V. Mummigatti **(2011)**. Studies on softwood grafting in wood apple (*Feronia limonia* L.). Acta Hort., **890:** 165-174. doi: 10.17660/ActaHortic.2011.890.22.

[11] C. B. Parmar, H. H. Sitapara, S. R. Vasava and H. J. Chaudhri **(2019)**. Effect of different time and growing conditions on growth parameters, success and survival of softwood grafting in mulberry (*Morus nigra* L.) cv. local. J. Pharmacogn. Phytochem., **8:** 2674-2677.

[12] M. Gotur, D. K. Sharma, S. L. Chawla, C. J. Joshi and K. Navya **(2017)**. Performance of wedge grafting in guava (*Psidium guajava* L.) under different growing conditions. Plant Arch., **17:** 1283-1287.

[13] B. V. Sivudu, M. L. N. Reddy, P. Baburatan and A. V. D. Dorajeerao **(2014)**. Effect of structural conditions on veneer grafting success and survival of mango grafts. Plant Arch., **14:** 71-75.

[14] A. Kumar **(2018)**. Effect of rootstock thickness on wedge grafting in guava (Psidium guajava L.) under different growing conditions. M.Sc. (Hort.) Thesis, CCS Haryana Agr. Univ., Haryana.

[15] L. Vanaja, D. V. Swami, B. P. Kumar and P. Subbaramamma **(2017)**. Studies on the effect of time of wedge grafting and growing conditions on growth and leaf characteristics of guava (*Psidium guajava* L.) grafts. Int. J. Curr. Microbiol. App. Sci., **6:** 1574-1580.

[16] B. Giri and P. C. Lenka **(2009)**. Effect of month of grafting on graft success in bael (*Aegle marmelos*). Orissa J. Hort., **37:** 61-62.

[17] R. R. Bhilare, N. M. Kanade, V. S. Ghule and B. G. Pawar **(2018)**. Effect of season and polytube cover cap on softwood grafting in lemon (*Citrus limon* L.) cv. Konkan lemon. J. Pharmacogn. Phytochem., **7:** 2803-2807.

[18] M. M. Baghel, U. A. Raut, M. Kamatyanatti and V. Ramteke **(2017)**. Studies on Cumulative influence of indole-3-butyric acid (IBA) and time of air layering in guava (*Psidium guajava* L.) cv. L-49. Res. J. Agric. Sci., **8:** 233-236.

[19] K. Thakur, P. Katiyar and V. Ramteke **(2016)**. Physiological and growth response of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] varieties to different growing seasons. The Ecoscan, **9:** 651-657.
[20] S. G. Angadi and R. Karadi **(2012)**. Standardization of softwood grafting technique in jamun under poly mist house conditions. Mysore J. Agr. Sci., **46:** 429-432.
[21] A. Anant **(2017)**. Effect of different environmental conditions on performance of sapota softwood grafts worked on invigorated khirni rootstock. M.Sc. (Hort.) Thesis Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.
[22] B. M. Kalabandi, S. Ziauddin and B. N. Shinde **(2014)**. Effect of time of softwood grafting on the success of sapota grafts in 50 % shade net under Marathwada conditions. Agri. Sci. Dig., 34: 151-153. doi: 10.5958/0976-0547.2014.00037.8.