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PERFORMANCE OF SOFTWOOD GRAFTING AND STANDARDIZATION OF GRAFTING TIME IN AONLA (*EMBLICA OFFICINALIS* L.) VARIETIES

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ABSTRACT

Aonla (*Emblica officinalis* L.), or Indian gooseberry, is highly valued in Ayurvedic medicine and a rich source of bioactive compounds like vitamin C, flavonoids, polyphenols and tannins. These compounds give aonla potent antioxidant, anti-inflammatory and immunomodulatory properties, making it important in the nutraceutical and pharmaceutical industries. Aonla is typically propagated through grafting, which ensures genetic uniformity and high-quality plant production. However, the success of grafting is influenced by various factors, such as the variety of aonla and the timing of grafting. This study aimed to evaluate the performance of softwood grafting across four aonla varieties and four grafting times to determine the optimal grafting time for improved success and survivability. The experiment was conducted in a two-factorial completely randomized design with two replications, comprising four aonla varieties and four grafting times. The results revealed that the variety NA-7, grafted on January 1st, exhibited the best overall performance, with the shortest bud sprouting time (9.10 days) and the highest graft union girth (9.10 mm), longest sprouted shoot length (32.95 cm), and internodal length (2.85 cm). The total chlorophyll content (60.68 SCMR Value), stomatal conductance (204.50 m mol m^{-2} s^{-1}), and leaf area (55.86 cm^2) were also highest in this variety. Additionally, NA-7 demonstrated the highest number of leaves per graft (22.50), graft success (90.50%), and survivability (88.50%). The Chakaiya variety showed similar performance, though slightly lower than NA-7. These findings suggest that grafting on January 1st is the optimal time for both the NA-7 and Chakaiya varieties, resulting in the highest graft success and overall plant health.

***Keywords* :** Aonla, propagation, variety, time of grafting

Introduction

Plants and their bioactive compounds have been the cornerstone of both traditional medicine systems and the modern pharmaceutical industry. Among the multitude of medicinal plants, Aonla (*Emblica officinalis* L.), also known as Indian gooseberry, is particularly distinguished for its wide-ranging therapeutic potential. This plant belongs to the Euphorbiaceae family and is a deciduous tree found extensively in tropical and subtropical regions of India. It is not only widely used in Indian traditional medicine (Ayurveda), but also regarded as one of the most potent rasayana (rejuvenative) herbs, especially beneficial for a variety of ailments related to the bones, liver, blood, and heart.

Among various propagation methods, grafting has emerged as a reliable technique for vegetative propagation of aonla. Grafting ensures uniformity in the production of aonla plants and allows the preservation of desirable genetic traits, which is particularly important for commercial cultivation. However, the success and survivability of grafts are influenced by several factors, including the selection of scion material, grafting technique, rootstock age, and environmental conditions such as temperature, humidity, and light (Hartmann *et al*., 1997). Among these factors, the timing of grafting and the choice of aonla variety are critical determinants of graft success.

Despite its importance, there remains a lack of a standardized approach for determining the optimal grafting time for aonla under various climatic conditions. The timing of grafting is a complex aspect, influenced by seasonal changes, environmental variables, and the specific growth characteristics of the aonla variety being propagated. These factors collectively affect the success, survivability, and overall growth of grafted plants. Hence, This study aimed to evaluate the performance of softwood grafting across four aonla varieties and four grafting times to determine the optimal grafting time for improved success and survivability.

Material and Methods

The present investigation was carried out at Main Horticulture Research and Extension Centre, University of Horticultural Science, Bagalkot, during the year 2020-21, which comes under northern dry zone of Karnataka (zone -3) and this location is situated at 16^0.10' north latitude and 17^0.42' east longitude and elevation of 542 m above mean sea level. The optimum sized one-year old aonla seedlings were used as a rootstock for grafting. The scion material was collected from the identified elite types of aonla trees of variety NA-4 (Kanchan), NA-5 (Krishna), NA-7 and Chakaiya from fruit orchard, Sector 70, MHREC, UHS, Bagalkot and are grafted on 1^{st} of January, February, March and April 2021 at 30 days interval.

The observations were recorded on various parameters *viz*., days taken for bud sprouting, girth at graft union, length of sprouted shoot, girth of sprouted shoot, internodal length of shoot, number of leaves per graft, grafts success, grafts survivability, leaf area, total chlorophyll content and stomatal conductance. After grafting operation, grafts were observed regularly for its greening till it was sprouted or dried and after that mean was computed. Numbers of leaves developed per graft, length of sprouted shoot (cm), girth of sprouted shoot (mm), internodal length of shoot (cm), leaf area (cm^2) were recorded, 90 days after grafting operation. Girth at graft union, girth of sprouted shoot of randomly selected five observational plants was recorded separately in each treatment with the help of digital vernier calliper recorded in millimetre. The grafts were under observation regularly up to 90 days after grafting operation and then final survival was recorded and after computing the mean, it was recorded as survivability percent of grafts. Total chlorophyll content was estimated by chlorophyll meter SPAD-502, stomatal conductance by porometer at 90 days after grafting.

The present study employed a two-factorial completely randomized design (CRD) with two replications to assess the performance of softwood grafting in aonla. The two factors were four aonla varieties (NA-4, NA-5, NA-7 and Chakaiya) and four grafting times (January 1^{st}, February 1^{st}, March 1^{st}, and April 1^{st}) with two replications. After grafting, observations were taken for 90 days, and the mean values for these parameters were computed. Statistical analysis was conducted using Analysis of Variance (ANOVA) to determine the significance of the main effects of variety and grafting time, as well as their interaction. The significance level was set at 5%.

Results and Discussion

Growth parameters

The variety NA-7 recorded the shortest time for bud sprouting (11.00 days), the largest girth at the graft union (8.68 mm), the longest sprouted shoot length (28.18 cm) and the highest girth of sprouted shoot (2.71 mm). Among grafting times, January 1st performed the best, with the shortest time for bud sprouting (10.30 days), the largest girth at the graft union (8.64 mm), the longest sprouted shoot length (30.33 cm), and the highest girth of sprouted shoot (3.38 mm). The interaction of variety and grafting time revealed that NA-7 grafted on January 1st exhibited the best outcomes, with the shortest time for bud sprouting (9.10 days), the largest girth at the graft union (9.10 mm), the longest sprouted shoot length (32.95 cm) and the highest girth of sprouted shoot (3.40 mm) (Table 1). The improved growth parameters observed in NA-7 grafted on January 1^{st} can be attributed to the genetic superiority of the variety and the favorable environmental conditions during January. The deciduous nature of aonla promotes the accumulation of reserve nutrients, supporting the grafting process. Optimal temperatures during January facilitate metabolic activities, including callus formation and graft union development, leading to better sprouting and growth. Similar results were reported by Kudmulwar *et al.* (2008) and Gurjar and Singh (2012) in aonla, where grafting time significantly influenced growth parameters.

Shoot and leaf parameters

NA-7 displayed the highest internodal length (2.31 cm) and the maximum number of leaves per graft (17.15). Grafting on January 1st resulted in the best internodal length (2.66 cm) and the maximum number of leaves per graft (21.08). The interaction of variety and grafting time indicated that NA-7 grafted on January 1st achieved the best performance, with the highest internodal length (2.85 cm) and the maximum number of leaves per graft (22.50). The enhanced shoot and leaf development in NA-7 grafted on January 1^{st} can be linked to the availability of adequate nutrients and favorable environmental conditions during this period (Table 2). The increased leaf area and internodal length contribute to better photosynthetic efficiency and nutrient absorption, which in turn support overall growth. Studies by Sharma *et al.* (2016) and Jalal *et al.* (2018) highlighted the importance of grafting time in influencing leaf development and internodal length, consistent with the current findings.

Physiological parameters

NA-7 showed the highest leaf area (48.38 cm²), total chlorophyll content (56.57 SCMR value) and stomatal conductance (181.86 m mol m^{-2} s^{-1}). Grafting on January 1^{st} resulted in the highest values for leaf area (45.78 cm²), total chlorophyll content (57.37 SCMR value), and stomatal conductance (176.26 m mol m^{-2} s^{-1}). The interaction revealed that NA-7 grafted on January 1st exhibited the best outcomes, with the highest leaf area (55.86 cm²), total chlorophyll content (60.68 SCMR value) and stomatal conductance (204.50 m mol m^{-2} s^{-1}). The superior physiological performance of NA-7 grafted on January 1^{st} can be ascribed to the genetic potential of the variety and the favorable conditions for photosynthetic activity during January (Table 3). A higher chlorophyll content and stomatal conductance enhance the plant's ability to capture and utilize light energy efficiently, resulting in better growth. These findings align with those of Shinde *et al.* (2015) and Rani *et al.* (2015), who reported similar trends in aonla and guava.

Graft success and survivability

The graft success rate was highest in Chakaiya (70.25%), while NA-7 recorded the highest survivability (65.31%). Grafting on January 1st achieved the highest graft success (86.63%) and survivability (83.81%). The interaction effect revealed that NA-7 grafted on January 1^{st} recorded the best results, with a graft success rate of 90.50% (Fig. 1) and survivability of 88.50% (Fig. 2). The higher graft success and survivability observed in NA-7 grafted on January 1^{st} reflect the synergy between genetic traits and environmental conditions. The availability of naturally cured scions and optimal climatic conditions during January facilitate better graft union formation and subsequent growth. These results are consistent with studies by Patil *et al.* (2010) and Kholia *et al.* (2017), emphasizing the importance of grafting time and scion quality in achieving successful propagation.

Conclusion

The results of the present study clearly indicate that the variety NA-7, when grafted on January 1^{st}, outperformed other varieties across most of the growth, physiological and graft success parameters. It exhibited the fastest bud sprouting, optimal graft union development, superior shoot growth, enhanced physiological performance and the highest graft success and survivability. The variety Chakaiya also performed well, though slightly lower than NA-7. Based on these findings, it can be concluded that scion material from variety NA-7, grafted on January 1^{st}, is highly suitable for large-scale aonla propagation at the nursery stage. However, further field trials focusing on yield and quality attributes are essential to evaluate the overall performance of these varieties under field conditions before making recommendations for their large-scale cultivation in the region.

Table 1 : Influence of variety and time of grafting on different growth parameters of aonla

Variety/ time	Days taken to sprouting					Girth at graft union (mm)					Length of sprouted shoot (cm)					Girth of sprouted shoot (mm)				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
V_1	11.50	12.50	14.00	15.20	13.30	8.18	8.05	7.90	7.28	7.85	27.80	24.45	23.00	19.60	23.71	3.15	2.73	2.05	1.84	2.44
V_2	10.90	11.60	12.70	15.50	12.68	8.28	7.83	7.45	7.18	7.68	28.60	24.95	23.25	21.10	24.48	3.23	2.90	2.35	1.88	2.59
V_3	9.10	10.60	11.40	12.90	11.00	9.10	8.90	8.53	8.18	8.68	32.95	30.00	25.65	24.10	28.18	3.40	2.93	2.63	1.87	2.71
V_4	9.70	10.50	11.70	13.30	11.30	9.00	8.30	8.26	7.98	8.38	31.95	27.85	26.00	21.95	26.94	3.75	2.70	2.16	1.87	2.62
Mean	10.30	11.30	12.45	14.23		8.64	8.27	8.04	7.65		30.33	26.81	24.48	21.69		3.38	2.81	2.30	1.86	

	S.Em ±	C.D (5%)	S.Em ±	C.D (5%)	S.Em ±	C.D (5%)	S.Em ±	C.D (5%)
Mean	0.07	0.21	0.03	0.09	0.20	0.61	0.04	0.12
T	0.07	0.21	0.03	0.09	0.20	0.61	0.04	0.12
V x T	0.14	0.42	0.07	0.21	0.41	1.23	0.08	0.25

T_1 : Grafted on January 1st
T_2 : Grafted on February 1st
T_3 : Grafted on March 1st
T_4 : Grafted on April 1st

V_1 : NA- 4 (Kanchan)
V_2 : NA- 5 (Krishna)
V_3 : NA- 7
V_4 : Chakaiya

Table 2 : Influence of variety and time of grafting on different growth parameters of aonla

Variety/ time	Internodal length of shoot (cm)					Number of leaves per graft				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
V_1	2.45	2.15	1.83	1.30	1.93	19.30	17.00	15.60	10.80	15.68
V_2	2.68	2.35	1.90	1.48	2.10	20.50	18.60	15.60	10.00	16.18
V_3	2.85	2.45	2.05	1.90	2.31	22.50	18.50	16.10	11.50	17.15
V_4	2.68	2.35	2.05	1.70	2.19	22.00	18.40	14.00	10.00	16.10
Mean	2.66	2.33	1.96	1.59		21.08	18.13	15.33	10.58	16.28
	S.Em ±		**C.D (5%)**			**S.Em ±**		**C.D (5%)**		
Mean	0.02		0.07			0.10		0.30		
T	0.02		0.07			0.10		0.30		
V x T	0.04		0.14			0.18		0.60		

T_1 : Grafted on January 1st
T_2 : Grafted on February 1st
T_3 : Grafted on March 1st
T_4 : Grafted on April 1st

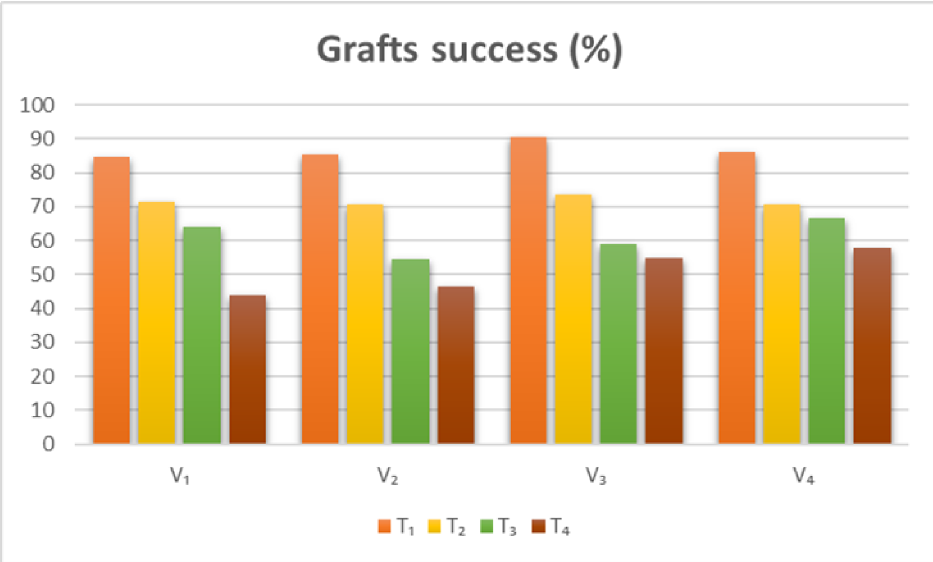
V_1 : NA- 4 (Kanchan)
V_2 : NA- 5 (Krishna)
V_3 : NA- 7
V_4 : Chakaiya

Table 3 : Influence of variety and time of grafting on different growth parameters of aonla

Variety/ time	Leaf area(cm^2)					Total chlorophyll content					Stomatal conductance (m mol $m^{-2}s^{-1}$)				
	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean	T_1	T_2	T_3	T_4	Mean
V_1	38.50	35.38	34.58	31.31	34.94	55.20	53.90	52.65	50.80	53.14	155.25	147.50	136.50	124.50	140.94
V_2	42.01	40.63	37.78	32.39	38.20	57.10	55.60	52.30	49.40	53.60	160.00	154.75	147.50	142.00	151.06
V_3	55.86	49.15	46.70	41.80	48.38	60.68	57.85	55.35	52.40	56.57	204.50	190.45	170.00	162.50	181.86
V_4	46.77	41.65	36.01	29.64	38.52	56.50	54.90	53.65	51.00	54.01	185.30	182.50	178.00	164.00	177.45
Mean	45.78	41.70	38.77	33.78		57.37	55.56	53.49	50.90		176.26	168.80	158.00	148.25	
	S.Em ±		C.D (5%)			S.Em ±		C.D (5%)			S.Em ±		C.D (5%)		
Mean	0.12		0.36			0.51		1.54			2.79		8.44		
T	0.12		0.36			0.51		1.54			2.79		8.44		
V x T	0.24		0.72			1.02		NS			5.58		NS		

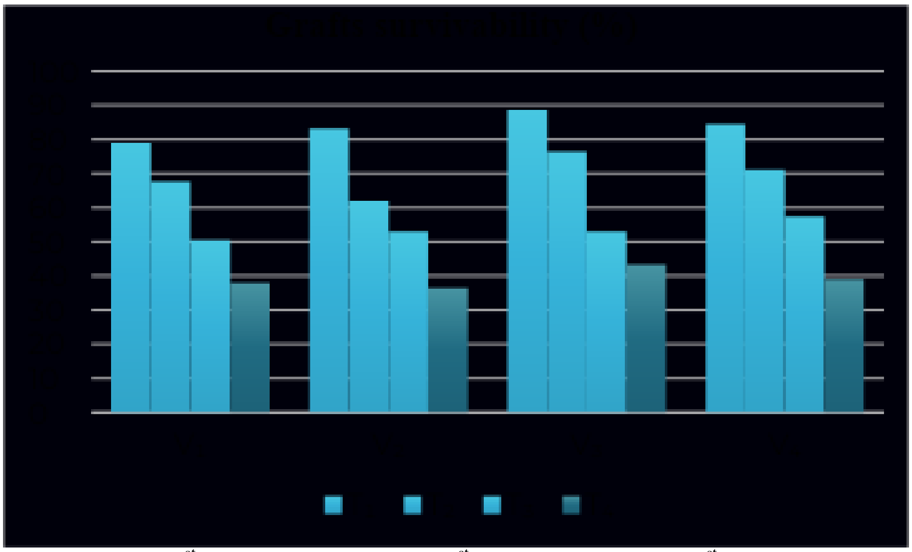
T_1 : Grafted on January 1st
T_2 : Grafted on February 1st
T_3 : Grafted on March 1st
T_4 : Grafted on April 1st
NS: Non-significan

V_1 : NA- 4 (Kanchan)
V_2 : NA- 5 (Krishna)
V_3 : NA- 7
V_4 : Chakaiya



T_1 : Grafted on January 1st, **T_2 :** Grafted on February 1st, **T_3 :** Grafted on March 1st, **T_4 :** Grafted on April 1st , **V_1 :** NA- 4 (Kanchan), **V_2 :** NA- 5 (Krishna), **V_3 :** NA- 7, **V_4 :** Chakaiya

Fig. 1 : Effect of variety and time of grafting on graft success of aonla



T_1 : Grafted on January 1st, **T_2 :** Grafted on February 1st, **T_3 :** Grafted on March 1st, **T_4 :** Grafted on April 1st , **V_1 :** NA- 4 (Kanchan), **V_2 :** NA- 5 (Krishna), **V_3 :** NA- 7, **V_4 :** Chakaiya

Fig. 2 : Effect of variety and time of grafting on graft survivability of aonla

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