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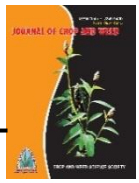

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Response of aonla (*Emblica officinalis* Gaertn.) cultivars to different dates of grafting

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ABSTRACT

Aonla is one of most suitable fruit crop for Bundelkhand region as it's require minimum water and can tolerate high pH up to 9. Owing to its diverse nutritional value, particularly its inclusion of vitamin C, aonla is a widely sought-after fruit for creation of many byproducts such as chyawanprash, trifla, murabba, candy, etc. An experiment was undertaken in open field condition at experimental field, Department of Fruit Science, Rani Lakshmi Bai Central Agricultural University, Jhansi (Uttar Pradesh) during 2021 with the aim to study the success and survival percentage of different aonla cultivars on local rootstock at different time intervals in winter season. The research work was started with factorial randomized block design with two factors, Varieties (NA-6, NA-7 and Chakaiya) and different dates (20, 30 January and 10, 20 February) of grafting. The scion of different varieties were grafted with wedge method of grafting on Local root stock of Aonla on 20th January, 30th January, 10th February and 20th February to check the different growth parameters viz., number of leaves, height of graft, number of primary branches, number of grafts sprouted, sprouting percentage, scion girth, survival percentage and number of days taken for sprouting in aonla. Three replications of each of the twelve treatment combinations were conducted. More number of leaves, maximum number of graft per treatment, minimum days take for sprouting, maximum sprouting percentage, more number of primary branches and maximum survival percentage were obtained when the plants were grafted on local rootstock at 20th January while height of graft and scion girth were found with NA-7 variety grafted at 30th January. For the Bundelkhand region, as per result obtained for aonla grafting, variety NA-7 is more suitable for getting better sprouting and other vegetative characters of grafted plant when it is grafted around 20th January using local rootstock.

Keywords: Aonla, grafting, sprouting, scion, rootstock

Aonla is a fruit tree botanically known as *Emblica officinalis* Gaertn. containing the 2n=28 chromosomal number. Indian gooseberry, frequently referred to as *Fruit of the 21st Century Amritphal fruit*, Aonla, or Usuri, Amla in India, is a native of tropical South-East Asia and a genus of the Euphorbiaceae family. According to Lilabati and Sahoo (2016), this tree has strong roots and can grow in a variety of soil types. Madhya Pradesh is on first position with the production of 403.77 (000 Tonnes) followed by Uttar Pradesh from an area 26.02 (000 ha) and 36.71 (000 ha) respectively (NHB-2021-22). Seeds and asexual (vegetative) ways are both used to propagate Aonla. Asexually it is propagated by patch budding, shield budding, chip budding, forkert budding and wedge grafting (Negi *et al.*, 2010). On the other hand, there is a lot of variability and the aonla plants grown from seeds do not grow true to type. As vegetatively propagated fruit trees are true to type and bear fruit early on, it has, therefore, been suggested that superior types of aonla be multiplied by using vegetative methods such as budding, grafting, inarching, etc. to get around the drawbacks of seed propagation (Hartmann *et al.*, 1997). Even though shield/patch budding in aonla has a relatively high success rate, it is a labor-intensive, time-consuming procedure that can only be carried out on seedling rootstocks that have been older than a year.

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Numerous factors, including the scion's source, the grafting season, the technique, the age of the rootstock, and meteorological conditions, affect the survival and success of grafts (Hartmann *et al*., 1997). Numerous other studies on the budding of aonla during the rainy season have already been finished, and this method is being used commercially to multiply aonla. The study on grafting of aonla is yet to be standardized in the Bundelkhand region to provide the planting material of aonla to the farmers round the year. Therefore, the goal of the current study is to determine and standardize the ideal growth conditions and times for aonla propagation in the Bundelkhand region.

MATERIALS AND METHODS

The research work entitled "Response of aonla (*Emblica officinalis* Gaertn.) cultivars to different dates of grafting" was undertaken in open field conditions at Experimental field, Department of Fruit Science, RLBCAU Jhansi, during 2021. There were twelve treatment combinations made with two factors (Variety and Date of grafting) which were replicated three times under Factorial Randomized Block Design (FRBD). Each treatment included 10 plants per replication. For grafting, ten months' old seedlings of the briskly growing rootstocks that were uniform in size and thickness were chosen. The rootstocks chosen for grafting were developed on our research farm by gathering seeds from likely 20-years-old locally available seedling plants. For the study, non-flowering shoots with dark green leaves that were roughly 15 cm long, straight, smooth, healthy, devoid of pests and diseases, and the same thickness as the rootstock was used to choose the scion stick from seven years old mature tree. The scion was procured from our own established orchard under semi-arid condition. Wedge grafting was done during the months of January and February at 10 days interval. The parameters considered in this study are number of grafts sprouted per treatment, days taken for first sprouting, sprouting percentage (%), number of primary branches/ graft, number of leaves per graft, height of graft (cm), scion girth (cm) and survival percentage (%).

Number of grafts sprouted per treatment

Regular observation was made up to 30 days after grafting (DAG) and total number of sprouted plants was counted and the mean value was noted for analysis.

Number of days taken for sprouting

Number of days taken for sprouting was calculated as the average of days for initiation of sprout and days for final sprouting.

Sprouting percentage

The total number of sprouted grafts under each treatment was recorded at 90 days after planting and the total number was converted into percentage. The mean percentage was noted for analysis.

Number of primary branches

After the successful grafting, the primary branches were counted and the mean value was taken for analysis.

Number of leaves per graft

The number of leaves per graft under each treatment was counted at 30, 60 and 90 days after grafting and mean value was noted.

Height of graft

The height of the grafted plants was recorded on 30, 60 and 90 DAG by using meter scale from the base of the plant to tip of the leaf.

Scion girth

The girth of the graft was measured 1 cm above from the graft joint using vernier caliper.

Survival percentage

The number of living plats was counted at 90 days after grafting and the total survival percentage was calculated and their average was worked out.

The graft success percentage and survival percentage were calculated by using following formulae:

$$Graft\ success\ percent = \frac{Total\ number\ of\ sprouted\ graft}{Total\ number\ of\ grafted\ plants} x\ 100$$

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

Analysis of variance (ANOVA) was the statistical method used to analyze the final data for each character that was recorded during the course of the study. As recommended by Panse and Sukhatme (1985), the importance of various treatments was assessed.

Table-1: Factors and their levels

Time of grafting		Varieties of aonla	
W1	20 January, 2021	V1	NA-6 (Narendra Aonla-6)
W2	30 January, 2021	V2	NA-7 (Narendra Aonla-7)
W3	10 February, 2021	V3	Chakaiya
W4	20 February, 2021		

Table-2: Details of treatment combinations

Treatment	Combinations
T_1:	$W_1 V_1$ [20 January (Deshi + NA-6)]
T_2:	$W_1 V_2$ [20 January (Deshi + NA-7)]
T_3:	W_1V_3 [20 January (Deshi + Chakaiya)]
T_4:	$W_2 V_1$ [30 January (Deshi + NA-6)]
T_5:	W_2V_2 [30 January (Deshi + NA-7)]
T_6:	W_2V_3 [30 January (Deshi + Chakaiya)]
T_7:	W_3V_1 [10 February (Deshi + NA-6)]
T_8:	$W_3 V_2$ [10 February (Deshi + NA-7)]
T_9:	$W_3 V_3$ [10 February (Deshi + Chakaiya)]
T_{10}:	W_4V_1 [20 February (Deshi + NA-6)]
T_{11}:	$W_4 V_2$ [20 February (Deshi + NA-7)]
T_{12}:	$W_4 V_3$ [20 February (Deshi + Chakaiya)]

Table-3: Meteorological data during experimentation

Month	Std met. Week	Temp. (^{0}C)		RH		Wind velocity (km/hr)	Rainfall (mm)	No. of rainy days	Evaporation (mm)
	1	22.7	10.3	87.0	65.0	2.9	0.0	0.0	2.5
	2	21.3	9.4	90.0	60.0	2.8	0.0	0.0	2.3
January	3	22.2	6.3	88.0	56.0	3.0	0.0	0.0	2.5
	4	21.0	5.7	88.0	59.0	3.0	0.0	0.0	2.5
	5	24.7	6.3	89.0	48.0	2.8	0.0	0.0	2.9
January -February	6	24.2	9.1	86.0	46.0	3.0	1.0	0.0	2.8
	7	27.5	10.9	88.0	43.0	3.6	3.8	0.0	3.5
February	8	28.8	12.1	79.0	42.0	3.4	0.0	0.0	3.8
	9	32.1	14.2	85.0	46.0	3.6	0.0	0.0	5.0
February -March	10	33.7	14.3	81.0	43.0	3.8	0.0	1.0	5.8
	11	31.6	14.6	86.0	39.0	4.2	4.6	1.0	5.9
March	12	34.8	16.6	81.0	37.0	3.9	4.2	1.0	6.4
	13	37.0	16.8	78.0	33.0	3.9	0.0	0.0	6.9
March-April	14	38.7	17.3	72.0	33.0	3.7	0.0	0.0	8.2
	15	38.4	18.8	64.0	36.0	4.5	0.0	0.0	8.6
April	16	39.1	19.0	60.0	36.0	5.3	0.0	0.0	9.2
	17	38.7	18.5	64.0	33.0	7.0	0.0	0.0	11.3
April-May	18	42.1	19.7	58.0	32.0	4.8	0.0	0.0	12.6
	19	38.1	21.1	56.0	38.0	4.8	0.6	0.0	10.5
May	20	35.6	21.3	71.0	44.0	5.9	2.3	2.0	8.6
	21	36.4	22.3	61.0	41.0	6.1	0.0	0.0	8.5
	22	39.6	25.3	57.0	39.0	6.7	3.8	1.0	10.3
May-June	23	41.8	27.3	53.0	32.0	6.2	0.0	0.0	11.6

RESULTS AND DISCUSSION

Number of grafts sprouted/ treatment

The three varieties of aonla were grafted on different dates of January to February. About 15 days after grafting, the bud sprouting was started and the maximum (9.62) number of grafts per treatment was sprouted under the treatment combination W1V2. In other varieties, the bud sprouting was also noted; whereas, the minimum number of sprouts was noted under the treatment combination W4V1. Rani *et al.* (2015) observed similar findings in guava. Chandra *et al*. (2011) also reported similar results in pomegranate. Additionally, according to Singh and Singh (2007), relative humidity plays a significant role in bud sprouting, with higher humidity causing guava buds to sprout earlier. The outcome supports the conclusions of Negi *et al.* (2010) in aonla. Dewangan *et al.* (2023) found maximum sprouts while working on cashew nut under baster region of Chhattisgarh.

Days taken for first sprouting

From the result shown in Table-4, it is depicted that the treatment W3V1 took minimum (9.70 days) time to come under first sprouting, while the treatment combination W4V3 sprouted very late (14.09 days).Similar results were noted by Patel *et al.* (2007) in Mandarin and Jalal *et al.* (2018) in Aonla. Wazarkar *et al.* (2009) in sapota, Sonawane *et al.* (2012) in carambola, Kumar *et al.* (2017) in guava, and Bodkhe and Rajput (2010) in jamun reported similar kind of findings.

Number of primary branches/graft

According to data recorded during experiment, the number of primary branches ~~was~~ ranged from 0.95 to 1.43 (Table 4). The scion shoot of NA-7 variety of aonla grafted on 20th January (W1V2), found to have better growth with maximum number of primary branches. Chakaiya, another variety of aonla, grafted on 20th February (W4V3) was very slow in growth and recorded minimum number of primary branches. The greatest number of primary branches per sapling in guava was reported by Beer *et al*. (2013), Paul and Pampanagouda(2010), and Roshan *et al*. (2013), which were greater than the current data. This could be because of the various species used in the research and the climate at the study locations.

Number of leaves at 30, 60 and 90 DAG

The data presented in Table-5 showed that effect of different dates of grafting was not able to affect the number of leaves at all three stages (30, 60 and 90 DAG) of data recording. Though non-significant, maximum numbers of leaves were found with treatment combination W1V2. It might be due to the current favourable temperature and relative humidity for plant activity, which on January 20th in the NA-7 cultivar led to more leaves with higher meristematic activity and early graft union healing. Similar type of findings were recorded by Kudmulwar *et al*. (2008), Patil *et al*. (2017) and Dhutraj *et al.* (2018) in custard apple; Chouksey *et al.* (2016) in guava, and Ghojag *et al.* (2011), Gadekar *et al*. (2011) and Chander *et al*. (2016) in Jamun.

Height of graft (cm) at 30, 60, 90 DAG

The height of graft increased up to 5.65 cm under treatment combination W1V2: but as the time is passes, the maximum (11.14cm and 16.15cm) height was recorded under the treatment combination W2V2 for other two stages (60 and 90 DAG) of data recording. The plant of Chakaiya grafted on local rootstock on 20th February exhibited lowest height. Ability of leaves to produce sufficient photosynthetic food was then used to accelerate the primary growth, resulting in a greater graft height on January 20 in the NA-7 cultivar. Similar results were noted in Jamun by Ghojage *et al.* (2011) and Chander *et al.* (2016); in Karonda by Bhavya *et al.* (2018) and in Mango by Karna *et al.* (2018). Poor vegetative growth in the grafts made on 20th February was primarily caused by the plants' reduced exposure to sunlight as a result of the cloudy weather and winter that was experienced during this month.

Sprouting percentage (%)

The data presented in table-8 depicted that the sprouting percentage in grafted plants was better with the variety NA-7 grafted on local root stock on 20th January, showing a maximum of 96.67 % sprouting. The variety NA-6 sprouted in medium on an average, while it was of lowest magnitude with the variety Chakaiya. Sonawane *et al*. (2012) reported similar outcomes in Carambola. Reshma *et al.* (2016) reported maximum percentage of sprouting by using scion shoot at different time in guava. Sharma *et al.* (2022) reported more sprouting percentage in walnut at different time of grafting during winter season.

Scion girth (mm) at 30, 60, 90 DAG

The girth of scion was noted at different time intervals (30, 60 and 90 days after grafting) and the average mean value was noted and presented in table-7. From table-7, it is clear that the treatment W2V2 at 30 DAG recorded maximum (4.69 mm) thickness of scion, while at 60 and 90 DAG the treatment combination bothW2V2 and W1V3 showed maximum (5.04 mm and 5.44 mm) increment in scion girth. Variation in scion girth across ~~the~~ different kinds may be associated with how well they differentiate parenchymal cells in the vascular system and develop calluses. Bhadra (2012) also noted comparable outcomes in carambola. The outcome was consistent with Sohnika *et al.* (2015)'s findings for guava. The highest stem thickness in wedge-grafted plants that we found here is consistent with the results of Somkuwar *et al.* (2009). Chalise *et al.* (2021) found maximum scion girth while working on walnut in open condition.

Survival %

All the grafted plants sprouted and performed well, but among them some of the plants were not able to survive till the transplanting. The data showed in table-8 clearly indicate that the maximum survival percentage of plants was noted when the scion of variety NA-7 grafted on local rootstock at 20th January; while the plants of treatment combination W3V1 survived less. It may be the cause that around 20th January the temperature and evaporation rate were minimum and humidity was somewhat high. These conditions are more favorable for proper sprouting and survival of the graft. Also the existence of varying levels of endogenous phytochemicals and the physiological stage of the scions at the time of grafting could be the cause of varying success rates of aonla varieties. A similar outcome was found in ber by Ghosh (2008). Syamal *et al.* (2012) also achieved comparable outcomes in guava by wedge grafting. Similar results were also observed by Sonawane *et al.* (2012) in carambola. Tewari and Bajpai (2002) reported that highest success of graft of aonla is possible in spring season. Similar research work is supported by Munthaj (2014) in guava and by Parmar *et al*, (2019).

Table-4: Effect of different dates of grafting on graft sprouting and No. of primary branches/graft

	No. of graft sprouted/ treatment				Number of days taken for sprouting				No. of primary branches/graft			
	V1	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**
W1	7.67	9.62	7.67	8.32	10.70	9.70	10.65	10.35	1.00	1.43	1.18	1.20
W2	7.00	7.00	7.00	7.00	11.97	10.70	10.81	11.16	1.07	1.36	1.14	1.19
W3	4.67	7.45	6.67	6.26	13.25	12.43	12.91	12.86	1.06	1.08	1.02	1.05
W4	5.00	7.00	7.33	6.44	14.01	13.52	14.09	13.87	0.95	1.01	0.94	0.96
Mean	6.08	7.77	7.17		12.48	11.59	12.12		1.02	1.22	1.07	
	W	**V**	**WxV**		**W**	**V**	**WxV**		**W**	**V**	**WxV**	
S.Em±	0.29	0.25	0.50		0.09	0.19			0.03	0.03	0.06	
CD 5%	0.85	0.73	1.47		0.27	0.54			0.10	0.08	0.17	

Table-5: Effect of different dates of grafting on number of leaves at 30, 60 and 90 DAG

Number of leaves at 30 DAG				Number of leaves at 60 DAG				Number of leaves at 90 DAG			
V1	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**
9.16	12.25	11.89	11.10	13.28	17.70	14.67	15.22	16.85	20.10	19.56	18.84
8.60	8.97	8.66	8.74	12.72	13.09	12.78	12.86	15.74	17.42	16.10	16.42
7.53	8.40	8.31	8.08	11.65	12.52	12.43	12.20	15.85	16.15	15.96	15.99
4.71	6.60	5.75	5.68	8.83	10.72	9.87	9.80	12.77	14.25	12.85	13.29
7.50	9.05	8.65		11.62	13.51	12.44		15.30	16.98	16.12	
A	**B**	**AxB**		**A**	**B**	**AxB**		**W**	**V**	**WxV**	
0.44	0.38	0.76		0.57	0.50	0.99		0.44	0.38	0.76	
1.29	1.11	NS		1.68	1.45	NS		1.28	1.11	NS	

Table-6: Effect of different dates of grafting on height of graft (cm) at 30, 60, 90 DAG

	Height of graft (cm) at 30 DAG				Height of graft (cm) at 60 DAG				Height of graft (cm) at 90 DAG			
	V1	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**
W1	4.69	5.65	5.24	5.19	10.26	10.91	9.83	10.33	15.21	15.46	15.21	15.29
W2	4.42	5.22	4.50	4.71	9.01	11.14	9.76	9.97	12.61	16.15	15.04	14.60
W3	4.19	4.69	4.24	4.37	8.45	9.89	9.84	9.39	13.42	15.48	14.39	14.43
W4	1.90	3.68	2.65	2.74	7.73	9.60	7.24	8.19	12.55	14.45	11.19	12.73
Mean	3.80	4.81	4.16		8.86	10.38	9.17		13.45	15.38	13.96	
		W	**V**	**WxV**		**W**	**V**	**WxV**		**W**	**V**	**WxV**
S.Em±		0.30	0.26	0.51	**S.Em±**	0.19	0.16	0.32	**S.Em±**	0.42	0.37	0.73
CD 5%		0.87	0.75		**CD 5%**	0.85	0.73	1.47	**CD 5%**	1.27	1.07	NS

Table-7: Effect of different dates of grafting on scion girth (mm) 30, 60, 90 DAG

	Scion girth (mm) at 30 DAG				Scion girth (mm) at 60 DAG				Scion girth (mm) at 90 DAG			
	V1	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**
W1	4.26	4.56	4.66	4.49	4.54	4.84	5.04	4.80	4.84	5.09	5.44	5.12
W2	4.29	4.69	4.46	4.48	4.64	5.04	4.84	4.84	4.91	5.40	5.12	5.14
W3	4.56	4.19	4.36	4.37	4.94	4.54	4.80	4.76	5.18	4.79	5.05	5.01
W4	4.24	4.19	4.56	4.33	4.69	4.61	4.78	4.69	4.92	4.89	5.01	4.94
Mean	4.34	4.41	4.51		4.70	4.75	4.86		4.96	5.04	5.16	
	W	**v**	**WxV**		**W**	**V**	**WxV**		**W**	**V**	**WxV**	
S.Em±	0.04	0.03	0.06		0.02	0.02	0.04		0.04	0.04	0.08	
CD 5%	0.11	0.09	0.19		0.07	0.06	0.12		0.13	0.11	0.22	

Table-8: Effect of different dates of grafting on sprouting % and Survival % of graft

	Sprouting %				Survival %			
	V1	**V2**	**V3**	**Mean**	**V1**	**V2**	**V3**	**Mean**
W1	78.33(8.88)	96.67(9.86)	76.67(8.78)	83.89(9.17)	96.24(9.84)	99.71(10.01)	96.16(9.83)	97.37(9.89)
W2	65.00(8.09)	85.67(9.27)	70.00(8.38)	73.56(8.58)	91.21(9.58)	97.67(9.91)	92.59(9.65)	93.82(9.71)
W3	66.67(8.16)	66.67(8.19)	85.67(9.28)	73.00(8.54)	81.57(9.06)	93.67(9.70)	87.22(9.36)	87.49(9.38)
W4	53.33(7.33)	73.33(8.59)	50.00(7.08)	58.89(7.67)	83.17(9.15)	84.52(9.22)	87.50(9.38)	85.06(9.25)
Mean	65.83(8.11)	80.58(8.98)	70.58(8.38)		88.05(9.40)	93.89(9.71)	90.87(9.56)	
	W	**V**	**WxV**		W	V	**WxV**	
S.Em±	2.53(0.16)	2.19(0.14)	4.39(0.27)		0.98(0.05)	0.85(0.05)	1.70(0.09)	
CD 5%	7.39(0.46)	6.40(0.39)	12.81(0.79)		2.87(0.15)	2.48(0.13)	4.97(0.27)	

Conclusion

On the basis of experiment conducted and data recorded, it can be concluded that the plants which were grafted on 20th January with the variety NA-7 (W1V2) was found as the best combination for maximum survival percentage by increasing the number of leaves, scion girth and other related parameters.

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