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Influence of Ramphal (*Annona reticulata* L.) rootstock on custard apple (*Annona squamosa* L.) cvs. 'Balanagar' and 'Arka Sahan'

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Abstract
An experiment entitled Influence of Ramphal (*Annona reticulata* L.) rootstock on custard apple (*Annona squamosa* L.) cvs. 'Balanagar' and 'Arka Sahan' were carried out at sector 70, MHREC, University of Horticultural Sciences, Bagalkot (Karnataka) during the year 2020-21, with an objective to study the influence of Ramphal rootstock on the graft's growth parameters and success of custard apple cultivars 'Balanagar' and 'Arka Sahan'. The trial was set up in a Completely Randomized Design with eight treatments and three replications. The scion from the mother plants of both the cultivar were grafted onto a Ramphal rootstock. Softwood grafting was carried out from 15th January to 28th February at fortnight intervals and observations were taken at 30 days intervals. The result of the current investigation's findings revealed that, within the varying treatments, the highest count of sprouts per graft (3.10), length of the sprouted shoot (25.37 cm), girth of scion above union (7.97 cm), number of leaves (26.54), leaf area (30.66 cm^2), length of longest root (34.73 cm) with highest graft success (95.55%) and graft survival (91.10%) at 90 DAG, was noted when grafting of 'Arka Sahan' was commenced on 15th February (T_7). Whereas the lowest number of sprouts per grafts (2.20), length of sprouted shoot (15.70 cm), girth of the scion above union (5.88mm), number of leaves (15.31), leaf area (16.26 cm^2), with minimal graft success (68.88%) and survivability (57.77%) were recorded in T_1 at 90 DAG respectively however, treatment T_7 is statistically on par with T_6 for most of the parameters studied. Therefore from the results, it can be inferred that, in the present investigation, softwood grafting of custard apple cv. 'Arka Sahan' performed on 15th February exhibited the best results.

Keywords: *Annona reticulata* L., *Annona squamosa* L., Softwood grafting, Ramphal, Balanagar, Arka Sahan

Introduction
Custard apple (*Annona squamosa* L.) an important arid terrain fruit for commerce is regarded as the most popular of the annonaceous fruits. The custard apple is native of tropical America and is commercially grown in tropical and subtropical areas all over the world. Due to its greater adaptation to different soil and climatic conditions and being free of pests and diseases, it is categorized as a semi-wild fruit. Custard apple is the most preferred monoecious fruit commonly known as Sitaphal, Sharifa, or Sugarsop in various section of the growing region.
Due to heterozygosity, seed propagation of Annona is inappropriate for the commercial production of true-to-type planting material. In the realm of vegetative propagation, softwood grafting is considered superior over patch budding, layering, and cuttings commenced from January to June in Gujarat Hiwale *et al.*, (2010) [6]. The use of softwood grafting has a distinct advantage over the other vegetative propagation methods since it is easy, affordable, high-quality grafts in a short period of time Kudmulwar *et al.*, (2008) [11]. The kind of rootstock, timing of propagation, and biochemical components present in the scion, which determines the development of callus at the graft union, are the key determinants of the extent of graft success and survivability. However, not all annonaceous species and varieties can be effectively employed as rootstocks. Even if it is conceivable to combine two species, the growth that results from the combination might not be commercially desirable. The combination must be able to grow long-lived and productive trees. Owing to the fact that, the research finding regarding the influence of Ramphal rootstock on different custard apple cultivars with respect to the growth performance, graft success, and survivability of different custard apple cultivars under the northern dry zone of Karnataka was lacking, the present trial was carried out.

Materials and Methods

The present investigation was performed at the Division of Fruit Science, sector 70, MHREC, College of Horticulture, University of Horticultural Sciences Bagalkot, situated within Karnataka's Northern dry zone (Zone 3), can be found at a geographical position of 16º46 North latitude, 74º59 East longitude, with an elevation of 533 meters above sea level. The trial was conducted during the year 2020-21 and laid out in Completely Randomized Design with eight treatments and three replications. To perform softwood grafting, forty-five uniform one-year-old Ramphal (*Annona reticulata* L.) seedlings were chosen as rootstock. Defoliated scion wood from the previous season's growth of custard apple cultivar 'Balanagar' and 'Arka Sahan' was utilized for grafting. Fifteen seedlings form a unit for each replication and Forty-five seedlings in each treatment. The experiment comprised of eight treatments *viz.*, T_1- Softwood grafting of 'Balanagar' on 15th January, T_2- Softwood grafting of 'Balanagar' on 30th January, T_3- Softwood grafting of 'Balanagar' on 15th February, T_4- Softwood grafting of 'Balanagar' on 28th February, T_5- Softwood grafting of 'Arka Sahan' on 15th January, T_6- Softwood grafting of 'Arka Sahan' on 30th January, T_7- Softwood grafting of 'Arka Sahan' on 15th February, T_8- Softwood grafting of 'Arka Sahan' on 28th February, 2021 with each treatment replicated thrice.

Periodical observations taken on the number of days till the first sprouting, number of sprouts per graft, length of the sprouted shoot, and scion girth, at 30, 60, and 90 DAG, the graft success at 30 DAG, number of leaves, leaf area and graft survival at 60 and 90 DAG, whereas, at the conclusion of the experiment, the measurement of the longest root was documented. To determine the leaf area (cm^2) of the observed grafts, the length and width of the leaves were multiplied together, taking into account the correction at 60 and 90 days after grafting. For leaf length, ascertain by measuring from the leaf tip to the point where it joins the petiole, while leaf width was measured at its widest point of leaf lamina.

$$\text{Correction factor} = \frac{\text{Actual leaf area}}{\text{Maximum length} \times \text{Maximum width}}$$

$$\text{Leaf area} = \text{Length} \times \text{Width} \times \text{Correction factor}$$

The diameter of the scion (mm) was recorded one inch above the graft union with the help of Vernier Calipers at 30, 60, and 90 days after grafting. Graft success percent (%) was determined by dividing the amount of grafts that sprouted by the sum total number of grafts prepared at 30 days after softwood grafting. the quantity of grafts survived out of the total count of successful grafts was calculated by the formula:

$$\text{Graft survival (\%)} = \frac{\text{Number of grafts survived}}{\text{Total number of successful graft}} \times 100$$

Statistical analysis: Data collected under different categories were analyzed statistically using one-way Fisher's ANOVA within Completely Randomized Design framework. SPSS version 20.0 software was employed to compute the (CD) critical difference at a significance level of 5%.

Results and Discussion

Data presented in Table 1 indicated that a significant difference with regards number of sprouts, length of sprouted shoot, girth of scion, duration of days taken for first sprouting, number of leaves per graft, and leaf area were recorded among different treatments tried**.** The grafting commenced on 30th January with 'Arka Sahan' scion produced the highest count of sprouts per graft (2.93, 3.20, and 3.40). While, the lowest count of sprouts per graft (2.00, 2.13, and 2.20) was obtained in T_1 at 30, 60, and 90 DAG respectively. The higher number of sprouts produced during 30th January and 15th February might be attributed to an adequate supply of healthy and matured scion sticks with possibly higher accumulation of carbohydrates and other biochemical constituents due to the longer defoliation period. Besides this, the favourable weather conditions experienced during the grafting dates could have contributed to the activation of swollen buds. Elevated temperatures and increased relative humidity significantly influenced the success of grafting Bhandari *et al.* (2021) [2]. Such observation was also obtained by Ghojage *et al.* (2011) [5] in Jamun who marked that, softwood grafting conducted in February yielded resulted in the highest (2.33) count of sprouts, surpassing the count for all other months.

The greatest (6.18, 14.96, and 25.37 cm) length of the sprouted shoot was recorded in treatment T_7 demonstrating significant superiority compared to all other treatments. On the other hand, the minimum length of sprouted shoot (1.97, 7.46, and 15.70 cm) was registered in treatment T_1. This could be ascribed to high accumulation of sucrose in phloem which leads to higher meristematic activity. Besides this, the presence of more counts of sprouts, leaves, as well as biggest leaf area might have produced profuse amounts of photosynthates needed for vegetative growth. This outcome closely aligns with the findings of Kudmulwar *et al.* (2008) [11] where they determine that 15th February grafts recorded the highest scion length (2.38 cm) in custard apple. Gadekar *et al.* (2010) [4] noted a comparable finding regarding Jamun. They found that the longest sprouts, measuring 11.17 cm, were recorded for grafts conducted on February 15th in Akola conditions.

The maximum girth of the scion (7.27, 7.61, and 7.97mm) was recorded in treatment T_7 which showed a notable and statistically significant increase compared to the other treatment whereas, the minimum girth of the scion (5.23, 5.60, and 5.88mm) was obtained in treatment T_1 at 30, 60 and 90 DAG. The scion's performance depends upon the stonic compatibility with rootstock and the quality of graft union. Therefore, this increment in the radial growth of the scion might be due to good cambial growth and vascular connectivity. These results align with research performed by Patil *et al.* (2017) [14] which confirmed that the highest scion girths (measuring 11.60, 11.80, and 12.10mm) were achieved when grafting was initiated on the 16th of February. Similarly, in aonla, the maximum scion girth (0.71 cm and 0.69 cm) was noted in cleft grafting than in tongue grafting (0.63 cm and 0.61 cm) Jalal *et al.* (2018) [7].

The mean data with respect to the count of days taken for first sprouting indicated that the softwood grafting of' 'Balanagar' performed on 15th February (T_3) took significantly the fewest count of days (8.13 days) for first sprouting which was on par with T_4 (9.06 days), whereas, the longest duration for the initial sprouting, which amounted to 13.80 days, was observed in T_5. This delay can be attributed to the genetic composition of the scions, which has an impact on both the histological and metabolic events occurring at the graft union.

The rapid physiological growth and heightened meristematic activities within the tissues of treatment T_3 likely contributed to the quicker healing of the graft union. Consequently, this facilitated the sooner scion sprouting in comparison to the grafts in rest of the treatments. These results are in agreement with the findings of Kudmulwar *et al.* (2008) [11] in custard apples, where they observed that the shortest duration for sprouting (15.33 days) was recorded when custard apple plants were grafted in February. Likewise, Joshi *et al.* (2011) [8] documented that the shortest duration for sprouting, which was 42.51 days, occurred when grafting took place in March, following that April (44.89 days) and May (50.83 days). Meanwhile, Kaur *et al.* (2022) reported a minimum sprouting time of 9.80 days for Sapota grafts when the grafting process began in March followed June that takes 9.83 days under the conditions of Punjab in North India.

The highest count of leaves (22.62 and 29.26) was recorded in treatment T_7 which was statistically at par with T_6 (21.08 and 27.63) and T_8 (20.50) at 60 and 90 DAG. In contrast, treatment T_1 exhibited the fewest leaves (11.66) at 60 DAG. However, when observed at 90 DAG, treatment T_2 (15.31) exhibited the highest leaf count. However, T_1 and T_2 both were statistically on par with each other. The establishment of strong graft union and continuity of cambial and vascular tissues resulting in better translocation of water and vital nutrients which in turn increase the metabolic activity thus, leading to the higher number of leave and better vegetative growth. A similar result was found by Patil *et al.* (2017) [14] who reported the grafts prepared on 16th February produced the highest count of leaves (25.47, 30.73, and 38.37) at 60, 120, and 180 days after grafting. Comparably, Singh and Singh (2015) [17] reported that, the highest number of leaves per plant was recorded in March at 120 DAG in Mahua (14.00) and Khirni (12.66).

Considerably the largest (26.54 cm^2 and 30.66 cm^2) leaf area was recorded in treatment T_7 which was found on par with T_8 (25.90 cm^2 and 29.00 cm^2) and T_6 (25.40 cm^2), while, the minimal leaf area was noted in treatment T_1 (14.53 cm^2 and 16.26 cm^2) which was found on par with T_2 (15.35 cm^2 and 18.66 cm^2) at 60 and 90 DAG. The greater area of the leaf may be attributed to the congenital composition of the 'Arka Sahan' which inherently possesses larger-sized leaves. Our results are in analogous with findings of Madala *et al.* (2019) [12] who concluded that the maximum leaf area (20.10) per graft was when grafting was done on 15th March. Pawar *et al.* (2018) [15] observed the highest leaf area (30.27 cm^2) was found in treatment 'Arka Sahan', the lowest leaf area (25.25 cm^2) was found to be in treatment cv. Tp-7 at 120 DAG.

The result concerning the success percentage of graft showed significant variations and were varied from 68.88 to 95.55 per cent. The highest (95.55%) graft success per cent was noticed in treatment T_7 alternatively, treatment T_1 had the lowest graft success rate, with a percentage of 68.88% which was found statistically at par with T_2 (73.33%). The survival percentage over success of grafts as influenced by different treatment recorded at 60 and 90 DAG as shown in the table 1. At 60 DAG, T_7 (93.33%) shown the highest survival percent, this was statistically at par with the treatment T_6 (91.10%) and T_8 (88.88%). The lowest survival percent was recorded in treatment T_1 (64.44%). At 90 DAG T_7 (91.10%) noted the highest survival while, the lowest were found in T_1 (57.77%). Higher graft success in February can be attributed to two main factors: first the presence of accumulated carbohydrates (Karabulut and celik, 2022) [9] and second favourable temperature and humidity conditions during and after the grafting process. These two crucial factors play a vital role in the formation of strong graft unions. Increased humidity prevents scion desiccation and thereby aids in preserving cell turgidity. Therefore, the plant grafted during February- March obtained climatic as well as plant biological benefits naturally that leads to higher graft success percentage. Our results are in line with Kudmulwar *et al.* (2008) [11] who documented the greatest success rate of grafts (88.87%) when grafting was conducted on February 15th. Furthermore, Ashok (2017) [1] recorded the highest graft success rate (74.14%) in custard apple, grafting took place on March 15th followed by March 1st. In Sapota, the highest success percentage (63.33%) was observed in the month of July by softwood grafting Nitish *et al.* (2019) [13].

The data pertaining to the length of the longest root under the influence of various treatments are presented in Table 1 revealing notable variation. The longest length of the root was recorded in treatment T_7 with a root length of 34.74 cm. However, T_7 was found at par with T_6 (32.56 cm) the shortest (20.09 cm) length of the longest root was noted in T_1 which was on par with T_2 (22.08 cm). This could be attributed to increased plant demand for water and nutrients, promoting accelerated vegetative growth. This, in turn, may have led to heightened root activity, ultimately contributing to improved root development in treatment T_7 grafts. Dhutraj *et al.* (2018) in tamarind recorded the maximum tap root length in grafts on 1st March. Similarly in Aonla first week of December had the root's largest measurement of 31.24 cm, while the first week of January showed the root's shortest measurement of 28.46 cm Roshan *et al.* (2013) [16].

Table 1: Effect of Ramphal rootstock on various growth parameters of custard apple cvs. Arka Sahan and Balanagar with different grafting dates

Treatment	Number of sprouts			Length of sprouted shoot (cm)			Girth of scion (mm)			Number of days required for sprouting (days)	Number of leaves		Leaf area (cm^2)		Success (%)	Survivability (%)		Length of longest root (cm)
	30 DAG	60DAG	90DAG	30 DAG	60 DAG	90 DAG	30 DAG	60 DAG	30 DAG		60 DAG	90 DAG	60 DAG	90 DAG	30 DAG	60 DAG	90 DAG	
T_1	2.00	2.13	2.20	1.97	7.46	15.70	5.23	5.60	5.88	11.53	11.66	17.30	14.53	16.26	68.88	64.44	57.77	20.09
T_2	2.18	2.23	2.43	2.77	10.28	17.73	5.65	5.86	6.03	10.13	12.6	15.31	15.35	18.66	73.33	71.10	66.66	22.08
T_3	2.45	2.60	2.74	4.55	11.88	22.6	6.24	6.52	6.74	8.13	19.84	23.56	18.03	21.05	82.22	77.77	73.33	31.81
T_4	2.23	2.41	2.62	3.30	10.66	18.53	5.89	6.24	6.40	9.06	15.03	20.04	17.01	19.63	75.55	73.33	68.88	26.52
T_5	2.20	2.30	2.46	4.36	11.32	22.32	5.59	5.93	6.27	13.80	19.45	24.69	23.33	26.73	88.88	86.66	84.44	23.23
T_6	2.93	2.73	2.83	5.45	13.00	24.23	6.40	6.60	6.89	12.66	21.08	27.63	25.40	28.06	93.33	91.10	88.88	32.56
T_7	2.73	2.83	3.10	6.18	14.96	25.37	7.27	7.61	7.97	10.98	22.62	29.26	26.54	30.66	95.55	93.33	91.10	34.73
T_8	2.36	2.63	2.82	4.96	12.76	23.93	6.20	6.52	6.77	11.87	20.5	25.77	25.90	29	91.11	88.88	86.66	31.56
SEm ±	0.14	0.09	0.12	0.20	0.54	0.99	0.18	0.19	0.15	0.58	0.92	0.98	0.72	0.83	1.92	1.75	2.08	0.92
CD (5%)	0.44	0.27	0.38	0.60	1.64	2.99	0.52	0.55	0.43	1.75	2.77	2.94	2.16	2.49	5.77	5.26	6.23	2.77

CD, Critical difference; SE±, Standard error mean; DAG- Days after grafting. Treatment details are provided under Material and Methods

Conclusion

Considering all the parameters examined, it can be inferred that there was a significant influence of Ramphal rootstock on the performance of the custard apple cvs. 'Balanagar' and 'Arka Sahan'. The softwood grafting was conducted on both 15th February as well as on 30th January using cv. 'Arka Sahan' as scion on ramphal (*Annona reticulata*) rootstock yielded the best outcomes in terms of several key factors, including the number and length of sprouted shoot, number of leaves, leaf area, scion girth, length of longest root along with overall graft success and survivability.

Declaration of interest

The authors declared no competing financial interest.

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