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Standardization of time of pruning and use of PGR for growth, yield, and quality in custard apple (*Annona squamosa* L.) Cv. Balanagar

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Abstract

The present investigation entitled “Standardization of time of pruning and use of PGR for growth, yield, and quality in Custard apple (*Annona squamosa* L.) Cv. Balanagar” was carried out at All India Coordinated Research Project on Arid Zone Fruits, Department of Horticulture, MPKV., Rahuri during March, 2023 to December, 2023 with objective to study the effect of different pruning dates on growth, yield and quality of custard apple and to study the effect of PGR on growth, yield and quality of custard apple. The experiment was laid out in Factorial Randomized Block Design (FRBD) comprised of two factors viz. pruning dates (4 level) i.e., P_1 (15th March), P_2 (15th April), P_3 (15th May), P_4 (15th June) and different concentration of plant growth regulator NAA (3 level) i.e., G_1 (25 ppm), G_2 (50 ppm), G_3 (75 ppm) which makes 12 treatment combinations with separate control treatment i.e. T_{13} and were replicated 2 times. However, as regard growth characters minimum number of days to sprout (15.08 days), number of shoots per tree (168.58), minimum days to flowering (34.91 days), maximum number of flowers per shoots (18.41), maximum fruit retention (47.94 %) was recorded in treatment P3 (15th May). Regarding the days required for last harvesting is minimum (112.33 days) in treatment P_4 (15th June) and days required for last harvesting (113.41 days) were recorded in treatment P_3 (15th May). It is evident from results that, the growth parameters viz., minimum number of days to sprout (15.68 days), number of shoots per tree (167.93), minimum days to flowering (36.12 days), maximum number of flowers per shoots (17.31), maximum fruit retention (45.38 %), the days required for last harvesting is minimum (117.62 days) were noted under the treatment G_3 (NAA 75 ppm). The interaction of 15th May pruning (P_3) and 75 ppm NAA (G_3) was consistently superior across most parameters. This combination significantly reduced days to sprouting (14.25 days) and days to flowering (34.50 days) while maximizing the number of shoots per tree (173.50), flowers per shoot (19.75), and fruit retention (52.45 %). Yield parameters, including the number of fruits per tree (68.25), fruit length (8.99 cm), fruit diameter (9.08 cm), and fruit weight (297.75 g), were also highest under P_3G_3. Furthermore, the shortest duration for last harvesting (111.50 days) was observed in 15th June pruning (P_4) combined with 75 ppm NAA (G_3), indicating its potential to expedite the fruiting cycle.

Keywords: Custard apple, pruning, NAA (Naphthalene acidic acid), flowering, yield and quality

1. Introduction

Custard apple (*Annona squamosa* L.), being a dryland crop, exhibits adaptability to a diverse range of soil and climatic conditions. Notably, it is relatively resilient against serious pest and disease issues, resulting in lower production expenditure. The climatic conditions in Maharashtra are particularly conducive to custard apple cultivation, further enhancing its suitability. Due to these favourable factors, there is considerable potential for expanding the cultivation area, increasing production volumes, and enhancing the overall productivity of custard apple in the region. Maharashtra stands as the leading state in custard apple production within the country, contributing significantly with a production volume of 92,320 tons. The major custard apple growing districts in Maharashtra include Beed, Pune, Buldhana, Nagpur, Dhule, Chhatrapati Sambhaji Nagar, Ahilyanagar, Akola and Solapur. Notably, the custard apples from Beed received a Geographical Indication Tag (GI) in 2016, underscoring the uniqueness and distinctiveness of the produce from this region. Custard apple plants, being deciduous, exhibit a natural response to stress by shedding their leaves, a mechanism that aids in preventing moisture loss through transpiration. This characteristic renders custard apple an ideal fruit crop for rainfed regions (Kumar *et al*., 2018) [16].

The climatic conditions in Maharashtra further enhance the suitability for custard apple cultivation, particularly during the Kharif season, requiring minimal efforts and reduced expenditure.

Custard apple, a delectable dryland fruit, offers numerous health benefits and is characterized by its nutritional richness. The fruits are notably low in saturated fat, cholesterol, and sodium, making them a wholesome choice. Custard apple has significantly diversified the range of available food options by offering a variety of nutrients, making it a rich source of carbohydrates, protein, fiber, and essential minerals like calcium, phosphorus, iron, and vitamin C. Recognized as a substantial energy source with a value of 104 Kcal, the fruit composition per 100 grams of pulp includes carbohydrates (23.5 g), moisture (70.5%), protein (1.6 g), minerals (0.9 g), fiber (3.1 g), calcium (17 mg), phosphorus (47 mg), iron (1.5 mg), and vitamin C (37 mg) (Parekh and Sharma, 1993) [24]. Beyond its role as a dietary component, various parts of the custard apple, including its immature fruits, seeds, leaves, bark, and roots, are utilized for medicinal purposes (Datta, 2017) [6]. This comprehensive nutritional profile and medicinal versatility make custard apple a valuable addition to both diet and traditional healthcare practices. The high dietary fibre content further aids in digestion, as noted by Navaneethakrishnan and Nattar in 2011 [19]. Recognizing its nutritional value, custard apple has become an integral part of promoting good health.

Pruning plays a pivotal role in custard apple cultivation, significantly influencing tree vigour, productivity, and fruit quality. It serves a dual purpose, not only enhancing fruit quality but also establishing a robust framework during the early stages to augment the fruit-bearing area. As the tree ages, neglecting regular annual pruning can result in weakened structures, compromising both fruit size and quality. Therefore, consistent pruning during the bearing stage is crucial, promoting the development of healthy shoots that contribute to optimal fruit-bearing area and the production of high-quality fruits in Guava (Bajpai *et al*., 1973) [1].

2. Materials and Methods

The study was carried out on "Standardization of time of pruning and use of PGR for growth, yield, and quality in Custard apple (*Annona squamosa* L.) Cv. Balanagar" was carried out at All India Coordinated Research Project on Arid Zone Fruits, Department of Horticulture, MPKV., Rahuri during March, 2023 to December 2023. The fifteen-year-old custard apple trees (four plants per treatment) were used for research programme. The experiment was laid out in Factorial Randomized Block Design (FRBD) comprised of two factors *viz*. pruning dates (4 level) i.e., P1 (15th March), P2 (15th April), P3 (15th May), P4 (15th June) and different concentration of plant growth regulator NAA (3 level) i.e., G1 (25 ppm), G2 (50 ppm), G3 (75 ppm) which makes 12 treatment combinations (T_1 to T_{12}) with separate control treatment i.e. T_{13} and were replicated 2 times. Spraying is on the date of 15 July, 2023, 01 August, 2023, 15 August, 2023.Data were subjected to statistical analysis as per the methods suggested by Panse and Sukhatme (1989).

3. Results and Discussions

3.1. Days to sprouting (from pruning)

The data from Table 1 showed that, effect of time of pruning was found to be significant. Significantly minimum number of days to sprouting (15.08 days) was found in treatment P_3 followed by treatment P_1 (16.08 days). This could be because pruning allows the plant to accumulate more carbohydrates, ensuring that sufficient nutrients are available for its metabolic and physiological processes, the timing of pruning aligning more closely with the optimal physiological state of the plant, which may enhance the growth rate. The more sprouting time observed in P_1 and P_4 could be due to suboptimal environmental conditions or physiological states at those pruning times, leading to delayed sprouting. These findings are in accordance with result reported by Suleman *et al*. (2006) [30] in guava, Ghum (2011) [7], Jadhav *et al.* (2020) [10], Jadhav *et al.* (2022) [11] in custard apple, Patil *et al*. (2018) [26] in acid lime. Different levels of plant growth regulators significantly influenced the days to sprout which was minimum number of days to sprout (15.68 days) in treatment G_3 (75 ppm) followed by days to sprout (16.75 days) in treatment G_2 (50 ppm). Interaction effects due to time of pruning and use of plant growth regulator was found significant on days to sprout analysis. Significantly minimum number of days to sprout (14.25 days) was found in treatment P_3 (15th May pruning) and higher concentration of NAA (75 ppm) (G_3) i.e. treatment T_9 (P_3G_3) followed by treatment T_6 (P_2G_3 i.e. 15th April pruning + 75 ppm) (14.75 days), treatment T_5 (P_2G_2 i.e. 15th April pruning + 50 ppm) (16.25 days) during experiment. However, maximum days to sprouting (20.25 days) was recorded in treatment T_{13} (control). The use of NAA spray also influenced the sprouting time, with 75 ppm (G_3) (15.68 days) showing the best results. NAA is known to promote cell division and elongation, which might explain the reduced sprouting time. The differences between G_1, G_2, and G_3 suggest that the concentration of NAA plays a crucial role, with 75 ppm (G_3) likely representing an optimal concentration for promoting faster sprouting. These findings are in accordance with result reported by Lokesha *et al.* (2022) [17], Prajapati *et al.* (2016) [27] in custard apple cv. Local.

3.2. Number of shoots emerged per branch

The data from Table 1 showed that, effect of time of pruning on number of shoots per branch was found to be significant during experiment. Significantly maximum number of shoots per branch (168.58) was found in Treatment P_3 (15th May). This suggests that P_3 is the optimal time for pruning to maximize vegetative growth. Pruning at this time might coincide with a period when the plant is most responsive to such interventions, possibly due to favourable environmental conditions or the physiological state of the plant. The reason is that pruning might lead to peripheral buds, release due to the elimination of terminal buds and therefore elimination of apical dominance. Therefore, the number of branches formed after pruning increases. These results are in line with the experimental findings of Singh *et al*. (2001) [29] and Nikumbhe *et al.* (2017) [20] in guava, Jadhav *et al.* (2020) [10] and Jadhav *et al.* (2022) [11] in custard apple and Kshirsagar *et al*. (2020) [14] in mango. Different levels of plant growth regulators significantly influenced the number of shoots per branch which was maximum number of shoots per branch (167.93) with higher concentration of NAA (75 ppm) during experiment. Interaction effects due to time of pruning and use of plant growth regulator was found significant on number of shoots per tree analysis. Significantly maximum number of shoots per tree (173.50) was found in treatment P_3 (15th May pruning) and higher concentration of NAA (75 ppm) (G_3) i.e.

treatment T_9 (P_3G_3) followed by treatment T_6 (P_2G_3 i.e. 15th April pruning + 75 ppm) (170.75), treatment T_8 (P_3G_2 i.e. 15th May pruning + 50 ppm) (168.50), treatment T_{12} (P_4G_3 i.e. 15th June pruning + 75 ppm) (168.50) during experiment. Interaction effects due to time of pruning and use of plant growth regulator was found significant on number of shoots per tree analysis. However, minimum number of shoots per branch (145.25) was recorded in water spray i.e. in treatment T_{13} (control). The application of NAA also impacts branching, with G_3 (167.93) showing the greatest effect. This result suggests that the concentration of NAA used in G_3 is most effective at promoting branching. NAA likely stimulates shoot initiation and development, leading to a higher number of branches.

3.3. Days to flowering (from pruning)

The data from Table 1 showed that, effect of time of pruning was found to be significant. Significantly minimum number of days to flowering (34.91 days) was recorded in treatment P3 followed by treatment P_2 (35.58 days). The 15th May pruning (P_3) resulted in the highest flower production per shoot. This may be due to the optimal balance between vegetative growth and flowering, as 15th May pruning might stimulate the plant to allocate more resources toward reproductive growth. In contrast, 15th March pruning (P_1) led to the fewest flowers per shoot, possibly because the plant may still be focusing on vegetative growth and recovery after pruning. The results demonstrate that both pruning time and the application of NAA significantly affects the days to flowering in custard apple. Treatment P_3 resulted in the earliest flowering, which might be due to optimal synchronization with the plants physiological state, allowing for a quicker transition from vegetative to reproductive phases. The result of present finding is in agreement with the finding of Jadhav *et al*. (2022) [11] in guava, Mohamed *et al*. (2010) [18] in custard apple. Different levels of plant growth regulators significantly influenced the days to flowering which was minimum number of days to flowering (36.12 days) in treatment G_3 followed by days to flowering (37.18 days) in treatment G_2. Interaction effects due to time of pruning and use of plant growth regulator was found significant on days to flowering. Significantly minimum days to flowering (34.50 days) was found in treatment P_3 (15th May pruning) and higher concentration of NAA (75 ppm) (G_3) i.e. treatment T_9 (P_3G_3) followed by treatment T_8 (P_3G_2 i.e. 15th May pruning + 50 ppm) (34.75 days), treatment T_6 (P_2G_3 i.e. 15th April pruning + 75 ppm) (34.75 Days), treatment T_7 (P_3G_1 i.e. 15th May pruning + 25 ppm) (35.50 days), treatment T_5 (P_2G_2 i.e. 15th April pruning + 50 ppm) (35.75 days), treatment T_4 (P_2G_1 i.e. 15th April pruning + 25 ppm) (36.25 days), treatment T_{12} (P_4G_3 i.e. 15th June pruning + 75 ppm) (36.75 days) during experiment. However, maximum days to sprouting (41.00 days) was recorded in treatment T_{13} (control). The NAA spray at G_3 concentration effectively reduced the days to flowering. NAA is known to influence the timing of flowering by affecting hormonal balance, particularly by modulating the levels of auxin and gibberellins, which are critical in the transition from vegetative to reproductive growth. This might be due to the C:N ratio which helps in balanced management of vegetative and reproductive phases and there by early flowering. The above results were in agreement with those of Prajapati *et al*. (2016) [27] in custard apple and Goswami *et al*. (2013) [8] in pomegranate.

3.4. Number of flowers per shoot

The data from Table 1 showed that, effect of time of pruning was found to be significant. Significantly maximum number of flowers per shoot (18.41) was found in Treatment P_3 followed by P_4 (16.75). The treatment P_3 resulted in the highest flower production per shoot. This may be due to the optimal balance between vegetative growth and flowering, as 15th May pruning (P_1) might stimulate the plant to allocate more resources toward reproductive growth. In contrast, 15th March pruning (P_1) led to the fewest flowers per shoot, possibly because the plant may still be focusing on vegetative growth and recovery after pruning. Severe pruning had a more detrimental effect on flowering compared to mild pruning. The reduction in the number of flowers in severely pruned branches is likely due to the loss of potential fruit-bearing wood. This could explain why mildly pruned branches produced a higher number of flowers. The result of present finding is in agreement with the finding of Jadhao *et al*. (2002) [9] in guava, Mohamed (2010) [18] in custard apple, Dahapute *et al*. (2018) [5] in custard apple, Singh et al. (2001) [29] in guava. Different levels of plant growth regulators significantly influenced the number of flowers per shoot which was maximum per shoot (17.31) in treatment G_3 followed by number of flowers per shoot (16.18) in treatment G_2. Interaction effects due to time of pruning and use of plant growth regulator was found significant on number of flowers per shoots. Significantly maximum number of flowers per shoot (19.75) was found in treatment P_3 (15th May pruning) and higher concentration of NAA (75 ppm) (G_3) i.e. treatment T_9 (P_3G_3) followed by treatment T_8 (P_3G_2 i.e. 15th May pruning + 50 ppm) (18.25), treatment T_6 (P_2G_3 i.e. 15th April pruning + 75 ppm) (18.00), treatment T_{12} (P_4G_3 i.e. 15th June pruning + 75 ppm) (17.75), treatment T_7 (P_3G_1 i.e. 15th May pruning + 25 ppm) (17.25) during experiment. However, minimum number of flowers per shoot (9.50 days) in treatment T_{13} (control). The application of NAA at G_3 concentration resulted in the highest flower production. NAA is known to influence the plants hormonal balance, promoting flowering by enhancing the synthesis of gibberellins and reducing the levels of inhibitory hormones such as abscisic acid. These findings are consistent with other studies on fruit trees, such as those by Hossain *et al*. (2018) in mango and Singh *et al.* (2017) [28] in guava, where plant growth regulators have been shown to significantly increase flower production when applied at optimal concentrations. The increase in number of flowers per shoot, might be due to plants remain physiologically more active to build up sufficient food stock for the developing flowers and fruits production, ultimately resulted into flower set. The above results were in agreement with those of Chaudhari *et al.* (2016) [2], Lokesha *et al.* (2022) [17] in custard apple and Chavan *et al.* (2009) [4] in sapota. Interaction effects due to time of pruning and use of plant growth regulator was found non-significant on number of flowers per shoot.

3.5. Fruit retention (%)

The data from Table 1 showed that, effect of time of pruning was found to be significant. Significantly maximum fruit retention (47.94 %) was found in treatment P_3. The treatment P_3 resulted in the highest fruit retention (%). This suggests that P_3 pruning might enhance the plant ability to support a larger number of fruits, potentially due to better carbohydrate allocation and improved overall plant health during the critical fruit-setting period. In contrast, treatment P_1 led to the lowest fruit retention, likely because the plants had less time to recover and build up resources needed to sustain fruit development. Different levels of plant growth regulators significantly influenced the use of plant growth regulator which was maximum fruit retention (45.38 %) in treatment G_3. Interaction effects due to time of pruning and use of plant growth regulator was found significant on fruit retention percentage. Significantly maximum fruit retention (52.45 %) was found in treatment P_3 (15th May pruning) and higher concentration of NAA (75 ppm) (G_3) i.e. treatment T_9 (P_3G_3) during experiment. However, minimum fruit retention (36.08 %) was recorded in treatment T_{13} (control) during experiment. The G_3 treatment, which had the highest concentration of NAA, resulted in the greatest fruit retention. NAA is known to reduce fruit drop by improving the strength of the fruit attachment to the plant, likely through its effects on enhancing cell wall integrity and reducing ethylene production, which is responsible for fruit abscission. The enhancement effect of NAA sprays on fruit retention (%) may be due to auxin, it is well known as inhibitors for abscisic acid and ethylene which cause fruit drop so, application of auxin (NAA), which would be helpful in increasing auxin level and thereby resulted in reduce fruit drop. The NAA being auxin compound might have reduced the cellulose activity and the abscission process which would have resulted in increased fruit retention. The response of NAA in increasing fruit retention confirms the earlier findings of Kulkarni (1993) in custard apple. These results are in confirmation with result obtained by Patel *et al*. (2010) [25], Chaudhary (2013) [3] in custard apple; Osama *et al*. (2015) [22] and Nkansah *et al*. (2012) [21] in mango. Pal and Ghosh (2019) [23] in pomegranate Kassem *et al*. (2011) [13] in ber.

Table 1: Effect of time of pruning and plant growth regulator on growth parameters of custard apple cv. Balanagar

Treatment details	Days to Sprout	Number of Shoots/branch	Days to Flowering	Number of flowers/shoot	Fruit Retention (%)	Days Required for last Harvesting
A) Pruning Time						
P1 (15th March)	17.33	155.00	39.25	13.25	38.98	133.50
P2 (15th April)	16.08	163.41	35.58	15.91	41.10	122.00
P3 (15th May)	15.08	168.58	34.91	18.41	47.94	113.41
P4 (15th June)	17.50	162.00	38.25	16.75	41.72	112.33
S.Em±	0.37	1.33	0.46	0.59	0.71	1.61
CD at 5%	1.16	4.11	1.42	1.84	2.20	4.97
B) PGR Spray (NAA)						
G1 (25 ppm)	17.06	157.18	37.68	14.75	40.61	123.81
G2 (50 ppm)	16.75	161.62	37.18	16.18	41.31	119.50
G3 (75 ppm)	15.68	167.93	36.12	17.31	45.38	117.62
S.Em±	0.32	1.15	0.40	0.51	0.62	1.39
CD at 5%	1.01	3.56	1.23	1.60	1.91	4.30
C) Interactions (Pruning time × PGR spray NAA)						
T_1 (P1G1)	17.75	151.00	39.75	12.25	37.46	137.00
T_2 (P1G2)	17.75	155.00	39.50	13.75	39.10	130.50
T_3 (P1G3)	16.50	159.00	38.50	13.75	40.39	133.00
T_4 (P2G1)	17.25	156.75	36.25	13.50	39.71	130.50
T_5 (P2G2)	16.25	162.75	35.75	16.25	41.25	122.00
T_6 (P2G3)	14.75	170.75	34.75	18.00	42.33	113.50
T_7 (P3G1)	15.75	163.75	35.50	17.25	46.33	114.25
T_8 (P3G2)	15.25	168.50	34.75	18.25	45.05	113.50
T_9 (P3G3)	14.25	173.50	34.50	19.75	52.45	112.50
T_{10} (P4G1)	17.50	157.25	39.25	16.00	38.93	113.50
T_{11} (P4G2)	17.75	160.25	38.75	16.50	39.84	112.00
T_{12} (P4G3)	17.25	168.50	36.75	17.75	46.38	111.50
T_{13} (control)	20.25	145.25	41.00	9.50	36.08	134.50
S.Em ±	0.65	2.31	0.80	1.03	1.24	2.79
CD at 5%	2.02	7.12	2.48	3.20	3.82	8.60

3.6. Days required for last harvesting (from pruning)

The data from Table 1 showed that, effect of time of pruning was found to be significant. Significantly the minimum days required for last harvesting (112.33) was recorded in treatment P_4 while maximum (133.50 days) was found in treatment P_1. The P_4 treatment, which involves the last pruning time, resulted in the earliest last harvesting, suggesting that later pruning may accelerate the overall growth and fruiting cycle. This could be due to the fact that later pruning might better align the vegetative growth phase with the optimal conditions for fruit maturation, leading to a shorter harvesting period. Conversely, the earliest pruning (P_1) led to the longest time to last harvest, likely because the trees require more time to recover from the 15th March pruning and complete the fruiting cycle. Pruning stimulates strong, vigorous, and juvenile growth in the vegetative parts of the plant. This suggests that pruned plants require a longer period to reach physiological maturity. Various pruning intensities on previous seasons shoots have shown significant results. i.e. the minimum number of days were observed in control pruning of previous year shoots, followed by 25 % pruning and 50 % pruning reported by Ghum (2011) [7] in custard apple. The above results were in agreement with those of Jadhav *et al.* (2022) [11], Pal and Ghosh *et al.* (2019) [23] in custard apple. Different levels of plant growth regulators significantly influenced the days required for last harvesting. which was minimum days required for last harvesting (117.62 days) was recorded in G_3. However, maximum days required for last harvesting (123.81 days) with lower concentration of NAA (25 ppm) i.e. G_1 during experiment. Interaction effects due to time of pruning and use of plant growth regulator was found significant on number of flowers per shoots. Significantly minimum number of days required for last harvest (111.50 days) was found in treatment P_4 (15th June pruning) and higher concentration of NAA (75 ppm) (G_3) i.e. treatment T_{12} (P_4G_3) followed by treatment T_{11} (P_4G_2 i.e. 15th June pruning + 50 ppm) (112.00 days), treatment T_9 (P_3G_3 i.e. 15th May pruning + 75 ppm) (112.50 days), treatment T_8 (P_3G_2 i.e. 15th May pruning + 50 ppm) (113.50 days), T_{11} (P_4G_1 i.e. 15th June pruning + 25 ppm) (113.50 days), T_6 (P_2G_3 i.e. 15th April pruning + 75 ppm) (113.50 days), T_7 (P_3G_1 i.e. 15th May pruning + 25 ppm) (114.25 days) during experiment. and maximum days (134.50 days) required for last harvesting in treatment T_{13} (control). The G_3 treatment, which involves the highest concentration of NAA, resulted in the shortest time to last harvesting This could lead to a more synchronized and potentially accelerated fruit development, reducing the overall time needed to complete the harvest. Similar results were reported by Yadava (2012) [31] in gooseberry and Kacha *et al*. (2012) [12] in phalsa.

4. Conclusion
On the basis of present investigation, the findings suggest that adopting a 15th May pruning schedule, combined with higher concentrations of NAA (75 ppm), is the most effective strategy for enhancing the growth, yield, and quality of custard apples. significantly improved growth parameters, such as early sprouting and flowering, the maximum number of shoots and flower, and maximum fruit retention and days for last harvesting.

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