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Enhancing custard apple quality and yield: the influence of pruning severity and nutrient management

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Abstract
An experiment entitled "Enhancing custard apple quality and yield: the influence of pruning severity and nutrient management" was conducted during the year 2019-20 at Shivar Block, Central Research Station, Akola. The primary objectives were to investigate the influence of pruning severity and integrated nutrient management (INM) on the yield and quality of custard apple (cv. Balanagar). The study employed a factorized randomized block design (FRBD) with nine treatment combinations and three replications, encompassing three pruning intensities (20 cm, 15 cm, and control) and three INM applications (I1: 75% RDF + 100g AM + 100g Azotobacter + 100g PSB + 0.50kg neem cake; I2: Half N + Full P&K + 100g AM + 100g Azotobacter + 100g PSB + 0.50kg neem cake with staggered nitrogen application; and control). The results demonstrated that pruning at 20 cm significantly enhanced days to flowering, fruit set percentage, number of fruits per plant, yield, and fruit quality, including average fruit weight, fruit volume, fruit-to-pulp ratio, pulp percentage, and various biochemical parameters such as total soluble solids, acidity, and sugar content. The INM regimen involving staggered nitrogen application (I2) showed superior performance across similar parameters. The combination of 20 cm pruning with the INM regimen (Half N + Full P&K + AM + Azotobacter + PSB + neem cake) applied at specific intervals (June, July, and August) resulted in the highest improvements in yield and fruit quality metrics. This study highlights the importance of strategic pruning and nutrient management in enhancing the productivity and quality of custard apple, providing a practical framework for growers to optimize their cultivation practices.

Keywords: Nutrient management, pruning, custard apple, yield, quality

Introduction

Custard apple (*Annona squamosa* L.), also known as sugar apple, sweetsop, sharifa, or sitaphal, is a highly favored tropical fruit in India, belonging to the family Annonaceae. This family comprises 40 genera, with the genus Annona consisting of approximately 120 species. Custard apple is celebrated for its delightful flavor, mild aroma, and sweet taste, attributes that contribute to its universal acceptance and popularity as a dessert fruit. Its creamy, granular, and sweet-acidic pulp is often consumed fresh or preserved in the form of jams, jellies, ice cream, and other dairy products.

The nutritional profile of custard apple is impressive, making it a valuable addition to diets. It is a rich source of carbohydrates, proteins, fiber, and essential minerals such as calcium, phosphorus, and iron, along with a significant amount of vitamin C. On a per 100g fruit pulp basis, custard apple contains 104 kcal, 23.5g of carbohydrates, 1.6g of protein, 0.9g of minerals, 3.1g of fiber, 17mg of calcium, 47mg of phosphorus, 1.5mg of iron, and 37mg of vitamin C. The fruit is available from August to December, with the peak season in October and November.

Custard apple has its origins in the West Indies and South America. Presently, it is cultivated in various regions worldwide, including Australia, Brazil, Chile, Egypt, India, Israel, the Philippines, Spain, Sri Lanka, and the USA. In India, the primary custard apple-producing states include Maharashtra, which has suitable climatic conditions for its production. The regions of Pune, Ahmadnagar, Aurangabad, Osmanabad, and Solapur are particularly noted for custard apple cultivation.

According to the National Horticulture Board, the area under custard apple cultivation in India was 38,000 hectares with a production of 320,000 metric tons in 2018-19.

Custard apple trees are small, deciduous, and well-adapted to drought conditions and sandy loam soils. They are also tolerant to a range of climatic conditions, making them suitable for cultivation in semi-arid regions with minimal inputs. The tree's robust nature and low maintenance requirements make it an ideal crop for dryland farming. Moreover, custard apple is relatively free from serious pests, diseases, and disorders, further enhancing its viability as a commercial fruit crop.

One critical practice influencing the yield and quality of custard apple is pruning. Pruning helps improve tree architecture, promotes better aeration and light penetration, and facilitates ease of cultural practices. It is essential for removing non-productive parts and directing the plant's energy towards fruit-bearing shoots. Regular pruning, particularly during the early stages of growth, helps establish a strong framework, increases the fruit-bearing area, and enhances fruit quality.

Another vital aspect of custard apple cultivation is nutrient management. The indiscriminate use of inorganic fertilizers and synthetic pesticides can lead to soil degradation and reduced long-term productivity. Integrated nutrient management (INM) is a sustainable approach that combines organic and inorganic fertilizers, ensuring balanced nutrient supply, maintaining soil health, and promoting environmentally friendly practices. INM aims to integrate all sources of plant nutrients to enhance crop growth and productivity efficiently and sustainably.

Despite the increasing commercial importance of custard apple, there is limited research on the optimal pruning intensity and nutrient management practices required to maximize yield and fruit quality. The present study was conducted to address this gap, evaluating the effects of pruning severity and INM on custard apple yield and quality. The findings aim to provide a practical framework for growers to enhance custard apple cultivation practices, ensuring higher productivity and better fruit quality.

Materials and Methods

The experiment was conducted on Twenty-year-old custard apple healthy plants of uniform growth of cultivar Balanagar at Shivar Block, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The plantation raised on light to medium black soil at 4 x 4 m spacing. Soil was medium clay, moderately deep, porous and having good drainage. The experiment was laid out in FRBD with three levels of pruning (20, 15, 0 cm from tip) and three levels of INM (I_1 - 75% RDF (194 g: 94 g: 94 g NPK/plant) +100 g AM +100 g *Azotobacter* + 100g PSB + 0.50 Kg neem cake at onset of monsoon. I_2 - Half N(97g) + Full P and K(94g:94g)+100 g AM +100 g *Azotobacte*r +100 g PSB + 0.50 Kg neem cake - Ist Application, 1/4 N(48g) - IInd Application and 1/4 N(48g) - IIIrd Application, respectively at one month interval and I_1 - Control) and replicated thrice. The pruning was done in the month of April 2021 on main shoot and subsequent secondary and tertiary shoot on whole plant, with different intensities of 15 cm and 20 cm from tip. Doses of nitrogen, potassium and phosphorous were applied in June as per treatment. Biofertilizers were applied by mixing with soil and neem cake as per treatment in first week of July.

Results and Discussion

Yield: Pruning significantly influenced yield, with P2 exhibiting a yield of 17.86 kg/plant, followed by P1 at 19.82 kg/plant, and the lowest yield observed in P3 at 13.70 kg/plant. This increase in yield with pruning could be attributed to enhanced solar radiation on mature shoots, aiding in greater photosynthate accumulation for fruiting. Integrated nutrient management also played a significant role, with I2 recording the highest yield at 19.61 kg/plant, followed by I1 at 17.05 kg/plant, and the control I3 at 14.72 kg/plant. The combined effect of pruning severity and integrated nutrient management showed an interaction effect, with P2I2 resulting in the highest yield of 23.73 kg/plant, followed by P1I2 at 19.26 kg/plant, and the lowest yield in P3I3 at 11.42 kg/plant. These results highlight the importance of both pruning and nutrient management strategies in optimizing yield in plants, supported by previous findings in sapota and guava.

Stony fruit (%)

Treatment P1 demonstrated the lowest stony fruit percentage (1.50%), consistent with research by Singh and Chauhan (1983) [4] on guava, where optimal pruning led to reduced fruit infestation. Similarly, treatment I2 displayed the minimum stony fruit percentage (2.06%), in line with the observations of Kumar and Rattanpal (2010) [6] in pomegranate cultivation, emphasizing the benefits of enhanced nutrient management. The interaction effect revealed that P1I2 resulted in the lowest stony fruit percentage (0.32%), echoing the synergistic outcomes reported by Dubey *et al*. (2001) [13] in custard apple cultivation when pruning and nutrient management were strategically combined. These results underscore the importance of tailored pruning techniques and integrated nutrient strategies in mitigating stony fruit issues in custard apple crops, corroborating established research in related fruit cultivation practices.

Table 1: Effect of integrated nutrient management and pruning on yield and yield parameters of custard apple.

Treatments	Yield (kg /plant)	Stony fruit (%)	Average weight of fruit (g)	Pulp (%)	Fruit to pulp ratio
	Pruning levels				
P_1	17.86	1.50	286.22	51.16 (45.66)	1.92
P_2	19.82	3.63	271.89	48.98 (44.41)	2.02
P_3	13.70	7.49	177.11	44.75 (41.98)	2.13
F-test	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.34	0.38	4.61	0.74	0.02
CD at 5%	1.03	1.15	13.83	2.23	0.05
INM					
I_1	17.05	4.71	258.11	49.03 (44.44)	2.04
I_2	19.61	1.06	279.44	51.13 (45.64)	1.93
I_3	14.72	6.85	197.67	44.73 (41.97)	2.11
F-test	Sig	Sig	Sig	Sig	Sig

SE(m) +	0.34	0.38	4.61	0.74	0.02
CD at 5%	1.03	1.15	13.83	2.23	0.05
Interaction					
P_1 x I_1	18.49	1.93	279.16	51.36(45.77)	1.97
P_1 x I_2	19.26	0.32	320.00	53.30 (46.89)	1.76
P_1 x I_3	15.83	2.27	259.50	48.83(44.32)	2.02
P_2 x I_1	18.82	3.23	281.33	47.43(43.52)	2.03
P_2 x I_2	23.73	0.64	324.33	53.31(46.89)	1.95
P_2 x I_3	16.91	7.03	210.00	46.21(42.82)	2.09
P_3 x I_1	13.84	8.97	213.83	48.31(44.03)	2.10
P_3 x I_2	15.83	2.23	194.00	46.78(43.15)	2.08
P_3 x I_3	11.42	11.27	123.50	39.15(38.73)	2.21
F-test	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.59	0.66	7.99	1.29	0.03
CD at 5%	1.776	1.991	23.960	3.856	0.078

Average weight of fruit (g)

Pruning intensity showed a clear effect, as evidenced by treatment P1 yielding the highest fruit weight at 286.22 g, while the lowest weight was observed in P3 at 177.11 g. This outcome aligns with the findings of Ali *et al*. (2009) [2] in guava, suggesting that increased fruit weight under specific pruning regimens is attributable to improved nutrient availability. Similarly, integrated nutrient management played a crucial role, with treatment I2 resulting in the highest fruit weight of 279.44 g, while the control treatment (I3) showed the lowest weight at 197.67 g. This finding is consistent with Lal and Dayal's (2014) [9] research, highlighting the significance of optimal nutrient supply throughout fruit growth in enhancing photosynthesis and, consequently, fruit weight. Furthermore, the interaction between pruning severity and nutrient management significantly influenced fruit weight, with treatment P2I2 exhibiting the highest weight at 324.33 g, closely followed by P1I2 at 320.00 g, while the lowest weight was recorded in P3I3 at 123.50 g. This interaction effect underscores the synergistic benefits of coordinated pruning and nutrient strategies, as emphasized by Pinalia *et al*. (2010) [11], for maximizing custard apple fruit weight.

Pulp (%)

The highest pulp percentage was observed with the P1 pruning treatment (51.16%), closely followed by P2 (48.98%), with the lowest in P3 (46.13%). For INM, treatment I2 yielded the highest pulp percentage (51.13%), followed by I1 (49.03%), with the control (I3) showing the lowest (46.12%). The interaction between pruning and INM showed that the combination P2I2 resulted in the highest pulp percentage (53.31%), closely matched by P1I2 (53.30%), while the lowest was in P3I3 (39.15%). These results align with Choudhary and Dhakare (2018) [8], who reported that proper pruning improves fruit quality in custard apples, who found that the use of organic manures and biofertilizers, along with inorganic fertilizers, enhances fruit quality in mango. The findings also support Pinalia *et al*. (2010) [11] in guava, emphasizing the combined benefits of pruning and nutrient management.

Fruit to pulp ratio: Pruning treatments showed that P1 had the highest ratio (1.92), followed closely by P2 (2.02), while P3 had the lowest ratio (2.13). Among integrated nutrient management treatments, I2 resulted in the highest ratio (1.93), followed by I1 (2.04), with the control treatment I3 showing the lowest ratio (2.11). The interaction effect analysis revealed that treatment combination P1I2 had the maximum ratio (1.76), indicating a synergistic effect of these practices on improving the fruit to pulp ratio. These findings emphasize the importance of considering both pruning and integrated nutrient management strategies for optimizing fruit quality in custard apple cultivation.

T.S.S. (^{0}B)

The study examined how pruning and integrated nutrient management affect the total soluble solids (T.S.S.) of custard apple fruits. Pruning significantly influenced T.S.S., with treatment P1 resulting in the highest value (24^{0}B), followed by P2 (22.09^{0}B), and the lowest in P3 (17.60^{0}B). This pattern suggests that pruning may lead to increased metabolites and faster shoot growth, supported by similar findings in guava and custard apple (Ali *et al*., 2009; Dahapute *et al*., 2018) [2, 7]. On the other hand, integrated nutrient management also had a significant impact, as treatment I2 exhibited the highest T.S.S. (23.45^{0}B), followed by I1 (20.60^{0}B), and the lowest in I3 (19.65^{0}B). This indicates the importance of proper nutrient supply and growth hormone induction for improving fruit quality, consistent with previous research on ber (Mahendra *et al*., 2009) [5]. Moreover, the interaction effect of pruning and integrated nutrient management was substantial, with treatment combination P1I2 showing the maximum T.S.S. (25.61^{0}B), followed by P2I2 (25.42^{0}B), and the lowest in P3I3 (16.16^{0}B). This underscores the synergistic impact of these practices on enhancing T.S.S., possibly through increased metabolites and improved enzyme functioning, as noted in studies on guava (Sharma *et al*., 2013; Jayswal *et al*., 2017) [10, 9].

Titratable acidity (%)

The effect of pruning and integrated nutrient management on titratable acidity (%T.A.) in custard apple fruits was investigated, drawing insights from previous studies. Pruning intensity, as observed by Bhagawati *et al*. (2015) [1] and Mahadevan and Kumar (2014) [3], significantly influenced % T.A., with unpruned plants (P3) exhibiting the highest acidity at 0.25% and heavily pruned plants (P1) showing the lowest at 0.21%. Similarly, integrated nutrient management, in line with findings by Sen and Chauhan (1983) [4], had a notable impact on % T.A., with the highest acidity observed in treatment I3 (0.25%) and the lowest in I2 (0.21%). However, despite these individual effects, there was no significant interaction effect observed between pruning and nutrient management on % T.A., suggesting that their combined influence did not significantly alter acidity levels.

TSS Acidity ratio

The study revealed significant impacts of pruning and integrated nutrient management on total soluble solids (T.S.S.) and acidity ratio in custard apple fruits, aligning with findings by Bhagawati *et al*. (2015) [1] and Mahadevan and Kumar (2014) [3] in guava. Pruning treatments resulted in varied T.S.S. and acidity ratios, with treatment P1 exhibiting the highest values (105.45), as supported by studies by Kumar and Rattanpal (2010) [6] in guava, followed by P2 (100.07), while the lowest was in P3 (84.90). Among integrated nutrient management treatments, I2 showed the highest T.S.S. and acidity ratio (109.47), as seen in similar findings by Sen and Chauhan (1983) [4] in pomegranate, followed by I1 (95.89), with I3 (control) recording the lowest (85.05). The interaction effect of pruning and integrated nutrient management, in line with studies by Choudhary and Dhakare (2018) [8] in custard apple and Pinalia *et al*. (2010) [11] in guava, further influenced these parameters, with the P1I2 combination showing the maximum T.S.S. and acidity ratio (117.26), followed by P2I2 (115.05), while the minimum was observed in P3I3 (76.30).

Total sugars

Pruning, particularly at severity levels P1 and P2, increased total sugar content, with P1 showing the highest at 22.35%, in line with findings by Ali *et al*. (2009) [2] in guava. Integrated nutrient management, especially treatment I2, led to the highest total sugar content at 23.37%, consistent with Dutta *et al*. (2010) [14] in litchi, attributed to nitrogen's involvement in energy sources like amino acids and sugars, as observed by Shukla *et al*. (2009) [17]. The interaction effect was notable, with treatment combination P1I2 resulting in the maximum total sugar (26.55%), as supported by previous research in guava by Ali *et al*. (2009) [2] and litchi by Dutta *et al*. (2010) [14], showcasing the importance of pruning and nutrient management strategies in enhancing fruit sugar content.

Reducing sugar (%): Pruning exerted a significant influence on reducing sugar content in custard apple, mirroring findings in guava studies by Dubey *et al*. (2001) [13] and Kumar and Rattanpal (2010) [6], where more severe pruning, particularly treatments P1 and P2, led to increased reducing sugar levels. Similarly, integrated nutrient management, as demonstrated by treatment I2, significantly enhanced reducing sugar content, a phenomenon also noted in guava research by Binepal *et al*. (2013) [15] and Shukla *et al*. (2009) [17] with the application of NPK and bio-fertilizers. The combined effect of pruning severity and integrated nutrient management, evidenced by combinations like P1I2 and P2I2, synergistically elevated reducing sugar content, aligning with observations in lemon studies by Ghosh *et al*. (2016) [16] and emphasizing the importance of tailored management practices for optimizing fruit quality.

Non reducing sugar (%)

Pruning severity and integrated nutrient management had a substantial impact on non-reducing sugar content in custard apple fruits, corroborating findings from previous studies. Singh and Chauhan (1983) [4] reported increasing sugar levels with higher pruning severity, consistent with the observed trend where treatment P1 (1.85%) and treatment I2 (1.85%) showed the highest non-reducing sugar content. Dubey *et al*. (2001) [13] and Shukla *et al*. (2009) [17] similarly found that integrated nutrient management, particularly treatments rich in NPK and bio-fertilizers, enhanced sugar content in guava fruits. These results collectively emphasize the importance of tailored pruning and nutrient management strategies in improving fruit quality metrics like sugar content in custard apple and related fruits.

Table 2: Effect of integrated nutrient management and pruning on fruit quality of custard apple

Treatments	T.S.S. (^{0}B)	Titratable acidity (%)	T.S.S and acidity ratio	Total Sugars (%)	Reducing sugar (%)	Non- Reducing sugar (%)
	Pruning levels					
P_1	24.00	0.21	105.45	22.35	20.51	1.85
P_2	22.09	0.23	100.07	21.32	19.57	1.74
P_3	17.60	0.25	84.90	17.97	16.37	1.51
F-test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.61	0.01	0.91	0.41	0.42	0.04
CD at 5%	1.83	0.02	2.73	1.22	1.26	0.11
INM						
I_1	20.60	0.22	95.89	20.23	18.53	1.69
I_2	23.45	0.21	109.47	23.37	21.53	1.85
I_3	19.65	0.25	85.05	18.04	16.49	1.55
F-test	Sig	Sig	Sig	Sig	Sig	Sig
SE(m) +	0.61	0.01	0.91	0.41	0.42	0.04
CD at 5%	1.83	0.02	2.73	1.22	1.26	0.11
Interaction						
P_1 x I_1	21.94	0.21	105.72	21.29	19.53	1.76
P_1 x I_2	25.61	0.20	117.26	26.55	24.55	2.00
P_1 x I_3	24.46	0.22	93.38	19.22	17.45	1.77
P_2 x I_1	22.54	0.23	99.68	21.01	19.20	1.81
P_2 x I_2	25.42	0.19	115.05	24.77	22.87	1.91
P_2 x I_3	18.32	0.26	85.46	18.16	16.65	1.51
P_3 x I_1	17.32	0.24	82.28	18.38	16.88	1.50
P_3 x I_2	19.32	0.24	96.11	18.79	17.16	1.63
P_3 x I_3	16.16	0.27	76.30	16.75	15.37	1.38
F-test	Sig	NS	Sig	Sig	Sig	NS
SE(m) +	1.06	0.01	1.58	0.71	0.73	0.06
CD at 5%	3.167	-	4.736	2.121	2.174	-

Conclusion
The study concludes that strategic pruning and integrated nutrient management significantly improve custard apple yield, fruit quality, and sugar content. Optimal combinations of pruning severity and nutrient supply show synergistic effects, enhancing overall productivity and market appeal. These findings align with previous research and highlight the importance of tailored orchard management for maximizing fruit quality and nutritional value in custard apple cultivation.

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