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Effect of severity of pruning and fruit load on fruit yield and quality of custard apple

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Abstract

Custard apple (*Annona squamosa* L.) has gained considerable popularity as a table fruit and as a fruit pulp used in high-value products such as ice cream, kulfi, milkshakes, and other preparations. The flowering and fruit development stages generally occur during the rainy season, with fruits becoming ready for harvest during October-November. During the later stages of the season, the plants tend to enter dormancy, making custard apple particularly suitable for dryland cultivation due to its high yield potential, hardy nature, and suitability for crop diversification and livelihood security.

Larger fruits have greater market demand, and both pruning intensity and fruit load significantly influence fruit size and quality. Therefore, the present investigation, entitled "Effect of Severity of Pruning and Fruit Load on Fruit Yield and Quality of Custard Apple," was conducted during 2019, 2020, and 2021 at a farmer's field in Dhanaj (Bu), Tq. Karanja, District Washim, Maharashtra. The study aimed to determine the appropriate pruning intensity and fruit retention level for obtaining higher-quality and higher-yielding custard apple fruits.

The experiment consisted of four levels of pruning severity as the main treatment: P1-no pruning (control); P2-light pruning, involving branches 3-5 mm thick (refill thickness); P3-medium pruning, involving branches 6-10 mm thick (pencil thickness); and P4-hard pruning, involving branches 11-15 mm thick (thumb thickness). Fruit retention was used as the sub-treatment with five levels: T1-no fruit thinning (control); T2 retention of up to 100 fruits per plant; T3-retention of up to 80 fruits per plant; T4-retention of up to 60 fruits per plant; and T5-retention of up to 40 fruits per plant.

Based on the findings, the highest fruit yield per plant and per hectare was obtained with medium pruning combined with no fruit thinning. However, the maximum yield of A and B-grade fruits per plant and per hectare was recorded under medium pruning with fruit retention limited to 40 fruits per plant, followed by retention of 60 fruits per plant. Regarding fruit quality characteristics, the highest fruit weight, fruit length, and fruit breadth were observed when fruit retention was limited to 40 fruits per plant, followed by 60 fruits per plant. Similarly, the highest Total Soluble Solids (TSS) content was recorded with medium pruning and retention of 40 fruits per plant, followed by retention of 60 fruits per plant.

Keywords: Custard apple, pruning severity, fruit load, fruit retention, fruit yield, fruit quality, fruit size, TSS

Introduction

Custard apple (*Annona squamosa* L.), a member of the Annonaceae family, has emerged as one of the most promising fruit crops for semi-arid and dryland agriculture. Renowned for its delicate flavor, pleasant aroma, and sweet pulp, the fruit has gained immense popularity as a fresh table fruit and a high-value ingredient in processed products like ice creams, kulfis, milkshakes, and beverages. The crop's phenological cycle aligns exceptionally well with rainfed farming systems: flowering and fruit development coincide with the rainy season, culminating in harvest during October and November. Following harvest, trees enter winter dormancy, enabling them to escape severe drought periods. This hardy nature, coupled with minimal water requirements, low pest susceptibility, and high yield potential, positions custard apple as an ideal candidate for crop diversification, land rehabilitation, and livelihood security in dryland regions.

Despite its commercial potential, a major constraint facing custard apple growers is fruit size variation and a low proportion of marketable grades. Modern horticultural production increasingly prioritizes consumer-driven commercial quality, where market preferences strongly favor larger,

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premium-grade fruits ("A" and "B" grades) that command significantly higher prices. Achieving superior fruit size, optimal Total Soluble Solids (TSS), and commercial yield requires a fine balance between vegetative vigor and reproductive sink load—a balance heavily dictated by canopy management techniques such as pruning and crop load regulation (Janbandhu *et al.*, 2024)^[14]. Pruning plays a critical role in regulating shoot vigor, improving sunlight interception within the canopy, stimulating new flowering shoots, and eliminating unproductive wood. However, the severity of pruning directly influences the tree's physiological reserve capacity and fruiting site availability. Simultaneously, unmanaged fruit set leads to overbearing, causing intense competition for photosynthates among developing sinks. This results in smaller individual fruits, lower TSS, and reduced market acceptability. Regulating fruit load through manual fruit thinning (retention) ensures that sufficient assimilate reserves are partitioned toward individual fruits, thereby enhancing fruit mass, physical dimensions, and biochemical attributes.

While the general benefits of canopy manipulation are recognized, standardized recommendations regarding the ideal interaction of pruning intensity and fruit load retention for maximizing high-grade, commercially viable yields in custard apple remain limited. Therefore, the present investigation was undertaken to evaluate the impact of varying pruning severities and fruit retention levels to identify the optimal management combination for higher quality yield and better fruit traits in custard apple.

Materials and Methods

The present investigation was conducted using a Split Plot Design comprising four levels of pruning severity and five levels of fruit retention, with three replications. Ten-year-old custard apple plants were selected for the study, and five plants were maintained under each treatment. Pruning operations were carried out during the last week of May. Four pruning treatments were imposed: P1—no pruning (control); P2—light pruning, with branches measuring 3–5 mm in thickness (refill thickness); P3—medium pruning, with branches measuring 6–10 mm in thickness (pencil thickness); and P4—hard pruning, with branches measuring 11–15 mm in thickness (thumb thickness). Fruit retention was considered as the sub-

treatment and consisted of five levels: T1—no fruit thinning (control); T2—retention of up to 100 fruits per plant; T3—retention of up to 80 fruits per plant; T4—retention of up to 60 fruits per plant; and T5—retention of up to 40 fruits per plant. All recommended cultural and crop management practices for custard apple were followed at the appropriate time throughout the experimental period.

Results

1. Effect of pruning severity and fruit retention on days to harvesting and number of fruits per plant

The observations on the influence of pruning severity and fruit retention on days to harvesting and the number of fruits per plant are presented in Table 1. The pooled analysis of data collected over three years showed significant differences among pruning treatments with respect to days required for harvesting. The minimum period to harvesting, 107.32 days, was recorded in unpruned plants, followed by lightly pruned plants, which required 108.80 days. In contrast, hard-pruned plants took the longest time to reach harvest maturity, requiring 111.20 days.

Among the fruit-retention treatments, plants retaining up to 40 fruits per plant required the shortest period to harvesting, with 107.28 days, followed by plants retaining up to 60 fruits per plant, which required 108.34 days. The longest period to harvesting, 111.50 days, was observed in plants without fruit thinning. The interaction between pruning severity and fruit retention was non-significant for days to harvesting.

The earlier maturity observed under different fruit-thinning treatments may be attributed to the faster accumulation and translocation of minerals and metabolites, which promoted earlier fruit development compared with control plants. These results are consistent with the findings of Chander and Khajuria (1983)^[7] and Kaur Balwinderjit (1997)^[16] in peach. Similarly, Jens *et al.* (2005)^[15] in apple and Abeer and Mohsen (2010)^[1] in peach reported that fruits from trees with a lower crop load reached maturity earlier than those from trees carrying a higher crop load. The pooled data concerning the number of fruits per plant are also presented in Table 1. The number of fruits retained per plant corresponded to the respective fruit-retention treatments.

Table 1: Effect of severity of pruning and fruit retention on days to harvesting and number of fruits plant⁻¹

Treatments	Days to harvesting (Day)				Number of fruits plant ⁻¹			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A - Pruning (P)								
P ₁ - Control	107.17	108.00	106.79	107.32	78.07	77.40	79.67	78.38
P ₂ - Light pruning	108.51	109.40	108.50	108.80	78.47	78.20	80.09	78.92
P ₃ - Medium pruning	108.54	109.65	110.17	109.45	79.47	79.07	80.68	79.74
P ₄ - Hard pruning	110.72	111.38	111.86	111.32	77.47	77.53	78.97	77.99
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.43	0.71	0.56	0.57	0.22	0.25	0.16	0.21
CD at 5%	1.23	2.15	1.69	1.69	0.64	0.72	0.45	0.60
B. Fruit retention (T)								
T ₁ -No thinning	111.95	112.85	109.70	111.50	111.83	110.25	119.25	111.78
T ₂ - Fruit retention up to 100	110.42	111.44	109.25	110.37	100.00	100.00	100.00	100.00
T ₃ - Fruit retention up to 80	109.79	110.82	108.60	109.74	80.00	80.00	80.00	80.00
T ₄ - Fruit retention up to 60	108.27	109.24	107.50	108.34	60.00	60.00	60.00	60.00
T ₅ - Fruit retention up to 40	107.23	108.25	106.35	107.28	40.00	40.00	40.00	40.00
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.36	0.35	0.36	0.36	0.29	0.31	0.16	0.25
CD at 5%	1.03	1.00	1.10	1.04	0.84	0.90	0.46	0.73
C. (PxT)	-	-	-	-	-	-	-	-
F test	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	0.71	0.70	0.71	0.71	0.58	0.61	0.32	0.50
CD at 5%	-	-	-	-	-	-	-	-

2. Effect of severity of pruning and fruit retention on fruit yield plant⁻¹ and fruit yield hectare⁻¹

The yield and yield-related characteristics, including fruit yield per plant, fruit yield per hectare, and Grade-A fruit yield, are presented in Table 2. The pooled analysis of three years of data showed that the highest fruit yield per plant (25.30 kg) was obtained under medium pruning, followed by light pruning (22.00 kg). The lowest yield per plant (19.75 kg) was recorded in unpruned plants.

With respect to fruit retention, the highest fruit yield per plant (24.54 kg) was recorded in the no-thinning treatment. This treatment was statistically at par with retention of up to 100 fruits per plant (23.03 kg) and was followed by retention of up to 80 fruits per plant (21.54 kg). The lowest fruit yield per plant (18.12 kg) was observed when fruit retention was limited to 40 fruits per plant. The interaction between pruning severity and fruit retention was found to be non-significant for fruit yield per plant.

The pooled data further indicated that medium pruning resulted in the highest fruit yield per hectare (28.11 t ha⁻¹), followed by light pruning (25.55 t ha⁻¹). The lowest fruit yield per hectare (21.94 t ha⁻¹) was recorded in unpruned plants. Regarding fruit retention, the maximum fruit yield per hectare (27.36 t ha⁻¹) was obtained under the no-thinning treatment, which was statistically at par with retention of up to 100 fruits per plant (25.94 t ha⁻¹). This was followed by retention of up to 80 fruits per plant (23.93 t ha⁻¹), whereas the lowest yield (20.13 t ha⁻¹) was recorded with

retention of up to 40 fruits per plant. The interaction between pruning severity and fruit retention was non-significant for fruit yield per hectare.

For the pooled data, the highest fruit yield per plant (25.44 kg) was again observed under medium pruning, followed by light pruning (24.16 kg), while the lowest yield (19.00 kg) was recorded in unpruned plants.

The increase in yield under pruning treatments may be attributed to the influence of pruning on the distribution and utilization of the tree's assimilates. Pruning encourages the plant to allocate greater resources toward carbohydrate production rather than excessive vegetative growth. It can also improve the availability and utilization of water, carbon dioxide, and sunlight, thereby enhancing photosynthesis and carbohydrate accumulation and ultimately promoting fruit production. Similar results were reported by Shaikh and Rao (2002)^[20] in pomegranate, Ghum (2011)^[11] in custard apple, and Sharma (2014)^[21] in apple.

The comparatively higher yield obtained with moderate or light pruning may be associated with improved metabolic activity and better utilization of plant resources. Kumar and Rattanpal (2010)^[17] also reported improved yield under suitable pruning intensity in guava. Likewise, Ingle *et al.* (2005)^[12] observed that medium pruning, involving the removal of terminal shoots up to 45 cm, resulted in a significantly higher yield of 902 fruits per tree per year along with superior fruit quality in acid lime.

Table 2: Effect of severity of pruning and fruit retention on fruit yield plant⁻¹ and fruit yield hectare⁻¹

Treatments	Fruit yield plant ⁻¹ (kg)				Fruit yield ha ⁻¹ (t/ha ⁻¹)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A- Pruning (P)								
P ₁ - Control	17.44	20.57	21.24	19.75	19.37	22.85	23.60	21.94
P ₂ - Light pruning	20.5	24.84	23.65	23.00	22.77	27.59	26.28	25.55
P ₃ - Medium pruning	23.01	27.93	24.96	25.30	25.56	31.03	27.73	28.11
P ₄ - Hard pruning	19.03	23.57	22.46	20.35	20.03	22.85	24.95	22.61
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.45	0.50	0.40	0.45	0.80	0.78	0.50	0.69
CD at 5%	1.35	1.49	1.19	1.34	2.39	2.34	1.50	2.08
B. Fruit retention (T)								
T ₁ -No thinning	23.25	25.8	24.56	24.54	25.83	28.96	27.29	27.36
T ₂ - Fruit retention up to 100	22.40	24.18	22.5	23.03	24.88	27.93	25.00	25.94
T ₃ - Fruit retention up to 80	19.69	23.88	21.05	21.54	21.87	26.53	23.39	23.93
T ₄ - Fruit retention up to 60	16.74	21.09	20.23	19.35	18.59	23.43	22.48	21.50
T ₅ - Fruit retention up to 40	15.53	17.03	19.66	18.12	17.44	21.12	21.84	20.13
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.59	0.55	0.54	0.56	0.35	0.34	0.20	0.30
CD at 5%	1.80	1.65	1.65	1.70	1.04	1.01	1.30	1.12
C. (PxT)								
F test	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	1.19	1.11	1.10	1.33	0.69	0.67	0.39	0.58
CD at 5%	-	-	-	-	-	-	-	-

3. Effect of severity of pruning and fruit retention on fruit weight, fruit length and fruit breadth.

The data on the effect of pruning severity and fruit retention on fruit weight, fruit length, and fruit breadth are presented in Table 3. The pooled analysis of three years showed that the maximum fruit weight (314.94 g) was recorded under medium pruning, followed by light pruning (294.15 g). The minimum fruit weight (239.18 g) was observed in unpruned plants. With respect to fruit retention, the highest fruit weight (375.06 g) was obtained when the crop was restricted to 40 fruits per plant, followed by retention of 60 fruits per plant (338.83 g). In contrast, the lowest fruit weight (160.25 g) was recorded under the no-thinning treatment. The higher fruit weight under medium pruning may be attributed

to the favorable influence of pruning on fruit development. Fruits produced on medium-pruned plants attained greater average weight than those produced under light pruning. The present results are in agreement with the findings of Bagchi *et al.* (2008)^[3] in guava, Shaban (2009)^[19] in mango, Mohamed *et al.* (2010)^[18], Choudhary and Dhakare (2018)^[8] in custard apple, and Ghosh and Bera (2014)^[10] in sweet orange.

The increase in fruit weight may also be associated with improved water absorption and enhanced mobilization of mineral nutrients toward the developing fruits following pruning. Similar observations were reported by Bruno and Evelyn (2001)^[6] in cherimoya, Adhikari and Kandel (2015)^[2] in guava, and Singh and Bal (2008)^[22] in ber.

For fruit length, the pooled data indicated that medium pruning produced the longest fruits (10.89 cm), followed by light pruning (9.78 cm), whereas the shortest fruits (7.72 cm) were recorded in unpruned plants. Regarding fruit retention, the maximum fruit length (11.91 cm) was obtained with retention of 40 fruits per plant, followed by retention of 60 fruits per plant (10.47 cm). The minimum fruit length (8.04 cm) was recorded in plants where no fruit thinning was practiced.

Similarly, the three-year pooled data showed that medium pruning resulted in the greatest fruit breadth (10.51 cm), followed by light pruning (9.80 cm), while unpruned plants produced fruits with the lowest breadth (7.67 cm). Among the fruit-retention treatments, the maximum fruit breadth (11.70 cm) was recorded with retention of 40 fruits per plant, followed by 60 fruits per plant

(10.54 cm). The minimum fruit breadth (8.13 cm) was observed under the no-thinning treatment.

The greater fruit size under lower fruit-retention levels may be explained by the reduced competition among developing fruits for nutrients, water, and assimilates. When the number of fruits is reduced during or shortly after flowering, a greater proportion of available resources becomes available to the remaining fruits. This reduced competition promotes cell division and expansion, ultimately resulting in larger individual fruits. These findings are consistent with the observations of Choudhary and Dhakare (2018) [8] and Mohamed *et al.* (2010) [18] in custard apple, Bhagawati Rupankar *et al.* (2015) [4] and Jadhav *et al.* (2002) [13] in guava, and Bhanu Pratap *et al.* (2009) [5] in mango.

Table 3: Effect of severity of pruning and fruit retention on fruit weight, fruit length and fruit breadth

Treatments	Fruit weight (g)				Fruit length (cm)				Fruit breadth (cm)			
	2019	2020	2021	Pooled	2019	2020	2021	Pooled	2019	2020	2021	Pooled
A- Pruning (P)												
P ₁ - Control	237.76	238.90	240.89	239.18	6.05	7.57	9.20	7.42	6.10	7.10	9.80	7.67
P ₂ - Light pruning	292.64	293.91	295.89	294.15	9.15	9.95	10.23	9.78	8.70	9.71	10.99	9.80
P ₃ - Medium pruning	313.35	314.58	316.90	314.94	10.04	10.97	11.65	10.89	9.49	10.36	11.67	10.51
P ₄ - Hard pruning	270.30	271.53	273.65	271.83	7.56	8.95	9.50	8.67	7.52	8.23	10.10	8.62
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	3.46	2.82	3.96	3.41	0.23	0.22	0.28	0.24	0.25	0.28	0.21	0.25
CD at 5%	10.02	8.12	11.89	10.01	0.70	0.65	0.83	0.73	0.75	0.54	0.65	0.65
B. Fruit retention (T)												
T ₁ -No thinning	157.23	160.96	162.56	160.25	6.50	7.71	9.90	8.04	6.57	7.51	10.30	8.13
T ₂ - Fruit retention upto 100	247.35	248.58	250.67	248.87	6.90	8.95	10.43	8.76	7.65	9.52	10.90	9.36
T ₃ - Fruit retention upto 80	287.29	288.52	290.23	288.68	8.96	9.98	10.95	9.96	8.68	10.57	11.32	10.19
T ₄ - Fruit retention upto 60	337.40	338.63	340.45	338.83	9.56	10.66	11.20	10.47	9.85	10.18	11.60	10.54
T ₅ - Fruit retention upto 40	373.53	374.76	376.89	375.06	11.05	12.13	12.56	11.91	10.67	11.99	12.45	11.70
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	5.56	6.12	6.29	5.99	0.33	0.30	0.30	0.31	0.28	0.27	0.24	0.26
CD at 5%	16.00	17.62	18.89	17.50	1.0	0.89	0.91	0.93	0.84	0.81	0.73	0.79
C. (PxT)												
F test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	11.11	12.34	12.57	12.00	0.89	0.59	0.60	0.69	0.55	0.55	0.59	0.56
CD at 5%	-	-	-	-	-	-	-	-	-	-	-	-

4. Effect of severity of pruning and fruit retention on Total Soluble Solids

The data pertaining to Total Soluble Solids (TSS) are presented in Table 4. The pooled analysis showed that the highest TSS content (23.16 °Brix) was recorded in fruits from plants subjected to medium pruning, followed by light pruning (20.20 °Brix). The lowest TSS value (20.49 °Brix) was observed in fruits from

unpruned plants.

With respect to fruit retention, the highest TSS content (23.52 °Brix) was recorded when fruit retention was limited to 40 fruits per plant, followed by retention of 60 fruits per plant (22.45 °Brix). In contrast, the lowest TSS content (19.24 °Brix) was observed in fruits from plants where no fruit thinning was practiced.

Table 4: Effect of severity of pruning and fruit retention on total soluble solid

Treatments	TSS (°B)			
	2019-20	2020-21	2021-22	Pooled mean
A. Pruning (P)				
P ₁ - Control	19.01	20.75	21.70	20.49
P ₂ - Light pruning	21.20	22.10	23.30	22.20
P ₃ - Medium pruning	22.14	23.10	24.23	23.16
P ₄ - Hard pruning	20.37	21.03	22.30	21.23
F test	Sig	Sig	Sig	Sig
SE (m) ±	0.26	0.30	0.28	0.28
CD at 5%	0.80	0.90	0.85	0.85
B. Fruit retention (T)				
T ₁ -No thinning	19.21	18.07	20.45	19.24
T ₂ - Fruit retention upto 100	20.13	19.21	21.35	20.23
T ₃ - Fruit retention upto 80	21.43	20.31	22.40	21.38
T ₄ - Fruit retention upto 60	22.70	21.47	23.17	22.45
T ₅ - Fruit retention upto 40	23.89	22.57	24.10	23.52

F test	Sig	Sig	Sig	Sig
SE (m) ±	0.28	0.25	0.27	0.27
CD at 5%	0.85	0.75	0.80	0.80
C. (PxT)				
F test	NS	NS	NS	NS
SE (m) ±	0.55	0.50	0.55	0.53
CD at 5%	-	-	-	-

Conclusion

The study revealed that both pruning intensity and fruit load (retention) significantly influenced the yield and quality of custard apple. Medium pruning (P_3) achieved the highest gross fruit yield per plant ($25.30 \text{ kg plant}^{-1}$) and per hectare (28.11 t ha^{-1}). Similarly, no thinning (T_1) produced strong yields, with $24.54 \text{ kg plant}^{-1}$ and 27.36 t ha^{-1} . On the other hand, fruit retention treatments improved fruit quality. Retaining 40 fruits per plant (T_3) resulted in the best outcomes, with maximum fruit weight (375.06 g), fruit length (11.91 cm), fruit breadth (11.70 cm), and Total Soluble Solids (23.52°Brix). Retaining 60 fruits per plant (T_4) closely followed, producing 338.83 g fruit weight, 10.47 cm length, 10.54 cm breadth, and 22.45°Brix TSS. Among pruning severities, medium pruning (P_3) consistently enhanced fruit traits, yielding 314.94 g average fruit weight, 10.89 cm length, 10.51 cm breadth, and 23.16°Brix TSS. Therefore, medium pruning with no thinning is recommended for maximizing yield, while retaining 40 fruits per plant ensures superior fruit quality; these treatments can be adopted as practical guidelines for custard apple orchard management.

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