The Pharma Innovation Journal 2023; 12(12): 2902-2906

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(12): 2902-2906

www.thepharmajournal.com
Received: 29-09-2023
Accepted: 27-10-2023

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Rejuvenation of old and senile custard apple (*Annona squamosa* L.) Orchard Cv. Balanagar

Suryawanshi SV, Deore SB, Wale SR, Wagh RB and Deshmukh AA

Abstract
The present investigation entitled "Rejuvenation of old and senile Custard apple (*Annona squamosa* L.) orchard cv. Balanagar" was carried out at AICRP on Arid Zone Fruits, Department of Horticulture, MPKV., Rahuri during May, 2022 to November, 2023 with an objective to standardize the rejuvenation technology to restore plant growth of old, senile custard apple orchard cv. Balanagar and to study the effect of rejuvenation on fruit yield of custard apple cv. Balanagar. The field trial was laid out in randomized block design with six treatments replicated four times. The results pertaining to growth parameters revealed that, treatment T_6 [Control] indicated least values for days to sprout (7.41 days), days to flowering (80 days), days to 1st crop (195.05 days) and maximum values for number of shoots at 15, 30, 45, 60, 75, 90, 105 and 120 days after rejuvenation (90.44, 103.85, 126.12, 144.90, 148.37, 150.74, 154.34 and 155.16, respectively). The treatment T_5 Recommended practice: University recommendation pruning at 75 days after harvesting with 25% pruning intensity reported the maximum value for leaf area (39.63 cm^2). However, none of the treatments registered mortality after reiterative pruning.
Maximum number of fruits per tree was observed in treatments T_6 [Control] during first year, second year and in pooled mean. The corresponding values were 63.07, 60.83 and 61.95 respectively. The treatments T_6 [Control] was followed by the treatment T_5: Recommended practice: University recommendation pruning at 75 days after harvesting with 25% pruning intensity (52.66) during the first year. Whereas, it was at par with the same treatment during second year of study (57.40) and in the pooled mean (55.03) in terms of number of fruits. The treatment T_5 : Recommended practice: University recommendation pruning at 75 days after harvesting with 25% pruning intensity has recorded maximum values for fruit length (7.94, 7.82 and 7.88 cm), fruit diameter (8.25,8.20 and 8.23 cm), fruit weight (289.23, 281.47 and 285.35 g) and yield (15.23, 16.15 and 15.69 kg/tree) during first year, second year and in pooled mean, respectively. During first year of trial no flowering and fruiting was observed in treatment T_1 [Retention of only main trunk at 45 to 60 cm height] Whereas, treatment T_2 [Retention of main trunk along with basal portion of the primary branches at 10 to 15 cm length reported the meagre flowering but no fruit setting.

Keywords: Custard apple**,** rejuvenation, pruning

Introduction
Custard apple (*Annona squamosa* L.) is tropical fruit crop, belongs to the family Annonaceae. Out of the several species of Annona, five are available in India and these are custard apple (*Annona squamosa*), cherimoya (*Annona cherimola*), soursop (*Annona muricata*), ramphal (*Annona reticulata*) and atemoya (*Annona atemoya*). These fruits thrive well in tropical and warmer sub-tropical regions of India. Among these, custard apple gained the most important position. It is known by different names, such as Sitaphal, Sugar apple or Sharifa in India. The custard apple is indigenous to tropical America but grown throughout southern Asia, including Malaysia, Guam, Philipines, and India. India has major share in custard apple production in the world. Assam, Bihar, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Uttar Pradesh, Andhra Pradesh and Tamil Nadu are major custard apple growing states in the country. Total area and production of custard apple in the country is 45,000 ha and 4,49,000 MT, respectively (NHB, 2021) [17]. India is leading in custard apple export with 50,714 shipments followed by Vietnam and South Korea with 1,682 and 98 shipments, respectively. (https://www.volza.com/p/custard-apple/export/)
Maharashtra is leading state in the country in custard apple production with production of 92,320 tons. Beed, Pune, Buldhana, Nagpur, Dhule, Aurangabad, Akola and Solapur are the major growing districts. In 2016, Beed custard apple received a Geographical Indication.

Tag (GI). The climatic conditions of Maharashtra are most favorable for custard apple production in *Kharif* season with minimum efforts and less expenditure. Being deciduous in nature, the plant sheds its leaves under stress period to prevent moisture losses through transpiration. Hence it is most suitable fruit crop for rainfed region (Kumar *et al*., 2018) [13].

Custard apple is delicious dryland fruit with many health and nutritional benefits. It is considered as good source of energy with the value of 140 K cal. (Bal and Singh, 2008) [3]. It is also rich source of dietary fiber which helps in indigestion (Navaneetrhakrishnan and Nattar, 2011) [16]. Recently, farmers have begun to preserve pulp in order to manufacture custard apple powder, beverages, and ice cream, as well as raw pulp consumption in desserts like custard apple rabdi, due to the extremely perishable nature of custard apple. In last few years it was observed that in old orchards regular canopy management is not followed. Which, leads to overcrowding of trees and resulted in unproductive and uneconomic orchards. Research efforts were initiated to standardize a technology for restoring the production potential of existing plantations by a technique called Rejuvenation.

Rejuvenation means pruning of branches at different severities to restore the productive capacity of the old and unproductive orchards. Redevelopment of canopy is possible by heading back or limb pruning (severe pruning) and pruning at different severities of existing senile trees which have exhausted canopies and erratic growth resulting in reduced yield. The main objective of the pruning is to remove the non-productive parts and to divert the energy into those parts that are capable of bearing fruits (Singh, 2005) [21]. It ensures the proper balance of crop load and the vegetative phase/leaf area that sustain it.

This is a fast growing semi deciduous tree grows up to a height of 3 to 4 m within two years and has an average lifespan of 25 years. Later on economic life of custard apple orchard is declined after 25-30 years. Existence of unproductive senile orchards has a telling impact on the socio-economic as well as livelihood status of the farmers. The traders and consumers are equally affected with low production and poor quality of produce. Uprooting such orchards and new plantation may not be a prudent option considering the long gestation period of establishment and resulting impact on livelihood of farmers families, environmental concerns as well as the investment cost. In this view, present investigation was carried out to provide exact and correct removal of plant parts in terms of length (distance) instead of percentage.

Materials and Methods

The present research was carried out at AICRP on Arid Zone Fruits, Department of Horticulture, MPKV., Rahuri during May, 2022 to November, 2023.Thirty two years old, custard apple orchard shows sign of decline in production were rejuvenated at different levels of pruning severity i. e., T_1: Retention of only main trunk at 45 to 60 cm height, T_2: Retention of main trunk along with only basal portion of primary branches at 10 to 15 cm length, T_3: Retention of main trunk along with primary branches at 45 to 100 cm length, T_4: Retention of main trunk including primary branches along with the only basal portion of secondary branches at 10 to 15 cm length, T_5: University recommendation pruning at 75 days after harvesting with 25% pruning intensity T_6: Control (without pruning).

The field trial was laid out in randomized block design with six treatments replicated four times. The observations were recorded for mortality, days to sprout, number of shoots, days to flowering, leaf area, days to first crop, number of fruits per tree, fruit length, fruit diameter, fruit weight, yield per tree.

Results and Discussion

The result obtained from the present investigation as well as relevant discussion have been summarized under following sub heads and given in Table. 1 2 and 3.

Mortality

Data presented in Table 1 clearly indicates that, rejuvenation treatments have no impact on survival of the tree. All the trees under rejuvenation treatment survived well indicating zero per cent mortality. Similar findings were reported by the Kshirsagar *et al.* (2017) [12] in mango. Who reported 100 per cent survival at different beheadings level (1 m, 1.5 m and 2 m) in mango.

Days to Sprout

The data pertaining to days to sprout is compiled in Table 1. The minimum number of days to sprout was recorded in the treatment T_6 [Control] (7.42 days) which was at par with the treatment T_5 (8.20 days). This was followed by the treatment T_4 (9.05 days). The highest number of days (19.80 days) to sprout was recorded in the treatment T_1 and it was followed by the treatment T_2 (12.42 days). Similar results were obtained by Nikumbhe *et al.* (2017) [18] reported delayed sprouting in pruned trees of guava.

Table 1: Effect of rejuvenation on plant growth of custard apple cv. Balanagar

Treatment No.	Mortality (%)	Days to Sprout	Days to Flowering	Leaf area (cm2)	Days to 1st Crop
T_1	0	19.80	0.00	39.63	0.00
T_2	0	12.42	121.00	41.13	0.00
T_3	0	11.10	115.00	41.65	235.01
T_4	0	9.05	104.00	43.06	229.83
T_5	0	8.20	88.33	45.37	202.97
T_6	0	7.42	80.00	30.03	195.06
SE (m) ±	0	0.43	3.23	1.59	7.52
C D at 5%	0	1.31	9.76	4.80	22.66

Number of Shoots

Data presented in Table 2 showed that effect of rejuvenation on number of shoots per plant has significant variation among different levels of pruning intensities. The maximum number of shoots (90.44) was observed in the treatment T_6 [Control] at 15 days after rejuvenation and similar trend was observed at 30 (103.85), 45 (126.12), 60 (144.90), 75 (148.37), 90 (150.74), 105 (154.34) and 120 (155.16) days after rejuvenation. The treatment T_1 has not reported any sprouting at 15 days after rejuvenation whereas minimum number of shoots was recorded at 30 (2.33), 45 (10.83), 60 (15.66), 75 (25.30), 90 (31.82), 105 (34.94) and 120 (35.87) days after rejuvenation in this treatment. This might be due to less number of vegetative buds in severely pruned trees. Further, continuous growth habit of the crop was mostly responsible for the growth of the unpruned trees (Control).

These results are in line with the experimental findings of Nikumbhe *et al.* (2017) [18] in guava, Jadhav *et al.* (2020) [9] and Jadhav *et al.* (2022) [10] in custard apple and Kshirsagar *et al*. (2020) [11] in mango. They found maximum number of shoots in unpruned trees.

Table 2: Effect of rejuvenation on number of shoots per plant at fifteen days intervals

Treatment No.	Number of shoots per plant at fifteen days intervals							
	15 DAR	30 DAR	45 DAR	60 DAR	75 DAR	90 DAR	105 DAR	120 DAR
T_1	0.00	2.33	10.83	15.66	25.30	31.82	34.94	35.87
T_2	5.35	13.02	18.67	21.99	30.17	39.61	40.62	41.27
T_3	6.25	16.33	26.25	35.53	43.58	45.68	47.21	47.90
T_4	11.03	23.75	32.33	37.88	42.56	49.78	50.09	51.28
T_5	48.62	62.67	69.63	81.01	89.67	92.97	95.79	96.71
T_6	90.44	103.85	126.12	144.90	148.37	150.74	154.34	155.16
SE (m) ±	0.99	1.38	3.35	2.29	2.48	2.93	3.21	3.45
C D at 5%	3.11	4.35	10.56	7.22	7.47	8.82	9.69	10.39

*DAR- Days after rejuvenation

Days to Flowering

Data presented in table 1. Revealed that, minimum days to flowering (80 days) were found in the treatment T_6 [Control] which was at par with treatment T_5 (88.33 days) and it was followed by the treatment T_4 (104 days).Whereas, it was maximum (121 days)in the treatment

T_2 and it was followed by the treatment T_3 (115 days) There was no flowering in treatment T_1 during the first year of experimentation.

Hiremath *et al.* (2017) [8] observed that among the different levels of pruning, maximum days were required for initiation of flowering in severe pruning whereas; unpruned trees (control) produced flowering earlier in guava. These findings lend support to present results.

Leaf Area (cm2)

Data related to effect of rejuvenation at different pruning intensities on leaf area (Table 1) revealed remarkable impact. Significantly maximum leaf area (45.37 cm2) was observed in the treatment T_5 which was at par with the treatments, T_4 (43.06 cm2), T_3 (41.65 cm2) and T_2 (41.13 cm2). Treatment T_6 [Control] registered lowest leaf area (30.03 cm2).In the present research, leaf area got influenced significantly by pruning intensity. The results of present findings are in agreement with the finding of Dahapute *et al.* (2018) [7] in custard apple. Leaf area was found maximum in pruned tress as compared with control.

Days to 1stCrop:

It is evident from the data summarized in Table 1, treatment T_6[Control] displayed minimum number of days to 1st crop (195.06 days) and it was at par with the treatment T_5

(202.97 days). Maximum days to first crop were recorded in treatment T_3 (235.01 days). Whereas, treatment T_1 and T_2 does not comes to bearing during the first year of rejuvenation. This indicates that severely pruned trees required long duration for physiological maturity. Pruning induced strong vigorous and juvenile growth event in the vegetative part of plant resulted in late flowering and fruiting. This might be the reason for longer duration of first crop.

Similar results were discovered by Chander *et al.* (2022) [5] and Jadhav *et al.* (2022) [10] in custard apple,

Number of Fruits per Tree (Fruits/tree)

The data regarding average number of fruits per tree for two successive years (2022 and 2023) and their pooled mean is presented in Table 3.

During the first year of rejuvenation, treatment T_6 [Control] substantially outperformed the other treatments by producing highest fruits per tree (63.07) It was followed by the treatment T_5 (52.66). Minimum number of fruits per tree was recorded in the treatment T_3 (9.00)and it was at par with the treatment T_4 (11). During first year of the experiment, treatment T_1 and treatment T_2, do not bear fruit.

In second year of study and in pooled results, the maximum number of fruits per tree (60.83 and 61.95 respectively) was recorded in the treatment T_6[Control] and it was at par with the treatment T_5 (57.40 and 55.03 respectively). Whereas, treatment T_1 recorded the minimum number of fruits per tree (10 and 5 respectively).

The results of present findings are in close vicinity of the findings of Mohamed *et al.* (2010) [15] and Jadhav *et al.* (2020) [9] in custard apple who mentioned less number of fruits in pruned treatments compared to control.

Fruit Length (cm)

The data on fruit length (cm) recorded during the year 2022 & 2023 summarized and presented in Table 3. During the first year of study, treatment T_5 recorded the maximum fruit length (7.94 cm) and it was at par with the treatment T_6 [Control] (7.12 cm). Minimum fruit length was observed in the treatment T_4[(6.66 cm) and it was at par with the treatment T_3 (6.83cm).

During the second year of study, maximum fruit length (7.82 cm) was recorded in the treatment T_5 and it was at par with the treatment T_6 [Control](7.00 cm). Treatment T_2[recorded the minimum fruit length (6.16 cm) and it was at par with the treatment T_1 (6.63 cm).

Pooled results showed that, the maximum fruit length (7.88 cm) was recorded in the treatment T_5Whereas, it was minimum in the treatment T_1 (3.32 cm) Present findings are in accordance with the findings of, Bhagawati *et al.* (2015) [4] in guava, Dahapute *et al.* (2018) [7] in custard apple.

Fruit Diameter (cm)

The data pertaining to fruit diameter was recorded during the year 2022 & 2023 and summarized in Table 3. The data revealed that, effect of rejuvenation has substantial impact on fruit diameter of custard apple.

The maximum fruit diameter (8.25 cm) was noticed in the treatment T_5 and it was at par with the treatment T_6 [Control] (7.34 cm) during the first year of the study. Whereas, minimum fruit diameter (6.24 cm) was recorded in the treatment T_3 and it was at par with the treatment T_4 (6.82cm).

During the second year of study, maximum fruit diameter (8.20 cm) was recorded in the treatment T_5It was at par with the treatment T_6 [Control] (7.26 cm) and was followed by rest of the treatments. Treatment T_1 recorded the minimum fruit diameter (6.44 cm).

In pooled results nonsignificant differences were observed in

respect of fruit diameter among the all treatments. However, numerically the maximum fruit diameter (8.23 cm) was recorded in treatment T_5 and it was minimum (3.22 cm) in the treatment T_1

In present investigation, large sized fruits were obtained in recommended pruning practice (T_5), because of age group difference within the treatment or due to the different levels of pruning intensity which affects the plant metabolism. Hence, response to heavy pruning may be less pronounced. The results of present findings concur with findings of Lal *et al.* (2008) [14] in mango, Singh *et al.* (2015) [20] in ber. Dahapute *et al.* (2018) [7] and Choudhary *et al.* (2020) [6] in custard apple, where fruit diameter got exceeds due to pruning.

Fruit Weight (g)

Perusal of data summarized in Table 3 showed that significant differences in terms of average weight of fruit (g)were observed among all the treatments during the year 2022 and 2023 and in pooled results.

Treatment T_5recorded the maximum average fruit weight (289.23 g) and it was at par with the treatment T_6 [Control](206.13 g) during the first year of the rejuvenation. Whereas, minimum average fruit weight (162.39 g) was recorded in the treatment T_3 and it was at par with the treatment T_4 (165.73 g). There was no bearing in treatment T_1 and T_2during the first year of study.

In second year of study highest average fruit weight (281.47 g) was recorded in the treatment T_5 and it was significantly superior over rest of the treatments. Treatment T_1 recorded the minimum average fruit weight (160.14 g) and it was at par with the treatment T_2[(168.33 g), T_3 (171.09 g) and T_4 (175. 51 g).

Pooled results in terms of average fruit weight of two successive years (2022 and 2023) varied significantly among the treatments. Maximum average fruit weight (285.35 g) was recorded in the treatment T_5 and it was at par with the treatment T_6 [Control] (203.24 g) and T_4 [(170.62 g). Whereas, the treatment T_1] recorded the minimum average fruit weight (80.07 g) and it was at par with the treatment T_2 (84.17g) and T_3 (166.74g).

In present findings, maximum average weight of fruit was observed in the treatment T_5 during both the year of study and also reflected in pooled analysis. It was at par with the treatment T_6 [Control] in first year and pooled results whereas, followed by in second year of study.

The reason for the enlargement of fruit size is caused by drawing of photosynthates to the fruit as a consequence of intensification of the sink as compare to other treatments. As fruit size increases it directly proportional to the fruit weight. Metabolic activities helped to increase the fruit size and fruit weight and thereby increase the fruit yield. Asrey *et al.* (2012) [2] in mango, Pal and Ghosh (2019) [19] & Choudhary *et al.* (2020) [6] in custard apple, Aleksandr *et al.* (2021) [1] in apple also reported similar findings.

Yield (kg/plant)

The data in terms of fruit yield (kg/plant) was recorded during the year 2022 & 2023 along with pooled results summarized and presented in Table 3. Data on yield revealed notable variations between the treatments. The maximum fruit yield (15.23 kg/plant) was recorded in the treatment T_5 and it was at par with the treatment T_6 [Control] (12.99 kg/plant). The minimum yield (1.46 kg/plant) was recorded in the treatment T_3 and it was at par with the treatment T_4 (1.82kg/plant). Whereas, Treatment T_1 and T_2 does not come to bearing during the first year of rejuvenation.

In second year of investigation highest yield (16.15 kg) was recorded in the treatment $T_5$and it was significantly superior over the rest of treatments. (Whereas, minimum fruit yield (1.6 kg/plant) was recorded in the treatment T_1 [and it was at par with the treatment T_2 (2.21 kg/plant).

Data regarding the pooled results showed that, maximum fruit yield (15.69 kg/plant) was recorded in treatment T_5 and it was at par with the treatment T_6[Control] (12.59 kg/plant). The minimum fruit yield (0.80 kg/plant) was recorded in the treatment T_1 and it was at par with treatments T_2 (1.11 kg/plant), T_3 (3.48 kg/plant) and T_4 (4.18 kg/plant).

Treatment T_1, T_2, T_3 and T_4 recorded minimum values for number of fruits, fruit length (cm), fruit diameter (cm), average fruit weight(g) and fruit yield (kg/plant). The values decreased with the increase in intensity of pruning. This may be attributed to the reduction in number of bearing shoots with severity of pruning and use of assimilates in vegetative growth which lead to the less number of fruits per tree.

Present results are in conformity with the finding of Lal *et al.* (2008) [14] and Asrey *et al.* (2012) [2] in mango, Aleksandr *et al.* (2021) [1] in apple.

Table 3: Effect of rejuvenation on yield parameters of custard apple cv. Balanagar

Treatment No.	No. of fruit/tree			Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)			Yield (kg/plant)		
	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled	2022	2023	Pooled
T_1	0.00	10.00	5.00	0.00	6.63	3.32	0.00	6.44	3.22	0.00	160.14	80.07	0.00	1.6	0.80
T_2	0.00	13.15	6.58	0.00	6.16	3.08	0.00	6.69	3.35	0.00	168.33	84.17	0.00	2.21	1.11
T_3	9.00	32.08	20.54	6.83	6.71	6.77	6.24	7.06	6.65	162.39	171.09	166.74	1.46	5.50	3.48
T_4	11.00	37.25	24.13	6.66	6.92	6.79	6.82	7.10	6.96	165.73	175.51	170.62	1.82	6.54	4.18
T_5	52.66	57.40	55.03	7.94	7.82	7.88	8.25	8.20	8.23	289.23	281.47	285.35	15.23	16.15	15.69
T_6	63.07	60.83	61.95	7.12	7.0	7.06	7.34	7.26	7.30	206.13	200.34	203.24	12.99	12.18	12.59
SE (m) ±	1.12	3.26	5.40	0.27	0.28	1.66	0.31	0.34	1.64	28.37	5.60	38.04	0.78	0.81	1.01
C D at 5%	3.38	9.81	19.66	0.83	0.89	NS	0.95	1.09	NS	85.11	16.81	115.38	2.36	2.45	3.70

Conclusion

From the findings of present investigation, it can be concluded that-Treatment T_5 and T_6 gave good response as compare to rest of the treatments in respect of growth and yield parameters. No mortality was observed in the treatments after reiterative pruning.

However, it is obvious that rejuvenated trees at severe intensity of pruning may show slow growth and development during first two to three years and may flourish and give the economic yield after three to five years of rejuvenation.

Considering the long term projection of rejuvenation, and in view to extending the economic life of the old senile custard

apple trees, pruning at different severities i.e. beheading of trunk at 45 to 60 cm height from ground level (T_1) and retention of main trunk along with only basal portion of primary branches at 10-15 cm length (T_2) will facilitate to develop manageable canopy at lower level and in subsequent years pruned trees will develop more fruit bearing branches through development of primary and secondary branches. In view to standardize exact level of pruning intensity further investigation is necessary.

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