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Induction of off-season flowering in custard apple (*Annona squamosa* L.) cv. Balanagar

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ABSTRACT

Pruning and defoliation are essential operations for inducing off-season flowering and fruiting to yield better quality and quantity of fruits in custard apple. Trees were subjected to two levels of pruning (25% and 50%) combined with use of chemical defoliants (urea 5%, Ethrel 2000ppm, potassium iodide 1%, or ortho-phosphoric acid 1%) besides the Control, with each treatment replicated thrice. Early initiation of flowering and better vegetative growth was seen in pruned (25%) and defoliated trees than in the Control or other treatments. Maximum off-season yield (10.33kg/ plant) was obtained in T_4 (25% pruning, combined with 5% urea spray as defoliant) and T_6 (25% pruning, combined with 1% potassium iodide-spray as defoliant). Findings of this investigation helped standardize pruning and defoliation practices on a scientific basis for off-season production of custard apple fruits.

Key words: Pruning, defoliation, off-season, custard apple, urea

INTRODUCTION

Custard apple belongs to the family Annonaceae which has 46 genera and around 500 to 600 species, most of them found in the Tropics. Of the several species of *Annona*, at least five are available in India and yield edible fruit. These are: custard apple (*Annona squamosa* L.), cherimoya (*Annona cherimola* Mill.), soursop (*Annona muricata* L.), 'Ramphal' (*Annona reticulata* L.) and atemoya (*Annona atemola* Hort.). Custard apple has been performing well under dryland conditions where other crops do not. The tree is small, more or less shrub-like, shedding leaves in winter. The flowers are borne on current season's growth (newly emerging young shoots). Flowers are bisexual and distinctly protogynous (Sampath and Jalikop, 2000). Pruning and defoliation are essential components for inducing off-season flowering while aiming at quality and quantity of fruits. In custard apple, fruiting occurs on the current season's growth. With this in view, the present investigation was conducted to test the effect of different pruning intensities in combination with chemical defoliation on induction of off-season cropping in custard apple cv. Balanagar.

MATERIAL AND METHODS

The experiment was laid out in the experimental orchard of custard apple at ICAR - Indian Institute of Horticultural Research, Bengaluru, during 2013-2014. Eleven-year-old trees of cv. Balanagar showing uniform vigour were selected for the study. Randomized Complete Block Design (RCBD) was followed, with two levels (25% and 50%) of pruning intensity combined with defoliating chemicals (urea 5%, Ethrel 2000ppm, potassium iodide 1%, ortho-phosphoric acid 1%) with Control. Each treatment was replicated thrice. Number of shoots that emerged (secondary and tertiary shoots were counted), length of the emerged shoots (from the point of emergence to the tip, in cm), number of flowering shoots, number of flowers per shoot, and number of flowers per plant were noted at monthly interval; days taken to first flower, duration of flowering, days taken to fruit-set from onset of pruning, average number of fruits per tree, and fruit yield (kg/tree) were recorded.

RESULTS AND DISCUSSION

Growth attributes

Pruning, when performed appropriately, provides the tree with a proper shape and size. It also enables essential operations for custard apple for enhancing production of quality fruits. Significant differences among treatments at different dates of observations for number of shoots that emerged were observed (Table 1). Maximum number of shoots emerged at 30, 60 and 90 days in treatment T_4 (66.0,

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86.00 and 125.67, respectively), which was on par with T_5, T_6, T_8, T_7, T_2 and T_{10}, and, no branches were seen in T_1 (Control- no pruning and no chemical spray). This could be due to greater availability of leaf area on shoots from 25% pruning compared to 50% pruning. Further, as T_4 is a combination (25% pruning + spray of 5% urea), more numerous shoots may have been induced, resulting in greater leaf area, consequently increased photosynthetic activity. The present findings are in line with Pandey *et al* (1998) who reported maximum number of shoots under 25% pruning in ber. At 120 days from treatment, T_1 (198.0) was found to be highly significant relative to other treatments; minimum shoot number was seen in treatments T_{11}, T_9, T_{10} and T_8. This could be attributed to the fact that Control trees were neither pruned nor sprayed with chemicals, and, sprouting occurred as a natural consequence of leaf shedding and production of new growth from all the buds, 120 days after treatment-imposition in the other trees. Bajwa *et al* (1986) found significantly high total number of shoots in unpruned ber trees. Lal and Prasad (1971) also found unpruned ber trees as producing more shoots compared to the pruned trees.

Data on length of shoot (Table 1) indicate significant differences among treatments, at monthly intervals. At 30 days of observation, maximum shoot length was seen in T_3 (6.3) and T_2 (5.5), at 60 days in T_{11} (13.57), T_3 (12.93) and T_8 (12.67), at 90 days in T_3 (25.23), and, at 120 days in T_5 (30.74) which was on par with T_{10}, T_3, T_{11} and T_9. Minimum shoot length was observed in T_1 (5.60). No shoots emerged in Control T_1 at 30, 60 or 90 days. Longest shoots were observed in the lightly pruned (25%) trees during initial stages of growth, in severely pruned (50%) trees at the end of growth period, and shortest shoots were seen in unpruned trees, throughout the growth period. Similar results were obtained by Dhaliwal *et al* (2014) in kinnow, and by Trevor and Steven (2009) in custard apple.

Yield attributes

Significant differences were noticed for number of flowering shoots per tree at monthly intervals (Table 2). At 30 days, maximum flower number was found in treatment T_4 (46.0), at 60 days in T_{11} (74.67), at 90 days in T2 (85.0), and was on par with T_5, T_6, T_8, T_{10}, T_2, T_{11}, T_7, T_3 and T_9. No shoots or flowers emerged in Control T_1 at 30, 60 or 90 days. These findings are in agreement with Guimond *et al* (1998) who found pruning in cherry trees to influence number of flowering shoots. Similar results were reported by Braswell and Spiers (2005) and Lord *et al* (1979). At 120 days, T_1 (148.33) was more significant than the other treatments and the least number of flowers were seen in T_3 (120.33), which was on par with T_7, T_8, T_9 and T_2. Control trees showed maximum number of flowering shoots at this stage, because, it was the main season for flowering in custard apple under Bengaluru conditions. Flowering period in treated trees ended at 120 days, as, the trees had started flowering early in the season, and, all the differentiated buds had bloomed. Similar results were reported by Mohamed and Fawzi (2010) in custard apple, and by Bruno and Evelyn (2001) in cherimoya.

At 30 days, higher number of flowers per shoot appeared in T_3, T_7 and T_8 (6.67); at 60 days, most number of flowers were found in T_{10} (6.67), and at 90 days in T_4 (6.33), which was on par with the other treatments, excepting T_1 and T_9 (4.67). At 120 days, more flowers per shoot were found in T_1 (12.67), followed by T_5 (7.00); the least number was seen in T_2 (5.00) and other treatments (Table 2). More

Table 1. Effect of various pruning levels and defoliants on shoot emergence and shoot length

Treatment		Number of shoots emerging per tree (days after pruning)				Length of emerged shoots (cm) (days after pruning)			
		30	60	90	120	30	60	90	120
T_1	Control (no pruning, no chemicals)	0.00	0.00	0.00	198.00	0.00	0.00	0.00	5.60
T_2	25% pruning (no chemicals)	61.00	81.00	121.00	176.00	5.50	9.53	18.03	27.30
T_3	50% pruning (no chemicals)	59.00	79.00	118.67	165.33	6.30	12.93	25.23	29.57
T_4	25% pruning + Urea 5%	66.00	86.00	125.67	175.00	4.10	9.23	23.67	29.20
T_5	25% pruning + Ethrel 2000ppm	64.67	83.33	123.67	171.33	5.23	10.13	21.00	30.74
T_6	25% pruning + Potassium iodide 1%	64.00	82.67	123.33	168.67	4.53	12.03	24.30	29.20
T_7	25% pruning + Ortho-phosphoric acid 1%	61.33	83.33	123.00	166.33	4.57	12.10	23.83	27.23
T_8	50% pruning + Urea 5%	63.00	83.00	121.67	162.33	5.33	12.67	23.83	26.30
T_9	50% pruning + Ethrel 2000ppm	60.67	80.00	119.33	160.67	3.53	13.20	23.27	29.27
T_{10}	50% pruning + Potassium iodide 1%	61.33	81.67	122.00	162.00	4.03	12.20	24.53	30.50
T_{11}	50% pruning + Ortho-phosphoric acid 1%	60.33	78.67	117.00	157.00	4.57	13.57	23.73	29.43
SEm±		1.637	1.436	1.558	1.842	0.311	0.330	0.683	0.519
CD *(*P=0.05)*		4.830*	4.237*	4.957*	5.433*	0.918*	0.974*	2.015*	1.532*

Table 2. Effect of various pruning levels and defoliants on number of flowering shoots and number of flowers

Treatment	Number of flowering shoots per tree (days after pruning)				Number of flowers per shoot (days after pruning)			
	30	60	90	120	30	60	90	120
T_1 Control (no pruning, no chemicals)	0.00	0.00	0.00	148.33	0.00	0.00	0.00	12.67
T_2 25% pruning (no chemicals)	41.00	61.67	85.00	123.33	5.67	5.00	5.00	5.00
T_3 50% pruning (no chemicals)	32.33	59.67	82.33	120.33	6.67	4.67	5.33	6.33
T_4 25% pruning + Urea 5%	46.00	64.67	83.00	124.33	5.00	5.67	6.33	5.00
T_5 25% pruning + Ethrel 2000ppm	44.67	62.00	83.67	123.33	5.33	5.00	5.67	7.00
T_6 25% pruning + Potassium iodide 1%	43.67	65.00	82.33	124.00	6.00	5.33	6.00	6.00
T_7 25% pruning + Ortho-phosphoric acid 1%	40.33	61.00	81.67	121.00	6.67	5.00	5.00	6.00
T_8 50% pruning + Urea 5%	42.00	62.00	82.67	122.33	6.67	4.67	5.00	6.00
T_9 50% pruning + Ethrel 2000ppm	40.00	61.00	79.67	122.67	6.33	5.67	4.67	6.00
T_{10} 50% pruning + Potassium iodide 1%	41.33	63.00	81.00	129.00	5.33	6.67	5.00	6.00
T_{11} 50% pruning + Ortho-phosphoric acid 1%	40.67	74.67	81.67	128.00	6.00	5.33	5.33	6.33
SEm±	2.140	9.798	1.409	1.830	0.526	0.469	0.536	0.521
CD *(P=0.05)*	6.313*	28.90*	4.157*	5.398*	1.551*	1.384*	1.582*	1.537*

Table 3. Effect of various pruning levels and defoliants on number of flowers

Treatment	Number of flowers per tree (days after pruning)			
	30 days	60 days	90 days	120 days
T_1 Control (no pruning, no chemicals)	0.00	0.00	0.00	989.00
T_2 25% pruning (no chemicals)	232.33	309.00	422.67	617.67
T_3 50% pruning (no chemicals)	216.67	277.33	438.33	762.67
T_4 25% pruning + Urea 5%	230.67	368.00	526.00	623.33
T_5 25% pruning + Ethrel 2000ppm	241.67	311.33	474.00	863.33
T_6 25% pruning + Potassium iodide 1%	261.00	347.33	494.00	744.33
T_7 25% pruning + Ortho-phosphoric acid 1%	269.00	305.00	410.67	724.67
T_8 50% pruning + Urea 5%	280.67	289.33	411.00	732.00
T_9 50% pruning + Ethrel 2000ppm	254.67	344.67	372.67	737.67
T_{10} 50% pruning + Potassium iodide 1%	219.33	422.00	403.00	773.33
T_{11} 50% pruning + Ortho-phosphoric acid 1%	241.67	504.33	436.00	810.67
SEm±	27.339	61.357	42.946	63.950
CD *(P=0.05)*	80.642*	180.98*	126.67*	188.62*

flowers per shoot were observed in pruned trees than in unpruned trees, as light-pruning removes apical dominance, resulting in bud-break from the lower portion of the shoot. These findings are in agreement with George and Nissen (1987) in custard apple. However, at 120 days, number of flowers per shoot in T_1 was more because of presence of more number of shoots at the time, naturally resulting in the highest number of flowers in unpruned trees. Similar results were obtained by Trevor and Steven (2009) in custard apple, and by Dhaliwal *et al* (2014) in kinnow. Kahn *et al* (2001) found an increase in the number of flowers per shoot after pruning in cherimoya.

As for number of flowers per tree (Table 3), at 30 days of treatment, more flowers per tree were observed in treatment T_8 (280.67), at 60 days in T_{11} (504.33), at 90 days in T_4 (526.00), and at 120 days in T_1 (989.0). Due to a higher number of flowering shoots, and more flowers per shoot in these treatments, the number of flowers per tree was high too. Similar results reported by Kahn *et al* (2001) revealed that pruning increased the number of flowers per tree in cherimoya and so did Trevor and Steven (2012) in atemoya.

All the pruning treatments together with defoliation gave better results as for early initiation of flowering. Significant difference was seen between pruning-with-defoliation, and unpruned trees (Table 4). Minimum number of days taken for emergence of the first flower were seen in T_8 (22.6), while longest time taken for the appearance of first flower was seen in Control T_1 (95.3) (Table 4). By pruning, apical dominance could be arrested thus, directing the movement of photosynthates to the lateral buds, thereby aiding flower initiation. Similar results were reported by Trevor and Steven (2012) in atemoya, and by Laura and Julian (2008 and 2009) in cherimoya.

Table 4 shows longer duration of flowering as observed in pruned defoliated tress than in Control trees; T_8 (130.0) showed the longest duration, followed by the other

Table 4. Effect of various pruning levels and defoliants on reproductive growth and yield

Treatment	Days taken to first flower	Duration of flowering (days)	Time taken for fruit-set (days)	Average no. of fruits per tree	Fruit yield/tree (estimated) (kg)
T_1 Control (no pruning, no chemicals)	95.3	73.00	156.00	32.00	8.00
T_2 25% pruning (no chemicals)	26.6	121.67	121.00	37.33	9.33
T_3 50% pruning (no chemicals)	24.6	123.00	117.67	30.00	7.50
T_4 25% pruning + Urea 5%	25.3	127.33	116.67	41.33	10.33
T_5 25% pruning + Ethrel 2000ppm	26.3	128.00	114.00	39.33	9.83
T_6 25% pruning + Potassium iodide 1%	26.6	129.00	111.67	41.33	10.33
T_7 25% pruning + Ortho-phosphoric acid 1%	25.6	129.00	112.33	40.33	10.08
T_8 50% pruning + Urea 5%	22.6	130.00	110.00	37.67	9.42
T_9 50% pruning + Ethrel 2000ppm	24.3	129.33	111.67	37.00	9.25
T_{10} 50% pruning + Potassium iodide 1%	24	126.33	110.67	38.33	9.58
T_{11} 50% pruning + Ortho-phosphoric acid 1%	23.6	127.67	109.00	36.67	9.17
SEm±	0.686	1.210	1.367	1.214	0.303
CD *(P=0.05)*	2.023*	3.56*	4.302*	3.583*	0.895*

treatments. This could be attributed to the fact that treated trees flowered earlier and continued to flower into the normal season. Minimum duration of flowering was seen in Control T_1 (73.00) where trees flowered in the normal season only. Similar results were reported by Trevor and Steven (2012) in atemoya, and by George and Nissen (1987) in custard apple.

Minimum number of days taken to fruit-set seen in treatment T_{11} (109.0) was on par with the other treated trees. Control T_1 (156.0) took longer to set fruit (Table 4), as photosynthate pruning increases photosynthate translocation to flower buds causing them to fruit earlier than in the Control. These findings are in accordance with that of Naira and Moieza (2014) and Lal *et al* (2000) in guava.

Average number of fruits per tree differed significantly among treatments. Pruning regimes, including defoliation, increased the mean number of fruits per tree over Control (Table 4). More fruits were seen in T_4 (41.33) and T_6 (41.33), whereas, fewest fruits were seen in T_1 (30.0). Pruning along with defoliation appears to have resulted in increase in new growth, culminating in higher translocation of photosynthates from the leaves to the shoots. Our results are in agreement with findings of Farre *et al* (2000) and Kahn *et al* (2001) in cherimoya.

Data presented in Table 4 reveal significant difference between treatments. Pruning at 25% produced higher yield than 50% pruning or that in unpruned trees. Pruning operation removed apical dominance, released lateral buds from correlative inhibition, and, changed the tree form and construction. This, in turn, enhanced flower-bud initiation in lateral buds, leading to increased yield. Maximum yield was obtained in T_4 (10.33) and T_6 (10.33), as more number of fruits were borne on the tree. Similar results were reported by Mohamed *et al* (2011) in plum, and by Demirtas *et al* (2010) in apricot. Minimum fruit yield was recorded in T_3 (7.50) and T_1 (8.0 which may be attributed to 50% pruning in T_3, resulting in reduced tree-size and available photosynthates. Mohamed and Fawzi (2010) reported a similar phenomenon in *Annona*.

The regular in season crop of *Annona* under Bengaluru conditions coincides with the South-West monsoon that is August; therefore, quality of the fruit is affected due to rains. The present investigation on induction of off-season flowering through pruning and chemical defoliants resulted in achieving off-season flowering and fruiting (in June) in cv. Balanagar. As *Annona* fruits are not available in the market during this period, growers will be able to get better market price and profits. In our findings, maximum off-season yield was obtained in T_4 (25% pruning, combined with 5% urea as spray) and T_6 (25% pruning, combined with 1% potassium iodide as spray). Our findings have helped standardize the cultural practices required on a scientific basis for off-season production of *Annona* fruits.

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