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NUTRIENTS CHANGES DURING OFF-SEASON FLOWERING IN CUSTARD APPLE (*ANNONA SQUAMOSA* L.) CV. BALANAGAR INDUCED BY PRUNING AND DEFOLIATION

G. M. VINAY*[1], R. CHITHIRAICHELVAN[1] AND G. K. HALESH[2]
[1]Division of Fruit Crops,
Indian Institute of Horticultural Research, Hesaraghatta Lake Post, Bangalore - 560 089, INDIA
[2]Department of Biotechnology and Crop Improvement, COH, Bengaluru - 560 065, INDIA
e-mail: vingeegmvegs@gmail.com

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***Corresponding author**

ABSTRACT

A field experiment was conducted during 2013-2014 to study the nutrients changes in the leaf of custard apple cv. Balanagar, under different pruning with defoliation treatments during off-season flowering. Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sulphur, Zinc, Manganese, Iron and Cupper concentrations were monitored before treatment application and after treatments application. All nutrient levels in leaves of Custard apple cv. Balanagar more in the treated trees than the before application of the treatments; N-2.65% (T_6), P-0.29% (T_7), K-2.33% (T_2), Mg-0.68% (T_7), S-0.59% (T_7), Zn-9.23ppm (T_9), Mn-75.85ppm (T_9), Cu-28.55ppm (T_7) but calcium 5.08% (T_1)and iron 335.33ppm (T_1) were more in the control tress than the before application and after application of the treatment. Such nutrients changes within the Balanagar leaves may have resulted in greater vegetative growth, flowering and fruiting, giving rise to off-season flowering with yield of 10.33 kg per plant in the treatment of 25 per cent pruning + Urea 5 per cent than the other treatments.

INTRODUCTION

Custard Apple belongs to the family Annonaceae. This family has 46 genera and between 500 to 600 species, most of which are found in the Tropics. Out of the several species of Annona, at least five are available in India yielding edible fruits. They are Custard Apple (*Annona squamosa*L.), Cherimoya (*Annona cherimola*Mill.), Soursop (*Annona muricata*L.), Ramphal (*Annona raticulata* L.) and Atemoya (*Annona atemoya* Hort.).Annona fruits have considerable importance in human nutrition, medicinal and cultural events (Thakur and Singh, 1967). The most important among them is custard apple (*Annona squamosa*L.) known by different names, such as "*Sitaphal*" or "*Sharifa*" in India, sugar apple and sweetsop in other countries.In India, custard apple is grown and mainly marketed in regional or national trade(George and Nissen, 1987).Custard apple has been performing well under dry land conditions where other crops do not come well. The custard apple tree is small, more or less shrub or tree, in winter it sheds the leaves. The flowers are borne on current season growth (new emerging young shoots). The flowers are borne on current season's growth(new emerging young shoots). Flowers are bisexual and distinctly protogynous. Anthesis occurs between 6-9pm. Flowers are cross pollinated and anemophyllus in nature. There is no distinct colour to sepals and petals (Sampathand Jalikop, 2000).Pruning and defoliation are essential components for the production of off season flowering and fruiting with quality and quantity of custard apple fruits, the nutrients level changes taking place within the custard apple leaves when the treatments are imposed is not clearly understood. Nutritional status of leaves may play an important rolein development of reproductive characters (Mohamed *et al.*,2010). Keeping in view of above mentioned facts, the present investigation was conducted to study how nutrient levels leaves got changed after different pruning intensities and defoliation chemicals used for treatments.

MATERIALS AND METHODS

Plant materials

The present experiment was conducted in the experimental orchard of custard apple at Indian Institute of Horticultural research, Bengaluru during 2013 and 2014. Twelve year old plants of cultivar Balanagar having uniform vigour were selected for the study.

Treatment details

The experiment was laid out in Randomized Complete Block Design (RCBD) with 2 levels (25% and 50%) of pruning combined with defoliating chemicals (Urea 5%, Ethrel 2000 ppm, Potassium iodide 1% and Orthophosphoric acid 1%) with control and each treatment replicated thrice.

Nutrient analysis

Two month old 5[th] node from the tip of shoot leaves are taken as sample from all the treatments and from control, and also one sample taken before application of the treatment from the experimental trees, one sample includes 50 number of leaves.

Estimation of nitrogen was done by using Kjeldahl distillation method. As the soil of experimental blocks acidic, Bray's Method was used to estimate the phosphorus content.The available K was estimated with the help of a flame photometer. Calcium and magnesium are determined by atomic absorption spectrophotometer after the removal of ammonium acetate and organic matter. Sulphur in the extract was estimated turbidimetrically using a spectrophotometer.Determination of micronutrients viz. Iron, Manganese, Copper and Zinc by using atomic absorption spectrophotometer (AAS), Gomez and Gomez (1984).

Soil analysis

Soil sampling taken by zig-zag way at middle of the four plants from cv. Balanagar field before and after the treatment application were used for the nutrient analysis. Analysis of soil and leaf nutrient contents were taken up before and after the treatments. Soil nutrient analysis was done only for better interpretation of the results with leaf nutrients.

Statistical design

RCBD (Randomized Complete Block Design).

Statistical analysis

Data generated through all experiments were statistically analyzed by adapting SAS v.9.3 package available at IIHR, Bengaluru.

RESULTS

Nutrient parameters

Nitrogen (%)

Significant differences were observed for the nitrogen content in the leaves of Balanagar before and after treatment application (Table 1).The maximum value was found in treatment T_6 (2.65) when compared to other treatments and the minimum (1.88) in before the treatments application and it was on par with the T_1 (1.93).

Phosphorus (%)

Significantly higher phosphorus was obtained in after treatment applications (Table 1), in T_7 (0.29) which was on par with the T_2 (0.26), T_3 (0.26) and T_4 (0.26); the minimum value (0.12) was seen in leaves before application of treatment which was on par with the control T_1 (0.12).

Potassium (%)

Data shown in Table 1 for potassium revealed that significant differences between the before treatment application and after. More amount was observed in T_2 (2.33) which was on par with T_7 (2.20) and before treatment application (2.13). The minimum amount of potassium was seen in the treatments T_1 (1.27) on par with T_8 (1.37) and T_{11} (1.47).

Calcium (%)

The values of calcium (Table 1) showed significant differences between before treatments application and higher value was obtained in after treatment application of T_1 (5.08) treatment, compared to less calcium content before treatment application (0.82).

Magnesium (%)

Significant differences between before and after treatment application were noticed. After treatment application indicated higher amount of magnesium compared to before application of treatment (Table 1), in T_7 (0.68) which was on par with T_6 (0.65). Minimum amount of magnesium was found in T_3 (0.25).

Sulphur (%)

Significant difference was noticed for sulphur among the treatments (Table 1), T_7 (0.59) on par with T_{10} (0.55) and before application of treatment; minimum amount of sulphur content was found in T_3 (0.33) and T_4 (0.33).

Zinc (ppm)

Data in Table 2 shows significant differences between the treatments before and after application of them; higher amounts of zinc were present in leaves after treatment application in T_9 (9.23) than other treatments and before application and the minimum amount of zinc (3.83) was observed before application of treatments.

Manganese (ppm)

Significant differences (Table 2) were also observed among the treatments and also before and after application of treatments; more amount of manganese was present in leaves of Balanagar T_6 (85.33) than other treatments and before application and the minimum amount of manganese (31.34) was also noticed in before application of treatment.

Iron (ppm)

Iron contents were significant among the treatments and before and after the treatments (Table 2); significantly higher amount of iron was found in T_1 (335.33) than other treatments. Minimum values for iron (53.83) were seen before treatment application.

Copper (ppm)

Data in Table 2 shows significant difference among the treatments before and after application. More amount of copper was noticed after the treatment application in T_7 (28.55) than other treatments and before the application; minimum amount of copper (7.35) was found before the application of treatments.

Yield parameters

Days required for first flowering

There were significant differences among the treatments. The minimum number of days for first flowering was found in the treatments T_8 (22.6), T_{11} (23.6), T_{10} (24.0), T_9 (24.3) and T_3 (24.6). Maximum number of days taken for first flowering was by T_1 (95.3) as shown in Table 3.

Duration of flowering (Days)

Table 3 shows maximum duration of flowering was in T_8 (130.0) and this treatment was on par with T_9, T_7, T_6, T_5, T_{11} and T_4 (129.33, 129.0, 129.0, 128.0, 127.67 and 127.33 respectively) and the minimum was found in T_1 (73.00).

Time taken for fruit set (Days)

Minimum number of days was taken for fruit set in treatment T_{11} (109.0) and this is on par with the T_8 (110.0), T_{10} (110.67), T_6 (111.67), T_9 (111.67) and T_7 (112.3); T_1 (156.0) took more number of days to set fruits (Table 3).

Table 1: Effects of different pruning levels and defoliation chemicals on macronutrient contents of custard apple cv. Balanagar leaves

Treatments		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
T_1	Control (no pruning, no chemicals)	1.93	0.12	1.27	5.08	0.52	0.41
T_2	25% pruning (no chemicals)	2.56	0.26	2.33	2.91	0.56	0.41
T_3	50% pruning (no chemicals)	2.50	0.26	1.60	2.73	0.25	0.33
T_4	25% pruning + Urea 5%	2.39	0.26	2.00	2.01	0.39	0.33
T_5	25% pruning + Ethrel 2000ppm	2.55	0.24	1.50	2.20	0.56	0.42
T_6	25% pruning + Potassium iodide 1%	2.65	0.23	1.57	4.42	0.65	0.54
T_7	25% pruning + Orthophosphoric acid 1%	2.15	0.29	2.20	3.59	0.68	0.59
T_8	50% pruning + Urea 5%	1.97	0.23	1.37	4.33	0.40	0.44
T_9	50% pruning + Ethrel 2000ppm	2.38	0.23	1.60	3.45	0.57	0.39
T_{10}	50% pruning + Potassium iodide 1%	2.53	0.23	1.70	2.51	0.37	0.55
T_{11}	50% pruning + Orthophosphoric acid 1%	2.34	0.22	1.47	2.65	0.62	0.43
	Before application of treatment	1.88	0.12	2.13	0.82	0.26	0.48
SEm±		0.02	0.01	0.10	0.02	0.01	0.01
CD (@ 5 %)		0.07	0.04	0.29	0.06	0.04	0.04

Table 2: Effects of different pruning levels and defoliation chemicals on micronutrient contents of custard apple cv. Balanagar leaves

Treatments		Zn (ppm)	Mn (ppm)	Fe (ppm)	Cu (ppm)
T_1	Control (no pruning, no chemicals)	5.68	48.49	335.33	20.96
T_2	25% pruning (no chemicals)	7.07	63.75	188.90	16.99
T_3	50% pruning (no chemicals)	5.89	74.81	158.10	16.57
T_4	25% pruning + Urea 5%	6.70	59.23	185.37	16.92
T_5	25% pruning + Ethrel 2000ppm	6.78	61.78	223.00	11.37
T_6	25% pruning + Potassium iodide 1%	7.13	85.33	190.33	24.08
T_7	25% pruning + Orthophosphoric acid 1%	8.18	67.79	193.43	28.55
T_8	50% pruning + Urea 5%	8.02	66.64	186.07	17.44
T_9	50% pruning + Ethrel 2000ppm	9.23	75.85	160.77	22.15
T_{10}	50% pruning + Potassium iodide 1%	5.66	63.41	193.67	12.70
T_{11}	50% pruning + Orthophosphoric acid 1%	6.38	67.89	186.70	16.76
	Before application of treatment	3.83	31.34	53.83	7.35
SEm±		0.03	0.21	0.08	0.01
CD (@ 5 %)		0.09	0.63	0.24	0.05

Table 3: Effects of different pruning levels and defoliation chemicals on reproductive traits of custard apple cv. Balanagar

Treatments		Days required for first flowering	Duration of flowering (Days)	Time taken for fruit set(Days)	Average fruits per plant(no.)	Fruit yield/ plant (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 + Orthophosphoric 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 + Orthophosphoric acid 1%	23.6	127.67	109.00	36.67	9.17
SEm±		0.68	1.21	1.36	1.21	0.30
CD (@ 5 % significance)		2.02	3.56	4.30	3.58	0.89

Average number of fruits per plant

Average number of fruits per plant varied significantly among the treatments; more number of fruits were found in T_4 (41.33), T_6 (41.33) which on par with T_7 (40.33), T_5 (39.33) and T_{10} (38.33). The minimum numbers of fruits were found in T_3 and T_1 (30.0, 32.0 respectively)Table 3.

Fruit yield (kg/plant)

The data presented in Table 3 revealed that significant differences were seen between the treatments and the maximum estimated yield was observed in T_4 (10.33) and T_6 (10.33) and these treatments were on par with T_7 (10.08), T_5 (9.83) and T_{10} (9.58). The minimum yield was found in T_3 (7.50) and T_1 (8.0).

DISCUSSION

Nutrient parameters

Nitrogen is the main nutrient for vegetative growth. The dormant period that occurs before flowering should be considered as a period of low nitrogen requirement, as simulative vegetative growth at this time would reduce flowering and productivity. In this investigation, nitrogen content in the leaves of Balanagar before and after application of treatment showed variance (Table 1). Among the treatments, 25 per cent pruning with potassium iodide 1.0 per cent (2.65) was found to contain the maximum amount of nitrogen than other treatments and the minimum (1.88) was seen in before application of treatments and was on par with the control (1.93). This difference may be due to more number of flowered shoots in the pruned and defoliated trees than the control and before application of treatments and also high nitrogen content in the soil leading to maximum amount of nitrogen found after the application of treatment. During reproductive phase, the concentration of nitrogen was observed to be higher than during vegetative phase. Corroborative results were reported by Sanjay *et al*. (2010) and Mohamed *et al*. (2010) in annona.

The leaf phosphorus content was not influenced by pruning intensities (Table 1). The higher phosphorus content was observed in treatments 25 per cent pruning with orthophosphoric acid 1.0 per cent (0.29), but no systematic trend was found in the level of phosphorus. This could be due to the antagonism between phosphate and nitrate anions at the absorption sites, and minimum value (0.12) was found in the before application of treatment and was on par with the control (0.12). The obtained results are in agreement with the findings of Sharma and Singh (1982) and Kaith *et al*. (2011).

The maximum Potassium level was recorded during reproductive phase, pruning intensities and their interaction (Table 1). Higher amounts of potassium was found in 25 per cent pruning without chemicals (2.33), and minimum amount of potassium was found in the control (1.27). Leaf content of potassium was not affected significantly between all tested treatments and untreated (control). Similar results were reported by Galila and El-Masry (1991) on annona.

The highest calcium content was recorded in unpruned control trees (5.08), which decreased with pruning severity (Table-1). It may be attributed to the fact that un-pruned trees had developed lesser number of new leaves primarily due to poor growth and less cell division activities, as a result, higher calcium might have accumulated in the leaves. On the other hand, pruning led to vigorous growth, and new leaves acted as sink for calcium. Leaves developed after pruning might have lowered the calcium content (0.82). The results are in agreement with the findings of Kaith *et al*. (2011) and Bisen *et al*. (2014).

Leaf magnesium content increased significantly with the pruning (Table 1). Maximum magnesium level was seen in 25 per cent pruning with orthophosphoric acid 1.0 per cent (0.68) and 25 per cent pruning with potassium iodide 1.0 per cent (0.65) and the minimum was in 50 per cent pruning without chemicals (0.25) and the content was the same before application of treatment (0.26). The accumulation of magnesium with the pruning was more due to more uptake of magnesium from the soil to the leaves and this may be because pruning helped to increase chlorophyll and rate of photosynthesis. Findings are similar to Thakur *et al*. (1981) and Helail and Eissa (1997) in mango.

Sulphur is an important constituent of some essential amino acids, which are needed for building up of proteins. Pruning intensity caused higher amount of sulphur (Table-1) accumulation in leaves of 25 per cent pruning with orthophosphoric acid 1.0 per cent (0.59) on par with 50 per cent pruning with potassium iodide 1.0 per cent (0.55), while minimum amount of sulphur content was found in 50 per cent pruning without chemicals (0.33) and 25 per cent pruning with urea 5.0 per cent (0.33). This may be due to the effect of pruning, encouraging vigorous vegetative growth which bear non-fruiting terminals having a higher percentage of sulphur than the fruiting terminals. Similar results were obtained by Sanjay *et al*. (2010) and Thakur *et al*. (1981).

Data in Table 2 shows significant differences between before and after application of treatments for micronutrients like Zinc, Manganese and Cupper (50 per cent pruning with ethrel 2000 ppm (9.23), 25 per cent pruning with potassium iodide 1.0 per cent (85.33), 25 per cent pruning with orthophosphoric acid 1.0 per cent (28.55), respectively) in Balanagar leaves. It was found that in treated trees with pruning and defoliation the contents were higher than before application of the treatments and control without pruning. It is further seen that there is variation in the content of these nutrients between before the experiment start and the control without any treatments. This could be because of the fertilizers application one month after the start of the experiment. Iron was found maximum in the control control (335.33) than other treatments and before application of the treatments (53.83). Fe accumulation is always in the older leaves as Iron is an immobile element and does not move to young leaves as a result of pruning or defoliation. It could be also due to the antagonistic effect of P on cationic micronutrients and also soil Fe content was more before the application of treatments. Similar results were also obtained by Guleryuz *et al*. (1996) and Lalithya *et al*. (2014).

Soil nutrient levels before and after treatments application

Yield attributes

All pruning treatments with defoliation gave better results for early initiation of flowering and there was a significant difference between the pruning with defoliation and unpruned trees (Table 3). The minimum number of days taken for first flowering in T_8 (22.6) and maximum number of days taken for

Soil nutrients Time of sampling	pH	EC (dsm-1)	OC (%)	N (ppm)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Before treatment	5.61	0.09	0.24	38.88	10.82	125	401	122
After treatment	5.64	0.10	0.72	116.64	10.33	145	220	184

Time of sampling	S (ppm)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Before treatment	11.85	58.21	113.84	0.90	3.30
After treatment	10.25	44.48	38.62	1.50	3.89

first flowering in control T_1 (95.3) are shown in Table 6. By pruning shoots, apical dominance could be arrested stopping the movement of photosynthates to lateral buds helped in early initiation. Similar results were reported by Trevor and Steven (2012) in atemoya and Laura and Julian (2008 and 2009) in cherimoya.

Table 3 shows the duration of flowering wherein longer duration of flowering was observed in pruning with defoliated tress than control trees; T_8 (130.0) showed the maximum followed by other treatments. This could be attributed to the fact that the treated trees flowered earlier and continued in the normal season. The minimum duration of flowering was found in control T_1 (73.00) which is obvious due to flowering in normal season only. Similar results reported by Trevor and Steven (2012) in atemoya and George and Nissen (1987) in custard apple.

Minimum number of days taken for fruit set in the treatment T_{11} (109.0) on par with other treated trees and control T_1 (156.0) found more number of days to fruit set (Table 3), because pruning increases photosynthetic translocation to fruit buds therefore formation of fruits earlier then the control. The present findings are in line with that of Naira and Moieza (2014), Lal *et al*. (2000) in guava.

The average number of fruits per tree differed significantly among the treatments; pruning regimes including defoliation increased mean number of fruits per tree than the control trees (Table 3). More number of fruits were found in T_4 (41.33) and T_6 (41.33) whereas the minimum number of fruits was in T_1 (30.0). Pruning with defoliation seems to have resulted in increased new growth resulting in higher photosynthates translocation from leaves to shoots. The results are in agreement with the findings of Farre*et al*. (2000) and Kahn *et al*. (2001) in cherimoya.

The data presented in Table 3 revealed significant difference between the treatments; 25% pruning produced more yield than 50% pruning and control. Pruning performed on shoots removed apical dominance, released lateral buds from correlative inhibition and changed tree form and construction which in turn, increased flower bud initiation from lateral buds and increased the yield. The maximum yield was obtained in T_4 (10.33) and T_6 (10.33) because of more number of fruits in a tree. Similar results were reported by Mohamed *et al*. (2011), Demirtas *et al*. (2010) and Jithendra *et al*. (2015). The minimum yield was recorded in T_3 (7.50) and T_1 (8.0). It may be attributed that in T_3, pruning was at 50% leading to reduce the tree size reduced production of photosynthates. Mohamed *et al*. (2010) reported a similar phenomenon in annona.

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