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Effect of application of PGR and chemicals on physical and physiological parameters of custard apple cv. Sindhan

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Abstract
An experiment was conducted to study the effect of application of PGR and chemicals on physical and physiological parameters of custard apple cv. Sindhan was carried out at Department of Horticulture, Junagadh Agricultural University, Junagadh during 2018. The treatments comprising of spray of GA_3, $CaCl_2$ and borax were applied to the tree at the time of flowering, 30 days after flowering and 60 days after flowering. Among the treatments spray of GA3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% were found to be maximum fruit length, diameter, volume, weight, marketable fruit, shelf life and minimum physiological loss in weight and spoilage as compare to the other treatments.

Keywords: Custard apple, GA_3, $CaCl_2$, borax, physical, physiological

Introduction
Custard apple (*Annona squamosa* L.) belongs to Annonaceae family and native to tropical America. Custard apple is considered as one of the delicious table fruit and is valued mainly for its sweet, mild flavoured pulp. The fruits of custard apple are very delicate and highly perishable. Being climacteric in nature, the biochemical changes in fruit after harvest occurs at a faster rate and shows very short storage life at room temperature due to its fast ripening, high respiration rate and ethylene production the mature fruit after harvest ripen become unfit for consumption. Therefore, the increase in shelf life of custard apple fruit will be an advantage to the growers. So to enhance the post harvest shelf life of the fruit is most important factor for getting remunerative profit during off season. Thus, the present study was conducted to study the "Effect of application of PGR and chemicals on physical and physiological parameters of custard apple cv. Sindhan" under ambient storage condition.

Material and Methods
This experiment was carried out at Junagadh Agricultural University, Junagadh during 2018 to study the effect of application of PGR ad chemicals on physical and physiological parameters of custard apple cv. Sindhan. The fruit from this experiment were harvested and brought to the laboratory of Department of Horticulture, Junagadh Agricultural University, Junagadh. The experiment was lay out in Randomized Block Design with factorial concept (FRBD) with three factors and three replications (1 tree/replication) and eighteen treatments. The applied treatments are as T_1 GA_3 50 ppm + $CaCl_2$ 1% + Borax 0.2%, T_2 GA_3 50 ppm + $CaCl_2$ 1% + Borax 0.4%, T_3 GA_3 50 ppm + $CaCl_2$ 1.5% + Borax 0.2%, T_4 GA_3 50 ppm + $CaCl_2$ 1.5% + Borax 0.4%, T_5 GA_3 50 ppm + $CaCl_2$ 2% + Borax 0.2%, T_6 GA_3 50 ppm + $CaCl_2$ 2% + Borax 0.4%, T_7 GA_3 100 ppm + $CaCl_2$ 1% + Borax 0.2%, T_8 GA_3 100 ppm + $CaCl_2$ 1% + Borax 0.4%, T_9 $GA_3$100 ppm + $CaCl_2$ 1.5% + Borax 0.2%, T_{10} GA_3 100 ppm + $CaCl_2$ 1.5% + Borax 0.4%, T_{11} GA_3 100 ppm + $CaCl_2$ 2% + Borax 0.2%, T_{12} GA_3 100 ppm + $CaCl_2$ 2% + Borax 0.4%, T_{13} GA_3 150 ppm + $CaCl_2$ 1% + Borax 0.2%, T_{14} GA_3 150 ppm + $CaCl_2$ 1% + Borax 0.4%, T_{15} GA_3 150 ppm + $CaCl_2$ 1.5% + Borax 0.2%, T_{16} GA_3 150 ppm + $CaCl_2$ 1.5% + Borax 0.4%, T_{17} GA_3 150 ppm + $CaCl_2$ 2% + Borax 0.2%, T_{18} GA_3 150 ppm + $CaCl_2$ 2% + Borax 0.4%.
The sprays were applied to the tree at the time of flowering, 30 days after first spray and 60 days after first spray. The observations were recorded at harvest, 2nd, 4th and 6th day of storage. The parameters were recorded *viz.* fruit length (cm), diameter (cm), volume (cm^3), weight (g),

physiological loss in weight (%), spoilage (%), marketable fruit (%) and shelf life (days). Results thus, obtained were subjected to statistical analysis.

Results and Discussion

The maximum fruit length (8.00, 7.99, 7.97 and 7.94 cm) was recorded with the foliar spray of GA3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% at harvest, 2nd, 4th and 6th day interval, respectively. Whereas, minimum fruit length (5.17, 5.15, 5.11 and 5.07 cm) was recorded in GA_3 @150 ppm + $CaCl_2$ @1% + borax @ 0.4% at harvest, 2nd, 4th and 6th day interval, respectively. The increased in fruit length may be due to increase in growth rate by cell division and cell enlargement. Similar trend was also observed by Syamal *et al.* (2010) [20] and Ca appear to have indirect role in hastening the process of cell division and cell elongation due to which the size of fruit might have improved and boron has indirect effect on fruit length. Similar findings have been reported by Maurya *et al.* (1973) [14] in mango, Chandra *et al.* (1994) [3] in guava and Bagul (2016) [1] in custard apple. Fruit length decreased with the increase in storage period. The decrease in fruit size during storage period may be due to shrinking of fruits caused by transpiration.

There was a significant difference among the various treatments with regards to fruit diameter. The maximum fruit diameter (8.08, 8.13, 8.15 and 8.12 cm) was recorded with GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% at harvest, 2nd, 4th and 6th day interval, respectively. Whereas, the minimum fruit diameter (5.04, 5.07, 5.09 and 5.05 cm) at harvest, 2nd, 4th and 6th day interval, respectively was recorded with GA_3 @150 ppm + $CaCl_2$ @1% + borax @ 0.4%. The increase in diameter of fruit may be due to cumulative effect of growth regulators also the increase in diameter of fruits may be due to the fact that mineral nutrients appear to have indirect role in hastening the process of cell division and cell elongation due to which the size of fruit might have improved. Similar findings have been reported by Rajput *et al.* (1977) [17], Chandra *et al.* (1994) [4], Brahmachari *et al.* (1997) [2] in guava, Syamal *et al.* (2010) [20] in papaya and Bagul (2016) [1] in custard apple.

Table 1: The effect of PGR and chemicals on fruit length and diameter of custard apple

Sr. no.	Fruit length (cm)				Fruit diameter (cm)			
	At harvest	2nd day	4th day	6th day	At harvest	2nd day	4th day	6th day
T_1	6.87	6.73	6.69	6.67	7.59	7.61	7.67	7.62
T_2	6.77	6.78	6.74	6.71	7.47	7.52	7.54	7.47
T_3	7.67	7.64	7.60	7.55	7.75	7.82	7.86	7.82
T_4	7.37	7.32	7.28	7.26	7.65	7.73	7.75	7.69
T_5	8.00	7.99	7.97	7.94	8.08	8.13	8.15	8.12
T_6	7.83	7.79	7.77	7.76	7.97	8.03	8.05	8.02
T_7	6.57	6.50	6.44	6.40	7.12	7.24	7.28	7.24
T_8	6.43	6.41	6.35	6.33	6.90	7.03	7.06	7.01
T_9	6.77	6.73	6.69	6.65	7.37	7.42	7.44	7.39
T_{10}	6.62	6.59	6.53	6.50	7.30	7.39	7.41	7.33
T_{11}	7.15	7.13	7.08	7.06	7.35	7.31	7.34	7.27
T_{12}	6.02	5.97	5.90	5.87	6.77	6.73	6.75	6.68
T_{13}	6.48	6.40	6.37	6.33	6.77	6.82	6.85	6.78
T_{14}	5.17	5.15	5.11	5.07	5.04	5.07	5.09	5.05
T_{15}	6.43	6.38	6.33	6.30	6.87	6.90	6.95	6.86
T_{16}	6.38	6.37	6.30	6.28	6.82	6.86	6.89	6.83
T_{17}	7.17	7.09	7.06	7.04	7.33	7.40	7.47	7.42
T_{18}	6.17	6.04	6.01	5.99	6.53	6.54	6.68	6.51
S.Em. ±	0.20	0.19	0.21	0.21	0.21	0.22	0.22	0.21
C.D. at 5%	0.58	0.56	0.60	0.61	0.61	0.62	0.62	0.61
C.V.%	5.12	5.02	5.44	5.55	5.15	5.19	5.16	5.14

Significantly, higher fruit volume (133.33, 130.67, 121.67 and 116.77 cm^3) was recorded registered under GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% at harvest, 2nd, 4th and 6th day interval, respectively. Whereas, minimum fruit volume (54.94, 52.67, 49.67 and 41.67 cm^3) was recorded under GA_3 @150 ppm + $CaCl_2$ @1% + borax @ 0.4% on at harvest, 2nd, 4th and 6th day interval, respectively. The increase in fruit volume due to accelerated rate of fruit growth, cell division and cell enlargement and more intercellular space with the application of higher concentration of growth substances and It might be due to the fact that calcium decreases the loss of weight by maintenance of the fruit firmness, retardation of respiratory rate and delayed senescence (Yadav *et al.* 2009) [21]. An increase in fruit volume might be due to involvement of micronutrients in cell division, cell expansion and increase volume of intercellular spaces in mesocarpic cells. It is conformity with the results of Singh *et al.* (2009) [18], Jadav (2014) [8] in guava and Yadav *et al.* (2009) [21] in ber.

Table 2: The effect of PGR ad chemicals on fruit volume and weight of custard apple

Sr. no.	Fruit volume (cm^3)				Fruit weight (g)			
	At harvest	2nd day	2nd day	4th day	At harvest	2nd day	4th day	6th day
T_1	104.00	98.00	90.33	84.67	160.00	154.41	146.29	140.01
T_2	101.33	93.67	89.33	81.33	156.17	150.45	142.70	135.35
T_3	119.67	117.00	113.33	105.33	171.78	166.65	157.47	150.52
T_4	112.00	110.00	101.33	94.67	165.00	159.44	150.95	144.41
T_5	133.33	130.67	121.67	116.77	182.67	178.07	168.96	160.83
T_6	126.00	123.00	117.00	100.00	177.33	172.57	163.74	155.68
T_7	89.33	83.00	76.33	69.33	149.67	142.19	136.40	130.36

T_8	81.67	76.00	72.67	66.33	148.00	140.12	134.65	128.77
T_9	98.33	94.00	89.00	80.67	155.00	148.81	141.52	135.23
T_{10}	92.67	89.33	83.67	73.67	154.67	147.90	141.04	134.75
T_{11}	120.33	117.33	105.00	100.00	172.00	166.67	158.35	150.77
T_{12}	96.67	90.33	81.33	76.00	147.41	142.83	135.66	129.18
T_{13}	77.33	75.33	71.33	68.67	147.33	139.97	133.87	127.98
T_{14}	54.94	52.67	49.67	41.67	107.56	100.75	95.47	90.28
T_{15}	79.33	75.33	69.00	64.00	145.00	137.50	131.90	126.08
T_{16}	75.37	71.67	68.67	60.00	144.00	136.39	130.94	125.11
T_{17}	110.00	108.33	98.33	92.67	171.67	166.08	158.05	150.64
T_{18}	93.33	89.67	79.33	69.67	152.92	147.52	140.43	133.86
S.Em. ±	2.99	3.03	2.87	2.80	5.07	4.65	4.69	4.44
C.D. at 5%	8.59	8.72	8.24	8.03	14.57	13.35	13.49	12.76
C.V.%	5.28	5.58	5.67	6.03	5.63	5.37	5.70	5.65

Maximum fruit weight (182.67, 178.07, 168.96 and 160.83 g) was found with GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% on at harvest, 2nd, 4th and 6th day interval, respectively. Whereas, minimum fruit weight (107.56, 100.75, 95.47 and 90.28 g) on at harvest, 2nd, 4th and 6th day interval, respectively with GA_3 @ 150 ppm + $CaCl_2$ @ 1% + borax @ 0.4%. Calcium might be faster the mobilization of metabolites in the fruits and involvement in cell division and cell expansion as well as increase in the volume of intercellular space in mesocarpic cells and borax spray increased fruit weight because it is an essential micronutrient and it is considered indispensable for the growth of all organisms. Similar result was also reported by Jagtap *et al.* (2013) [9] in Kagzi lime, Kirmani *et al*. (2013) [12] in plum, Patidar (2017) [16] in custard apple and Yadav *et al*. (2017) in guava [22].

The lower physiological loss in weight (2.52, 7.51 and 11.96%) was found in GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% (182.67, 178.07, 168.96 and 160.83 g) on at 2nd, 4th and 6th day interval, respectively. Whereas, the highest physiological loss in weight (6.33, 11.23 and 16.04%) on at 2nd, 4th and 6th day interval, respectively was recorded with GA_3 @150 ppm + $CaCl_2$ @1% + borax @ 0.4%. The reduction in weight loss possibly due to reduced loss in moisture through transpiration, it may also be due to lower respiration rate and metabolic process and the decrease in weight loss by application of calcium might be due to its role in the maintenance of the fruit firmness, retardation of respiratory rate and delayed senescence (Yadav *et al.* 2009) [21]. Sudhavani and Ravishankar (2002) [19] in mango, Kumar *et al*. (2005) [13] in aonla, Chahal *et al*. (2012) [3] and Deepa *et al*. (2018) [6] in pomegranate. The physiological loss in weight of fruit increased as the storage period advanced irrespective of any treatment.

Similarly, minimum spoilage (20.00 and 33.33%) was registered in GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% on at 4th and 6th day of storage, respectively. Whereas maximum spoilage (62.56 and 88.88%) was observed in GA_3 @ 150 ppm + $CaCl_2$ @ 1% + borax @ 0.4% on at 4th and 6th day of storage, respectively. The spoilage of custard apple fruits increased as the storage period advanced irrespective of any treatment. The reduction in weight loss possibly due to reduced loss in moisture through transpiration, it may also be also due to lower respiration rate and metabolic process. It might be due to calcium compounds significantly thickened middle lamella of fruit cells owing to increased deposition of calcium pectate and thereby maintained the cell wall rigidity which inhibits the penetration and spread of pathogens in fruits (Gupta *et al*. 1987) [7]. Similar result has also been reported by Jawandha *et al.* (2007) [10], Yadav *et al.* (2009) [21] in ber and Bagul (2016) [1] in custard apple.

The maximum marketable fruit (80.00 and 66.67%) was registered in GA3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% on at 4th and 6th day of storage, respectively. Whereas the minimum marketable fruit (37.44 and 11.12%) for 4th and 6th day, respectively with GA_3 @ 150 ppm + $CaCl_2$ @ 1% + borax @ 0.4%. The increase in fruit marketability might be due decrease in production of ethylene which is responsible for the fast ripening of fruits improved fruit colour development and appearance (Cheour *et al.*, 1990) [5]. The higher percentage of marketable fruits was obtained only when there had been reduction loss in weight, spoilage and quality of the fruits with respect to chemical constituents. Also similar results were obtained by Karemera and Habimana (2014) [11] and Patel *et al.* (2015) [15] in mango.

There was a significant difference among the various treatments with regards to shelf life. The maximum shelf life (6.67 days) was fond with GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2%. The minimum shelf life (2.45 days) was found with GA_3 @ 150 ppm + $CaCl_2$ @ 1% + borax @ 0.4%. It is true that the storage life or keeping quality of fruit are decreased as storage period increased. May be due to fast rate of physiological process like ripening. Gibberellins retarded ripening and thereby increase shelf life calcium also plays a number of roles such as an increase in the fruit firmness which leads benefits like slower ripening and increased the shelf life and boron has indirect effect on shelf life. The present investigation is in conformity with the results reported by Karemera and Habimana (2014) [11] in mango and Deepa *et al.* (2018) [6] in pomegranate.

Table 3: The effect of PGR ad chemicals on PLW, spoilage, marketable fruit and shelf life of custard apple

Sr. no.	PLW (%)			Spoilage (%)		Marketable fruit (%)		Shelf life
	2nd day	4th day	6th day	4th day	6th day	4th day	6th day	
T_1	3.51	8.57	12.51	28.89	46.67	71.11	53.33	5.67
T_2	3.67	8.62	12.68	33.33	53.33	66.66	46.67	5.33
T_3	3.00	8.33	12.39	24.45	42.22	75.55	57.78	6.33
T_4	3.36	8.52	12.48	26.67	44.45	73.33	55.55	6.00
T_5	2.52	7.51	11.96	20.00	33.33	80.00	66.67	6.67
T_6	2.69	7.67	12.22	24.45	40.00	75.55	60.00	6.33
T_7	5.00	8.86	12.90	37.78	60.00	62.22	40.00	5.33

T_8	5.33	9.03	13.01	42.22	64.45	57.78	35.55	5.00
T_9	3.99	8.77	12.78	35.55	53.33	64.45	46.67	5.67
T_{10}	4.38	8.83	12.86	37.78	55.55	62.22	44.45	5.67
T_{11}	3.10	7.93	12.35	22.22	42.22	77.78	57.78	6.33
T_{12}	3.11	7.97	12.36	24.44	44.45	75.56	55.55	6.00
T_{13}	5.00	9.13	13.06	44.45	71.11	55.55	28.89	5.00
T_{14}	6.33	11.23	16.04	62.56	88.88	37.44	11.12	2.45
T_{15}	5.17	9.03	13.05	40.00	68.89	60.00	31.11	4.67
T_{16}	5.28	9.07	13.12	42.22	71.11	57.78	28.89	4.00
T_{17}	3.25	7.93	12.25	24.45	46.67	75.55	53.33	6.33
T_{18}	3.53	8.17	12.47	28.89	51.11	71.11	48.89	5.67
S.Em. ±	0.13	0.26	0.38	1.53	1.75	1.92	1.75	0.24
C.D. at 5%	0.38	0.74	1.08	4.39	5.04	5.53	5.04	0.70
C.V.%	5.68	5.63	5.11	7.93	5.59	5.00	6.64	7.70

Conclusion

From the forgoing discussion it can be concluded that spray of GA_3 @ 50 ppm + $CaCl_2$ @ 2% + borax @ 0.2% extend the shelf life up to 6.67 days by maintaining the physical and physiological parameters under ambient storage condition.

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