Original Research Article

"Studies on the effect of plant growth regulators on physical parameters of sapota [*Manilkaraachras* (Mill.) Forsberg] cv. Cricket Ball under Agro-climatic condition of Chhattisgarh plains"

ABSTRACT

The present investigation was undertaken during the year 2020-21 and 2021-22 at experimental field of Horticulture ~~instructional~~ Instructional Farm, Department of Fruit Science, College of Agriculture, IGKV, Raipur (C.G.), India. The experiment was conducted on twenty years old trees of sapota cv. Cricket Ball with foliar spray of different concentrations of plant growth regulators applied at 50 per cent flowering and pea stage of fruit growth. The experiment was laid out in Randomized Block Design with ~~having~~ twenty five treatments, and three replication for each treatment. ~~which replicates thrice.~~Thus, a total of 75 data collection made available at each time. Physical parameters of fruit *viz.,* fruit weight (126.36 g), fruit volume (121.59 ml), fruit diameter (6.69 cm), fruit length (6.92 cm) and pulp weight (112.61 g) of sapota fruits were increased considerably with the treatment GA_3 @ 150 ppm, while, the peel weight (8.79 g) was reduced under the same treatment. The specific gravity (1.045 g ml^{-1}) was recorded maximum under the treatment ethrel @ 1000 ppm. However, a reduction in number of seeds per fruit (4.50) and seed weight (4.38 g) was observed by the foliar feeding of NAA @ 100 ppm treatment. What was the main findings that support the main objective of the study?

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Comment [U2]: Asingle value indicates absolute value and thus missess the variations in value. Thus, better to give the ranges i.e 126.36g ± 3.0g and etc for the given values.

Comment [U3]: This is less scientifc and not clear representation on what is meant by considerable.

Keywords: *CCC, foliar feeding,GA_3, NAA, physical parameters*

1. INTRODUCTION

Sapota[*Manilkaraachras* (Mill.) Forsberg] an evergreen fruit tree, generally known as chiku in India, belongs to family Sapotaceae and is native fruit of tropical America specially the Southern Mexico and Central America. It is getting popular in countries *viz.,* India, Srilanka, Jamaica, Burma, Philippines, Central Asia and Southern Florida. Many fruit growers were attracted to the cultivation of sapota on account of its better adaptation to diverse soil and climatic conditions. It prefers a humid tropical climate having high humidity, abundant rainfall and moderate winters. It requires 125-250 cm of yearly rainfall and a temperature range of 11–34 °C. As a result, the coastal climate is suitable for its cultivation.

The unripe fruit produce milky white product after drying, which is base material for making Chickle, it is also known as "Gataparcha" is commercially produced. It is mainly used as dessert fruits bedside many processed products are prepared from sapota namely Halwa, Juice, Milk Shake, Shrikhand, fruit Jam. Mature fruits are used for making mixed fruits jams and provide a valuable source of raw materials for manufacture of industrial glucose, protein and natural fruits jellies.

India is considered to be the largest producer of sapota in the world. In India, sapota cultivation covers 163.90 thousand hectares (2.34%) of fruit area, producing 1495 thousand metric tonnes (1.83%) of fruit production with a productivity of 9.1 metric tonnes per hectare [3]. Maharashtra, Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala, Uttar Pradesh, West Bengal, Punjab, Haryana and some humid regions of Rajasthan are among the regions in which it is commercially cultivated.

In Chhattisgarh, total area under sapota is 340 hectares with an annual production of 1578 metric tonnes[3]. The remarkable expansion in area reveals grower's readiness to embrace this fruit in exchange for significant financial rewards. Growth regulating chemicals govern all stages of crop development by using these at particular stage of fruit growth and development to have its maximum effect. Different concentrations of plant growth regulators like - synthetic auxin, gibberellin and CCC have been reported to increase the physic-chemical parameters *i.e.* fruit length, fruit diameter, fruit volume, specific gravity, average pulp weight, average peel weight, number of seeds per fruit,seed weight per fruit and weight of fruit in sapota[5].

Amongst different synthetic auxins, NAA seems to be most useful in terms of fruit setting and fruit retention in sapota. Likewise, CCC and GA_3 was found to enhance the number of flowers and number of fruits per tree [1].

2. MATERIAL AND METHODS

2.1 Experimental Set Up - The present investigation was carried out during the year 2020-21 and 2021-22 at experimental field of Horticulture instructional Farm, Department of Fruit Science College of Agriculture, IGKV, Raipur (C.G.). Raipur district comes under dry, sub-humid agro-climatic region. The place receives an annual rainfall of 1200-1400 mm most of which (85%) is received from third week of June to mid September and very little during October and February. The maximum temperature goes as high as 42.5^{0}C during summer and minimum as below 7.0 ^{0}C during winter months. The soil of experimental field was clay-loam, which is locally known as *Dorsa* in the region.

The experimental trees used were twenty year old trees of sapota variety Cricket Ball spaced at 10 x 10 metres. The treatments consisted different concentration of plant growth regulators applied at 50 per cent flowering and pea stages. The spraying was done on third week of August at 50 per cent flowering stage and last week of September at pea stage in both the years. As the plants selected in the orchard are maintained under uniform cultural practise (disk harrow ploughing, check basin irrigation, use of plant protection measures, as observed).

2.1.1 Statistical Analysis -The experiment was laid out in Randomized Block Design having twenty five treatments, which replicates thrice.The statistical analysis was carried out for each observed character under the study using MS-Excel, OPSTAT. The data investigations were analyzedas help to book by Gomez and Gomez. [8]

2.1.1.1 ***Tree Characters*** - Under physical parameters, the observations *i.e.* fruit weight(g), fruit diameter (cm), fruit length (cm), fruit volume (ml), specific gravity (g ml^{-1}), pulp weight (g), peel weight (g), number of seeds per fruit and seed weight per fruit (g). What was the weighing equipment used for the weight measurement?

3. RESULTS AND DISCUSSION

The results pertaining to various aspects of physical parameters of fruit are summarized as follows:

Fruit weight (g)

During first year, second year and comparing the results of pooled data, the maximum average fruit weight 128.69, 124.03 and 126.36 g was recorded under the treatment GA_3 @ 150 ppm at 50 per cent flowering + pea stage, which was found non-significant differences with the treatments T_9& T_{10} and T_9 having respective average fruit weights 123.43 & 121.00 and 124.42 g during second year as well as pooled mean. However the minimum average fruit weight 96.47, 94.11 and 95.29 g was observed under the untreated control. The foliar spray of GA_3 at flowering increases cell elongation by enlargement of vacuoles and loosens the cell wall and increases its plasticity which eventually increased fruit weight. The above findings are in close conformity with the results of Singh et al.[13].

Fruit diameter (cm)

During first year, second year and as per the result of pooled mean is concerned, the maximumfruit diameter 6.88, 6.96 and 6.92 cm was noticed under the treatment GA_3 @150 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments T_9, T_6, T_5, T_3& T_8 and T_9, T_6, T_3, T_{10} &T_{11} and T_9, T_6, T_3, T_5& T_8 having respective fruit diameters of 6.62, 6.60, 6.50, 6.49 & 6.48 cm and 6.88, 6.83, 6.70, 6.68 & 6.66 cm and 6.75, 6.71, 6.60, 6.58 & 6.55 cm. However the minimum fruit diameter 5.17, 5.04 and 5.36 cm was registered under the control. The increased fruit diameter might be due to exogenous application of NAA and GA_3 that caused cell elongation by enlargement of vacuoles and loosening of cell wall after increasing its plasticity. The results are in close conformity with the findings of Jain et al.[9] and Akshayet al.[2].

Fruit length (cm)

Result obtained during first year, second year and as per the result of pooled mean is concerned, the maximum fruit length 6.42, 6.69 and 6.55 cm was noticed under the treatment GA_3 @ 100 ppm at 50 per cent flowering + pea stage, which was found statistically on par with the treatments T_{12}, T_6, T_3, T_5& T_8 and T_9, T_3, T_5, T_7 &T_6 and T_9, T_3, T_6, T_5& T_8 having fruit lengths 6.41, 6.37, 6.24, 6.22 & 6.21 cm and 6.62, 6.62, 6.41, 6.38 & 6.30 and 6.52, 6.43, 6.33, 6.31 & 6.25 cm, respectively. However, the minimum fruit length 5.07, 4.76 and 4.91 cm was noticed under the untreated control. Increase in length of fruit by GA_3 application was probably due to an increase in the volume of mesocarp cells. The above findings are in close conformity with the results obtained by Patilet al.[12].

Fruit volume (ml)

Result obtained during first year, second year and as per the result of pooled mean is concerned, the maximum fruit volume 123.73, 119.44 and 121.59 ml was noticed under the treatment GA_3 @ 150 ppm at 50 per cent flowering + pea stage, which was found non-significant with the treatments T_9 and T_9& T_{10} andT_9 having fruit volume of 120.97 and 119.27 & 116.84 and 120.12 ml, respectively. However the minimum fruit volume 93.63, 91.41 and 92.52 ml was registered under

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Comment [U5]: Based on Koppen climatic classification or what?

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Comment [U8]: High variation of temperature, thus the timeline of the study with the temperature variation (humidity/solar radiation and etc.) amy affect the findings. In not included in the study, at least worth mentioning in the discussion.

Comment [U9]: Based on which classification system?

Comment [U10]: Not clear.

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Comment [U13]: Better state the month/year. Same comments throughout text for this sentence.

Comment [U14]: Data presentation need to be revised.

Comment [U15]: Syntax error

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the control. The increased in volume of the fruit due to increase size of fruit by application of GA_3 increased size of fruit by cell elongation. Similar findings have also been obtained by Bhujbalet al.[5].

Specific gravity (g ml^{-1})

It is evident from the data of first year, second year and pooled mean, the maximum specific gravity 1.046, 1.040 and 1.040 g ml^{-1} was seen under the treatment ethrel @ 1000 ppm at 50 per cent flowering + pea stage, which also showed statistically on par with the treatmentT_{15}, T_{18}, T_{13}, T_{17}, T_6&T_{14} and T_{15}, T_{18}, T_{13}, T_{17}, T_6& T_{14} and T_{15}, T_{18}, T_{13}, T_{17}, T_{14}& T_6 having specific gravity of 1.045, 1.045, 1.044, 1.043, 1.042 & 1.042 and 1.044, 1.043, 1.043, 1.041, 1.041 & 1.039 and 1.045, 1.044, 1.044, 1.043, 1.042 & 1.041 g ml^{-1}, respectively. However the minimum specific gravity 1.031, 1.029 and 1.030 g ml^{-1} was registered under the control. The increase in specific gravity of the fruit may be due to increase in either flesh or stone or in fruit weight Gibberellins and ethrel are mainly involved in the subsequent phases of cell expansion of fruits, after cell division. The findings of present investigation are in accordance with Daberaoet al.[6].

Pulp weight (g)

Results based on first year, second year and pooled mean, the maximum average pulp weight was 115.19, 110.03 and 112.61 g was recorded under the treatment GA_3 @ 150 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments T_9& $T_{10}$and T_9having average respective pulp weights 109.58 & 107.00 and 110.12 g during second year as well as pooled mean. However the minimum pulp weight 80.87, 78.52 and 79.69 g was observed untreated the control. This might be due to higher accumulation and translocation of extra metabolites from other parts of the plant towards developing fruits. Similar findings have also been obtained by Kavyashreeet al. [11].

Peel weight (g)

During first year, second year and as per the result of pooled data is concerned, the minimum peel weight 8.61, 8.88 and 8.79 g, was registered under the treatment GA_3 @ 150 ppm at 50 per cent flowering + pea stage, which showed significantly at par with the treatment $T_{12,}$ T_{24}, $T_{19,}$ T_3& T_1 and $T_{12,}$ T_9, $T_{3,}$ T_2 & T_5 having respective average peel weights 8.98, 9.00, 9.00, 9.00 & 9.09 g and 9.15, 9.24, 9.25, 9.26 and 9.29 g, during second year as well as pooled mean. However the maximum average peel weight 10.51, 10.35 and 10.43 g was noticed under the control. The present findings are in close conformity with the results of Joshi et al. [10].

Number of seeds per fruit

During first year, second year and of investigation, findings obtained on the basis of pooled data, the minimum number of seeds per fruit 4.66, 4.33 and 4.50 was registered under the treatment NAA @ 100 ppm at 50 per cent flowering stage, which showed statistically at par with the treatment $T_{12,}$ T_4, T_{21}& T_{23} and $T_{12,}$ T_4, T_{23}& T_6 and $T_{12,}$ T_4, $T_{23,}$ T_6 & T_{15} having respective number of seeds per fruit 4.75, 4.83, 4.91 & 5.08 and 5.00, 5.16, 5.33 & 5.33 and 4.87, 5.00, 5.20, 5.25 & 5.29, while the maximum number of seeds per fruit 6.66, 6.50 and 6.58 was observed under the control. The reduction in number of seeds may probably be due to the parthenocarpic fruit development stimulated by these hormonal sprays. Similar findings have also been obtained by Jain et al. [9].

Seed weight per fruit (g)

Results on the basis of first year, second year and pooled mean, the minimum seed weight per fruit 4.18, 4.43 and 4.38 g was observed under the treatment NAA @ 100 ppm at pea stage, which showed statistically at par with the treatment T_4, T_3& T_9 and T_7, T_{11}& T_3 and $T_{1,}$ $T_{11,}$ T_4& T_5 having respective seed weight per fruit 4.18, 4.28 & 4.31 g and 4.43, 4.44 & 4.45 g and 4.41, 4.42, 4.45 and 4.47 g. However the maximum seed weight per fruit 5.08, 5.24 and 5.16 g was observed under the control. The reason behind increased seed weight with increased NAA application enhances the auxin level of plant, which more synthesized in seeds as compared to vegetative part, hence ultimately increased seed weight. Similar findings have also been obtained by Desai et al. [7] and Bagulet al.[4].

Table 1: Effect of foliar feeding of different concentrations of plant growth regulators on average fruit weight (g), fruit diameter (cm), fruit length (cm), fruit volume (ml) and specific gravity (g/ml) of sapota cv. Cricket Ball

Treatments	Average fruit weight (g)			Fruit diameter (cm)			Fruit length (cm)			Fruit volume (ml)			Specific gravity (g/ml)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_0 - Control (water spray)	96.47 n	94.11 m	95.29 m	5.17 d	5.04 g	5.36 f	5.07 d	4.76 i	4.91 i	93.63 l	91.41 n	92.52 k	1.031 a	1.029 a	1.030 a
T_1 - NAA @ 100 ppm at 50% flowering stage	113.27 hi	107.12 ghi	110.19 hi	6.00 bcd	6.28 bcde	6.14 abcdef	5.83 abc d	5.89 bc def	5.86 a bcdefgh	109.14 gh	103.52 ijk	106.33 hi	1.038 a	1.035 a	1.036 a
T_2 - NAA @ 100 ppm at pea stage	112.96 i	105.82 hij	109.39 i	6.14 bcd	6.23 bcde	6.19 abcdef	5.94 abc d	5.65 de fgh	5.79 b cdefgh	109.03 gh	102.3 k	105.66 i	1.036 a	1.034 a	1.035 a
T_3 -NAA @ 100 ppm at 50% flowering + pea stage	121.15 cd	111.36 ef	116.25 ef	6.49 b	6.70 b	6.60 ab	6.24 abc	6.62 a	6.43 a bc	116.48 cd	107.3 gh	111.89 fg	1.040 a	1.038 a	1.039 a
T_4 -NAA @ 200 ppm at 50% flowering stage	116.74 efg	116.5 cd	116.62 ef	6.29 bc	6.59 bcd	6.44 abc	6.17 abc	6.08 ab cde	6.12 a bcdefg	112.26 fg	112.47 cde	112.36 ef	1.040 a	1.036 a	1.038 a
T_5 -NAA @ 200 ppm at pea stage	119.99 cde	113.84 de	116.92 ef	6.50 b	6.66 bc	6.58 ab	6.22 abc	6.41 ab	6.31 a bcd	115.48 cdef	109.88 efg	112.68 ef	1.039 a	1.036 a	1.038 a
T_6 -NAA @ 200 ppm at 50%	122.1	118.0	120.1	6.60 a	6.83 a	6.71	6.37 ab	6.30 ab	6.33 a	117.2	113.6	115.4	1.042	1.039	1.04

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Same comments goes to all other studied parameters throughout the text.

Comment [U20]: The authors states that many of their data is in aacordance/conformity/similar with several previous study, however from reveiewer perspective, it remains unclear the connectivity of this present study and referenced studies.

Comment [U21]: Same as above.

flowering + pea stage	9^{bcd}	3^{bc}	1^{cd}	b	b	a		c	bcd	7^{cd}	cd	3de	a	a	0^{a}
T_7 - GA_3 @ 100 ppm at 50% flowering stage	120.71^{cd}	116.7cd	118.71^{de}	6.21^{a}bc	6.61^{a}bcd	6.41abcd	5.98^{abc}d	6.38^{ab}	6.18^{a}bcdef	116.6cd	112.79^{cde}	114.69^{ef}	1.036a	1.034a	1.035^{a}
T_8 -GA_3 @ 100 ppm at pea stage	116.51^{fgh}	118.02^{bc}	117.26^{de}	6.48^{a}b	6.62^{a}bcd	6.55ab	6.21^{abc}	6.29^{ab}c	6.25^{a}bcde	112.71^{ef}	114.27^{bc}	113.49^{ef}	1.035a	1.033a	1.034^{a}
T_9 -GA_3 @ 100 ppm at 50% flowering + pea stage	125.41^{b}	123.43^{a}	124.42^{ab}	6.62^{a}b	6.88^{a}	6.75a	6.42^{a}	6.62^{a}	6.52^{a}b	120.97^{ab}	119.27^{a}	120.12^{bc}	1.037a	1.035a	1.036^{a}
T_{10} -GA_3 @ 150 ppm at 50% flowering stage	123.12^{bc}	121^{ab}	122.06^{bc}	6.21^{a}bc	6.68^{a}bc	6.45abc	6.05^{abc}d	6.22^{ab}cd	6.14^{a}bcdefg	118.84^{bc}	116.84^{ab}	117.84^{cd}	1.037a	1.035a	1.036^{a}
T_{11} -GA_3 @ 150 ppm at pea stage	119.66^{cdef}	118.81^{bc}	119.24^{cde}	6.44^{a}b	6.66^{a}bc	6.55ab	6.14^{abc}	6.29^{ab}c	6.21^{a}bcde	115.63^{cde}	114.89^{bc}	115.26^{de}	1.036a	1.034a	1.035^{a}
T_{12} -GA_3 @ 150 ppm at 50% flowering + pea stage	128.69^{a}	124.03^{a}	126.36^{a}	6.88^{a}	6.96^{a}	6.92a	6.41^{a}	6.69^{a}	6.55^{a}	123.73^{a}	119.44^{a}	121.59^{b}	1.040a	1.038a	1.039^{a}
T_{13} -Ethrel @ 500 ppm at 50% flowering + pea stage	99.34mn	98.37^{l}	98.85^{l}	5.91^{a}bcd	5.29^{fg}	5.60def	5.57^{abc}d	5.01^{hi}	5.29^{hi}	95.13kl	94.46n	94.79k	1.044a	1.041a	1.043^{a}
T_{14} -Ethrel @ 500 ppm at pea stage	101.01^{lm}	97.28^{l}m	99.15^{l}	5.67^{bc}d	5.34^{fg}	5.51ef	5.33^{cd}	5.15^{gh}i	5.24^{hi}	96.92^{j}kl	93.62n	95.27k	1.042a	1.039a	1.041^{a}
T_{15} -Ethrel @ 500 ppm at 50% flowering + pea stage	103.82^{jkl}	102.15^{k}	102.99^{k}	5.75^{bc}d	5.59^{ef}g	5.67cdef	5.62^{abc}d	5.26^{fg}hi	5.44^{fg}hi	99.31^{j}	97.85m	98.58^{j}	1.045a	1.043a	1.044^{a}
T_{16} -Ethrel @ 1000 ppm at 50% flowering stage	103.57^{kl}	103.29^{jk}	103.43^{k}	5.41^{cd}	5.44^{fg}	5.42ef	5.25^{cd}	5.05^{hi}	5.15^{hi}	99.01^{j}m	98.99^{j}	99^{j}	1.046a	1.044a	1.045^{a}
T_{17} -Ethrel @ 1000 ppm at pea stage	102.07^{lm}	108.49^{fgh}	105.28^{ijk}	5.33^{cd}	5.59^{ef}g	5.46ef	5.25^{cd}	5.18^{gh}i	5.21^{hi}	97.85^{j}k	104.17^{ijk}	101.01^{j}	1.043a	1.041a	1.042^{a}
T_{18} -Ethrel @ 1000 ppm at 50% flowering + pea stage	114.28^{ghi}	113.82^{de}	114.05^{fg}	5.68^{bc}d	5.71^{ef}g	5.69cdef	5.34^{cd}	5.51^{ef}gh	5.42^{g}hi	109.32^{gh}	108.93^{fg}	109.13^{gh}	1.045a	1.043a	1.044^{a}
T_{19} -Cycocel @ 200 ppm at 50% flowering stage	101.59^{lm}	104.5^{l}jk	103.04^{k}	5.81^{bc}d	5.63^{ef}g	5.72cdef	5.76^{abc}d	5.48^{ef}gh	5.62^{d}efghi	98.22^{j}k	101.17^{kl}	99.7^{j}	1.035a	1.033a	1.034^{a}
T_{20} -Cycocel @ 200 ppm at pea stage	100.49^{lm}	106.38^{ghij}	103.43^{k}	5.67^{bc}d	5.74^{ef}g	5.45ef	5.40^{bcd}	5.43^{fg}h	5.42^{g}hi	97.22^{j}k	103.13^{ijk}	100.18^{j}	1.034a	1.031a	1.033^{a}
T_{21} -Cycocel @ 200 ppm at 50% flowering+ pea stage	106.09^{ijk}	109.56^{fg}	107.82^{ij}	5.65^{bc}d	5.90^{cd}ef	5.77bcdef	5.44^{abc}d	5.42^{fg}h	5.43^{g}hi	102.36^{i}	105.84^{hi}	104.1^{i}	1.037a	1.035a	1.036^{a}
T_{22} -Cycocel @ 400 ppm at 50% flowering stage	107.05^{j}	109.1fg	108.08^{ij}	5.71^{bc}d	5.84^{d}efg	5.77bcdef	5.49^{abc}d	5.53^{ef}gh	5.51^{ef}ghi	103.37^{i}	105.34^{hij}	104.35^{i}	1.036a	1.034a	1.035^{a}
T_{23} -Cycocel @ 400 ppm at pea stage	111.58^{i}	114.14^{de}	112.86^{gh}	5.77^{bc}d	5.91^{cd}ef	5.84bcdef	5.51^{abc}d	5.74^{cd}efg	5.63^{d}efghi	107.68^{h}	110.43^{def}	109.05^{gh}	1.036a	1.034a	1.035^{a}
T_{24} -Cycocel @ 400 ppm at 50% flowering + pea stage	118.98^{def}	117.33^{c}	118.15^{de}	6.47^{a}b	6.04^{bc}def	6.25abcde	5.93^{abc}d	5.61^{ef}gh	5.77^{c}defgh	114.5def	113.11^{cd}	113.81^{ef}	1.039a	1.037a	1.038^{a}
SE(m)±	**3.35**	**3.00**	**2.58**	**0.250**	**0.105**	**0.144**	**0.264**	**0.160**	**0.179**	**3.210**	**2.918**	**3.080**	**0.003**	**0.001**	**0.002**
CD at 5%	**9.55**	**8.56**	**7.36**	**0.714**	**0.299**	**0.411**	**0.753**	**0.456**	**0.511**	**9.155**	**8.322**	**8.785**	**0.006**	**0.003**	**0.004**

**The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level. These letters have been affixed based on CD- value comparison of treatment means.*

Table 2: Effect of foliar feeding of different concentrations of plant growth regulators on average pulp weight (g), average peel weight (g), number of seed per fruit and seed weight per fruit (g) of sapota cv. Cricket Ball

Treatments	Average pulp weight (g)			Average peel weight (g)			Number of seed per fruit			Seed weight per fruit (g)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_0 - Control (water spray)	80.87^{n}	78.52^{l}	79.69^{k}	10.51^{a}	10.51^{a}	10.51^{a}	6.66^{a}	6.50^{a}	6.58^{a}	5.08^{a}	5.24^{a}	5.16^{a}
T_1 - NAA @ 100 ppm at 50% flowering stage	99.39^{hi}	93.54^{gh}	96.46^{fgh}	9.51^{abcd}	9.51^{abcd}	9.51^{abcd}	4.66^{g}	4.33^{d}	4.50^{e}	4.36^{defg}	4.49^{b}	4.42^{b}
T_2 - NAA @ 100 ppm at pea stage	98.94^{hi}	92.5^{gh}	95.72^{gh}	9.62^{abcd}	9.62^{abcd}	9.62^{abcd}	5.58^{bcdefg}	5.33^{abcd}	5.45^{bcde}	4.38^{cdefg}	4.43^{b}	4.41^{b}
T_3 -NAA @ 100 ppm at 50% flowering + pea stage	107.35^{bcde}	97.91^{ef}	102.63^{e}	9.48^{abcd}	9.48^{abcd}	9.48^{abcd}	5.91^{abcd}	5.41^{abcd}	5.66^{abcd}	4.31^{efg}	4.45^{b}	4.38^{b}
T_4 -NAA @ 200 ppm at 50% flowering stage	102.98^{fg}	102.7^{cd}	102.84^{e}	9.48^{abcd}	9.48^{abcd}	9.48^{abcd}	4.83^{efg}	5.16^{bcd}	5.00^{cde}	4.28^{fg}	4.66^{ab}	4.47^{b}
T_5 -NAA @ 200 ppm at pea stage	106.22^{cdef}	100.09^{de}	103.16^{e}	9.39^{bcd}	9.39^{bcd}	9.39^{bcd}	5.50^{bcdefg}	5.66^{abc}	5.58^{abcd}	4.38^{defg}	4.61^{ab}	4.49^{b}
T_6 -NAA @ 200 ppm at 50% flowering + pea stage	109.39^{bc}	104.21^{bc}	106.8^{cd}	10.28^{ab}	10.28^{ab}	10.28^{ab}	5.16^{cdefg}	5.33^{abcd}	5.25^{bcde}	4.48^{bcdefg}	4.70^{ab}	4.59^{b}
T_7 - GA_3 @ 100 ppm at 50%	105.85^{def}	103^{cd}	104.43^{de}	10.31^{ab}	10.31^{ab}	10.31^{ab}	5.33^{cdefg}	5.83^{abc}	5.58^{abcd}	4.55^{bcdef}	4.44^{b}	4.49^{b}

flowering stage												
T_8 -GA_3 @ 100 ppm at pea stage	101.48^{gh}	104.22^{bc}	102.85^{e}	10.41^{ab}	10.41^{ab}	10.41^{ab}	5.91^{abcd}	5.75^{abc}	5.83^{abcd}	4.62^{bcde}	4.52^{ab}	4.57^{b}
T_9 -GA_3 @ 100 ppm at 50% flowering + pea stage	110.65^{b}	109.58^{a}	110.12^{ab}	9.14^{cd}	9.14^{cd}	9.14^{cd}	5.50^{bcdefg}	5.41^{abcd}	5.45^{bcde}	4.35^{defg}	4.83^{ab}	4.59^{b}
T_{10} -GA_3 @ 150 ppm at 50% flowering stage	109.1^{bcd}	107^{ab}	108.05^{bc}	9.55^{abcd}	9.55^{abcd}	9.55^{abcd}	5.91^{abcd}	5.50^{abcd}	5.70^{abcd}	4.46^{bcdefg}	4.69^{ab}	4.58^{b}
T_{11} -GA_3 @ 150 ppm at pea stage	105.37^{ef}	105.1^{bc}	105.23^{cde}	9.83^{abc}	9.83^{abc}	9.83^{abc}	5.83^{abcde}	6.08^{abc}	5.95^{abc}	4.45^{cdefg}	4.45^{b}	4.45^{b}
T_{12} -GA_3 @ 150 ppm at 50% flowering + pea stage	115.19^{a}	110.03^{a}	112.61^{a}	8.61^{d}	8.61^{d}	8.61^{d}	4.75^{fg}	5.00^{cd}	4.87^{de}	4.48^{bcdefg}	4.54^{ab}	4.51^{b}
T_{13} -Ethrel @ 500 ppm at 50% flowering + pea stage	84.12^{mn}	83.47^{k}	83.79^{j}	10.43^{ab}	10.43^{ab}	10.43^{ab}	6.41^{ab}	6.08^{abc}	6.25^{ab}	4.78^{b}	4.61^{ab}	4.70^{ab}
T_{14} -Ethrel @ 500 ppm at pea stage	85.94^{lm}	82.4^{k}	84.17^{j}	10.42^{ab}	10.42^{ab}	10.42^{ab}	5.75^{abcdef}	6.33^{ab}	6.04^{abc}	4.64^{bcde}	4.70^{ab}	4.67^{ab}
T_{15} -Ethrel @ 500 ppm at 50% flowering + pea stage	88.95^{kl}	87.34^{j}	88.15^{i}	10.29^{ab}	10.29^{ab}	10.29^{ab}	5.00^{defg}	5.58^{abcd}	5.29^{bcde}	4.57^{bcdef}	4.59^{ab}	4.58^{b}
T_{16} -Ethrel @ 1000 ppm at 50% flowering stage	88.53^{kl}	88.37^{ij}	88.45^{i}	10.33^{ab}	10.33^{ab}	10.33^{ab}	5.58^{bcdefg}	6.00^{abc}	5.79^{abcd}	4.71^{bc}	4.70^{ab}	4.71^{ab}
T_{17} -Ethrel @ 1000 ppm at pea stage	86.96^{lm}	93.26^{gh}	90.11^{i}	10.47^{ab}	10.47^{ab}	10.47^{ab}	6.16^{abc}	6.25^{abc}	6.20^{ab}	4.64^{bcde}	4.93^{ab}	4.78^{ab}
T_{18} -Ethrel @ 1000 ppm at 50% flowering + pea stage	99.58^{hi}	98.86^{e}	99.22^{f}	10.18^{abc}	10.18^{abc}	10.18^{abc}	5.16^{cdefg}	5.83^{abc}	5.50^{bcde}	4.52^{bcdef}	4.81^{ab}	4.66^{ab}
T_{19} -Cycocel @ 200 ppm at 50% flowering stage	87.02^{lm}	90.69^{hi}	88.85^{i}	9.88^{abc}	9.88^{abc}	9.88^{abc}	5.16^{cdefg}	5.83^{abc}	5.50^{bcde}	4.68^{bcd}	4.81^{ab}	4.7^{ab}
T_{20} -Cycocel @ 200 ppm at pea stage	85.68^{lm}	92.56^{gh}	89.12^{i}	10.18^{abc}	10.18^{abc}	10.18^{abc}	5.75^{abcdef}	6.16^{abc}	5.95^{abc}	4.62^{bcde}	4.64^{ab}	4.63^{b}
T_{21} -Cycocel @ 200 ppm at 50% flowering+ pea stage	91.72^{jk}	95.53^{fg}	93.62^{h}	9.81^{abc}	9.81^{abc}	9.81^{abc}	4.91^{defg}	6.00^{abc}	5.45^{bcde}	4.56^{bcdef}	4.75^{ab}	4.65^{ab}
T_{22} -Cycocel @ 400 ppm at 50% flowering stage	92.76^{j}	94.97^{fg}	93.86^{h}	9.62^{abcd}	9.62^{abcd}	9.62^{abcd}	5.25^{cdefg}	5.91^{abc}	5.58^{abcd}	4.66^{bcd}	4.94^{ab}	4.80^{ab}
T_{23} -Cycocel @ 400 ppm at pea stage	97.03^{i}	99.96^{de}	98.49^{fg}	9.93^{abc}	9.93^{abc}	9.93^{abc}	5.08^{defg}	5.33^{abcd}	5.20^{bcde}	4.61^{bcde}	5.00^{ab}	4.80^{ab}
T_{24} -Cycocel @ 400 ppm at 50% flowering + pea stage	104.78^{ef}	103.29^{c}	104.04^{de}	9.58^{abcd}	9.58^{abcd}	9.58^{abcd}	5.25^{cdefg}	6.25^{abc}	5.75^{abcd}	4.61^{bcde}	5.03^{ab}	4.82^{ab}
SE(m)±	**3.35**	**2.93**	**2.54**	**0.030**	**0.030**	**0.030**	**0.283**	**0.414**	**0.282**	**0.028**	**0.133**	**0.069**
CD at 5%	**9.56**	**8.38**	**7.27**	**0.085**	**0.085**	**0.085**	**0.807**	**0.806**	**0.805**	**0.080**	**0.381**	**0.197**

**The superscript letter indicates that the treatment means with same letters are at par at 5% level of significance, while the means with different letters are significantly different at 5% level. These letters have been affixed based on CD- value comparison of treatment means.*

4. CONCLUSION

The consumer demand, which is usually based on physical characteristics of sapota fruit, can be improved by the application of plant growth regulators. The average fruit weight, fruit diameter, length of fruit, peel weight, pulp weight and fruit volume were improved with the use of GA_3 @ 100 and 150 ppm at 50 per cent flowering + pea stage of fruit growth and development. The specific gravity was noticed maximum under the ethrel @ 1000 ppm. However, the number of seeds and seed weight was reduced with the application of plant growth regulators as compared to no application (control).

Comment [U22]: A better problem statement canbe discussed in the introduction and expanded in the literature review would add value to this statement. Otherwise, revise the statement.

Comment [U23]: By how much, in weight/percentage and/or how?

Comment [U24]: Revise the concluding statement. Non supportive of the primary study objective.

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