



Studies on the Effect of Plant Growth Regulators on Physical Parameters of Sapota [*Manilkara achras* (Mill.) Forsberg] cv. Cricket Ball under Agro-climatic Condition of Chhattisgarh Plains

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was undertaken during the year July/2020-June/21 and July/2021-June/22 at experimental field of Horticulture 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, 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 twenty five treatments, and three replication for each

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treatment. Thus, a total of 75 data collection made available at each time. Physical parameters of fruit viz., fruit weight (126.36 g \pm 31.07g), fruit volume (121.59 ml \pm 29.07 ml), fruit diameter (6.69 cm \pm 1.33 cm), fruit length (6.92 cm \pm 2.01 cm) and pulp weight (112.61 g \pm 2.01 g) of sapota fruits were increased with the treatment GA₃ @ 150 ppm, while, the peel weight (8.79 g \pm 1.72 g) was reduced under the same treatment. The specific gravity (1.045 g \pm 0.015 gml⁻¹) was recorded maximum under the treatment ethrel @ 1000 ppm. However, a reduction in number of seeds per fruit (4.50 \pm 2.08) and seed weight (4.38 g \pm 0.78 g) was observed by the foliar feeding of NAA @ 100 ppm treatment. The consumer demand, which is usually based on physical characteristics of sapota fruit, can be improved by the application of plant growth regulators. On the basis of the experience gained and results obtained after completion of present investigation, the most appropriate concentration and their time of application should be standardized for different cultivars of sapota.

Keywords: CCC; foliar feeding; GA₃; NAA; physical parameters.

1. INTRODUCTION

Sapota [*Manilkara achras* (Mill.) Forsberg] Cricket Ball 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 Chicklet, 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 [1]. 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 [1]. 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 physico-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 [2].

In recent years, considerable attention has been given to increase the fruit set and to check fruit drop of many fruit crops with the help of plant growth regulators. Different groups of plant growth regulators like auxins, gibberellins and ripening hormones at various concentrations have been reported to influence the flowering, fruit set, fruit retention, ripening advancement characters and quality characters of several fruit crops. Amongst different synthetic auxins, NAA seems to be most useful in terms of fruit setting and fruit retention in sapota. Likewise, CCC and GA₃ was found to enhance the number of flowers and number of fruits per tree [3].

2. MATERIALS AND METHODS

2.1 Experimental Set Up

Raipur district comes under dry, sub-humid agro-climatic region. It is situated in the central part of Chhattisgarh on 21°16'N latitude and 81°36'E longitude at an altitude of 298.0 metre above Mean Sea Level. The source of rainfall is South-

West Monsoon. The (Raipur) 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. May is the hottest and December is the coolest month of the year. The pattern of rainfall, particularly during June to September months has great variation from year to year. The maximum temperature goes as high as 42.5°C during summer and minimum as below 7.0 °C during winter months. The atmospheric humidity is high from June to October. 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 and use of plant protection measures).

2.2 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, Operational Statistics. The data investigations were analyzed as help to book by Gomez and Gomez [4].

2.3 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). The fruit length and diameter was calculated by selecting ten fruits randomly from each replication using digital vernier calipers and the fruit weight, pulp weight, peel weight and seed weight was separately recorded using electronic balance in gram and the mean was calculated.

3. RESULTS AND DISCUSSION

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

Fruit weight (g): As per the result of first year, second year and pooled mean, the maximum average fruit weight 128.69, 124.03 and 126.36 g was recorded under the treatment GA₃ @ 150 ppm at 50 per cent flowering + pea stage, which was found non-significant differences with the treatments T₉ & T₁₀ and T₉ having respective average fruit weights 123.43 & 121.00 and 124.42 g. However the minimum average fruit weight 96.47, 94.11 and 95.29 g was observed under the untreated control. The foliar spray of GA₃ 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. [5].

Fruit diameter (cm): A preview of data of first year, second year and pooled mean is concerned, the maximum fruit diameter 6.88, 6.96 and 6.92 cm was noticed under the treatment GA₃ @150 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments T₉, T₆, T₅, T₃ & T₈ and T₉, T₆, T₃, T₁₀ & T₁₁ and T₉, T₆, T₃, T₅ & T₈ 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 GA₃ 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. [6] and Akshay et al. [7].

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 GA₃ @ 100 ppm at 50 per cent flowering + pea stage, which was found statistically on par with the treatments T₁₂, T₆, T₃, T₅ & T₈ and T₉, T₃, T₅, T₇ & T₆ and T₉, T₃, T₆, T₅ & T₈ 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. The above findings are in close conformity with the results obtained by Patil et al. [8].

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 ^h	94.11 ^m	95.29 ^h	5.17 ^d	5.04 ^a	5.36 ^e	5.07 ^d	4.76 ^l	4.91 ^l	93.63 ^l	91.41 ^l	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 ^{ghl}	110.19 ^{hi}	6.00 ^{abcd}	6.28 ^{abcde}	6.14 ^{abcd}	5.83 ^{abcd}	5.89 ^{bcd}	5.86 ^{abcd}	109.14 ^{gh}	103.52 ^{jk}	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 ^j	6.14 ^{abcd}	6.23 ^{abcde}	6.19 ^{abcd}	5.94 ^{abcd}	5.65 ^{cd}	5.79 ^{bcd}	109.03 ^{gh}	102.3 ^{jk}	105.66 ^{hi}	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 ^{df}	6.49 ^{ab}	6.70 ^{ab}	6.60 ^{ab}	6.24 ^{abc}	6.62 ^a	6.43 ^{abc}	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 ^{df}	6.29 ^{abc}	6.59 ^{abcd}	6.44 ^{abc}	6.12 ^{abc}	6.08 ^{abcde}	6.12 ^{abcd}	112.26 ^{fg}	112.47 ^{ode}	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 ^{df}	6.50 ^{ab}	6.66 ^{abc}	6.58 ^{ab}	6.22 ^{abc}	6.41 ^{ab}	6.31 ^{abcd}	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% flowering + pea stage	122.19 ^{bcd}	118.03 ^{bc}	120.11 ^{cd}	6.60 ^{ab}	6.83 ^{ab}	6.71 ^a	6.37 ^{ab}	6.30 ^{abc}	6.33 ^{abcd}	117.27 ^{cd}	113.6 ^{cd}	115.43 ^{de}	1.042 ^a	1.039 ^a	1.040 ^a
T ₇ - GA ₃ @ 100 ppm at 50% flowering stage	120.71 ^{cd}	116.7 ^{cd}	118.71 ^{de}	6.21 ^{abc}	6.61 ^{abcd}	6.41 ^{abcd}	5.96 ^{abcd}	6.38 ^{ab}	6.18 ^{abcd}	116.6 ^{cd}	112.79 ^{cde}	114.69 ^{ef}	1.036 ^a	1.034 ^a	1.035 ^a
T ₈ - GA ₃ @ 100 ppm at pea stage	116.51 ^{gh}	118.02 ^{bc}	117.26 ^{de}	6.48 ^{ab}	6.62 ^{abcd}	6.55 ^{ab}	6.21 ^{abc}	6.29 ^{abc}	6.25 ^{abcde}	112.71 ^{ef}	114.27 ^{bc}	113.49 ^{ef}	1.035 ^a	1.033 ^a	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 ^{ab}	6.88 ^a	6.75 ^a	6.42 ^a	6.62 ^a	6.52 ^{ab}	120.97 ^{ab}	119.27 ^a	120.12 ^{bc}	1.037 ^a	1.035 ^a	1.036 ^a
T ₁₀ - GA ₃ @ 150 ppm at 50% flowering stage	123.12 ^{bc}	121 ^{ab}	122.06 ^{bc}	6.21 ^{abc}	6.68 ^{abc}	6.45 ^{abc}	6.05 ^{abcd}	6.22 ^{abcd}	6.14 ^{abcd}	118.84 ^{bc}	116.84 ^{ab}	117.84 ^{cd}	1.037 ^a	1.035 ^a	1.036 ^a
T ₁₁ - GA ₃ @ 150 ppm at pea stage	119.66 ^{cdef}	118.81 ^{bc}	119.24 ^{cde}	6.44 ^{ab}	6.66 ^{abc}	6.55 ^{ab}	6.14 ^{abc}	6.29 ^{abc}	6.21 ^{abcde}	115.63 ^{cde}	114.89 ^{bc}	115.26 ^{de}	1.036 ^a	1.034 ^a	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	6.92 ^a	6.41 ^a	6.69 ^a	6.55 ^a	123.73 ^a	119.44 ^a	121.59 ^b	1.040 ^a	1.038 ^a	1.039 ^a
T ₁₃ - Ethrel @ 500 ppm at 50% flowering + pea stage	99.34 ^{mn}	98.37 ^l	98.85 ^l	5.91 ^{abcd}	5.29 ^g	5.60 ^{def}	5.57 ^{abcd}	5.01 ^{hi}	5.29 ^{hi}	95.13 ^{kl}	94.46 ^l	94.79 ^k	1.044 ^a	1.041 ^a	1.043 ^a
T ₁₄ - Ethrel @ 500 ppm at pea stage	101.01 ^m	97.28 ^{lm}	99.15 ^l	5.67 ^{bcd}	5.34 ^g	5.51 ^{ef}	5.33 ^{cd}	5.15 ^{ghi}	5.24 ^{hi}	96.92 ^{kl}	93.62 ^l	95.27 ^k	1.042 ^a	1.039 ^a	1.041 ^a
T ₁₅ - Ethrel @ 500 ppm at 50% flowering + pea stage	103.82 ^{kl}	102.15 ^k	102.99 ^k	5.75 ^{bcd}	5.59 ^{efg}	5.67 ^{cdef}	5.62 ^{abcd}	5.26 ^{ghi}	5.44 ^{ghi}	99.31 ^l	97.85 ⁿ	98.58 ^l	1.045 ^a	1.043 ^a	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 ^g	5.42 ^{ef}	5.25 ^{cd}	5.05 ^{hi}	5.15 ^{hi}	99.01 ^l	98.99 ^m	99 ^l	1.046 ^a	1.044 ^a	1.045 ^a
T ₁₇ - Ethrel @ 1000 ppm at pea stage	102.07 ^m	108.49 ^{gh}	105.28 ^{jk}	5.33 ^{cd}	5.59 ^{efg}	5.46 ^{ef}	5.25 ^{cd}	5.18 ^{ghi}	5.21 ^{hi}	97.85 ^{jk}	104.17 ^{jk}	101.01 ^l	1.043 ^a	1.041 ^a	1.042 ^a
T ₁₈ - Ethrel @ 1000 ppm at 50% flowering + pea stage	114.28 ^{ghi}	113.82 ^{de}	114.05 ^{fg}	5.68 ^{bcd}	5.71 ^{efg}	5.69 ^{cdef}	5.34 ^{cd}	5.51 ^{efgh}	5.42 ^{ghi}	109.32 ^{gh}	108.93 ^{fg}	109.13 ^{gh}	1.045 ^a	1.043 ^a	1.044 ^a
T ₁₉ - Cycocel @ 200 ppm at 50% flowering stage	101.59 ^m	104.5 ^{jk}	103.04 ^k	5.81 ^{bcd}	5.63 ^{efg}	5.72 ^{cdef}	5.76 ^{abcd}	5.48 ^{efgh}	5.62 ^{defghi}	98.22 ^{jk}	101.17 ^{kl}	99.7 ^l	1.035 ^a	1.033 ^a	1.034 ^a
T ₂₀ - Cycocel @ 200 ppm at pea stage	100.49 ^m	106.38 ^{ghl}	103.43 ^k	5.67 ^{bcd}	5.74 ^{efg}	5.45 ^{ef}	5.40 ^{bcd}	5.43 ^{efgh}	5.42 ^{ghi}	97.22 ^{kl}	103.13 ^{kl}	100.18 ^l	1.034 ^a	1.031 ^a	1.033 ^a
T ₂₁ - Cycocel @ 200 ppm at 50% flowering+ pea stage	106.09 ^k	109.56 ^g	107.82 ^l	5.65 ^{bcd}	5.90 ^{cdef}	5.77 ^{bcd}	5.44 ^{abcd}	5.42 ^{efgh}	5.43 ^{ghi}	102.36 ^l	105.84 ^{hi}	104.1 ^l	1.037 ^a	1.035 ^a	1.036 ^a
T ₂₂ - Cycocel @ 400 ppm at 50% flowering stage	107.05 ^l	109.1 ^g	108.08 ^l	5.71 ^{bcd}	5.84 ^{defg}	5.77 ^{bcd}	5.49 ^{abcd}	5.53 ^{efgh}	5.51 ^{efghi}	103.37 ^l	105.34 ^{hj}	104.35 ^l	1.036 ^a	1.034 ^a	1.035 ^a
T ₂₃ - Cycocel @ 400 ppm at pea stage	111.58 ^l	114.14 ^{de}	112.86 ^{gh}	5.77 ^{bcd}	5.91 ^{cdef}	5.84 ^{bcd}	5.51 ^{abcd}	5.74 ^{cdefg}	5.63 ^{defghi}	107.68 ^h	110.43 ^{def}	109.05 ^{gh}	1.036 ^a	1.034 ^a	1.035 ^a
T ₂₄ - Cycocel @ 400 ppm at 50% flowering + pea stage	118.98 ^{def}	117.33 ^c	118.15 ^{de}	6.47 ^{ab}	6.04 ^{bcd}	6.25 ^{abcde}	5.93 ^{abcd}	5.61 ^{efgh}	5.77 ^{cdefgh}	114.5 ^{def}	113.11 ^{cd}	113.81 ^{ef}	1.039 ^a	1.037 ^a	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 ^h	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 ^{gh}	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 ^{bcd}	4.38 ^{cdefg}	4.43 ^b	4.41 ^b
T ₃ - NAA @ 100 ppm at 50% flowering + pea stage	107.35 ^{bcd}	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 ^g	102.7 ^{cd}	102.84 ^e	9.48 ^{abcd}	9.48 ^{abcd}	9.48 ^{abcd}	4.83 ^{fg}	5.16 ^{bcd}	5.00 ^{cde}	4.28 ^g	4.66 ^{ab}	4.47 ^b
T ₅ - NAA @ 200 ppm at pea stage	106.22 ^{cd}	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 ^{bcd}	4.48 ^{bcd}	4.70 ^{ab}	4.59 ^b
T ₇ - GA ₃ @ 100 ppm at 50% flowering stage	105.85 ^{def}	103 ^{cd}	104.43 ^{de}	10.31 ^{ab}	10.31 ^{ab}	10.31 ^{ab}	5.33 ^{abcd}	5.83 ^{abc}	5.58 ^{abcd}	4.55 ^{bcd}	4.44 ^b	4.49 ^b
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 ^{bcd}	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 ^{bcd}	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 ^{bcd}	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 ^{bcde}	6.08 ^{abc}	5.95 ^{abc}	4.45 ^{cde}	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 ^g	5.00 ^{cd}	4.87 ^{de}	4.48 ^{bcd}	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 ^{abc}	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 ^{bcdef}	6.33 ^{ab}	6.04 ^{abc}	4.64 ^{bcd}	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 ^{bcd}	4.57 ^{bcd}	4.59 ^{ab}	4.58 ^b
T ₁₆ - Ethrel @ 1000 ppm at 50% flowering stage	88.53 ^{kl}	88.37 ^j	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 ^{bcd}	4.93 ^{ab}	4.78 ^{ab}
T ₁₈ - Ethrel @ 1000 ppm at 50% flowering + pea stage	99.58 ^{hi}	98.86 ^g	99.22 ^f	10.18 ^{abc}	10.18 ^{abc}	10.18 ^{abc}	5.16 ^{cdefg}	5.83 ^{abc}	5.50 ^{bcd}	4.52 ^{bcd}	4.81 ^{ab}	4.66 ^{ab}
T ₁₉ - Cycocel @ 200 ppm at 50% flowering stage	87.02 ^{lm}	90.69 ^{hi}	88.85 ^j	9.88 ^{abc}	9.88 ^{abc}	9.88 ^{abc}	5.16 ^{cdefg}	5.83 ^{abc}	5.50 ^{bcd}	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 ^j	10.18 ^{abc}	10.18 ^{abc}	10.18 ^{abc}	5.75 ^{bcdef}	6.16 ^{abc}	5.95 ^{abc}	4.62 ^{bcd}	4.64 ^{ab}	4.63 ^b
T ₂₁ - Cycocel @ 200 ppm at 50% flowering+ pea stage	91.72 ^{jk}	95.53 ^g	93.62 ^h	9.81 ^{abc}	9.81 ^{abc}	9.81 ^{abc}	4.91 ^{defg}	6.00 ^{abc}	5.45 ^{abcd}	4.56 ^{bcd}	4.75 ^{ab}	4.65 ^{ab}
T ₂₂ - Cycocel @ 400 ppm at 50% flowering stage	92.76 ^j	94.97 ^g	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 ^f	9.93 ^{abc}	9.93 ^{abc}	9.93 ^{abc}	5.08 ^{defg}	5.33 ^{abcd}	5.20 ^{bcd}	4.61 ^{bcd}	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}	5.75 ^{abc}	5.75 ^{abcd}	4.61 ^{bcd}	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

Fruit volume (ml): Data recorded 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 GA₃ @ 150 ppm at 50 per cent flowering + pea stage, which was found non-significant with the treatments T₉ and T₉ & T₁₀ and T₉ 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 the control. The increased in volume of the fruit due to increase size of fruit by application of GA₃ increased size of fruit by cell elongation. Similar findings have also been obtained by Bhujbal et al. [2].

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. 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 Daberao et al. [9].

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 GA₃ @ 150 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments T₉ & T₁₀ and T₉ having 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 Kavyashree et al. [10].

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 GA₃ @ 150 ppm at 50 per cent flowering + pea stage, which showed significantly at par with the treatment T₁₂, T₂₄, T₁₉, T₃ & T₁ and T₁₂, T₉, T₃, T₂ & T₅ 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. [11].

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 T₁₂, T₄, T₂₁ & T₂₃ and T₁₂, T₄, T₂₃ & T₆ and T₁₂, T₄, T₂₃, T₆ & T₁₅ 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. [6].

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 T₄, T₃, & T₉ and T₇, T₁₁ & T₃ and T₁, T₁₁, T₄ & T₅ 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. [12] and Bagul et al. [13].

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 GA₃ @ 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). Intensive study should be made on the effect of different concentrations of plant growth regulators in relation to fruit retention, fruit drop and their effect on physical parameters of fruit. The most appropriate concentration and their time of application should be standardized for different cultivars of sapota.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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