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# Studies on the effect of plant growth regulators on flowering, fruit retention, fruit drop and yield of sapota [*Manilkara achras* (Mill.) Forsberg] cv. Cricket Ball under Agro-climatic condition of Chhattisgarh Plains

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**Abstract**
The present investigation was undertaken during the year 2020-21 and 2021-22 at experimental field of Horticulture instructional Farm, Department of Fruit Science College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). 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 having twenty five treatments, which replicates thrice. It was observed that the plant growth regulators significantly impacted on flowering and fruiting characteristics of sapota cv. Cricket Ball. NAA was found most effective to reduce the fruit drop and increased the fruit retention percentages during whole investigation period. The maximum number of flowers per shoot (11.08), number of fruits per shoot (4.78), fruit set (43.13%), fruit retention (21.25%) and as regard yield, the treatment NAA 200 ppm, when applied at 50 per cent flowering and pea stage of fruit development produced significantly more number of fruits (189.16) as well as yield (22.72 kg/tree), whereas, a reduction in fruit drop per cent (74.13) was observed by the application of same treatment as compared to water spray (control). As far as ripening advancement characters is concerned, application of ethrel @ 1000 ppm at 50 per cent flowering + pea stage ($T_{18}$) significantly reduced the days to first harvest (211.50), days to last harvest (231.66) and length of harvest period (20.16) as compared to rest of the other treatments tested under the present investigation.

**Keywords:** Sapota, CCC, NAA, $GA_3$, flowering, fruit retention

## Introduction
Sapota [*Manilkara achras* (Mill.) Forsberg] is one of India's most important tropical fruit crops and belongs to the Sapotaceae family. This plant is native to tropical South America, particularly southern Mexico and Central America. Sapota's chromosome number is 2n = 26. In India, it is mainly cultivated for its fruits, while, in South East Mexico and other countries "Chickle" is commercially produced. The unripe fruit produce milky white product after drying, which is base material for making Chickle, it is also known as "Gataparcha".

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. Sapota fruits contain water (73.7%), carbohydrates (20-22 g/100 g), fibre (1-5 g/100 g), mineral matter (0.25-0.50 g/100 g), calcium (28 mg), phosphorus (27 mg) and iron (1-5 g/100 g). India is the world's largest producer of sapota. 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 (Anon., 2019) [2].

In Chhattisgarh, total area under sapota is 340 hectares with an annual production of 1578 metric tonnes (Anon., 2019) [2]. In the agro-climate of the plain regions of Chhattisgarh, poor fruit set and fruit drop have been observed and tree production is very low due to self-incompatibility. As a result, plant growth regulators may be the way to maximise this crop's yields by enhancing flowering and fruit set. Cricket Ball is an important cultivar; it has an attractive large-round fruits having crisp or gritty pulp with moderate sweetness and flavour. Sapota bears fruit on the axis of the leaves on new season growth and produces a huge number of flowers in several flushes throughout the year and as a result, flowers and fruits drop at

various phases of development, from flowering to fruit setting to fruit maturity of the fruits. However, fruit drop at later stages of development drastically reduces the yield. Therefore, fruit set is the most important factor, which determines the yield.

Sapota is a crop with a high level of heterozygocity and pollination is assisted significantly by wind. Around 90 per cent of flower buds turn in to blooms and only about 10 per cent of the entire fruit set develops into complete fruits that will last to maturity, while 50 per cent of the open un-pollinated flowers fail to set fruit. The major problem confronting sapota crop is heavy flower and fruit drop (Garhwal, 2015) [6]. Auxins, gibberellins and growth retardants among other plant growth regulators have been shown to alter flowering, fruit set, fruit retention, ripening advancement characters and quality features of various fruit crops at various concentrations.

The prolonged period required for fruit maturity might be due to the too long period of lag phase and very slow growth in the initial stages of fruit development (Patil *et al.*, 2011) [14]. This long period is no doubt, a disadvantageous. This problem seems to be due to disharmony caused by plant hormones.

## Materials and methods

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, Indira Gandhi Krishi Vishwavidyalaya, 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 $^0$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 years old trees of sapota variety Cricket Ball spaced at 10 x 10 metres. The experiment was laid out in Randomized Block Design having twenty five treatments, which replicates thrice. The treatments consisted different concentration of plant growth regulators applied at flowering and pea stages are $T_0$ (control), $T_1$ (NAA @ 100 ppm at 50 per cent flowering stage), $T_2$ (NAA @ 100 ppm at pea stage), $T_3$ (NAA @ 100 ppm at 50 per cent flowering + pea stage), $T_4$ (NAA @ 200 ppm at 50 per cent flowering stage), $T_5$ (NAA @ 200 ppm at pea stage), $T_6$ (NAA @ 200 ppm at 50 per cent flowering + pea stage), $T_7$ ($GA_3$ @ 100 ppm at 50 per cent flowering stage), $T_8$ ($GA_3$ @ 100 ppm at pea stage), $T_9$ ($GA_3$ @ 100 ppm at 50 per cent flowering + pea stage), $T_{10}$ ($GA_3$ @ 150 ppm at 50 per cent flowering stage), $T_{11}$ ($GA_3$ @ 150 ppm at pea stage), $T_{12}$ ($GA_3$ @150 ppm at 50 per cent flowering + pea stage), $T_{13}$ (Ethrel @ 500 ppm at 50 per cent flowering stage), $T_{14}$ (Ethrel @ 500 ppm at pea stage), $T_{15}$ (Ethrel @ 500 ppm at 50 per cent flowering + pea stage), $T_{16}$ (Ethrel @ 1000 ppm at 50 per cent flowering stage), $T_{17}$ (Ethrel @ 1000 ppm at pea stage), $T_{18}$ (Ethrel @ 1000 ppm at 50 per cent flowering + pea stage), $T_{19}$ (Cycocel @ 200 ppm at 50 per cent flowering stage), $T_{20}$ (Cycocel @ 200 ppm at pea stage), $T_{21}$ (Cycocel @ 200 ppm at 50 per cent flowering+ pea stage), $T_{22}$ (Cycocel @ 400 ppm at 50 per cent flowering), $T_{23}$ (Cycocel @ 400 ppm at pea stage) and $T_{24}$ (Cycocel @ 400 ppm at 50 per cent flowering + pea stage). 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.

The observations on flowering, fruiting and yield parameters *viz*., number of flowers per shoot, number of fruits per shoot, number of fruit set per shoot, fruit set (%), fruit drop (%), fruit retention (%), days to first harvest, days to last harvest length of harvest period, number of fruits per tree and yield per tree were recorded as per standard procedures and statistically analyzed.

## Results and Discussion

The results pertaining to various aspects of flowering, fruiting and yield parameters were summarized as follows:

### Number of flowers per shoot

During first year of investigation the maximum number of flowers per shoot (11.33) was observed under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments $T_4$, $T_{12}$, $T_3$, $T_5$, $T_{24}$, and $T_{10}$ having respective number of flowers per shoot 10.83, 10.83, 10.66, 10.66, 10.66 and 10.50 under the present trial. The minimum number of flowers per shoot (8.50) was recorded under the control.

During second year of investigation the maximum number of flowers per shoot (10.83) was noticed under the same treatment, which was found non-significant differences with the treatments $T_{10}$, $T_3$, $T_4$, $T_9$, $T_{12}$ and $T_{21}$ having respective number of flowers per shoot 10.66, 10.50, 10.50, 10.50, 10.50 and 10.50, while the minimum number of flowers per shoot (8.33) was registered under the control.

As per the result of pooled data is concerned, the maximum number of flowers per shoot (11.08) was recorded under the superiority of treatment NAA @ 200 ppm applied at 50 per cent flowering + pea stage, which was non-significant differences with the treatments $T_4$, $T_{12}$, $T_3$, $T_{10}$, $T_{24}$ and $T_5$ having number of flowers per shoot 10.66, 10.66, 10.58, 10.58, 10.58 and 10.41, respectively. However the minimum number of flowers per shoot (8.41) was noticed under the treatment $T_0$ (control). The increase in number of flowers might be due to NAA and CCC may further attributed to the reason that plants remain physiologically more active to build up sufficient food stock for the developing flowers by creating favourable C/N ratio in terminals ultimately resulted into increased number of flowers. The present findings are in close conformity with the results obtained by Sahu *et al.* (2018) [16] and Akshay *et al.* (2020) [1] in sapota.

### Number of fruit set per shoot

During first year of investigation, the maximum number of fruit set per shoot (4.88) was observed under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments $T_3$, $T_{12}$, $T_4$ and $T_5$ having number of fruit set per shoot 4.56, 4.51, 4.43 and 4.35, respectively. The minimum number of fruit set per shoot (2.96) was recorded under the control.

A preview of data of second year indicated the similar trends in terms of number of fruit set per shoot among different treatments with maximum (4.67) was recorded under the same treatment, which was found non-significant differences with the treatments $T_3$, $T_4$, $T_{12}$ and $T_9$ having number of fruit set per shoot 4.43, 4.36, 4.36 and 4.33, respectively. However the minimum number of fruit set per shoots (2.96) was noticed under the control.

Results based on pooled data, the sane treatment recorded maximum number of fruit set per shoot (4.78), which was found non-significant differences with the treatments $T_3$, $T_{12}$ and $T_4$ having respective number of fruit set per shoot 4.50, 4.44 and 4.40 under the present trial. However the minimum numbers of fruit set per shoot (2.96) was observed under the control. The maximum fruit set in sapota cv. Cricket Ball with the application of NAA might be due to the fact that developing fruits requires auxins in higher quantity and fruit drop occurs, when the level of auxins goes down so exogenous application of auxin fulfills the deficiency and checks fruit drop and ultimately increases the fruit set. Results are in closely in accordance with earlier work done by Bhujbal *et al.* (2013) [4] and Singh *et al.* (2020) [17] in sapota.

**Fruit set (%)**

The maximum fruit set percentages 43.09, 43.18 and 43.13 was observed during first year, second year and pooled data of experiment under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage, which was found statistically at par during both year as well as pooled mean with the treatments $T_3$ having respective fruit set percentages 42.80, 42.23 and 42.52, respectively. However the minimum fruit set percentages of 34.89, 35.61and 35.25 was registered under the control. The increment in fruit set per cent might be due to the application of NAA and $GA_3$ significantly reduced flower and fruit drop and subsequently increased fruit set and its retention. The above findings are in close conformity with the results obtained by Ingale *et al.* (2008) [8] and Sahoo *et al.* (2020) [15] in sapota.

**Fruit retention (%)**

During first year, second year and pooled data of investigation the maximum fruit retention percentages 25.96, 26.71 and 26.34 was noticed under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage, which was found statistically at par with the treatments $T_3$ having respective fruit retention percentages 24.85 during first year, while the minimum fruit retention percentages 12.27, 12.38 and 12.32 was observed under the control. The increased fruit retention up to maturity might be due to proper supplementation of the nutrients and prevention in the formation of an abscission layer by inhibiting the enzymatic activities with the application of NAA. The above results are in close agreement with those of Nambisan *et al.* (2007) [12] and Guvvali *et al.* (2017) [7] in sapota.

**Fruit drop (%)**

Result obtained during first year and second year, of experimentation the minimum fruit drop percentages 75.06 and 73.19 was registered under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage, which showed non-significant differences with the treatment $T_3$ & $T_4$ having respective fruit drop percentages of 75.07 & 76.51 during first year of trial. However the maximum fruit drop percentages 87.53 and 87.41was registered under the control.

Results on the basis of pooled data, the minimum fruit drop percentages 74.13 was registered under the treatment NAA @ 200 ppm at 50 per cent flowering + pea stage which showed statistically at par with the treatment $T_3$ & $T_4$ having respective fruit drop percentages of 75.13 & 76.46, while the maximum fruit drop percentages 87.47 was observed under the control. The reduction in fruit drop up to maturity might be due to proper supplementation of the nutrients and prevention in the formation of an abscission layer by inhibiting the enzymatic activities with the application of NAA. This results corroborates the findings of Nagargoje *et al.* (2007) [11] in sapota.

**Days to first harvest**

During first year, second year and findings obtained on the basis of pooled data, the minimum days to first harvest 211.00, 210.33 and 211.50 was observed under the treatment ethrel @ 500 ppm at 50 per cent flowering + pea stage, while the maximum days to first harvest 133.66, 231.33 and 232.50 was recorded under the control. The advancement in ripening of the sapota fruits might be due to ethylene causes upsurge in respiration and advances the ripening of fruits. Further ethylene destructs the chlorophyll and enhances the synthesis of anthocyanin in the peel of the fruits. The above findings are in close conformity with the results of Joshi *et al.* (2016) [9] in sapota.

**Days to last harvest**

During first year, second year and as per the result of pooled mean is concerned the minimum days to last harvest 211.00, 229.00 and 231.66 was registered under the superiority of treatment ethrel @ 1000 ppm at 50 per cent flowering + pea stage. However the maximum days to last harvest 276.66, 271.33 and 274.00 was found under the control. This might be due to the effect of ethrel that causes fruit initiation and early fruiting by decreasing the concentration of ABA in plant shoot. These results are close consistency with the findings reported by Chavan *et al.* (2009) [5] in sapota.

**Length of harvest period**

Table 2 clearly showed that during first year, second year and pooled data of investigation, the minimum length of harvest period 21.66, 18.66 and 20.16 days was noticed under the superiority of treatment ethrel @ 1000 ppm at 50 per cent flowering + pea stage, which also showed statistically at par with the treatment $T_{17}$ having the length of harvest period 20.33 days during second year, while the maximum length of harvest period 43.00, 40.00 and 41.50 days was recorded under the control. The advancement in ripening of the sapota fruits might be due to ethylene destructs the chlorophyll and enhances the synthesis of anthocyanin in the peel of the fruits. Promotion of colour and enhancement in fruit maturity with ethrel application. The above results are in close agreement with those of Panigrahi *et al.* (2011) [13] in sapota.

**Number of fruits per tree**

It is evident from the data of first year, second year and findings obtained on the basis of pooled data, the maximum number of fruits per tree 188.00, 190.33 and 189.16 was noticed under the superiority of treatment NAA @ 200 ppm at 50 per cent flowering + pea stage. However the minimum number of fruits per tree 147.66, 144.33 and 146.00 was registered under the control. The reason for the maximum number of fruits per tree might be due to the highest fruit set and fruit retention percentages achieved by $GA_3$ and NAA applied at flowering stage. The above findings are in close conformity with the results obtained by Kavyashree *et al.* (2018) [10] in sapota.

**Yield per tree (kg)**

During first year, second year and pooled data of the investigation, the maximum yield per tree 22.97, 22.46 and 22.72 kg was observed under the treatment $T_6$ (NAA @ 200 ppm) at 50 per cent flowering + pea stage, which was found non-significant differences with the treatments $T_{12}$, $T_3$ and $T_9$ with yield per tree 22.05, 21.72 and 21.62 kg, respectively during first year of trial. However the minimum yield per tree 14.25, 13.58 and 13.91 kg was registered under the control. This might be attributed to reason that plants remain physiologically more active to build up sufficient food stock for developing flowers and fruits ultimately leading the higher yield. The present results were in accordance with the findings of Bagul *et al.* (2021) [3] in sapota.

**Table 1:** Effect of foliar feeding of different concentrations of plant growth regulators on number of flowers per shoot, number of fruit set per shoot, fruit set (%), fruit retention (%) and fruit drop (%) of sapota cv. Cricket Ball

| Treatments | Number of flowers per shoot | | | No. of fruit set per shoot | | | Fruit set (%) | | | Fruit retention (%) | | | Fruit drop (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2021-22 | 2020-21 | Pooled |
| $T_0$ - Control (water spray) | 8.50$^{g}$ | 8.33$^{g}$ | 8.41$^{g}$ | 2.967$^{h}$ | 2.96$^{b}$ | 2.96$^{h}$ | 2.96$^{h}$ | 34.89$^{l}$ | 35.61$^{k}$ | 35.25$^{n}$ | 12.38$^{m}$ | 12.32$^{l}$ | 87.53$^{a}$ | 87.41$^{a}$ | 87.47$^{a}$ |
| $T_1$ - NAA @ 100 ppm at 50% flowering stage | 10.33$^{abcd}$ | 10.00$^{abcdef}$ | 10.16$^{bcd}$ | 4.21$^{bcde}$ | 4.02$^{ab}$ | 4.11$^{bcde}$ | 4.11$^{bcde}$ | 40.75$^{bcde}$ | 40.23$^{c}$ | 40.49$^{def}$ | 21.90$^{d}$ | 21.43$^{d}$ | 79.02$^{ij}$ | 78.09$^{lm}$ | 78.56$^{kl}$ |
| $T_2$ - NAA @ 100 ppm at pea stage | 10.00$^{bcde}$ | 10.333$^{abcd}$ | 10.16$^{bcd}$ | 4.11$^{bcdef}$ | 4.10$^{ab}$ | 4.10$^{bcde}$ | 4.10$^{bcde}$ | 41.12$^{bc}$ | 39.68$^{cd}$ | 40.40$^{def}$ | 20.49$^{ef}$ | 20.49$^{de}$ | 79.50$^{i}$ | 79.50$^{jk}$ | 79.50$^{jk}$ |
| $T_3$ - NAA @ 100 ppm at 50% flowering + pea stage | 10.66$^{abc}$ | 10.50$^{abc}$ | 10.58$^{abc}$ | 4.56$^{ab}$ | 4.43$^{ab}$ | 4.50$^{ab}$ | 4.50$^{ab}$ | 42.80$^{a}$ | 42.23$^{ab}$ | 42.52$^{ab}$ | 24.80$^{b}$ | 24.83$^{b}$ | 75.07$^{l}$ | 75.19$^{o}$ | 75.13$^{n}$ |
| $T_4$ - NAA @ 200 ppm at 50% flowering stage | 10.83$^{ab}$ | 10.50$^{abc}$ | 10.66$^{ab}$ | 4.43$^{abc}$ | 4.36$^{ab}$ | 4.40$^{ab}$ | 4.40$^{ab}$ | 40.90$^{bcd}$ | 41.58$^{b}$ | 41.24$^{cd}$ | 23.42$^{c}$ | 23.45$^{c}$ | 76.51$^{kl}$ | 76.40$^{no}$ | 76.46$^{m}$ |
| $T_5$ - NAA @ 200 ppm at pea stage | 10.66$^{abc}$ | 10.16$^{abcde}$ | 10.41$^{abc}$ | 4.35$^{abcd}$ | 4.05$^{ab}$ | 4.20$^{bcd}$ | 4.20$^{bcd}$ | 40.77$^{bcde}$ | 39.84$^{c}$ | 40.31$^{def}$ | 23.35$^{c}$ | 23.61$^{c}$ | 77.49$^{jk}$ | 77.13$^{mn}$ | 77.31$^{lm}$ |
| $T_6$ - NAA @ 200 ppm at 50% flowering + pea stage | 11.33$^{a}$ | 10.83$^{a}$ | 11.08$^{a}$ | 4.88$^{a}$ | 4.67$^{a}$ | 4.78$^{a}$ | 4.78$^{a}$ | 43.09$^{a}$ | 43.18$^{a}$ | 43.13$^{a}$ | 26.71$^{a}$ | 26.34$^{a}$ | 75.06$^{l}$ | 73.19$^{p}$ | 74.13$^{n}$ |
| $T_7$ - $GA_3$ @ 100 ppm at 50% flowering stage | 9.00$^{fg}$ | 9.16$^{efg}$ | 9.08$^{fg}$ | 3.55$^{fgh}$ | 3.55$^{ab}$ | 3.55$^{fg}$ | 3.55$^{fg}$ | 39.48$^{defg}$ | 38.73$^{def}$ | 39.10$^{ghi}$ | 18.95$^{gh}$ | 18.49$^{f}$ | 81.96$^{fg}$ | 81.81$^{gh}$ | 81.88$^{h}$ |
| $T_8$ - $GA_3$ @ 100 ppm at pea stage | 10.16$^{bcd}$ | 9.83$^{abcdef}$ | 10.00$^{bcde}$ | 3.91$^{cdefg}$ | 3.76$^{ab}$ | 3.84$^{cdefg}$ | 3.84$^{cdefg}$ | 38.54$^{fghi}$ | 38.32$^{fgh}$ | 38.43$^{hij}$ | 18.61$^{gh}$ | 18.38$^{f}$ | 81.93$^{fg}$ | 81.46$^{hi}$ | 81.69$^{h}$ |
| $T_9$ - $GA_3$ @ 100 ppm at 50% flowering + pea stage | 10.33$^{abcd}$ | 10.50$^{abc}$ | 10.41$^{abc}$ | 4.20$^{bcde}$ | 4.33$^{ab}$ | 4.26$^{bc}$ | 4.26$^{bc}$ | 40.66$^{bcde}$ | 41.30$^{b}$ | 40.98$^{cde}$ | 20.33$^{ef}$ | 20.13$^{e}$ | 80.07$^{hi}$ | 80.13$^{ij}$ | 80.10$^{ij}$ |
| $T_{10}$ - $GA_3$ @ 150 ppm at 50% flowering stage | 10.50$^{abcd}$ | 10.66$^{ab}$ | 10.58$^{abc}$ | 4.18$^{bcdef}$ | 4.26$^{ab}$ | 4.22$^{bcd}$ | 4.22$^{bcd}$ | 39.88$^{cdef}$ | 40.00$^{c}$ | 39.94$^{efg}$ | 19.39$^{fg}$ | 18.84$^{f}$ | 81.29$^{gh}$ | 80.60$^{hij}$ | 80.95$^{hi}$ |
| $T_{11}$ - $GA_3$ @ 150 ppm at pea stage | 10.50$^{abcd}$ | 10.00$^{abcdef}$ | 10.25$^{bcd}$ | 4.12$^{bcdef}$ | 3.95$^{ab}$ | 4.03$^{bcdef}$ | 4.03$^{bcdef}$ | 39.30$^{efgh}$ | 39.48$^{cde}$ | 39.39$^{fgh}$ | 19.02$^{gh}$ | 18.50$^{f}$ | 81.60$^{gh}$ | 80.89$^{hi}$ | 81.24$^{hi}$ |
| $T_{12}$ - $GA_3$ @ 150 ppm at 50% flowering + pea stage | 10.83$^{ab}$ | 10.50$^{abc}$ | 10.66$^{ab}$ | 4.51$^{abc}$ | 4.36$^{ab}$ | 4.44$^{ab}$ | 4.44$^{ab}$ | 41.69$^{ab}$ | 41.55$^{b}$ | 41.62$^{bc}$ | 21.22$^{de}$ | 20.29$^{de}$ | 79.52$^{i}$ | 78.60$^{kl}$ | 79.06$^{jk}$ |
| $T_{13}$ - Ethrel @ 500 ppm at 50% flowering + pea stage | 9.16$^{efg}$ | 9.00$^{fg}$ | 9.08$^{fg}$ | 3.36$^{gh}$ | 3.31$^{ab}$ | 3.34$^{gh}$ | 3.34$^{gh}$ | 36.72$^{jk}$ | 36.85$^{ij}$ | 36.79$^{lm}$ | 13.29$^{m}$ | 13.53$^{kl}$ | 86.11$^{ab}$ | 86.64$^{ab}$ | 86.37$^{ab}$ |
| $T_{14}$ - Ethrel @ 500 ppm at pea stage | 9.50$^{defg}$ | 9.00$^{fg}$ | 9.25$^{efg}$ | 3.41$^{gh}$ | 3.26$^{ab}$ | 3.34$^{gh}$ | 3.34$^{gh}$ | 36.00$^{kl}$ | 36.29$^{jk}$ | 36.15$^{mn}$ | 13.02$^{m}$ | 12.97$^{l}$ | 85.39$^{bc}$ | 86.32$^{abc}$ | 85.85$^{bcd}$ |
| $T_{15}$ - Ethrel @ 500 ppm at 50% flowering + pea stage | 9.66$^{cdef}$ | 9.33$^{defg}$ | 9.50$^{def}$ | 3.66$^{efg}$ | 3.56$^{ab}$ | 3.61$^{efg}$ | 3.61$^{efg}$ | 37.93$^{ghij}$ | 38.23$^{fgh}$ | 38.08$^{ijk}$ | 14.56$^{kl}$ | 14.61$^{jk}$ | 87.24$^{a}$ | 85.23$^{bcde}$ | 86.24$^{abc}$ |
| $T_{16}$ - Ethrel @ 1000 ppm at 50% flowering stage | 10.00$^{bcde}$ | 9.5$^{cdef}$ | 9.75$^{cdef}$ | 3.65$^{efg}$ | 3.58$^{ab}$ | 3.61$^{efg}$ | 3.61$^{efg}$ | 36.52$^{jkl}$ | 37.72$^{fghi}$ | 37.12$^{klm}$ | 13.56$^{lm}$ | 13.24$^{l}$ | 85.43$^{bc}$ | 85.83$^{bcd}$ | 85.63$^{bcd}$ |
| $T_{17}$ - Ethrel @ 1000 ppm at pea stage | 10.00$^{bcde}$ | 9.66$^{bcdef}$ | 9.83$^{bcdef}$ | 3.61$^{efgh}$ | 3.56$^{ab}$ | 3.58$^{efg}$ | 3.58$^{efg}$ | 36.15$^{kl}$ | 36.83$^{ij}$ | 36.49$^{m}$ | 13.40$^{m}$ | 13.53$^{kl}$ | 86.04$^{ab}$ | 86.42$^{abc}$ | 86.23$^{abc}$ |
| $T_{18}$ - Ethrel @ 1000 ppm at 50% flowering + pea stage | 9.83$^{bcdef}$ | 10.33$^{abcd}$ | 10.08$^{bcd}$ | 3.72$^{defg}$ | 3.96$^{ab}$ | 3.84$^{cdefg}$ | 3.84$^{cdefg}$ | 37.91$^{ghij}$ | 38.39$^{efg}$ | 38.156$^{ijk}$ | 15.09$^{jk}$ | 15.14$^{ij}$ | 84.95$^{bcd}$ | 84.78$^{de}$ | 84.87$^{cde}$ |
| $T_{19}$ - Cycocel @ 200 ppm at 50% flowering stage | 9.83$^{bcdef}$ | 10.16$^{abcde}$ | 10.00$^{bcde}$ | 3.73$^{defg}$ | 3.81$^{ab}$ | 3.77$^{cdefg}$ | 3.77$^{cdefg}$ | 38.02$^{ghij}$ | 37.54$^{ghi}$ | 37.78$^{jkl}$ | 15.40$^{jk}$ | 15.75$^{hij}$ | 83.89$^{cde}$ | 85.30$^{bcde}$ | 84.59$^{def}$ |
| $T_{20}$ - Cycocel @ 200 ppm at pea stage | 9.83$^{bcdef}$ | 10.16$^{abcde}$ | 10$^{bcde}$ | 3.65$^{efg}$ | 3.78$^{ab}$ | 3.71$^{defg}$ | 3.71$^{defg}$ | 37.13$^{ijk}$ | 37.21$^{hij}$ | 37.17$^{klm}$ | 14.80$^{jk}$ | 14.90$^{ij}$ | 85.00$^{bcd}$ | 85.19$^{cde}$ | 85.09$^{bcde}$ |
| $T_{21}$ - Cycocel @ 200 ppm at 50% flowering+ pea stage | 10.33$^{abcd}$ | 10.5$^{abc}$ | 10.417$^{abc}$ | 4.12$^{bcdef}$ | 4.03$^{ab}$ | 4.08$^{bcdef}$ | 4.08$^{bcdef}$ | 39.97$^{cdef}$ | 38.72$^{def}$ | 39.35$^{fgh}$ | 17.02$^{i}$ | 16.76$^{gh}$ | 83.42$^{def}$ | 83.12$^{fg}$ | 83.27$^{fg}$ |
| $T_{22}$ - Cycocel @ 400 ppm at 50% flowering stage | 9.83$^{bcdef}$ | 10.16$^{abcde}$ | 10.00$^{bcde}$ | 3.76$^{defg}$ | 3.88$^{ab}$ | 3.82$^{cdefg}$ | 3.82$^{cdefg}$ | 38.29$^{ghi}$ | 38.19$^{fgh}$ | 38.24$^{ijk}$ | 15.79$^{j}$ | 15.87$^{hi}$ | 84.06$^{cd}$ | 84.20$^{ef}$ | 84.13$^{ef}$ |
| $T_{23}$ - Cycocel @ 400 ppm at pea stage | 10.33$^{abcd}$ | 10.00$^{abcdef}$ | 10.16$^{bcd}$ | 3.90$^{cdefg}$ | 3.77$^{ab}$ | 3.83$^{cdefg}$ | 3.83$^{cdefg}$ | 37.73$^{hij}$ | 37.75$^{fghi}$ | 37.74$^{jkl}$ | 15.36$^{jk}$ | 15.37$^{ij}$ | 84.60$^{bcd}$ | 84.63$^{de}$ | 84.62$^{def}$ |
| $T_{24}$ - Cycocel @ 400 ppm at 50% flowering + pea | 10.66$^{abc}$ | 10.50$^{abc}$ | 10.58$^{abc}$ | 4.20$^{bcde}$ | 4.20$^{ab}$ | 4.20$^{bcd}$ | 4.20$^{bcd}$ | 39.37$^{defg}$ | 40.00$^{c}$ | 39.69$^{fg}$ | 18.03$^{hi}$ | 17.82$^{fg}$ | 82.37$^{efg}$ | 81.96$^{gh}$ | 82.17$^{gh}$ |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| stage | | | | | | | | | | | | | | | |
| S.E(m)± | 0.25 | 0.29 | 0.17 | 0.10 | 0.11 | 0.07 | 0.07 | 0.67 | 0.35 | 0.36 | 0.41 | 0.42 | 0.83 | 0.51 | 0.55 |
| CD at 5% | 0.73 | 0.83 | 0.48 | 0.30 | 0.31 | 0.21 | 0.21 | 1.93 | 1.02 | 1.02 | 1.19 | 1.20 | 2.37 | 1.47 | 1.59 |

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 days to first harvest, days to last harvest, length of harvest period, number of fruits per tree and yield per tree (kg) of sapota cv. Cricket Ball

| Treatments | Days to first harvest | | | Days to last harvest | | | Length of harvest period | | | Number of fruits per tree | | | Yield per tree (kg) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2020-21 | 2021-22 | Pooled | 2021-22 | 2020-21 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled | 2020-21 | 2021-22 | Pooled |
| $T_0$ - Control (water spray) | 233.66$^{a}$ | 231.33$^{a}$ | 232.50$^{a}$ | 276.66$^{a}$ | 271.33$^{a}$ | 274.00$^{a}$ | 43.00$^{a}$ | 40.00$^{a}$ | 41.50$^{a}$ | 147.66$^{o}$ | 144.33$^{p}$ | 146.00$^{o}$ | 14.25$^{n}$ | 13.58$^{k}$ | 13.91$^{m}$ |
| $T_1$ - NAA @ 100 ppm at 50% flowering stage | 226.00$^{cde}$ | 224.33$^{fg}$ | 225.16$^{efg}$ | 263.00$^{e}$ | 260.00$^{ef}$ | 261.50$^{ef}$ | 37.00$^{ef}$ | 35.66$^{de}$ | 36.33$^{f}$ | 174.66$^{d}$ | 171.00$^{fg}$ | 172.83$^{de}$ | 19.79$^{fgh}$ | 18.31$^{efgh}$ | 19.05$^{efgh}$ |
| $T_2$ - NAA @ 100 ppm at pea stage | 222.66$^{g}$ | 219.33$^{j}$ | 221.00$^{h}$ | 259.00$^{f}$ | 254.00$^{h}$ | 256.50$^{gh}$ | 36.33$^{ef}$ | 34.66$^{efg}$ | 35.50$^{f}$ | 172.66$^{e}$ | 176.33$^{d}$ | 174.50$^{d}$ | 19.51$^{fgh}$ | 18.65$^{def}$ | 19.08$^{efg}$ |
| $T_3$ - NAA @ 100 ppm at 50% flowering + pea stage | 218.00$^{h}$ | 223.00$^{gh}$ | 220.5$^{hi}$ | 254.00$^{h}$ | 258.00$^{fg}$ | 256.00$^{gh}$ | 36.00$^{f}$ | 35.00$^{ef}$ | 35.50$^{f}$ | 179.33$^{b}$ | 182.33$^{b}$ | 180.83$^{b}$ | 21.72$^{abc}$ | 20.3$^{bc}$ | 21.01$^{bcd}$ |
| $T_4$ - NAA @ 200 ppm at 50% flowering stage | 223.00$^{fg}$ | 220.33$^{ij}$ | 221.66$^{h}$ | 257.00$^{g}$ | 253.33$^{h}$ | 255.16$^{hi}$ | 34.00$^{g}$ | 33.00$^{g\ i}$ | 33.50$^{g}$ | 171.33$^{efg}$ | 168.66$^{hij}$ | 170.00$^{gh}$ | 20$^{efg}$ | 19.65$^{cde}$ | 19.83$^{def}$ |
| $T_5$ - NAA @ 200 ppm at pea stage | 218.33$^{h}$ | 215.33$^{kl}$ | 216.83$^{k}$ | 251.33$^{i}$ | 246.66$^{j}$ | 249.00$^{k}$ | 33.00$^{ghi}$ | 31.33$^{j}$ | 32.16$^{hi}$ | 177.33$^{c}$ | 178.33$^{c}$ | 177.83$^{c}$ | 21.28$^{bcde}$ | 20.3$^{bc}$ | 20.79$^{bcd}$ |
| $T_6$ - NAA @ 200 ppm at 50% flowering + pea stage | 216.00$^{i}$ | 221.00$^{hij}$ | 218.50$^{j}$ | 248.00$^{j}$ | 251.66$^{hi}$ | 249.83$^{k}$ | 32.00$^{ij}$ | 30.66$^{jk}$ | 31.33$^{ij}$ | 188.00$^{a}$ | 190.33$^{a}$ | 189.16$^{a}$ | 22.97$^{a}$ | 22.46$^{a}$ | 22.72$^{a}$ |
| $T_7$ - $GA_3$ @ 100 ppm at 50% flowering stage | 231.66$^{b}$ | 229.33$^{b}$ | 230.50$^{b}$ | 272.66$^{b}$ | 268.33$^{b}$ | 270.50$^{b}$ | 41.00$^{b}$ | 39.00$^{ab}$ | 40.00$^{b}$ | 171.00$^{efg}$ | 169.66$^{gh}$ | 170.33$^{fgh}$ | 20.64$^{bcdef}$ | 19.8$^{bcd}$ | 20.22$^{cde}$ |
| $T_8$ - $GA_3$ @ 100 ppm at pea stage | 230.66$^{b}$ | 227.00$^{cde}$ | 228.83$^{c}$ | 270.66$^{c}$ | 265.66$^{c}$ | 268.16$^{c}$ | 40.00$^{b}$ | 38.66$^{abc}$ | 39.33$^{bc}$ | 170.66$^{efg}$ | 173.00$^{e}$ | 171.83$^{efg}$ | 19.88$^{efgh}$ | 20.42$^{bc}$ | 20.15$^{cde}$ |
| $T_9$ - $GA_3$ @ 100 ppm at 50% flowering + pea stage | 225.66$^{cde}$ | 222.66$^{gh}$ | 224.16$^{g}$ | 264.33$^{de}$ | 260.33$^{e}$ | 262.33$^{e}$ | 38.66$^{c}$ | 37.66$^{bc}$ | 38.16$^{cd}$ | 172.33$^{ef}$ | 171.66$^{ef}$ | 172.00$^{ef}$ | 21.62$^{abcd}$ | 21.19$^{b}$ | 21.4$^{bc}$ |
| $T_{10}$ - $GA_3$ @ 150 ppm at 50% flowering stage | 227.33$^{c}$ | 229.00$^{bc}$ | 228.16$^{cd}$ | 265.66$^{d}$ | 266.00$^{c}$ | 265.83$^{d}$ | 38.33$^{cd}$ | 37.00$^{cd}$ | 37.66$^{de}$ | 166.33$^{hij}$ | 163.33$^{kl}$ | 164.83$^{ij}$ | 20.49$^{cdef}$ | 19.76$^{bcd}$ | 20.12$^{cde}$ |
| $T_{11}$ - $GA_3$ @ 150 ppm at pea stage | 226.66$^{cd}$ | 226.66$^{de}$ | 226.66$^{de}$ | 264.00$^{de}$ | 265.33$^{c}$ | 264.66$^{d}$ | 37.33$^{de}$ | 38.66$^{abc}$ | 38.00$^{d}$ | 170.33$^{fg}$ | 167.66$^{h\ j}$ | 169.00$^{h}$ | 20.38$^{cdef}$ | 19.92$^{bcd}$ | 20.15$^{cde}$ |
| $T_{12}$ - $GA_3$ @ 150 ppm at 50% flowering + pea stage | 222.66$^{g}$ | 225.66$^{ef}$ | 224.16$^{g}$ | 258.66$^{fg}$ | 262.66$^{d}$ | 260.66$^{ef}$ | 36.00$^{f}$ | 37.00$^{cd}$ | 36.50$^{ef}$ | 171.33$^{efg}$ | 169.66$^{ghi}$ | 170.50$^{fgh}$ | 22.05$^{ab}$ | 21.05$^{bc}$ | 21.55$^{b}$ |
| $T_{13}$ - Ethrel @ 500 ppm at 50% flowering + pea stage | 213.66$^{j}$ | 216.66$^{k}$ | 215.16$^{l}$ | 239.00$^{lm}$ | 243.66$^{k}$ | 241.33$^{m}$ | 25.33$^{m}$ | 27.00$^{m}$ | 26.16$^{mn}$ | 154.33$^{n}$ | 152.33$^{o}$ | 153.33$^{n}$ | 15.33$^{mn}$ | 14.98$^{jk}$ | 15.15$^{lm}$ |
| $T_{14}$ - Ethrel @ 500 ppm at pea stage | 215.66$^{i}$ | 213.66$^{lm}$ | 214.66$^{l}$ | 240.33$^{l}$ | 237.00$^{l}$ | 238.66$^{n}$ | 24.66$^{mn}$ | 23.33$^{n}$ | 24.00$^{o}$ | 158.00$^{m}$ | 153.33$^{o}$ | 155.66$^{m}$ | 15.95$^{lm}$ | 14.91$^{jk}$ | 15.43$^{l}$ |
| $T_{15}$ - Ethrel @ 500 ppm at 50% flowering + pea stage | 211.00$^{k}$ | 212.667$^{mn}$ | 211.83$^{m}$ | 236.00$^{no}$ | 239.00$^{l}$ | 237.50$^{n}$ | 25.00$^{mn}$ | 26.33$^{m}$ | 25.66$^{n}$ | 160.333$^{l}$ | 157.66$^{n}$ | 159.00$^{l}$ | 16.63$^{jklm}$ | 16.1$^{ij}$ | 16.37$^{kl}$ |
| $T_{16}$ - Ethrel @ 1000 ppm at 50% flowering stage | 213.66$^{j}$ | 216.00$^{k}$ | 214.83$^{l}$ | 237.66$^{mn}$ | 238.33$^{l}$ | 238.00$^{n}$ | 24.00$^{no}$ | 22.33$^{n}$ | 23.16$^{o}$ | 158.66$^{lm}$ | 156.33$^{n}$ | 157.50$^{l}$ | 16.43$^{jklm}$ | 16.14$^{ij}$ | 16.29$^{kl}$ |
| $T_{17}$ - Ethrel @ 1000 ppm at pea stage | 213.33$^{j}$ | 211.00$^{n}$ | 212.16$^{m}$ | 236.66$^{n}$ | 231.33$^{m}$ | 234.00$^{o}$ | 23.33$^{o}$ | 20.33$^{o}$ | 21.83$^{p}$ | 160.33$^{l}$ | 157.66$^{n}$ | 159.00$^{l}$ | 16.37$^{jklm}$ | 17.11$^{hi}$ | 16.74$^{jk}$ |
| $T_{18}$ - Ethrel @ 1000 ppm at 50% flowering + pea stage | 212.66$^{jk}$ | 210.33$^{n}$ | 211.50$^{m}$ | 234.33$^{o}$ | 229.00$^{m}$ | 231.66$^{p}$ | 21.66$^{p}$ | 18.66$^{o}$ | 20.16$^{q}$ | 165.00$^{j}$ | 162.66$^{l}$ | 163.83$^{j}$ | 18.85$^{ghi}$ | 18.51$^{defg}$ | 18.68$^{fgh}$ |
| $T_{19}$ - Cycocel @ 200 ppm at 50% flowering stage | 225.00$^{de}$ | 228.00$^{bcd}$ | 226.50$^{ef}$ | 258.33$^{fg}$ | 262.66$^{d}$ | 260.50$^{f}$ | 33.33$^{gh}$ | 34.66$^{efgh}$ | 34.00$^{g}$ | 167.33$^{hi}$ | 164.66$^{k}$ | 166.00$^{i}$ | 16.99$^{jkl}$ | 17.2$^{ghi}$ | 17.1$^{ijk}$ |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_{20}$ - Cycocel @ 200 ppm at pea stage | 226.00$^{cde}$ | 223.00$^{gh}$ | 224.50$^{g}$ | 258.33$^{fg}$ | 256.66$^{g}$ | 257.50$^{g}$ | 32.33$^{hij}$ | 33.66$^{fghi}$ | 33.00$^{gh}$ | 162.33$^{k}$ | 160.66$^{m}$ | 161.50$^{k}$ | 16.3$^{klm}$ | 17.08$^{hi}$ | 16.69$^{jk}$ |
| $T_{21}$ - Cycocel @ 200 ppm at 50% flowering+ pea stage | 218.00$^{h}$ | 220.33$^{ij}$ | 219.16$^{ij}$ | 249.33$^{j}$ | 249.66$^{i}$ | 249.50$^{k}$ | 31.33$^{j}$ | 29.33$^{kl}$ | 30.33$^{j}$ | 168.00$^{h}$ | 169.66$^{ghi}$ | 168.83$^{h}$ | 17.82$^{ij}$ | 18.58$^{def}$ | 18.2$^{ghi}$ |
| $T_{22}$ - Cycocel @ 400 ppm at 50% flowering stage | 224.66$^{ef}$ | 225.33$^{ef}$ | 225.00$^{fg}$ | 254.66$^{h}$ | 253.33$^{h}$ | 254.00$^{i}$ | 30.00$^{k}$ | 28.00$^{lm}$ | 29.00$^{k}$ | 165.33$^{j}$ | 164.00$^{kl}$ | 164.66$^{ij}$ | 17.69$^{ijk}$ | 17.89$^{fgh}$ | 17.79$^{hij}$ |
| $T_{23}$ - Cycocel @ 400 ppm at pea stage | 225.66$^{cde}$ | 222.33$^{ghi}$ | 224.00$^{g}$ | 255.00$^{h}$ | 249.66$^{i}$ | 252.33$^{j}$ | 29.33$^{k}$ | 27.33$^{m}$ | 28.33$^{kl}$ | 165.66$^{ij}$ | 164.66$^{k}$ | 165.16$^{ij}$ | 18.48$^{hi}$ | 18.8$^{def}$ | 18.64$^{fgh}$ |
| $T_{24}$ - Cycocel @ 400 ppm at 50% flowering + pea stage | 217.33$^{hi}$ | 219.66$^{j}$ | 218.50$^{j}$ | 245.33$^{k}$ | 246.33$^{j}$ | 245.83$^{l}$ | 28.00$^{l}$ | 26.66$^{m}$ | 27.33$^{lm}$ | 170.00$^{g}$ | 168.33$^{hij}$ | 169.16$^{h}$ | 20.22$^{defg}$ | 19.75$^{bcd}$ | 19.99$^{de}$ |
| S.E(m)± | 0.938 | 1.393 | 0.828 | 1.004 | 1.705 | 0.918 | 0.486 | 0.872 | 0.482 | 1.51 | 1.14 | 1.17 | 0.59 | 0.55 | 0.46 |
| CD at 5% | 2.675 | 3.972 | 2.363 | 2.864 | 4.863 | 2.620 | 1.386 | 2.488 | 1.376 | 4.32 | 3.25 | 3.36 | 1.70 | 1.57 | 1.33 |

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

## Conclusion

The duration for flowering, fruiting and flowering to maturity can be altered by the application of plant growth regulators. Among the various concentration of plant growth regulators, treatment $T_6$ (NAA 200 ppm) and $T_3$ (NAA @ 100 ppm) applied at 50 per cent flowering + pea stage was found superior over other treatments for increasing the number of flowers per shoot, number of fruit set per shoot, fruit set (%), fruit retention (%), number of fruits as well as yield of sapota and ultimately decreased the fruit drop (%) as compared to control. In case of ripening advancement characters, application of Etherel @ 500 and 1000 ppm advanced the ripening of fruits by 18 and 21 days, respectively during first and second year of the investigation.

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