



RESEARCH ARTICLE

# Influence of plant growth regulators on yield attributes and physical parameters of fruit quality in sapota under the eastern tropical region of India

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## Abstract

The present study was conducted at Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar, during 2022 and 2023 to evaluate the impact of the application of plant growth regulators on fruit set, yield and physical fruit quality of Sapota (*Manilkara zapota* L.) cv. DHS-1. The experiment was designed in a randomized completely block design with nine treatments consisting of NAA (50 and 100 ppm), CPPU (5 and 7.5 ppm), SA (150 and 300 ppm) and Homobrassinolide (10 and 15 ppm) and water as control. Treatments were imposed on 24-year-old, uniformly grown sapota trees, planted at 10m x 10m spacing, at flowering, fruit set and one month after fruit set. In general, the application of PGRs was effective in augmenting fruit sets, fruit retention, yield attributes and physical fruit quality over control. However, the application of NAA and CPPU performed better at higher doses. The treatment NAA @100 ppm resulted in the highest fruit set (34.76 %), fruit retention (57.46% at 30 DAFS, 28.48 % at 120 DAFS), yield (47.77 kg/tree) and physical fruit viz. pulp content (93.80%), dry matter (26.15%), fruit length (7.47 cm) and fruit width (6.57 cm). Pearson correlation coefficient analysis showed positive links among fruiting, yield, yield attributing traits and physical fruit quality parameters of sapota, as well as a negative correlation for peel content.

## Keywords

plant growth regulators; foliar spray; pea stages; yield

## Introduction

Sapota (*Manilkara zapota* L.), known as chico, chikoo, sapodilla, lamut and cicle, belongs to the Sapotaceae family. It is native to Mexico and Colombia and grows in tropical biome (1). The fruits are highly flavourful and nutritious. Pulp is mellow, sweetened and crumbly. It features a sandy, granular texture and a distinctive aroma. Sapota fruits are rich in phenolic compounds and ascorbic acid, which leads to their various health benefits for humans. Sapota fruit is also known to contain sugars, protein, amino acids, and carotenoids. It has high levels of minerals, including potassium, copper, iron, zinc, and calcium (2, 3). In Central and South American countries, its bark and fruits produce milky latex, used to produce a commercial product known as Gutta parcha. This latex is a critical ingredient in the preparation of chewing gum (Chickle).

In India, it ranks as the sixth most significant commercial fruit, following mango, banana, citrus, apple, and guava. Cultivation of this fruit in India began in Gholwad village, Maharashtra, in 1898. (4). Being hardy with minimal incidence of weeds, disease and pests, its cultivation has been spread in tropical and subtropical regions of India. The major sapota-producing states are Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Gujarat, West Bengal, Odisha and Haryana. Odisha, located on the eastern coast of India, cultivates sapota in both coastal and interior districts, including Jagatsinghpur, Balasore, Khurda, Kendrapara, Puri, Cuttack and Ganjam. In Odisha, sapota is grown over an area of approximately 3.36 thousand hectares, yielding an annual production of about 15.72 thousand metric tonnes (5).

The flowering is generally erratic, and this trend has facilitated fruit harvest throughout the year. In tropical areas, substantial fruit drop and poor fruit retention are significant challenges to achieving sapota's high yield potential despite abundant flowering (6). Hormonal unevenness and the struggle to photo-assimilate among emerging fruits are the chief factors among various causes (7).

Ample attention has been given to escalating many fruit crops' quantitative and qualitative traits by exogenous application of PGRs. The use of PGRs is considered a crucial element for enhancing the production of superior fruits in the horticulture sector (8). Foliar feeding of PGRs at specific stages of flowering and fruit development can help address issues of irregular flowering and low fruit set (9). PGRs, alternatively referred to as bio-stimulants or bio-inhibitors, operate intracellularly to modulate specific enzymes or enzyme systems, thereby facilitating the regulation of plant metabolism (10). Using PGRs has shown notable growth, yield and quality outcomes in various fruit crops (3).

The challenges of poor fruit set, low fruit retention, and decreased yield in commercially grown sapota in tropical regions must be addressed. There is a need for further research and efforts in this area. The response of the crops to PGRs depends on various factors like dose of application, time of application, edapho-climatic factor, etc. Therefore, the present research was designed to determine the influence of PGRs on fruit set, fruit retention, yield attributes and physical fruit quality of sapota (*Manilkara zapota* L.) cv. DHS-1 (Dharwad Hybrid Sapota-1) under the eastern tropical region of India. A quick pictorial chart representing the research work methodology is encapsulated in Figure 1.

## Materials and Methods

The present experiment was plotted during 2021 and 2022 at the research farm site of ICAR-IIHR-Central Horticultural Experiment Station, Bhubaneswar, Odisha. Humid, hot and tropical conditions characterized the climate at the experimental site. The site is situated at 20° 15' N latitude and 85° 15' E longitude, with an elevation of 42 meters above mean sea level.

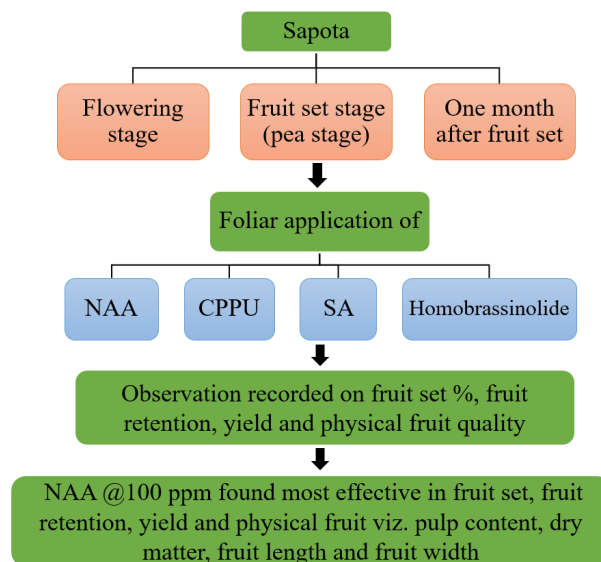


Fig. 1. Pictorial chart form representation of the experiment.

The soil in the experimental site was characterized by sandy loam, consisting of 73.40% sand, 17.25% silt and 9.35% clay. It was highly acidic with a pH of 4.49 with available nitrogen (186.74 kg/ha) comprising low levels of organic carbon (0.24%) and phosphorus (12.15 kg/ha), while potassium levels were moderate (181.51 kg/ha).

Maintenance of the research field was carried out as per standard cultural practices. The experiment was carried out in RCBD design with nine treatments consisting of NAA @50, 100, CPPU @5ppm, 7.5ppm, SA @150ppm, 300ppm and Homobrassinolide @10 ppm, 15 ppm keeping one treatment control (water spray). Each treatment was replicated three times and each replication consisted of four plants. The application of PGRs was done each year at flowering, fruit setting (pea stage) and one month after fruit setting.

The fruits were picked at the full mature stage. Fruit yield and physical fruit quality attributes were recorded and analyzed at a central laboratory in the Central Horticultural Experiment Station (ICAR-IIHR), Bhubaneswar. Recorded data of various parameters were statistically analyzed using the variance technique (11). Duncan's Multiple Range Test was employed to determine significant differences at the  $p=0.05$  level. As regulated by growth regulators, Pearson correlation coefficients among fruiting, yield, yield attributing traits and physical fruit quality parameters of sapota were worked out using KAUGRAPES software.

The data presented in Table 1 revealed that the number of flowers per shoot ranges from 7-9 in sapota crops, and the application of PGRs was found to be significantly effective in fruit sets and the total number of fruits per shoot. Among the different PGRs, the maximum fruit set (34.76 %) and the total number of fruits per shoot (2.77) were recorded with T4 (NAA @100 ppm), which was significantly higher than the rest of the treatments, followed by T2 (CPPU 7.5 ppm), whereas the minimum was recorded under control. The positive influence of NAA on fruits per shoot and fruit set could be attributed to its role in translocating and mobilizing the stored metabolites or photosynthates from source to sink (12). The results are supported by many scientists (13-16).

**Table 1:** Pooled data on the effect of NAA, CPPU, SA and Homobrassinolide on flowering, fruit set % and yield of sapota cv. DHS-1.

Treatments	Flower/shoot	fruits/shoot	Fruit set	Fruits/trees	Average fruit weight	Yield
	(nos.)	(nos.)	(%)	(nos.)	(g)	(kg/tree)
T <sub>1</sub>	7.97 <sup>cd</sup>	2.19 <sup>bc</sup>	27.52 <sup>d</sup>	340.77 <sup>d</sup>	127.98 <sup>c</sup>	43.61 <sup>d</sup>
T <sub>2</sub>	8.08 <sup>b</sup>	2.64 <sup>a</sup>	32.71 <sup>b</sup>	347.31 <sup>b</sup>	132.73 <sup>b</sup>	46.10 <sup>b</sup>
T <sub>3</sub>	7.94 <sup>b</sup>	2.35 <sup>b</sup>	29.65 <sup>c</sup>	344.09 <sup>c</sup>	129.07 <sup>c</sup>	44.41 <sup>c</sup>
T <sub>4</sub>	7.98 <sup>a</sup>	2.77 <sup>a</sup>	34.76 <sup>a</sup>	354.20 <sup>a</sup>	134.87 <sup>a</sup>	47.77 <sup>a</sup>
T <sub>5</sub>	7.58 <sup>cd</sup>	1.94 <sup>de</sup>	25.54 <sup>f</sup>	323.88 <sup>e</sup>	125.26 <sup>d</sup>	40.57 <sup>f</sup>
T <sub>6</sub>	7.32 <sup>d</sup>	1.75 <sup>ef</sup>	23.96 <sup>e</sup>	321.04 <sup>h</sup>	122.73 <sup>e</sup>	39.40 <sup>e</sup>
T <sub>7</sub>	7.78 <sup>c</sup>	2.00 <sup>cd</sup>	25.77 <sup>f</sup>	331.91 <sup>f</sup>	125.42 <sup>d</sup>	41.63 <sup>e</sup>
T <sub>8</sub>	7.92 <sup>cd</sup>	2.08 <sup>cd</sup>	26.26 <sup>e</sup>	340.00 <sup>e</sup>	127.93 <sup>c</sup>	43.50 <sup>d</sup>
T <sub>9</sub>	7.17 <sup>e</sup>	1.67 <sup>f</sup>	23.31 <sup>h</sup>	316.08 <sup>i</sup>	121.78 <sup>e</sup>	38.49 <sup>h</sup>

T<sub>1</sub>:CPPU 5ppm; T<sub>2</sub>: CPPU 7.5 ppm; T<sub>3</sub>: NAA 50 ppm; T<sub>4</sub>: NAA 100 ppm; T<sub>5</sub>: SA 150 ppm; T<sub>6</sub>: SA 300 ppm; T<sub>7</sub>: Homobrassinolide10 ppm; T<sub>8</sub>: Homobrassinolide15ppm; T<sub>9</sub>: Control (Water spray)

The values marked with the same alphabets are non-significant at P>0.05, NS: Non-significant.

Further, figure 2 exhibited a decreasing trend of fruit retention with the progression of fruit maturity, regardless of given treatments. Fruit retention at 30 days after fruit set (DAFS) was found to range from 50.50 to 57.46 %, although, at the fruit maturity stage (120 DAFS), it was recorded from 20.27 to 28.48 %. It is apparent from the glancing at data that foliar spray of NAA @100 ppm (T<sub>4</sub>) substantially upgraded the fruit retention in sapota. The treatment T<sub>4</sub> (NAA @100 ppm) achieved the supreme fruit retention (57.46 %) at 30 DAFS, closely followed by T<sub>2</sub>, i.e. CPPU 7.5 ppm (55.66 %). The results remained the same throughout the observation period (60, 90 and 120 DAFS). The positive influence of NAA on fruit retention could be due to its role in facilitating appropriate augmentation of nutrients and anticipation of creating an abscission layer by some inhibiting enzymatic activities (17). The results also align closely with the findings of other researchers (13, 15, 18).

The yield data presented in Table 1 shows that all the treatments of PGRs significantly boosted the sapota produce in terms of fruit number, average fruit weight and yield over the control. However, the effect was more prominent for NAA @100 ppm. Among the different chemical sprays, a maximum number of fruits per tree (354.20), average fruit weight (134.87 g), and yield tree (47.77 kg/tree) was recorded with T<sub>4</sub> (NAA @100 ppm), which was significantly higher than rest of the treatments, followed by T<sub>2</sub> (CPPU 7.5 ppm) whereas the minimum was recorded under control. Regarding average fruit weight (g), T<sub>6</sub> (SA 300 ppm) was at par with the power. The highest number of fruits per tree using NAA might be attributed to

the substantial fruit set and fruit retention attained by applying NAA. The significant influence of NAA on the increase in fruit weight could be due to its effect on cell elongation and cell wall loosening, which increased its plasticity (9). The enhancement in fruit yield may be attributed to more results in yield-related components, namely, fruit weight and number. The findings are consistent with the previous study outcomes (16, 18-20).

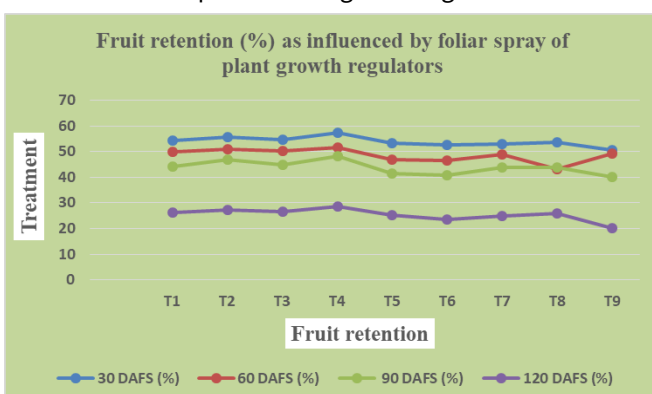
The data presented in Table 2 about physical fruit quality indicated a significant influence on fruit pulp, dry matter and lowest peel. In contrast, no significant impact was observed in fruit length, width, seed content and seed weight.

It is observed that application of T<sub>4</sub> (NAA @100 ppm) resulted in maximum fruit pulp (93.80 %) and dry matter (26.15 %) with the lowest peel (4.68 %), whereas the minimum was recorded under control. The effect of NAA on increasing pulp weight and reducing peel weight may be attributed to the enlargement of cell size and intracellular spaces, along with a more significant accumulation of water, sugars and other soluble solids in it, which resulted in the enhanced translocation of metabolites towards fruit development (12, 21). Previously, similar findings were also noted in banana fruit (22).

The effect of treatments on fruit length (cm), fruit width (cm), seed content (%), and seed weight was reported to have a non-significant effect. The results are aligned with previously conducted work as well (23). However, maximum fruit length (7.47 cm), fruit width (6.57 cm), seed content (1.52 %) and seed weight (2.05 g) were found with T<sub>4</sub> (NAA @100 ppm), followed by T<sub>2</sub> (CPPU 7.5 ppm) whereas the minimum (6.21 cm, 5.23 cm, 0.79 %, 0.97 g) was recorded under control.

### Correlation study among fruiting traits, yield attributing traits and physical fruit quality parameters of sapota:

Pearson correlation coefficient analysis was conducted on pooled data to examine the relationships among fruiting traits, yield attributing traits and physical fruit quality parameters of sapota as affected by growth regulators. The data illustrated in Fig. 3 shows that flowering and fruiting characters like flower per shoot, fruit per shoot, fruit set and fruit retention exhibited substantial positive correlations with fruits per tree, average fruit weight, fruit



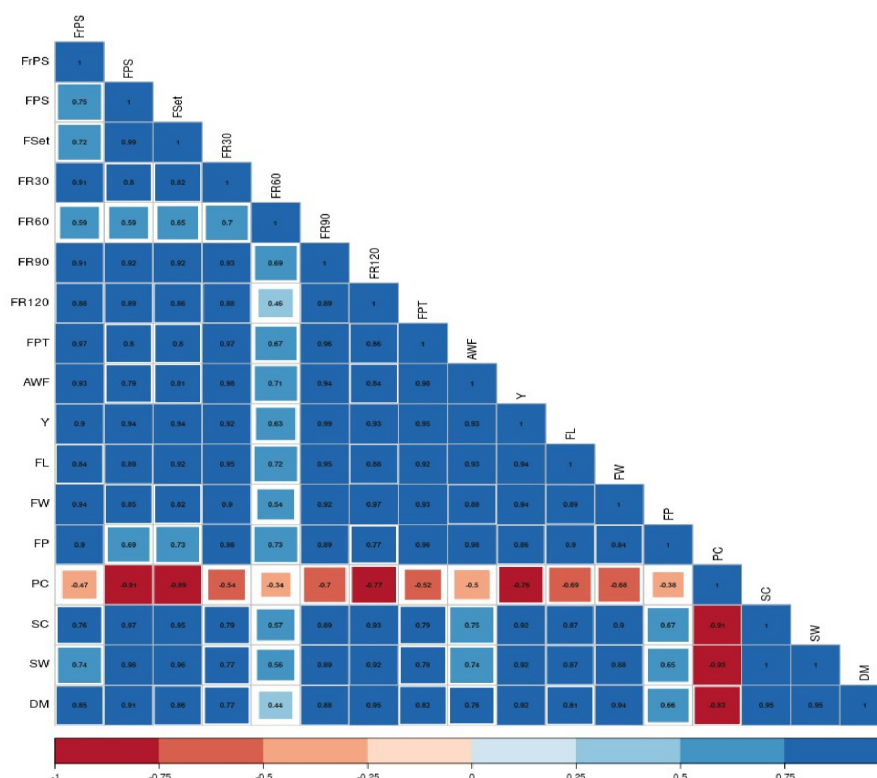
**Fig. 2.** Fruit retention (%) as influenced by foliar spray of plant growth regulators in sapota cv. DHS-1.

**Table 2:** Pooled data on the effect of NAA, CPPU, SA and Homobrassinolide on physical fruit quality parameter sapota cv. DHS-1.

Treatments	Fruit length (cm)	Fruit width (cm)	Fruit Pulp (%)	peel (%)	seed content (%)	Seed weight (g)	Dry matter (%)
T <sub>1</sub>	6.59 <sup>cd</sup>	6.30 <sup>cd</sup>	90.07 <sup>d</sup>	8.66 <sup>d</sup>	1.27 <sup>c</sup>	1.63 <sup>c</sup>	24.63 <sup>b</sup>
T <sub>2</sub>	7.18 <sup>b</sup>	6.42 <sup>b</sup>	92.54 <sup>b</sup>	6.07 <sup>f</sup>	1.40 <sup>b</sup>	1.86 <sup>b</sup>	26.22 <sup>a</sup>
T <sub>3</sub>	7.06 <sup>b</sup>	6.41 <sup>bc</sup>	90.95 <sup>c</sup>	7.72 <sup>e</sup>	1.33 <sup>bc</sup>	1.72 <sup>c</sup>	24.80 <sup>b</sup>
T <sub>4</sub>	7.47 <sup>a</sup>	6.57 <sup>a</sup>	93.80 <sup>a</sup>	4.68 <sup>g</sup>	1.52 <sup>a</sup>	2.05 <sup>a</sup>	26.15 <sup>a</sup>
T <sub>5</sub>	6.59 <sup>cd</sup>	5.88 <sup>f</sup>	88.74 <sup>f</sup>	10.22 <sup>b</sup>	1.04 <sup>ef</sup>	1.31 <sup>ef</sup>	20.58 <sup>e</sup>
T <sub>6</sub>	6.49 <sup>d</sup>	5.81 <sup>f</sup>	88.32 <sup>f</sup>	10.70 <sup>b</sup>	0.99 <sup>f</sup>	1.21 <sup>f</sup>	18.84 <sup>f</sup>
T <sub>7</sub>	6.67 <sup>c</sup>	6.14 <sup>e</sup>	88.66 <sup>f</sup>	10.20 <sup>b</sup>	1.14 <sup>d</sup>	1.43 <sup>d</sup>	22.39 <sup>d</sup>
T <sub>8</sub>	6.60 <sup>cd</sup>	6.21 <sup>de</sup>	89.43 <sup>e</sup>	9.47 <sup>c</sup>	1.11 <sup>de</sup>	1.42 <sup>de</sup>	23.60 <sup>c</sup>
T <sub>9</sub>	6.21 <sup>e</sup>	5.23 <sup>g</sup>	86.57 <sup>g</sup>	12.64 <sup>a</sup>	0.79 <sup>g</sup>	0.97 <sup>g</sup>	15.75 <sup>g</sup>

T<sub>1</sub>:CPPU 5ppm; T<sub>2</sub>: CPPU 7.5 ppm; T<sub>3</sub>: NAA 50 ppm; T<sub>4</sub>: NAA 100 ppm; T<sub>5</sub>: SA 150 ppm; T<sub>6</sub>: SA 300 ppm; T<sub>7</sub>: Homobrassinolide 10 ppm; T<sub>8</sub>: Homobrassinolide 15ppm; T<sub>9</sub>: Control (Water spray)

The values marked with the same alphabets are non-significant at P>0.05, NS: Non-significant.

**Fig. 3.** Correlation study among fruiting traits, yield attributing traits and physical fruit quality parameters of sapota.

FrPS- flower per shoot, FPS- fruit per shoot, FSet- fruit set, FR30- Fruit Retention @30DAFS, FR60- Fruit Retention @60DAFS, FR90- Fruit Retention @90DAFS, FR120-Fruit Retention @120DAFS, AWF- average fruit weight, Y- Yield, FL- fruit length, FW- fruit width, FP- fruit pulp, PC-peel content, SC- seed content, SW- Seed weight, DM- Dry matter.

yield, fruit length, fruit width, fruit pulp, seed content, seed weight and dry matter. However, the correlation was significantly negative with peel content. Similarly, yield-attributing traits like fruits per tree and average fruit weight were found to be positively correlated with fruit per shoot, fruit set, fruit retention, fruit yield, fruit length, fruit width, fruit pulp, seed content, seed weight and dry matter, but exhibited negative correlation with peel content. Further, a significant correlation existed among physical fruit quality parameters like fruit length, fruit width, fruit pulp, seed content, seed weight, dry matter and other parameters like fruit per shoot, fruit set, fruit retention, fruits per tree, average fruit weight and fruit yield. Peel content of sapota fruit established a negative correlation with all the characters.

## Conclusion

From the two-year study, it may be concluded that foliar application of NAA @100 ppm during flowering, fruit set and one month after fruit set improved fruit set, fruit retention, number of fruits per tree, yield and physical fruit quality, viz. pulp content, dry matter, fruit length and fruit width. Therefore, this research can be helpful for farmers as it demonstrates that the use of PGRs can be an effective tool for improving production and quality and ensuring profitable sapota farming.

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facilities during the research period. Their assistance has contributed significantly to the success of this study.

### Authors' contributions

All the authors contributed to the above work, starting from designing the experiment, collecting data, assisting with statistical analysis, interpretation of results, and manuscript preparation. Conceptualization of research (DG, GCA); Designing of the experiments (DG, GCA, DS); Contribution of experimental materials (GCA, DS); Execution of field/lab experiments and data collection (DG, GCA, DS, AAK); Analysis of data and technical guidance (DG, SCS, SS, CS); Preparation of the manuscript (DG, GCA, DS); modifications and coordination (CS, KKS, AAK). All the authors read and approved the final manuscript.

### Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interest to declare.

**Ethical issues:** None

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