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Plant bioregulators induced manipulation in the yield attributes of mango cv. Langra

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ABSTRACT

The present study was carried out in two successive years to evaluate the comparative efficacy of CPPU and NAA combination in improving the yield attributes of Langra mango. Higher fruit drop and low fruit retention are the most critical constraints for mango production under north Indian conditions. Fruit drop starts occurring just after fruit set and continues till harvest, leading to substantial economic loss to the growers. The foliar application of CPPU 10 ppm + NAA 20 ppm and CPPU 20 ppm + NAA 30 ppm immediately after the fruit set resulted in a significant reduction in fruit drop in comparison to the control (water spray). Various physical attributes like endocarp size (5.16 cm), pedicel length (1.20 cm), pedicel thickness (4.02 mm), fruit weight (248.12 g), fruit size (7.46 cm width and 9.83 cm length), fruit volume (243.52 cc), and specific gravity (1.02) got improved with CPPU 10 ppm + NAA 20 ppm followed by CPPU 20 ppm + NAA 30 ppm than the control. In conclusion, the spray of CPPU 10 ppm + NAA 20 ppm proved to be an effective treatment for managing fruit drop and improving yield attributes in Langra mango.

Key words: *Mangifera indica* L., Auxin, Cytokinin, Fruit drop.

INTRODUCTION

Mango (*Mangifera indica* L.) is a delectable fruit belonging to the family Anacardiaceae that evolved in the Indo-Myanmer region. The world's top mango grower is India, followed by Pakistan and Indonesia. Mango production in India is 24.96 million metric tons annually, and the crop covers 2.62 million hectares area (Anon, 2). Langra is a popular variety of mango commercially cultivated in North and Eastern Indian states like Punjab, Delhi, Uttar Pradesh and Bihar. It is a mid-season variety with oblong to oval-shaped fruits, waxy light green colour, with medium fruit size. However, Langra mango has production limits such as irregular bearing, heavy fruit drop, and low fruit yield (occasionally 0.1% fruit retention). High fruit drop is caused by lack of pollination, sink rivalry, self-incompatibility, embryo abortion, hormonal imbalance, nutrient insufficiency, climatic variables, insufficient moisture, and low photosynthetic efficiency. Mango fruit abscission takes place as growth stimulants (auxins, cytokinins, and gibberellins) are less abundant than inhibitors such as abscisic acid and ethylene (Krisanapook *et al*., 9). Various PBRs like NAA, 2,4-D, 2,4,5-T, cytokinin, gibberellins, and cycocel, regulate plant nutrition and hormones, improving mango fruit set and reducing fruit abscission. CPPU (forchlorfenuron), a synthetic cytokinin with powerful growth-regulating properties, accelerates fruit growth by boosting cell division and elongation. CPPU enhances fruit set (Fathi *et al.*, 6), while BA increases the fruit size (Merwad *et al.*, 11). The physical fruit attributes of date palm have been reported to be improved by the application of NAA and IAA (Al-Qurashi *et al.*, 1). Mango fruit retention increases when exogenous NAA is applied during the pea and marble stages of fruit development (Vejendla *et al*., 20) and improved fruit retention and fruit weight of Keitt mango by foliar application of NAA and GA_3 at full bloom stage (Nkansah *et al*., 13). Many factors, including fruit set, fruit size, fruit drop, *etc*., play a crucial role in achieving sustainable fruit yield in mango.

The previous research emphasized the prospective effect of bioregulators on enhancing fruit yield and quality attributes; however, the information is inconsistent and further research is required to design a protocol for the application of plant bioregulators (PBRs) to reduce the fruit drop percentage with improved yield contributing attributes. Therefore, an experiment was conducted to assess the relative efficacy of CPPU and NAA combinations for regulating the fruit yield in mango cv. Langra.

MATERIALS AND METHODS

The current study was made on 35-years-old Langra mango trees, grafted on Ramkela mango rootstock and planted at a distance of 10 m × 10 m cultivar at PAU Regional Station, Bahadurgarh

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(30.3627° N, 76.4708° E), Patiala during of 2021-22 and 2022-23. The experimental trees were sprayed with CPPU 10 ppm + NAA 20 ppm (T_1) or CPPU 20 ppm + NAA 30 ppm (T_2) immediately after the fruit set. The control plants were sprayed only with normal water (T_3). During the entire course of investigations, the cultural practices were applied as per the '*Package of Practices for Cultivation of Fruit Crops',* Punjab Agricultural University, Ludhiana. Fruit retention and periodic fruit drop per cent were recorded with the standard formula described by Darshan *et al*. (4). The fruits were weighed using a digital scale, and the average weight was recorded in grams. Using digital Vernier calipers, the endocarp length, pedicel length, and pedicel thickness were measured and expressed in cm/ mm. The fruit length and fruit width were measured with the help of digital Vernier calipers and expressed in cm. Fruit volume as estimated using the water displacement method and represented in cubic cm. The experiment was laid out in a randomized block design with five replications. The data were analyzed for variance using the SAS (V 9.4, SAS Institute Inc., USA) package. The interaction means were subjected to analysis of variance, and pairwise comparisons were performed using Tukey HSD ($p \leq 0.05$), where it was found that there was a significant difference.

RESULTS AND DISCUSSION

It is clear from the data presented in (Table 1) that the use of plant bioregulators (PBRs) led to a considerable increase in the endocarp of fruits when compared to untreated fruits. The biggest endocarp length (5.16 cm) was recorded in treatment T1, whereas it was the smallest (4.26 cm) in untreated plants (T_3). There are typically intimate relationships and synchronized processes between the development of seeds and fruits. It is now widely acknowledged that seeds contain a variety of hormones, such as cytokinin, GA, and auxins, which regulate fruit size and encourage the growth of surrounding tissues (Ozga *et al.*, 14). During the stages of fruit development, when cell division is followed by a phase of cell expansion, auxin and cytokinin levels increase in the developing seed (Devoghalaere *et al.,* 5).

The pedicel length and pedicel thickness of mango fruits were significantly improved by the application of CPPU and NAA (Fig. 1 & 2), which also contributed to reduced fruit drop and higher fruit retention. The trees sprayed with CPPU 10 ppm + NAA 20 ppm (T_1) produced the highest pedicel length (1.20 cm) and thickness (4.02 mm), followed by trees sprayed with CPPU 20 ppm + NAA 30 ppm (T_2) and sprayed only with normal water (T_3). The improvement in pedicel length and thickness of mango fruits after spraying CPPU and NAA at a lower concentration might be due to an increase in the cell division, cell elongation, cell number, and cell layer, which were unseen in untreated plants or trees sprayed at higher concentration of CPPU and NAA. Furthermore, CPPU and NAA may have increased the thickness of the

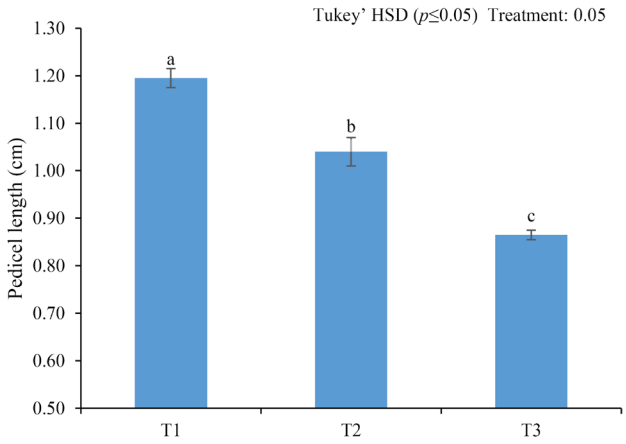

Fig. 1. Effect of PGRs on pedicel length of mango cv. Langra. Data represent the mean ± standard error of the mean of five replicates (pooled means for 2 years).

Table 1. Effect of PBRs on endocarp size, fruit growth and specific gravity of mango cv. Langra (pooled means for two seasons).

Treatment	Endocarp size (cm)	Fruit weight (g)	Fruit width (cm)	Fruit length (cm)	Fruit volume (cc)	Specific gravity
CPPU 10 ppm + NAA 20 ppm (T_1)	5.16 ± 0.06^a	248.12 ± 3.71^a	7.46 ± 0.05^a	9.83 ± 0.06^a	243.52 ± 3.38^a	1.02 ± 0.004^a
CPPU 20 ppm + NAA 30 ppm (T_2)	4.94 ± 0.03^b	228.02 ± 5.80^b	7.27 ± 0.03^b	9.46 ± 0.06^b	226.17 ± 5.48^b	1.01 ± 0.004^a
Control (T_3)	4.26 ± 0.02^c	207.72 ± 3.57^c	7.09 ± 0.04^c	9.13 ± 0.05^c	209.97 ± 2.81^c	0.99 ± 0.004^b
Tukey' HSD ($p \leq 0.05$)	0.11	11.47	0.12	0.16	10.39	0.01

*Mean with the same letters does not vary significantly ($p \leq 0.05$).

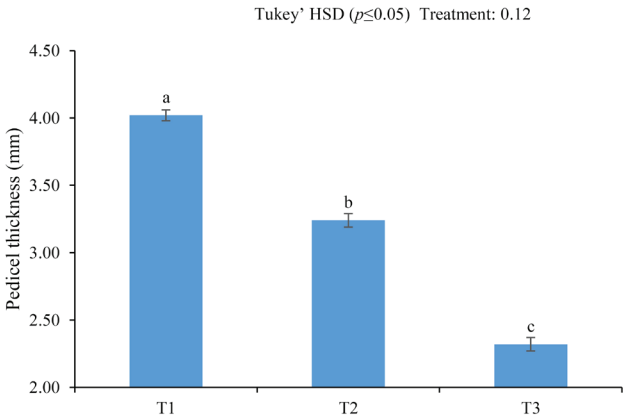

Fig. 2. Effect of PGRs on pedicel thickness of mango cv. Langra. Data represent the mean ± standard error of the mean of five replicates (pooled means for 2 years).

pedicel by increasing the number and density of cells within the pedicel. These results conform with the results on sweet cherry (Canli *et al*., 3) and grape (Senthilkumar *et al*., 16).

The data presented in (Table 2) demonstrate that pre-harvest application of CPPU and NAA significantly improved the fruit retention of mango cv. Langra fruits. The trees that received CPPU 10 ppm + NAA 20 ppm (T_1) exhibited an average maximum fruit retention of (2.49%), which was higher than the trees sprayed with CPPU 20 ppm + NAA 30 ppm (T_2). However, the untreated plants (T_3) showed the lowest fruit retention (1.33%). CPPU and NAA play vital roles in fruit retention by promoting growth, inhibiting premature fruit drop, and ensuring optimal fruit development. CPPU and NAA have a significant impact on boosting fruit sets and final fruit retention due to their ability to galvanize and assimilate to metabolically active areas like fruitlets (Guirguis *et al*., 7). It also assists in strengthening the cell walls of the abscission layer, thereby reducing fruit shedding by promoting cell division and the synthesis of proteins, RNA, and DNA. Similar outcomes were also observed in mangoes treated with NAA 50 ppm by Vejendla *et al*. (20).

The use of plant bioregulators prior to harvest reduced the fruit drop percentage of mango cv. Langra (Table 2). The lowest fruit drop percentage (97.50%) was recorded in treatment T1, which T2 closely followed. However, it was lowest (98.66%) in the control treatment (T_3). Fruit drop in mango may be caused by a lack of auxins, gibberellins, and cytokinins, as well as a high concentration of inhibitors such as ethylene and abscisic acid (Krisanapook *et al*., 9). An abscission layer forms at the fruit attachment site when ethylene and abscisic acid levels in the panicle increase and cause the fruit to drop. NAA and CPPU are well-known for inhibiting the production of ethylene and abscisic acid. Our findings are consistent with the report of Pujari *et al.* (15) on custard apple.

The pre-harvest spraying of plant bioregulators significantly improved the fruit weight and size of mango cv. Langra over the untreated ones (Table 1). The trees that received CPPU 10 ppm + NAA 20 (T_1) produced the highest fruit weight (248.12 g) and size (7.46 cm width and 9.83 cm length) of mango fruits,

Table 2. Effect of PBRs on fruit retention and periodic fruit drop of mango cv. Langra (pooled means for two seasons).

Treatment	Fruit retention per panicle at 15-day interval (%)						
	15 Day	30 Day	45 Day	60 Day	75 Day	At harvest	Mean
CPPU 10 ppm + NAA 20 ppm (T_1)	4.42^{a}	3.53^{c}	1.91^{f}	1.85^{f}	1.62^{gh}	1.62^{gh}	2.49 ± 0.18^{a}
CPPU 20 ppm + NAA 30 ppm (T_2)	4.18^{b}	2.31^{e}	1.76^{fg}	1.48^{hi}	1.19^{jk}	1.19^{jk}	2.02 ± 0.17^{b}
Control (T_3)	2.56^{d}	1.58^{h}	1.32^{ij}	1.05^{k}	0.83^{l}	0.68^{m}	1.33 ± 0.11^{c}
Mean	3.72 ± 0.20^{a}	2.47 ± 0.19^{b}	1.66 ± 0.06^{c}	1.46 ± 0.08^{d}	1.21 ± 0.08^{e}	1.16 ± 0.10^{e}	
Tukey's HSD (p≤0.05)	Treatment = 0.04 Stage = 0.08 Interaction (T × S) = 0.18						
Periodic fruit drop (%)							
CPPU 10 ppm + NAA 20 ppm (T_1)	95.57^{c}	96.46^{bc}	98.08^{ab}	98.15^{ab}	98.38^{ab}	98.38^{ab}	97.50 ± 0.26^{b}
CPPU 20 ppm + NAA 30 ppm (T_2)	95.81^{c}	97.68^{abc}	98.23^{ab}	98.52^{ab}	98.80^{a}	98.80^{a}	97.98 ± 0.25^{b}
Control (T_3)	97.43^{abc}	98.42^{ab}	98.67^{a}	98.94^{a}	99.17^{a}	99.32^{a}	98.66 ± 0.21^{a}
Mean	96.27 ± 0.33^{c}	97.52 ± 0.33^{b}	98.33 ± 0.27^{ab}	98.54 ± 0.28^{a}	98.79 ± 0.28^{a}	98.84 ± 0.29^{a}	
Tukey's HSD (p≤0.05)	Treatment = 0.49 Stage = 0.93 Interaction (T × S) = 2.13						

*Mean with the same letters does not vary significantly (p≤0.05).

as compared to CPPU 20 ppm + NAA 30 ppm (T_2). However, the untreated mango plants (T_3) produced the lowest fruit weight (207.72 g) and fruit size (7.09 cm width and 9.13 cm length). The improvement in physical attributes of mango fruits (fruit weight, fruit width and fruit length) after foliar application of CPPU and NAA might be due to their impacts on cell proliferation and expansion, which increased the size of the fruit by increasing the carbohydrate sink which might have contributed to the rise in fruit weight, fruit width and fruit length (Kassem *et al.*, 8). The above findings are similar to those reported by Mostafa *et al.* (12) on avocado, Kulkarni *et al*. (10) on Kesha mango and Sharma *et al.* (17) on plum.

The data presented in (Table 1) demonstrate a significant difference in fruit volume between treatments. Mango trees sprayed with CPPU 10 ppm + NAA 20 ppm (T_1) produced the lowest fruit volume (243.52 cc), which was comparable to T_2 treatment. In contrast, plants sprayed with only normal water (T_3) had the lowest fruit volume (209.97 cc). The role of each plant bio-regulator or combination was to multiply and lengthen the meristem cells, which increased the fruit volume. Foliar application of NAA and CPPU also boost fruit mesocarp cell development, which, therefore, leads to an increase in fruit volume in mango fruits (Stern *et al.*, 19). Similar results were also observed by Kaseem *et al.* (8) in date palms with the use of 75 mg/L NAA.

Application of plant bioregulators *via* foliar means resulted in a statistically significant change in the specific gravity of mango fruits (Table 1). Mango fruits had a maximum specific gravity (1.02) in response to plants receiving a lower dose of plant growth regulators CPPU 10 + NAA 20 ppm (T_1), which was closely followed by plants receiving a higher dose of plant bio-regulators CPPU 20 + NAA 30 ppm (T_2). On the other hand, plants sprayed with normal water (T_3) had the lowest specific gravity (0.99) of fruits. The reason why fruits lose specific gravity when they ripen could be due to the conversion of insoluble starch into soluble sugars. Therefore, by lowering weight loss and respiration losses, the application of plant growth hormones before harvest helped to maintain a greater specific gravity. The findings of this investigation conform with the results of Singh *et al*. (18) on the guava cv. Allahabad Safeda, with the use of NAA.

The present investigation demonstrated that the application of plant growth regulators immediately after fruit set at lower concentrations (CPPU 10 ppm + NAA 20 ppm) significantly improves the pedicel length and pedicel thickness of mango fruits, which ultimately led to yield contributing characteristics of mango cv. Langra.

AUTHORS' CONTRIBUTION

Conceptualization of research (KSG, MSG, NK); Designing of the experiments (KSG, DD); Execution of field/lab experiment and data collection (DD), Analysis of data and interpretation (KSG, DD); Preparation of manuscript (DD, KSG).

DECLARATION

The authors declare that they do not have any conflict of interest.

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