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Influence of foliar application of NAA, urea, Nano-urea and Biofertisol on fruit drop and retention of mango (*Mangifera indica* L.) cv. Langra

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Abstract
The present investigation entitled "Influence of Foliar Application of NAA, Urea, Nano-urea and Biofertisol on Fruit Drop and Retention of Mango (*Mangifera indica* L.) cv. Langra" was carried out at the Fruit Research Station, Imalia, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the year 2022-23 on 23 years old mango plants cv. Langra spacing at 12 × 12 m. This experiment was carried out with statistical method RBD (Randomized Block Design) having three replications. Three levels of each i.e., NAA (20,30,40 ppm), Urea (2%, 3% and 4%), Nano-urea (0.2%, 0.3% and 0.4%) and Biofertisol (5ml/litre, 10ml/litre and 15 ml/litre) were sprayed at full bloom and pea stage of mango. In this experiment all the treatments significantly influenced the initial fruit set & percentage, number of fruits at pea, marble and pre-harvest stage, fruit drop at pea, marble and pre-harvest stage and final fruit retention compared to control. Foliar application of NAA @ 40ppm at full bloom and pea stage gave maximum number of initial fruit set & Fruit set percentage (12.12 and 1.86%), number of fruits at pea, marble and pre-harvest stage (5.11, 3.0 and 1.31) and minimum fruit drop percentage at pea, marble and pre-harvest stage (57.85%, 75.43% and 89.32%, respectively) with higher fruit retention (10.78%) at harvest stage compare to other treatments.

Keywords: Mango, langra, foliar spray, NAA, urea, nano-urea, biofertisol, fruit drop

1. Introduction
The plant species known as Mango, scientifically classified as *Mangifera indica* L., is a member of the Anacardiaceae family. It has a chromosomal number of 2n= 4x= 40. Due to its nutritional value and economic significance, it is one of the most popular and widely grown fruits in the tropics. The cultivation of this crop on the Indian subcontinent has been documented for a period exceeding 4000 years, as noted by De Candolle in 1904. In India, the mango is often referred to as the "King of the fruits" due to its significant historical and religious significance, alluring perfume, and captivating flavour (Dutta *et al*., 2013) [9]. Mangoes have become a prominent item in international commerce due to their exceptional quality (Iqbal *et al*., 2012) [13]. According to Bhowmick *et al*., (2012) [7], the mango is recognised as the National Fruit of India. The major states in India that contribute to mango production are Andhra Pradesh, Uttar Pradesh, Bihar, Karnataka, Tamil Nadu, West Bengal, Odisha, and Maharashtra. In the state of Madhya Pradesh, the total land area dedicated to mango cultivation amounts to 42.11 thousand hectares, resulting in an annual output of 526.23 thousand tonnes (NHB, 2021) [4].
In India, the flowering period starts in January and concludes in April. The time of blooming is rather brief, often lasting between 2 and 3 weeks. Under conditions of low temperatures, there is a possibility for extension, whereas under conditions of high temperatures, there is a possibility for constriction. The duration required for the achievement of fruit maturation varies between 100 and 150 days, depending upon the specific cultivar, geographical location of cultivation, and diverse meteorological influences. According to Iyer *et al*. (1989) [14], there is a clear correlation between the early fruit set and the percentage of perfect blooms. However, the ultimate fruit set is not contingent upon this proportion. In their study, Kumar *et al*. (2018) [17] examined the flowering and fruiting patterns of five prominent mango cultivars, namely Langra, Zardalu, Bombai, Himsagar, and Bangalora. Their findings revealed that the cultivar Langra had the greatest fruit drop rate, reaching 97.70%.

An elevation in the level of auxin is associated with a phase of accelerated growth, while an elevated level of inhibitor is associated with a faster rate of fruit abscission. Indeed, the formation of an abscission layer at the site of fruit attachment occurs as a consequence of increased concentrations of abscisic acid and ethylene in the panicle, leading to the eventual detachment of the fruit (Sahu *et al*., 2020) [22]. One of the horticultural practices that have been shown to effectively minimize fruit drop, boost production, and improve fruit quality in mangoes is the use of growth regulators (NAA and GA3) by foliar spray (Anila and Radha, 2003) [3]. Auxin has been well recognised for its ability to block the activity of ethylene in several plant species (Beyer, 1976) [5]. The variability in effectiveness and concentration of plant growth regulators on a plant species' flowering, fruit set, and retention has been shown in different agro-climatic conditions.

2. Materials and Methods

2.1 Location

The experiment was conducted at the Fruit Research Station, Imalia, Department of Horticulture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the year 2022-23.

2.2 Experimental Details

Total 39 mango plants cv Langra aged of 23 years old with plant spacing at 12 × 12 m was selected. The experiment was laid out in randomized block design with thirteen treatments and three replications. The treatments are as follows- two spray of Control (T_1), NAA @ 20 ppm (T_2), NAA @ 30ppm (T_3), NAA @ 40 ppm (T_4), Urea @ 2% (T_5), Urea @ 3% (T_6), Urea @ 4% (T_7), Nano-Urea @ 0.2% (T_8), Nano-Urea @ 0.3% (T_9), Nano-Urea @ 0.4% (T_{10}), Biofertisol @ 0.5% (T_{11}), Biofertisol @ 1.0% (T_{12}) and Biofertisol @ 1.5% (T_{13}) at full bloom and pea stage. Before spraying 20 panicles of each treatment were tagged and number of fruits was counted. The initial fruit set was calculated by counting the number of fruit set at initial stage from the total number of hermaphrodite flowers on tagged twigs.

2.3 Method of measurement

2.3.1 Initial fruit set (%)

The initial fruit set percentage was calculated by dividing the number of fruit set at initial stage from the total number of hermaphrodite flowers on tagged twigs. The initial fruit set percentage was calculated by using the formula given below:

$$\text{Initial fruit set}(\%) = \frac{\text{Initial fruit set}}{\text{Number of hermaphrodite flower}} \times 100$$

2.3.2 Number of fruits at pea, marble and pre-harvest stage

The panicles which were tagged for recording the number of fruits at pea stage, were subsequently counted at marble stage and pre-harvest stage and their average values were calculated.

2.3.3 Fruit drop (%) at pea stage per panicle

The total number of fruits were considered as fruit set at the grain stage. The number of fruits retained on each tagged panicle was recorded at pea stage. Fruit fall were also recorded at 15 days interval. Then the difference between total number of initial fruit set (grain stage) to the total number of fruits at pea stage. The fruit drop was calculated on the percent basis.

$$\text{fruit drop (\%)at pea stage} = \frac{\text{Initial fruit set} - \text{fruits at pea stage}}{\text{Total number of initial fruit}} \times 100$$

2.3.4 Fruit drop at marble stage per panicle (%)

The total number of fruits were considered as fruit set at the grain stage. The panicles which were tagged for recording the number of fruits at pea stage, were subsequently counted at marble stage. Similarly, fruit fall were also recorded at 15 days interval The difference between total number of fruits at grain stage to the total number of fruits at marble stage. Fruit drop at marble stage were calculated on the percent basis.

$$\text{fruit drop (\%) at marble stage} = \frac{\text{Initial fruit set} - \text{fruits at marble stage}}{\text{Total number of initial fruit}} \times 100$$

2.3.5 Fruit drop at maturity stage per panicle (%)

Fruit drop at pre-harvest stage were calculated on the percent basis.

$$\text{Fruit drop \%) at pre-harvest stage} = \frac{\text{Initial fruit set} - \text{No.of fruits at pre-harvest stage}}{\text{Total number of initial fruit}} \times 100$$

2.3.6 Final fruit retention

Fruit retention (%) per panicle was calculated using the below mentioned formula.

$$\text{Final fruit retention}(\%) = \frac{\text{Retained mature fruits}}{\text{Total number of initial fruit}} \times 100$$

3. Result and Discussion

3.1 Effect of NAA, Urea, Nano-urea and Biofertisol on initial fruit set, fruits at pea, marble and harvest stage

The initial number and percentage of fruit set (12.12 and 1.86%) shown in Table (1), the number of fruits at pea, marble, and pre-harvest stage shown in Table (2) which are (5.1, 3.0 and 1.3, respectively) were significantly maximized by foliar spray of NAA 40 ppm and statistically at par with foliar spray of NAA 30 ppm, NAA 20 ppm, urea 3% and urea 4%. It might be due to the effect of NAA on plant growth is greatly dependent on the time of application and concentration. NAA has been shown significantly increase in the plant by exogenous application. Due to these causes fruit setting was enhanced (Yadav *et al.* (2021) [25]. Similar results were obtained by Pujari *et al*. (2016) [21] in Alphonso mango and Bhamare *et al*. (2014) [6] in mango cv. Mallika. Guirguis *et al*. (2010) [12] reported promoting effect on fruit set and retention by reducing ABA content, thus the application of NAA and CPPU at different concentrations and at different time of application were beneficial to increase fruit set at pea and marble stage and ultimately for fruit retention at harvest than the control. These findings are in accordance with the reports and Kulkarni *et al*. (2017) [16] in mango.

Similarly, foliar spray of urea has also shown a great influence in maximizing the number of fruits at pea, marble and maturity stage. It might be due to urea which increases the auxin synthesis and reduces the formation of abscission layer that helps in strong attachment of fruit with the stalk. The obtained results of urea regarding their positive effect on fruit set, number of fruits was in harmony with the previous findings of Sharma *et al*. (1990) [24], Salama *et al*. (2016) [23] in mango and Patel *et al.* (2018) [20] in citrus.

Table 1: Effect of foliar application of NAA, Urea, Nano-urea, and Biofertisol on initial fruit set and initial fruit set (%).

Notation	Treatment	Numbers of hermaphrodite flowers panicles^{-1}	Initial fruit set	Initial fruit set (%)
T_1	Control (Water)	690.30	9.93 ^{h}	1.44 ^{f}
T_2	NAA @ 20 ppm	678.67	12.07 ^{a}	1.78 ^{b}
T_3	NAA @ 30 ppm	683.63	12.11 ^{a}	1.77 ^{b}
T_4	NAA @ 40 ppm	651.67	12.12 ^{a}	1.86 ^{a}
T_5	Urea @ 2%	670.17	11.54 ^{cd}	1.72 ^{bc}
T_6	Urea @ 3%	689.63	12.04 ^{a}	1.75 ^{b}
T_7	Urea @ 4%	686.63	11.94 ^{ab}	1.74 ^{b}
T_8	Nano urea @ 0.2%	691.74	11.22 ^{de}	1.62 ^{de}
T_9	Nano urea @ 0.3%	675.00	11.83 ^{abc}	1.75 ^{b}
T_{10}	Nano urea @ 0.4%	695.16	11.62 ^{bc}	1.67 ^{cd}
T_{11}	Biofertisol @ 0.5%	673.33	10.59 ^{g}	1.57 ^{e}
T_{12}	Biofertisol @ 1%	688.08	10.74 ^{fg}	1.56 ^{e}
T_{13}	Biofertisol @ 1.5%	681.41	10.97 ^{ef}	1.61 ^{de}
	SE(m)±	n-s	0.11	0.02
	C. D. (*p=0.05*)		0.33	0.06
	C.V (%)		1.70	2.10

Table 2: Effect of foliar application of NAA, Urea, Nano-urea, and Biofertisol on number of fruits at pea stage, marble stage and pre-harvest stage.

Notation	Treatment	Number of fruits		
		At pea stage	At marble stage	At pre-harvest stage
T_1	Control (Water)	3.14 ^{i}	1.23 ^{f}	0.48 ^{h}
T_2	NAA @ 20 ppm	5.03 ^{a}	2.70 ^{b}	1.02 ^{b}
T_3	NAA @ 30 ppm	5.06 ^{a}	2.98 ^{a}	1.29 ^{a}
T_4	NAA @ 40 ppm	5.11 ^{a}	3.00 ^{a}	1.31 ^{a}
T_5	Urea @ 2%	4.00 ^{e}	1.99 ^{d}	0.84 ^{d}
T_6	Urea @ 3%	5.04 ^{a}	2.90 ^{a}	1.28 ^{a}
T_7	Urea @ 4%	4.90 ^{b}	2.38 ^{c}	0.94 ^{c}
T_8	Nano urea @ 0.2%	3.96 ^{e}	1.91 ^{d}	0.79 ^{e}
T_9	Nano urea @ 0.3%	4.69 ^{c}	2.29 ^{c}	0.91 ^{c}
T_{10}	Nano urea @ 0.4%	4.30 ^{d}	1.99 ^{d}	0.72 ^{f}
T_{11}	Biofertisol @ 0.5%	3.40 ^{h}	1.68 ^{e}	0.64 ^{g}
T_{12}	Biofertisol @ 1%	3.60 ^{g}	1.73 ^{e}	0.65 ^{g}
T_{13}	Biofertisol @ 1.5%	3.71 ^{f}	1.77 ^{e}	0.68 ^{f}
	SE(m)±	0.04	0.03	0.01
	C. D. (*p=0.05*)	0.12	0.10	0.03
	C.V (%)	1.59	2.58	2.26

3.2 Effect of NAA, Urea, Nano-urea and Biofertisol on fruit drop and retention (%)

In table (3) shows that fruit drop percentage at pea, marble and mature stages, treatment NAA @ 40 ppm gave notably lowest fruit drop i.e. (57.85%, 75.26% and 89.22%. respectively) which was significantly at par with NAA 30ppm, and urea 3% at pea, marble and pre-harvest stage. It might be due to deficiency of auxins, coupled with a high level of growth inhibitors i.e., abscisic acid and ethylene cause fruit drop. In fact, when the concentrations of abscisic acid and ethylene increase in the panicle, as a result abscission layer is formed at the site of fruit attachment, which ultimately drops down (Kulkarni *et al*.,2017) [16]. At this stage the competition among developing fruits starts and auxin content of the fruit become low, fruit drop occurs due to formation of abscission layer and retention of fruit are ultimately decrease and fruit drop enhance. In present investigation, the exogenous application of NAA might have increased the concentration of auxin in plants which possibly prevent the formation of an abscission layer by inhibiting the enzymatic activities to reduction of fruit drop. Similar findings were reported by Abd El-Rhman *et al*. (2017) [1], Gattass *et al*. (2018) [10] in mango.

As for as fruit retention per panicle is concerned, Table (4) shows the maximum fruit retention (10.78%) was recorded with NAA 40 ppm which was significantly at par with NAA 30ppm and urea 3%. It is generally known that auxin content in fruit when become low, fruit drop occurs due to formation of abscission layer and retention of fruits are decreased as a result of exhaustion of auxin Anand *et al*. (2003) [2] in mango. The increased fruit retention up to maturity is due to proper supplementation of the nutrients and prevention in formation of abscission layer by inhibiting the enzymatic activities with the application of NAA. These are in harmony with the findings of Ghosh *et al*. (2016) [11] mango.

Similarly, the urea has helped in fruit retention because urea stimulates the synthesis of chlorophyll which results in synthesis of endogenous auxins and auxin prevents the abscission and facilitated the ovary to remain attached with the shoot, resulting in lower fruit drop. All the growth promoting substances significantly decreased the percentage of fruit drop in all the three stages i.e. pea, marble and pre harvest fruit stage and increased fruit retention percentage. These findings are line up with Jat and Kacha (2014) [15] in guava, Salama *et al*. (2016) [23] in mango and Patel *et al*. (2018) [20] in citrus.

Table 3: Effect of foliar application of NAA, Urea, Nano-urea, and Biofertisol on fruit drop percentage at pea, marble and pre-harvest stage.

Notation	Treatment	Fruit drop percentage (%)		
		At pea stage	At marble stage	At pre-harvest stage
T_1	Control (Water)	68.37 ^{g}	87.58 ^{g}	95.15 ^{f}
T_2	NAA @ 20 ppm	58.44 ^{a}	77.70 ^{b}	91.56 ^{b}
T_3	NAA @ 30 ppm	58.23 ^{a}	75.43 ^{a}	89.32 ^{a}
T_4	NAA @ 40 ppm	57.85 ^{a}	75.26 ^{a}	89.22 ^{a}
T_5	Urea @ 2%	65.28 ^{de}	82.74 ^{d}	92.74 ^{d}
T_6	Urea @ 3%	58.17 ^{a}	75.89 ^{a}	89.33 ^{a}
T_7	Urea @ 4%	58.94 ^{ab}	80.04 ^{c}	92.14 ^{c}
T_8	Nano urea @ 0.2%	64.66 ^{d}	82.99 ^{de}	92.98 ^{d}
T_9	Nano urea @ 0.3%	60.34 ^{b}	80.65 ^{c}	92.35 ^{c}
T_{10}	Nano urea @ 0.4%	62.96 ^{c}	82.90 ^{de}	93.83 ^{e}
T_{11}	Biofertisol @ 0.5%	67.90 ^{gf}	84.11 ^{f}	93.94 ^{e}
T_{12}	Biofertisol @ 1%	66.52 ^{ef}	83.92 ^{ef}	93.97 ^{e}
T_{13}	Biofertisol @ 1.5%	66.14 ^{de}	83.89 ^{ef}	93.76 ^{e}
	SE(m)±	0.57	0.33	0.12
	C. D. (*p=0.05*)	1.65	0.95	0.34
	C.V (%)	1.58	0.69	0.22

Table 4: Effect of foliar application of NAA, Urea, Nano-urea, and Biofertisol on fruit retention at maturity stage (%).

Notation	Treatment details	Final fruit retention (%)
T_1	Control (Water)	4.85 ^{f}
T_2	NAA @ 20 ppm	8.44 ^{b}
T_3	NAA @ 30 ppm	10.68 ^{a}
T_4	NAA @ 40 ppm	10.78 ^{a}
T_5	Urea @ 2%	7.26 ^{d}
T_6	Urea @ 3%	10.67 ^{a}
T_7	Urea @ 4%	7.86 ^{c}
T_8	Nano urea @ 0.2%	7.02 ^{d}
T_9	Nano urea @ 0.3%	7.65 ^{c}
T_{10}	Nano urea @ 0.4%	6.17 ^{e}
T_{11}	Biofertisol @ 0.5%	6.06 ^{e}
T_{12}	Biofertisol @ 1%	6.03 ^{e}
T_{13}	Biofertisol @ 1.5%	6.24 ^{e}
	SE(m)±	0.12
	C. D. (*p=0.05*)	0.34
	C.V (%)	2.60

4. Conclusion

The findings suggested that foliar application of NAA @ 40ppm significantly enhances the fruit retention, flowering, fruiting and reduces the fruit drop percentage in mango cv. Langra. Implementing NAA @ 40ppm could be a valuable strategy for mango growers aiming to optimize yield, fruit quality, and overall economic gain. The foliar spray of urea 3%, NAA (20ppm and 30ppm) was found next best treatment in this aspect.

5. Competing interests

Authors have declared that no competing interests exist.

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