Effect of pre-harvest application of GA₃, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali

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Abstract
To investigate the effect of pre-harvest application of GA₃, Naphthalene acetic acid and borax on fruit drop, yield and quality of Mango cv. Amrapali, an experiment was carried out in the Garden, Department of Horticulture, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.) during the cropping season 2018-2019. The experiment was laid out in Randomized Block Design (RBD) with three replication and ten treatments viz., GA₃ @ 25 ppm (T₁), GA₃ @ 50 ppm (T₂), GA₃ @ 75 ppm (T₃), NAA @ 20 ppm (T₄), NAA @ 40 ppm (T₅), NAA @ 60 ppm (T₆), borax @ 0.2% (T₇), borax @ 0.4% (T₈) including a control or water spray (T₀). Spraying of plant growth regulators and micronutrient was done at pea stage of fruits set on 2nd March, 2019. From the results obtained during present experimentation, it is reported that pre-harvest spraying of GA₃ at 25 ppm results significant decrease in fruit drop (85.77%) with increase in fruit retention (14.23 %) and number of fruits per panicle (6.43). Plants sprayed with the GA₃ at 50 ppm results significantly more fruit yield (50.67 kg/tree) of fruits having more polar (9.11 cm) and equatorial diameter (7.39 cm), more pulp (74.56%), pulp: stone ratio (7.12) with decrease in peel (14.94%) and stone per cent (10.51%). Increased fruit weight (244.59 g), volume (255.43 cc), specific gravity (1.09 g/cc), total soluble solids (18.36 °Brix), total sugars (17.75%), ascorbic acid (37.60 mg/100g) were also found with the pre-harvest spraying of GA₃ at 75 ppm, whereas titratable acidity (0.50%) contents in the fruits were drastically reduced under this treatment.

Keywords: Mango, amrapali, gibberellic acid, NAA, borax, fruit drop, fruit retention, yield and quality

Introduction
Mango (Mangifera indica L.) has been cultivated in the Indian subcontinents for well over 4000 years, belongs to the family Anacardiaceae and is indigenous to North-East India and North Myanmar in the foot hills of the Himalaya. India shares about 34.75% area and 22.41% production of total fruits cultivated area and total fruit production, respectively. Mango fruits are rich source of vitamin-A and fairly good source of vitamin-C. Fruits are considered as excellent one for table purpose. Various type of products can be prepared from both immature green and ripeen fruits. Young and unripe fruits are utilized for culinary purpose because of their acidic taste. Ripe fruits are utilized in preparing squash, nectar, jam, jelly, cereals flakes, custard powder, baby food, toffee etc.

The foliar application of plant growth regulators and micronutrients has an important role in improving fruit set, productivity and quality of fruits. Foliar application is based on the principle that the nutrients are quickly absorbed by nature's opening of the leaves and transported to different parts of the plant to fulfil the functional requirement of nutrition. Plant growth regulators and micronutrient such as GA₃, NAA and borax plays an important role in increasing fruits set, fruit yield and quality. Naphthalene acetic acid (NAA) is also very helpful in the induction of flowering, prevent shedding of flowering buds, flowers and unripe fruits, increase fruit size and also increase the yield and quality of many fruits, whereas GA₃ application is found more effective in maximum fruit retention percentage per panicle with increase in fruit size and fruit weight in mango and in many other fruits crops. Boron also plays an important role in ovule development, pollen tube growth, fruit set and quality improvement. The intensity of damage caused by fruit dropping can also be minimized by the foliar application of plant growth regulators and micro-nutrients. It also helps in improving yield and fruit quality parameters in mango and other fruits.

Materials and Methods
The present investigation was carried out on 22 years old plants of Mango cv. Amrapali located in the garden, Department of Horticulture, Chandra Shekhar Azad University of
Agriculture and Technology, Kanpur (U.P.) during 2019, in Randomized Block Design (RBD) and replicated thrice with ten treatments viz., GA\(_3\) @ 25 ppm (T\(_1\)), GA\(_3\) @ 50 ppm (T\(_2\)), GA\(_3\) @ 75 ppm (T\(_3\)), NAA @ 20 ppm (T\(_4\)), NAA @ 40 ppm (T\(_5\)), NAA @ 60 ppm (T\(_6\)), borax @ 0.2% (T\(_7\)), borax @ 0.4% (T\(_8\)), borax @ 0.6% (T\(_9\)) including a control or water spray (T\(_{10}\)). Spraying of plant growth regulators and micronutrient were done at pea stage of fruits set on 22nd March, 2019. One plant was taken as an unit per treatment. Data were recorded at 15th day’s intervals after foliar application till harvesting and harvesting was done in the month of May, 2019. The observations were recorded on per cent fruit drop, per cent fruit retention and number of fruits per panicles. The physical characters of fruits viz., fruit size (polar and equatorial diameter), weight, fruit volume (cc), pulp, peel and stone per cent, pulp: stone ratio, specific gravity, fruit yield and the chemical characters i.e., fruit total soluble solids (TSS), total sugars, ascorbic acid (vitamin C) and titratable acidity content were studied after harvest as per method suggested in (AOAC, 1980)\(^{[1]}\).

Results and Discussion
Fruits drop and retention per cent
During present investigation, it is observed that significant increase in fruit retention with reduced fruit drop was recorded by the use of plant bio-regulators and micro-nutrient (Table 1). The maximum fruit retention and minimum fruit drop per cent was recorded with the pre-harvest application of GA\(_3\) @ 25 ppm (14.23% and 85.77%, respectively) followed by borax @ 0.6% (13.45% and 86.55%, respectively). However, the minimum fruit retention and maximum fruit drop per cent (7.39% and 92.61%, respectively) was recorded in plants kept as control, where non amount of plant bio-regulators and micronutrient was used. This increase in fruit retention and reduction in fruit drop per cent might be due to the suppression of ABA biosynthesis and increase in the endogenous level of auxin and other metabolites in the plant. Therefore, an exogenous application of gibberellins and auxin might have improved fruit retention and reduced drop per cent. The present findings are in accordance with Vashistha et al.\((2010)^{[17]}\), Singh et al.\((2017)^{[9]}\), Kumar et al.\((2018b)^{[6]}\) in mango, Tripathi and Shukla\((2010)^{[14]}\) in strawberry and Tripathi et al.\((2018)^{[15]}\) in Aonla. Tripathi et al.\((2019)^{[19]}\) also reported maximum fruit retention and minimum fruit drop in mango cv. Amarpali with the combined application of GA\(_3\) @ 50 ppm + NAA @ 40 ppm.

Table 1: Effect of pre-harvest application of GA\(_3\), Naphthalene acetic acid and borax on fruit drop, fruit retention and yield in Mango cv. Amarpali

| Treatments          | Fruit drop (%) | Fruit retention (%) | Number of fruits per panicle |
|---------------------|----------------|---------------------|-----------------------------|
| GA\(_3\) @ 25 ppm (T\(_1\)) | 85.77          | 14.23               | 6.43                        |
| GA\(_3\) @ 50 ppm (T\(_2\)) | 88.26          | 11.74               | 4.97                        |
| GA\(_3\) @ 75 ppm (T\(_3\)) | 88.72          | 11.28               | 4.77                        |
| NAA @ 20 ppm (T\(_4\))   | 90.09          | 9.91                | 5.62                        |
| NAA @ 40 ppm (T\(_5\))   | 89.11          | 10.89               | 5.37                        |
| NAA @ 60 ppm (T\(_6\))   | 87.75          | 12.25               | 5.13                        |
| Borax @ 0.2% (T\(_7\))   | 88.70          | 11.30               | 5.13                        |
| Borax @ 0.4% (T\(_8\))   | 87.53          | 12.47               | 5.40                        |
| Borax @ 0.6% (T\(_9\))   | 86.55          | 13.45               | 5.67                        |
| Control (water spray only) (T\(_{10}\)) | 92.61          | 7.39                | 4.13                        |

Number of fruits per panicle
Significantly higher number of fruits per panicle (6.43) was obtained from the plants which were treated with GA\(_3\) at 25 ppm followed by NAA at 20 ppm (5.62) treated plants (Table 1). This increased under fruits of panicle may be the results of higher fruit retention and less drop with GA\(_3\) at 25 ppm treatment. The results are in conformity with the findings of Singh et al.\((2017)^{[9]}\) and Kumar et al.\((2018b)^{[6]}\) in mango.

Fruit yield
The pre-harvest application of GA\(_3\) @ 50 ppm followed by NAA @ 40 ppm were found to be best to enhance fruit yield of 50.67 kg/tree and 49.77 kg/tree, respectively, whereas the minimum fruit yield (36.58 kg/tree) was recorded in plants kept under control (Fig. 1). The enhancement in fruit yield due to foliar feeding of plant bio-regulators and micronutrient by plant leaves might be attributed to more luxuriant vegetative growth to the initial stage, which later on results synthesis of more metabolites for developing fruits. The result of present finding is in accordance with Tripathi and Shukla\((2008)^{[13]}\), Singh and Tripathi\((2010)^{[14]}\) in strawberry, who reported higher fruit yield with the application of GA\(_3\) at 100 ppm. More or less similar results were also reported by Tripathi et al.\((2018)^{[15]}\), Bhaduria et al.\((2018)^{[2]}\) in aonla, Kumar et al.\((2018a)^{[5]}\), Tripathi et al.\((2019)^{[19]}\) in mango.

Fruit Size
The maximum polar and equatorial diameter of fruits were recorded with the pre-harvest application of GA\(_3\) 50 ppm (9.11 cm and 7.39 cm, respectively), whereas minimum polar and equatorial diameter (8.01 cm and 6.92 cm, respectively) of fruit was recorded in fruit produced from the plants kept under control (Table 2). The reasons for this increase in fruit size in polar and equatorial diameter with spraying of plant bio-regulators and micronutrient may be because of efficient accumulation of metabolites in initial stage of developing fruits. Spraying of plant bio-regulators and micronutrient might have regulated the cell-wall permeability and increased absorption, thereby allowing more water mobility in fruits resulting an enlargement of fruit size. These results are in close conformity with the findings of Singh et al.\((2017)^{[9]}\), who also found increase in fruit size with pre-harvest application of GA\(_3\) at 50 ppm in mango cv. Amarpali. The results are in line with the findings of Kumar et al.\((2018a)^{[5]}\) in mango, Singh and Tripathi\((2010)^{[14]}\), Tripathi and Shukla\((2010)^{[14]}\) in strawberry, Tripathi et al.\((2018)^{[15]}\), Bhaduria et al.\((2018)^{[2]}\) in Aonla.
Weight, volume and specific gravity of fruit

Fruit weight, volume and specific gravity was significantly influenced by the foliar application of plant bio-regulators and micronutrient. The significantly higher weight (244.59 g), volume (255.43 g/cc) and specific gravity (1.09 g/cc) of fruit was recorded in the fruits produced from the plants treated with GA3 75 ppm, while the minimum weight (190.55 g), volume (200.93 g/cc) and specific gravity (0.99 g/cc) of fruit was recorded under control (Table 2). Weight, volume and specific gravity of fruits gets reduced with the reduction in the concentration of plant bio-regulators and micronutrient in all treatments. Gibberellic acid and borax are directly or indirectly involved in the photosynthesis in the plants and then they were translocated to the fruits during their growth and development, which increase the reserved food material in the fruits and ultimately increase weight and volume of fruits. This increase in weight and size with reduction in stone weight of fruit, results an increase in specific gravity of fruits. These results have got the support of Singh et al. (2017) [5], Bhadauria et al. (2018) [6] in aonla, Tripathi et al. (2019) [7] in mango.

Pre-harvest application of GA3 @ 50 ppm resulted significant increase in pulp per cent (74.56%) and reduction of peel and stone per cent (14.94% and 10.51%, respectively) in mango fruits. The minimum pulp per cent (60.41%) and maximum peel and stone per cent (22.39% and 17.21%, respectively) was recorded in fruits harvested from the plants kept as control (Table 2). This increase in pulp per cent may be due to more absorption of water, plant bio-regulators and micronutrient which ultimately increase the volume of intercellular spaces in the pulp. These results are in accordance with the findings of Tripathi et al. (2018) [8], who recorded higher pulp in aonla cv. NA 7 with the spraying of GA3 @ 50 ppm. These results are in line with the reports of Kumar et al. (2018a) [9], Bhadauria et al. (2018) [6] and Tripathi et al. (2019) [7] in mango.

Titratable acidity

The minimum titratable acidity per cent was found in fruits which were produced from the plants treated with GA3 @ 75 ppm (18.36 °Brix and 17.75%, respectively) followed by NAA @ 60 ppm (18.23 °Brix and 16.56%, respectively), while minimum total soluble solids and total sugar contents (16.16 °Brix and 13.84%, respectively) were recorded in fruits which were produced from the plants kept under control (Table 3). This increase in titratable solids and total sugar content of fruits may be due to the fact that the adequate amount of GA3 and NAA improve the auxin content that acted as catalyst in oxidation process. GA3 also indirectly influences many enzyme systems in plants, out of these the role of gibberellins in activation of amylase enzyme is well known which are responsible for the conversion of starch into sugar thus improve the TSS and total sugars contents in fruits. Gibberellins are known to play a crucial role in the sugar metabolism of plants. These results have got the support with the findings of Dubey et al. (2017) in strawberry, Shukla et al. (2011), Tiwari et al. (2017), Kumar et al. (2018a) [3] in mango and Lal et al. (2015) in kinnow. Tripathi et al. (2019) [7] also reported increased TSS and total sugar content in mango with the application of GA3 50 ppm + NAA 40 ppm.

Table 2: Effect of pre-harvest application of GA3, Naphthalene acetic acid and borax on physical characters of fruits in Mango cv. Amrapali

| Treatments | Polar diameter of fruits (cm) | Equatorial diameter of fruits (cm) | Average fruit weight (g) | Fruit volume (cc) | Specific gravity (g/cc) | Pulp (%) | Peel (%) | Fruit stone (%) | Pulp/stone ratio |
|------------|------------------------------|-----------------------------------|--------------------------|-----------------|----------------------|---------|---------|--------------|-----------------|
| GA3 @ 25 ppm (T1) | 8.51 | 7.14 | 215.82 | 223.90 | 1.01 | 67.44 | 18.60 | 13.96 | 4.84 |
| GA3 @ 50 ppm (T2) | 9.11 | 7.39 | 210.90 | 212.77 | 1.05 | 74.56 | 14.94 | 10.51 | 7.12 |
| GA3 @ 75 ppm (T3) | 8.15 | 7.04 | 244.59 | 255.43 | 1.09 | 64.91 | 20.82 | 14.27 | 4.61 |
| NAA @ 20 ppm (T4) | 8.19 | 7.09 | 234.43 | 240.67 | 1.03 | 66.08 | 19.84 | 14.08 | 4.70 |
| NAA @ 40 ppm (T5) | 8.95 | 7.29 | 238.50 | 237.37 | 1.05 | 72.81 | 16.14 | 11.05 | 6.72 |
| NAA @ 60 ppm (T6) | 8.90 | 7.19 | 238.08 | 253.18 | 1.06 | 69.06 | 17.63 | 13.31 | 5.19 |
| Borax @ 0.2% (T7) | 8.29 | 7.11 | 199.51 | 216.82 | 1.02 | 66.97 | 18.95 | 14.08 | 4.78 |
| Borax @ 0.4% (T8) | 8.59 | 7.15 | 239.33 | 246.62 | 1.03 | 68.33 | 17.98 | 13.69 | 5.01 |
| Control (water spray only) (T9) | 8.01 | 6.92 | 190.55 | 200.93 | 0.99 | 60.41 | 22.39 | 17.21 | 3.57 |
| S. E. m ± | 0.21 | 0.23 | 4.29 | 3.90 | 0.02 | 1.12 | 0.89 | 0.78 | 0.34 |
| CD at 5% | 0.62 | NS | 12.85 | 11.66 | 0.05 | 3.34 | 2.68 | 2.33 | 1.01 |

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### Table 3: Effect of pre-harvest application of GA<sub>3</sub>, Naphthalene acetic acid and borax on chemical composition of fruits in Mango cv. Amrapali

| Treatments                  | T.S.S. (°Brix) | Total sugar (%) | Titratable acidity (%) | Ascorbic acid (mg/100g pulp) |
|-----------------------------|---------------|-----------------|------------------------|------------------------------|
| GA<sub>3</sub> @ 25 ppm (T<sub>1</sub>) | 17.59         | 15.58           | 0.61                   | 36.46                        |
| GA<sub>3</sub> @ 50 ppm (T<sub>2</sub>) | 17.52         | 16.05           | 0.59                   | 37.00                        |
| GA<sub>3</sub> @ 75 ppm (T<sub>3</sub>) | 18.36         | 17.75           | 0.50                   | 37.60                        |
| NAA @ 20 ppm (T<sub>4</sub>) | 17.25         | 15.55           | 0.61                   | 35.22                        |
| NAA @ 40 ppm (T<sub>5</sub>) | 17.54         | 16.19           | 0.55                   | 35.31                        |
| NAA @ 60 ppm (T<sub>6</sub>) | 18.23         | 16.56           | 0.54                   | 35.42                        |
| Borax @ 0.2% (T<sub>7</sub>) | 16.83         | 14.37           | 0.61                   | 33.24                        |
| Borax @ 0.4% (T<sub>8</sub>) | 16.92         | 14.43           | 0.57                   | 33.57                        |
| Borax @ 0.6% (T<sub>9</sub>) | 17.00         | 14.48           | 0.57                   | 34.47                        |
| Control (water spray only) (T<sub>10</sub>) | 16.16         | 13.84           | 0.64                   | 28.81                        |

S. E. m ± 0.19 0.16 0.02 0.45
CD at 5% 0.56 0.46 0.05 1.35

**Ascorbic acid**
Significantly higher quantity of ascorbic acid (37.60 mg) was recorded in fruits which were produced from the plants treated with GA<sub>3</sub> @ 75 ppm, followed by 37.00 mg in GA<sub>3</sub> @ 50 ppm treated plants, whereas lower amount of ascorbic acid (28.81 mg) content was recorded in fruits which were produced from the plants kept under control (Table 3). This increase in ascorbic acid content with gibberellic acid application might be due to uninterrupted synthesis of its precursor like glucase-6-phosphate during conversion of starch into various sugars and low rate of oxidation. These results have got the support with the findings of Tripathi and Shukla (2006) [21], Dubey et al. (2017) [3] in strawberry, Shukla et al. (2011) [8] in aonla and Tripathi et al. (2019) [19] in mango.

**Fig 1: Effect of pre-harvest application of plant bio-regulators and micronutrient on fruit yield (kg/tree)**

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