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Effect of pre-harvest application of GA_3, 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 GA_3, 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.*, 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 @ 40 ppm (T_6), NAA @ 60 ppm (T_7), borax @ 0.2% (T_8), borax @ 0.4% (T_9) including a control or water spray (T_{10}). Spraying of plant growth regulators and micronutrient was done at pea stage of fruits set on 2st March, 2019.
From the results obtained during present experimentation, it is reported that pre-harvest spraying of GA_3 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 GA_3 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 ^{0}Brix), total sugars (17.75%), ascorbic acid (37.60 mg/100g) were also found with the pre-harvest spraying of GA_3 at 75 ppm, whereas titratable acidity (0.50%) contents in the fruits ware 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 ripen 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 natural 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 GA_3, 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 flower buds, flowers and unripe fruits, increase fruit size and also increase the yield and quality of many fruits, whereas GA_3 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. Amrapali

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
S. E. m ±	0.47	0.21	0.26
CD at 5%	1.41	0.62	0.77

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 of fruits per 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], Bhadauria *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], Bhadauria *et al.* (2018) [2] in Aonla.

Table 2: Effect of pre-harvest application of GA_3, 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
GA_3 @ 25 ppm (T_1)	8.51	7.14	215.82	223.90	1.01	67.44	18.60	13.96	4.84
GA_3 @ 50 ppm (T_2)	9.11	7.39	210.90	212.77	1.05	74.56	14.94	10.51	7.12
GA_3 @ 75 ppm (T_3)	8.15	7.04	244.59	255.43	1.09	64.91	20.82	14.27	4.61
NAA @ 20 ppm (T_4)	8.19	7.09	233.43	240.67	1.03	66.08	19.84	14.08	4.70
NAA @ 40 ppm (T_5)	8.95	7.29	238.50	237.37	1.05	72.81	16.14	11.05	6.72
NAA @ 60 ppm (T_6)	8.90	7.19	238.08	253.18	1.06	69.06	17.63	13.31	5.19
Borax @ 0.2% (T_7)	8.29	7.11	199.51	216.82	1.02	66.97	18.95	14.08	4.78
Borax @ 0.4% (T_8)	8.59	7.15	239.33	246.62	1.03	68.33	17.98	13.69	5.01
Borax @ 0.6% (T_9)	8.57	7.15	214.57	218.69	1.04	68.07	18.16	13.77	4.95
Control (water spray only) (T_{10})	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

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 GA_3 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) [9], Bhadauria *et al.* (2018) [2] in aonla, Tripathi *et al.* (2019) [19] in mango.

Pulp, peel and stone per cent

Pre-harvest application of GA_3 @ 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 inter-cellular spaces in the pulp. These results are in accordance with the findings of Tripathi *et al.* (2018) [15], who recorded higher pulp in aonla cv. NA 7 with the spraying of GA_3 @ 50 ppm. These results are in line with the reports of Kumar *et al.* (2018a) [5], Bhadauria *et al.* (2018) [2] and Tripathi *et al.* (2019) [19] in mango.

Pulp/stone ratio

Pre-harvest application of GA_3 @ 50 ppm (7.12) resulted significant increase in pulp/stone ratio followed by NAA @ 40 ppm (6.72), whereas minimum pulp/stone ratio (3.57) was recorded in plants produced from the plants kept under control (Table 2). This increase in pulp/stone ratio might be due to increase in pulp per cent, volume of inter-cellular spaces in the pulp and decrease in stone per cent. These results have got the support with the findings of Tripathi *et al.* (2018) [15], Bhadauria *et al.* (2018) [2] in aonla, Tripathi *et al.* (2019) [19] in mango. This improvement in pulp: stone ratio might be due to more accumulation of food substances in elongated cell and intercellular space of mesocarp.

Total soluble solids and Total sugars

Maximum amount of total soluble solids (TSS) and total sugar content in fruits were found which were produced from the trees sprayed with GA_3 @ 75 ppm (18.36 ^{0}Brix and 17.75%, respectively) followed by NAA @ 60 ppm (18.23 ^{0}Brix and 16.56%, respectively), while minimum total soluble solids and total sugar contents (16.16 ^{0}Brix and 13.84%, respectively) were recorded in fruits which were produced from the plants kept under control (Table 3). This increase in total soluble solids and total sugar content of fruits may be due to the fact that the adequate amount of GA_3 and NAA improve the auxin content that acted as catalyst in oxidation process. GA_3 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) [5] in mango and Lal *et al.* (2015) in kinnow. Tripathi *et al.* (2019) [19] also reported increased TSS and total sugar content in mango with the application of GA_3 50 ppm + NAA 40 ppm.

Titratable acidity

The minimum titratable acidity per cent was found in fruits which were produced from the plants treated with GA_3 @ 75 ppm (0.50%), whereas the maximum titratable acidity per cent (0.64%) was recorded in fruits which were produced from the plants kept under control (Table 3). Titratable acidity content of fruits was found less with the foliar application of plant bio-regulators and micronutrient, which might be due to an increase in translocation of photosynthates (carbohydrates) and more metabolic conversion of acids to sugars by the revers reaction of glycolytic path way which is utilized in various physiological activities. These results are in accordance with the reports of Tripathi *et al.* (2019) [19], who also reported increased TSS and total sugar content in mango with the application of GA_3 50 ppm + NAA 40 ppm. Results obtained during present experimental period are also in line with the findings of Dubey *et al.* (2017) in strawberry, El-Rhman (2017) in mango, Shukla *et al.* (2011), Tiwari *et al.* (2017) and Tripathi *et al.* (2018) [15] in aonla.

Table 3: Effect of pre-harvest application of GA_3, Naphthalene acetic acid and borax on chemical composition of fruits in Mango cv. Amrapali

Treatments	T.S.S. (^{0}Brix)	Total sugar (%)	Titratable acidity (%)	Ascorbic acid (mg/100g pulp)
GA_3 @ 25 ppm (T_1)	17.59	15.58	0.61	36.46
GA_3 @ 50 ppm (T_2)	17.52	16.05	0.59	37.00
GA_3 @ 75 ppm (T_3)	18.36	17.75	0.50	37.60
NAA @ 20 ppm (T_4)	17.25	15.55	0.61	35.22
NAA @ 40 ppm (T_5)	17.54	16.19	0.55	35.31
NAA @ 60 ppm (T_6)	18.23	16.56	0.54	35.42
Borax @ 0.2% (T_7)	16.83	14.37	0.61	33.24
Borax @ 0.4% (T_8)	16.92	14.43	0.57	33.57
Borax @ 0.6% (T_9)	17.00	14.48	0.57	34.47
Control (water spray only) (T_{10})	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

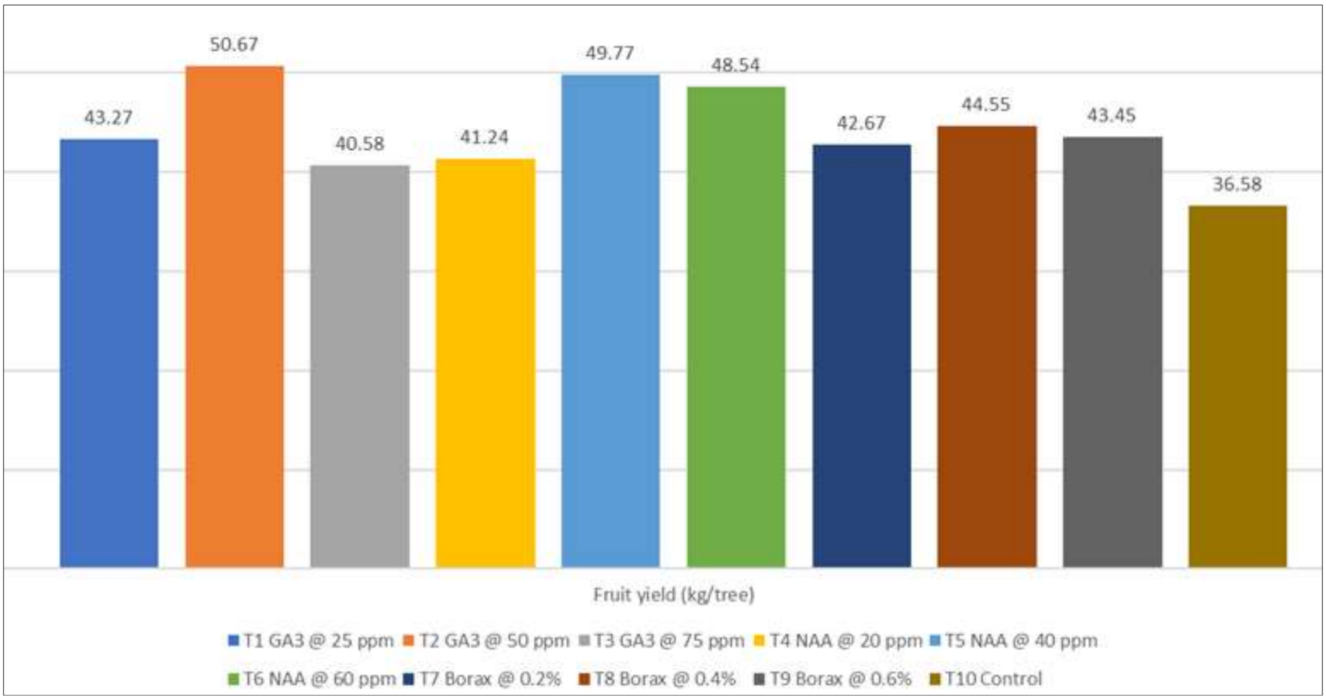

Fig 1: Effect of pre-harvest application of plant bio-regulators and micronutrient on fruit yield (kg/tree)

Ascorbic acid

Significantly higher quantity of ascorbic acid (37.60 mg) was recorded in fruits which were produced from the plants treated with GA_3 @ 75 ppm, followed by 37.00 mg in GA_3 @ 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) [12], Dubey *et al.* (2017) [3] in strawberry, Shukla *et al*. (2011) [8] in aonla and Tripathi *et al.* (2019) [19] in mango.

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