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Effect of GA_3, NAA and Zinc Sulphateon Fruit Retention, Drop,Yield and quality of Mango (*Mangifera indica* L.) cv. Dashehari

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ABSTRACT: An experiment was carriedout in Horticulture Garden, Department of Fruit Science, C. S. Azad University of Agriculture and Technology, Kanpur (U.P.), India, during the year 2022 to study the effect of GA_3, NAA and zinc sulphateon fruit retention, drop, yield and quality of mango (*Mangifera indica* L.) cv. Dashehari and found that the increased level of $ZnSO_4$ had influenced in terms of minimum fruit drop with increased fruit retention and fruit yield as compared to other treatments including control. For this ten treatments *viz.;* three levels of each GA_3 (20, 40 and 60 ppm), NAA (25, 50 and 75 ppm) and $ZnSO_4$ (0.6, 0.8 and 1.0%) along with control, replicated thrice in RBD were used for the experimental work. The recommended dose of fertilizers were applied in all treatments including control. The plant growth regulators and micro-nutrient were sprayed on the tree at the pea stage of fruit on 21/03/2022 with a sprayer having a very fine nozzle. The foliar application of micronutrients along with plant bio-regulators plays an important role in manipulating many physiological phenomena, improving yield, quality and enhancing the productivity of plants by fulfilling the nutritional needs of fruit crops. From the experiment, it is reported that the treatment of $ZnSO_4$ @1.0 % significantly reduced fruit drop (90.15%) with increased number of fruits per panicle (8.42), highest fruit retention (9.85%), polar and equatorial diameter of fruit(12.68 cm and 8.15 cm), fruit volume (260.17 cc), fruit weight (256.51 g) and fruit yield per tree (54.58 kg), stone percent (17.51 %), pulp content (71.69 %) with minimum peel content (18.23%). The same treatment also produced a favourable effect on fruit quality in terms of increased TSS (19.06°Brix), total sugars (16.06 %), ascorbic acid (38.58 mg/100g pulp) and reduced titratable acidity (0.50%). The specific gravity of fruit (1.01 g/cc) was recorded maximum in fruits which was produced from the plants treated with $ZnSO_4$ at 0.8 %.

Keywords: Mango, Fruit retention, Drop, Yield, Quality, NAA(naphthalene acetic acid),GA_3 (gibberellic acid), $ZnSO_4$ (Zinc Sulphate).

INTRODUCTION

The mango (*Mangifera indica* L.) is one of the most well-known and delightful tropical fruit and it ranks first among all commercial fruits grown in India, also known as the 'King of Fruit'. It belongs to the family of Anacardiaceae, having chromosome number 2n=4x=40. The mango sector has immense potential to contribute significantly in the country's economic development and better international trade relationships. It is native to the Himalayan foothills of northeast India and north Myanmar and is believed to have originated in the Indo-Burma region. India, Bangladesh, Burma, Sri Lanka, China, Malaysia, Florida, Hawaii and Mexico are major mango producing countries in the world. Mangoes are regarded as delicious table fruit. Both immature (green) and ripe fruits are used for making a variety of products. The food processing industry uses green mature fruits to make amazing products such as custard powder, mango powder, pickles, dried slices and chutneys. Squash, nectar, cereal flakes, toffees, jam and jelly are prepared from ripe fruits. Mangoes are regarded highly by Unani physicians due to their numerous therapeutic properties.

In fruit production, the importance of plant bio-regulators and micronutrients cannot be neglected, although they are needed in minor quantities and playsa vital role in plant metabolism and other activities. Fruit set, production and quality all are influenced by plant bio-regulators and micro-nutrient like GA_3, NAA and $ZnSO_4$. Zinc is required for the better growth and development of fruit crops. Foliar applications of plant bio-regulators and micro-nutrients have a significant role in increasing fruit set, yield and quality. It also adds in the recovery of nutritional and physiological abnormalities in fruit trees. The principle behind foliar spray is that PBR's and nutrients are efficiently absorbed by leaves and transported to various sections of the plant to meet the functional demand of plants. Nutrient application in the form of foliar spray is an obvious solution to the problem of nutrient scarcity. This strategy is extremely useful for correcting trace element deficiency, restoring nutrient supply that has been interrupted and mitigating stress factors that limit their availability. This approach has been applied to a variety of fruit crops including guava, pineapple and citrus etc. Keeping these in view present experiment was caried out in the plains of North India.

MATERIALAND METHODS

Twelve years old but properly maintained plants of the mango cv. Dashehari were selected for the purpose of experimentation in the Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.), India, during the year 2022. There were ten treatments *viz.*; three levels of each GA_3 (20, 40 and60 ppm), NAA (25, 50 and 75 ppm) and $ZnSO_4$ (0.6, 0.8 and 1.0%) along with control, replicated thrice in RBD were used for the experimental work. The recommended dose of fertilizers was applied in all treatments including control. The plant growth regulators and micro-nutrient were sprayed on the plants at pea stage of fruit development on 21/03/2022 with a sprayer having a very fine nozzle. The detergent powder was well mixed in the spray solution which act as a sticker before spraying. The information recorded on different parameters during experimentation was statically analysed.

Observations on the number of fruits per panicle, fruit drop and fruit retention percentage, polar and equatorial diameter of fruits were recorded during the fruiting season. At each picking, data on fruit weight and yield per plant were recorded. Data on fruit volume, specific gravity, pulp, peel and stone percentage were recorded. The TSS of fruits was recorded with the assistance of Erma hand refractometer. The titratable acidity, total sugars and ascorbic acid content were determined by the techniques as recommended in AOAC (1980).

RESULTS AND DISCUSSION

Number of fruits per panicle: Significantly maximum number of fruits per panicle (8.42) was recorded in plants which were treated with ($ZnSO_4$ @ 1.0 %.) followed by T_6 (NAA @50 ppm) and T_7 (NAA @75 ppm) treatment, whereas, plant kept under control (T_1) gave the minimum quantity (2.82) of fruits per panicle (Fig. 1). The greater number of fruits per panicle were produced due to early panicle emergence and production of higher hydrolytic enzyme activity and also leaf metabolite mobilization for panicle development. Similar findings were recorded by the Majumder *et al.* (2011); Jackson *et al.* (2019) in Mango.

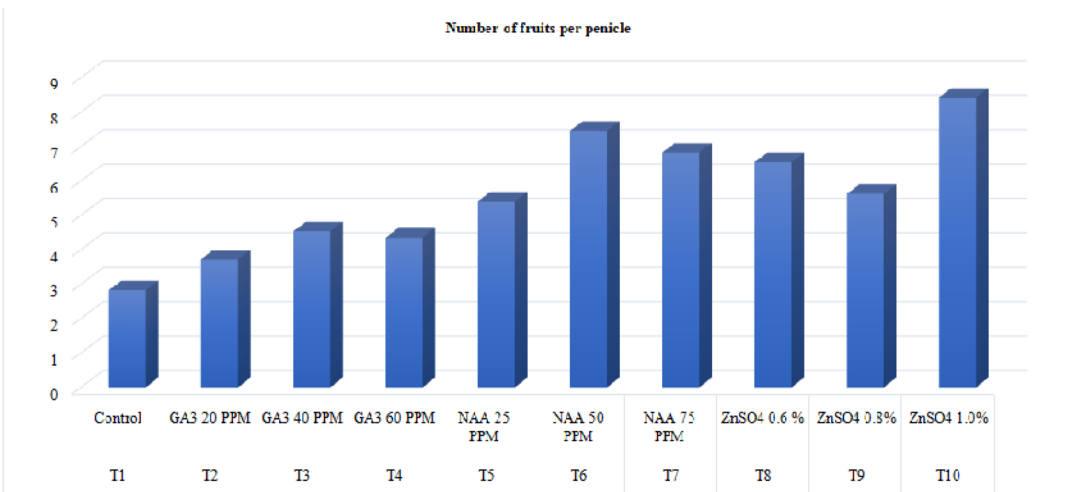

Fig. 1. Effect of pre-harvest application of GA_3, NAA and zinc sulphate on the number of fruits per panicle.

Fruit drops and retention: The application of plant bio-regulators and micronutrients was found to have a substantial impact on the number of fruits that were retained and dropped during the current trial. Pre-harvest spray of $ZnSO_4$ @ 1.0 % resulted in the highest fruit retention and lowest fruit drop (9.85% and 90.15%, respectively) followed by NAA @ 75 ppm and GA_3 @ 60 ppm, respectively whereas, plants kept under control treatment (T_1), where non-amount of any plant bio-regulators or micronutrient was applied, showed the lowest fruit retention and highest fruit drop (4.74% and 95.26%, respectively). Zinc sulphate at a higher level increased the foliar zinc content which ultimately encourages the endogenous production of auxin thereby reducing fruit drop and increasing fruit retention. The results are in agreement with the finding of Khan (2009); Singh *et al.* (2009); Singh *et al.* (2012); Kumar *et al.* (2017) in Aonla.

Weight of fruit (g): During the current experiment, all treatments significantly performed better in terms of average fruit weight (g) as compared to the control (Table 1). Application of $ZnSO_4$ @ 1.0% showed the maximum average fruit weight (256.51g), followed by GA_3 @ 60 ppm and NAA@ 75 ppm, respectively, whereas, the control treatment (T_1) where non-amount of any plant bio-regulators or micronutrient were applied, had the lowest fruit weight (200.32 g). This increase in the weight of fruits might be due to better supply of nutrients and photosynthates in plants treated with foliar application of zinc which might have made a rapid synthesis of metabolites particularly carbohydrate and their translocation to the fruits causing relatively greater pulp content. The result is in agreement with the findings of Yadav *et al.* (2011**)** in guava cv. L-49. Kumar *et al*. (2017) in aonla also recorded increased fruit weight with zinc sulphate @ 0.6 % application.

Fruit yield (kg/tree): Pre-harvest applications of $ZnSO_4$ @ 1.0 % have shown to be the most effective treatment in increasing fruit production, which was recorded as 54.58 kg/tree followed by $ZnSO_4$ @ 0.6 % and $ZnSO_4$ @ 0.8 %, respectively, while the control (T_1) treatment,where non-amount of any plant bio-regulators or micronutrient were applied produced the lowest (32.36 kg/tree) fruit yield (Fig. 2). During the current experimental period, an increase in fruit yield is directly related to the significance of these plant bio-regulators and micronutrient in improving physiological activities in plants which increases fruit retention percentage, polar diameter and equatorial diameter along with an increased average weight of fruits. The application of zinc also proved highly helpful in the process of photosynthesis, mobilization of food materials and accumulation of quality constituents promoting physical attributes like fruit size and weight which ultimately increased the yield. The present results are in agreement with the reports of Tripathi and Shukla (2010) in strawberry, Brahmachari *et al.* (1997); Saraswat *et al. (*2006) in litchi.

Fruit Diameter: The foliar treatment of plant bio-regulators and micronutrient had a substantial impact on fruit diameters. The fruits produced from the plants treated with $ZnSO_4$ @ 1.0 % had a significantly higher polar and equatorial diameter of fruit (12.68 and 8.15 cm, respectively) followed by $ZnSO_4$ @ 0.6 % and $ZnSO_4$ @ 0.8 %, respectively, while the fruits produced from the plants kept under control (T_1) treatment showed the lowest polar 8.25 cm and equatorial diameter 6.21 cm (Table 1). This increase in the size of fruits in mango can be attributed to the greater mobilization of water into fruits and food material from the site of their production to the storage organs under the influence of applied plant bio-regulators and micronutrients. An increase in cell size is usually a factor in plant growth, there are some pieces of evidence that auxin is effective in reducing the size of the stone and softens the cell wall, thus increasing its flexibility and plasticity. This would allow stretching of cell wall along with greater water uptake and increased cell size which ultimately increase the size of fruits. The present results are in agreement with the reports of Sharma *et al.* (2005); Saraswat *et al. (*2006) in litchi.

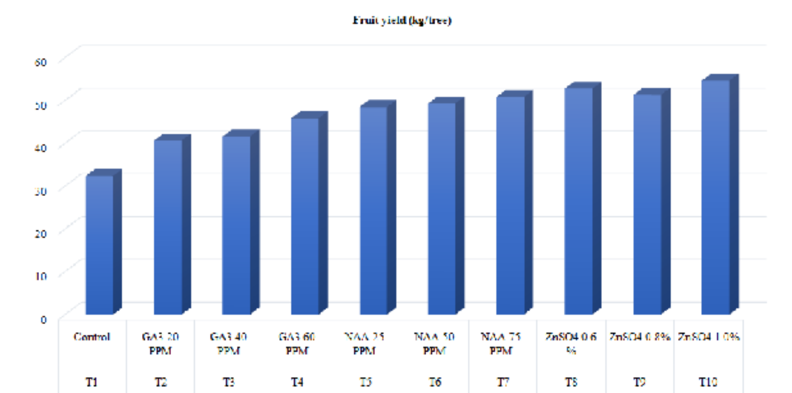

Fig. 2. Effect of pre-harvest application of GA_3, NAA and zinc sulphate on fruit yield (kg/tree).

Table 1: Effect of GA_3, NAA and zinc sulphateon fruit drop, fruit retention and yield parameters of Mango (*Mangifera indica* L.) cv. Dashehari.

Treatments	Fruit retention (%)	Fruit drop (%)	Fruit weight (g)	Polardiameter (cm)	Equatorialdiamet (cm)	Fruit volume (cc)	Specific gravity (g/cc)
Control	4.74	95.26	200.32	8.25	6.21	212.60	0.95
GA_3 @ 20ppm	5.16	94.84	228.37	8.65	6.82	228.44	1.00
GA_3 @ 40 ppm	5.59	94.41	221.68	8.57	6.86	215.61	0.99
GA_3 @ 60 ppm	6.46	93.54	250.24	9.23	7.25	256.48	0.98
NAA @ 25 ppm	6.72	93.28	237.70	8.37	7.45	243.77	0.97
NAA @ 50 ppm	6.96	93.04	240.68	9.36	7.59	252.59	0.96
NAA @ 75 ppm	7.49	92.51	246.55	10.52	7.52	241.60	1.01
$ZnSO_4$ @ 0.6%	7.55	92.45	236.69	9.83	6.92	250.61	0.95
$ZnSO_4$ @ 0.8%	8.31	91.68	240.38	11.23	7.83	238.62	1.01
$ZnSO_4$ @1.0 %	9.85	90.15	256.51	12.68	8.15	260.17	0.99
S.E.(m) ±	0.42	0.54	3.80	0.22	0.08	3.63	0.004
C.D. at 5%	1.25	1.62	11.32	0.66	0.24	10.78	0.01

Fruit volume (cc): The foliar treatment of plant bio-regulators and micronutrients had a substantial impact on fruit volume. The fruits produced from the plants treated with $ZnSO_4$ @ 1.0 % had significantly higher volumes of fruit (260.17 cc) followed by $ZnSO_4$ @ 0.6 % and $ZnSO_4$ @ 0.8 %, respectively, while the control (T_1) treatment showed the lowest (212.60 cc) fruit volume (Table 1). Fruit volume decreases due to the application of plant bio-regulators and micronutrient concentrations are lowered across all treatments.The present results are in agreement with the reports of Sharma *et al.* (2005) and Saraswat *et al. (*2006) in litchi.

Specific gravity: The application of plant bio-regulators and micronutrient had a significant effect on the specific gravity of fruits (Table 1). It was found that the trees treated with $ZnSO_4$ @ 0.8 % (T_9) and NAA @ 75 ppm (T_7) produced fruits with greater specific gravity (1.01 g/cc), followed by the application of NAA @ 75 ppm (T_7) and GA_3 @20 ppm, respectively, while the lowest specific gravity of fruits (0.95g/cc) was found in control (T_1) treatment, where non-amount of any plant bio-regulators or micronutrient was applied. The specific gravity of fruits is also noted to decrease with plant bio-regulators and micro-nutrient doses. Plant bio-regulators and nutrient are either directly or indirectly involved in photosynthesis in plants, after which they are transferred to the fruits during their growth and development results in increasing the amount of stored food in the fruits and ultimately increasing the weight and volume of fruits. This increase in specific gravity with the use of zinc might be due to the increase in fruit pulp and decrease in stone weight. These findings are in agreement with the results of various other workers such as Verma *et al.* (2008); Singh *et al.* (2016); Verma *et al.* (2016); Kumar *et al.* (2017) in Aonla. This increase in specific gravity of fruits with the use of zinc might be due to an increase in fruit pulp and decrease in stone weight.

Pulp, peel and stone per cent: Pre-harvest application of plant bioregulators and micronutrient also showed a significant effect on quality parameters; pulp, peel and stone percentage. Application of $ZnSO_4$ @ 1.0% resulted in a considerable increase in pulp (71.69 %) and reduction of peel and stone per cent (18.23 % and 10.08 %, respectively) in mango fruits. Fruits produced from the plants which were kept under control, where non-amount of any plant bio-regulators or micronutrient were applied, had the lowest pulp percentage (59.46%) and highest peel and stone percentage (22.51% and 18.03%, respectively). This increase in fruit pulp with the application of zinc sulphate might be due to the direct involvement of zinc in the acceleration of biochemical activity in plant parts and translocation of mineral nutrients during the process of fruit development. These findings are in accordance with the results of Singh *et al.* (2009); Tiwari *et al.* (2017); Kumar *et al.* (2017) in aonla and Singh *et al.* **(**2017) in mango.

Total soluble solids and total sugars content: The data collected for total soluble solids and total sugar content clearly showed that the highest TSS (19.06 ^{0}Brix) were found in fruits which were produced from trees sprayed with $ZnSO_4$ @ 1.0 % followed by GA_3 @ 60 ppm and NAA @75ppm respectively, where as the highest increase in total sugars (16.06 %) was also found in fruits that were produced from the plants treated with $ZnSO_4$ @ 1.0 % followed by NAA @ 25 ppm and $ZnSO_4$ @ 0.6 %, respectively (Table 2). However, the lowest amounts of TSS (15.70^0 Brix) and total sugars (12.52 %) were found in fruits which were produced from the tree which were kept under control (T_1) treatment *i.e.,* where non-amount of any plant bio-regulators or micronutrient were applied. This increase in the total soluble solids and total sugars content of fruits may be due to the fact that plant bio-regulators and micronutrients play an important role in photosynthesis which ultimately leads to the accumulation of carbohydrates with a greater conversion of starch into sugar (source to sink) which ultimately results an increase in the TSS and total sugars content of mango fruits in the presence of these plant bio-regulators and micronutrients. The adequate amount of zinc improved the auxin content and it also acted as a catalyst in the oxidation process. The results are in close conformity with the finding of Shrivastava *et al.* (2006); Vashistha *et al.* (2010); Singh *et al.* (2017) in mango. Bhowmick *et al.* (2012) also noted maximum total sugars and non-reducing sugar with the application of $ZnSO_4$ @1.0% in mango cv. Amrapali.

Table 2: Effect of GA_3, NAA and zinc sulphateon physico-chemical quality of Mango (*Mangifera indica* L.) cv. Dashehari.

Treatments	Pulp percent (%)	Peelpercent (%)	Stone percent (%)	T.S.S. (^{0}B)	Total sugars (%)	Titratable acidity(%)	Ascorbic acid (mg/100g pulp)
Control	59.46	22.51	18.03	15.70	12.52	0.69	27.39
GA_3 @ 20ppm	63.62	21.23	15.15	16.12	14.29	0.59	36.39
GA_3 @ 40 ppm	68.67	20.65	10.68	16.72	14.59	0.56	36.28
GA_3 @ 60 ppm	63.68	21.51	14.81	18.20	13.86	0.57	36.54
NAA @ 25 ppm	67.48	20.02	12.50	16.51	15.43	0.58	36.49
NAA @ 50 ppm	66.51	19.80	13.69	17.07	14.34	0.54	37.56
NAA @ 75 ppm	66.21	20.05	13.74	17.52	13.37	0.60	36.60
$ZnSO_4$ @ 0.6%	65.91	21.51	12.58	16.31	15.28	0.59	36.52
$ZnSO_4$ @ 0.8%	68.77	19.75	11.48	16.14	14.19	0.55	37.02
$ZnSO_4$ @1.0 %	71.69	18.23	10.08	19.06	16.06	0.50	38.58
S.E.(m) ±	0.67	0.31	0.47	0.21	0.15	0.02	3.15
C.D. at 5%	1.00	0.94	1.35	0.64	0.46	0.007	1.05

Titratable acidity: The use of plant bio-regulators and micronutrient significantly influenced the titratable acidity percent in fruits. The minimum titratable acidity (0.50%) was found in fruits which were produced from the plants treated with $ZnSO_4$ @ 1.0% followed by NAA @ 50 ppm and $ZnSO_4$ @ 0.8%, respectively, whereas, the maximum titratable acidity (0.69%) was recorded in fruits which were kept under control (T_1) treatment (Table 2). Titratable acidity content in 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 reverse reaction of the glycolytic pathway which is utilized in various physiological activities. Another reason for the reduction in titratable acidity percent might be the early ripening of fruits which was induced by the plant bio-regulators and micronutrient spray due to which degradation of acids might have occurred. Results obtained during the present experimental period are also in line with the findings of Shukla *et al.* **(**2011); Tiwari *et al.* (2017); Singh *et al.* (2001); Kumar *et al.* (2017) in aonla.

Ascorbic acid: Ascorbic acid content of fruits was significantly influenced by plant bio-regulators and micronutrient application as compared to control. A higher quantity of ascorbic acid (38.58 mg/100g pulp) was recorded in fruits which were produced from the plants treated with $ZnSO_4$ @1.0% followed by NAA @ 50 ppm and $ZnSO_4$ @ 0.8 %,whereas, the lowest amount of ascorbic acid content (27.39 mg/100g pulp) was recorded in fruits which were produced from the plants kept as control treatment (Table 2). The increased ascorbic acid content of fruit juice was due to an increase in the synthesis of catalytic activity of enzymes and coenzymes, which are represented in ascorbic acid synthesis. An adequate amount of zinc improves the auxin content and it also acts as a catalyst in the oxidation process. These findings are in close accordance with the results of Rajak *et al.* (2010), who reported maximum ascorbic acid content (mg/100 g pulp) in fruits with $ZnSO_4$ @ 0.6% and borax @ 0.8% and minimum under control in mango cv. Amrapali fruits. Tripathi and Shukla (2008) also found increased ascorbic acid content with GA_3 treatment in strawberry.

CONCLUSION

The above-mentioned results clearly show that the pre-harvest spray of $ZnSO_4$ @ 1.0 % (T_{10}) had a positive effect on fruit set, fruit drop and fruit retention as well as a higher number of fruit sets per panicle. On the other hand, the used materials increased the yield of Dashehari mango with fruit weight and yield per tree followed by treatment including all sprayed materials. As fruit quality parameters (physical and chemical properties) are concerned, it is clear that spraying of $ZnSO_4$ @ 1.0 % gave a high improve in quality parameters as compared with the control.

FUTURE SCOPE

The use of plant bio-regulators and micro-nutrients have significant importance in increasing the yield and quality of fruits with the reduction in fruit drop with increased fruit retention. Since mango is an important fruit crop all over the world in the sub-tropical climate. That's why in the future, more studies can be carried out on other cultivars alone or in the combination of both *i.e.*, plant bio-regulators and micro-nutrient on more parameters to standardize doses specific to the particular regions.

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Conflict of Interest: None.

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