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Influence of plant growth regulators and nutrients on fruit retention, yield and quality attributes of mango (*Mangifera indica* L.) cv. Amrapali

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Abstract
An investigation was carried-out at fruit research station, Department of Horticulture, JNKVV, Jabalpur during the season of 2014-15 on 5 years old orchard of mango, to evaluate the positive effect of foliar sprays of PGR' and nutrients on fruiting, yield and quality characteristics in Amrapali mango. The experiment was laid out in Randomized Block design in three replications and treatments replicated thrice by using single tree as a units. Each treatment was carried out one tree for each replication. Spraying of combination of nutrients viz., KNO_3 (2%), urea (2%), $ZnSO_4$ (0.8%) and $FeSO_4$ (0.4%) and growth regulators viz., NAA (50 & 25 ppm) and GA_3 (30 & 20 ppm) was compared with control (no spray). The experimental results indicate that the foliar spray of GA_3 30 ppm + KNO_3 2% showed better performance in Higher number of fruits at initial stage (63.81), more fruit retention percentage at harvest stage (1.94%), fruit yield (14.70 kg/ tree), fruit weight (182.29 g), fruit length(9.91 cm), fruit width (6.90 cm), fruit volume (172.01 ml) and peel weight(31.36 g). Under the treatment T_6 (NAA 50 ppm + KNO_3 2%) was recorded significantly maximum pulp weight (105.73g) which were at par with T_2. However, it was noted minimum in control (T_{17}) and reverse trend was noted in case of stone weight. Significantly minimum stone weight (21.41g) was recorded in treatment T_6 (NAA 50 ppm + KNO_3 2%).
Biochemical parameter like TSS, Acidity, Ascobic acid, Reducing sugar, Total sugar and Non-reducing sugar were observed. However the chemical composition of fruit *viz*., maximum TSS (22.05 ^{0}Brix), TSS: acid ratio (184.22), Ascorbic acid content (54.33 mg/100g), reducing sugars (6.90%), total sugars (18.09%) and minimum acidity content (0.12%) were recorded with the application of T_{14} (GA_3 30 ppm + KNO_3 2%) which was at par with T_{10}(GA_3 20 ppm+ KNO_3 2%) during the year of experimentation.

Keywords: GA_3, KNO_3, fruiting, physico-chemical quality, yield, Mango

Introduction
Mango (*Mangifera indica* L.) is the premier fruit among the tropical fruits and has been in cuitivation in the Indian subcontinent since several centuries. Mango is the king of fruit, is a member of Anacardiaceae family. Mangoes are most famous for it's exotic flavours, taste, and attractive colour. Mango is a delicious fruit and holds a great degree of nutritive value. Modulation of flowering and fruit set by spraying of various hormones and nutrients is the best alternative to mitigate or reduce the climate changes effect on mango. Various chemicals and plant growth regulators application have been standardized for enhancing and uniform flowering in mango. The main objective of a mango grower is to harvest maximum quantity with good quality of marketable fruits at the lowest cost in early season. Application of several chemicals before the induction of flowering has been tried at various levels to regulate the crop and to gain the higher yield.
Spraying of NAA @ of 50-100 ppm has shown the effect in early flowering (Davenport, 2007) [10] in mango. Naphthalene acitic acid (NAA), an auxin group of plant growth regulator was found to have an effect on the flower promoting activity in mango (Beyer, 1976) [7]. There is need to study the effect of foliar application of growth regulator, macro and micro nutrients on bearing, yield and biochemical quality of mango. Foliar sprays of plant growth regulators and nutrients not only improves the size but also enhance qualitative parameters of fruit. The foliar application of macro-nutrients and plant growth regulators have very important role in improving the productivity and quality of fruits. It has also beneficial role in recovery of nutritional and physiological disorders in fruit trees grown under sodic soil condition. Various trials have earlier conducted on foliar sprays of macro-nutrients and PGR's in different fruit species and shown significant response to improving yield and quality of fruits.

Potassium is known for development of fruit, movement of sugars and indirectly photosynthesis. Since potassium enhances internal fruit quality while gibberellic acid is known for its anti senescing properties, promotes cell elongation and improve quality of fruit.

In this study an attempt has been made to see the "Influence of plant growth regulators and nutrients on fruit retention, yield and quality attributes of mango (*Mangifera indica* L.) cv Amrapali."

Material and Methods

The present investigation was conducted at the fruit research station, Department of Horticulture, College of Agriculture, JNKVV Jabalpur, during the year 2014-15 on 5-years-old trees of mango cv. Amrapali. The experiment was laid out in Randomized Block design in three replications and treatments replicated thrice by using single tree as a units. Each treatment was carried out one tree for each replication. Spraying of combination of nutrients viz., KNO_3 (2%), urea (2%), $ZnSO_4$ (0.8%) and $FeSO_4$ (0.4%) and growth regulators viz., NAA (50 & 25 ppm) and GA_3 (30 & 20 ppm) was compared with control (no spray).

The randomized block design was adopted with 17 treatments as shown in table (1):

Table 1: Treatment details

Symbols	Treatments
T1	NAA 25 ppm + Urea 2%
T2	NAA 25 ppm + KNO_3 2%
T3	NAA 25 ppm + $ZnSO_4$ 0.8%
T4	NAA 25 ppm + $FeSO_4$ 0.4%
T5	NAA 50 ppm + Urea 2%
T6	NAA 50 ppm + KNO_3 2%
T7	NAA 50 ppm + $ZnSO_4$ 0.8%
T8	NAA 50 ppm + $FeSO_4$ 0.4%
T9	GA_3 20 ppm + Urea 2%
T10	GA_3 20 ppm + KNO_3 2%
T11	GA_3 20 ppm + $ZnSO_4$ 0.8%
T12	GA_3 20 ppm + $FeSO_4$ 0.4%
T13	GA_3 30 ppm + Urea 2%
T14	GA_3 30 ppm + KNO_3 2%
T15	GA_3 30 ppm + $ZnSO_4$ 0.8%
T16	GA_3 30 ppm + $FeSO_4$ 0.4%
T17	Control

Determinations

Number of fruits at initial stage

Number of fruits at initial stage was counted and average of number of fruits at initial stage was computed.

Fruit retention percentage at harvest stage

The total number of fruits per panicle of 10 tagged panicles was counted at harvest stage, and average was worked out. Fruit retention (%) per panicle was than calculated using the below mentioned formula.

Fruit retention (%) at harvest stage =

$$\frac{\text{No. of fruits per panicle at harvest stage}}{\text{Number of fruits at initial stage}} \text{ X } 100$$

Fruit length (cm)

Fruits from each treatment were harvested at maturity and their length was measured in centimeters with the help of Vernier callipers. Average length was worked out under each treatment.

Fruit width (cm)

Fruits from each treatment were harvested at maturity and their width was measured in centimeters with the help of Vernier callipers. Average width was worked out under each treatment.

Fruit volume (ml)

The volume of fruit was recorded in ml by displacement method.

Fruit weight (g)

Weight of the fresh harvested fruits was taken on electronic balance and average weight of fruit was calculated under different treatments.

Pulp weight (g)

After removal of peel from ripe selected fruits, the pulp was also removed from the stone with the help of steel knife and weighed.

Peel weight (g)

After removal of peel from ripe selected fruits, it was weighed by electronic balance.

Stone weight (g)

After removal of peel from ripe selected fruits pulp was also removed from the stone with the help of steel knife and weighed.

Fruit yield (kg/ tree)

Fruit yield of each treatment was recorded in kg/tree with the help of weighing balance.

TSS (ºBrix)

The juice extract was used for determination of TSS by Hand Refractrometer. Few drops of extracted juice were placed over the surface of prism and the hinged part was placed back. The refractrometer was then placed against the sun and the readings were recorded by revolving the eye piece at room temperature (AOAC, 1970).

Acidity (%)

For titrable acidity estimation, 5g of crushed fruit sample or segments or 5 ml of syrup was taken and diluted with distilled water and filtered through muslin cloth and the filtrate was made upto 50 ml. To 5 ml of aliquot taken in a conical flask few drops of phenolphthalein indicator were added. The solution was titrated against 0.1 N NaOH until a definite pink colour, which persisted for at least 30 seconds, was obtained and the titre value was recorded.

Total acid (%) =

$$\frac{\text{Titre x Normality of NaOH x Vol. Made up x Eq. Wt. of acid}}{\text{Wt. of sample x Volume taken for titration x 1000}} \text{ x } 100$$

TSS: Acidity ratio

The TSS and acidity ratio of fruit was calculated by dividing the TSS by the acidity.

$$\text{TSS: Acidity ratio} = \frac{\text{Average value of TSS}}{\text{Average value of acidity}}$$

Ascorbic acid (mg/100g)

The ascorbic acid was estimated by titration method using 2, 6-dichlorophenol indophenols dye as per the method reported by Ranganna (1991). To 2 g of fruit sample or segment or 2 ml of syrup 8 ml of meta phosphoric acid was added and filtered with muslin cloth. To 2 ml of the filtrate 5 ml of meta phosphoric acid was added and titrated against the dye solution.

The amount of ascorbic acid was calculated by using the following formula:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Ascorbic acid (mg) taken x Vol. Made up x Vol. of dye}}{\text{Dye used for standard x Wt. of sample x Vol. of sample taken}} \times 100$$

Reducing sugar (%)

Pipette 10ml of mixed Fehling solution into 250 ml conical flask (5A and 5B). The burette was filled with the sample solution prepared. Then run into the flask almost the whole volume(15-50ml) of solution required to reduce the Fehling solution so that 0.5-1.0 ml is require to later complete titration. Mixed the content and was heated to boiling and boiled moderately for 2 min. Then added 3 drops of methylene blue and by not touching the sides. Titration was completed within 1min by adding 2-3 drops of sugar solution at 5-10 sec intervals, until the indicator is completely decolorized from blue to brick red of cuprous oxide. Noted the volume of the solution required.

Note: End point was determined within 1 drop of sugar and not interrupting the boiling more than few seconds as the indicator undergoes back oxidation rapidly when air has free excess into the flask.

Calculation

$$\text{Reducing sugar \%} = \frac{\text{Factor x Dilution x 100}}{\text{Titre value x Weight of sample}}$$

Total sugar (%)

50 ml of the clarified solution was pipette into 250 ml flask and added 5g of citric acid and 50 ml of water. It was boiled gently for 10 min to complete inversion of sucrose, and then cooled. Transferred it to 250ml flask and neutralized with 1N NaOH using phenolphthalein and make up volume and was titrated with Fehling solution.

Calculation

$$\text{Total sugar \%} = \frac{\text{Factor x Dilution x 100}}{\text{Titre value x Weight of sample}}$$

Non reducing sugar (%)

Non reducing sugar % = Total sugar % - Reducing sugar %

Results and Discussion

Effect of foliar spray's of plant growth regulators and nutrients on fruit retention, yield and physical quality attributes of mango

During 2014-15, table 2 show the significantly higher fruit set (63.81) was recorded in trees sprayed with treatment T_{14} (GA3 30 ppm + KNO3 2%) as compared to the other treatments and minimum was registerded under the control and also the highest fruit retention (1.94 %) at harvest stage was recorded with GA3 30 ppm + KNO3 2%. The optimum supply of nutrients to the bearing mango trees help in retaining more number of fruits (Singh, 1974; Sharma *et al*., 1990). The treatments exerted profound significant influences on number of fruit set per panicle. The application of gibberellic acid in the present investigation has increased the intensity of flowering, better fruit set, better fruit retention, which might have resulted in increase in the number of fruits per tree. These findings are in agreement with the findings of Kumar *et al*. (2003) [21], Baghel and Tiwari (2003) [2], Ruby and Brahmachari (2004) [33].

Data of table 2 shows that maximum fruit weight (182.29 g), fruit length (9.91 cm), fruit width (6.90 cm), fruit volume (172.01 ml) and peel weight (31.36g) observed under T_{14}(GA3 30 ppm + KNO3 2%), whereas the minimum result noted with T17(control).

Application of growth regulators and nutrients improve the qualitative parameters of fruit. The results obtained from the study revealed that all the quality parameters were found significant This may be because of contribution of potassium nitrate along with growth regulator. The quality improvement in fruits may be due to proper supply of nutrients and induction of growth hormones, which stimulates cell division, cell elongation, increase in weight of fruits, better translocation of water uptake and deposition of nutrients. These findings are in close conformity with the findings of Ray *et al*. (1991) [32].

In foliar feeding the nutrients are applied directly to the site of metabolism. This increase could be attributed to enhanced carbohydrate metabolism. This is in agreement with Vijayalakshmi and Srinivasan (2000) [42], Yeshitela (2004) [43], Kumari *et al*. (2007) [20] and Stino *et al*. (2011) [38] in mango.

Under the treatment T_6 (NAA 50 ppm + KNO_3 2%) was recorded significantly maximum (105.73 g) pulp weight which were at par with T_2 (NAA 25 ppm + KNO_3 2%). However, it was noted minimum (86.89g) in control (T_{17}). Treatment T_6 (NAA 50 ppm + KNO_3 2%) was recorded significantly minimum (21.41g) stone weight followed by T_2 (NAA 25 ppm + KNO_3 2%) and T_5 (NAA 50 ppm + Urea 2%) as compared to other treatments. While, it was noted maximum in control (T_{17}). Increase in the pulp weight of fruit, all treatments affected differently and showed significant difference for fruit pulp weight, it is due to increase of fruit weight. Increased sink demand by induced application of auxin is closely related to the activation of invertase cell wall-bound in the core and invertase neutral and NAD-dependent sorbitol dehydrogenase in the pulp during rapid fruit growth. These findings are in agreement with the findings of Malik *et al*. (2000) [24], Ram and Bose (2000) [31], Hammam *et al*. (2001) [16], Ruby and Brahmachari (2004) [33], Saxena (2004) [35], Debaje *et al*. (2011) [11], Moazzam *et al*. (2011) [26], Singh and Banik (2011) [36] and Yadav *et al*. (2011) [40].

The highest yield per tree (14.70 kg/tree) was found under T_{14} (GA3 30 ppm + KNO3 2%) treatment, whereas lowest yield was found in T17 (control). The trees sprayed with GA_3 and potassium nitrate has recorded maximum yield may be due to the prolonged duration of flowering, fruit set, increase in fruit set per panicle, prevention of abscission of young fruit lets, increase in the number of fruits per tree, better fruit retention and better utilization of nutritional resources with in the trees would have resulted in the increase in fruit yield. These findings are in agreement with the findings of Bhowmick and Banik (2011) [3], Wahdan *et al*. (2011) [39], Yadav *et al*. (2011) [40], Nkansah *et al*. (2012) [27], Sarker and Rahim (2013) [34],

Oosthuyse (2013) [28], Golla (2014) [14] and Dheeraj *et al* (2016) [12].

Effect of foliar spray's of plant growth regulators and nutrients on biochemical characteristics of mango

The application of growth regulators and nutrients improve the qualitative parameters of fruit. The results obtained from the study revealed that all the quality parameters were found significant except non- reducing sugar (2014-15). The significant higher TSS (22.05 ^{0}Brix) was recorded in the treatment T_{14} (GA_3 30 ppm + KNO3 2%) which was at par with T_{10} (GA_3 20 ppm + KNO_3 2%) during the years and it was minimum with T_{17} (control), while reducing sugars, total sugars, TSS: Acid ratio and ascorbic acid content in fruit were also in similar trend as the TSS. However, maximum reduction of acidity (0.12%) was noted with the application of T_{14} (GA_3 30 ppm +KNO_3 2%). Maximum reducing sugars (6.90%), total sugars (18.09%), TSS: Acid ratio (184.22) and ascorbic acid (54.33 mg/100g) were recorded in T_{14} respectively. The result of non-reducing sugars was found not significant. Minimum value for reducing sugars, total sugars, TSS: acid ratio and ascorbic acid were recorded in T_{17} (control) whereas, maximum value for acidity noted with control. This may be because of contribution of potassium nitrate along with growth regulator. The quality improvement in fruits may be due to proper supply of nutrients and induction of growth hormones, which stimulates cell division, cell elongation, increase in weight of fruits, better translocation of water uptake and deposition of nutrients. These findings are in close conformity with the findings of Ray *et al*. (1991) [32] who reported that application of GA_3 at 100 ppm increased TSS in sapota fruits. An increase in TSS during fruit ripening could be due to hydrolysis of starch into sugars. The increase in TSS may be accounted to the hydrolysis of the polysaccharides, conversion of organic acid into soluble sugars and enhanced solubilisation of insoluble starch and pectin present in cell wall and and middle lamella (Gupta and Brahmachari, 2004) [15]. The treatments "K" and "N" containing nutrients show the decrease in fruit acidity. The depletion in organic acids could be due to fast conversion of acid into sugars and their derivatives or their utilization in respiration or both (Gupta and Brahmachari, 2004) [15]. "K" acts as a catalyst that accelerates the rate of reaction in plants (Jones, 1979) [18].

In foliar feeding the nutrients are applied directly to the site of metabolism. In present investigation, the total sugars in fruits of treated trees were significantly higher than control. This increase could be attributed to enhanced carbohydrate metabolism. This is in agreement with Vijayalakshmi and Srinivasan (2000) [42], Yeshitela (2004) [43], Kumari *et al*. (2007) [20] and Stino *et al*. (2011) [38] in mango.

Table 2: Influence of plant growth regulators and nutrients on fruit retention, yield and physical quality of mango (*Mangifera indica* L.) cv Amrapali.

Treatments	Number of fruits at initial stage	Fruit retention percentage at harvest stage	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	Fruit volume (ml)	Pulp weight (g)	Peel weight (g)	Stone weight (g)	Fruit yield (kg/ tree
NAA 25ppm+Urea 2%	59.10	1.06	169.01	8.90	6.00	124.80	102.66	26.21	24.87	12.04
NAA 25ppm +KNO_3 2%	61.65	1.38	171.45	9.77	6.45	160.18	104.64	26.82	24.09	13.49
NAA25ppm+$ZnSO_4$ 0.8%	57.97	0.72	150.32	8.56	5.86	105.03	100.86	24.38	27.48	10.32
NAA25ppm+$FeSO_4$ 0.4%	58.93	0.47	146.69	7.55	5.35	82.47	99.85	23.93	30.01	8.40
NAA 50 ppm +Urea 2%	59.37	1.03	168.96	9.15	6.14	138.96	103.48	26.34	24.09	12.52
NAA50 ppm+KNO_3 2%	62.71	1.51	175.78	9.82	6.70	163.81	105.73	28.80	21.41	13.95
NAA50ppm+$ZnSO_4$ 0.8%	59.09	0.73	151.12	8.67	5.98	110.16	100.86	24.50	28.19	11.25
NAA50ppm+$FeSO_4$ 0.4%	59.10	0.63	147.48	7.81	5.49	91.85	100.26	24.31	29.14	9.31
GA_3 20 ppm + Urea 2%	59.33	1.32	176.38	9.45	6.26	146.83	101.57	29.42	26.87	12.91
GA_3 20 ppm +KNO_3 2%	63.13	1.77	181.85	9.91	6.76	165.68	101.51	30.79	25.83	14.38
$GA_3$20ppm +$ZnSO_4$ 0.8%	53.95	0.90	158.73	8.26	5.61	117.64	98.73	25.99	30.77	10.68
$GA_3$20ppm +$FeSO_4$ 0.4%	53.84	0.69	152.33	7.83	4.97	93.07	94.52	24.97	31.04	10.32
GA_3 30 ppm + Urea 2%	59.54	1.27	178.09	9.67	6.36	148.60	101.48	29.85	26.13	13.08
GA_3 30 ppm +KNO_3 2%	63.81	1.94	182.29	9.91	6.90	172.01	102.11	31.36	25.80	14.70
$GA_3$30ppm +$ZnSO_4$ 0.8%	54.00	1.07	160.11	8.34	5.71	119.43	100.01	25.65	30.31	11.09
$GA_3$30ppm +$FeSO_4$ 0.4%	54.68	0.75	156.61	8.06	5.22	103.73	94.88	25.37	30.87	10.19
Control	53.69	0.40	140.08	7.27	4.51	77.28	87.08	23.38	31.21	7.91
SEm ±	0.28	0.05	1.11	0.08	0.07	3.29	0.42	0.19	0.25	0.18
CD 5%	0.81	0.15	3.20	0.22	0.21	9.51	1.22	0.54	0.73	0.53

Table 3: Influence of plant growth regulators and nutrients on biochemical parameters of mango (*Mangifera indica* L.) cv Amrapali.

Treatments	TSS (0ºBrix)	Acidity (%)	TSS: Acidity	Ascorbic acid (mg/100g)	Reducing Sugar (%)	Non –reducing Sugar (%)	Total sugar (%)
NAA 25ppm+Urea 2%	20.51	0.14	142.90	49.27	5.98	11.39	17.37
NAA 25ppm +KNO_3 2%	21.32	0.13	158.33	51.46	6.59	11.17	17.76
NAA25ppm+$ZnSO_4$ 0.8%	19.58	0.16	122.64	46.07	4.95	11.52	16.47
NAA25ppm+$FeSO_4$ 0.4%	19.08	0.19	99.83	42.03	4.40	11.29	15.69
NAA 50 ppm +Urea 2%	20.80	0.15	143.19	49.29	6.29	11.25	17.54
NAA50 ppm+KNO_3 2%	21.37	0.13	160.76	51.61	6.67	11.37	18.04
NAA50ppm+$ZnSO_4$ 0.8%	19.67	0.16	125.35	46.47	5.28	11.41	16.69
NAA50ppm+$FeSO_4$ 0.4%	19.31	0.18	109.41	43.43	4.34	11.30	15.64
GA_3 20 ppm + Urea 2%	20.80	0.14	148.63	50.01	6.33	11.27	17.60
GA_3 20 ppm +KNO_3 2%	21.40	0.13	166.48	52.33	6.84	11.23	18.07
$GA_3$20ppm +$ZnSO_4$ 0.8%	19.95	0.16	128.16	46.69	5.59	11.19	16.78

$GA_3$20ppm +$FeSO_4$ 0.4%	19.52	0.18	111.14	43.56	4.62	11.18	15.80
GA_3 30 ppm + Urea 2%	21.02	0.14	151.22	50.88	6.53	11.23	17.76
GA_3 30 ppm +KNO_3 2%	22.05	0.12	184.22	54.33	6.90	11.19	18.09
$GA_3$30ppm +$ZnSO_4$ 0.8%	20.23	0.15	133.40	48.48	5.86	11.11	16.97
$GA_3$30ppm +$FeSO_4$ 0.4%	19.59	0.18	111.36	45.95	4.73	11.31	16.04
Control	18.92	0.22	85.21	39.93	3.62	11.10	14.72
SEm ±	0.27	0.005	3.83	1.95	0.16	0.21	0.17
CD 5%	0.79	0.01	11.05	5.64	0.46	N.S.	0.48

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