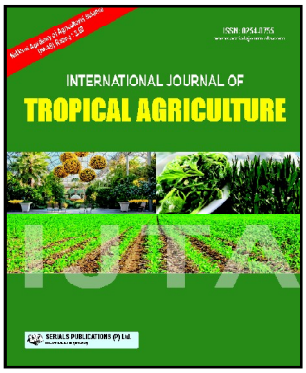

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Effect of Plant Growth Regulators (NAA, 2, 4-D and GA_3) on Fruit Retention and Quality of Mango cv. Dasehri

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Abstract: This study was conducted to evaluate the effects of NAA, 2,4-D and GA3 on mango cultivar 'Dasehri' at pea stage. The experiment was laid out in Randomized Complete Block Design with following 7 treatments and 3 replications i.e. Control; 20 ppm NAA; 40 ppm NAA; 20 ppm 2,4-D; 40 ppm 2,4-D; 20 ppm GA3; 40 ppm GA3. Number of fruit set, fruit growth (length, diameter and size), fruit quality (TSS, ascorbic acid, total sugar) and yield/tree were recorded. Results indicated that among the treatments, 2,4-D sprayed at 20 ppm proved to be very effective with 66% more fruit retention over control. Application of GA3 (40 ppm) followed by 2, 4-D (20 ppm) resulted in a significant enhancement of fruit size in terms of fruit length and weight, respectively. In regard to fruit quality, fruit weight significantly increased by GA3 (40 ppm) followed by 2, 4-D (20 ppm) (238.8 and 230.1 g), which was 21.8 and 17.4% that of the control (196.0 g), respectively. Acidity of fruit was significantly reduced (at full ripe stage) the spray of all the PGR's the better spray were 40 ppm NAA, 20 ppm 2,4-D and 20 ppm GA3. Yield was significantly increased by 20 ppm and 40 ppm 2, 4-D. In general, better results were found at 20 ppm and 40 ppm 2, 4-D, than GA3 and NAA. It was concluded that all PGRs NAA 2,4-D and GA3 spray have positive effects on fruit development, reduced fruit drop and improved fruit quality of mango under field conditions.

Keywords: Dasehri, fruit drop, fruit quality, mango, plant growth regulator

INTRODUCTION

Mango (*Mangifera indica* L.) unarguably is one of the oldest and choicest tropical fruits of the world and is rightly designated as "King of all fruits". Mango is believed to be indigenous to the Indian sub-continent. It is under cultivation in India for more

than 4000 years and hence conspicuous bonds have been formed between the fruit and cultural history of the country. At present, it is currently being grown in at least 111 countries spreading over five continents with an area of 3.7 m ha with a total production of 26.28 metric tons. The average productivity is 7.10 tons/ha "as reported by FAO [1]". India still dominates the world production and ranks first with a total area 2209('000) Ha production of 18643 ('000) MT "as reported by Govt. of India, MOA [2]". Other countries which follow India in mango production (m tons) are China (3.62), Thailand (1.75), Mexico (1.50), Pakistan (1.07), Philippines (0.89) and Indonesia (0.80). Both ripe and unripe mangoes are high potential for employment and income generation being utilized for agro-industries. Mango food processing industry prepares wide varieties of products like jellies, jams, juices, cutfresh fruit, dried chips, fruit concentrate and fruit leather. Mango pulp is a major fruit product exported agro-processed (>10% in total export of horticultural produce) product from India worth about 800 Cr and fruits around 250 Crs.

The plant growth regulators (PGR) act as messengers and are needed in small quantities at low concentrations. Generally their site of action and biosynthesis are different. Most of the plant growth regulators exhibit a broad spectrum and thus a single PGR may influence several entirely different processes e.g., "as described by Jawed *et al.* [3], Kassem *et al.* [4]". Moreover, plant growth regulators enhance the rapid changes in physiological and biochemical characters and improve crop productivity. Reference indicated "Paroussi *et al.* [5]" that among agricultural practices which may increase the fruit production and improve the quality of several other fruit crops are the applications of plant growth regulators, especially gibberellic acid. Gibberellic acid has been reported to influence vegetative growth, flowering, fruiting and various disorders in many fruit crops. It is also used widely in other horticultural crops for stimulating fruit set in various fruit species, such as peach i.e. earlier reference Stutte and Gage [6]; 'Clementine' mandarin, Talon *et al.* [7]; pear, Deckers and Schoofs, [8]; also to control apple russeting, Taylor and Knight [9]; and cracking of pomegranate fruit, Sepahi [10]. Moreover, sprays of GA3 have been widely adopted in commercial orchards because they have consistently been shown to increase fruit size and firmness of cherry reported by Clayton *et al.* [11]. Moreover, GA3 increased the yield of fruit in Balady mandarin reported by El-Sese [12], and increases soluble solids as well as fruit weight in sweet cherry reported by Basak *et al.* [13]. Furthermore, synthetic auxins are effective in enhancing fruit growth when applied during the second stage of fruit development reported by Westwood [14]. According to Elisa *et al.* [15] synthetic auxin increases total antioxidant capacity and nutritional quality in transgenic Silcora seedless grape. These auxins are known for their ability to increase cell enlargement reported by Westwood [14], Arteca [16], thus enhancing fruit growth in certain species such as peach Agusti *et al.* [17]; loquat, Agusti *et al.* [18]; Citrus, Agusti *et al.* [19]; litchi (Stern and Gazit [20]. Many studies Stern *et al.* [21] have intended to prevent fruit abscission in lychee using synthetic auxins, mainly NAA (naphthaleneacetic acid), 2,4-D (2,4-dichlorophenoxyacetic acid), 2,4,5-T (2,4,5-trichlorophenoxyacetic acid). It was also reported by Baogang *et al.* [22] that 2,4-D increased total sugar content and enhanced the activities of antioxidant enzymes. Furthermore, the 2,4-D, GA_3 application signiûcantly reduced acidity percentage and increased vitamin C content of citrus fruits reported by Xiao *et al.* [23].

A major problem in mango production worldwide is the premature fruit drop that shockingly results decreasing yield and productivity up to 50%. Besides external factors like heat and humidity, drought, disturbances in water and mineral supply, diseases and pests *etc*, there are certain internal factors also among which concentration of auxins is of

prime importance governing the abscission layer formation. Reddy and Prasad [24] reported fruit drop is inversely correlated with the period of low auxin production during the development of fruits, might be due to nature of auxins to increase the osmotic pressure of cell sap which is responsible for uptake of water and consequently results in increased growth. Similarly, Babu and Lavaniya [25], Baghel and Sarnaik [26] and the application of plant regulators at the right time has been found effective in controlling fruit drop, if the abscission layer is found to be due to low auxin content reported by Venkatesan and Mohideen [27].

Several studies i.e. Chen, [28]; Prakash and Ram, [29] showed that PGRs application increased fruit set in mango through the capacity of a fruit to prevent itself from being shed, relates positively of the fruit ability to produce growth promoting hormones. The applications of synthetic PRGs such as CPPU, GAs and NAA have been reported by several other authors like Burondkar *et al.*, [30]; Oosthuyse, [31], [32]; Singh and Ram, [33] to enhance fruit retention in mango and might suggest a correlation of deficiency or metabolic and or transformational alterations of natural occurring hormone values at early stages of fruit development with fruit drop in mango earlier by Malik and Singh, [34]; and Ram, [35].

The present study was, therefore undertaken to ascertain the effect of different doses of PGRs on mango crop for fruit retention, yield and quality.

MATERIALS AND METHODS

Experimental Details and Treatments

This investigation was carried out during the year 2004-05 at Mango farm of Govt. Garden (Rajkiya Udyan) Alambagh, Lucknow (26°56´ N 80°52´E) with average annual rainfall ranging between 650 - 750 mm.

The following treatments were tried in triplicate with randomized block design on about 15+ years old mango trees (cv. Dasehri) T_1: control; T_2: 20 ppm NAA; T_3: 40 ppm NAA; T_4: 20 ppm 2,4-D; T_5: 40 ppm 2,4-D; T_6: 20 ppm GA_3;T_7: 40 ppm GA_3.

For preparation of NAA solution, the stock solution was made in 20 mg NAA dissolved in a small quantity of absolute alcohol. The requisite volume of 1000 ml solution was prepared by adding distilled water to obtain 20 ppm NAA solution. The same procedure was adopted to obtain 40 ppm NAA, 20 ppm 2,4-D, 40 ppm 2,4-D, 20 ppm GA_3 and 40 ppm GA_3. Those solutions were uniformly sprayed on pea stage (5-6 mm; 10-15 days after fertilization) with the help of foot sprayer in the evening hours. Break-thru at 0.1% was used as wetting agent in all the treatments.

Five uniform panicles of Dasehri were randomly selected and total fruitlets were counted at the time of spray and at harvest. Each one tree was considered as replicate. Normal cultural practices were adopted throughout the year to maintain the orchard in healthy condition. Data on the monthly summary of the weather variables (rainfall, temperature and relative humidity) for the trial site were collected throughout the period of study, but not presented because it was relatively stable and within ranges ideal for growth and fruiting in mango.

Fruit size was measured in terms of fruit length and diameter. The fruit size was measured with the help of Vernier callipers and measured in centimetre up to two decimal points and weight of three randomly selected fruits from each treatment under each replication was taken using the sensitive digital balance and average weight per fruit was calculated in grams. Total soluble solids (TSS) of ripening fruit was determined with the help of a hand refractometer (0-32° Brix) by putting a few drops of juice on the prism. The refractometer was calibrated with distilled water before use. Ascorbic acid content was determined by 2, 6-

Dichlorophenol-indophenol method. Titratable acidity percentage was estimated by standard method described by A.O.A.C. [36]. Statistical analysis of the data was carried out by the method of analysis of variance as outlined by Gomez and Gomez, [37].

RESULTS AND DISCUSSION

Physical characteristics and yield

The data presented in table 1 clearly showed that all the treatments significantly enhanced fruit retention in dusheri while the maximum fruit retention (8.39%) was observed with treatment T4 with the spray of 20 ppm 2, 4 – D closely followed by T5 with 40 ppm 2, 4 – D spray minimum retention of Mango fruits was recorded in control plants (5.05%) without hormone spray. Similarly, fruit length was also increased by all the treatments, with 2, 4-D being the most effective, especially at lower concentration 20 ppm. The maximum length (14.91 cm) was observed with treatment T4 (20 ppm 2,4-D) followed by T6, T7, T5, T2, T3 attaining 14.87 cm, 14.24 cm, 13.12 cm, 13.05 cm respectively. The minimum length of fruit (10.80 cm) was measured in control treatment, where only water was sprayed on the fruits. Best treatment results 38.00 percent length was improved over control.

Width of fruit was significantly improved by use of PGRs. The maximum width of fruit (12.79 cm) was measured in treatment T4 (20 ppm 2, 4-D) and is followed by treatment T6 (12.68cm), T7 (12.66 cm), T5 (12.00 cm), T2 (11.61 cm) and T3 (11.54 cm). On the contrary control treatment (T1) recorded the minimum width of 8.60 cm. All treatments except T5 significantly enhanced width of the fruit over control. Best treatment results 48.70 percent width was improved over control.

Weight of fruit was significantly improved by spray of the PGR's. The maximum average weight (238.80 g) was recorded under treatment T7 (40 ppm GA3). However, it was followed by treatment T6 (234.00 g), T4 (230.10 g), T5 (228.76 g), T3 (226.20 g), & T2 (222.65 g) respectively. On the other hand minimum weight was recorded in treatment T1 (196.00 g) with water spray only. In regard to fruit quality, fruit weight significantly increased by GA3 (40 ppm) followed by 2, 4-D (20 ppm) (238.8 and 230.1 g), which was 21.8 and 17.4% that of the control (196.0 g), respectively.

Application of NAA increased fruit retention by increasing internal auxin (IAA) content or antagonizing adverse effects of endogenous hormones like ethylene and ABA. There is correlation reported by Wright [38] between abscission and endogenous auxin level and existence of high level of internal auxin which prevents frit drop.

Application of 2, 4-D at Pea and Marble stages appears to be better than prebloom stage. Among the auxin, both, NAA and 2, 4-D was found to increase fruit retention. In problem treatments 20 ppm NAA spray resulted in maximum fruit retention. Since prebloom applications have not been tried by other workers, this is the first report showing better effect of NAA as prebloom spray or fruit retention in Mango.

In our results, application of 40 ppm NAA at Pea stage and 20 ppm NAA at marble stage gave maximum fruit retention amongst is concentrations tried. Thus, higher concentration of NAA was required at pea stage than that of at prebloom and marble stage. Irrespective of the concentration required, the decreasing response to auxins for fruit retention from prebloom to marble stage suggest the involvement of some other hormonal factor in fruit retention and growth of Dashehari mango. Therefore, the use of auxin to control fruit drop and improve fruit retention appears to be very much linked with the stage of application of growth regulators. This may also be the major reason for varied response to Auxin applications by various workers at different stages of fruit growth confirmed

by Srivastava [39], Arora and Singh, [40]; Singh and Chadha, [41]. The concentration for maximum response to 2, 4-D at each stage was lower than that of NAA which may be because of higher biological activity of 2,4-D than NAA. However, Weaver [42] on other plants have also observed better effect of NAA on fruit retention than 2, 4-D.

Computed yield was significantly affected by NAA, 2, 4-D and GA3 sprays. Maximum yield (91.00kg) was obtained in treatment T5 (40 ppm 2, 4-D) which was followed by T4 (82.00kg), T7 (75.00kg), T6 (73.00) kg and T2 (62.00kg) and it was minimum in control T1 (41.00kg). Treatment T5 was significantly better than rest of the treatment. Yield just doubled (2 times and 2.21times) with the use of T4 (20 ppm 2, 4-D) and T5 (40 ppm 2, 4-D) respectively. The increase in the number of fruits and yield in hormone treated plants are in conformity to results obtained by other researchers i.e. Hairdry *et al.*, [43]; Nguyen and Yen, [44].

Quality parameters

Data presented in Table 2 showed that at maturity stage the maximum TSS was (17.40%) was found in T7 (40 ppm GA3), which was followed by treatment T5 (17.10%), T4 (16.50 %), T6 (16.40%), T3 (15.30%) and T2 (15.10%) respectively, Treatment T4 was noted significantly better than rest of the treatment. Similarly, the better results for total sugar at maturity stage were found with 20 ppm 2,4-D and 20 ppm GA3 (16.06% and 16.04%). The minimum sugar (13.59%) was recorded in control. The other treatments were intermediate in response. Similar observations have been made earlier by Baghel *et al.* [45], Sharma *et al.* [46] in various cultivars of Mango and Grewal *et al.* [47] in Ber. They reported the increase in TSS (21.02%) with NAA 40 ppm may be due by the hydrolysis of Polysaccharides and conversion of organic acids into soluble sugars and enhanced solubilization of insoluble starch and pectin present in the cell wall and middle lamella.

Our results showed that total sugar content was also favourably improved by spray of PBR's. The best concentration were again 40 ppm 2,4-D and 20 ppm 2,4-D. The supporting reference are Leopold (1958), reported at 2,4-D 20 ppm was most effective for improving sugar content.

It is obvious from the mean values that foliar applications of all plant hormone treatment were significantly effective in reducing the acidity (%) in the fruit. Under treatments T6 (20 ppm GA3) and T3 (40 ppm NAA) application recorded 0.51% and

Table 1
Mean values of plant growth regulators on fruit retention, fruit length, width and fruit weight of mangoes

Treatments	*Fruit retention(%)*	*Fruit length(cm)*	*Fruit width(cm)*	*Fruit weight(g)*	*Yield(kg / tree)*
T_1: control	5.05	10.80	8.60	196.00	41.00
T_2: 20 ppm NAA	6.66	13.12	11.61	222.65	62.00
T_3: 40 ppm NAA	7.69	13.05	11.54	226.20	72.00
T_4: 20 ppm 2,4-D	8.39	14.91	12.79	230.10	82.00
T_5: 40 ppm 2,4-D	8.23	14.24	12.00	228.76	91.00
T_6: 20 ppm GA_3	7.41	14.87	12.68	234.00	73.00
T_7: 40 ppm GA_3	6.65	14.70	12.66	238.80	75.00
SEm(±)	0.34	0.21	0.32	1.20	2.40
CD at 5%	1.07	0.65	0.96	3.80	5.99

Table 2
Main effects of location, season and hormone concentration on fruit quality and yield of Dasehri mango

Treatments	*TSS(°B)*	*Total Sugars (%)*	*Titrable acidity (%)*	*Ascorbic acid (mg/100g)*
T_1: control	15,40	13.59	0.740	30.79
T_2: 20 ppm NAA	15.10	14.40	0.620	32.91
T_3: 40 ppm NAA	15.30	14.72	0.530	38.12
T_4: 20 ppm 2,4-D	16.50	16.06	0.570	39.26
T_5: 40 ppm 2,4-D	17.10	15.48	0.610	40.97
T_6: 20 ppm GA_3	16.40	16.04	0.510	35.80
T_7: 40 ppm GA_3	17.40	15.96	0.530	38.70
SEm(±)	0.049	0.06	0.07	1.59
CD at 5%	0.150	0.18	0.21	4.92

0.53% acidity respectively. However, the control recorded 0.740% acidity.

Applied PBR's (NAA, 2, 4-D and GA3) were found significantly effective in reducing the acidity in Mango fruit T4 (20 ppm GA3) proved more effective in reducing the acidity followed by T5 (40 ppm NAA) and so on. This result is in conformity with earlier studies of Bal *et al.* [48,49] and Prasad and Pathak [50].

The maximum ascorbic acid content (40.97 mg/100g fruit pulp) was found in treatment T5 (40 ppm NAA) and the minimum ascorbic acid content was in T1 (control). The fruit of treatment T1 was found significantly inferior from all other treatments in this regard. The treatment T5 was closely followed by T4 treatment and did not significantly differ from each other, while being significantly different from all other treatments. The treatment (T3 and T7) and (T2 and T6) which did not differ significantly from each other. Similar results were also found by Sharma *et al.* [51] in Langra mango. They reported depletion in organic acids could be due to fast conversion of acids into sugar and their derivatives or for utilization in respiration or both.

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