Annals of Plant and Soil Research 23(1): 71-76 (2021)
https://doi.org/10.47815/apsr.2021.10032

Effect of foliar application of nitrogen and plant growth regulators on bearing, physico-chemical constituents and shelf-life of mango (*Mangifera indica* L.)

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Received: October, 2020; Revised accepted: December, 2020

ABSTRACT

The experiment was carried out on ten-year-old Amarapali mango (Mangifera indica L) in randomized block design with seventeen treatments with three replications at BAU, Ranchi to study the effect of foliar application of nitrogen and plant growth regulators on bearing and physico-chemical constituent and self life of mango. Among the different treatments, application of 200ppm ethephon had most favourable effect in causing earliness in panicle emergence days (16.0 days), initiation of first flower (12.3 days) and days to initiation of fruit set (10.3 days) over control. Whereas application of 2000ppm triadimefon in combination with 2% urea increased intensity of flowering shoot to the extent of88.5% in fruit plant. The maximum number of fruit set per panicle (44.7), fruit retention (12.1%) and number of harvested fruit per tree (194.4) were observed with combined use of 100ppm SA and 2% urea as compared to control. The highest TSS (25.1 ^{0}Brix) and reducing sugar (3.0%) content were registered under 100ppm GA_3, while the highest phenol (2.84mg/100g) was recorded from the fruits of the plants sprayed with 200ppm ethephon in combination with 2% urea. However, minimum (11.1%) physiological loss in weight (PLW) was recorded in 100ppm SA along with 2% urea.

Keywords: Foliar application, plant growth regulators, physico-chemical constituents, mango

INTRODUCTION

Mango (*Mangifera indica* L.), an important fruit crop of India, is greatly relished for its succulence, exotic flavour and delicious taste. Amrapali, a cross between Neelum and Dushehari, has assumed significance in diversified fruit culture in north India. However, it has also low orchard efficiency and its cultivation is confronted with some serious problems. Among several reasons for low productivity, flower initiation and high incidence of fruit drop at initial stage of fruit development has been a problem of serious concern and various factors attributed to these maladies include depletion of nutrients,assimilate limitations (Prado, 2010) and hormonal imbalance (Kulkarni *et al.,* 2017). For several fruit crop species, foliar nutrition has become routine in addition to, or as an alternative to, soil supply. (Bhamare *et al.,* 2014; Sahoo *et al.,* 2014).Similarly, in high yielding crops, foliar nutrient can be supplied to overcome transient situations where roots uptake is inadequate to meet the nutrient demand of the whole plant or specific organ such as fruit. Plant nutrient, particularly the level of N has more influence on the growth, yield and quality of mango than any other single plant nutrient. Foliar fertilization offers an opportunity to apply a significant portion of the total plant N requirement in a more efficient manner than traditional flood or ground application (Salama *et al.,* 2016). The deficiency of nutrients and growth regulator also causes flower and fruit drop of varying degree at various stages (Tsomu and Patel, 2019). The use of plant growth regulators has assumed as an integral part of new and modern system of fruit production. Multifarious effects of auxins in control of flower and fruit drop as well as most striking and typical responses of gibbrellins on various growth and developmental phases of actively growing plant parts are apparent (Salama *et al.,* 2016).Recently, salicylic acid ($C_7H_6O_3$) as aspirin and triadimefon (Triazole) have been accepted as a new plant growth regulator and found to generate a wide range of metabolic and physiological responses in plants there by affecting their growth and development (Amin *et al.,* 2013; Koo *et al.,* 2020). Salicylic acid, a phenolic compound induces flowering, increases flower life, retards senescence and increases cell metabolic rate. The sustained level of SA may be a pre requisite for the synthesis of auxin and/or cytokinin. It has also been established that triadimefon (Bayleton) possess a chlorophenyl which can protect plant against various stresses (Nair *et al.,* 2012) delayed the

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onset of leaf senescence and increased anti-oxidant enzyme activities. The present study was undertaken to examine the effects of foliar application of urea, thio-urea and PGRs (GA_3, NAA, ethephon, SA and triadimefon) alone or incombination with urea on bearing, fruit production, physico-chemical compositions as well as shelf life of mango cv. Amrapali.

MATERIALS AND METHODS

The present investigation was conducted in two fruiting seasons at Horticulture garden, Birsa Agricultural University, Ranchi on uniform, well managed 10 years of Amrapali mango tree planted at a distance of 5 X 5 m. There were seventeen treatments viz., 2% urea, 1000 ppm thio-urea, 100 ppm GA_3, 40 ppm NAA, 200 ppm ethephon, 100 and 200 ppm SA, 1000 and 2000 ppm triadimefon and all the PGRs incombination with urea along with control (water spray) each replicated thrice in RBD. These treatments were applied as spray in first week of December (before panicle initiation) and last week of March (after fruit set), using full tree as a unit of treatment. The orchard soil was sandy loam in texture with pH 5.4, low in organic carbon 4.0 g kg^{-1} low in available nitrogen (245 kg ha^{-1}), medium in phosphorus (30 kg ha^{-1}), potassium (160 kg ha^{-1}).Ten uniform shoots were selected randomly in each treatment and tagged. Date of panicle emergence and days to first flowering as well as days to fruit set was calculated in days after spraying of chemicals and these were recorded by visual observation through regular visiting the orchard. Total numbers of fruits per panicle on the tagged shoot initially and at the time of fruit maturity were counted and percent fruit retention was calculated on the basis of initial number of fruit set. Total number of fruits per tree were counted initially and at the time of harvest. Samples of 30 represented fruits were collected randomly from all sides of each plant and average fruit weight (g) was calculated whereas fruit size was measured using a vernier calliper. The fruit pulp, quality analysis including TSS, reducing sugar, acidity content, sugar/acid ratio, phenol were performed by following the method of Ranganna (1977).Mango fruit were harvested at commercial maturity from the orchard. Thereafter, fruit were transferred into bamboo baskets and kept at ambient condition (26-32 and 65-75% RH) for about 2 weeks in different lots. Fruits were assessed daily during shelf life evaluation for skin colour and firmness changes. Subjective visual skin colour ratings were; 1. 100% green; 2.25% yellow; 3.50% yellow; 4.75% yellow and 5. 100% yellow. Hand firmness rating was 1. hand; 2. firm; 3. slightly soft; 4. soft, and 5. very soft. Data obtained for each year were pooled for each experiment and subjected to statistical analysis by following the method of variance described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Flowering

The pooled data (Table 1)revealed that flowering characters were significantly influenced by the use of various plant growth regulators at different concentrations. Among different treatments, application of 200 ppm ethaphon had most favourable effect in causing earliness in panicle emergence (16.0 days), days to initiation of first flower (12.3 days) and days to initiation of fruit set (10.3 days) over control. It could be observed from the data that days to initiation of panicle took only 45.5 days after spraying, whereas days to initiation of first flowering and fruit set took 63.8 and 81.8 days, respectively as compared to control. Early differentiation of panicle and flower buds as well as shortage of duration required for flowering probably due to suppression of vegetative growth which might have created such condition in the shoot meristems conducive to early differentiation of flower primordial which in turn resulted early panicle emergence and flowering. In mango, exogenous application of ethephon inihibited vegetative growth of shoot and promoted flowering. Application of triadimefon (2000 ppm) in combination with urea (2%) increased the intensity of flowering shoot (88.5%) in fruit plant which was found almost equally effective with SA 100 ppm mixed with urea (88.5%) and triadimefon 2000 ppm (88.2%) alone. There are evidences that GA_3 plays an inhibitory role in mango flowering (Salama*et al.,*2016) and triadimefon, a triazole compound has ability to reduce GA_3 biosynthesis in shoot, resulted in profuse flowering. Similarly, SA also has greatest floric activity and enhances flowering in fruit plant. Salicylic acid (100 and

200 ppm) combined with urea (2%) increased the panicle growth in terms of length and spread over all other treatments. Being potent plant growth regulator, SA plays an important role in regulating a number of plant physiological process including increase in cell metabolic rate and for the synthesis of auxin and/or cytokinin . Further, auxin increases the linear growth of stem which involves cell division, cell expansion and cell differentiation (Kulkarni *et al.,* 2017) hence resulted into increase in panicle growth. Besides, SA nitrogen as consequences of urea also enhanced carbohydrate reserve and auxin synthesis which in turn played a decisive role in this regard.

Table 1: Effect of chemicals on flowering characters of Amrapali mango

Treatments	Days to panicle emergence	Day to first flowerings	Days to fruit set	% of flowering shoot	Panicle length (cm)	Panicle spread (cm)
Urea-2%	53.7	69.8	95.0	55.0 (48.0)	28.5	10.0
Thiourea-1000ppm	52.2	68.8	91.3	61.4 (51.9)	29.6	10.4
GA_3-100ppm	52.7	68.3	93.5	58.2 (50.0)	29.6	10.2
NAA-40ppm	56.0	70.6	93.5	72.7 (58.6)	29.1	9.9
Ethephon 200ppm	45.5	63.8	87.8	82.8 (65.4)	30.8	10.9
Salicylic Acid-100ppm	51.0	69.8	92.1	84.8 (67.1)	32.4	12.4
Salicylic Acid-200ppm	48.8	68.3	90.3	86.1 (68.1)	32.0	11.8
Triadimefon- 1000ppm	51.7	70.0	91.5	85.0 (67.8)	32.3	11.5
Triadimefon- 2000ppm	47.2	67.3	90.8	88.2 (73.4)	32.7	11.9
$GA_3$100ppm + Urea-2%	56.0	69.7	94.5	68.5 (56.0)	29.8	10.4
NAA40ppm + Urea-2%	57.7	70.3	94.3	72.2 (58.4)	29.7	10.3
Ethephon 200ppm + Urea-2%	48.5	67.3	91.0	82.0 (64.9)	30.6	11.0
SA 100 ppm + Urea-2%	51.5	69.1	92.0	88.5 (70.2)	33.1	12.3
SA 200 ppm + Urea-2%	50.0	69.7	90.6	84.8 (70.6)	33.4	12.0
Tri 1000 ppm + Urea-2%	50.0	71.0	92.3	88.5 (66.2)	31.5	11.3
Tri 2000 ppm + Urea-2%	53.7	72.2	92.8	88.5 (66.5)	31.6	11.2
Control Water spray	61.5	76.1	98.1	48.6 (38.1)	23.8	8.3
SEM (±)	1.1	1.7	1.95	3.1	1.0	0.4
CD (5%)	3.3	4.8	5.5	9.4	2.9	1.3
CV (%)	5.8	5.6	6.0	7.2	8.8	11.7

Fruiting

The perusal of data (Table 2) indicated that the spray of chemical treatments significantly increased the number of fruit set per panicle and fruit retention percentage over control. The mean maximum number of fruit set per panicle (44.7) and fruit retention (12.1%) were recorded at SA 100 ppm combined with urea (2%) spray as compared to mean minimum at control i.e. number of fruit set percentage (24.4) and fruit retention of 5.8%. The developing fruits need auxin in higher quantity and fruit drops occur when auxin levels goes down. By exogenous application of SA and urea, the deficiency of the auxins was met and ultimately fruit drop checked which resulted into more fruit retention. As both SA and urea are capable of synthesizing auxin as suggested by several workers earlier. The obtained results are in line with those reported by Nicholas and Embree (2004) on apple tree. The maximum fruit size (11.6 cm and 7.7 cm) was obtained with $GA_3$100ppm. Improvement in fruit size following application of chemicals was probably due to faster rate of fruit growth owing to rapid cell division and cell enlargement. The exogenous application of GA_3 might have increased the indigenous level of growth promoting substances which in turn stimulated cell division and elongation consequently rate of growth and development of fruit was enhanced, resulted in larger fruit size. The present result are in corroboration with observations made by Rohit (2014) in Langra mango with GA_3 application. Yield attributing characters in mango studied in terms of number of fruits per plant showed that the maximum number of harvested fruits per tree (194.4) was obtained with SA 100ppm + urea (2%) followed by SA 200 ppm + (2%) urea(177.0). The increase in number of fruits harvested per tree is due to higher fruit set and fruit retention percentage/panicle. The lowest number of fruit per tree (40.2) was obtained in control. Higher yield with SA treatment was reported by Karlidag*et al.* (2009) on strawberry.

Table 2: Effect of chemicals on fruiting characters of Amrapali mango

Treatments	Fruit set /panicle	Fruit retention (%)	Fruit length (cm)	Fruit breadth (cm)	Fruits / tree	Pulp (%)	Stone (%)
Urea-2%	29.1	7.2 (15.7)	10.3	6.8	59.4	59.4	13.3 (20.9)
Thiourea-1000ppm	33.3	7.8 (16.1)	10.7	7.2	75.8	75.8	15.4 (23.1)
GA_3-100ppm	31.4	8.2 (16.6)	11.6	7.7	87.9	87.9	12.4 (20.6)
NAA-40ppm	32.7	6.9 (15.2)	10.2	6.9	76.3	76.3	16.6 (23.9)
Ethephon 200ppm	38.	8.8 (17.1)	11.1	7.4	119.7	119.7	15.0 (23.1)
Salicylic Acid-100ppm	38.9	10.7 (19.0)	10.8	7.3	158.9	158.9	17.8 (24.9)
Salicylic Acid-200ppm	42.6	10.4 (18.8)	10.2	7.2	153.6	153.6	16.0 (23.8)
Triadimefon- 1000ppm	41.3	9.7 (18.4)	10.6	6.9	160.0	160.0	15.9 (23.7)
Triadimefon- 2000ppm	42.8	11.2 (18.9)	10.4	6.9	153.9	153.9	15.8 (23.7)
$GA_3$100ppm + Urea-2%	32.8	7.8 (16.8)	11.3	7.5	99.5	99.5	14.9 (22.6)
NAA40ppm + Urea-2%	37.2	7.1 (15.9)	10.7	6.9	99.2	99.2	13.6 (21.6)
Ethephon 200ppm + Urea-2%	34.3	9.1 (17.6)	11.5	7.2	113.8	113.8	13.2 (21.3)
SA 100 ppm + Urea-2%	44.7	12.1 (20.1)	9.7	6.6	194.4	194.4	16.1 (23.6)
SA 200 ppm + Urea-2%	39.8	11.4 (21.2)	9.8	6.7	177.0	177.0	11.1 (19.8)
Tri 1000 ppm + Urea-2%	41.2	9.8 (18.2)	9.8	6.7	155.1	155.1	17.5 (24.7)
Tri 2000 ppm + Urea-2%	38.2	10.0 (19.6)	9.9	6.7	152.9	152.9	14.4 (22.2)
Control Water spray	24.	5.8 (14.5)	8.5	6.1	40.2	40.2	21.9 (28.0)
SEM (±)	1.0	0.7	0.4	0.4	5.8	5.8	1.52
CD (5%)	2.8	2.3	1.3	1.2	16.4	16.4	NS
CV (%)	7.0	6.0	10.1	16.7	12.5	12.5	9.36

Maximum pulp recovery of 71.4% and minimum stone percentage (11.1) were recorded from the fruits treated with 200 ppm SA + urea (2%) followed by GA_3 100 ppm (71.2%) and minimum in control (60.6%). The results are in close proximity with the findings of Bhowmick and Banik (2006) in Langra mango with GA_3 application. Increase in pulp percentage due to SA might be due to its participation in regulation of several physiological processes related to production of photosynthates, total drymatter and also with the increase in cell size of mesocarp. However, role of GA_3 in this regard may be due to its role in increasing cell elongation and increase in sink demand through enhancement of phloem unloading or/and metabolism of carbon assimilates of fruits.

The data (Table 3) clearly indicated that TSS was highest (25.1 ^{0}Brix) in the fruits sprayed with 100 ppm GA_3followed by triadimefon 2000ppm + 2% urea (24.3^{0}Brix) and they were statistically at par. Like TSS, reducing sugar content was also maximum under 100ppm GA_3 (3.0%). Total soluble solid contents was recorded lowest (20.2^{0}Brix) in the fruits from control plants, whereas lowest reducing sugar (1.7%) in 200 ppm SA. According to Ghosh (2016) increase in TSS caused by 100ppm GA_3might be due to higher rates of transpiration and respiration, and increases in physiological loss in weight and breakdown of complex polymers into simple substances by hydrolytic enzymes of fruits. Similar findings have been reported in mango cv. Alphanso fruits by Dalvi *et al.* (2009).The lowest acidity percentage (0.2) and highest sugar acid ratio (52.5) were measured from the fruits in the plants sprayed with 40ppm NAA followed by 200ppm SA (46.3) which was also statistically at par. The results also agree to those of Kulkarni *et al.* (2017) in mango CV. Kesha. The increase in this ratio was directly due to increase in sugar content and decrease in acidity of fruits. Further, it was observed that highest phenol (2.84 mg/100gm) was recorded from the fruits of the plants sprayed with ethephon 200ppm + urea (2%) and found statistically comparable with 2000 ppm triadimefon + 2% urea (2.6mg/100g), whereas lowest phenol content (1.2 mg/100g) was registered under 100 ppm SA. The increased phenol content due to triadimefon might be due to its increased antioxidant enzyme activity (Ragupathi*et al.,* 2008). The results agreed to some extent with Jaleel *et al.* (2008) with triazole compound in *Catharanthus roseus*.

Table 3 Effect of chemicals on physico-chemical characters of Amrapali mango

Treatments	TSS (^{o} Brix)	Reducing sugar (%)	Acidity (%)	Total Sugar/ Acid	Phenol (mg/100g)	PLW (%)	Net Profit/Plant (Rs.)
Urea-2%	22.1	2.7	0.3	29.6	1.7	14.5 (22.4)	105.8
Thiourea-1000ppm	21.1	2.6	0.3	23.1	1.5	13.1 (21.2)	216.6
GA_3-100ppm	25.1	3.0	0.2	34.1	2.5	13.9 (21.8)	103.0
NAA-40ppm	22.6	2.5	0.2	52.5	1.6	13.1 (21.2)	206.7
Ethephon 200ppm	21.1	2.5	0.2	30.6	1.5	13.4 (21.5)	279.0
Salicylic Acid-100ppm	22.5	1.8	0.2	41.2	1.2	12.2 (20.4)	365.8
Salicylic Acid-200ppm	20.5	1.7	0.1	46.3	2.1	12.6 (20.7)	364.8
Triadimefon- 1000ppm	22.6	2.1	0.2	32.1	2.1	12.2 (20.4)	246.8
Triadimefon- 2000ppm	22.1	1.9	0.3	41.2	1.7	13.8 (21.8)	138.3
$GA_3$100ppm + Urea-2%	23.6	2.5	0.3	25.1	2.1	15.0 (22.8)	42.6
NAA40ppm + Urea-2%	19.9	1.5	0.3	24.0	2.1	14.5 (22.4)	169.5
Ethephon 200ppm + Urea-2%	22.8	2.8	0.2	29.6	2.8	14.6 (22.4)	199.0
SA 100 ppm + Urea-2%	23.2	2.2	0.3	33.1	2.4	11.1 (19.4)	343.9
SA 200 ppm + Urea-2%	21.9	2.4	0.2	40.1	1.9	13.3 (21.4)	353.4
Tri 1000 ppm + Urea-2%	23.7	2.4	0.3	23.1	1.5	11.8 (20.0)	158.2
Tri 2000 ppm + Urea-2%	24.3	2.9	0.3	30.0	2.6	14.8 (22.6)	46.2
Control Water spray	20.3	2.0	0.1	44.6	1.7	19.5 (26.2)	147.6
SEM (±)	0.4	0.0	0.007	2.8	0.4	0.9	
CD (5%)	1.3	0.1	0.02	8.0	0.1	2.7	
CV (%)	4.7	6.7	6.8	22.5	5.8	5.9	

The perusal of the data (Table 3) clearly indicated that on the last day of observation (13th day storage) minimum physiological loss in weight (11.1%) in SA 100 ppm + 2% urea and in 1000 ppm triadimefon + 2% urea (11.8%) were observed. However, maximum PLW 19.5% were noted in control (water sprayed). Decrease in PLW percent due to salicylic acid treatment might be due to inhibition of ethylene biosynthesis. An ethylene suppression role might have extended the shelf life (green life) of fruit. The highest average net profit per plant was obtained in treatment SA 100 ppm followed by SA 200 ppm and 200 ppm SA + urea 2% and their corresponding amounts were Rs. 365.8/plant, Rs. 364.8/plant and Rs. 353.4/plant, respectively.

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