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Sachin Devlal
Research Scholar, Department of Horticulture, Raja Balwant Singh College Bichpuri, Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India

Vishwanath
Associate Professor, Department of Horticulture, Raja Balwant Singh College Bichpuri, Agra, Uttar Pradesh, India

Mahesh Kumar Singh
Research Scholar, Department of Horticulture, Raja Balwant Singh College Bichpuri, Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India

Rajat Kumar Sharma
Research Scholar, Department of Horticulture, Raja Balwant Singh College Bichpuri, Dr. Bhimrao Ambedkar University, Agra, Uttar Pradesh, India

Corresponding Author:
Vishwanath
Associate Professor, Department of Horticulture, Raja Balwant Singh College Bichpuri, Agra, Uttar Pradesh, India

Response of different plant growth regulators on fruiting, yield and quality of bael (*Aegle marmelos* Correa.)

Sachin Devlal, Vishwanath, Mahesh Kumar Singh and Rajat Kumar Sharma

Abstract
An experiment was carried out at Experimental Research Farm, R.B.S College Bichpuri, Agra (U.P.) during the year of 2029-21 to study the response of different plant growth regulators on fruiting, yield and quality of bael (*Aegle marmelos* Correa.). The experiment was laid out in Randomized Block Design having three replications and ten treatments. There were 10-treatments *viz*., NAA @ 20, 30 and 40 ppm; GA_3 @ 20, 40 and 60 ppm; 2, 4-D @ 10, 20 and 30 ppm; and control (water spray). Out of ten treatments applied, two times foliar application of NAA 20 ppm at before flowering stage and fruit set stage found significant to reducing fruit drop, increase fruit yield and quality of bael fruits.

Keywords: *Aegle marmelos*, plant growth regulators, fruit yield and quality

Introduction
Bael (*Aegle marmelos Correa*) comes under Rutaceae family. It is a valuable native fruit of India. It is a holy tree in Hinduism and is proffered in the devotion of Hindu God Lord Shiva and Goddess Parvati thus, the tree is additionally known by the name 'Shivaduma' (The Tree of Shiva). Its medicinal possessions have been portrayted in prehistoric treatises like Charaka Samhita, Upvana Vinod, and Yajurveda, and it has also been depicted in the paintings of Ajanta Caves. Different parts of the plant have been used in ethnic-medicine as astringent, antidiarrhoeal, antidycentric, antipyretic, antiulcer, antidiabetes, antimicrobial, anticancer, radioprotective, and anti-helminthic. The root is also used as a prime element of 'dasmula' (10 roots): an Ayurvedic formulation known to be a panacea for stomach ailments. Fresh leaves are also used as a remedy for dropsy, beriberi, and asthma (Maity *et al.*, 2009) [6]. Though a tree of subtropical origin, bael shows wide adaptability and performs equally well in tropical, arid, and semi-arid regions (Singh *et al.*, 2018) [10]. It grows easily in waste land and sandy soils of arid eco-system, having low fertility status and poor moisture-holding capacity. The fruit of bael is possess a rigid shell and a central core inside the fruit having 8 to 20 faintly defined triangular fragments. The fruit contains fine dark-orange walls filled with aromatic pale-orange, pasty, honeyed, resinous, more or less astringent, pulp. A major component of the fruit is the mucilage and marmelos in (0.5%). In addition to that, important constituents like reducing sugar, essential oils, ascorbic acid, and various minerals are also found in fruit pulp.
Bael is one of the foremost important under-utilized fruit crops grown in poor soils and in adverse climatic situations where fruit setting and fruit drop seems to be a major problem. Bale is self-fruitful and there's a very heavy initial fruit set but final retention is extremely low thus heavy fruit drop. There are many reports regarding beneficial effects of various plant growth regulators on fruit setting and controlling fruit drop in arid fruit crops. Ghosh *et al.*, (2012) [4] application of different doses of NAA @ 15, 20, 25 and 30ppm and observed that sprayed of NAA at 15 ppm was the most effective in reducing the fruit drop at different months after fruit set which resulted in doubling of fruit production as compared to control and improved fruit size in sweet orange. Ashraf *et al.*, (2013) [2] conducted an experiment to see the influence of 2,4-D in Kinnow and observed improved fruit weight, more number of fruits per plant, juice percentage, total soluble solids (TSS), ascorbic acid content, acidity, TSS/acid ratio, and reduced the fruit drop.GA_3 treatments considerably reduced fruit drop, increased fruit set, and improved the fruit yield of ber. GA_3 at 60 ppm recorded the lowest fruit drop and highest fruit set and yield (Singh et al., 2001) [11]. But the work done on this aspect on bael is scanty.

Keeping in view an experiment was conducted to standardize the different concentration of plant growth regulators improving the fruiting and quality of bael.

Materials and Methods

The experiment was conducted at horticulture research farm, R.B.S College Bichpuri, Agra (U.P.) during the year 2019-20 and 2020-21. The experimental area is situated at 27.20 N latitude 78.50 East longitudes at height of 168m above the mean sea level. The climate of experimental site is sub-tropical with large variation between summer and winter temperature. During the summer, temperature ranges from 30°C to 46°C or even more during May and June whereas in winter, it ranges from 1°C to 22 °C. The mean annual precipitation fluctuates around 670 mm (average of last decade) and most part (84%) of it is received during the month of July to September and about 16 per cent of rain in rest of the year which is too erratic in distribution and intensity.

The experiment was conducted on 10-year old trees of bael cv. KagziEtawah planted at 8m x8 m spacing. The trees of uniform age, size and vigour were selected. The experiment was laid out in Randomized Block Design having three replications and ten treatments. The treatments were; T_1 (NAA @ 20 ppm), T_2 (NAA @ 30 ppm), T_3 (NAA @ 40 ppm), T_4 (GA_3 @ 20 ppm), T_5 (GA_3 @ 40 ppm), T_6 (GA_3 @ 60 ppm), T_7 (2, 4-D @ 10 ppm) T_8 (2, 4-D @ 20 ppm), T_9 (2, 4-D @ 30 ppm) and T_{10} (Control, Water Spray). The first spray was done before flowering (growth initiation) and second spray was done at two weeks after first spray (after fruit set).Observations were recorded on fruit set (%), fruit drop (%), fruit retention (%), fruit yield/plant (kg), fruit weight(g),fruit length (cm), fruit diameter (cm), fruit volume(ml), fruit skull (%), fruit pulp (%), fiber (%), fruit mucilage (%),total soluable solids (°B), titrable acidity (%), total sugar (%). The TSS content of fruits was measured by using hand refractometer, following the procedure described in A.O.A.C. (1980) [1]. Titratable acidity and Total sugar determination by Rangana (1986) [9]. The data on various parameters were analysed statistically as suggested by Panse and Sukhatme (1978) [8].

Results and Discussion

Effect on Fruiting and Yield

Data presented in Table 1 revealed that spraying of plant growth regulators influenced fruit set percentage of bael significantly. The maximum fruit set (67.33%) was found in NAA 20 ppm followed by NAA 30 ppm and GA_3 60 ppm. While control (water spray) plants resulted in minimum fruit set percentage. It is clear from the data that effect of plant growth regulators on fruit drop, fruit retention and fruit yield was superiors from control. Minimum fruit drop (85.66%) was noticed in NAA 20 ppm followed by NAA 30 ppm and 2, 4-D 30 ppm. While maximum fruit drop was found in control. Fruit retention percentage was significantly higher than rest of the treatments. Spraying of NAA 20 ppm resulted in maximum fruit retention percentage (9.21%), which was statistically at par with NAA 30 ppm. Fruit retention percentage was found minimum in control plants. These findings are in accordance with the reports quoted by Uniyal and Misra (2015) [12] who also found minimum fruit drop and maximum fruit retention with NAA 20 ppm when sprayed in bael tree. The present findings are in conformity with the report Kundu and Ghosh (2017) [5] who also found the maximum fruit set maximum fruit retention and minimum fruit drop when applied NAA 20 ppm in bael tree. It is well documented that auxin content in fruit when become low, fruit drop occurs due to formation of abscission layer and retention of fruits are decreased as a result of exhaustion of auxin. In present investigation exogenous application of NAA might have act to prevention of abscission layer and thus, retention of fruit is increased. From the investigation, it was clear that bael tree experiences severe fruit drop after fruit setting and the drop seems to be related to many factors like hormonal imbalances nutrition, moisture stress etc. The maximum fruit yield per plant (41.13 kg) noticed in NAA 20 ppm followed by NAA 30 ppm. While the minimum fruit yield found by control. Similar result was reported by Kundu and Ghosh (2017) [5] in bael. Improvement in fruit yield might be maximum fruit set, maximum fruit retention and least fruit drop.

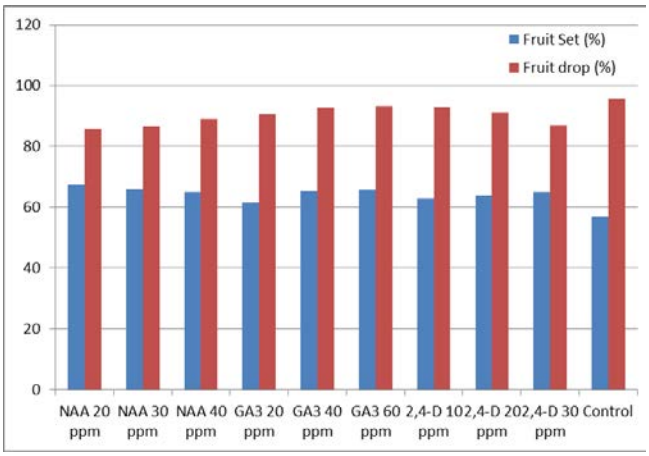

Fig 1: Fruit set (%) and Fruit drop (%)

Effect on Physical Parameters

Physical parameters of fruits were significantly improved from the control by the different treatments of plant growth regulators (Table 2). The maximum fruit weight (894.32 g), fruit length (18.05 cm) and fruit diameter (17.42 cm) found in NAA 20 ppm followed by NAA 30 ppm, while, these parameters were minimum in control. Fruit volumes recorded highest as (2.22 ml) in treatment NAA 20 ppm was statistically at par with the fruit volumes as 2.14 ml, 2.11 ml, 2.11 ml and 2.08 ml found under T_2, T_6 and T_9.

These results were in conformity with the effect of NAA in bael (Uniyal and Mishra, 2015) [12], NAA in Eureka lemon (Devi *et al.*, 2018) [3] and NAA in ber (Yadav *et al.*, 2021) [13]. The improvement in fruit size, weight and fruit volume by treated NAA were probably might be due to promoting cell division, cell elongation and decreased volume of intracellular space in the monocarpic cell. NAA might have improved the synthesis of more photosynthates and their movement towards fruiting area may have increased fruit weight and fruit volume. The pulp recovery percentage was maximum (60.92%) from the fruit of the plant sprayed with NAA at 20 ppm followed by NAA at 30 ppm. Minimum pulp recovery was obtained from the control plants. The minimum fruit skull (16.74%) and fruit mucilage (6.26%) were found in NAA 20 ppm followed by NAA 30 ppm against the maximum recorded under control. The minimum fruit fiber found in control. These findings get support to the reports of in Uniyal

and Mishra (2015) [12] and closely confined by Kundu and Ghosh (2017) [5].

Effect on Chemical Parameters

The data revealed that treatment NAA 20 ppm significantly influenced the chemical parameters (Table 2). The maximum TSS (36.13 °B) was recorded in plants sprayed with NAA 20 ppm followed by NAA 30 ppm and minimum in fruits from control plants. NAA might have caused diversion of more solids metabolites towards developing fruits and increasing amylase activity and thus, there was conversion of starch into simple sugar thereby enhancing TSS content. These findings are similar with accordance of Nawaz *et al.*, (2008) [7] in kin now mandarin and Yadav *et al.*, (2021) [13] in ber. The minimum titrable acidity (0.37) was found in NAA 20 ppm and maximum acidity observed in control. The reason for behind low acidity might be due to degradation of organic acids.

Treatment of NAA 20 ppm significantly revealed maximum of 24.71% total sugar followed by NAA 30 ppm over control. Increase in total sugar may attributed due to NAA which may accelerated the conversion of starch and other polysaccharide in soluble from of sugar which promoted sugar content. These findings are collaborated with the reports of Kundu and Ghosh (2017) [5] and Uniyal and Mishra (2015) [12] in bael.

Table 1: Response of plant growth regulators on fruiting and physical parameters of bael

Treatment	Fruit set (%)	Fruit drop (%)	Fruit retention (%)	Fruit Yield/ Plant (kg)	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (cm)
NAA 20 ppm	67.33	85.66	9.21	41.13	894.32	18.05	17.42	2.22
NAA 30 ppm	66.14	86.63	8.72	39.06	886.96	17.73	17.10	2.14
NAA 40 ppm	64.99	88.96	7.61	38.26	845.20	17.31	16.94	2.08
GA_3 20 ppm	61.58	90.58	5.18	36.27	784.04	15.54	14.92	2.02
GA_3 40 ppm	65.30	92.55	6.02	38.66	865.67	16.83	16.01	2.05
GA_3 60 ppm	65.82	93.07	6.23	37.50	819.78	17.33	16.48	2.11
2,4-D 10 ppm	62.92	92.89	5.54	36.52	754.39	16.15	15.93	2.05
2,4-D 20 ppm	63.84	91.00	5.92	37.47	824.36	16.68	16.52	2.02
2,4-D 30 ppm	64.96	86.92	6.55	37.86	728.85	17.13	16.98	2.11
Control	56.69	95.53	1.92	30.96	701.65	15.13	14.05	1.87
S.Em±	0.48	0.40	0.36	0.23	0.35	0.13	0.12	0.05
CD at 5%	1.43	1.21	1.09	0.68	1.25	0.40	0.38	0.15

Table 2: Response of plant growth regulators on physio-chemical parameters of Bael

Treatment	Fruit skull (%)	Fruit fiber (%)	Fruit pulp (%)	Fruit mucilage (%)	TSS (°B)	Titrable acidity (%)	Total sugar (cm)
NAA 20 ppm	16.74	9.38	60.92	6.26	36.13	0.37	24.71
NAA 30 ppm	17.84	9.75	59.75	6.62	35.26	0.39	24.22
NAA 40 ppm	18.12	10.02	59.18	6.97	34.84	0.42	23.04
GA_3 20 ppm	18.44	10.30	58.30	7.46	33.96	0.44	22.70
GA_3 40 ppm	18.98	9.89	59.76	7.37	35.33	0.38	23.47
GA_3 60 ppm	18.70	9.67	58.96	7.15	34.39	0.47	23.16
2,4-D 10 ppm	17.96	10.18	58.46	7.72	34.63	0.48	22.50
2,4-D 20 ppm	18.12	9.52	59.91	7.34	34.59	0.54	22.53
2,4-D 30 ppm	17.94	9.98	60.05	6.46	35.40	0.57	23.26
Control	19.20	9.12	57.24	8.08	33.31	0.76	20.40
S.Em±	0.23	0.08	0.34	0.10	0.20	0.06	0.13
CD at 5%	0.69	0.26	1.03	0.31	0.60	0.01	0.41

Conclusion

On the basis of above results, it may be concluded that first spray of NAA@ 20ppm before flowering stage and second spray on interval of two weeks after fruit set) helps to reducing fruit drop, increase fruit yield and quality of bael fruits.

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