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Effect of plant growth regulator and nutrients on chemical composition and yield of Ber (*Ziziphus mauritiana* Lamk.) cv. *Thai Apple* under Bundlekhand region of Uttar Pradesh

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Abstract
An experiment was conducted on foliar application of plant growth regulator and nutrients on chemical composition of ber (*Ziziphus mauritiana* Lamk.) under Bundelkhand region of Uttar Pradesh. The experiment was laid out in Randomized Block Design with 12 treatments and three replications. Among the physical and chemical parameter of fruit, significant maximum fruit set (35.17), fruit length (4.97), fruit width (4.37), fruit weight (53.10), pulp weight (50.68), seed weight (2.42), total soluble solids (15.08 ^{0}Brix), protein (0.85%), total sugar (9.25%), reducing (6.32%), non-reducing sugar (2.93%), and average fruit yield (32.02 kg/tree) were recorded with the application of GA_3 (50ppm) + NAA (30ppm) +KNO_3(2%). Minimum ascorbic acid (26.70 ma/100) and titratable acidity (0.26%) content were recorded with application of GA_3 (50ppm) + NAA (30ppm) + KNO_3 (2%), while highest ascorbic acid (46.93 mg/100) and titratable acidity (0.43%) were recorded with the application of Urea (2%) and MOP (2%), respectively.

Keywords: Ber, GA_3, NAA, nutrients and quality

Introduction
Ber or Indian jujube (*Ziziphus mauritiana* Lamk.) belong to family Rhamenaceae, is one of the most ancient and common fruit of Indian subcontinents and South Western China. The genus *Ziziphus* consists of 50 species of which 18-20 are indigenous to India. Ber is grown under rain -fed condition in arid and semi-arid region of India and has been identified as highly drought and heat tolerant fruit crop. It is cultivated widely for its resistance to grow in drought and other diversified soil and climatic conditions. It is a hardy tree that copes with extremes temperature and thrives well under dry conditions. Fruit quality is found best under hot sunny and dry conditions but there should be a support to the growth and flowering leaving enough soil moisture to carry the fruit to maturity. The ber plant is quick growing, early bearing and spreading tree. It has remarkable adoptability enabling to grow in wide range of agro-climatic situation and soils. The area under ber in India is about 50 million hectare and production consists of 513 million tons. Bundelkhand region of Uttar Pradesh is congenial for Ber cultivation which can be grown on variety of soils including marginal soil and various kinds of waste land, situation such as sodic, saline soil, ravines, arid, semi-arid condition etc.
It is very popular among consumers due to its high nutritive value but comparatively lower market price. Its fruit are delicious and are usually eaten fresh. Also fruit of ber is considered more nutritive than apple for its higher protein, Beta-carotene and vitamin-C (70-165 mg/100g fruit pulp), (Rai and Gupta 1994).
Fruit pulp contains carbohydrates (12.8-13.6%), TSS (20.10 ^{0}Brix), acidity (0.34%) and total sugar (6.97%). Among the amino acids, asparagine, arginine, glutamic acid, aspartic acid, glycine, serine, alfa serine and threonine are found in ber pulp (Bal, 1981) [4]. For getting getting best quality ber, it can be achieved with the foliar application of plant growth regulators and nutrients. The research on these aspects mostly conducted under arid and semi-arid part India. But under Bundelkhand region, meager information is available on such type of research and recommendations. So, experiment was carried out to find out the best combination of growth regulators and nutrients for the enhancement in quality of ber fruit.

Materials and Methods

The experiment was carried out at the Horticulture Instruction Farm, College of Horticulture, Banda University of Agriculture & Technology, Banda, during the year 2020-21. Fruit crops ber (*Ziziphus mauritiana* Lamk.) cv. Thai Apple was selected for this study and foliar spray were made by using GA_3, NAA, K_2SO_4, KNO_3, MOP and Urea. First foliar application of plant growth regulators and nutrients was applied during last week of September (After flowering) and second foliar application was applied during last week of November (at pea stage). The selected trees were uniform in size and three year old.

The climate of Bundalkhand region is chiefly by semi-arid/tropical that has dry & warm summer, pleasant monsoon and mildly cold winter. The region receives an average rain fall of around 800 mm of which more than 80-90% occurs during only three months *i.e.* July, August, and September. The annual temperature is relatively high and it ranges in between 35-48 ^{0}C summer seasons, 23-28 ^{0}C rainy seasons and 12-20 ^{0}C winter season. The treatment combinations *i.e.* T_1-Control, T_2-GA_3 (50ppm), T_3- NAA (30ppm), T_4- K_2SO_4 (2%), T_5-KNO_3(2%), T_6-MOP (2%), T_7-Urea (2%), T_8- GA_3 (50ppm) + NAA (30ppm), T_9-GA_3 (50ppm) + NAA (30ppm) + K_2SO_4 (2%), T_{10}-GA_3 (50ppm) + NAA (30ppm) + KNO_3 (2%), T_{11}- GA_3 (50ppm) + NAA (30ppm) + MOP (2%) and T_{12}- GA_3 (50ppm) + NAA (30ppm) + Urea (2%) were tested in Randomized Blocks Design with three replication. Total soluble solids content of fruit was determined with the help of a hand refractometer, protein was estimated by method of Lowry *et al*. (1951), sugar was estimated by method of Lane and Eynon (1923) whereas ascorbic acid and acidity were suggested by (A.O.A.C., 1970). The data were analyzed statistically by the analysis of variance method as suggested by Panes and Sukhatme (1985) [14].

Result and Discussion

Effect on fruit

It is clear from the experiment that plant growth regulators and nutrients had a significant effect on initial fruit set and final fruit set (Table-1). Maximum initial fruit set 75.42% was recorded with the application of GA_3 50ppm + NAA 30ppm + KNO_3 2%, followed by GA_3 50ppm + NAA 30ppm + MOP 2%. Maximum final fruit set 35.17% was recorded with the GA_3 50ppm + NAA 30ppm + KNO_3 2%, closely followed by GA_3 50ppm + NAA 30ppm +MOP 2% (34.21%). The finding in line with Devi *et al.* (2019) who reported that foliar application of GA_3 and NAA gave best result in term of fruit set of ber. In conformity to above experiment, Yadav *et al.* (2014) [25] also recorded highest fruit set with 15ppm NAA + 20ppm GA_3 + 1.5% Urea in ber.

Higher initial fruit set (63.81%) was also obtained by foliar spray of GA_3 (30ppm + KNO_3 2%) reported by Parauha and Pandey (2019) [15]. Gibberellins play a vital role to increase endogenous auxin content of fruit (Phillips *et al.* 1959) [16] which in true favors the pollen germination and growth of pollen tube thus increasing fruit set. Beneficial role of NAA in reducing fruit drop may be explained from the fact that it maintains ongoing physiological process of inhibition of abscission (Tomaszewska *et al.*, 1970) [23]. KNO_3 played a vital role in fruit set, it might be due to fact that role of potassium in cell wall construction which leads to higher percentage of fruit set compare to control.

Effect on fruit length, width, weight, and volume

It is perusal from the data presented in the table-1 that plant growth regulators and nutrient had a significant effect on physical attributes of fruit (Table 1) Maximum fruit length 4.97 cm was measured with the application of GA_3 50ppm + NAA 30ppm + KNO_3 2%, which is *at par* with the application of GA_3 50ppm + NAA 30ppm + MOP 2% (4.83cm). Highest fruit width 4.37 cm was observed under GA_3 50ppm + NAA 30ppm + KNO_3 2% followed by GA_3 50ppm + NAA 30ppm + MOP 2% (4.10). Highest fruit weight (53.10 g) was recorded under GA_3 50ppm + NAA 30ppm + KNO_3 2% followed by GA_3 50ppm + NAA 30ppm + MOP 2% (52.60 g). Highest fruit volume 53.40 ml was noted with the application of GA_3 50ppm + NAA 30ppm + KNO_3 2%, closely followed by the application of GA_3 50ppm + NAA 30ppm + MOP 2% (53.00ml). Increase in fruit length, width, volume and weight with the foliar application of KNO_3 was noted by Ebraheim *et al.* (1993) [9] in "Balady" mandarins. Lal *et al.* (2001) [13] also observed increase in physical attributes of fruit "Umran" ber with application of potassium in combination with nitrogen. The increase in fruit length, width, and volume and fruit weight can be attributed to the involvement of NAA in cell division, cell expansion and increased volume of inter-cellular spaces in the mesocarpic cells. In conformity to our finding Grewal *et al.* (1993) [11], Kale *et al.* (2000) [12] and Yadav (2002) [24] also observedthat plant growth regulators played significant role in fruit growth of ber.

Effect on fruit specific gravity, pulp weight and seed weight

While conducting an experiment, it is clear from the table-1 that maximum specific gravity (0.994) was recorded with the application of GA_3 50ppm + NAA 30ppm KNO_3 2%, which is *at par* with GA_3 50ppm + NAA 30ppm + MOP 2% (0.992). Maximum pulp weight (50.68g) was achieved with GA_3 50ppm + NAA 30ppm + KNO_3 2%, it was followed by GA_3 50ppm + NAA 30ppm + MOP 2% (50.07g). The highest pulp:stone ratio (20.94) was recorded with the application of GA_3 50ppm +NAA 30ppm +KNO_3 2%, followed by GA_3 50ppm + NAA 30ppm + MOP 2% (19.79). Maximum seed weight (2.86g) was recorded with control. It was closely followed by urea 2% (2.82g). Minimum seed weight 2.42g was observed in GA_3 50ppm + NAA 30ppm + KNO_3 2%. The possible reasons for enhancement in fruit pulp weight, pulp: stone ratio and specific gravity with GA_3, NAA and KNO_3 might be due to the fact that higher synthesis of metabolites and enhanced mobilization of food and minerals from other parts of the plants towards the developing fruits as it is a well established fact that the fruit acts as extremely active metabolic sink. These results are in close proximity with the finding of Kale *et al.* (2000) [12], Singh and Randhawa (2001) [21, 22] in ber. Increased fruit physical parameter in ber with exogenous foliar application of GA_3, NAA and KNO_3 has been also recorded by Arora and Singh (2014) [3] and Samant *et al.* (2008) [20] in ber.

Effect on fruit TSS and Protein

It is perusal from the data presented in table-2, the maximum TSS value 15.08 ^{0}Brix content was recorded with application of GA_3 50ppm + NAA 30ppm +KNO_3 2%, followed by GA_3 50ppm + NAA 30ppm + MOP 2% (14.41 ^{0}Brix) and lowest value was recorded with control. However, all the growth

regulator and nutrient application had significantly higher TSS value. Similarly, application of GA_3 50ppm + NAA 30ppm + KNO_3 2% recorded significantly higher values of protein (0.85) followed by GA_3 50ppm + NAA 30ppm + MOP 2% and GA_3 50ppm + NAA 30ppm +K_2SO_4 2% (0.79), while lowest values (0.66) was recorded with control. The increase the values of total soluble solid, sugar and protein in ber might be due to the fact that growth regulators and nutrients helps in transformations of polysaccharides and pectin into soluble compounds and translocation of sugars from leaves to the developing fruits through cellular membranes by formation of an ionizable sugar borate complex and also improvements in root biomass of plant to uptake nutrients from soil. The plant growth regulators used in the study (GA_3, NAA) is known to increase membrane permeability in plant cells and improvement in water relation which might facilitate accelerated breakdown of organic acids stored in cell vacuoles with consequent increase in TSS content. Similar finding was reported by Prakash *et al*. (2014) [17].

In close proximity to our findings, Bal *et al.* (1984) [6] also recorded that the application of NAA increased the percentage of TSS significant in ber. The positive effect of plant growth regulators on quality of ber and results that application of GA_3 20ppm was the most effective in inducing highest increase in total soluble solids as compared to other treatment. Potassium promotes the translocation of photosynthesis (sugar) for plant growth and storage in fruit and roots. The highest TSS recorded by application of nutrients *ie*. KNO_3 might be due to lesser utilization of sugar in metabolic processes as a result of reduced respiration.

Effect on sugar and ascorbic acid

Data presented in table-2 showed that maximum sugar content 9.25% was recorded with application of GA_3 50ppm + NAA 30ppm +KNO_3 2%, followed by GA_3 50ppm + NAA 30ppm + MOP 2% (8.62%) and lowest value was recorded with control. Maximum ascorbic acid 46.93 content was recorded with application of Urea (2%), followed by control (39.90) and lowest value recorded with GA_3 50ppm + NAA 30ppm +KNO_3 2% (26.70). The growth regulators also promote the enzymatic activities and enzymes metabolized the carbohydrates into simple sugar. These results are in agreement with the reports of Ram *et al.* (2005) [18] and Gill and Bal (2013) [10] in ber. Positive outcome of total sugar, reducing sugar and non-reducing sugar might be due to the fact the plant growth regulators promoted hydrolysis of starch into sugar or reduced competition between the fruits for metabolites. Significant decrease in acidity of Umran fruits with higher concentration of GA_3 and NAA were recorded by Kale *et al*. (2000) [12]. Singh and Randhawa (2001) [21, 22] reported that the application of NAA at 30ppm results in the lowest acidity (0.24) in ber. The beneficial effects of potassium in reducing fruit acidity have been supported by Singh and Bal (2008) [5]. An Increase in ascorbic acid content might be due to perpetual synthesis of glucose-6-phophate throughout the growth and development of fruit which is thought to be the precursor of vitamin-C Bhati and Yadav (2003) [7]. The application of potassium results an increase in ascorbic acid content in ber cv. Gola (Rathore and Chandra, 2002) [19].

Effect on yield

It is apparent from the data presented in table-2 showed that maximum yield (32.02 kg/tree) was recorded with application of GA_3 50ppm + NAA 30ppm +KNO_3 2%, followed by GA_3 50ppm + NAA 30ppm + MOP 2% (31.35 kg/tree) and lowest value was recorded when water sprayed (20.72kg/tree). In conformity with experimental data Sharma *et al.* (2019) reported that application of GA_3 @ 50ppm recoded significant higher fruit yield (83.27 kg/tree) in aonla. The increase in yield per plant is obviously due to the increase in volume and weight of the fruit with the combined application of GA_3, NAA and KNO_3. The increase in the fruit yield with the foliar application of nutrients may be attributed to increase fruit size, fruit weight and minimum fruit drop. In addition, more cell division, cell elongation and translocation of photo-synthates and metabolites from leaves to the developing fruit which resulted in higher fruit yield. The highest fruit yield recorded by foliar spray of KNO_3, may be attributed to better uptake and mobilization of nutrients to sink leading to better fruit development. These findings are also supported by the results of Prakash *et al.* (2014) [17] who applied KNO3 (2%) in pomegranate.

Table 1: Effect of plant growth regulators and nutrients on initial fruit set, final fruit set andphysical parameters of ber cv. Thai Apple

Treatments	Initial fruit set (%)	Final fruit set (%)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Fruit volume (ml)	Specific gravity	Pulp weight (g)	Seed weight (g)	Pulp/ stone ratio
T_1: Control (water spray)	68.00	21.42	3.50	2.60	35.17	36.60	0.960	32.86	2.86	11.49
T_2: GA_3 (50 ppm)	71.87	29.93	4.00	3.40	37.20	38.40	0.968	34.5	2.70	12.78
T_3: NAA (30 ppm)	72.18	29.73	4.20	3.60	40.80	41.60	0.973	38.16	2.64	14.45
T_4: K_2SO_4 (2%)	71.46	30.23	4.10	3.50	39.40	40.60	0.970	36.78	2.62	14.04
T_5: KNO_3(2%)	71.63	31.27	3.80	3.20	41.70	42.90	0.972	39.02	2.68	14.56
T_6: MOP (2%)	70.12	28.20	3.70	2.90	38.87	39.95	0.972	36.07	2.80	12.88
T_7: Urea (2%)	69.56	27.43	3.93	2.90	38.70	40.00	0.967	35.88	2.82	12.72
T_8: GA_3(50ppm) + NAA (30 ppm)	72.54	32.13	4.20	3.90	48.17	49.40	0.975	45.53	2.64	17.25
T_9: GA_3(50ppm) + NAA (30 ppm) +K_2SO_4(2%)	73.14	33.57	4.80	4.00	51.20	51.80	0.988	48.60	2.60	18.69
T_{10}: GA_3 (50ppm) + NAA (30 ppm) +KNO_3 (2%)	75.42	35.17	4.97	4.37	53.10	53.40	0.994	50.68	2.42	20.94
T_{11}: GA_3(50ppm) + NAA (30 ppm) +MOP (2%)	74.45	34.21	4.83	4.10	52.60	53.00	0.992	50.07	2.53	19.79
T_{12}: GA_3(50ppm) + NAA (30 ppm) +Urea (2%)	72.30	32.17	4.10	3.70	45.60	46.20	0.976	42.93	2.67	16.08
S.Em±	0.83	0.79	0.12	0.14	1.32	0.90	0.004	0.89	0.01	0.78
C.D. at 5%	2.44	2.32	0.37	0.41	3.89	2.65	0.013	2.64	0.03	2.31

Table 2: Effect of plant growth regulators and nutrients on chemical characters of ber cv. Thai Apple

Treatments	TSS (^{O}Brix)	Protein (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Ascorbic acid (mg/100g	Titratable acidity (%)	Average fruit yield kg/tree
T_1: Control (water saray)	9.00	0.66	4.16	2.14	6.30	39.90	0.42	20.72
T_2: GA_3(50 ppm)	10.30	0.75	5.14	2.06	7.20	36.70	0.40	28.18
T_3: NAA (30 ppm)	12.00	0.78	5.45	2.40	7.85	38.27	0.35	28.40
T_4: K_2SO_4(2%)	10.30	0.72	4.90	2.05	6.95	26.70	0.35	27.49
T_5: KNO_3 (2%)	12.40	0.70	5.32	2.36	7.65	30.50	0.34	27.80
T_6: MOP (2%)	10.30	0.73	4.35	2.41	6.76	31.50	0.43	26.84
T_7: Urea (2%)	9.90	0.69	5.04	2.11	7.28	46.93	0.36	25.27
T_8: GA_3(50 ppm) +NAA (30 ppm)	12.83	0.76	5.67	2.19	7.86	34.40	0.33	29.50
T_9: GA_3(50 ppm) +NAA (30 ppm) +K_2SO_4(2%)	13.20	0.79	5.84	2.66	8.38	28.60	0.32	30.25
T_{10}: GA_3 (50 ppm) +NAA (30 ppm) +KNO_3 (2%)	15.08	0.85	6.32	2.93	9.25	26.70	0.26	32.02
T_{11}: GA_3(50 ppm) +NAA (30 ppm) +MOP (2%)	14.42	0.81	5.96	2.72	8.62	28.40	0.29	31.35
T_{12}: GA_3(50 ppm) +NAA (30 ppm) +Urea (2%)	12.50	0.75	4.90	2.00	6.90	44.60	0.39	28.50
S.Em±	0.66	0.02	0.17	0.10	0.31	0.97	0.01	0.87
C.D. at 5%	1.96	0.07	0.49	0.30	0.90	2.87	0.03	2.58

Conclusion

On the basic of result obtained during the present investigation, foliar spray of plant growth regulator and nutrients exhibited significant improvement of fruit set, fruit quality and yield of ber. Two foliar sprays (1st during last week of September after flowering and 2nd during last week of November at pea stage) i.e., T_{10} (GA_3 50ppm + NAA 30ppm +KNO_3 2%) improved fruit set, fruit yield and physico-chemical attributes (high TSS, protein, total sugar, reducing sugar, non-reducing sugar, minimum titratable acidity) of ber cv. Thai Apple. Therefore, it is concluded that the application of GA_3 50ppm + NAA 30ppm +KNO_3 2% is the best combination for improving fruit set, reducing fruit drop and improving quality attributes as well as fruit yield of ber cv. Thai Apple. Treatment T_{11} (GA_3 50ppm + NAA 30ppm +MOP 2%) and T_9 (GA_3 50ppm + NAA 30ppm +K_2SO_4 2%) were second and third best treatment, and showed *at par* values with T_{10} (GA_3 50ppm + NAA 30ppm +KNO_3 2%) for fruit set, fruit retention, physic-chemical attributes and fruit yield. Hence, foliar spray of T_{10} (GA_3 50ppm + NAA 30ppm +KNO_3 2%) can be recommended to ber fruit growers and researchers to improve fruit set, fruit quality and fruit yield of ber cv. Thai Apple.

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