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Influence of Different Levels of GA_3 and Urea on Fruiting Behavior, Yield and Qualitative Characters of Ber (*Zizyphus mauritiana* Lamk.) cv. Banarasi Karaka

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ABSTRACT

The present experiment was conducted during October, 2022 to March, 2023 at Horticulture Garden, Department of Fruit Science of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P, India. The experiment was layout in RBD with three replicates of each treatment. Total 10 treatments including one control viz., GA_3 15 ppm, GA_3 20 ppm, GA_3 25 ppm, GA_3 30 ppm, Urea 2%, GA_3 15 ppm and urea 2%, GA_3 20 ppm and urea 2%, GA_3 25 ppm and urea 2%, GA_3 30 ppm and urea 2% and Control i.e., water spray. The present investigation, it is reported that the application of GA_3 30 ppm and Urea 2% with significantly increased initial fruit set (169), fruit retention (84.22%) and decreased fruit drop (84.22%), increased fruit weight (15.44 g), pulp weight (14.43 g), fruit length (4.52 cm), diameter (2.99 cm), volume (16.80 cc) and yield (31.50 kg) branch^{-1} and minimum stone weight (1.01 g), pulp: stone ratio (14.29) and quality parameters like; TSS (15.30 °Brix), ascorbic acid (99.25 mg) 100 g^{-1} of fruit pulp and total sugars (9.99%) and decreased titratable acidity (0.10%) content. Hence, plants treated with GA_3 30 ppm and urea 2% can further be used to improve the fruiting, overall yield improvement, and quality characteristics of Banarasi Karaka cultivar of ber.

KEYWORDS: GA_3, ppm, urea, ber, growth, fruit drop, yield

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1. INTRODUCTION

Ber (*Zizyphus mauriatiana* L.) commonly known as king of arid fruit, belongs to the Rhamnaceae family. *Ziziphus* consists of 50 species of which 18–20 are indigenous to India. It is cultivated widely for its resistance to grow in drought and other diversified soil and climatic conditions. Ber is a hardy tree that copes with extreme temperatures, thrives well under dry conditions, and is known as the 'King of Arid Fruits'. It requires less care and is even in neglected condition. However, produces sufficient fruits and can be successfully grown under the most unfavorable soil, water, and climate conditions. It grows even on marginal soil and various kinds of wasteland situations such as sodic saline soil, ravines, and arid, semi-arid regions including the platen area of Bundelkhand and South India (Singh et al., 2016).

Because of its strong economic returns, low cultivation costs, wide range of adaptation, and capacity to endure drought. It is frequently grown due to its hardiness and capacity for weight in a variety of soil types and weather conditions, including drought. It is a tiny tree or shrub that is 8 to 10 m tall with stipular spines, a spreading crown, and numerous drooping limbs. The trunk has a minimum diameter of 40 cm. The fruit's skin is silky, shiny, trim, and tight. China is the largest producer of ber fruit followed by India. India occupied an area of 53,000 hectares with an annual production of 570,000 mt year^{-1} (Anonymous, 2021). In India, the major growing states are Uttar Pradesh, Bihar, Madhya Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, and Andhra Pradesh. In Uttar Pradesh, the major Ber-growing regions are Varanasi, Aligarh, Faizabad, Agra, and the Rae Bareli districts.

Ber fruit contains 14% sugars, 150 mg 100 g^{-1} of vitamin C, besides other minerals. However, certain alkaloids, flavonoids, steroid tannins, saponins, and fatty acids have been extracted and chemically characterized from various *Ziziphus* species**.** Different parts of ber plants like roots, bark, leaves, flowers, seeds are used in ayurvedic and medicine for the treatment of diarrhea, ulcers, biliousness, indigestion, cough, headache, bleeding gums, asthma. Ripe fruits are eaten fresh and utilized in the preparation of jam, jelly, preserves, and candy and they can be dried to prepare a product like 'Chuhhara'. Ber juice can be prepared from fresh fruit and used for making squash. It is also used as a blood purifier and appetizer **(**Baloda et al., 2012).

The PGRs are widely used for increasing fruit set, controlling fruit drop, and enhancing the quality and uniform maturity (Sahoo et al., 2019). Application of Gibberellins are primarily used to regulate physiological processes, but they can also be utilized commercially to enhance the fruit quality of various crops, such as apples, grapes, citrus, grape fruit, and berries. The extension of rachis cells, floral thinning, and grapeberry growth are three physiological processes that have all been affected.

Foliar application of 1% urea and GA_3 50 ppm can significantly increase the fruit set, fruit retention, and yield. These treatments significantly reduced the fruit drop and increased fruit retention also the Nitrogen contents of the leaf increased by foliar application of urea (Sharma et al., 2013). The optimum dose of plant growth regulators (i.e., NAA 60 ppm and GA_3 30 ppm) and Urea 2% application was found under agro-climatic conditions of the Malwa plateau for obtaining maximum vegetative growth and yield, improving the reproductive parameters, physical characteristics, and quality of the fruit (Karole and Tiwari, 2016).

As mentioned above, this study aims to improve the fruiting attributes, physical attributes, fruit yield, and quality of Banarasi Karaka cultivar of Ber.

2. MATERIALS AND METHODS

This investigation was carried out at the Horticulture Garden, Department of Fruit Science at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, UP, India during *rabi* (October, 2022 to March, 2023). Geographically, Kanpur falls in a subtropical climate and is situated at 26' 28 ^{0}N (latitude) and 80' 28 ^{0}E (longitude) and about 135 meters above mean sea level. The experimental layout was RBD with three replicates of each treatment. Total 10 treatments including one control viz., T_1 (GA_3 15 ppm), T_2 (GA_3 20 ppm), T_3 (GA_3 25 ppm), T_4 (GA_3 30 ppm), T_5 (Urea 2%), T_6 (GA_3 15 ppm and urea 2%), T_7 (GA_3 20 ppm and Urea 2%), T_8 (GA_3 25 ppm and urea 2%), T_9 (GA_3 30 ppm and urea 2%) and T_0 (Control *i.e.*, water spray). The recommended dose of fertilizers was applied in all treatments including a control. The mentioned solutions of GA_3 and urea with different concentrations were sprayed over the leaves of each treatment to deliver a homogeneous spray across the whole ber plant in the morning hours on November 26, 2022; during the fruit setting stage. The detergent powder was well mixed in the spray solution which act as a sticker before spraying. For control there was only water spray was allowed. The information recorded on different parameters during the experimental period was statistically analyzed.

3. RESULTS AND DISCUSSION

3.1. Fruiting parameters

3.1.1. Initial fruit set

The physical characteristics of fruits are an expression of fruiting activity which was significantly influenced by GA_3 and urea and their combined treatments over control. It is clear from the Table 1, the data that fruit sets of all treatments were found to be significant over control. The maximum initial fruit set (169) was recorded under T_9 (GA_3 30 ppm and urea 2%) followed by T_8 (GA_3 25 ppm and Urea 2.0%) and T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatments. While the minimum initial fruit set (150) was observed under T_0 (control) treatment. It is clear that enhancing concentration of GA_3 and Urea individually enhanced fruit set in ascending order of magnitude and it was also observed with their similar trends with coupled treatments and maximized fruit set in enhancing manner with their increasing concentration. The findings are in line with the respect of Dubey et al. (2017) in Strawberry; Sharma et al. (2011) and Singh et al. (2016) in Ber; Singh and Tripathi (2023) in Guava; and Kashyap et al. (2023) in Phalsa.

Table 1: Effect of foliar application of GA_3 and urea on fruit set, fruit drop, fruit retention fruit yield and its attributes of ber

Treatments	Initial fruit set	Fruit drop (%)	Fruit retention (%)	Fruit yield (kg branch^{-1})	Pulp weight (g)	Stone weight (g)	Pulp: stone ratio
T_0 (Control)	150	93.10	6.90	21.10	9.95	1.20	8.29
T_1 (GA_3 15 ppm)	154	89.90	10.10	27.21	13.93	1.15	12.12
T_2 (GA_3 20 ppm)	156	88.97	11.03	28.45	13.72	1.18	11.63
T_3 (GA_3 25 ppm)	157	87.55	12.45	28.90	13.63	1.19	11.46
T_4 (GA_3 30 ppm)	158	87.20	12.80	29.50	13.77	1.21	11.39
T_5 (Urea 2%)	160	86.05	13.95	29.62	13.97	1.13	12.37
T_6 (GA_3 15 ppm and urea 2%)	164	85.15	14.85	30.31	14.07	1.08	13.03
T_7 (GA_3 20 ppm and urea 2%)	165	84.92	15.08	30.85	14.19	1.06	13.39
T_8 (GA_3 25 ppm and urea 2%)	167	84.76	15.24	31.13	14.30	1.04	13.75
T_9 (GA_3 30 ppm and urea 2%)	169	84.22	15.78	31.50	14.43	1.01	14.29
SEd±	3.26	1.68	0.29	0.39	0.23	0.02	0.26
CD (p=0.05)	6.84	3.56	0.62	1.18	0.48	0.04	0.54

3.2. *Fruit drop and retention (%)*

The foliar application of plant growth regulators and urea brought a change in fruit retention in ber fruit (Table 1). Treatments T_9 was recorded significantly minimized fruit drop (84.22%) with maximum fruit retention (15.78%) followed by T_8 (GA_3 25 ppm and urea 2%) and T_7 (GA_3 20 ppm and urea 2%) treatment. While, control (T_0) treatment showed minimum fruit retention (6.90%) with maximized fruit drop i.e., 93.10%. The data about the effect of foliar treatment of GA_3 and urea as well as their combined treatments consistently and positively influenced fruit drop in ber fruits. In this regard, maximum fruit drop (93.10%) was recorded under control (T_0) treatment. It might be due to metabolic activities of plants like meristematic activities as well as photosynthesis which turns less fruit drop. It promoted retention of fruit percentage and improved the source-sink relationship which favorably influenced the metabolic status resulting in better check of fruit drop. Enhancing retention of some number of fruits on the plants with higher availability of photosynthates ultimately promoted auxin synthesis which is necessary for fruit. The higher availability of auxin might have accelerated the fruit retention process in ber. Urea and GA_3 were also incorporated in enhancing the fruit retention process in the present investigation. Similar results have been reported by), Tripathi et al. (2019), Anushi et al. (2021) and Kumar et al. (2022) in Mango; Singh and Tripathi (2023) in guava; Gupta et al. (2022) and Radha et al. (2023) in litchi; Sharma et al. (2011), Gill and Bal (2009) and Singh et al. (2016) in ber.

3.2. *Physical parameters*

3.2.1. *Fruit length (cm), fruit diameter (cm)*

The results on the physical characteristics were also shown and significantly influenced by the application of plant growth regulator (GA_3) and Urea (Table 2). The observations exhibited that fruit length, and fruit diameter, were significantly maximized at 4.52 cm and 2.99 cm, respectively under the treatment of T_9 (GA_3 30 ppm and urea 2%) closely followed by T_8 (GA_3 25 ppm and urea 2%) T_7 (GA_3 20 ppm and urea 2%), T_6 (GA_3 15 ppm and urea 2%). While the minimum fruit length (3.10 cm) and fruit

Table 2: Effect of foliar application of GA_3 and urea on physical and biochemical attributes of ber

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume (cc)	T.S.S (°Brix)	Ascorbic acid (mg 100 g^{-1})	Titratable acidity (%)	Total sugars (%)
T_0 (Control)	3.10	2.20	11.15	11.40	13.20	81.30	0.40	8.20
T_1 (GA_3 15 ppm)	3.62	2.72	14.78	13.64	14.10	95.05	0.36	8.90
T_2 (GA_3 20 ppm)	3.67	2.85	14.90	13.88	14.11	95.08	0.37	8.92
T_3 (GA_3 25 ppm)	3.80	2.82	14.82	14.44	14.14	95.10	0.38	8.95
T_4 (GA_3 30 ppm)	3.92	2.78	14.98	14.87	14.20	95.12	0.39	8.98
T_5 (Urea 2%)	4.06	2.88	15.10	15.17	14.70	96.95	0.20	9.75
T_6 (GA_3 15 ppm and urea 2%)	4.17	2.93	15.15	15.54	14.80	97.10	0.16	9.80
T_7 (GA_3 20 ppm and urea 2%)	4.25	2.95	15.25	15.90	14.95	97.85	0.13	9.88
T_8 (GA_3 25 ppm and urea 2%)	4.40	2.96	15.34	16.47	15.12	98.34	0.11	9.96
T_9 (GA_3 30 ppm and urea 2%)	4.52	2.99	15.44	16.80	15.30	99.25	0.10	9.99
SEd±	0.09	0.05	0.35	0.25	0.240	1.96	0.006	0.17
CD (p=0.05)	0.19	0.10	0.75	0.53	0.50	4.12	0.014	0.36

diameter (2.20 cm) were found with T_0 (control) treatment. The improvement in fruit size (length and diameter) is due to the maximum mobilization of food materials from the site of their production to the storage organs under the influence of applied plant bio-regulator (GA_3) and urea. The significant increase in cell division and cell enlargement with the increase in fruit size and fruit weight with the application of gibberellic acid. The findings align with the report by Singh et al. (2016) and Sharma et al. (2011) in ber; Singh et al. (2017) in mango; Bhadauria et al. (2018) and Tripathi et al. (2018) in aonla; Kumar et al. (2023) and Kashyap et al. (2023) in phalsa; Gupta et al. (2022); and Radha et al. (2023) in litchi.

3.2.2. Fruit volume(cc)

The plants were treated with the application of GA_3 30 ppm urea 2% (T_9) and expressed significant maximum fruit volume (16.80 cc) closely followed by treatment T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and Urea 2%), and T_6 (GA_3 15 ppm and urea 2%). The untreated plants i.e., control (T_0) exhibited significantly the minimum fruit volume (11.40 cc). The increased fruit volume might be due to a better supply of nutrients with the application of GA_3 30 ppm and urea 2% with the increased fruit volume due to the rapid synthesis of metabolites and photosynthates their translocation to the fruits which ultimately promoted fruit volume. Similar results have been reported by Tripathi et al. (2019), Singh et al. (2017); Khan et al. (2022) and Anushi et al. (2021) in mango; Singh et al. (2016) in ber; Bhadauria et al. (2018); Tripathi et al. (2018) in aonla; Kumar et al. (2023); Kashyap et al. (2023) in phalsa.

3.2.3. Fruit weight(g) and fruit yield (kg branch^{-1})

The weight of fruit and fruit yield were found significantly affected by the application of plant growth regulators (GA_3) and urea over control (Table 1). The plants were treated with the application of GA_3 30 ppm urea 2% (T_9) and expressed significant maximum fruit weight (15.44 g) and fruit yield (31.50 kg branch^{-1}) closely followed by treatment T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and urea 2%), and T_6 (GA_3 15 ppm and urea 2%). The untreated plants i.e., control (T_0) exhibited significantly the minimum fruit weight (11.15 g) and fruit yield (21.10 kg branch^{-1}). The improvement in fruit weight, as well as fruit yield, is due to the maximum mobilization of food materials from the site of their production to the storage organs under the influence of applied plant bio-regulator (GA_3) and urea. The significant increase in cell division and cell enlargement with the increase in fruit size so ultimately increment of fruit weight as well as fruit yield. The findings align with the report by Sharma et al. (2011) and Singh et al. (2016) in ber; Khan et al. (2022) in mango; Tiwari et al. (2017) and Tripathi et al. (2018) in aonla; Radha et al. (2023) in litchi; and Kashyap et al. (2023) in phalsa.

3.2.4. Pulp weight(g), stone weight (g), and pulp stone ratio

The fresh weight of pulp was determined by deducting stone weight and peel from fruit weight (Table 1). Data recorded on pulp weight treatment T_9 (GA_3 30 ppm and Urea 2%) significantly maximized (14.43 g) pulp weight and proved more effective followed by T_8 (GA_3 25 ppm and Urea 2%), T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment, while, the minimum (9.95 g) pulp weight was revealed under control (T_0 treatment). Various concentrations of plant growth regulators and urea influenced greatly and consistently on stone weight of fruit. In this regard, significantly lesser (1.01 g) stone weight was revealed under treatment T_9 (GA_3 30 ppm urea 2%) followed by treatment T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm urea 2%) and T_6 (GA_3 15 ppm urea 2%) treatment. The plants were treated under the control significantly registered maximum stone weight i.e., 1.20 g. The pulp stone^{-1} ratio was calculated treatment-wise, dividing pulp weight by stone weight. A significant maximum pulp stone ratio (14.29) was received from the treatment T_9 (GA_3 30 ppm and urea 2%) closely followed by T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment. The minimum pulp stone ratio (8.29) was exhibited under untreated plants i.e., control.

The increase in pulp weight and reduction in stone weight in ber fruits were observed with the application of growth regulators and urea might be due to the optimum supply of plant nutrients and growth hormones in the right amount during the growth period responding to comparatively vigorous vegetative development of the plants and seems ultimately more production of photosynthates. A couple of treatments of growth regulators i.e., GA_3 and urea motivated and accelerated the metabolic activities of plants which stimulated the manufacturing of considerably greater amounts of food materials. These are translocated into food-bearing areas and enhance fruit weight, pulp weight, and pulp stone^{-1} ratio of fruits. Similar results have been reported by Tripathi et al. (2019); Painkra et al. (2012) in mango; Tiwari et al. (2017) and Tripathi et al. (2018) in aonla; Kale et al. (2000); Singh et al. (2016) in ber.

3.3. Quality traits

3.3.1. T.S.S. (°Brix)

Foliar application of GA_3 and urea significantly improved the fruit quality like; total soluble solids over its control (T_0) treatment (Table. 2). The data of T.S.S. (15.30 °Brix) showed a significant maximum exhibited under the foliar spray of treatment T_9 (GA_3 30 ppm and urea 2%) followed by T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and Urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment. The minimum (13.20 °Brix) total soluble solid was obtained with the untreated plant T_0 (control). The enhancement of T.S.S. of treated plants might be due to an increase in the mobilization of carbohydrates from the source to sink in fruit by plant hormones. Besides this, these growth regulators also promoted enzymatic activities and metabolized the carbohydrates into simple sugar and available nitrogen causing strengthening phenomena in the fruit juice which helps to improve of total soluble solids content in the fruit of Ber. These findings are in line with the reports of Jawandha et al. (2008); Katiyar et al. (2010) in ber; Kumar and Tripathi (2009); Verma et al. (2023) in strawberry; Tripathi et al. (2019) in mango; Singh and Tripathi (2023) in guava; Gupta et al. (2022); Radha et al. (2023) in litchi; Kashyap et al. (2023) in phalsa; and Tripathi et al. (2018) in aonla.

3.3.2. Ascorbic acid (mg 100 g^{-1} fruit pulp)

The findings consistently elaborated significant differences with the application of gibberellic acid and urea concerning the ascorbic acid content of ber fruits (Table 2). The maximum ascorbic acid (99.2 mg 100 g^{-1}) was assessed with the treatment of T_9 (GA_3 20 ppm and urea 2%) followed by T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment. In contrast, the poorest ascorbic acid (81.30 mg 100 g^{-1}) was found under the untreated plant T_0 (control). The enhancement in ascorbic acid content has been shown owing to the improvement of ascorbic acid in ber fruit due to metabolic activities involving certain enzymes and metabolic ions under the influence of plant growth regulators and urea. It might be also due to the actual synthesis of glucose 6-phosphate throughout the growth and development of fruit which is through the precursor of ascorbic acid (Vitamin C). It possibly and considerably happened with plant growth regulators i.e., GA_3 and urea in the present investigation. These findings conform with the reports of Tiwari et al. (2017) and Tripathi et al. (2018) in aonla; Kashyap et al. (2023) in phalsa; Dubey et al. (2017) and Kumar and Tripathi (2009) in strawberry; Singh et al. (2017) and Tripathi et al. (2019) in mango.

3.3.3. Titratable acidity (%)

Effect of plant growth regulators and urea concentrations consistently and significantly influenced acidity content in Ber fruit (Table 2). The plants treated with GA_3 20 ppm and urea 2% (T_9) showed significantly minimized titratable acidity (0.10%) followed by T_8 (GA_3 25 ppm and urea 2%), T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment. This reduction in acidity might be due to growth regulators and urea by fat conversion of sugar into their derivatives. The reaction involving the reverse glycolytic pathway might have been used in respiration or both. It has been performed with the influence of the GA_3 strengthening phenomenon of nitrogen (urea). These findings are in line with the report of Kashyap et al. (2023) in Phalsa; Kumar and Tripathi (2009) and Verma et al. (2023) in Strawberry; Singh et al. (2017) and Tripathi et al. (2019) in mango; Gupta et al. (2022) in litchi; Tripathi et al. (2018) in aonla.

3.3.4. Total sugars (%)

In the present investigation effect of plant growth regulator (GA_3) and urea concentrations profoundly and significantly influenced the total sugar content in ber fruit. Treatment T_9 (GA_3 30 ppm+urea 2%) was recorded at maximum total sugars (9.99%) followed by T_8 (GA_3 25 ppm and Urea 2%), T_7 (GA_3 20 ppm and urea 2%) and T_6 (GA_3 15 ppm and urea 2%) treatment, while, untreated plants (T_0) found that significant minimum total sugar (8.20%). Increasement of total sugar content in ber fruits might be due to photosynthetic activities and the formation of more carbohydrate content and its translocation is also maximized in fruits. Sugars are also critically converted into their derivatives by reactions involving several glycolytic pathways. In this experimentation, GA_3 and urea also greatly improved in strengthening these phenomena which enhanced total sugar content in fruits. These findings are in line with the reports of Katiyar et al. (2010) in ber; Singh et al. (2017) and Tripathi et al. (2019) in mango; Gupta et al. (2022) in litchi; Kashyap et al. (2023) in phalsa; Verma et al. (2023) and Kumar and Tripathi (2009) in strawberry; Tripathi et al. (2018) in aonla.

4. CONCLUSION

The foliar spray of GA_3 30 ppm and urea 2% on ber fruit crop resulted in significant improvement of flowering and fruiting behavior, which ultimately leads to physical and biochemical attributing parameters of ber.

5. ACKNOWLEDGMENT

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