The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
21(1): 174-184, 2026 www.thebioscan.com

Studies on Foliar Feeding of Plant Growth Regulators and Micronutrients on fruiting attributes of Ber (*Ziziphus mauritiana* Lamk) fruits cv. Gola

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DOI: 10.63001/tbs.2026.v21.i01.pp174-184

Keywords
Ber, Fruit setting time, Fruit setting, Fruit drop and Fruit retention

Received on:
14-11-2025

Accepted on:
11-12-2025

Published on:
13-01-2026

ABSTRACT

The present study was conducted on 6-year-old Ber (*Ziziphus mauritiana* Lamk.) plants grown under sodic soil conditions at the Production Processing of Fruits and User Waste Land, Akma, under the Department of Fruit Science, College of Horticulture & forestry, of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.) during 2023- 24 and 2024-25. The objective of the investigation was to evaluate the impact of foliar application of plant growth regulators and micronutrients on fruiting character of Ber cv. Gola fruits. The experiment was laid out in a RBD (Randomized Block Design) and data were collected on key preharvest parameters including Fruit setting time, Fruit setting (%), Fruit drop (%) and Fruit retention (%). Among the treatments, T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) consistently resulted in the minimize Fruit setting time, increased the Fruit setting (%), least the Fruit drop (%) and higher the Fruit retention (%) during both the years and pooled mean as compared to control.

INTRODUCTION

Ber (*Zizyphus mauritiana* Lamk.), belonging to the family Rhamnaceae, has a tetraploid chromosome number of 2n=4X=48, is one of the oldest and most common fruits of the Indo-China region. It has been cultivated in the Indian subcontinent since ancient times for its fresh fruits. It was a significant fruit in ancient India, and sages during the Vedic period sustained themselves on it. The name of the genus "*Ziziphus*" is derived from "Zizaif," the Arabic term for the ber fruit (Baily, 1947). The genus *Zizyphus* consists of over 100 species, with 18 to 40 species found growing in India. The fruit size and quality vary across species, such as *Z. jujuba*, *Z. mauritiana*, *Z. lotus*, *Z. vulgaris*, *Z. ocenoplia*, *Z. sativa*, and *Z. mistol*. There is still some inconsistency in the nomenclature of the commonly cultivated species like *Z. jujube Lamk.*, *Z. mauritiana Lamk.*, and *Z. vulgaris Lamk.* Additionally, species such as *Z. numularia* and *Z.*

rotundifolia are also found in the Indian subcontinent. While *Z. jujube* is primarily cultivated in temperate regions, *Z. mauritiana* thrives in tropical to subtropical climates.

Ber is renowned for its high nutritional value (Majumder *et al*., 2017). It contains ascorbic acid (90-180 mg/100 g), vitamin A (55 mg/100 g), thiamine (0.13 mg/100 g), and riboflavin (0.19 mg/100 g). It also has a total soluble solids (TSS) content of 17-20% and an acidity level of 0.21%. Additionally, ber contains 70 IU of β-carotene, 0.8 g of protein, 0.3 g of fat, 17 g of carbohydrates, 4 mg of calcium, 9 mg of phosphorus, and 1.8 mg of iron per 100 g of fruit (Yadav and Singh, 2001). According to Morton (1987), ber fruits contain 5.41-10.5 g of total sugars per 100 g of pulp, including 1.4-6.2 g of reducing sugars, 3.2-8.0 g of non-reducing sugars, and 0.2-1.1 mg of citric acid. Remarkably, ber is reported to have higher levels of vitamin C, protein, and minerals than both apple and mango (Bakshi and Singh, 1974). Ber is well-suited for arid and semi-arid environments due to its drought tolerance, xerophytic traits, salt tolerance (up to 40 ESP and 12-15 dS/m), spiny structure, deep taproot system, and its ability to shed leaves during hot summers (Pathak, 1991). It can tolerate soils with pH levels above 9 and limited soil and water salinity (Hooda *et al.* 1990). Foliar application of GA_3, NAA, zinc, and boron can lead to improved fruiting attributes.

Micronutrient Zinc plays a vital role in human health involved in protein synthesis, produce seeds, and mature at different rates. Having a requirement for Tryptophan is converted into indole acetic acid during metabolism. Spraying zinc on trees increases flowering, fruit set, fruit size, and helps control fruit drop, ultimately increasing yield. Foliar zinc application can result in improved fruit yield and quality, which may reduce premature fruit drop.

Boron is a minor nutrient that inhibits plant growth when it is deficient. Plants use boron primarily to facilitate fluid movement from the leaves (source) to the active areas (sink) during photosynthesis. Shaaban (2010) explains that this element regulates gene expression and cell membrane activity. In addition to stimulating protein biosynthesis, it increases vitamin C and B levels through its effect on DNA synthesis. In addition to improving tree growth, the purpose was to increase quality and quantity of fruits produced.

The NAA (Naphthalene Acetic Acid) plant hormone is a synthetic auxin hormone that greatly increases cellulose fiber production in plants. NAA is sprayed at different concentrations on different fruit crops to control fruit drop. In addition to inhibiting fruit drop, NAA strengthens the pedicle. It is common for fruit pedicles to become more visible following fruit set, thereby promoting vascular development. Fruit drop in Ber fruit is prevented by high auxin content in the abscission zone. According to several plants, auxin content and fruit growth are directly related, so spraying NAA on fruit might have increased their auxin levels, thereby influencing development of their various components.

Several aspects of plant growth and development are controlled by gibberellic acids, which are plant hormones that are synthesized from geranyl diphosphate. They include seed germination, stem elongation, flowering, fruit development, and gene expression in the cereal aleuronic layer. A major use of gibberellin has been to manipulate a wide range of physiological processes as well as to improve fruit quality commercially. As a result of GA_3, ber fruit retained more fruit and dropped fewer fruits.

MATERIALS AND METHODS

A present experiment was conducted at the Production Processing of Fruits and User Waste Land, Akma, under the Department of Fruit Science,College of Horticulture & forestry, of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, (U.P.) during 2023-24 to 2024-25.The experiment made use of the Ber Gola cultivar. Well established healthy and uniform trees of ber the trees were about 6 years old and were properly maintained by adopting proper horticultural practices and recommended dose ofplant growth regulators and micronutrients. During the course of investigation, the whole orchard was kept under clean and uniform cultural practices. 36 trees of ber were taken and on each tree three unique branches were selected and used as one unit (for one treatment). Thus one unit was selected on 36 trees of ber. The experiment included 12 treatments, each comprising of foliar sprays of GA_3, NAA, zinc sulphate, Borax and control. The specifics of the treatment allocation are as Follows: T_1 (Control), T_2(GA_3 20 ppm), T_3 (NAA 30 ppm),T_4 ($ZnSO_4$ 0.5 %), T_5 (Borax 0.5 %), T_6 (GA_3 20 ppm + NAA 30 ppm), T_7 (GA_3 20 ppm + $ZnSO_4$ 0.5 %), T_8 (GA_3 20 ppm + Borax 0.5 %), T_9 (NAA 30 ppm + $ZnSO_4$ 0.5 %), T_{10} (NAA 30 ppm + Borax 0.5 %), T_{11} ($ZnSO_4$ 0.5 % + Borax 0.5 %) and T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %). On First spraying in September and second spraying in November 2023-24 and 2024-25, at the Flowering and fruit setting stage, plant growth regulators and micronutrients were sprayed into the leaves of each treatment to give a homogeneous spray over the whole ber plant treatment.The analysis of variance (ANOVA) of the data was carried out by the techniques as by Raghuramula *et al.* 1983.

Fruit setting time:

The date of the start of the fruit set and the end of the fruit set was recorded. The duration between the start and end of the fruit set denotes the time of the fruit set.

Fruit setting (%)

To study fruit set per cent under natural conditions, 100 flowers were tagged in each direction of the tree (*i.e.,* East, West, North and South) at the time of flowering. The initial fruit set was recorded after 10 days of fruit setting. Per cent initial fruit set was calculated using the following:

$$\text{Fruit Set (\%)} = \frac{\text{No. of initial fruit set}}{\text{No. of flowers tagged at inital stage}} \times 100$$

Fruit drop (%)

The total number of fruits retained fruits on observation day was substracted from the fruit set to get a number of fruit drops on observation day. The fruit drop was calculated against the total fruit drop from the tagged shoot.

$$\text{Fruit drop (\%)} = \frac{\text{Total no. of fruit set} - \text{Total no. of fruit at harvest time}}{\text{Total no. of fruit set}} \times 100$$

Fruit retention (%)

To get the fruit retention, the number of flowers retained in the form of fruits was recorded at the time of fruit harvesting and per cent value was worked out as follows:

$$\text{Fruit retention (\%)} = \frac{\text{No. of fruit at harvest}}{\text{Initial no. of fruit set}} \times 100$$

RESULTS AND DISCUSSION

Fruit Setting Time

The data presented in Table-1 reveals the effect of plant growth regulators and micronutrients on fruit setting time during both the years (2023-24 and 2024-25) of study.

In the year 2023-2024, the earliest fruit setting was observed on 6th September in treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), followed by T_8 (GA_3 20 ppm + Borax 0.5%) 7th September, respectively. The latest fruit setting, on the other hand, was recorded on 12th September under the control treatment T_1, indicating delayed reproductive development in the absence of use of plant growth regulators and micronutrients.

A similar trend was noted in the following year, 2024-2025, where the earliest fruit setting occurred on 5rd September in T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), followed by T_8 (GA_3 20 ppm + Borax 0.5%) on 6th September, and T_{10} (NAA 30 ppm + Borax 0.5%) on 7th September. Conversely, the control (T_1) showed delayed fruit setting on 11th September.

Ackerman (1961) found that many jujube cultivars set fruit poorly without cross pollination, fruit set depends on physiological and environmental conditions. Time of anthesis also varies with cultivar (Dhaliwal and Bal, 1998).The application of NAA was found to enhance the plant's metabolic activity by stimulating meristematic growth, which subsequently promotes increased vegetative development, higher photosynthetic activity, and ultimately results in earlier and greater fruit set. Similar findings have been reported by Pandey (2011) in ber, Zang and Lei (2000) and Shankar *et al*. (2002) in guava.

Fruit setting (%)

A perusal of data on fruit setting percentage presented in Table-1 indicated that all treatments have a significant effect in improving the fruit setting percentage over control. During 1st year 2023-2024, the highest fruit setting percentage (41.00%) was recorded under treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was significantly superior to all other treatments. Which was at par with followed by T_8 (GA_3 20 ppm + Borax 0.5%) and T_{10} (NAA 30 ppm + Borax 0.5%), which recorded fruit setting percentages of 40.50% and 40.28%, respectively. The lowest fruit setting percentage (31.90%) was recorded under the control (T_1).

A similar trend was observed in 2024-2025. The maximum fruit setting percentage (42.31%) was again observed in T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was at par with followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 41.72% and T_{10} (NAA 30 ppm + Borax 0.5%), with 41.41%. The minimum fruit setting percentage (32.22%) was recorded in the control (T_1), indicating the least effectiveness without any foliar application.

Pooled data in Table-1 shows that all the treatments increased fruit setting % significantly over the control. The maximum fruit setting percentage (41.66%) was recorded in T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was significantly superior over all other treatments. It was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 41.11%, T_{10} (NAA 30 ppm + Borax 0.5%) with 40.84%, and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with 39.73%. On the contrary, the lowest pooled value (32.06%) was recorded under the control treatment (T_1).

The results clearly indicate that the combined foliar application of GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%, in the form of T_{12}, significantly enhanced fruit setting percentage in ber. This suggests a positive synergistic effect of plant growth regulators and micronutrients on improving reproductive efficiency and yield potential in ber.

In the present study, fruit set was significantly higher in plants treated with GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %, which may be attributed to the enhanced mobilization of carbohydrates from the leaves to the developing fruits (Sharma *et al*. 2018). These findings are consistent with those reported by Kanpure *et al*. (2016), Sen *et al.* (2016), and Patel *et al*. (2023) in ber. Previous studies have also emphasized the essential role of boron in higher plants, particularly in processes such as flowering, pollen germination, and fruit development (Desouky *et al*. 2009). Boron is known to be critical for optimal pollen germination, rapid pollen tube growth, and has been shown to reduce flower drop. Additionally, it enhances the pollen-producing capacity of anthers and improves pollen viability, which collectively contributes to higher fruit set (Thompson and Batjer, 1950). Therefore, boron likely played a significant role in increasing fruit set in the present investigation.

Table-1 Effect of foliar feeding of plant growth regulators and micronutrients on Fruit setting time and Fruit setting of Ber cv. Gola

Treatments	**Fruit setting time**		**Fruit setting (%)**		
	2023-2024	**2024-2025**	**2023-2024**	**2024-2025**	**Pooled**
T_1: Control	12-Sep	11-Sep	31.90	32.22	32.06
T_2: GA_3 20 ppm	11-Sep	10-Sep	32.20	32.59	32.39
T_3 : NAA 30 ppm	10-Sep	10-Sep	34.09	34.63	34.36
T_4 : $ZnSO_4$ 0.5 %	10-Sep	9-Sep	33.30	33.77	33.53
T_5 : Borax 0.5 %	10-Sep	10-Sep	36.65	37.31	36.98
T_6 : GA_3 20 ppm + NAA 30 ppm	8-Sep	8-Sep	37.32	38.07	37.69
T_7 : GA_3 20 ppm + $ZnSO_4$ 0.5 %	8-Sep	10-Sep	35.85	36.64	36.24
T_8 : GA_3 20 ppm + Borax 0.5 %	7-Sep	6-Sep	40.50	41.72	41.11
T_9 : NAA 30 ppm + $ZnSO_4$ 0.5 %	9-Sep	9-Sep	39.14	40.08	39.61

T_{10} : NAA 30 ppm + Borax 0.5 %	7-Sep	7-Sep	40.28	41.41	40.84
T_{11} : $ZnSO_4$ 0.5 % + Borax 0.5 %	8-Sep	8-Sep	39.22	40.24	39.73
T_{12} : GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %	6-Sep	5-Sep	41.00	42.31	41.66
SEm±			0.55	0.54	1.56
CD at 5%			1.63	1.62	4.60

Fruit drop (%)

A perusal of Table-2 reveals that the foliar application of plant growth regulators and micronutrients had a marked significant influence on the reduction of fruit drop percentage in Ber cv. Gola during both the years of study.During 2023–2024, the minimum fruit drop (57.13%) was recorded in treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was significantly superior over all other treatments in reducing fruit drop. This was followed by T_8 (GA_3 20 ppm + Borax 0.5%) and T_{10} (NAA 30 ppm + Borax 0.5%), which recorded 58.30% and 60.74% fruit drop, respectively. On the contrary, the highest fruit drop percentage (69.89%) was recorded under the control (T_1)

A similar pattern was observed during the year 2024–2025. Treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) again recorded the lowest fruit drop (58.96%), which was significantly superior over rest of the treatments. It was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 60.05% and T_{10} (NAA 30 ppm + Borax 0.5%) with 62.44%. The maximum fruit drop (70.59%) was again noted under the control (T_1), reaffirming the limited effect of untreated plants on fruit retention.

The pooled data reinforces these findings. The minimum fruit drop (58.05%) was recorded under treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was significantly superior over rest of the treatments. This was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 59.18%, T_{10} (NAA 30 ppm + Borax 0.5%) with 61.59%, and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with 63.11%. The highest average fruit drop (70.24%) was recorded in the untreated control (T_1).

Fruit drop may be attributed to low auxin activity or a limited supply of auxin-like precursors in developing fruits, as reported in navel orange by Lima and Davies (1984). In the present study, the reduction in fruit drop observed with the application of plant growth regulators and micronutrients may be due to the correction of endogenous auxin deficiency, which likely prevents the formation of the abscission layer by inhibiting the activity of enzymes such as pectinase, cellulase, and polygalacturonase (Singh and Singh, 1976) in ber. The present findings are also supported by previous studies conducted by Dhillon and Singh (1968), Bal *et al*. (1982), Yadav (1998, 2002) in guava, Singh *et al*. (2001), Kaur *et al*. (1997) in kinnow mandarin and Saraswathi *et al*. (2003) in mandarin. Furthermore, Singh *et al*. (2001) reported that application of NAA at 20 ppm reduced fruit drop in 'Umran' ber, while Singh and Singh (1976) observed a similar effect with 10 ppm NAA in ber.

Fruit retention (%)

The data in table-2 reveals that the foliar application of plant growth regulators and micronutrients significantly enhanced the fruit retention percentage in ber cv. Gola during both years (2023- 2024 to 2024-2025) of the study.

In year 2023–2024, the maximum fruit retention (42.87%) was observed in treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was significantly superior to all other treatments. This was followed by T_8 (GA_3 20 ppm + Borax 0.5%) and T_{10} (NAA 30 ppm + Borax 0.5%), which recorded 41.70% and 39.26% fruit retention, respectively. The lowest fruit retention (30.11%) was recorded under the control (T_1), indicating poor performance without treatment.

Similar results were observed during the year 2024–2025. Treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) again recorded the highest fruit retention (41.04%), which was significantly superior over the rest of the treatments. It was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 39.95% and T_{10} (NAA 30 ppm + Borax 0.5%) with 37.65%. While the lowest fruit retention (29.41%) was once again noted in the untreated control (T_1).

Pooled data across both years confirm the consistency of these results. The highest average fruit retention (41.95%) was recorded under treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%). This was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with 40.82%, T_{10} (NAA 30 ppm + Borax 0.5%) with 38.45%, and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with 36.89%. In contrast, the lowest pooled fruit retention (29.76%) was observed in T_1 (Control).

The application of GA_3, NAA, $ZnSO_4$, and Borax was found to have a positive impact, as these treatments play a crucial role in the translocation of carbohydrates and the synthesis of auxins toward the sink tissues, thereby enhancing pollen viability and fertilization. These results are in agreement with the findings of Kanpure *et al*. (2016), Sen *et al*. (2016), Devi *et al*. (2019), Gangadhar *et al*. (2019), Pal *et al*. (2020), Chouhan *et al*. (2022), and Patel *et al*. (2023). Furthermore, the increased fruit retention observed in the study may be attributed to the reduction in fruit drop, likely due to the improved carbohydrate availability and enhanced water uptake stimulated by boron application. Similar results were reported by Pandey (1999) and Bhati and Yadav (2004), who noted maximum fruit retention in ber with the application of NAA at 20 ppm.

Table-2 Effect of foliar feeding of plant growth regulators and micronutrients on fruit drop and fruit retention of Ber cv. Gola

Treatments	Fruit drop (%)			Fruit retention (%)		
	2023-2024	2024-2025	Pooled	2023-2024	2024-2025	Pooled
T_1: Control	69.89	70.59	70.24	30.11	29.41	29.76
T_2: GA_3 20 ppm	68.15	68.97	68.56	31.85	31.03	31.44
T_3 : NAA 30 ppm	68.78	69.88	69.33	31.22	30.12	30.67
T_4 : $ZnSO_4$ 0.5 %	66.94	67.88	67.41	33.06	32.12	32.59
T_5 : Borax 0.5 %	67.12	68.33	67.72	32.88	31.67	32.27

T_6 : GA_3 20 ppm + NAA 30 ppm	65.55	66.86	66.21	34.45	33.14	33.79
T_7 : GA_3 20 ppm + $ZnSO_4$ 0.5 %	65.00	66.43	65.72	35.00	33.57	34.28
T_8 : GA_3 20 ppm + Borax 0.5 %	58.30	60.05	59.18	41.70	39.95	40.82
T_9 : NAA 30 ppm + $ZnSO_4$ 0.5 %	63.60	65.13	64.37	36.40	34.87	35.63
T_{10} : NAA 30 ppm + Borax 0.5 %	60.74	62.44	61.59	39.26	37.65	38.45
T_{11} : $ZnSO_4$ 0.5 % + Borax 0.5 %	62.30	63.92	63.11	37.70	36.08	36.89
T_{12} : GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %	57.13	58.96	58.05	42.87	41.04	41.95
SEm±	1.05	0.90	1.02	0.58	0.50	1.45
CD at 5%	3.10	2.65	2.91	1.72	1.46	4.28

CONCLUSION

Based on the results of the present investigation, it can be concluded that foliar application of T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) was significantly superior to the control in enhancing fruiting behavior, and overall quality attributes of ber fruits. The T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) treatment effectively reduced the fruit setting time and fruit drop. Additionally, it significantly improved parameters such as the fruit set and fruit retention.

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