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

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ABSTRACT

The study was carried out on six-year-old Ber (*Ziziphus mauritiana* Lamk.) trees cultivated under sodic soil conditions at the Production Processing of Fruits and User Waste Land, Akma. The research was undertaken within the Department of Fruit Science, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), during the academic years 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 Flowering initiation time, Number of flowers per shoot, Days taken to 50 % flowering, Days taken for full bloom. Among the treatments, T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%) consistently minimized the time required for flowering initiation, increased the number of flowers per shoot, and reduced the days taken to reach 50% flowering as well as full bloom, across both years and in the pooled mean, compared with the control.

INTRODUCTION

Ber (*Ziziphus mauritiana* Lamk.), a member of the family Rhamnaceae with a tetraploid chromosome number of 2n = 4X = 48, is among the oldest and most widely grown fruits in the Indo-China region. In the Indian subcontinent, it has been cultivated since ancient times for its fresh fruits. Historically, Ber held great significance in India, with sages during the Vedic period relying on it as a source of sustenance. The genus name *Ziziphus* originates from "Zizaif," the Arabic word 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.

Naphthalene Acetic Acid (NAA) is a synthetic auxin that enhances cellulose fiber production in plants. It is commonly applied at varying concentrations across fruit crops to reduce fruit drop. Beyond this, NAA strengthens the pedicel, which becomes more prominent after fruit set and supports vascular development. In Ber, fruit drop is minimized due to elevated auxin levels in the abscission zone. Since auxin content is closely linked with fruit growth, NAA application likely increased auxin levels, thereby promoting the development of different fruit components.

Gibberellic acids, synthesized from geranyl diphosphate, are plant hormones that regulate several aspects of growth and development, including seed germination, stem elongation, flowering, fruit formation, and gene expression in the cereal aleurone layer. Commercially, gibberellins are widely used to influence diverse physiological processes and enhance fruit quality. In Ber, the application of GA_3 resulted in greater fruit retention and reduced fruit drop.

Zinc is an essential micronutrient that supports protein synthesis, seed production, and plant maturation. It acts as a cofactor in converting tryptophan to indole-3-acetic acid (IAA), a key auxin regulating growth. Foliar application of zinc enhances flowering, fruit set, and fruit size, while reducing premature fruit drop, thereby improving yield and quality in crops like Ber.

Boron is an essential micronutrient, and its deficiency restricts plant growth. It plays a key role in facilitating the translocation of photosynthates from source leaves to sink tissues. According to Shaaban (2010), boron regulates gene expression and cell membrane function. It also stimulates protein biosynthesis and enhances vitamin C and B levels through its influence on DNA synthesis. Beyond promoting tree growth, boron application improves both the quality and quantity of fruit production.

MATERIALS AND METHODS

The experiment was conducted at the Production Processing of Fruits and User Waste Land, Akma, under the Department of Fruit Science, College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), during 2023–24 and 2024–25. The study utilized the Ber Gola cultivar, with healthy, uniform six-year-old trees maintained through standard horticultural practices and recommended applications of plant growth regulators and micronutrients. The orchard was managed under clean and consistent cultural practices. A total of 36 trees were selected, and three distinct branches from each tree were treated as one experimental unit. 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.

Flowering initiation time:

The tagged shoots were observed to note when the inflorescence (axillary cyme) emerges on shoot on a branch, time and date of appearance of the first inflorescence in each replication of the different treatments were recorded for further presentation.

Number of flowers per shoots:

The number of flowers per shoot was calculated by the count method from selected branches in each direction and in each treatment and their average was expressed as a number of flowers per shoot.

Days taken to 50 % flowering:

This observation was recorded by visiting the experimental field every day after inflorescence emergence and the number of days was counted from the date of first spraying to the day when 50 per cent of flowers opened on the inflorescence.

Days taken for full bloom:

Number of days taken from treatment application to full bloom was recorded.

RESULTS AND DISCUSSION

Flowering initiation time:

A perusal of Table 1 reveals the significant influence of foliar application of plant growth regulators and micronutrients on flowering initiation time of ber (cv. Gola) during both the years of investigation.

During 2023-2024, the earliest flowering was observed under T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), where flowering initiated on 8th August, followed closely by T_8 (GA_3 20 ppm + Borax 0.5 %) on 9th August and T_{10} (NAA 30 ppm + Borax 0.5 %) on 10th August. These treatments initiated flowering earlier than the rest. On the other hand, the latest flowering was recorded in the control treatment (T_1), where flowering initiation occurred on 15th August.

The data pertaining a similar trend was also noted during 2024-2025. The earliest flowering was again observed in T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), with flowering initiating on 7th August, which initiated flowering earlier than all other treatments. This was followed by T_8 (GA_3 20 ppm + Borax 0.5 %) on 8th August, T_{10} (NAA 30 ppm + Borax 0.5 %) on 9th August. In contrast, the latest flowering was again noted under the control (T_1), where flowering started on 14th August. Results from the present investigation clearly indicate that the earliest flowering initiation occurred in plants treated with GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5% treatments.

The flowering of Ber is linked to a reduction in vegetative growth, and available evidence strongly suggests that flower initiation depends on the presence of an unidentified factor or factors synthesized in the leaves that promote flowering. Oksher *et al.* (1980) found that NAA (Naphthalene Acetic Acid) has flowering-promoting effects. On the other hand, GA_3 promotes morpho-physiological growth in plants by stimulating cytogenesis and cell enlargement, along with promoting the synthesis of DNA, RNA, and proteins. These changes are possible because GA_3 acts as a sink for plant-available nutrients. Zinc is crucial for the evolution and utilization of CO_2, carbohydrate metabolism, protein synthesis, and the production of RNA and auxins. Boron plays a key role in regulating the metabolism involved in carbohydrate translocation, cell wall development, and RNA synthesis (Ram and Bose, 2000). The results of the present investigation indicated that the earliest flowering initiation was observed in plants treated with a combination of GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %. These findings are consistent with those reported by Sajid *et al.* (2010) in sweet orange, Krishna *et al.* (2017) in mango, and Das *et al*. (2020) in ber.

Number of flowers per shoots:

Examining Table 1shows that in both the 2023-2024 and 2024-2025 study years, foliar application of micronutrients and plant growth regulators had a substantial impact on the number of flowers per shoots in Ber cv. Gola. During the year 2023-2024, the maximum number of flowers per shoot (20.00) was recorded in treatment GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%, which was significantly superior over 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 19.00 and 18.00 flowers per shoot, respectively. The lowest number of flowers per shoot (13.00) was recorded under the treatment control (T_1).

A similar trend was observed during 2024-2025. The highest number of flowers per shoot (20.64) was again noted 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%) with 19.57 flowers per shoot and T_{10} (NAA 30 ppm + Borax 0.5%) with 18.50 flowers per shoot. The lowest number of flowers per shoot (13.13) was again observed in the treatment T_1.

The pooled data also supports these findings. The highest average number of flowers per shoot (20.32) was recorded with 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%) with (19.28), T_{10} (NAA 30 ppm + Borax 0.5%) with 18.25, and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with (17.42) flowers per shoot. On the other hand, the lowest pooled value (13.06) was recorded under the 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% significantly enhanced the flowering potential of ber by increasing the number of flowers per shoot. This suggests a synergistic effect of plant growth regulators and micronutrients in promoting reproductive growth in ber.

GA_3 enhanced inflorescence growth, resulting in the production of more flowers. Similarly, increasing the concentration of borax spray also led to a higher number of flowers per shoot. This effect may be due to the critical role these nutrients play in the translocation of carbohydrates and auxin synthesis to the sink, which in turn enhances pollen viability and fertilization (Dewanshu *et al*., 2017). These findings align with previous studies by Das *et al*. (2020) in Ber, Kumar and Tripathi (2009) and Khushbu *et al*. (2021) in strawberry.

Table-1 Effect of foliar feeding of plant growth regulators and micronutrients on Flowering initiation time and Number of flowers per shoots of Ber cv. Gola

Treatments	Flowering initiation time		Number of flowers per shoots		
	2023-2024	2024-2025	2023-2024	2024-2025	Pooled
T_1: Control	15-Aug	14-Aug	13.00	13.13	13.06
T_2: GA_3 20 ppm	14-Aug	13-Aug	14.33	14.51	14.42
T_3 : NAA 30 ppm	14-Aug	13-Aug	15.00	15.24	15.12
T_4 : $ZnSO_4$ 0.5 %	14-Aug	12-Aug	14.67	14.87	14.77
T_5 : Borax 0.5 %	13-Aug	13-Aug	15.00	15.27	15.13
T_6 : GA_3 20 ppm + NAA 30 ppm	13-Aug	12-Aug	15.33	15.64	15.49
T_7 : GA_3 20 ppm + $ZnSO_4$ 0.5 %	14-Aug	12-Aug	15.67	16.01	15.84
T_8 : GA_3 20 ppm + Borax 0.5 %	9-Aug	8-Aug	19.00	19.57	19.28
T_9 : NAA 30 ppm + $ZnSO_4$ 0.5 %	12-Aug	10-Aug	17.00	17.41	17.20
T_{10} : NAA 30 ppm + Borax 0.5 %	10-Aug	9-Aug	18.00	18.50	18.25
T_{11} : $ZnSO_4$ 0.5 % + Borax 0.5 %	11-Aug	11-Aug	17.20	17.65	17.42
T_{12} : GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %	8-Aug	7-Aug	20.00	20.64	20.32
SEm±			0.24	0.26	0.67
CD at 5%			0.69	0.77	1.98

Days Taken to 50% Flowering:

A perusal of Table 2 reveals that foliar application of plant growth regulators and micronutrients significantly influenced the days taken to 50% flowering of ber cv. Gola during both years of investigation. During 2023-2024, the minimum days taken to 50% flowering (8.30 days) 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 all other treatments. This was followed by T_8 (GA_3 20 ppm + Borax 0.5%) and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with 8.50 and 8.77 days, respectively. The maximum days taken to 50% flowering (12.50 days) was observed in control treatment T_1.

Similar trend was also noted in 2024-2025, where the lowest days to 50% flowering (8.57 days) were again noted 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%) (8.76 days) and T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) (9.00 days). The control (T_1) recorded the maximum days to 50% flowering (12.63 days).

The pooled data further supports these findings. The minimum average days taken to 50% flowering (8.43 days) was recorded with 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%) with (8.63 days), T_{11} ($ZnSO_4$ 0.5% + Borax 0.5%) with (8.88 days). On the other hand, the maximum pooled days to 50% flowering (12.56 days) was observed in 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%significantly reduced the days taken to 50% flowering in ber, suggesting a synergistic effect of plant growth regulators and micronutrients in accelerating reproductive development.

The early blooming of flower buds observed with NAA treatment may be linked to its ability to promote the flow of metabolites toward the flowering buds, thereby accelerating floral development (Krishna *et al*., 2017). The results showed that the application of micronutrients and GA_3 positively influenced the reduction in the number of days required to reach 50% flowering in Ber. Specifically, $ZnSO_4$ and GA_3 played a significant role in shortening the time taken to reach 50% flowering in Ber. Similar findings have been reported by Kanpure *et al*. (2016) and Sen *et al*. (2016) in Ber.

Days Taken for Full Bloom:

The data in Table 2 shows an overview of the effect of plant growth regulators and micronutrients treatments on days taken for full bloom in ber cv. Gola during both the years (2023-24 and 2024-25) of investigation. During 2023-2024, the minimum days taken for full bloom (19.70 days) 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 effect was followed by T_8 (GA_3 20 ppm + Borax 0.5%) and T_{10} (NAA 30 ppm + Borax 0.5%), with 19.83 and 20.00 days, respectively. The maximum days for full bloom (25.57 days) was observed in control treatment T_1.

Similarly, in 2024-2025, the lowest days taken for full bloom (20.33 days) was noted in 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 (20.43 days). The highest days for full bloom (25.82 days) were recorded under control (T_1).

The pooled data corroborates these findings, with the minimum average days for full bloom (20.02 days) recorded under treatment T_{12} (GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5% + Borax 0.5%), which was followed by T_8 (GA_3 20 ppm + Borax 0.5%) with (20.43 days) (20.13 days), T_{10} (NAA 30 ppm + Borax 0.5%) with (20.28 days). The maximum pooled days (25.70 days) were observed in the control treatment T_1.

The early blooming of flower buds observed with NAA treatment can be attributed to its role in enhancing the translocation of metabolites toward the developing floral buds, thereby speeding up floral development (Krishna *et al*., 2017). GA_3 is known to promote early flowering and increase flower size, particularly in crops that require a floral induction phase, as noted by Ahmed *et al*.

(2017) in grapes. Zinc, a key micronutrient, plays a crucial role in enzyme activation, protein synthesis, and auxin metabolism factors essential for flower development. Similar findings were reported by Sen *et al*. (2016) in Ber and Lal *et al*. (2013) in guava.

Table-2 Effect of foliar feeding of plant growth regulators and micronutrients on Days taken to 50 % flowering and Days taken for full bloom of Ber cv. Gola

Treatments	Days taken to 50 % flowering			Days taken for full bloom		
	2023-2024	2024-2025	Pooled	2023-2024	2024-2025	Pooled
T_1: Control	12.50	12.63	12.56	25.57	25.82	25.70
T_2: GA_3 20 ppm	11.93	12.08	12.00	24.40	24.69	24.54
T_3 : NAA 30 ppm	11.10	11.28	11.19	24.90	25.30	25.10
T_4 : $ZnSO_4$ 0.5 %	10.83	10.99	10.91	25.10	25.45	25.28
T_5 : Borax 0.5 %	9.80	9.98	9.89	23.47	23.89	23.68
T_6 : GA_3 20 ppm + NAA 30 ppm	10.20	10.40	10.30	21.53	21.96	21.75
T_7 : GA_3 20 ppm + $ZnSO_4$ 0.5 %	10.03	10.25	10.14	20.90	21.36	21.13
T_8 : GA_3 20 ppm + Borax 0.5 %	8.50	8.76	8.63	19.83	20.43	20.13
T_9 : NAA 30 ppm + $ZnSO_4$ 0.5 %	9.43	9.66	9.55	21.17	21.68	21.42
T_{10} : NAA 30 ppm + Borax 0.5 %	9.00	9.25	9.13	20.00	20.56	20.28
T_{11} : $ZnSO_4$ 0.5 % + Borax 0.5 %	8.77	9.00	8.88	20.17	20.70	20.43
T_{12} : GA_3 20 ppm + NAA 30 ppm + $ZnSO_4$ 0.5 % + Borax 0.5 %	8.30	8.57	8.43	19.70	20.33	20.02
SEm±	0.14	0.16	0.48	0.32	0.36	1.02
CD at 5%	0.41	0.47	1.41	0.95	1.05	3.00

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 reduce flowering initiation time, 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 increased the number of flowers per shoot and and reduced the days taken to reach 50% flowering as well as full bloom. Additionally, it significantly improved parameters such as the fruit set and fruit retention.

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