

Original Research Article

Effect of Plant Growth Regulators and Nutrients on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola Under Semi-arid Condition of Rajasthan

ABSTRACT

Immature fruit drop during early growth stages is a common issue in ber, often caused by hormonal imbalances, embryo abortion, and adverse weather. This leads to significant fruit loss in November-December, resulting in reduced yield and profitability. Given these factors, it is essential to manage them through foliar application of plant growth regulators and nutrients and other best practices. The present experiment was carried out at Horticulture Farm, Sri Karan Narendra College of Agriculture, Jobner (Rajasthan) during two successive years i.e. 2022-23 and 2023-24 to investigate the "Effect of Plant Growth Regulators and Nutrients on Growth Parameters of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola". The research trial consisted of 10 year old ber plants, using the Randomized Block Design (RBD) and three replications, while the experiment consisted of 10 treatments comprising five levels of plant growth regulators (Control, 2, 4-D @ 10 ppm, NAA @ 40 ppm, GA₃ @ 40 ppm and Ethrel @ 25 ppm) and five levels of nutrients (control, KNO₃ @ 1.5%, ZnSO₄ @ 0.6%, FeSO₄ @ 0.6% and Borax @ 0.6%). The first foliar spray of treatments was done just after flowering (second week of September), while the second foliar spray was done 30 days after the first spray (second week of October). Results clearly indicated that among plant growth regulators, application of NAA @ 40 ppm significantly improved growth parameters viz.; gain in tree height, gain in trunk girth, gain in plant spread [E-W and N-S (cm²)] over rest of the treatments except GA₃ @ 40 ppm which was found statistically at par to NAA @ 40 ppm during experimentation. However, in case of nutrients, application of ZnSO₄ @ 0.6% significantly improved plant growth viz.; gain in plant height, gain in trunk girth and gain in plant spread [E-W and N-S (cm²)] over rest of the treatments except KNO₃ @ 1.5% which was found statistically at par to ZnSO₄ @ 0.6% during experimentation.

Keywords- Growth, Ber, Plant Growth Regulators, Nutrients, and Gola.

INTRODUCTION

The ber, or Indian jujube belongs to the genus *Ziziphus* and family Rhamnaceae which consist 50 genera and 600 species (Pareek, 1983 ; Bansali, 1975), the genus *Zizyphus* consists of 135 species of which nearly 90 species are found in the old world and whereas the 45 other species are confined to the new world. The generic name is derived from ‘Zizouf’, which is the arabic name of the fruit of *Z. lotus* Lamk. The species *Zizyphus mauritiana* Lamk. is indigenous to India and is tetraploid ($2n=4x=48$). The origin of ber is be India to South - Western Asia, where it is found under varying climatic condition. Ber is grown in India traditionally from ancient times where it has been in use for almost 4,000 years (Sharma *et al.*, 2011).

It is popularly called as poor man’s apple due to its high nutritional quality such as higher protein (0.8 g), β -carotene (70 IU), vitamin C (50-100 mg/100g pulp) contents as well as medicinal value. The ber fruit pulp is rich in carbohydrates contains 12.88% (Singh *et al.*, 2023) of which, 5.6% are sucrose, 1.5% glucose, 2.1% fructose and 1.0% starch. In some aspects, it is better than apple (Meghwal *et al.*, 2022). The growing importance countries of ber in India, China, Afghanistan, Iran, Russia, Syria, Myanmar, Australia, and the USA (Singh and Chandra, 2022). In India, ber cultivated in various part of the country particularly in arid and semi-arid regions covering 53,000 hectare area with production of 58,6000 MT with the productivity of 11.05 tonnes (Anonymous, 2022). The major ber growing states are Punjab, Uttar Pradesh, Haryana, Rajasthan, Madhya Pradesh, Bihar, Maharashtra, Assam, Andhra Pradesh, Tamil Nadu and West Bengal.

Plant growth regulators play a crucial role in coordinating developmental processes within plants. Environmental factors can influence hormone metabolism and distribution, leading to changes in growth and development. Additionally, these hormones regulate the expression of the plant's intrinsic genetic potential. The control of genetic expression by phytohormones occurs at both transcriptional and translational levels. Hormone receptors and plant growth regulators have been identified on cell membranes, highlighting their significance. The application of plant growth regulators and growth hormones has become essential in agricultural practices, particularly for fruit crops (Bhatt *et al.*, 2020).

Nutrition plays major role for the production of fruit crop. Likewise, macro as well micronutrients improve the quality and quantity of production in ber (Dalal *et al.*, 2011). Furthermore, nutrients like potassium, boron, zinc and ferrous are very important nutrients required for growth and development of plants which are pre-requisites for better production of

ber crop (Meena *et al.*, 2008; Choudhary *et al.*, 2020). Patel *et al.* (2021) reported that foliar application of nutrients plays a vital role in improving the quality and is comparatively more effective for rapid recovery of plants.

The foliar feeding of fruit trees has increased much importance in recent years, as nutrients applied through soil are needed in higher quantity because some amount leaches down and some become unavailable to the plant due to complex soil reactions. In light of this, the current study was conducted to investigate the 'Effect of Nutrients on Growth, Fruit drop and Physical attributes of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola' during 2021-2023

MATERIALS AND METHODS

Location and Climate: The field experiments were carried out at Horticulture Farm Sri Karan Narendra College of Agriculture, Jobner (Rajasthan), which is located at 26° 05' N latitude and 75° 28' E longitude. The elevation is 427 meters above sea level, and the yearly precipitation is 300 mm to 400 mm.

Planting Material: The present experiment was conducted on 75 healthy and uniform plants were selected in the orchard of Gola cultivar of ber plants of ten years old after budding. The fruit plants were planted according to square system at 6 × 6 m² distance. The each treatment of application were applied two times in a year i.e. first spray in the second week of September (after flowering) and second spray at 30 days after first spray in the second week of October until total saturation of foliage of experimental plants. The control trees were sprayed with water. However, the response of plants to these may vary depending upon the soil and agro-climatic conditions. Soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen, medium in phosphorus and potassium content. Water of this area is partially saline in nature.

Experimental details: A Randomized Block Design (RBD) and replicated thrice was used to plan the experiment and 10 treatments with five levels of plant growth regulator (control, 2, 4-D @ 10 ppm, NAA @ 40 ppm, GA₃ @ 40 ppm and Ethrel @ 25 ppm) and five levels of nutrients (control, KNO₃ @ 1.5%, ZnSO₄ @ 0.6%, FeSO₄@ 0.6% and Borax @ 0.6%). Three plants per treatment was taken.

The observations recorded on growth parameters viz., **gain in plant height** (m) was measured with the help of a graduated staff from the bottom to the top of the tree, **gain in trunk girth** (cm) was measured 30 cm above the ground level with the help **of thread (meter scale) started from the end of** the growing season and expressed as increment in trunk girth in centimetres (cm), increase in plant spread in the **N-S direction (cm²) and E-W direction (cm²)** was measured by using a measuring tape and was expressed in centimetre (cm). These parameters were measured twice in a year, before application of treatments in the month of September, 2022 and February, 2023 and again in the month of September, 2023 and February, 2024 and the difference between these periods was considered as 'gain'.

STATISTICAL ANALYSIS

To test the significance of variation in the data obtained from various growth attributes, fruit drop and physical attributes the technique of statistical analysis of variance was suggested by Fisher (1950) for Factorial Randomized Block Design. Significance of difference in the treatment effect was tested through 'F' tests at 5% level of significance and CD (critical difference) was calculated, wherever the results were significant.

RESULTS AND DISCUSSION

1. Gain In plant Height (m)

The data pertaining in table 1 revealed that the application of plant growth regulators had a notable effect on the gain in plant height for ber. The maximum gain in plant height (2.48, 2.64 m) were observed with treatment P₂ (NAA @ 40 ppm), **following by the P₃ treatment that gave (2.43 and 2.49) which** was significantly better than all other treatments during both the years respectively. This treatment (P₃) was found statistically at par to it. Further data mentioned in same table indicates that the application of various nutrients also significantly influenced the gain in plant height during course of the study. The maximum gain in plant height (2.54, 2.81 m) was observed with application of ZnSO₄ @ 0.6% (N₂). This was significantly better over all the treatments except KNO₃ @ 1.5% which was remained at par to ZnSO₄ @ 0.6% during both the years, respectively.

2. Gain in trunk girth (cm)

Data pertaining to the effect of plant growth regulators presented in Table 1 indicated that foliar application of various plant growth regulators showed significant effects on gain in trunk girth. The maximum gain in trunk girth (3.30, 3.42 cm) was recorded in treatment P₂ (NAA @ 40 ppm) followed by treatment P₃ (GA₃ @ 40 ppm) compare with control that gave minimum (2.71, 2.76 cm) under control during both years as well as in pooled mean, respectively. The per cent gain in trunk girth under treatment P₂ was found to be 22.60 per cent more as compared to control in pooled analysis. The critical examination of data presented in same table indicated that the application of nutrients also significantly increased the trunk girth during experimentation. The application of treatment N₂ (ZnSO₄ @ 0.6%) exhibited significantly maximum gain in trunk girth (3.44, 3.40 cm) over rest of the treatments except N₁ (KNO₃ @ 1.5%) which was statistically at par to it during both the years as well as in pooled analysis, respectively.

Table 1 Effect of plant growth regulators and nutrients on gain in plant height and trunk girth after pruning of ber

Treatments	Gain in plant height (m)			Gain in trunk girth (cm)		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Plant Growth Regulators						
P ₀ – Control	2.03	2.25	2.14	2.71	2.76	2.74
P ₁ - 2,4-D @ 10 ppm	2.15	2.38	2.27	2.95	3.07	3.01
P ₂ - NAA @ 40 ppm	2.48	2.64	2.56	3.30	3.42	3.36
P ₃ - GA ₃ @ 40 ppm	2.43	2.49	2.46	3.28	3.20	3.24
P ₄ - Ethrel @ 25 ppm	2.16	2.31	2.24	2.92	3.14	3.03
SEm±	0.104	0.091	0.076	0.111	0.067	0.080
CD (P=0.05)	0.296	0.259	0.217	0.315	0.191	0.227
Nutrients						
N ₀ – Control	1.98	2.06	2.02	2.61	2.71	2.66
N ₁ – KNO ₃ @ 1.5%	2.42	2.59	2.51	3.22	3.33	3.28
N ₂ – ZnSO ₄ @ 0.6%	2.54	2.81	2.67	3.44	3.40	3.42
N ₃ – FeSO ₄ @ 0.6%	2.09	2.22	2.15	2.78	2.96	2.87
N ₄ – Borax @ 0.6 %	2.21	2.41	2.31	3.11	3.19	3.15
SEm±	0.104	0.091	0.076	0.111	0.067	0.080
CD (P=0.05)	0.296	0.259	0.217	0.315	0.191	0.227

3. Increase in plant spread N-S (cm²)

It is evident from data (Table 2) that foliar application of plant growth regulators had a significant effect on increase in plant spread. The maximum increase in spread (306.53, 319.27 cm²) was recorded with foliar application of treatment P₂ (NAA @ 40 ppm) which was found statistically at par with treatment GA₃ @ 40 ppm (393.93 and 304.67 cm²) during both the years as well as in pooled mean, respectively. However, minimum increase in plant spread (250.53, 280.67 cm²) was observed under control during individual year and in pooled analysis, respectively. Data further indicated in same table that foliar applications of different nutrients also had significant increase in plant spread during experimentation. Application of Zinc sulphate @ 0.6% (N₂) recorded significantly maximum (308.33 and 330.93 cm²) increase in plant spread followed by KNO₃ @ 1.5% over rest of the treatments in pooled (302.54 and 324.67 cm²). The increase in plant spread under treatment N₂ (Zinc sulphate @ 0.6%) was recorded highest than control during both the years as well as in pooled analysis.

4. Increase in plant spread in E-W direction (cm²)

The data (Table 2) clearly indicated that foliar application of different plant growth regulators had a considerable impact on the Increase in plant spread (E-W direction). The use of NAA @ 40 (P₂) ppm resulted significantly higher increase in plant spread (E-W direction) (318.7 and 325.73 cm²) over rest of the treatments except GA₃ @ 40 ppm (313.7 and 32.92 cm²) which was statistically at par to it during course of study. This treatment registered 17.96 per cent higher plant spread than control in pooled analysis. The critical examination of data presented in table 2 indicated that the application of nutrients also significantly increased the plant spread (E-W direction) during both years and in pooled mean. The application of ZnSO₄ @ 0.6% exhibited maximum increase in plant spread (329.27 and 336.53 cm²) following by KNO₃ @ 1.5% (312.00 and 332.20 cm²) during experimentation. The increase in spread under treatment N₂ was registered 23.99 per cent higher than control in pooled analysis.

Table 2 Effect of plant growth regulators and nutrients on increase in plant spread after pruning of ber

Treatments	Increase in plant spread (N X S direction) in cm ²			Increase in plant spread (E X W direction) in cm ²		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Plant Growth Regulators						
P ₀ – Control	250.53	280.67	265.60	262.13	285.00	273.57

P ₁ - 2,4-D @ 10 ppm	270.67	285.47	277.76	292.40	311.67	302.03
P ₂ - NAA @ 40 ppm	306.53	319.27	312.90	318.87	325.73	322.30
P ₃ - GA ₃ @ 40 ppm	293.93	304.67	299.30	313.07	321.92	317.49
P ₄ - Ethrel @ 25 ppm	266.07	281.27	273.67	290.93	300.40	295.67
SEm±	13.463	9.698	6.844	8.913	8.343	6.402
CD (P=0.05)	38.281	27.577	19.460	25.342	23.723	18.203
Nutrients						
N ₀ – Control	249.47	257.13	253.30	259.07	278.40	268.73
N ₁ – KNO ₃ @ 1.5%	302.54	324.67	313.29	312.00	332.20	322.10
N ₂ – ZnSO ₄ @ 0.6%	308.33	330.93	319.63	329.27	336.53	332.90
N ₃ – FeSO ₄ @ 0.6%	253.40	267.07	260.23	276.93	293.27	285.10
N ₄ – Borax @ 0.6 %	274.00	291.53	282.77	300.13	304.32	302.23
SEm±	13.463	9.698	6.844	8.913	8.343	6.402
CD (P=0.05)	38.281	27.577	19.460	25.342	23.723	18.203

The findings of present investigation (Table 1 and 2) showed that application of different plant growth regulators significantly enhanced the growth characters of ber. Foliar apply of plant growth regulator NAA @ 40 ppm increased the gain Growth parameter (plant hight, trunk girth and plant spread) as compared to control however application of GA₃ @ 40 ppm remained at par to it in all these growth characters. NAA proved most effective in increasing vegetative although followed by GA₃. This might be due to that application of NAA that have the crucial role to stimulate cell division, cell enlargement and cell elongation in the apical region. The elongation of cell is due to increasing osmotic pressure and permeability of cytoplasm to water. It may also be due to decreasing cell wall pressure and increasing cell-wall elasticity (Iqbal *et al.* 2009). NAA increases amylase activity, membrane permeability, formation of energy rich phosphate and cell wall plasticity. NAA proved most effective in increasing vegetative characters followed by GA₃. The results are in accordance with the also findings of by Kale *et al.*, (2000), Gami (2019) and Karole and Tiwari (2016) in ber, Sharma and Tiwari (2015) in guava.

The results show that plant spread and height were increased significantly with the foliar application of nutrients. This improvement may be attributed to the synthesis of tryptophan, a precursor for auxin, which is crucial for growth and development. These findings are consistent

with those of Razzaq *et al.* (2013) and Ullah *et al.* (2012) in Kinnow mandarin. Zinc also contributes to starch formation and functions as a co-factor for enzymes such as alcoholic anhydras, carbonic anhydras, and RNA polymerase. Additionally, zinc influences nucleic acid metabolism, protein synthesis, and photosynthetic activity (Alloway, 2008). The increase in vegetative growth has been reported by Supriya *et al.* (1993) in Assam lemon, Chopra *et al.* (2023) in pant lemon, Ram and Bose (2000) in mandarin, Haque *et al.* (2000) in mandarin orange, Ahmad *et al.* (2012) in tangerine, Gurjar *et al.* (2015) in Kinnow and Chaudhary *et al.* (2016) in Kinnow mandarin.

CONCLUSION

Based on the present study conducted for two continuous years, it may be concluded that among the plant growth regulators application of NAA @ 40 ppm (P₂); amid nutrients application of KNO₃ @ 1.5 % (N₁) proved superior in respect to the growth parameters *viz.*; gain in tree height, gain in trunk girth, gain in plant spread [E-W and N-S (cm²)] of ber fruits.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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REFERENCES

Ahmed, N., Zhang, B., Chachar, Z., Li, J., Xiao, G., Wang, Q., and Tu, P. 2012. Micronutrients and their effects on horticultural crop quality, productivity and sustainability. *Scientia Horticulturae*, **323**: 112512.

Alloway, B.J. 2008. Zinc in Soils and Crop Nutrition. *International Zinc Association and International Fertilizer Association*, **16**.

Anonymous. 2022. 2nd Advance Estimate of Area and Production of Horticulture crops www.nhb.gov.in.

Bansali, A.K. 1975. Morphological study of the family Rhamnaceae of India Ph.D. University of Jodhpur, Rajasthan India.

Bhatt, D., Nath, M., Sharma, M., Bhatt, M. D., Bisht, D. S., & Butani, N. V. (2020). Role of growth regulators and phytohormones in overcoming environmental stress. *Protective chemical agents in the amelioration of plant abiotic stress: biochemical and molecular perspectives*, 254-279.

Chaudhary, P., Kaushik, R.A., Rathore, R.S., Sharma, M. and Kaushik, M.K. 2016. Improving growth, yield and quality of Kinnow mandarin through foliar application of potassium and zinc. *Indian Journal of Horticulture*, **73**(4): 597-600.

Chopra, M.L., Meena, K.K., Choudhary, R., Mahala, K. and Bhateshwar M.C. 2023. Influence of nano nitrogen and zinc sulphate on growth characteristics of lemon (*Citrus limon* L.) *The Pharma Innovation Journal*, **12**(9): 2067-2070.

Choudhary, R.B., Bairwa, L.N., Garhwal, O.P. and Negi, P. 2020. Effect of plant growth regulators and nutrients on yield attributing characters and yield of ber (*Zizyphus mauritiana* Lamk.) cv. Gola. *Journal of Pharmacognosy and Phytochemistry*, **9**(4): 1968-1972.

Dalal, R.P.S., Navjot, A.T. and Brar, J.S. 2011. Effect of foliar application of nutrients on leaf mineral composition and yield of Ber (*Zizyphus mauritiana* Lamk.) under arid conditions. *Annals of Arid Zone*, **50**(1): 53-56.

Fisher, R.A. 1950. Statistical Methods for Research Worker. Oliver and Boyd. Edinburgh.

Gami, J., Sonkar, P., Haldar, A. and Patidar, D.K. 2019. Effect of pre harvest spray of ZnSO₄, KNO₃ and NAA on growth, yield and quality of ber (*Zizyphus mauritiana* Lamk.) cv. Seb under malwa plateau conditions. *International Journal of Current Microbiology and Applied Sciences*, **8**(3): 1977-1984.

- Gurjar, M.K., Kaushik, R.A. and Baraily, P. 2015. Effect of zinc and boron on the growth and yield of Kinnow mandarin. *International Journal of Scientific Research*, **4**(4): 207-208.
- Haque, R., Roy, A. and Pramanick, M. 2000. Response of foliar application of Ca, Zn, and B on improvement of growth and yield of mandarin orange in Darjeeling hills of West Bengal. *Horticultural Journal*, **13**(2):15– 20
- Iqbal, M., Khan, M.Q., Jalal-ud-Din Khalid and Rehman, M. 2009. Effect of foliar application of NAA on fruit drop, yield and physico-chemical characteristics of guava (*Psidium guajava* L.) cultivar Red Flesh. *Journal of Agricultural Research*, **47**(3): 259-269.
- Kale, V.S., Dod, V.N., Adpawar, R.N. and Bharad, S.G. 2000. Effect of PGR on fruit characters and quality of ber. *Crop Research (Hisar)*, **20**(2): 327- 333.
- Karole, B. and Tiwari, R. 2016. Effect of pre-harvest spray of growth regulators and urea on growth, yield and quality of ber under malwa plateau conditions. *Annals of Plant and Soil Research*, **18**(1): 18-22.
- Meena, V.S., Yadav, P.K. and Meena, P.M. 2008. Yields attributes of ber (*Ziziphus mauritiana*) cv. Gola as influenced by foliar application of ferrous sulphate and borax. *Agriculture Science Digest*, **28**(3): 219-221.
- Meghwal, P.R., Singh, A. and Singh, D. 2022. Underutilized fruits and vegetables in hot arid regions of India: status and prospects: a review. *Agricultural Reviews*, **43**(1): 38-45.
- Pareek, O.P. 1983. The jujube. *Indian Council of Agricultural Research, New Delhi*, 71.
- Patel, M.V., Parmar, B.R., Bhandari, D.R., Christian, H.J. and Surela, V.A. 2021. Effect of foliar application of nutrient sources on fruit quality of sapota cv. Kalipatti. *The Pharma Innovation Journal*, **10**(7): 830-833.
- Ram, R. A. and Bose, T.K. 2000. Effect of foliar application of magnesium and micro-nutrients on growth, yield and fruit quality of mandarin orange (*Citrus reticulata* Blanco). *Indian journal of Horticulture*, **57**(3): 215-220.
- Razzaq, K., Khan, A.S., Malik, A.U., Shahid, M. and Ullah, S. 2013. Foliar application of zinc influence leaf mineral status, vegetative and reproductive growth, yield and fruit quality of Kinnow mandarin. *Journal Plant Nutrition*, **36**: 1479-1495.
- Sharma, J., Sharma, S.K., Panwar, R.D. and Gupta, R.S. 2011. Fruit retention, yield and leaf nutrient content of ber as influence by foliar application of nutrient and growth regulators. *Environment and Ecology*, **29**:627-631.

- Sharma, R.A. and Tiwari, R. 2015. Effect of growth regulator sprays on growth, yield, and quality of guava under Malwa Plateau conditions. *Ann. Plant Soil Res.*, **17**(3): 287-291.
- Singh D. and Chandra Y.S. 2022. Effect of Foliar Application of NAA on Yield and Economics of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola. *International Journal of Agriculture Sciences*, **14**(12): 12093-12095.
- Singh, R., Pathak, S., Pandey, L. and Kumar, A. 2023. Effect of plant growth regulators and micro-nutrient on quality of Ber (*Zizyphus mauritiana* Lamk.) cv. Gola. *International Journal of Plant & Soil Science*, **35**(18): 909-916.
- Supriya, L., Bhattacharya, R.K. and Langthasa, S. 1993. Effect of foliar application of chelated and non-chelated Zinc on growth and yield of Assam lemon. *Department of Horticulture Assam Agriculture University, India*, Pp- 43-44.
- Ullah, S., Khan, A.S., Malik, A.U., Afzal, I., Shahid, M. and Razzaq, K. 2012. Foliar application of boron influences the leaf mineral status, vegetative and reproductive growth, yield and fruit quality of 'kinnow' mandarin (*Citrus reticulata* Blanco.). *J. Plant Nutri.*, **35**(13): 2067-2079