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

Sonali Choudhary [a], K.K. Meena [b], O.P. Garhwal [a], M.K. Sharma [a], S.K. Dadhich [b], S.S. Rajput [b], Mahendra Choudhary [c*] and Kalpana Choudhary [d]

[a] SKNAU, Jobner, Jaipur, Rajasthan, India.
[b] RARI, Durgapura, Jaipur, Rajasthan, India.
[c] GB Pant University of Agriculture and Technology, Pantnagar, UK, India.
[d] Agriculture University, Jodhpur, Rajasthan, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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**Corresponding author: E-mail: mcrchoudhary99@gmail.com;*

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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 nurtients 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 expeirment consisted of 10 treatments comprising five levels of plant growth regulators (Control, 2, 4-D @ 10 ppm, NAA @ 40 ppm, GA_3 @ 40 ppm and Ethrel @ 25 ppm) and five levels of nutrients (control, KNO_3 @ 1.5%, $ZnSO_4$ @ 0.6%, $FeSO_4$ @ 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 (cm^2)] over rest of the treatments except GA_3 @ 40 ppm which was found statistically at par to NAA @ 40 ppm during experimentation. However, in case of nutrients, application of $ZnSO_4$ @ 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 (cm^2)] over rest of the treatments except KNO_3 @ 1.5% which was found statistically at par to $ZnSO_4$ @ 0.6% during experimentation.

Keywords: Growth; ber; plant growth regulators; nutrients; gola.

1. 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

2. 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 260 05' N latitude and 750 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 m^2 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, GA_3 @ 40 ppm and Ethrel @ 25 ppm) and five levels of nutrients (control, KNO_3 @ 1.5%, $ZnSO_4$ @ 0.6%, $FeSO_4$@ 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 (cm^2) and E-W direction (cm^2) 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'.

2.1 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.

3. RESULTS AND DISCUSSION

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 P_2 (NAA @ 40 ppm), following by the P_3 treatment that gave (2.43 and 2.49) which was significantly better than all other treatments during both the years respectively. This treatment (P_3) was found statistically at par to it. Further data mentioned in same Table 1 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 $ZnSO_4$ @ 0.6% (N_2). This was significantly better over all the treatments except KNO_3 @ 1.5% which was remained at par to $ZnSO_4$ @ 0.6% during both the years, respectively.

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 P_2 (NAA @ 40 ppm) followed by treatment P_3 (GA_3 @ 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 P_2 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 1 indicated that the application of nutrients also significantly increased the trunk girth during experimentation. The application of treatment N_2 ($ZnSO_4$ @ 0.6%) exhibited significantly maximum gain in trunk girth (3.44, 3.40 cm) over rest of the treatments except N_1 (KNO_3 @ 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)		
Plant Growth Regulators	**2022-23**	**2023-24**	**Pooled**	**2022-23**	**2023-24**	**Pooled**
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

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		
Plant Growth Regulators	**2022-23**	**2023-24**	**Pooled**	**2022-23**	**2023-24**	**Pooled**
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

Increase in plant spread N-S (cm^2): 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 cm^2) was recorded with foliar application of treatment P_2 (NAA @ 40 ppm) which was found statistically at par with treatment GA_3 @ 40 ppm (393.93 and 304.67 cm^2) during both the years as well as in pooled mean, respectively. However, minimum increase in plant spread (250.53, 280.67 cm^2) was observed under control during individual year and in pooled analysis, respectively. Data further indicated in same Table 2 that foliar applications of different nutrients also had significant increase in plant spread during experimentation. Application of Zinc sulphate @ 0.6% (N_2) recorded significantly maximum (308.33 and 330.93 cm^2) increase in plant spread followed by KNO_3 @ 1.5% over rest of the treatments in pooled (302.54 and 324.67 cm^2). The increase in plant spread under treatment N_2 (Zinc sulphate @ 0.6%) was recorded highest than control during both the years as well as in pooled analysis.

Increase in plant spread in E-W direction (cm^2): 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 (P_2) ppm resulted significantly higher increase in plant spread (E-W direction) (318.7 and 325.73 cm^2) over rest of the treatments except GA_3 @ 40 ppm (313.7 and 32.92 cm^2) 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 $ZnSO_4$ @ 0.6% exhibited maximum increase in plant spread (329.27 and 336.53 cm^2) following by KNO_3 @ 1.5% (312.00 and 332.20 cm^2) during experimentation. The increase in spread under treatment N_2 was registered 23.99 per cent higher than control in pooled analysis.

The findings of present investigation (Tables 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 GA_3 @ 40 ppm remained at par to it in all these growth characters. NAA proved most effective in increasing vegetative although followed by GA_3. 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 GA_3. 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.

4. 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 (P_2); amid nutrients application of KNO_3 @ 1.5 % (N_1) 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 (cm^2)] 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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