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Harshvardhan Kanwar
M.Sc. Scholar, Department of
Horticulture, Suresh Gyan
Vihar University, Jaipur,
Rajasthan, India

Usha Shukla
Assistant Professor,
Department of Horticulture,
School of Agriculture, Suresh
Gyan Vihar University,
Jaipur, Rajasthan, India

Dipayan Sarkar
Assistant Professor,
Department of Horticulture,
School of Agriculture, Suresh
Gyan Vihar University,
Jaipur, Rajasthan, India

Manoj Kumar Bundela
Assistant Professor,
Department of Horticulture,
School of Agriculture, Suresh
Gyan Vihar University,
Jaipur, Rajasthan, India

Laxman Singh Dhayal
Professor, Department of
Genetics and Plant Breeding,
School of Agriculture, Suresh
Gyan Vihar University,
Jaipur, Rajasthan, India

Corresponding Author:
Usha Shukla
Assistant Professor,
Department of Horticulture,
School of Agriculture, Suresh
Gyan Vihar University,
Jaipur, Rajasthan, India

Effect of plant growth regulators and nutrients on growth, yield and quality attributes of Ber (*Ziziphus mauritiana* Lamk.)

Harshvardhan Kanwar, Usha Shukla, Dipayan Sarkar, Manoj Kumar Bundela and Laxman Singh Dhayal

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Abstract

The present investigation was conducted at the Agricultural Research Farm, Suresh Gyan Vihar University, Jaipur to study the effect of plant growth regulators and nutrients on growth, yield and quality attributes of ber (*Ziziphus mauritiana* Lamk.). The experiment was laid out in factorial randomized block design with two factors viz. first factor: Plant growth regulators (5 levels, NAA and GA₃ @ 25 and 50ppm) and second factor: nutrients (5 levels, borax and zinc @ 0.2 and 0.4%) replicated thrice. The observed data was analyzed in OPSTAT. The results revealed significant differences among the treatments. Among the treatment combination, GA₃ @ 50 ppm + ZnSO₄ @ 0.4% (N₄P₄) recorded the maximum fruit length of 3.94, maximum fruit length of 3.317 cm, maximum number of fruits per tree of 648.568, maximum fruit weight of 43.75g, maximum fruit yield per tree of 28.53 kg, maximum total soluble solids of 16.08 °Brix, maximum total sugar of 12.18%, ascorbic acid content of 114.60 mg/100 g, highest returns and maximum B:C ratio whereas the minimum was observed in control. Although these results are only indicative and require further experimentation to arrive at more consistent and credible conclusion, the treatment GA₃ @ 50 ppm + ZnSO₄ @ 0.4% (N₄P₄) may be recommended for obtaining higher yield and superior quality of Ber.

Keywords: Ber (*Ziziphus mauritiana*), Gibberellic acid (GA₃), zinc sulphate (ZnSO₄), plant growth regulators, fruit yield, fruit quality

Introduction

Indian jujube, sometimes known as "poor man's fruit," is a hardy fruit crop that has been grown for centuries in semi-arid and tropical regions of Africa, China, and India. Ber is a well-known member of the Rhamnaceae family because it can withstand extreme heat, drought, and salt, three of the most common environmental stresses that kill off most fruit crops. It is deciduous and highly resistant to frost. Its draught hardiness, xerophytic nature, tolerance to salt (40 ESP and 12-15 dSm⁻¹), deep tap root system, spiny nature and ability to shed its leaves during hot summer have helped the plant to adopt well to the arid and semi-arid conditions (Singh and Kumar, 2017) [1]. The cultivation of ber crop is gaining popularity in many parts of India such as Rajasthan, Haryana, Uttar Pradesh, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamilnadu. In the world, China is the largest producer of ber and India holds second rank. India occupies an area of 53000 hectares with an annual production of 586000 MT per year in India (Anonymous, 2024) [2]. It is also grown in other countries like Iran, Syria, Australia, USA, France, Italy, Spain, and Africa. Ber can be grown on variety of soils including marginal soil and various kinds of waste land situation such as sodic saline soil, ravines, arid, semi-arid region. Crop growth and fruit quality are all heavily influenced by macro and micronutrients. Nutrients such as potassium (K), phosphorus (P), and nitrogen (N) are essential for the metabolic processes and growth of plants. Chlorophyll production, protein synthesis, and vegetative growth are all dependent on nitrogen. The growth and development of ber trees involve several complex physiological processes which are highly influenced by external inputs like PGRs and nutrients. Flowering in ber is often asynchronous and irregular, leading to heavy fruit drop and low fruit set. PGRs such as NAA, 2,4-D, and GA₃ have been used successfully to regulate these processes by improving fruit retention and fruit growth.

Materials and Methods

The present study was conducted on the Agricultural Research Farm, Department of Horticulture, School of Agriculture at Suresh Gyan Vihar University, Jaipur (Rajasthan) during 2025-26. Variety Gola was selected for this study and it was laid out in Factorial Randomized Block Design of two factors which were first factor: Plant growth regulators with 5 levels viz. control (P_0), NAA @ 25 PPM (P_1), NAA @ 50 PPM (P_2), GA_3 @ 25PPM (P_3) and GA_3 @ 50 PPM (P_4) and second factor with five levels viz. Control (N_0), Borax @ 0.2% (N_1), Borax @ 0.4% (N_2), $ZnSO_4$ @ 0.2% (N_3) and $ZnSO_4$ @ 0.4% (N_4) replicated thrice. On October 15th, the PGR and micro-nutrient spray was applied, and on November 15th, the second spray was applied. The observed data was analyzed in OPSTAT.

Results and Discussion

The results showed that plant growth regulators and nutrients had a significant effect on growth, yield and quality of Ber. Among the different treatments, maximum fruit length (3.940 cm), fruit diameter (3.317 cm) were recorded with treatment N_4P_4 (GA_3 @ 50 ppm X $ZnSO_4$ @ 0.4%) (Table 1). The findings in line with Devi *et al.* (2019) who reported that foliar application of GA_3 gave best result in term of fruit set of ber (*Ziziphus mauritiana* Lamk.) cv. Banarasi Karaka. Similar results were obtained by Rathod *et al.* (2019) [4] in aonla (*Emblica officinalis* Gaertn.) cv. Gujarat Aonla. Gill and Bal (2009) [3] stated that reductions in fruit drop and increase in fruit size of ber (*Ziziphus mauritiana* Lamk) and Kaur (2021) [5] stated that application of 50 ppm GA_3 increased the fruit setting, fruit retention and size in Litchi. Yadav *et al.* (2014) [6] also recorded highest fruit size and set with (15 ppm NAA + 20 ppm GA_3 + 1.5% urea) in ber. Among the different treatments parameters related to fruit yield like fruit yield per tree (kg), average fruit weight (gm), number of fruit per tree were recorded maximum with treatment N_4P_4 (GA_3 @ 50 ppm X $ZnSO_4$ @ 0.4%) (Table 1, 2). Result found in conformity with Sharma *et al.* (2017) [1] who reported that application of GA_3 @ 50 ppm recorded significantly higher fruit yield (83.27kg/plant) in Aonla cv. NA-7. Sultana *et al.* (2016) [7] observed highest fruit yield (121.67 quintal/ha) of litchi by foliar application of NAA at 20 ppm similar finding observed Kundu and Ghosh (2017) [8]. Among the different treatments best results of quality attributes of fruits i.e. acidity (%), total soluble solids, total sugars and ascorbic acid (mg/100 g) were recorded with treatment N_4P_4 (GA_3 @ 50 ppm X $ZnSO_4$ @ 0.4%) (Table 3). The results corroborated with the findings of Singh (1973) [9] who recorded the highest TSS in the fruits of ber cv. Banarasi Karaka with application of growth regulators. Bal *et al.* (1982) [10] reported that application of plant growth regulators had significant positive effect on TSS contents of ber fruits. The increase in ascorbic acid content may have resulted owing to enhance synthesis of ascorbic acid, due to favorable metabolic activity involving certain enzymes and metallic ions under the influence of plant growth regulators and micronutrients. An Increase in ascorbic acid content might be due to perpetual synthesis of glucose-6-phosphate throughout the growth and development of fruits which is thought to be the precursor of vitamin C (Bhadauria *et al.*, 2018) [11]. The application of GA_3 and zinc results an increase in ascorbic acid content in ber cv. Gola. (Rathore and Chandra, 2002) [12] in ber cv. Gola. Among all

treatments, T_{24} recorded the maximum gross income of Rs 243,771/ha, net income of Rs 167,971/ha and highest benefit: cost ratio of 2.22, while T_0 (control) recorded the minimum values with gross income of Rs 170,202/ha, net income of Rs 101,202/ha and B:C ratio of 1.47. Among NAA treatments, T_{14} (NAA @ 50 ppm × $ZnSO_4$ @ 0.4%) recorded highest gross income of Rs 236,853/ha, net income of Rs 161253/ha and B:C ratio of 2.13, while among GA_3 treatments, T_{22} (GA_3 @ 50 ppm × Borax @ 0.4%) recorded highest gross income of Rs 240,713/ha, net income of Rs 165513/ha and B:C ratio of 2.20 (Table 10). The treatments T_{22} and T_{24} were found most remunerative giving highest returns and maximum B:C ratio (>2) indicating their economic feasibility for ber cultivation.

Table 1: Effect of Plant Growth Regulators and Micronutrients foliar spray on fruit length (cm), fruit diameter (cm) and number of fruits per tree of Ber cv. Gola

Factors	Fruit length (cm)	Fruit diameter (cm)	Number of fruits per tree
P_0	3.211	2.844	593.471
P_1	3.695	3.079	620.557
P_2	3.848	3.265	637.641
P_3	3.721	3.072	625.164
P_4	3.875	3.193	642.682
C.D. at 5%	0.138	0.173	26.759
SE(m) ±	0.048	0.06	9.382
N_0	3.411	2.992	611.449
N_1	3.683	3.061	622.618
N_2	3.75	3.125	627.555
N_3	3.717	3.109	626.224
N_4	3.789	3.166	631.667
C.D. at 5%	0.138	0.173	26.759
SE(m) ±	0.048	0.06	9.382
$P_0 \times N_0$	2.3	2.75	564.297
$P_0 \times N_1$	3.38	2.82	595.342
$P_0 \times N_2$	3.447	2.88	599.976
$P_0 \times N_3$	3.413	2.85	600.659
$P_0 \times N_4$	3.517	2.92	607.081
$P_1 \times N_0$	3.593	2.95	612.076
$P_1 \times N_1$	3.653	3.01	618.396
$P_1 \times N_2$	3.727	3.08	623.085
$P_1 \times N_3$	3.697	3.142	621.658
$P_1 \times N_4$	3.803	3.214	627.57
$P_2 \times N_0$	3.757	3.193	630.424
$P_2 \times N_1$	3.833	3.245	635.928
$P_2 \times N_2$	3.903	3.317	640.617
$P_2 \times N_3$	3.863	3.275	638.375
$P_2 \times N_4$	3.883	3.296	642.86
$P_3 \times N_0$	3.623	2.98	615.949
$P_3 \times N_1$	3.697	3.05	622.677
$P_3 \times N_2$	3.757	3.11	628.385
$P_3 \times N_3$	3.727	3.08	626.55
$P_3 \times N_4$	3.803	3.14	632.259
$P_4 \times N_0$	3.78	3.087	634.501
$P_4 \times N_1$	3.853	3.18	640.747
$P_4 \times N_2$	3.917	3.24	645.714
$P_4 \times N_3$	3.883	3.2	643.879
$P_4 \times N_4$	3.94	3.26	648.568
C.D. at 5%	0.309	0.38	59.643
SE(m) ±	0.108	0.135	20.978
CV (%)	6.06	7.58	5.8

Table 2: Effect of Plant Growth Regulators and Micronutrients foliar spray on average fruit weight (g), fruit yield per tree (kg) and acidity (%) of Ber cv. Gola

Factors	Average fruit weight (g)	Fruit yield per tree (kg)	Acidity (%)
P ₀	36.1	21.338	0.35
P ₁	39.26	24.256	0.295
P ₂	42.34	26.866	0.249
P ₃	40.92	25.624	0.284
P ₄	43.06	27.824	0.236
C.D. at 5%	1.635	1.165	0.013
SE(m) ±	0.573	0.408	0.005
N ₀	39	23.91	0.303
N ₁	40.01	24.798	0.291
N ₂	41.02	25.796	0.274
N ₃	40.31	25.27	0.282
N ₄	41.34	26.134	0.263
C.D. at 5%	1.635	1.165	0.013
SE(m) ±	0.573	0.408	0.005
P ₀ X N ₀	35.2	20.07	0.379
P ₀ X N ₁	35.95	20.87	0.358
P ₀ X N ₂	36.4	21.87	0.337
P ₀ X N ₃	36.1	21.6	0.348
P ₀ X N ₄	36.85	22.28	0.327
P ₁ X N ₀	37.6	22.91	0.316
P ₁ X N ₁	38.1	23.45	0.305
P ₁ X N ₂	40.85	25.34	0.284
P ₁ X N ₃	38.55	23.85	0.295
P ₁ X N ₄	41.2	25.73	0.274
P ₂ X N ₀	41.6	26.1	0.263
P ₂ X N ₁	42.1	26.64	0.253
P ₂ X N ₂	42.75	27.25	0.242
P ₂ X N ₃	42.35	26.9	0.253
P ₂ X N ₄	42.9	27.44	0.232
P ₃ X N ₀	38.4	23.55	0.305
P ₃ X N ₁	41.05	25.44	0.295
P ₃ X N ₂	41.7	26.34	0.274
P ₃ X N ₃	41.45	26.1	0.284
P ₃ X N ₄	42	26.69	0.263
P ₄ X N ₀	42.2	26.92	0.253
P ₄ X N ₁	42.85	27.59	0.242
P ₄ X N ₂	43.4	28.18	0.232
P ₄ X N ₃	43.1	27.9	0.232
P ₄ X N ₄	43.75	28.53	0.221
C.D. at 5%	3.64	2.6	0.03
SE(m) ±	1.282	0.913	0.01
CV (%)	5.49	6.28	6.64

Table 3: Effect of Plant Growth Regulators and Micronutrients foliar spray on Total soluble solids (⁰Brix), total sugar (%) and ascorbic acid (mg/100 g) of Ber cv. Gola

Factors	Total soluble solids (⁰ Brix)	Total sugar (%)	Ascorbic acid (mg/100 g)
P ₀	13.27	9.978	82.7
P ₁	14.494	10.985	94.24
P ₂	15.604	11.796	108.02
P ₃	14.64	10.956	96.953
P ₄	15.7	11.868	109.233
C.D. at 5%	0.331	0.293	1.511
SE(m) ±	0.116	0.103	0.53
N ₀	14.298	10.731	93.06
N ₁	14.58	10.994	96.753
N ₂	14.934	11.31	100.66
N ₃	14.756	11.134	98.013
N ₄	15.14	11.413	102.66
C.D. at 5%	0.331	0.293	1.511
SE(m) ±	0.116	0.103	0.53
P ₀ X N ₀	12.8	9.608	78.2
P ₀ X N ₁	13.1	9.826	81.4
P ₀ X N ₂	13.45	10.126	84.6
P ₀ X N ₃	13.28	9.986	83.2
P ₀ X N ₄	13.72	10.346	86.1
P ₁ X N ₀	14.05	10.566	89.4
P ₁ X N ₁	14.32	10.846	92.6
P ₁ X N ₂	14.68	11.326	96.4
P ₁ X N ₃	14.5	10.986	94.2
P ₁ X N ₄	14.92	11.2	98.6
P ₂ X N ₀	15.18	11.42	102.3
P ₂ X N ₁	15.46	11.68	106.4
P ₂ X N ₂	15.82	11.96	110.8
P ₂ X N ₃	15.6	11.82	108.2
P ₂ X N ₄	15.96	12.1	112.4
P ₃ X N ₀	14.2	10.58	91.2
P ₃ X N ₁	14.48	10.86	95.26
P ₃ X N ₂	14.84	11.12	99.3
P ₃ X N ₃	14.66	10.98	97.4
P ₃ X N ₄	15.02	11.24	101.6
P ₄ X N ₀	15.26	11.48	104.2
P ₄ X N ₁	15.54	11.76	108.1
P ₄ X N ₂	15.88	12.02	112.2
P ₄ X N ₃	15.74	11.9	107.06
P ₄ X N ₄	16.08	12.18	114.6
C.D. at 5%	0.74	0.652	3.37
SE(m) ±	0.26	0.28	1.18
CV (%)	3.05	3.58	2.09

Table 4: Economic analysis of the treatments

Treatment	Total cost (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	BC ratio
T ₀	69,000	170,202	101,202	1.47
T ₁	69,800	183,584	113,784	1.63
T ₂	70,400	189,436	119,036	1.69
T ₃	70,000	185,959	115,959	1.66
T ₄	70,800	191,948	121,148	1.71
T ₅	71,200	197,561	126,361	1.77
T ₆	72,000	202,318	130,318	1.81
T ₇	72,600	218,352	145,752	2.01
T ₈	72,400	205,844	133,444	1.84
T ₉	73,200	221,854	148,654	2.03
T ₁₀	73,600	225,079	151,479	2.06
T ₁₁	74,400	229,829	155,429	2.09
T ₁₂	75,000	235,182	160,182	2.14
T ₁₃	74,800	232,115	157,315	2.10
T ₁₄	75,600	236,853	161,253	2.13
T ₁₅	71,400	203,134	131,734	1.85
T ₁₆	72,200	219,295	147,095	2.04
T ₁₇	72,800	224,871	152,071	2.09
T ₁₈	72,600	222,838	150,238	2.07
T ₁₉	73,400	227,923	154,523	2.11
T ₂₀	73,800	229,846	156,046	2.11
T ₂₁	74,600	235,643	161,043	2.16
T ₂₂	75,200	240,713	165,513	2.20
T ₂₃	75,000	238,332	163,332	2.18
T ₂₄	75,800	243,771	167,971	2.22

Conclusion

The ber (*Ziziphus mauritiana* L.), commonly referred to as Indian jujube, has long been recognized as a hardy fruit tree well adapted to arid and semi-arid climates, with its economic and nutritional significance steadily increasing in recent decades. From the present study it can be concluded that application of plant growth regulators (PGRs) like GA₃ @ 50 ppm and nutrients like ZnSO₄ @ 0.04% enhanced not only the vegetative performance of Ber trees but also their reproductive efficiency and fruit quality traits and benefit cost ratio.

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