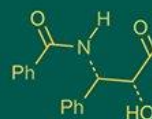


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(8): 261-265
www.biochemjournal.com
Received: 08-05-2026
Accepted: 12-06-2026

Kapil Dev
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Chandan Singh
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Arun Sahu
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Mandvi Srivastava
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Raghubeer Singh
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Corresponding Author:
Chandan Singh
School of Agriculture Science,
Vikrant University, Chitora
Road, Gwalior, Madhya
Pradesh, India

Effect of integrated nutrient management on growth, yield and quality of Ber (*Ziziphus mauritiana* Lamk.) cv. Umran

Kapil Dev, Chandan Singh, Arun Sahu, Mandvi Srivastava and Raghubeer Singh

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8Sd.9436>

Abstract

A field experiment was conducted on bearing-age ber (*Ziziphus mauritiana* Lamk.) trees of cv. Umran at Agriculture Research and Development Centre, Sakatpura, School of Agriculture Science, Vikrant University, Gwalior, Madhya Pradesh to study the effect of integrated nutrient management (INM) on growth, yield and fruit quality. The experiment comprised ten treatments laid out in a Randomised Block Design (RBD) with three replications. Treatments included an absolute control (T_1), 100% recommended dose of fertilizer (RDF) as chemical NPK (T_2), and eight INM combinations incorporating farmyard manure (FYM), vermicompost (VC), biofertilizers (*Azotobacter* + PSB) and foliar micronutrients ($ZnSO_4$ 0.5% + borax 0.2%) with varying proportions of chemical NPK. The comprehensive INM treatment T_{10} (75% NPK + FYM 25 kg/tree + *Azotobacter* + PSB + foliar $ZnSO_4$ + borax) recorded the maximum plant height (4.18 m), shoot length (25.4 cm), leaf area (13.2 cm²) and SPAD value (39.4). T_{10} gave the highest initial fruit set (38.6%), minimum fruit drop (29.6%), maximum yield per plant (50.0 kg; 78.0 q/ha) and premium fruit weight (26.8 g). Fruit quality was also best under T_{10} : TSS 16.4°Brix, TSS:acid ratio 37.3 and ascorbic acid 84.2 mg/100 g. Leaf analysis revealed subclinical zinc deficiency (10.2 ppm) even under 100% chemical NPK, confirming the criticality of micronutrient correction on calcareous MP soils. Post-harvest soil organic carbon was maximum (0.48%) in T_{10} vs. 0.30% in T_2 . Economically, T_{10} gave the highest net return (₹2,43,600/ha) and benefit:cost ratio (4.56). The treatment T_{10} is recommended as the most productive, highest-quality and most profitable nutrient management package for ber cultivation under Madhya Pradesh conditions.

Keywords: Ber, *Ziziphus mauritiana*, INM, farmyard manure, vermicompost, *Azotobacter*, zinc, boron and fruit quality

1. Introduction

Ber (*Ziziphus mauritiana* Lamk.), the Indian jujube, is one of the hardiest and most economically important arid-zone fruit crops of the Indian subcontinent. It belongs to the family Rhamnaceae and is cultivated extensively across the semi-arid and sub-humid tracts of Rajasthan, Madhya Pradesh, Gujarat, Uttar Pradesh and Maharashtra. The crop is uniquely adapted to hot, dry climates, alkaline and calcareous soils, and rainfed conditions, making it the fruit crop of choice for marginal and degraded land in the drylands of central India (Pareek, 2001) [21]. Nutritionally, ber fruits are a rich source of ascorbic acid (65-90 mg/100 g), dietary sugars, calcium and iron, making them an important component of the diet of rural communities in dryland regions where fresh fruit diversity is limited (Goyal & Singh, 2001) [9]. Madhya Pradesh ranks second in ber production nationally, with approximately 89,400 hectares under cultivation and an annual output of 1,98,700 metric tonnes. Despite this scale, the average productivity of 2.22 t/ha is well below the genetic potential (NHB, 2022-23; MPDA, 2021) [18, 17]. Among the principal yield-limiting factors, imbalanced and unscientific nutrient management is foremost. The calcareous, alkaline soils of MP's major ber-growing districts (Chambal valley, Vindhyan plateau) are characteristically low in organic carbon (<0.5%), available nitrogen, phosphorus, and the micronutrients zinc and boron, which are deficient in the majority of commercial orchards (Shukla & Dhake, 2006) [26]. Conventional management in most orchards relies on chemical fertilizers alone, without organic matter

supplementation or micronutrient correction — an approach that addresses macronutrient deficiency but leaves soil health, micronutrient status and biological fertility largely unaddressed.

Integrated Nutrient Management (INM) — the balanced, complementary use of chemical fertilizers, organic manures, biofertilizers and micronutrient supplements — has been recommended as the most sustainable approach to orchard fertility management (Roy *et al.*, 2006; Tandon, 2005) [24, 32]. Research in several states has confirmed that INM combining 75% of the recommended chemical NPK with FYM or vermicompost, biofertilizer inoculants (*Azotobacter* + PSB) and foliar micronutrient sprays can achieve or exceed the yield of 100% chemical NPK while improving soil health, fruit quality and farm profitability (Kumari *et al.*, 2015; Mishra & Singh, 2010; Singh *et al.*, 2012) [13, 16, 30]. However, location-specific evidence for Madhya Pradesh's specific soil and agro-climatic conditions has been lacking. The present investigation was therefore designed to evaluate ten INM treatment combinations for their effect on the growth, yield, fruit quality, leaf nutrient status, post-harvest soil fertility and economics of ber cv. Umran under MP conditions, with the objective of identifying the most productive and economically optimal INM package for adoption by the state's ber growers.

2. Materials and Methods

The field experiment was conducted during 2024-25 on seven-year-old, bearing-age ber trees of cv. Umran at Agriculture Research and Development Centre, Sakatpura, School of Agriculture Science, Vikrant University, Gwalior, Madhya Pradesh. The experimental soil was sandy loam (pH 7.82; EC 0.42 dS/m; organic carbon 0.28%; available N 148.4, P 14.2, K 182.4 kg/ha; DTPA-Zn 0.42 ppm, hot-water-soluble B 0.38 ppm) — characteristic of the Vindhyan plateau ber-growing zone. The experiment was laid out in a Randomised Block Design (RBD) with ten treatments and three replications (one tree per experimental unit; planting density 156 trees/ha; 8 × 8 m spacing). The Recommended Dose of Fertilizer (RDF) was N:P₂O₅:K₂O = 750:250:500 g/tree/year (Pareek, 2001; Chadha, 2001) [21].

Organic manures (FYM and vermicompost), the full dose of phosphorus and potassium, and 50% of nitrogen were applied as a basal dressing in the drip-line trench in late June. The remaining 50% nitrogen was applied as a top dressing at initial fruit set (~30 days after full bloom). Biofertilizer inoculants (*Azotobacter chroococcum* + *Bacillus megaterium* PSB; carrier-based, $\geq 1 \times 10^7$ CFU/g) were mixed with organic manure and applied alongside the basal dressing. Foliar sprays of ZnSO₄ (0.5%) and borax

(0.2%) were applied at pre-flowering and 30 days after fruit set using a knapsack sprayer. All cultural operations (pruning, irrigation, weeding, plant protection) were uniform across treatments.

Observations were recorded on eight vegetative growth parameters, three flowering behaviour parameters, three fruit set and retention parameters, seven yield parameters, seven physico-chemical quality parameters, five leaf nutrient parameters and eight post-harvest soil fertility parameters, following standard procedures. TSS was measured by hand refractometer; acidity by NaOH titration; total and reducing sugars by the Lane and Eynon method; ascorbic acid by DCPIP dye titration; all procedures as per AOAC (2000) [6] and Ranganna (1986) [22]. Leaf macronutrients were determined after Kjeldahl digestion; micronutrients by AAS (AOAC, 2000) [6]. Soil parameters were determined by standard methods: pH by glass electrode (Jackson, 1973) [11]; available N by alkaline permanganate (Subbiah & Asija, 1956) [31]; available P by Olsen's method (Olsen *et al.*, 1954) [19]; available K by flame photometry; available Zn by DTPA extraction (Lindsay & Norvell, 1978) [14]; available B by hot-water extraction (Berger & Truog, 1939) [7]. Statistical analysis was performed using ANOVA for RBD; treatment means were compared by the Critical Difference (CD) at 5% significance (Panse & Sukhatme, 1985) [20].

3. Results and Discussion

Vegetative Growth Parameters, all vegetative growth parameters showed highly significant responses to the INM treatments (Table 2). Plant height ranged from 3.42 m (T₁) to 4.18 m (T₁₀). The 100% chemical NPK treatment (T₂) gave a plant height of 3.86 m, while T₁₀ was 8.3% superior to T₂, demonstrating that INM integration produces measurable improvements in canopy development beyond what chemical fertilization alone can achieve.

Shoot length ranged from T₁₀ (25.4) followed by T₇ (23.6) and T₈ (23.2) the most directly relevant vegetative parameter for ber productivity, as flowers and fruits are borne exclusively on new shoots, Leaf area highest recorded in T₁₀ (13.2) followed by T₇ (12.4) and T₈ (12.2), SPAD value highest recorded in T₁₀ (39.4) followed by T₇ (37.6) and T₈ (37.2), Trunk girth highest recorded in T₁₀ (32.6) followed by T₇ (31.8) and T₈ (31.6), Number of branch Trunk girth highest recorded in T₁₀ (9.0) followed by T₇ (8.6) and T₈ (8.4) reflecting the combined effect of improved nitrogen supply (from biofertilizer-fixed N and organic N mineralisation), better soil physical condition improving root activity, and zinc-stimulated chlorophyll synthesis.

Table 1: Effect of INM treatments on vegetative growth parameters of ber cv. Umran

Treatments	Plant height (m)	Shoot length (cm)	Leaf area (cm ²)	SPAD value	Trunk girth (cm)	No. of branch
T ₁	3.42	14.2	8.2	28.4	24.6	5.8
T ₂	3.86	19.4	10.8	33.6	28.4	7.4
T ₃	3.94	21.2	11.4	35.2	29.8	7.8
T ₄	3.98	21.8	11.6	35.8	30.4	8.0
T ₅	3.96	21.4	11.5	35.4	30.2	7.9
T ₆	4.02	22.4	11.9	36.4	31.0	8.2
T ₇	4.08	23.6	12.4	37.6	31.8	8.6
T ₈	4.06	23.2	12.2	37.2	31.6	8.4
T ₉	4.04	22.8	12.1	37.0	31.2	8.3
T ₁₀	4.18	25.4	13.2	39.4	32.6	9.0
CD 5%	0.14	0.82	0.42	1.24	0.84	0.32
SEm±	0.05	0.28	0.14	0.43	0.29	0.11

Means of three replications. CD = Critical Difference at 5% significance; SEm = Standard Error of Mean

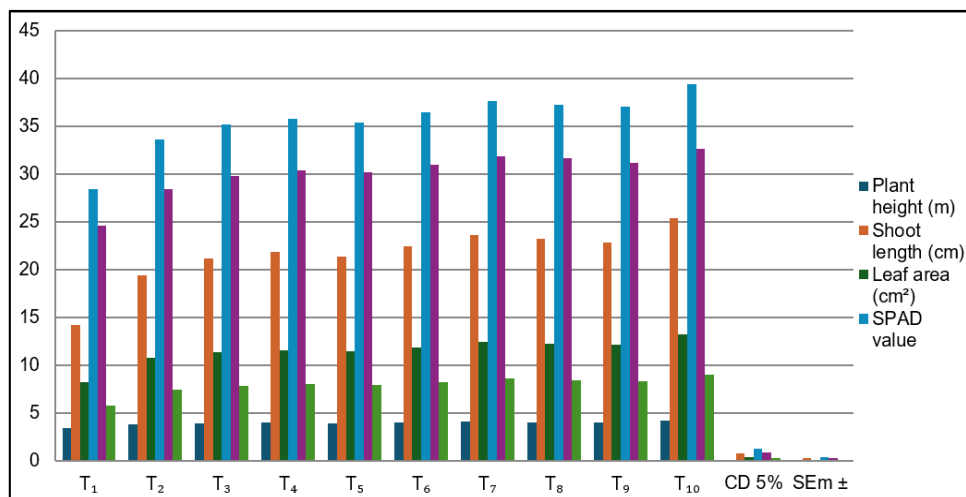


Fig 1: Effect of INM treatments on vegetative growth parameters of ber cv. Umran

These findings align with Kumari *et al.* (2015) ^[13] and Singh *et al.* (2012) ^[30], who reported superior canopy development in INM-treated ber over chemical NPK-only treatments.

Table 2: Effect of INM treatments on flowering behaviour, fruit set and retention of ber cv. Umran

Treatments	Days to flower init.	Duration of flowering (days)	Flowers/shoot	Initial fruit set (%)	Fruit drop (%)	Fruit retention at 90 d (%)
T ₁	58.4	18.2	12.4	21.4	48.2	32.6
T ₂	52.8	21.4	16.8	28.6	40.6	40.4
T ₃	51.4	22.6	17.8	30.8	38.4	42.6
T ₄	50.8	23.0	18.2	31.4	37.6	43.4
T ₅	51.2	22.8	18.0	31.0	38.0	43.0
T ₆	50.2	23.4	18.6	32.2	36.8	44.2
T ₇	49.4	24.2	19.4	33.4	35.2	45.8
T ₈	49.8	24.0	19.2	33.0	35.6	45.4
T ₉	49.6	23.8	19.0	34.8	33.4	47.6
T ₁₀	48.2	25.4	20.6	38.6	29.6	51.4
CD 5%	1.18	0.82	0.62	1.24	1.62	1.44
SEm±	0.41	0.28	0.21	0.43	0.56	0.50

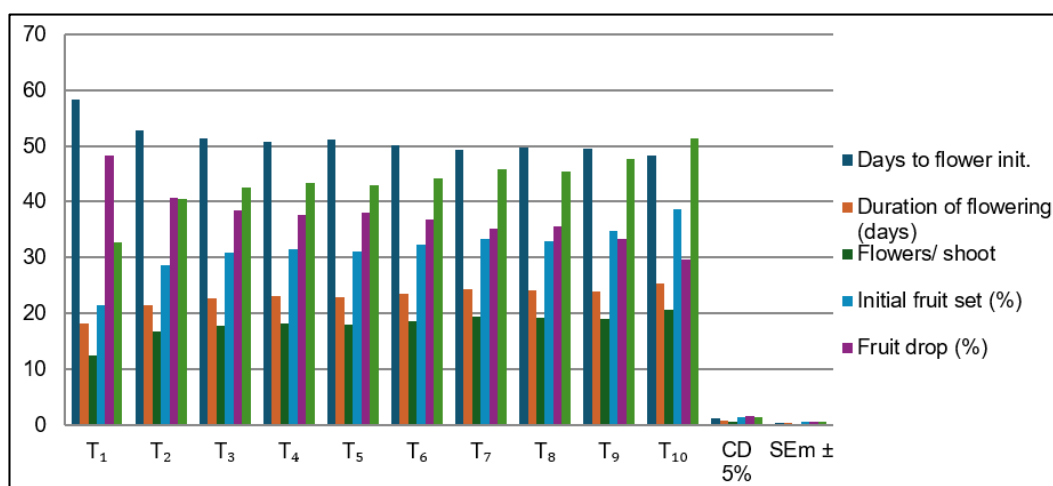


Fig 2: Effect of INM treatments on flowering behaviour, fruit set and retention of ber cv. Umran

Flowering Behaviour, Fruit Set and Retention: The INM treatments significantly influenced all flowering and fruiting parameters (Table 3). Days to flower initiation decreased from 58.4 days (T₁) to a minimum of 48.2 days (T₁₀), indicating that well-nourished trees initiate flowering 10 days earlier — a commercially important advantage as it lengthens the fruit development period and allows harvest before the peak of post-monsoon temperature stress. The maximum number of flowers per shoot (20.6) and the

longest flowering duration (25.4 days) were both recorded in T₁₀. The initial fruit set percentage was maximum in T₁₀ (38.6%) and minimum in T₁ (21.4%); the particularly high fruit set in T₉ (34.8%) and T₁₀ (38.6%) — the treatments incorporating foliar ZnSO₄ and borax — provides specific evidence for the roles of zinc in IAA-mediated pollen tube elongation and boron in pollen tube cell wall synthesis during the fertilisation process, as documented by Singh and Godara (2002) ^[29] and Rathore *et al.* (2019) ^[23]. Fruit drop

was minimum in T₁₀ (29.6%) vs. 40.6% in T₂, reflecting better potassium-mediated pedicel integrity and zinc-maintained IAA levels that suppress premature abscission.

4. Conclusions

The present investigation conclusively establishes that INM combining 75% of the recommended chemical NPK with FYM (25 kg/tree), *Azotobacter* + PSB biofertilizer inoculants, and foliar sprays of ZnSO₄ (0.5%) and borax (0.2%) at pre-flowering and early fruit set (T₁₀) is the most productive, highest-quality and most profitable nutrient management strategy for ber cv. Umran under Madhya Pradesh conditions. T₁₀ gave maximum fruit yield (50.0 kg/plant; 78.0 q/ha), premium fruit weight (26.8 g), best TSS (16.4°Brix), highest ascorbic acid (84.2 mg/100 g), maximum soil organic carbon (0.48%) and the best B:C ratio (4.56).

The study further confirms that: (i) subclinical zinc deficiency occurs even under 100% chemical NPK on calcareous MP soils, and micronutrient correction through foliar sprays is an essential INM component; (ii) organic manure supplementation builds soil organic carbon and enhances long-term orchard sustainability beyond what chemical fertilizers can achieve alone; and (iii) even the simplest organic supplement (T₃: 75% NPK + FYM) is more profitable than 100% chemical NPK (B:C 3.13 vs. 2.72). The INM treatment T₁₀ is recommended for immediate extension to ber growers of Madhya Pradesh; T₇ (75% NPK + FYM + biofertilizers, B:C 3.79) is recommended as the best alternative for resource-constrained farmers who cannot yet access micronutrient inputs.

References

- Ahirwar CS, Singh AP, Nath R, Verty P. Assessment of effect of nitrogen and phosphorus on the phenological and fruit characters of okra (*Abelmoschus esculentus* L.). Int J Curr Microbiol Appl Sci. 2021;10(2):1918-1925.
- Ahirwar CS, Hussain A. Effect of vermicompost on growth, yield and quality of vegetable crops. International Journal of Applied and Pure Science and Agriculture. 2015;1(8):49-56.
- Ahirwar CS, Prashad VM. Variability pattern in agromorphological characters in tomato genotypes (*Lycopersicon esculentum* Mill.). Trends in Biosciences. 2013;6(6):758-761.
- Ahirwar CS, Singh DK. SDS-PAGE based protein profiling and diversity assessment of indigenous genotypes of cucumber. Indian Academy of Horticultural Sciences. 2019;76(4):683-690.
- Ahirwar SC, Prashad VM. Variability pattern in agromorphological characters in tomato genotypes (*Lycopersicon esculentum* Mill.). Trends in Biosciences. 2013;6(6):758-761.
- AOAC. Official methods of analysis. 17th ed. Gaithersburg (MD): Association of Official Analytical Chemists; 2000.
- Berger KC, Truog E. Boron determination in soils and plants. Industrial & Engineering Chemistry Analytical Edition. 1939;11(10):540-545.
- Chadha KL, editor. Handbook of horticulture. New Delhi: Indian Council of Agricultural Research; 2001.
- Goyal RK, Singh G. Nutritive value and medicinal properties of ber. Beverage and Food World. 2001;28(10):38-41.
- Gupta RK, Singh P. Economic evaluation of integrated nutrient management in ber under Chhattisgarh conditions. International Journal of Chemical Studies. 2020;8(3):2248-2254.
- Jackson ML. Soil chemical analysis. New Delhi: Prentice Hall of India; 1973.
- Kumar V, Kumar A, Yadav AL, Singh C. Organic farming in India: Challenges and policy support. Plant Archives. 2024;24:1345-1349.
- Kumari P, Singh B, Yadav A. Influence of integrated nutrient management on yield and quality of ber cv. Umran. Indian Journal of Horticulture. 2015;72(3):345-350.
- Lindsay WL, Norvell WA. Development of a DTPA soil test for zinc, iron, manganese, and copper. Soil Science Society of America Journal. 1978;42(3):421-428.
- Meena NL, Kumar R, Sharma S. Long-term effect of integrated nutrient management on soil health in ber orchards. Journal of Soil and Water Conservation. 2021;20(4):402-410.
- Mishra DS, Singh VK. Response of ber to integrated nutrient management under semi-arid conditions. Annals of Arid Zone. 2010;49(2):203-210.
- MPDA. Horticulture statistics of Madhya Pradesh. Bhopal: Directorate of Horticulture, Government of Madhya Pradesh; 2021.
- NHB. Indian horticulture database 2022-23. Gurugram: National Horticulture Board, Ministry of Agriculture and Farmers Welfare, Government of India; 2023.
- Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. USDA Circular No. 939. Washington (DC): USDA; 1954.
- Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. New Delhi: Indian Council of Agricultural Research; 1985.
- Pareek OP. Ber. New Delhi: Indian Council of Agricultural Research; 2001.
- Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. 2nd ed. New Delhi: Tata McGraw-Hill; 1986.
- Rathore TS, Sharma H, Meena A. Combined effect of zinc and boron on fruit set, yield and quality of ber cv. Umran. Indian Journal of Horticulture. 2019;76(2):282-288.
- Roy RN, Finck A, Blair GJ, Tandon HLS. Plant nutrition for food security. FAO Fertilizer and Plant Nutrition Bulletin No. 16. Rome: Food and Agriculture Organization; 2006.
- Sharma RR, Singh R. Improving yield and quality of ber through nutrient management. Acta Horticulturae. 2006;696:305-310.
- Shukla V, Dhake AV. Ber cultivation in Madhya Pradesh: Status and prospects. Gwalior: RVSKVV Farmer's Bulletin; 2006.
- Singh AP, Ahirwar CS, Tripathi LK, Verty P, Nath R. Influence of nitrogen and phosphorus on the growth and yield of okra (*Abelmoschus esculentus* L.). International Journal of Chemical Studies. 2020;8(2):2448-2451.

28. Singh C, Nath R. Farming system and sustainable agriculture: Agricultural reform. Sgoc Publication; 2020.
29. Singh HP, Godara NR. Effect of boron and zinc on yield and quality of ber. Haryana Journal of Horticultural Sciences. 2002;31(1-2):22-26.
30. Singh S, Sehwat SK, Dahiya DS. Effect of *Azotobacter* and PSB on growth and yield of ber cv. Umran. Haryana Journal of Horticultural Sciences. 2012;41(3-4):183-188.
31. Subbiah BV, Asija GL. A rapid procedure for the estimation of available nitrogen in soils. Current Science. 1956;25(8):259-260.
32. Tandon HLS. Fertilizers in Indian agriculture. New Delhi: Fertiliser Development and Consultation Organisation; 2005.
33. Tiwari VN, Mishra S. Integrated nutrient management in ber cv. Umran under Madhya Pradesh conditions. International Journal of Chemical Studies. 2017;5(6):1884-1890.
34. Yadav RK, Sehwat SK. Effect of organic amendments and biofertilizers on ber production and quality. Current Agriculture Research Journal. 2018;6(1):45-52.
35. Yadav VS, Kumar D, Sharma SK. Integrated nutrient management in ber: A comprehensive review. Horticultural Plant Journal. 2019;5(3):98-107.