International Journal of Bio-resource and Stress Management https://ojs.pphouse.org/index.php/IJBSM

Crossref

IJBSM December 2025, 16(12): 01-08

Article AR6707

Research Article

Natural Resource Management

DOI: HTTPS://DOI.ORG/10.23910/1.2025.6707

Effect of Pruning Severity and Nutrient Application on Growth, Yield and Quality of Ber cv. Banarasi Karaka

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0009-0003-3829-4315

ABSTRACT

The present investigation was carried out during *rabi* (October, 2024 to March, 2025) at Horticulture Garden, Department of Fruit Science of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, U.P, India, entitled Effect of Pruning Severity and Nutrient Application on Growth, Yield and Quality of ber (*Zizyphus mauritiana* Lamk.) cv. Banarasi Karaka in a Randomized Block Design with nine treatments and three replications. The study revealed significant variations in growth, yield and quality parameters due to different combinations of fertilizers, organics and biofertilizers. Among the treatments, application of 50% RDF, vermicompost 2 kg, Azotobacter 100 g, PSB 100 g, and Azospirillum 100 g (T_7) consistently outperformed others by recording the highest vegetative growth viz., shoots 34.14, shoot length 4.05 m, diameter 3.45 cm and canopy spread 32.15 m², fruit morphometric traits viz., length 3.57 cm, diameter 3.30 cm, weight 21.89 g, volume 22.13 ml, pulp 20.03 g, stone 1.85 g and yield (30.11 kg plant^{-1}). Quality parameters were also maximized under treatment T_7, with the lowest acidity (0.13%) and superior values for TSS (20.47°Brix), TSS: acid ratio (146.27), ascorbic acid (70.13 mg (100 g)$^{-1}$), and total sugars (9.26%). The treatment (T_8) with 75% RDF, Vermicompost 2 kg, Azotobacter (100 g), PSB (100 g) ranked second, while control (T_1) consistently recorded the lowest values across all attributes. The results clearly demonstrated that the integrated application of organics, biofertilizers, and reduced chemical fertilizers not only enhanced vegetative growth and yield but also improved fruit quality, highlighting T_7 as the most effective treatment for sustainable berry production.

KEYWORDS: Ber, pruning, vermicompost, biofertilizers, growth, yield, quality

Citation* (VANCOUVER)*: Kumar et al., Effect of Pruning Severity and Nutrient Application on Growth, Yield and Quality of Ber cv. Banarasi Karaka. *International Journal of Bio-resource and Stress Management,* 2025; 16(12), 01-08. HTTPS://DOI.ORG/10.23910/1.2025.6707.

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 20th September 2025 RECEIVED in revised form on 19th November 2025 ACCEPTED in final form on 05th December 2025 PUBLISHED on 10th December 2025

1. INTRODUCTION

Ber (*Ziziphus mauritiana* Lamk.), commonly known as Indian jujube, is a hardy, drought-tolerant fruit crop widely cultivated in arid and semi-arid regions of India and several tropical countries. Its ability to produce nutritious fruits under suboptimal soil and climatic conditions makes it vital for resource-limited farming systems. It is often referred to as the "king of arid fruits" and "poor man's apple," and it holds significant economic and nutritional value in marginal ecosystems. Ber belongs to the family Rhamnaceae and has a tetraploid chromosome number (2n=4x=48); the species exhibits notable genetic diversity across cultivars and regions (Pandey et al., 2023; Saroj and Kumar, 2023).

India is a primary centre of origin for *Ziziphus mauritiana* and ranks second globally in ber cultivation, with approximately 52,000 ha under production, yielding about 526,000 mt annually (Anonymous, 2023). Major producing states include Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana, Punjab, Gujarat, Bihar, and parts of Maharashtra, Andhra Pradesh, and Tamil Nadu. Nutritionally, ber fruit rich in vitamins C, A, and B-complex, calcium, phosphorus, iron and dietary fibre, with documented medicinal uses in treating gastrointestinal, dermatological and respiratory ailments. Its adaptability to extreme climatic variations (5–45°C, 300–1000 mm rainfall) and poor soils underscores its suitability as a climate-resilient crop for sustainability.

Pruning is a key cultural practice in ber production, as flowering and fruiting occur on the current season's shoots. Proper pruning stimulates the emergence of new shoots, balances vegetative and reproductive growth and helps rejuvenate senile orchards (Shashi et al., 2022; Singh et al., 2015).

There is an urgent need for a nutritional package under semi-arid climatic and alkaline soil conditions to attain long-term sustainability for quality fruit production. Vermicompost provides essential nutrients to plants (Kumar et al., 2023). Vermicompost and biofertilizers are being used to improve the growth and fruit quality by producing phytohormones and enhancing the uptake of plant nutrients (Tripathi et al., 2017). The application of organic manure and biofertilizer for better plant growth (Pratap and Tripathi 2025). Organic amendments are known to improve soil fertility and enhance microbial activity (Shukla et al., 2025). Integrated application of organic manure and biofertilizers, such as FYM and PSB can significantly enhance the fruits physical and biochemical attributes (Chouhan and Tripathi, 2025).

Biofertilizers, such as Azotobacter, phosphate-solubilizing bacteria, and mycorrhizal fungi to improve nutrient availability through nitrogen fixation, phosphate solubilization, and enhanced root absorption (Smith and Smith, 1997; Hazarika and Ansari, 2007). The P-solubilizers containing bacteria or fungi may convert the insoluble form of phosphate to a soluble form by producing organic acids (Bhadauria and Tripathi, 2023). Bio-fertilizers are formulations containing beneficial microorganisms such as nitrogen-fixing bacteria and phosphate-solubilizing bacteria (Tripathi et al., 2016). Biofertilizers proved to be the most effective in enhancing fruit yield, profitability and long-term soil sustainability (Sonkar and Tripathi, 2025). The integrated use of pruning and organic nutrient sources has the potential to improve yield, quality, and orchard longevity in a sustainable manner (Uma and Kumar, 2025).

Although the influence of pruning and nutrient application in ber has been studied to some extent, comprehensive evaluations combining different pruning severities with organic and biological nutrient sources under specific agro-climatic conditions remain limited. Evidence on their synergistic effects in improving growth, yield and fruit quality, particularly in ageing orchards of Central Uttar Pradesh, is still scarce. Moreover, cultivar-specific responses to such integrated approaches have not been systematically documented. To address these gaps, the present investigation was conducted to examine the effect of pruning severity and nutrient application on the growth, yield, and quality of ber cv. Banarasi Karaka.

2. MATERIALS AND METHODS

In the experiment investigation was conducted during *rabi* (October, 2024 to March, 2025) at Horticulture Garden, Department of Fruit Science, College of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, India, on ber cv. Banarasi Karaka. Geographically, Kanpur falled in a subtropical climate and was situated at 26' 28 ^{0}N (latitude) and 80' 28 ^{0}E (longitude) and about 135 m above mean sea level. The trees were approximately 50 years old and were properly maintained through the adoption of proper horticultural practices, including severe pruning in May and June, and a recommended dose of fertilizers. During the investigation, the entire orchard was maintained under clean and uniform cultural practices. The 27 ber plants were selected for the experiment, with each plant constituting an individual treatment. The orchard soil, which had ber trees, was a sandy loam with a pH of 7.15. All the trees were maintained through uniform cultural practices throughout the experimental period.

In all, nine treatments were comperising of combination of three levels each of RDF, Vermicompost, Azotobacter, Azospirillum, PSB along with control replicated thrice in Randomised Block Design as T_1: Control (without fertilizers), T_2: 75% RDF+Vermicompost 2 kg, T_3: 75% RDF+Vermicompost 2 kg+Azotobacter (100g), T_4: 75% RDF+Vermicompost 2 kg+Azospirillum (100 g), T_5: 75% RDF+Vermicompost 2 kg+PSB (100g), T_6: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100g), T_7: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)+Azospirillum (100 g), T_8: 75% RDF +Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g), T_9: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)+Azospirillum (100 g). The trees were applied with inorganic and bio-fertilizers as a basal dose was done before the emergence of new shoots (third week of July). All the trees were maintained under uniform cultural practices during the period of experimentation. Fruits were harvested at the mature stage.

Qualitative and quantitative parameters were recorded for each treatment under growth, yield and quality attributes. Growth parameters included the number of shoots (primary and secondary branches counted and averaged), plant spread (m²) measured in E–W and N–S directions using a measuring tape, shoot length (m) from shoot base to tip, and shoot diameter (cm) measured with a digital vernier caliper. All growth measurements were taken four months after pruning. Yield parameters comprised fruit weight (g), fruit diameter (cm), fruit length (cm), stone weight (g), pulp weight (g), fruit volume (ml), and yield plant^{-1} (kg). Fruit weight, length, and diameter were measured from randomly selected fruits in all four canopy directions. Quality parameters included total soluble solids (°Brix, by hand refractometer), ascorbic acid content (mg (100 g)$^{-1}$ pulp) was determined by the procedure detailed (Annonymous 1984), titratable acidity (%) by acid-alkali titration (Anonymous, 1984), total sugars (%) estimated by Fehling's solution method and TSS: acid ratio computed as the quotient of TSS and acidity values.

The data were analyzed according to the method described by Panse and Sukhatme (1985). To compare treatments and determine the effectiveness of different treatments, all data were subjected to statistical analysis. Significant responses at the 5.0% level were computed as needed. Critical differences (C.D.) were calculated to compare the effects of various treatments.

Table 1: Effect of pruning severity and nutrient application on shoot length, shoot diameter, number of shoots and plant spread of ber

Treatment	Shoot length (m)	Shoot diameter (cm)	No. of shoots	Plant spread (m²)
T_1: Control	2.42	2.07	17.05	25.19
T_2: 75% RDF+ Vermicompost 2 kg	2.63	2.42	19.52	27.32
T_3: 75% RDF+ Vermicompost 2 kg +Azotobacter (100 g)	3.15	3.06	25.18	29.47
T_4: 75% RDF+ Vermicompost 2 kg+Azospirillum (100 g)	2.89	2.80	21.11	28.19
T_5: 75% RDF+ Vermicompost 2 kg+PSB (100 g)	3.04	2.90	23.75	29.13
T_6: 50% RDF+ Vermicompost 2 kg +Azotobacter (100 g) + PSB (100 g)	3.69	3.22	30.80	30.67
T_7: 50% RDF+ Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)+Azospirillum (100 g)	4.05	3.45	34.14	32.15
T_8: 75% RDF+ Vermicompost 2 kg +Azotobacter (100 g)+PSB (100 g)	3.85	3.37	32.07	31.45
T_9: 75% RDF+ Vermicompost 2 kg +Azotobacter (100 g)+Azospirillum (100 g)	3.40	3.16	27.23	29.76
SEm±	0.08	0.04	0.42	0.52
CD (p=0.05)	0.25	0.12	1.28	1.58

3. RESULTS AND DISCUSSION

3.1 Growth parameters

Data presented in Table 1 revealed that growth parameters, including shoot length (m), shoot diameter (cm), number of shoots, and plant spread (m²), were significantly influenced by pruning severity and nutrient application. The significantly maximum shoot length (4.05 m) was recorded with the application of treatment T_7 (50% RDF+Vermicompost 2 kg+Azotobactor 100 g+PSB 100 g+Azospirillum 100 g) followed by T_8 (75% RDF+Azotobactor 100 g+PSB 100 g), whereas and minimum shoot length was recorded under control T_1 (2.42 m). The maximum shoot diameter (3.45 mm) was recorded with the application by T_7 (50% RDF+Vermicompost 2 kg+Azotobactor 100 g+PSB 100 g +Azospirillum 100 g), followed by 75% RDF+Azotobactor 100 g+PSB 100 g (T_8), whereas and minimum shoot diameter was recorded under control T_1

(2.07 mm). The significantly maximum number of shoots (34.14) was recorded with the application of treatment by T_7 (50% RDF+Vermicompost 2 kg+Azotobactor 100 g+PSB 100 g+Azospirillum 100 g followed by T_8 (75% RDF+Azotobactor 100 g+PSB 100 g), whereas and minimum number of shoots was recorded under control T_1 (17.05). The significantly maximum increase in canopy spread in E–W and N–S direction (32.15 m^2) was recorded with the application of treatment T_7 (50% RDF+Vermicompost 2 kg+Azotobactor 100 g+PSB 100 g+Azospirillum 100 g) followed by T_8 (75% RDF+Azotobactor 100 g+PSB 100 g) whereas, minimum (25.19 m^2) o f canopy spread recorded under T_1 (control). The improvement in growth parameters of ber due to the application of biofertilizers and organic manures could be attributed to the enhanced availability of nitrogen, phosphorus, potassium, and other essential nutrients. In contrast, the control treatment experienced poor nutrient supply, which restricted growth. Nitrogen was involved in protoplasm and amino acid synthesis, as well as auxin activity, thereby increasing meristematic activity and promoting vegetative growth. Phosphorus played a key role in photosynthesis and in the synthesis of starch, sucrose and proteins, while potassium improved assimilate translocation. Similar results were reported in ber by Lal et al. (2003), Prasad (2005), and Sharma et al. (2005).

Vermicompost, a slow-release manure enriched with macro- and micronutrients, improved soil by reducing C: N ratio, increasing humic acid, cation exchange capacity and water-soluble carbohydrates (Talashikar et al. 1999). The increase in plant height was attributed to improved soil moisture retention, nutrient supply, and biological activity, which enhanced absorption, carbohydrate assimilation, and tissue formation. Biofertilizers also improved growth by developing microbial colonies and producing growth substances. Azotobacter fixed atmospheric nitrogen and released gibberellins, IAA, and cytokinins, which enhanced root growth, nutrient uptake, and nitrogen use efficiency. Phosphate–solubilising bacteria made insoluble phosphorus available by producing organic acids and enzymes, and also produced amino acids and phytohormones, promoting better growth. Similar beneficial effects of organic and biofertilizers have been reported in guava by Ram and Pathak (2007), Dutta et al. (2009), Goswamy et al. (2012) and in aonla by Aseri et al. (2009).

3.2. *Physical and yield parameters*

The physical attributes of ber fruits were significantly influenced by pruning severity and nutrient application (Table 2). The significantly maximum fruit weight (21.89 g), length (3.57 cm), diameter (3.30 cm), volume (22.13 ml), pulp weight (20.03 g) and stone weight (1.85 g) were obtained with the application of 50% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g+Azospirillum 100 g (T_7),

Table 2: Effect of pruning severity and nutrient application on fruit length, fruit weight, fruit diameter, volume of fruit, pulp weight, stone weight, and yield of ber fruits

Treatment	Fruit length (cm)	Fruit weight (g)	Fruit diameter (cm)	Volume of fruit (ml)	Pulp weight (g)	Stone weight (g)	Fruit yield kg plant^{-1}
T_1: Control	3.26	16.25	2.91	16.36	15.01	1.23	19.15
T_2: 75% RDF+Vermicompost 2 kg	3.31	18.89	3.09	19.72	17.51	1.37	25.62
T_3: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)	3.46	20.16	3.22	20.87	18.31	1.50	27.39
T_4: 75% RDF+Vermicompost 2 kg+Azospirillum (100 g)	3.39	19.32	3.17	20.12	17.92	1.39	26.71
T_5: 75% RDF+Vermicompost 2 kg+PSB (100 g)	3.42	19.56	3.19	20.45	18.14	1.41	27.14
T_6: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g) + PSB (100 g)	3.51	20.46	3.25	21.09	18.84	1.61	28.09
T_7: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)+Azospirillum (100 g)	3.57	21.89	3.30	22.13	20.03	1.85	30.11
T_8: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)	3.54	20.88	3.27	21.333	19.19	1.71	28.66
T_9: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)+Azospirillum (100 g)	3.49	20.13	3.23	21.010	18.53	1.59	27.75
SEm±	0.05	0.30	0.05	0.25	0.24	0.02	0.45
CD (p=0.05)	0.16	0.93	0.15	0.77	0.74	0.07	1.38

which was markedly superior over control (T_1). The increase in fruit size, weight and volume might be due to enhanced photosynthetic efficiency and dry matter accumulation through the combined application of vermicompost and biofertilizers. The role of nitrogen fixers in dry matter translocation and growth regulator synthesis has been emphasized by Awasthi et al. (1998). Similar findings were also reported by Singh et al. (2012) in aonla; Katiyar et al. (2012) and Mishra et al. (2011) in ber.

The positive effects of biofertilizers on fruit length, diameter, pulp weight, and stone weight could be attributed to enhanced nutrient uptake, hormonal induction, improved photosynthesis, and efficient translocation of assimilates, which collectively promote better fruit development. These results were in line with the reports of Mahendra et al. (2009) in ber; and Dwivedi et al. (2010) in guava.

Fruit yield was also significantly improved by integrated nutrient treatments. The maximum yield (30.11 kg plant^{-1}) was recorded with T_7 (50% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g+Azospirillum 100 g), followed by T_8 (75% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g), which was superior to the control (T_1). Similarly, the maximum average fruit weight (21.97 g), fruit number tree^{-1} (1571.67), and yield tree^{-1} (34.14 kg) were obtained with T_7 (50% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g+Azospirillum 100 g). The higher yield might be explained by the roles of nitrogen in protein, enzyme, and chlorophyll synthesis; phosphorus in protoplasm and carbohydrate formation; and potassium in regulating carbohydrate metabolism and enzyme activity, which enhanced fruit size and yield. These observations were consistent with Dayal et al. (2010) in ber. The increase in yield due to biofertilizer application could also be linked to a better nutrient status, enhanced uptake, and metabolic regulation by PSB and Azotobacter, which improved chlorophyll content, meristematic activity, photosynthesis, and carbohydrate metabolism. Similar results have been documented by Shukla et al. (2025) in Dragon fruit, Dwivedi et al. (2012) in guava and Hazarika et al. (2011) in banana.

3.3. *Quality parameters*

The application of organics and RDF, combined with biofertilizers, not only increased yield but also improved the quality parameters of ber fruits (Table 3). The maximum TSS (20.47°Brix), total sugars (9.26%), ascorbic acid (70.13 mg 100 g^{-1}), TSS: acid ratio (146.27) and minimum titratable acidity (0.13%) were recorded with T_7 (50% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g+Azospirillum 100 g), followed by T_8 (75% RDF+ Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g) both significantly superior to control (T_1). Improvement in fruit quality might be attributed to enhanced nutrient availability and uptake from the rhizosphere. These results were supported by the findings of Pandey et al. (2023), Korwar et

Table 3: Effect of pruning severity and nutrient application on titratable acidity, TSS, TSS: acid ratio, total sugar, and ascorbic acid of ber

Treatment	Titratable acidity %	TSS (°Brix)	TSS: Acid ratio	Total sugar (%)	Ascorbic acid (mg 100 g^{-1} pulp)
T_1: Control	0.22	14.23	46.57	6.84	57.40
T_2: 75% RDF+Vermicompost 2 kg	0.19	16.45	82.29	8.02	61.06
T_3: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)	0.17	18.09	100.54	8.31	67.38
T_4: 75% RDF+Vermicompost 2 kg+Azospirillum (100 g)	0.18	17.62	92.77	8.1	63.81
T_5: 75% RDF+Vermicompost 2 kg+PSB (100 g)	0.17	17.89	99.43	8.17	65.73
T_6: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g) +PSB (100 g)	0.16	19.11	127.66	8.67	68.6
T_7: 50% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)+Azospirillum (100 g)	0.13	20.47	146.27	9.26	70.13
T_8: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)+PSB (100 g)	0.14	19.19	127.99	9.13	69.15
T_9: 75% RDF+Vermicompost 2 kg+Azotobacter (100 g)+Azospirillum (100 g)	0.16	19.03	111.93	8.39	68.02
SEm±	0.006	0.19	5.45	0.18	1.24
CD (p=0.05)	0.01	0.58	19.48	0.56	3.77

al. (2006), and Singh et al. (2012) in aonla. The reduction in titratable acidity was likely due to the conversion of organic acids into sugars and their utilization in respiration, while the increase in TSS and sugars could be attributed to the metabolic transformation of starch and polysaccharides into soluble sugars and their rapid translocation to developing fruits, as reported by Athani et al. (2009) in guava.

Higher ascorbic acid content in fruits from vermicompost +NPK+Azotobacter+PSB application was also confirmed by Tripathi et al. (2010) and Yadav et al. (2010). The improvement might be attributed to enhanced microbial activity, leading to improved nitrogen fixation, phosphorus solubilization, and the secretion of growth-promoting substances, which accelerated physiological processes such as carbohydrate and ascorbic acid synthesis (Gupta and Tripathi, 2012). Azotobacter and PSB together contribute 20–30% N and 25–50% P_2O_5 to the soil, thereby improving fruit quality through rapid nutrient mineralisation and transformation, as well as the production of growth regulators such as IAA, GA, cytokinins, vitamins, and amino acids. Similar results were also reported in guava (Sharma et al., 2009; Shukla et al., 2009) and in aonla by Singh et al. (2008).

4. CONCLUSION

The present investigation revealed significant variations among different treatments. Among all treatments, T_7 (50% RDF+Vermicompost 2 kg+Azotobacter 100 g+PSB 100 g+Azospirillum 100 g) consistently performed with the highest value for plant growth, yield and improved the quality traits of ber fruits.

5. ACKNOWLEDGEMENT

The authors acknowledge the Department of Fruit Science for providing plant materials and the Chandra Shekhar Azad University of Agriculture and Technology (CSAUAT), Kanpur, for providing the field for the experiment.

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