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Dharmale AY
Department of Horticulture (Fruit Science), School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh, India

Dhurve L
Department of Horticulture (Fruit Science), School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh, India

Haldar A
Department of Horticulture (Fruit Science), School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh, India

Pandey G
Department of Horticulture (Fruit Science), School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh, India

Corresponding Author:
Dharmale AY
Department of Horticulture (Fruit Science), School of Agricultural Sciences, G.H. Raisoni University, Saikheda, Pandhurna, Madhya Pradesh, India

Effect of integrated application of inorganic fertilizers and biofertilizers on growth, yield and economics of papaya (Carica papaya L.) Cv. red lady

Dharmale AY, Dhurve L, Haldar A and Pandey G

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Abstract
The present investigation was carried out during the Rabi season at the Instructional Research Farm of G.H. Raisoni University, Dhoda Borgaon, Sausar, Pandhurna (M.P.), with the objective of studying the effect of different levels of inorganic fertilizers integrated with varying doses of biofertilizers (Azotobacter, Phosphate Solubilizing Bacteria and Potassium Solubilizing Bacteria) on the vegetative growth, yield and economics of papaya *cv.* Red Lady. The experiment was laid out in Randomized Block Design (RBD) with nine treatments and three replications. Data recorded on eleven growth and yield parameters were subjected to analysis of variance and treatment effects were highly significant ($p < 0.01$) for all characters studied. Treatment T4 (75% RDF + 50 g each of Azotobacter, PSB and KSB) recorded the maximum plant height (243.39 cm), plant girth (32.21 cm), number of leaves (62.25), leaf area (1912.04 cm²), number of nodes (71.21), number of fruits per plant (32.78), fruit weight (1924.30 g) and fruit yield per plant (31.60 kg), besides the earliest flowering (140.14 days) and fruit maturity (199.37 days), while T1 (control) recorded the lowest values across nearly all parameters. T4 also secured the highest gross return (₹8,08,960/ha) and net return (₹5,95,145/ha), though its benefit-cost ratio (3.78) was exceeded by T5 (4.33) and T7 (4.32), both achieved at substantially lower cultivation cost. The results establish that integrating biofertilizers with a reduced (75%) dose of inorganic fertilizer performs at par with or better than the full recommended dose, while improving cultivation economics and reducing chemical fertilizer dependence.

Keywords: Papaya, Red Lady, biofertilizers, Azotobacter, PSB, KSB, RDF, integrated nutrient management, economics

Introduction
Papaya (Carica papaya L.), family Caricaceae, is a fast-growing, semi-perennial tropical fruit crop native to Central America (Purseglove, 1968) [19] that is valued for its high content of vitamin A, vitamin C, folate and dietary fibre, and for the proteolytic enzymes papain and chymopapain used across the pharmaceutical, food-processing and cosmetic industries (Badrie and Schauss, 2010) [1]. India is the world's leading papaya producer, contributing approximately 44 per cent of global output (NHB, 2023) [15], with Madhya Pradesh among the major producing states. Papaya is an exceptionally heavy feeder, and adequate nitrogen, phosphorus and potassium nutrition is critical for optimizing growth, yield and fruit quality. Inorganic fertilizers have traditionally supplied the bulk of this nutrient demand (Chandra, 2014) [4], but exclusive reliance on chemical fertilizers has raised concerns over declining soil organic matter, reduced microbial diversity and negative environmental externalities such as leaching and eutrophication (Dahunsi *et al.*, 2021) [7].
Biofertilizers containing Azotobacter chroococcum, Phosphate Solubilizing Bacteria (PSB) and Potassium Solubilizing Bacteria (KSB) offer a biologically sound complement to inorganic nutrition: Azotobacter fixes atmospheric nitrogen and produces auxins, gibberellins and cytokinins that stimulate root and shoot growth (Bhattacharyya and Jha, 2012) [2], PSB solubilizes fixed soil phosphorus, and KSB mobilizes unavailable soil potassium. Several workers have reported that substituting 25-50 per cent of the recommended dose of fertilizer (RDF) with biofertilizers sustains or enhances productivity while lowering input costs (Hari and Binu, 2021 [10]; Prajapati *et al.*, 2024 [19]). However, information specific to the black cotton soil (Vertisol) belt of the Satpura plateau region of Madhya Pradesh, covering growth,

yield and economics together for the commercially dominant cv. Red Lady, remains limited. The present study was therefore undertaken to evaluate the combined effect of different levels of inorganic fertilizers and biofertilizer doses on the growth, yield and economics of papaya cv. Red Lady under the agro-climatic conditions of Saikheda, Madhya Pradesh.

2. Materials and Methods

The experiment was conducted during the Rabi season at the Instructional Research Farm, G.H. Raisoni University, Dhoda Borgaon, Village-Saikheda, Tah. Sausar, Dist. Pandhurna (M.P.), a Vertisol (black cotton soil) tract of the Satpura hill range belt receiving 1,100-1,300 mm annual rainfall. The trial was laid out in Randomized Block Design (RBD) with nine treatments and three replications (27 plots; plot size 4 m × 3 m; spacing 1.8 m × 1.8 m; 4 plants/plot), using papaya cv. Red Lady (F1 hybrid). The recommended dose of fertilizer (RDF) was N 200 g + P2O5 200 g + K2O 250 g per plant per year (through urea, single super phosphate and muriate of potash) together with 20 kg FYM/plant applied basally. The nine treatments comprised T1: 100% RDF (control), T2: 100% RDF + 50 g each of Azotobacter, PSB and KSB, T3: 100% RDF + 25 g each, T4: 75% RDF + 50 g each, T5: 75% RDF + 25 g each, T6: 50% RDF + 50 g each, T7: 50% RDF + 25 g each, T8: 25% RDF + 25 g each, and T9: 25% RDF + 50 g each of the biofertilizer consortium. Phosphorus and potassium were applied in two splits (at transplanting and 60 DAT) and nitrogen in three splits (transplanting, 60 and 120 DAT); biofertilizers were applied as soil application in two splits at transplanting and 60 DAT.

Observations were recorded on plant height, plant girth, number of leaves per plant, leaf area, leaf area index, number of nodes, days to first flowering, days to fruit maturity, number of fruits per plant, fruit weight and fruit yield per plant, following standard procedures, from three randomly tagged plants per plot. Leaf area was computed as length × maximum width × 0.73 (Ghosh *et al.*, 1996), and leaf area index as total leaf area per plant divided by land area per plant. The economics of cultivation total cost, gross return (yield × ₹16/kg), net return and benefit-cost ratio was worked out for each treatment. All data were subjected to analysis of variance for RBD (Panse and Sukhatme, 1995) [18], and treatment means were compared using the critical difference (CD) at the 5% level of probability wherever the F-test was significant.

3. Results and Discussion

The analysis of variance revealed that treatment effects were highly significant ($p < 0.01$) for all eleven growth and yield characters studied, confirming a pronounced influence of the integrated inorganic-biofertilizer regimes on the performance of papaya cv. Red Lady. Leaf area and fruit weight showed the largest treatment mean sum of squares, reflecting the greatest absolute variation induced by the treatments, while leaf area index showed the smallest, consistent with its naturally narrow range. Treatment-wise mean values for all parameters are presented in Table 1.

3.1 Growth Parameters

Treatment T4 (75% RDF + 50 g each of Azotobacter, PSB and KSB) recorded the maximum plant height (243.39 cm), statistically at par with T6 (240.53 cm) and T2 (240.05 cm), against a minimum of 191.60 cm under the control (T1). The same treatment also produced the maximum plant girth (32.21 cm vs. 23.04 cm in T1), the maximum number of leaves per plant (62.25 vs. 41.06), the maximum leaf area (1912.04 cm² vs. 1453.55 cm²) and the maximum number of nodes (71.21 vs. 61.47). The highest leaf area index (5.00) was recorded under T2, statistically at par with T4 (4.96), against a minimum of 3.29 under T1 notably, T4 matched T2's LAI while using 25% less inorganic fertilizer, indicating that the biofertilizer consortium can substantially offset a reduction in chemical fertilizer dose. These improvements are attributable to the combined effect of biological nitrogen fixation by Azotobacter, phosphorus and potassium solubilization by PSB and KSB, and the production of gibberellins, auxins and cytokinins by these organisms, which together enhance meristematic activity, internode elongation, cell division and vascular development. The findings agree with Prajapati *et al.* (2024) [18], who reported maximum plant height, girth and node number in papaya cv. Red Lady under the identical 75% RDF + 50 g biofertilizer combination, and with Srivastava *et al.* (2014) [21] and Chattopadhyay and Mandal (2022) [5], who documented similar growth responses to integrated nutrient management in papaya.

3.2 Yield Parameters

T4 recorded the earliest flowering (140.14 days) and earliest fruit maturity (199.37 days), against the latest flowering under T1 (169.93 days) and latest maturity under T3 (215.68 days), reflecting accelerated vegetative-to-reproductive transition under favourable nitrogen and phosphorus supply. The same treatment recorded the maximum number of fruits per plant (32.78, ~49% more than the control's 22.05), the maximum fruit weight (1924.30 g, against a minimum of 1484.12 g under T8), and the maximum fruit yield per plant (31.60 kg, a 54.8% improvement over the control's 20.41 kg). The overall yield hierarchy was T4 > T5 > T7 > T6 > T9 > T8 > T3 > T2 > T1, with the 75% RDF + biofertilizer treatments (T4, T5) outperforming even the 100% RDF + full biofertilizer treatment (T2), indicating that 75% RDF is the more efficient chemical input level once a full biofertilizer dose is applied. These results corroborate Prajapati *et al.* (2024) [18] and Hari and Binu (2021) [10], both of whom recorded the highest fruit number and yield under comparable integrated treatments in papaya cv. Red Lady, and Bhardwaj and Bajpai (2015) [3], who linked potassium nutrition to reduced days to maturity and higher fruit weight.

3.3 Economics

The economics of cultivation, presented in Table 2, showed that T2 (100% RDF + 50 g each of Azotobacter, PSB and KSB) incurred the highest cultivation cost (₹2,24,729/ha) owing to the combined expense of full-dose inorganic fertilizer and the maximum biofertilizer dose, while T1 (control) incurred the lowest (₹1,52,729/ha). T4 recorded the highest gross return (₹8,08,960/ha) and net return (₹5,95,145/ha) of all treatments, but its benefit-cost ratio (3.78) was exceeded by T5 (75% RDF + 25 g each; B:C = 4.33) and T7 (50% RDF + 25 g each; B:C = 4.32), both of which achieved comparable net returns (₹5,91,721/ha and ₹5,53,481/ha respectively) at substantially lower cultivation cost (₹1,77,815/ha and ₹1,66,903/ha). T2 recorded the lowest benefit-cost ratio (2.55) of all treatments, reflecting its disproportionately high input cost relative to yield

advantage. This pattern the most profitable treatment in absolute terms not necessarily being the most efficient in relative terms is consistent with diminishing economic returns beyond a certain input threshold, and agrees with the findings of Prajapati *et al.* (2024) [18], who similarly identified biofertilizer-supplemented reduced-RDF treatments as the most economically remunerative for papaya cv. Red Lady. On this basis, T4 is best suited to resource-rich growers seeking maximum absolute profit per hectare, whereas T5 (and T7) is better suited to small and marginal farmers seeking the highest return per rupee invested under limited working capital.

Table 1: Effect of Different Levels of Inorganic Fertilizers and Biofertilizers on Growth and Yield of Papaya cv. Red Lady (Mean of Three Replications)

Treatment	Plant Ht (cm)	Plant Girth (cm)	Leaves/ Plant	Leaf Area (cm^2)	LAI	Nodes	Days to 1st Flr.	Days to Maturity	Fruits/ Plant	Fruit Wt (g)	Yield (kg/plant)
T1	191.60	23.04	41.06	1453.55	3.29	61.47	169.93	213.79	22.05	1695.55	20.41
T2	240.05	29.13	57.66	1867.08	5.00	68.00	164.21	211.45	23.10	1780.46	22.37
T3	216.33	26.81	53.68	1686.31	4.40	64.25	166.79	215.68	24.12	1660.66	23.93
T4	243.39	32.21	62.25	1912.04	4.96	71.21	140.14	199.37	32.78	1924.30	31.60
T5	219.67	28.05	54.38	1741.66	4.53	64.75	148.61	207.83	29.14	1757.25	30.06
T6	240.53	28.92	56.57	1811.54	4.81	66.06	152.93	209.32	28.53	1741.15	26.77
T7	214.40	27.39	52.72	1651.03	4.30	63.92	157.62	208.91	28.50	1783.87	28.14
T8	215.91	25.88	51.63	1603.31	4.32	64.00	162.43	212.96	27.51	1484.12	24.56
T9	226.57	28.37	54.78	1754.43	4.70	64.26	157.41	208.55	26.63	1594.32	25.64
SEm±	2.28	0.63	0.39	35.85	0.05	1.16	1.16	1.74	0.37	31.24	0.22
CD @5%	6.78	1.88	1.16	106.51	0.16	3.43	3.45	5.18	1.11	92.83	0.65

Az = Azotobacter; RDF = Recommended Dose of Fertilizer (FYM 20 kg + N 200 g + P2O5 200 g + K2O 250 g per plant)

Table 2: Economics of Papaya cv. Red Lady Cultivation under Different Inorganic Fertilizer-Biofertilizer Combinations

Treatment	Total Cost (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C Ratio
T1: 100% RDF	1,52,729	5,22,496	3,69,767	3.42
T2: 100% RDF + 50g Az+PSB+KSB	2,24,729	5,72,672	3,47,943	2.55
T3: 100% RDF + 25g Az+PSB+KSB	1,88,729	6,12,608	4,23,879	3.25
T4: 75% RDF + 50g Az+PSB+KSB	2,13,815	8,08,960	5,95,145	3.78
T5: 75% RDF + 25g Az+PSB+KSB	1,77,815	7,69,536	5,91,721	4.33
T6: 50% RDF + 50g Az+PSB+KSB	2,02,903	6,85,312	4,82,409	3.38
T7: 50% RDF + 25g Az+PSB+KSB	1,66,903	7,20,384	5,53,481	4.32
T8: 25% RDF + 25g Az+PSB+KSB	1,55,990	6,28,736	4,72,746	4.03
T9: 25% RDF + 50g Az+PSB+KSB	1,91,990	6,56,384	4,64,394	3.42

Gross Return = Yield (kg/ha) × ₹16/kg; Net Return = Gross Return − Total Cost; B:C Ratio = Gross Return ÷ Total Cost

4. Conclusion

The integration of biofertilizers (Azotobacter, PSB and KSB) with inorganic fertilizers significantly improved the vegetative growth, earliness, yield and economics of papaya cv. Red Lady over sole application of inorganic fertilizer. Treatment T4 (75% RDF + 50 g each of Azotobacter, PSB and KSB) emerged as the most effective treatment for maximizing growth, yield and absolute net profit, while T5 (75% RDF + 25 g each) proved most efficient in terms of return per rupee invested. The results demonstrate that 75 per cent of the recommended dose of inorganic fertilizer, when supplemented with an appropriate biofertilizer consortium, can match or exceed full-dose inorganic fertilization, offering papaya growers of the Satpura plateau region of Madhya Pradesh a scientifically sound, economically remunerative and environmentally sustainable nutrient management strategy. Sole reliance on inorganic fertilizer, though the least expensive option, was the least productive and among the least profitable strategies evaluated, reinforcing the case for biofertilizer integration in commercial papaya cultivation.

References

1. Badrie N, Schauss AG. Soursop (*Annona muricata* L.): composition, nutritional value, medicinal uses and toxicology. In: Watson RR, Preedy VR, editors. Bioactive Foods in Promoting Health: Fruits and Vegetables. Academic Press; 2010. p. 621-643.
2. Bhattacharyya PN, Jha DK. Plant growth-promoting rhizobacteria (PGPR): emergence in agriculture. World J Microbiol Biotechnol. 2012;28(4):1327-1350.
3. Bhardwaj RL, Bajpai NK. Effect of potassium fertilizer on growth, quality, yield and profitability of papaya (*Carica papaya* L.) cv. Red Lady. Prog Hortic. 2015;47(2):224-228.
4. Chandra KK. Growth, fruit yield and disease index of *Carica papaya* L. inoculated with *Pseudomonas striata* and inorganic fertilizers. J Biofertil Biopestic. 2014;5(2):146.
5. Chattopadhyay P, Mandal G. Effect of integrated nutrient management on growth and yield of papaya (*Carica papaya* L.). Biol Forum. 2022;14(3):577-580.
6. Chaveevan P, *et al.* Effect of biofertilizer and mineral fertilizer combination on plant growth. 2010.
7. Dahunsi SO, Oranusi S, Owolabi JB, Efeovbokhan VE. Crop performance and soil fertility improvement using organic fertilizer produced from valorization of *Carica papaya* fruit peel. Sci Rep. 2021;11:4696.
8. Department of Agriculture and Farmers Welfare (DAFKW). Final Estimates 2024-25 and First Advance Estimates 2025-26 of Horticulture Crops. Government of India; 2026.
9. Dutta P, Kundu S, Chatterjee S. Effect of bio-fertilizers on homestead fruit production of papaya cv. Ranchi. Acta Hortic. 2010;851:441-446.

10. Hari D, Binu B. Effect of organic manures and biofertilizers on growth and yield attributes of papaya (*Carica papaya* L.). J Trop Agric. 2021;59(1).
11. Kundu S. Effect of biofertilizers on vegetative growth of mango cv. Amrapali under different fertilizer levels. 2011.
12. Manjunath BL, Gautam S, Raghupathi HB. Standardisation of fertigation in papaya for higher productivity and profitability. J Hortic Sci. 2024;18(1):1-8.
13. Maurya K, Silas VJ, Kumar J, Devi KA. Effect of plant growth regulators on growth, yield and quality of papaya (*Carica papaya* L.) cv. Pusa Nanha. J Adv Biol Biotechnol. 2025;28(7):678-685.
14. Mishra P, Baksh H, Singh R, Srivastav A. Effect of organic manures and bio-fertilizers on growth and yield of papaya (*Carica papaya* L.) cv. Red Lady. Crop Res. 2024;59(1-2):31-35.
15. National Horticulture Board (NHB). Indian Horticulture Database 2023. Ministry of Agriculture and Farmers Welfare, Government of India; 2023.
16. Nowembabazi A, Taulya G, Tinzaara W. Contribution of biofertilizer (*Frateuria aurantia*) in an integrated potassium management package on growth of apple banana. Open J Soil Sci. 2021;11(1):521-537.
17. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. 4th ed. New Delhi: ICAR; 1995.
18. Prajapati A, Singh J, Bhatnagar P, Chopra R, Aravindaraj K. Study on inorganic fertilizers and bio fertilizers on growth of papaya (*Carica papaya* L.) cv. Red Lady. Int J Agric Sci. 2024;20:95-98.
19. Purseglove JW. Tropical Crops: Dicotyledons. London: Longmans; 1968.
20. Sahu A, Radha TK, Das L, Sahoo L, Devi M, Sarangi SK. Comparative effects of *Azotobacter vinelandii* and urea on soil enzyme activities and fruit quality of papaya (*Carica papaya* L.). Sci Hortic. 2025;353:113464.
21. Srivastava A, Singh JK, Singh HK. Integrated nutrient management (INM) on growth, yield and quality of papaya (*Carica papaya* L.) cv. CO-7. Asian J Hortic. 2014;9(2):390-395.