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Influence of Biofertilizers and NPK Levels on Yield, Quality, Economics and Nutrient Uptake by Cluster Bean (*Cyamopsis tetragonoloba* L. Taub.) and Soil Health

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Authors' contributions

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

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Abstract

The integrated application of chemical fertilisers in conjunction with biofertilisers plays a critical role in maintaining soil health and enhancing the quality of agricultural produce. Cluster bean (*Cyamopsis tetragonoloba* L. Taub.), commonly referred to as guar, is a multipurpose leguminous crop widely cultivated across the arid and semi-arid regions of the country. A field experiment was conducted during the Rabi season of 2021 at the Department of Agronomy, College of Agriculture, Dapoli, to evaluate the effects of biofertilisers and varying levels of NPK fertilisation on the yield, quality, and nutrient uptake of cluster bean

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(*Cyamopsis tetragonoloba* L. Taub.), as well as their influence on soil properties. The experiment was laid out in a Randomised Block Design comprising ten treatment combinations, each replicated three times. The data revealed significant improvement in growth, yield, nutrient content and available nutrient status of soil at harvest with the sole and combined application of nutrients through chemical fertilisers and biofertilizers. It was observed that the growth, yield, and nutrient content were maximum with the application of 40:60:60 NPK kg ha^{-1} + Biofertilizers. In the post-harvest status of soil, a significant increase was observed in the enrichment of soil fertility with the application of 40:60:60 NPK kg ha^{-1} + Biofertilizers. The study concludes that the application of 40:60:60 NPK kg ha^{-1} + Biofertilizers has a beneficial effect for obtaining higher pod yield, soil fertility status, economic return, net profit and B: C ratio.

Keywords: Biofertilizers; NPK levels; cluster bean; guar.

1. Introduction

Cluster bean (*Cyamopsis tetragonoloba* L. Taub.), commonly known as guar, is a multipurpose legume extensively cultivated across the arid and semi-arid regions of India (Chimate et al., 2023). It is a self-pollinated, diploid (2n = 14) leguminous crop, characterised by its drought tolerance, deep rooting system, and annual growth habit (Bhatt et al., 2017; Sathwara et al., 2025). India accounts for approximately 82% of global guar production, with cultivation spanning 2.33 million hectares and an average pod yield of 428 kg per hectare (Jilen et al., 2022). The crop's deep-penetrating roots facilitate efficient utilisation of available soil moisture, thereby enhancing its suitability for rainfed agriculture. Cluster bean holds considerable economic importance due to its wide-ranging industrial applications, including textiles, paper, oil extraction, pharmaceuticals, food processing, cosmetics, mining, explosives, and oil drilling (Sourabh et al., 2024). In the Konkan region, the area under cluster bean cultivation is steadily expanding; consequently, the provision of adequate nutrients is critical to achieving optimal yield and quality, given the crop's responsive nature. Ensuring an appropriate supply of plant nutrients is fundamental both for enhancing productivity and for sustaining soil fertility.

In this context, the integrated application of chemical fertilisers and biofertilisers plays a crucial role in sustaining soil fertility and enhancing crop quality. Biofertilisers are natural formulations containing living microorganisms—such as bacteria, fungi, and cyanobacteria—that improve soil nutrient status and promote plant growth. In contrast to conventional chemical fertilisers, biofertilisers function in harmony with the soil ecosystem by stimulating beneficial microbial populations, enhancing nutrient availability, and improving soil structure (Daniel et al., 2022; Beleri, 2023).

Biofertilisers do not directly supply nutrients to crops; rather, they facilitate nutrient availability through biological processes such as atmospheric nitrogen fixation and the conversion of insoluble phosphates into plant-available forms (Chaudhary et al., 2022; Zhao et al., 2024; Yadav & Yadav, 2024). Among the commonly used biofertilisers, *Rhizobium* and phosphate-solubilising bacteria (PSB) have demonstrated considerable potential in improving nutrient use efficiency. Biofertilisers therefore represent a cost-effective, sustainable, and renewable source of plant nutrients that can effectively complement chemical fertilisers. Singh et al. (2007) reported that the combined application of organic manure and chemical fertilisers not only supported improved crop growth but also prevented the decline in soil organic carbon, thereby significantly reducing the gap between potential and actual crop yields.

Lateritic soils are typically characterised by deficiencies in available phosphorus, low to moderate levels of available nitrogen (Dongale, 1989), and similarly low to moderate levels of available potassium. In the lateritic soils of the Konkan region, the limited availability of phosphorus is primarily attributed to the low concentration of soluble phosphorus and the high phosphorus-fixing capacity of these soils (Dongale, 1989).

The present study was therefore undertaken to evaluate the effects of biofertilisers and varying levels of NPK fertilisation on the yield and quality of cluster bean, as well as their influence on soil properties in the lateritic soils of the Konkan region.

2. Materials and Method

A field experiment was carried out during the Rabi season of 2021 at the Department of Agronomy, College of Agriculture, Dapoli, on sandy loam soils characterised by a bulk density of 1.44 Mg m^{-3}, particle density of

2.35 Mg m^{-3}, pH 5.2, organic carbon content of 10.10 g kg^{-1}, available nitrogen of 225.79 kg ha^{-1}, available P_2O_5 of 7.10 kg ha^{-1}, and available K_2O of 276.78 kg ha^{-1}. The experiment was laid out in a Randomised Block Design with ten treatment combinations, each replicated three times. Farmyard manure (FYM) was applied at a rate of 10 t ha^{-1} to all treatments except the absolute control. The cluster bean variety *Pusa Navbahar* was sown at a spacing of 45 × 15 cm. Biofertilisers, including *Rhizobium* and phosphate-solubilising bacteria (PSB), were applied as a seed treatment at a rate of 200 g per 10 kg of seed immediately before sowing, followed by shade drying to ensure effective microbial inoculation.

All other crop management practices, including irrigation, weed control, and plant protection measures, were implemented as per the recommended package of practices for the region (Chimate et al., 2023). Post-harvest, the nutrient content of both seed and straw was determined, along with the soil's available nitrogen, P_2O_5, and K_2O, following standard analytical procedures. The recorded data were subjected to statistical analysis using established methods to evaluate the significance of treatment effects.

3. Results and Discussion

3.1 Yield

The data clearly indicate that both seed and stover yields were significantly influenced by the application of varying doses of NPK, with and without biofertilisers, compared to the control (Table 1). The treatment comprising 40:60:60 kg ha^{-1} NPK combined with biofertilisers recorded the highest seed and stover yields. In terms of seed yield, this treatment was statistically at par with T3 (40:40:40 kg ha^{-1} NPK), T4 (20:40:40 kg ha^{-1} NPK + biofertilisers), T5 (40:40:60 kg ha^{-1} NPK), T6 (40:40:60 kg ha^{-1} NPK + biofertilisers), and T9 (40:60:60 kg ha^{-1} NPK + biofertilisers). However, for stover yield, 40:60:60 kg ha^{-1} NPK + biofertilisers proved significantly superior over all other treatments. An adequate supply of nitrogen during the early vegetative stages promotes rapid plant growth and overall biomass accumulation. During the reproductive stage of crop development, the assimilate demand of developing sinks often exceeds the supply derived from concurrent photosynthesis. Under such conditions, previously stored assimilates are mobilised and translocated to active sinks, including pods and seeds, thereby increasing the number of pods per plant and seeds per pod (Manohar et al., 2018).

The efficiency of inorganic fertilisers is further improved when applied in combination with biofertilisers. Inoculation with *Rhizobium* enhances root development and nodulation, increases nutrient availability, and stimulates vigorous vegetative growth and dry matter accumulation. These physiological improvements collectively contribute to enhanced flowering, pod formation, and ultimately higher pod yield. In addition, phosphate-solubilising bacteria (PSB) play a significant role by reducing phosphorus fixation through chelation and by converting otherwise insoluble phosphorus into plant-available forms. This process facilitates improved nutrient uptake and consequently enhances yield-related attributes (Chimate et al., 2023).

3.2 Quality Parameter

The protein content increased with the application of 40:40:60 NPK kg ha^{-1} +BF and T_{10} 40:60:60 NPK kg ha^{-1} +BF, which was significantly superior over all other treatments (Table 1). Higher nitrogen in the pod is directly responsible for higher protein because it is a primary component of amino acids, which constitute the basis of protein content. The reason for higher nitrogen content might be due to increased activity of nitrate reductase enzyme due to inoculation of the seed with *rhizobium,* which increases the concentration of healthy strains of *rhizobium* in the rhizosphere, which results in more atmospheric nitrogen fixation for plant use (Meena *et al*. 2006).

3.3 Nutrient Content

Analysis of the data revealed that the application of graded doses of NPK, both with and without biofertilisers, significantly enhanced the nitrogen content in the seeds and stover of cluster bean compared to the absolute control. The observed increase in nitrogen content can be attributed to multiple factors, including the direct addition of nitrogen through chemical fertilisers, biological nitrogen fixation by *Rhizobium*, and the mineralisation of organic matter, which releases macro- and micronutrients into the soil solution, making them available for plant uptake. Among the treatments, T10 recorded the highest nitrogen content in both seed (1.88%) and stover (0.319%), and was statistically comparable to T6, indicating the synergistic effect of combined NPK fertilisation and biofertiliser application on nitrogen accumulation in cluster bean.

Table 1. Effect of different levels of NPK with and without biofertilizers on yield, quality and economics of the cluster bean

Tr. No.	Treatment	Green pod yield (q ha^{-1})	Stover yield (kg ha^{-1})	Protein content (%)	Gross returns (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	B: C ratio
T_1	Absolute control	29.35	597.27	10.56	182072.7	153384.3	28688.4	1.19
T_2	Biofertilizers only	31.82	676.80	10.62	197688.0	158192.6	39495.4	1.25
T_3	40:40:40 NPK kg ha^{-1}	69.48	858.67	10.73	425466.7	261372.8	164093.9	1.63
T_4	40:40:40 NPK kg ha^{-1} + BF	73.07	863.00	11.08	447050.0	267175.8	179874.2	1.67
T_5	40:40:60 NPK kg ha^{-1}	69.02	861.67	10.62	422736.7	261671.3	161065.4	1.62
T_6	40:40:60 NPK kg ha^{-1} + BF	72.04	861.83	11.73	440858.3	266897.3	173961.0	1.65
T_7	40:60:40 NPK kg ha^{-1}	62.21	853.50	10.79	381795.0	255365.4	126429.6	1.50
T_8	40:60:40 NPK kg ha^{-1} + BF	67.62	865.67	11.14	414376.7	263001.5	151375.2	1.58
T_9	40:60:60 NPK kg ha^{-1}	71.25	862.33	11.20	436123.3	265227.9	170895.4	1.64
T_{10}	40:60:60 NPK kg ha^{-1} + BF	76.53	879.33	11.73	467973.3	272687.7	195285.6	1.72
S.E.(m) ±		2.56	4.11	0.10	-	-	-	-
C.D. (*P* = .05)		7.61	12.20	0.30	-	-	-	-

Table 2. Effect of different NPK levels with and without biofertilizers on content and uptake of macro-nutrients (NPK)

Tr. No.	Treatment	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
		seed	stover	seed	stover	seed	stover
T_1	Absolute control	1.69	0.111	0.15	0.088	0.52	0.21
T_2	Biofertilizers only	1.70	0.159	0.16	0.091	0.63	0.23
T_3	40:40:40 NPK kg ha^{-1}	1.72	0.209	0.18	0.129	0.73	0.25
T_4	40:40:40 NPK kg ha^{-1} + BF	1.77	0.219	0.20	0.121	0.77	0.26
T_5	40:40:60 NPK kg ha^{-1}	1.70	0.215	0.19	0.121	0.83	0.30
T_6	40:40:60 NPK kg ha^{-1} + BF	1.88	0.267	0.19	0.131	0.84	0.29
T_7	40:60:40 NPK kg ha^{-1}	1.73	0.224	0.22	0.133	0.79	0.26
T_8	40:60:40 NPK kg ha^{-1} + BF	1.78	0.295	0.23	0.139	0.80	0.27
T_9	40:60:60 NPK kg ha^{-1}	1.79	0.243	0.23	0.140	0.83	0.32
T_{10}	40:60:60 NPK kg ha^{-1} + BF	1.88	0.319	0.25	0.141	0.85	0.30
S.E.(m) ±		0.016	0.03	0.01	0.01	0.02	0.022
C.D. (*P* = .05)		0.047	0.09	0.03	0.03	0.06	0.064

Detailed examination of the data revealed that total phosphorus (P) content increased with biofertiliser seed inoculation compared with the sole application of chemical fertiliser combinations. The significantly highest total P content was recorded under treatment T10 (40:60:60 kg NPK ha^{-1} + biofertilisers), with values of 0.25% in seed and 0.141% in stover, which was statistically at par with treatment T9. The enhanced P content observed under the combined application of biofertilisers and potassium may be attributed to increased activities of nitrogenase and nitrate reductase enzymes in the soil. These processes promote greater biological nitrogen fixation by *Rhizobium* and enhance phosphorus availability through improved solubilisation in the soil.

A significant increase in potassium (K) content was also observed, which can be attributed to the direct addition of potassium through fertiliser inputs to the soil's available nutrient pool. Additionally, the decomposition of organic matter releases both macro- and micronutrients into the soil solution, thereby improving their availability for plant uptake. The results indicated that higher K content was achieved with potassium application at 60 kg ha^{-1} compared with the lower dose of 40 kg ha^{-1}. Treatment T10 (40:60:60 kg NPK ha^{-1} + biofertilisers) recorded the significantly highest K content (0.85% in seed and 0.30% in stover), which was statistically comparable with treatments T5, T6, and T9.

3.4 Soil Status

The highest soil organic carbon content was recorded in treatment T10 (40:40:60 kg ha^{-1} NPK + biofertilisers), reaching 11.80 g kg^{-1} at flowering and 12.40 g kg^{-1} at harvest. At flowering, T10 was statistically at par with T6 and T8, while at harvest it was comparable to T4. Across all treatments, soil organic carbon increased from flowering to harvest, likely due to multiple contributing factors, including the pre-sowing application of farmyard manure, deposition of plant litter, recycling of fine root biomass, release of root exudates, and reduced oxidation of organic matter during the crop growth period.

Regarding soil available nitrogen, the highest values at both flowering and harvest were also observed under T10 (40:60:60 kg ha⁻¹ NPK + biofertilisers), measuring 298.97 kg ha⁻¹ and 264.47 kg ha⁻¹, respectively. A general decline in available nitrogen from flowering to harvest was noted across all treatments, which may be attributed to the percolative nature of lateritic soils, facilitating nitrogen losses through leaching and denitrification, in addition to uptake by growing plants. Comparable trends of declining soil nitrogen in lateritic soils have been previously reported by Thorbole (2002).

Table 3. Effect of different levels of NPK with and without biofertilizers on available soil nutrient status

Tr. No.	Treatment	Organic carbon ($g\ kg^{-1}$)		Available N ($kg\ ha^{-1}$)		Available P_2O_5 ($kg\ ha^{-1}$)		Available K_2O ($kg\ ha^{-1}$)	
		At flowering	At harvest	At flowering	At harvest	At flowering	At harvest	At flowering	At harvest
T_1	Absolute control	9.50	10.30	221.61	203.84	7.00	6.56	268.80	246.40
T_2	Biofertilizers only	11.10	11.30	236.25	223.70	7.34	6.85	280.00	227.73
T_3	40:40:40 NPK kg ha^{-1}	10.90	11.80	251.93	226.84	8.25	7.93	298.67	276.27
T_4	40:40:40 NPK kg ha^{-1} + BF	11.30	12.10	263.42	234.15	9.04	8.21	302.40	280.00
T_5	40:40:40 NPK kg ha^{-1}	10.80	11.20	258.20	232.06	8.34	7.62	313.60	291.20
T_6	40:40:40 NPK kg ha^{-1} + BF	11.50	11.80	271.79	246.70	8.65	7.99	317.33	294.93
T_7	40:40:40 NPK kg ha^{-1}	10.70	11.30	267.61	233.11	12.93	11.18	302.40	272.53
T_8	40:40:40 NPK kg ha^{-1} + BF	11.60	11.90	283.29	255.06	13.34	12.41	306.13	280.00
T_9	40:40:40 NPK kg ha^{-1}	11.30	12.00	274.92	248.79	13.49	12.72	324.80	298.67
T_{10}	40:40:40 NPK kg ha^{-1} + BF	11.80	12.40	298.97	264.47	13.74	13.42	328.53	294.93
S.E.(m) ±		0.16	0.13	1.55	2.49	0.23	0.37	6.13	7.11
C.D. (P = .05)		0.48	0.39	4.61	7.40	0.69	1.11	18.23	21.11

At both the flowering and harvest stages, the highest soil available P_2O_5 levels (13.74 kg ha⁻¹ and 13.42 kg ha⁻¹, respectively) were recorded under treatment T10 (40:60:60 kg ha⁻¹ NPK + biofertilisers), which was statistically comparable with treatments T8 and T9. The significant enhancement of soil phosphorus availability by phosphate-solubilising biofertilisers is likely attributable to the secretion of organic and inorganic acids. These acids act on residual insoluble phosphates, converting them into orthophosphate forms that are readily available for crop uptake and growth.

Significantly 40:60:60 NPK kg ha^{-1} +BF (T_{10}) recorded highest available potassium *i.e.,* 328.53 kg ha^{-1} at flowering was found to be at par with the treatment T_5, T_6, and T_9, while 298.67 kg ha^{-1} of available potassium at harvest stage was recorded in treatment T_9 *i.e.,* 40:60:60 NPK kg ha^{-1} was found at par with treatments T_4, T_5, T_6, T_8 and T_{10}.

3.5 Economics

An assessment of the data showed that the highest gross returns (4,67,973.3 Rs. ha^{-1}), net return (1,95,285.6 Rs. ha^{-1}) and B: C ratio (1.72) and was found in the treatment T_{10} (40:60:60 NPK kg ha^{-1}+ BF) therefore, treatment T_{10} (40:60:60 NPK kg ha^{-1}+ BF) rated as most effective and profitable treatment (Table 1).

4. Conclusion

From the study, it could be concluded that for getting maximum yield, economic return, benefit-cost ratio, as well as enhancing nutrient status of the soil and thereby improving the soil fertility status, the combined application of chemical fertilisers with biofertilizers (*rhizobium* and PSB) of 40:60:60 NPK kg ha^{-1}+ BF is beneficial.

Disclaimer (Artificial Intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

Competing Interests

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Beleri, P. S. (2023). Microbial solutions to soil health: The role of biofertilizers in sustainable agriculture. *Environmental Reports*. https://doi.org/10.51470/ER.2023.5.2.06

Bhatt, R. K., Jukanti, A. K., & Roy, M. M. (2017). Cluster bean [Cyamopsis tetragonoloba (L.) Taub.], an important industrial arid legume: A review. *Legume Research: An International Journal*, *40*(2). http://arccarticles.s3.amazonaws.com/webArticle/articles/1LR3599.pdf

Chaudhary, P., Singh, S., Chaudhary, A., Sharma, A., & Kumar, G. (2022). Overview of biofertilizers in crop production and stress management for sustainable agriculture. *Frontiers in Plant Science, 13*, 930340. https://doi.org/10.3389/fpls.2022.930340

Chimate, P., Khobragade, N. H., Wahane, M. R., Rajemahadik, V. A., Thorat, S. B., Thakare, U. E., ... & Vardam, D. G. (2023). Effect of biofertilizers and NPK levels on yield and nutrient uptake by cluster bean (*Cyamopsis tetragonoloba* L. Taub.) in lateritic soils of Konkan.

Daniel, A. I., Fadaka, A. O., Gokul, A., Bakare, O. O., Aina, O., Fisher, S., ... & Klein, A. (2022). Biofertilizer: The future of food security and food safety. *Microorganisms, 10*(6), 1220. https://doi.org/10.3390/microorganisms10061220

Dongale, J. H. (1989). *Phosphorus fractions in relation to P availability and the response of crops to fertilizer phosphorus in lateritic soil of Konkan* (Ph.D. Thesis). Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (MS).

Jilen, B., Pugalendhi, L., Devi, H. U. N., & Priya, R. S. (2022). Evaluation of cluster bean (*Cyamopsis tetragonoloba* L.) genotypes for vegetable pod yield and guar gum production. *International Journal of Environment and Climate Change, 12*(12), 29–37. https://doi.org/10.9734/ijecc/2022/v12i121436

Manohar, C. V. S., Sharma, O. P., & Verma, H. P. (2018). Nutrient status and yield of cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.) as influenced by fertility levels and liquid biofertilizers. *Journal of Pharmacognosy and Phytochemistry, 7*(5), 1840–1843.

Meena, K. R., Dahama, A. K., & Reager, M. L. (2006). Effect of phosphorus and zinc fertilization on growth and quality of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Annals of Agricultural Research, New Series, 27*(3), 224–226.

Sathwara, J. N., Patel, P. J., & Panchal, R. J. (2025). Genetic variability, correlation and path analysis in cluster bean (CYAMOPSIS TETRAGONOLOBA L. TAUB.). *Plant Archives*, *25*(2), 536-542. https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-2.064

Singh, S. R., Najar, G. R., & Singh, U. (2007). Productivity and nutrient uptake of soybean (*Glycine max*) as influenced by bio-inoculants and farmyard manure under rainfed conditions. *Indian Journal of Agronomy, 52*(4), 325–329. https://indianjournals.com/article/ija-52-4-012

Sourabh, Bharose, R., Kumar, R., Kumar, H., Tripathi, M., & Kumar, S. (2024). Optimizing growth and yield of cluster bean (*Cyamopsis tetragonoloba* L.) var. Neelam-61 through integrated use of inorganic fertilizers, organic manure and *Rhizobium* inoculation. *Asian Journal of Soil Science and Plant Nutrition, 10*(3), 444–452. https://doi.org/10.9734/ajsspn/2024/v10i3356

Thorbole, S. B. (2002). *Impact of integrated use of fertilizers on growth, yield, quality and nutrient uptake by okra (Abelmoschus esculentus (L.) Monech) and changes in nutrient availability in lateritic soil* (M.Sc. (Ag.) Thesis). Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra.

Yadav, A., & Yadav, K. (2024). Challenges and opportunities in biofertilizer commercialization. *SVOA Microbiol*, *5*(1), 1-14. https://sciencevolks.com/microbiology/pdf/SVOA-MB-05-037.pdf

Zhao, G., Zhu, X., Zheng, G., Meng, G., Dong, Z., Baek, J. H., ... & Jia, B. (2024). Development of biofertilizers for sustainable agriculture over four decades (1980–2022). *Geography and Sustainability*, *5*(1), 19-28. https://www.sciencedirect.com/science/article/pii/S2666683923000652

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