

ECONOMICS OF MUNG BEAN (*VIGNA RADIATA* L.) SEED PRODUCTION UNDER INTEGRATED NUTRIENT MANAGEMENT PRACTICES

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ABSTRACT

A field experiment was conducted during the summer seasons of 2024 and 2025 at the Research Farm of the Department of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana, to evaluate the effect of integrated nutrient management on productivity and profitability of mungbean varieties under North-Western Plain Zone conditions. The experimental site was located at 30°17' N latitude and 77°03' E longitude, at an altitude of 264 m above mean sea level. The experiment was laid out in a Factorial Randomized Block Design with three replications, comprising three mungbean varieties, namely MH 421, MH 1142 and MH 1762, and eight nutrient management treatments involving different combinations of nitrogen, phosphorus, Rhizobium and nano fertilizers. The crop was sown during April in both years at a seed rate of 20 kg ha⁻¹ with 30 cm × 10 cm spacing. Seeds were inoculated with Rhizobium culture at 10 ml kg⁻¹ seed, and recommended agronomic practices were followed uniformly. The results showed significant variation in seed yield and economic returns among the varieties and nutrient management treatments. The treatment combination T6V2 (20 kg N + 60 kg P₂O₅ + Rhizobium with MH 1142) recorded the highest seed yield of 11.04 and 11.25 q ha⁻¹ during 2024 and 2025, respectively. It also recorded gross returns of ₹96,798.72 and ₹98,640.00 ha⁻¹, net returns of ₹58,906.78 and ₹60,748.06 ha⁻¹, and B:C ratios of 2.55 and 2.60, respectively. Across nutrient management treatments, T6 recorded the highest mean seed yield of 10.68 and 10.90 q ha⁻¹, with B:C ratios of 2.47 and 2.52 in the respective years, while MH 1142 showed comparatively higher mean productivity among the varieties. The cost of cultivation ranged from ₹36,412.20 ha⁻¹ under T1 to ₹38,417.20 ha⁻¹ under T8. The nano-fertilizer treatments T7 and T8 showed moderate economic performance. Overall, the integration of 20 kg N + 60 kg P₂O₅ with Rhizobium, particularly with MH 1142, improved mungbean productivity and profitability under the experimental conditions of the North-Western Plain Zone.

KEYWORDS: Mung bean, Integrated nutrient management, Rhizobium, Nano fertilizers, Seed yield, Economic analysis, Benefit - cost ratio

INTRODUCTION

Green gram (*Vigna radiata* L.) commonly known as mung bean, is one of the most important pulse crops grown in tropical and subtropical regions of the world. It is widely cultivated in Asia, particularly in countries like India, China, Thailand and Myanmar due to its short duration, nitrogen-fixing ability and high nutritional value. Globally, mung bean is grown on about 7.3 million hectares with an annual production of approximately 5.3 million tonnes, having an average productivity of around 730 kg ha⁻¹ (Nair and Schleiermacher., 2020; FAOSTAT, 2024).

India is the largest producer and consumer of green gram, contributing nearly 55–60% of global production. During 2023–24, green gram was cultivated over about 5.0 million hectares with a production of 3.2 million tonnes and an average productivity of approximately 640 kg ha⁻¹ (Directorate of Economics and Statistics, 2024). In Haryana, green gram is gaining importance as a summer and kharif pulse crop due to its suitability in crop diversification systems. The crop is cultivated on approximately 35 - 45 thousand hectares, with a production of around 20–25 thousand tonnes and an average productivity ranging between 550–600 kg ha⁻¹ (Department of Agriculture & Farmers Welfare, Haryana, 2023). However, yield of mungbean is below the national potential, largely due to inadequate nutrient management and improper varietal selection.

Among the improved mung bean varieties recommended for North Indian conditions MH 421, MH 1142 and MH 7162 are widely cultivated due to their adaptability, yield stability and responsiveness to nutrient management practices. MH 421 is a widely adapted and stable variety suitable for semi-arid regions, particularly Haryana and adjoining states. It is known for its better nutrient responsiveness and consistent performance under integrated crop management practices. Studies have shown that MH 421 performs efficiently under improved nutrient conditions, contributing to higher productivity and better crop performance (Dhayal et al., 2025). Average yield of this variety is approximately 8.0–8.5 q ha⁻¹ under improved management conditions (Yadav et al., 2025). MH 1142 is a recently released high-yielding variety developed by CCS HAU, Hisar and is gaining popularity due to its disease resistance and higher economic returns. It shows better performance in terms of seed yield and profitability compared to older varieties like MH 421. Average yield is around 10–12 q ha⁻¹ under recommended agronomic practices (Shiksha et al., 2025 and Global Agriculture: Food Security with Sustainability., 2025). Its resistance to major diseases such as mungbean yellow mosaic virus (MYMV) and adaptability across multiple states make it highly suitable for inclusion in nutrient management studies. MH 7162 is an improved high-yielding variety developed for better adaptability and productivity under varying agro-climatic conditions. It is characterized by improved plant type, better pod setting and enhanced yield potential under balanced fertilization and

integrated nutrient management practices (CCSHAU recommendations). Average yield is approximately 9–11 q ha⁻¹ under optimal management conditions (HAU package of practices / varietal recommendations). This variety is particularly important in research trials due to its higher yield potential and responsiveness to nutrient inputs.

Integrated Nutrient Management (INM) has emerged as a key strategy for enhancing productivity, profitability and sustainability of mungbean (*Vigna radiata* L.) cultivation, particularly under conditions of declining soil fertility and imbalanced fertilizer use. Being a leguminous crop, mungbean has the inherent ability to fix atmospheric nitrogen through symbiotic association with *Rhizobium*, yet its yield potential remains constrained due to inadequate and inefficient nutrient supply, especially phosphorus and micronutrients (Meena et al., 2016).

The combined application of inorganic fertilizers with organic manures such as farmyard manure (FYM), vermicompost and biofertilizers like *Rhizobium* and phosphate-solubilizing bacteria (PSB) has been reported to significantly improve growth, nodulation and yield attributes of mungbean. Integrated use of these nutrient sources enhances nutrient availability, improves soil physical properties and stimulates microbial activity, leading to better nutrient uptake and utilization efficiency (Singh et al., 2020). Studies have shown that the application of recommended doses of fertilizers (RDF) along with FYM and biofertilizers increased seed yield by 15–35% over sole chemical fertilization (Meena et al., 2021; Singh et al., 2021).

In addition to yield enhancement, INM plays a crucial role in improving the economic returns of mungbean cultivation. The integration of organic and biological inputs reduces dependency on costly chemical fertilizers, thereby lowering the cost of cultivation while simultaneously increasing productivity. This results in higher net returns and improved benefit–cost (B:C) ratio. Angadi and Patil (2018) reported that INM practices significantly enhanced profitability of mungbean cultivation due to increased yield and better resource-use efficiency. Similarly, field studies have demonstrated that combined application of fertilizers with biofertilizers and organic manures not only improved seed yield but also resulted in higher net income and economic efficiency compared to sole fertilizer application (Kumar et al., 2021). Moreover, INM contributes to long-term soil health by maintaining soil organic carbon, enhancing nutrient cycling and preventing nutrient mining, which is critical for sustaining productivity in intensive cropping systems. Therefore, the adoption of integrated nutrient management practices is essential for achieving higher yield, improved economic returns and sustainable mungbean production.

Sustained growth in agricultural production and productivity relies heavily on the development of high-yielding varieties and the timely availability of quality seeds to farmers. It has been reported that quality seed alone can enhance crop production by about 15–20 per cent, which may further increase up to 40 per cent when complemented with efficient management of other agricultural inputs (Anonymous, 2007a). In addition, the use of high-quality seeds ensures better uniformity and genetic purity of crops, ultimately resulting in improved market value. Quality seed production is a highly specialized activity and farm-saved seeds cannot serve as an effective substitute for certified seeds due to their lower genetic purity and reduced germination potential (Singh et al., 1990). The cost of seed represents a significant share of the total cost of mung bean cultivation, highlighting the need for its economic evaluation for both farmers and seed producers. While several studies have examined the economics of mung bean cultivation for grain production (Samant, 2014; Poonia, 2017; Prem et al., 2017; Angadi and Patil, 2018; Jat et al., 2016; Dash and Rautaray, 2017; Dash et al., 2018) and seed production in other crops (Pal et al., 2016a, 2016b, 2016c), Limited research has been conducted specifically on the economics of mung bean seed production; therefore, the present investigation was undertaken to assess and compare the economics of certified seed production and grain production of mung bean. Despite the significance of mung bean as a major pulse crop, most existing studies have predominantly focused on the economics of grain production, with comparatively little attention given to seed production economics under varying nutrient management practices. In addition, very few studies have examined the combined effects of chemical fertilizers, biofertilizers and nano inputs on economic returns. There is also limited information available on the interaction between improved varieties and nutrient management practices in influencing profitability. Moreover, the economic potential of certified seed production, which generally commands a higher market value than grain, remains largely unexplored. Another critical gap is the lack of comparative economic analyses based on recent price scenarios, particularly those aligned with Minimum Support Price (MSP) evaluations. Therefore, the present study was undertaken to address these gaps by evaluating the economics of mung bean seed production under integrated nutrient management practices across different varieties, thereby providing a more comprehensive and practical understanding for both farmers and researchers.

MATERIALS AND METHODS

A field experiment was conducted during the Summerseasons of 2024 and 2025 at the Research Farm of the Department of Agriculture, Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana. The experimental site is geographically located at 30°17' N latitude and 77°03' E longitude, at an altitude of 264 m above mean sea level. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications, comprising three mungbean varieties and eight nutrient management treatments. The three mungbean varieties included in the study were MH 421, MH 1142 and MH 7162, which are well adapted to the North-Western Plain Zone of India. The nutrient management treatments consisted of: T₁ (15 kg N + 40 kg P₂O₅ as recommended dose of fertilizers), T₂ (15 kg N + 60 kg P₂O₅), T₃ (20 kg N + 60 kg P₂O₅), T₄ (RDF + *Rhizobium*), T₅ (15 kg N + 60 kg P₂O₅ + *Rhizobium*), T₆ (20 kg N + 60 kg P₂O₅ + *Rhizobium*), T₇ (RDF + nano urea @ 2 ml/ha + nano DAP + *Rhizobium*) and T₈ (RDF + nano urea @ 4 ml/ha + nano DAP + *Rhizobium*). The crop was sown during April in both years using a seed rate of 20 kg/ha, maintaining a spacing of 30 cm between rows and 10 cm between plants. The gross plot size was 3.3 × 3.0 m, while the net plot size was 2.7 × 2.4 m. All recommended agronomic practices were followed uniformly across treatments. Prior to sowing, seeds were inoculated with *Rhizobium* culture at the rate of 10 ml per kg of seed.

The crop was harvested at maturity and seed yield from each net plot was recorded after proper drying, threshing and cleaning. The yield data were converted into kilogram per hectare for further analysis. The economics of mungbean cultivation were worked out by calculating the cost of cultivation, gross returns, net returns and benefit-cost ratio. The total cost of cultivation was computed by summing both fixed and variable costs. Fixed costs included land rental value, depreciation on farm implements and interest on fixed capital, whereas variable costs comprised expenditure on seed, fertilizers, biofertilizers, labour for various field operations, irrigation and plant protection measures.

Gross returns were calculated by multiplying seed yield (q/ha) with the prevailing market price of produce. Net returns were obtained by subtracting the total cost of cultivation from the gross returns. The benefit-cost (B:C) ratio was calculated as the ratio of gross returns to the total cost of cultivation. The data recorded during the course of investigation were statistically analysed using the analysis of variance (ANOVA) technique appropriate for Factorial Randomized Block Design as described by Gomez and Gomez (1984). The significance of treatment effects was tested at the 5 per cent level of probability.

RESULT AND DISCUSSION

The economics of mungbean cultivation as influenced by different nutrient management practices and varieties during the Summerseasons of 2024 and 2025 revealed significant variation in terms of seed yield, cost of cultivation, gross returns, net returns and benefit-cost (B:C) ratio.

The data presented in Table 1 indicate that the total cost of cultivation remained uniform across all the varieties, namely V1 (MH 421), V2 (MH 1142) and V3 (MH 1762), within each nutrient management treatment. Since the fixed cost was constant at ₹32,738 for all treatment combinations and the variable cost depended on the nutrient management treatment, varietal differences did not influence the cost of cultivation. Therefore, V1, V2 and V3 recorded identical costs under their respective nutrient management treatments.

In contrast, the integrated nutrient management treatments exhibited considerable variation in the total cost of cultivation. The highest total cost of cultivation was recorded under T8 (RDF + nano urea + nano DAP) at ₹38,417.20 per ha, followed by T6 at ₹37,891.94 per ha and T5 at ₹37,827.20 per ha. The higher cost under these treatments was mainly due to the additional expenditure associated with the application of nano fertilizers, Rhizobium and other nutrient inputs. The lowest total cost of cultivation was recorded under T1 (15 kg N + 40 kg P₂O₅), amounting to ₹36,412.20 per ha, owing to its comparatively lower variable input cost. The total cost under T4 and T7 was ₹36,527.20 and ₹37,672.20 per ha, respectively, while T2 and T3 recorded ₹37,712.20 and ₹37,776.94 per ha, respectively.

Overall, the results indicate that varietal differences did not affect the cost of cultivation, whereas the type and level of nutrient inputs substantially influenced the variable and consequently the total cost of cultivation. The increase in total cost under treatments involving additional nutrient sources reflects the expenditure associated with these inputs. Similar trends in cost variation due to nutrient inputs were also reported by Jat et al. (2016) and Dash et al. (2018).

The data on seed yield (q ha⁻¹) during 2024 - 25 and 2025-26 clearly indicate that both integrated nutrient management practices and varietal differences influenced mung bean productivity. The seed yield data presented in Table 2 revealed considerable variation among varieties and nutrient management treatments during both years.

Among the varieties, the highest seed yield was recorded by V2 (MH 1142) under most nutrient management treatments, particularly under T6, where it produced 11.04 q ha⁻¹ in 2024 and 11.25 q ha⁻¹ in 2025. V1 (MH 421) and V3 (MH 1762) showed comparatively variable performance across the nutrient management treatments. The overall superior performance of MH 1142 under several treatments indicates its better yield potential and response to improved nutrient availability.

Table 1: Effect of integrated nutrient management on total cost of cultivation

Treatments	Variable Cost (Rs.)	Fixed Cost (Rs.)	Total Cost of Cultivation (Rs.)
Varieties			
V1 (MH 421)	4,666.06*	32,738	37,404.06*
V2 (MH 1142)	4,666.06*	32,738	37,404.06*
V3 (MH 1762)	4,666.06*	32,738	37,404.06*
Treatments			
T1	3,674.20	32,738	36,412.20
T2	4,974.20	32,738	37,712.20
T3	5,038.94	32,738	37,776.94
T4	3,789.20	32,738	36,527.20
T5	5,089.20	32,738	37,827.20
T6	5,153.94	32,738	37,891.94
T7	4,934.20	32,738	37,672.20
T8	5,679.20	32,738	38,417.20

Among the integrated nutrient management treatments, T6 (20 kg N + 60 kg P₂O₅ + Rhizobium) recorded the highest seed yield when averaged across varieties, with particularly high yields of 10.56, 11.04 and 10.45 q ha⁻¹ for V1, V2 and V3, respectively, during 2024. During 2025, the corresponding yields increased to 10.81, 11.25 and 10.63 q ha⁻¹. Thus, T6

emerged as the most productive nutrient management treatment in both years. T5 and T3 also produced comparatively higher seed yields, indicating a positive response of mung bean to increased nutrient availability and integrated nutrient management. In contrast, T2 generally recorded lower productivity, particularly in combination with V3, where seed yield was 8.12 q ha⁻¹ in 2024. The results indicate that balanced nutrient application, particularly when supplemented with Rhizobium, enhanced mung bean productivity. These findings are in close agreement with Poonia (2017) and Angadi and Patil (2018), who reported significant yield improvement in mungbean with integrated nutrient management practices. The economic evaluation of mung bean seed production during 2024 and 2025 further demonstrated substantial differences in gross returns, net returns and benefit–cost ratio among nutrient management treatments and varieties. The gross returns were calculated using the seed yield and MSP of ₹8,768 per quintal. Since the total cost of cultivation varied among nutrient management treatments, the differences in net returns and B:C ratio reflected both productivity and input expenditure.

Among the individual treatments, T6 recorded the highest gross returns of ₹93,671.47 ha⁻¹ in 2024 and ₹95,542.00 ha⁻¹ in 2025. It also recorded the highest net returns of ₹55,779.53 ha⁻¹ and ₹57,650.06 ha⁻¹, respectively. The corresponding B:C ratios were 2.47 and 2.52, respectively. This superior economic performance was associated with the highest mean seed yield of 10.68 q ha⁻¹ in 2024 and 10.90 q ha⁻¹ in 2025. The higher economic returns under T6 may be attributed to the combined application of 20 kg N + 60 kg P₂O₅ along with Rhizobium, which resulted in better productivity compared with the other nutrient-management treatments.

Among the varieties, V2 (MH 1142) generally showed better economic performance than V1 (MH 421) and V3 (MH 1762). V2 recorded an average gross returns of ₹88,600.92 ha⁻¹ in 2024 and ₹89,604.59 ha⁻¹ in 2025, with corresponding net returns of ₹51,061.07 and ₹52,064.74 ha⁻¹, respectively. The B:C ratio increased from 2.36 in 2024 to 2.39 in 2025. This better economic performance was associated with its comparatively higher mean seed yield of 10.09 q ha⁻¹ in 2024 and 10.22 q ha⁻¹ in 2025.

Among the nutrient-management treatments, T2 recorded comparatively lower economic returns, with a gross returns of ₹78,298.24 ha⁻¹ in 2024 and ₹82,156.33 ha⁻¹ in 2025. The corresponding net returns were ₹40,586.04 and ₹44,444.13 ha⁻¹, while the B:C ratios were 2.08 and 2.18, respectively. The comparatively lower economic returns under T2 were associated with its lower mean seed yield of 8.93 q ha⁻¹ in 2024 and 9.37 q ha⁻¹ in 2025.

The treatment T4 also produced satisfactory economic returns. It recorded a gross returns of ₹85,312.64 ha⁻¹ in 2024 and ₹85,400.33 ha⁻¹ in 2025, with net returns of ₹48,785.44 and ₹48,873.13 ha⁻¹, respectively. The B:C ratio under T4 was 2.34 in both years. The treatment T5 also performed well, recording gross returns of ₹89,141.33 and ₹91,011.67 ha⁻¹ and net returns of ₹51,314.13 and ₹53,184.47 ha⁻¹ during 2024 and 2025, respectively. Its B:C ratio increased from 2.36 to 2.41.

The nano-fertilizer treatments T7 and T8 produced moderate economic returns. T7 recorded a gross returns of ₹85,488.00 ha⁻¹ in 2024 and ₹85,634.13 ha⁻¹ in 2025, with corresponding net returns of ₹47,815.80 and ₹47,961.93 ha⁻¹. Its B:C ratio remained at 2.27 in both years. T8 recorded gross returns of ₹85,517.23 and ₹86,335.57 ha⁻¹ and net returns of ₹47,100.03 and ₹47,918.37 ha⁻¹ during the respective years, with B:C ratios of 2.23 and 2.25. The comparatively higher cost of cultivation under T8 reduced its net economic advantage despite its seed yield being comparable with some other treatments.

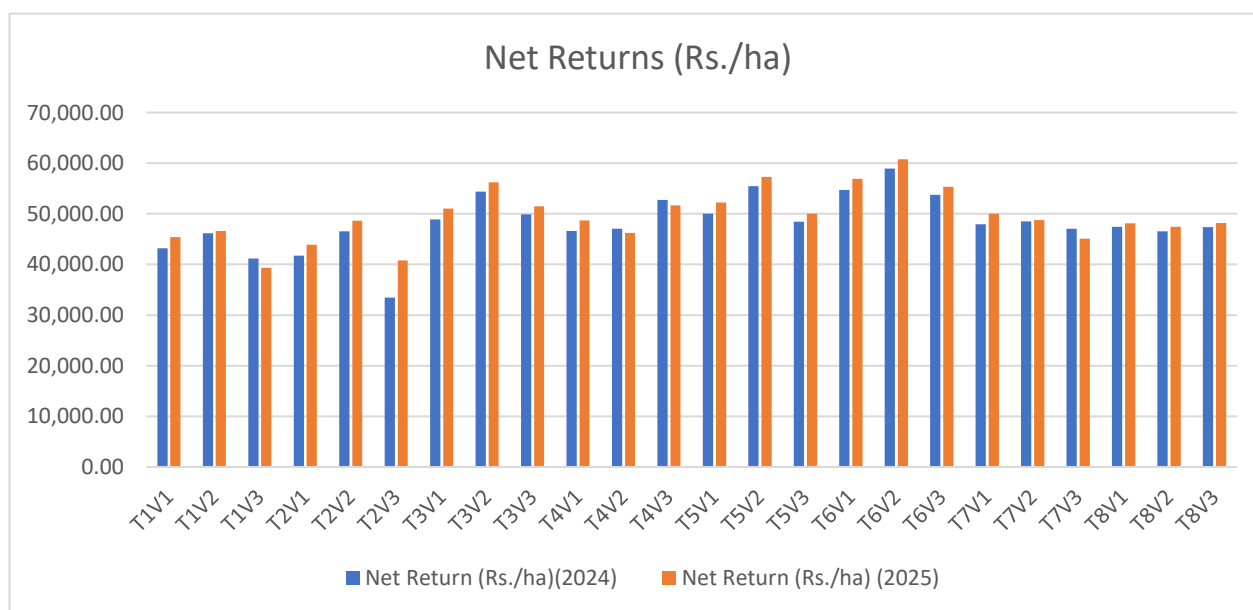
A year-wise comparison showed that seed yield and economic returns generally improved during 2025 compared with 2024 for most treatments. For example, T6 increased its mean seed yield from 10.68 to 10.90 q ha⁻¹, while gross returns increased from ₹93,671.47 to ₹95,542.00 ha⁻¹. The net returns increased from ₹55,779.53 to ₹57,650.06 ha⁻¹, and the B:C ratio increased from 2.47 to 2.52. Similarly, V2 showed an increase in mean seed yield from 10.09 to 10.22 q ha⁻¹, accompanied by an increase in gross returns from ₹88,600.92 to ₹89,604.59 ha⁻¹ and net returns from ₹51,061.07 to ₹52,064.74 ha⁻¹. These results indicate improved productivity and profitability during the second year under most of the treatment combinations.

Overall, the results demonstrate that integrated nutrient management substantially influenced both productivity and profitability of mung bean. Among the nutrient-management treatments, T6 (20 kg N + 60 kg P₂O₅ + Rhizobium) recorded the highest mean seed yield, gross returns, net returns and B:C ratio in both years. Among the varieties, V2 (MH 1142) showed comparatively higher economic returns and B:C ratio than V1 and V3. The combination of balanced nitrogen and phosphorus fertilization with Rhizobium, particularly under T6, therefore showed favourable economic performance under the experimental conditions. These findings are in agreement with the observations of Prem et al. (2017) and Pal et al. (2016), who reported that integrated nutrient management can improve productivity and economic returns in pulse crops.

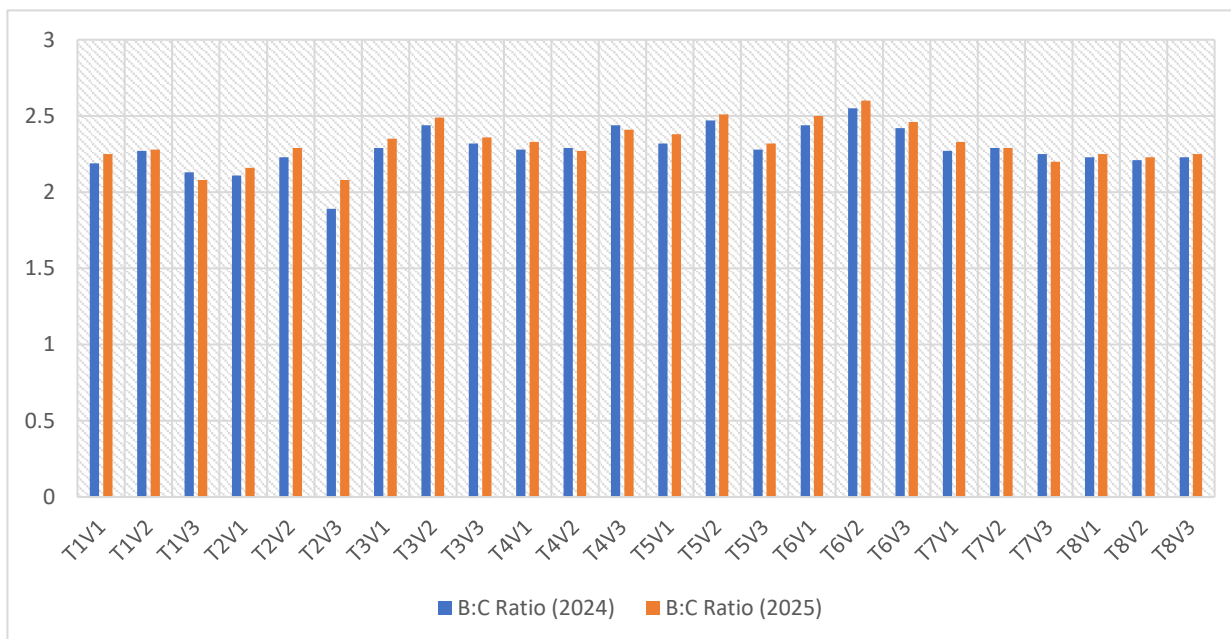
Table: 2 Effect of integrated nutrient management on economics in mungbean

Treatment s	2024					2025				
	Seed Yield (q/ha) 2024	Gross Return s (Rs./ha)	Cost of Cultivat ion (Rs./ha)	Net Returns(Rs./h a)	B:C Rati o	Seed Yield (q/ha) 2025	Gross Return s (Rs./ha)	Cost of Cultivat ion (Rs./ha)	Net Return s (Rs./ha)	B:C Rati o
V1 (MH 421)	9.82	86,082	37,540	48,543	2.29	10.05	88,316	37,540	50,777	2.35
V2 (MH 1142)	10.09	88,601	37,540	51,061	2.36	10.22	89,605	37,540	52,065	2.39

V3 (MH 1762)	9.61	84,254	37,540	46,714	2.25	9.73	85,324	37,540	47,784	2.27
T1 (15 kg N + 40 kg P ₂ O ₅)	9.12	79,935	36,412	43,523	2.20	9.15	80,198	36,412	43,786	2.20
T2 (15 kg N + 60 kg P ₂ O ₅)	8.93	78,298	37,712	40,586	2.08	9.37	82,156	37,712	44,444	2.18
T3 (20 kg N + 60 kg P ₂ O ₅)	10.13	88,820	37,777	51,043	2.35	10.34	90,690	37,777	52,913	2.40
T4 (15 kg N + 40 kg P ₂ O ₅ + Rhizobium)	9.73	85,313	36,527	48,785	2.34	9.74	85,400	36,527	48,873	2.34
T5 (15 kg N + 60 kg P ₂ O ₅ + Rhizobium)	10.17	89,141	37,827	51,314	2.36	10.38	91,012	37,827	53,184	2.41
T6 (20 kg N + 60 kg P ₂ O ₅ + Rhizobium)	10.68	93,671	37,892	55,780	2.47	10.90	95,542	37,892	57,650	2.52
T7 (RDF + 2 ml nano urea + 2 ml nano DAP ha ⁻¹)	9.75	85,488	37,672	47,816	2.27	9.77	85,634	37,672	47,962	2.27
T8 (RDF + 4 ml nano urea + 4 ml nano DAP ha ⁻¹)	9.75	85,517	38,417	47,100	2.23	9.85	86,336	38,417	47,918	2.25



Graph: 1 Effect of integrated nutrient management on net returns in mungbean



Graph: 2 Effect of integrated nutrient management on B:C ratio in mungbean

CONCLUSION

The study demonstrated that varietal selection and integrated nutrient management influenced the productivity and profitability of mung bean seed production under North-Western Indian conditions. Based on two years of experimentation during 2024 and 2025, considerable variation was observed in seed yield and economic returns among the tested varieties and nutrient management treatments. Among the nutrient management treatments, T6 (20 kg N + 60 kg P₂O₅ + Rhizobium) performed best, recording the highest mean seed yield of 10.68 and 10.90 q ha⁻¹, gross returns of ₹93,671.47 and ₹95,542.00 ha⁻¹, net returns of ₹55,779.53 and ₹57,650.06 ha⁻¹, and B:C ratios of 2.47 and 2.52 during 2024 and 2025, respectively. T5 (15 kg N + 60 kg P₂O₅ + Rhizobium) and T3 (20 kg N + 60 kg P₂O₅) followed T6 in overall economic performance. Among the varieties, V2 (MH 1142) showed comparatively better performance, with mean seed yields of 10.09 and 10.22 q ha⁻¹ and B:C ratios of 2.36 and 2.39 during 2024 and 2025, respectively. In contrast, T2 recorded the lowest mean economic performance among the nutrient management treatments, with B:C ratios of 2.08 and 2.18 in the two years. The cost of cultivation ranged from ₹36,412.20 ha⁻¹ under T1 to ₹38,417.20 ha⁻¹ under T8. Despite the higher cost associated with T6 (₹37,891.94 ha⁻¹), its higher seed productivity resulted in greater net returns and economic efficiency. The nano-fertilizer treatments T7 and T8 showed moderate performance, with B:C ratios ranging from 2.23 to 2.27, and did not match the economic performance of T6. Overall, the findings indicate that T6 (20 kg N + 60 kg P₂O₅ + Rhizobium) was the most favourable nutrient management treatment, while V2 (MH 1142) showed comparatively better varietal performance. The integration of balanced N and P fertilization with Rhizobium therefore offers a suitable approach for improving seed productivity and profitability of mung bean under the experimental conditions of North-Western India.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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REFERENCES

1. Agricultural Statistics at a Glance (2024). Directorate of Economics and Statistics, Ministry of Agriculture, Govt. of India. Available at: desagri.gov.in (accessed on 13-04-2026).
2. Angadi, S. and Patil, B.L. (2018). Economics of cost of cultivation of greengram in Gadag district of Karnataka. J. Pharmacogn. Phytochem. 7: 1206–1210.
3. Anonymous (2007a). DSR–Perspective Plan Vision 2025. ICAR–Directorate of Seed Research, Mau, Uttar Pradesh, India.
4. Anonymous (2007b). Post harvest profile of green gram. Directorate of Marketing and Inspection, Nagpur, India. Available at: agmarknet.gov.in (accessed on 13-04-2026).
5. Chotechuen, S. (1996). Breeding of mungbean for resistance to environmental stresses. In: Mungbean Germplasm: Collection, Evaluation and Utilization for Breeding Program. Pp: 52–59.
6. Dash, S.R. and Rautaray, B.K. (2017). Growth parameters and yield of green gram varieties in coastal plains of Odisha. Int. J. Curr. Microbiol. Appl. Sci. 6: 1517–1523.

7. Dash, S.R., Rautaray, B.K. and Dhal, A. (2018). Yield gap analysis and constraints in green gram cultivation. *Int. J. Curr. Microbiol. Appl. Sci.* 7: 338–346.
8. Directorate of Economics and Statistics (2024). Ministry of Agriculture & Farmers Welfare, Govt. of India (accessed on 13-04-2026).
9. Department of Agriculture and Farmers Welfare, Haryana (2023). Govt. of Haryana. India. Production of Cereals and pulses in State. Accessed on 24-04-2026.
10. Dhayal, B. C., Shukla, U. N., Singh, U., Kumhar, S. R. and Sutaliya, R. (2025). Nutrient response and yield of mungbean in response to zinc and iron through agronomic mechanism of biofortification. *Ann. Agri. Res.*, 46(2): 123-230.
11. FAOSTAT (2024). Statistics for 2023-2024 (production).<https://www.fao.org/faostat>. Accessed on 26-04-2026.
12. Global Agriculture: Food Security with Sustainability. (2025). High Yielding Moong Bean Variety for Jharkhand. Seed Industry. Accessed on 24-04-2026.
13. Jat, J.L., Singh, V. and Kumhar, B.L. (2016). Economic analysis and growth indices of mungbean. *Int. J. Adv. Biol. Res.* 6: 292–295.
14. Kumar, S. (2021). Effect of Integrated Nutrient Management in Summer Mungbean. MSc Thesis. Haryana Agricultural University, Hisar. Haryana. India.
15. Meena, S., Swaroop, N. and Dawson, J. (2016). Effect of integrated nutrient management on growth and yield of green gram (*Vigna radiata* L.). *Agri. Sci. Dig. Res. J.*, 36(1): 63-65.
16. Meena, H., Bharati, V., Dwivedi, D.K., Singh, S.K., Choudhary, R. and Singh, H. (2021). Effect of integrated nutrient management on yield attributes and yield of black gram cv. pu-31. *Leg. Res. Int. J.* 44(11): 1353-1357.
17. Nair, R. and Schleiermacher, P. (2020). Global status and economic importance of mungbean. In: *The Mungbean Genome*. Springer. Pp: 1–8.
18. Nsoukpoe-Kossi, C.N., AgIvanov, A.G., Veeranjanyulu, K. and Leblanc, R.M. (1999). Protective action of abscisic acid on photosynthesis. *Photosynthetica* 36: 51–60.
19. Pal, G., Radhika, C., Singh, R.K., Udaya, B.K., Ram, H. and Rajendra, P.S. (2016a). Comparative economics of groundnut production. *J. Exp. Agric. Int.* 14: 1–9.
20. Pal, G., Radhika, C., Singh, R.K., Udaya Bhaskar, K., Ram, H. and Rajendra Prasad, S. (2016b). Economic analysis of pigeonpea seed production. *Sci. World J.*: 1–7.
21. Pal, G., Radhika, C., Singh, R.K., Udaya Bhaskar, K., Ram, H. and Rajendra Prasad, S. (2016c). Economics of seed vs grain production of pigeonpea. *Legume Res.* 39: 806–809.
22. Poehlman, J.M. (1991). *The Mungbean*. Oxford & IBH Publishing Co., New Delhi.
23. Poonia, A.K. (2017). Economic analysis of green gram production in Rajasthan. M.Sc. Thesis, BHU, Varanasi.
24. Prem, G., Ahmad, A., Singh, V.D., Kumar, A., Choudhary, R. and Kumar, R. (2017). Growth and yield of summer mungbean under different sowing methods. *Int. J. Agric. Eng.* 10: 275–279.
25. Rank, P.H., Patel, R.J., Lunagaria, M.M. and Tiwari, M.K. (2025). Enhancing green gram production through resource management technologies. *Legume Res.* 48: 909–918.
26. Samant, T.K. (2014). Evaluation of growth and yield parameters of green gram. *Agric. Update* 9: 427–430.
27. Singh, G., Asokan, S.R. and Asopa, V.N. (1990). *Seed Industry in India: A Management Perspective*. Oxford & IBH Publishing Co., New Delhi.
28. Shiksha, Aaina, S., Bharti, A., Singh, I. and Sharma, S., (2025). Optimizing primary nutrients for enhanced performance of mung bean (*Vigna radiata* L) varieties. *Int. J. Res. Agron.*8(6):911-914.
29. Singh, R. K., Singh, S. R. K., Tripathi, U., Srivastav, V. and Rai, H. K. (2021). Enhance the productivity and nutrient use efficiency of greengram (*Vigna radiata*) through inorganic nutrients and biofertilizers. *Indian J. Agric. Sci.*91(3):417-20
30. Singh, S.P., Patel, C.R. and Paikra, K.K. (2020). Organic Farming: Prospects, constraints, opportunities and strategies for sustainable agriculture in chhattisgarh-A review. *Int. J. Pl. S. Sci.* 32(4): 35-50.
31. Yadav, B. L., Khan, I., Vyas, G. K., Yadav, M. R. and Kumar, R.(2025). Impact of integrated crop management on production potential of green gram varieties IPM02-14 and MH-421 under semi- arid conditions of (III-A Zone) Rajasthan. *Leg. Res.*, 48(9)-1566-1569.