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## Synergistic effect of inorganic fertilizer, organic manure and biofertilizer on the performance of moong bean (*Vigna radiata* L.)

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### Abstract

Moongbean is a major pulse crop in India valued for its high nutritional content and ability to fix atmospheric nitrogen. However, its average yield remains low due to imbalanced nutrient management. This research was conducted during *Kharif* 2024 at Guru Kashi University, Bathinda (Punjab) to evaluate the synergistic effects of organic manure, inorganic and biofertilizers on growth and yield of moongbean (*Vigna radiata* L.). The experiment comprised eight treatments laid out in a Randomized Block Design with three replications. Results showed that plants treated with *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 100% RDF achieved the highest plant height (67.3 cm), branches plant<sup>-1</sup> (5.70), and dry matter accumulation (71.2 q ha<sup>-1</sup>). This treatment also recorded the maximum pods plant<sup>-1</sup> (45.88), seeds pod<sup>-1</sup> (13.9), pod length (9.61 cm), and 1000-grain weight (39.20 g). It yielded the highest grain yield (10.73 q ha<sup>-1</sup>), stover yield (32.07 q ha<sup>-1</sup>), biological yield (42.50 q ha<sup>-1</sup>), harvest index (24.51%), and the best benefit-cost ratio (2.40). Thus, *Rhizobium* inoculation combined with FYM and 100% RDF emerged as the most effective strategy for boosting moongbean productivity.

**Keywords:** Fertilizer, FYM, *Rhizobium*, Moongbean

### 1. Introduction

Moongbean (*Vigna radiata* L.) is an important pulse crop widely grown in India and other parts of South and East Asia. Moong bean is recognized as a promising legume in India because of its nutritional quality, offering high protein, fiber, and essential micronutrients (Dahiya *et al.*, 2015)<sup>[8]</sup>. In India, moongbean ranks as the third most widely grown and produced pulse crop, following chickpea and pigeon pea. India also holds the top spot in global pulse production, contributing approximately 26.8% to the total world output with approximately 26.05 million tonnes of pulses production in 2022-23 with cultivated area of 29-30 million hectares. During the 2023-24 agricultural year, moongbean accounted for around 10.04% of India's total pulse production, covered 3.09 million hectares and produced approximately 1.51 million tonnes with an average yield of 489 kg ha<sup>-1</sup>. In Punjab, moong bean is grown mainly after wheat harvest, occupying about 3.3 thousand hectares and producing 3.3 thousand tonnes with an average yield of 996 kg ha<sup>-1</sup>.

Moongbean plays a important role in Indian agriculture. It is among the major pulse crops in India, cultivated under sole, mixed, and multiple cropping systems during the *kharif* (rainy), spring and summer seasons across a broad spectrum of agro-climatic conditions (Ram *et al.*, 2014)<sup>[16]</sup>. Besides its food value, it benefits soil health by fixing atmospheric nitrogen through symbiosis with *Rhizobium* bacteria. This biological nitrogen fixation can contribute between 9 and 137 kg N ha<sup>-1</sup>, reducing the need for synthetic fertilizers for following crops. Moreover, incorporating residues to the soil promotes biological activity, as indicated by increased levels of dehydrogenase activity and carbon dioxide (CO<sub>2</sub>) evolution (Singh and Sekhon. 2005)<sup>[21]</sup>. The residual benefits of moong bean cultivation on subsequent cereal crops contributing the equivalent of up to 68 kg ha<sup>-1</sup> of nitrogen fertilizer (Wani *et al.*, 1995)<sup>[24]</sup>.

However, the productivity of moong bean in India remains lower than its potential, mainly due to poor nutrient management. Excessive reliance on chemical fertilizers has led to soil

degradation, nutrient imbalance, and increased production costs, making cultivation less sustainable (Diwedi and Diwedi, 2007)<sup>[9]</sup>. Organic fertilizers such as farmyard manure (FYM) improve soil structure, microbial activity, and nutrient availability (Fairhurst, 2012; Babulkar *et al.*, 2000)<sup>[10, 3]</sup>, while biofertilizers like *Rhizobium* inoculants enhance nitrogen fixation and plant growth (Kalson *et al.*, 2024)<sup>[11]</sup>. Combining organic, inorganic, and biofertilizer sources has been shown to improve crop yields, nutrient uptake, and soil health while reducing production costs (Kapoor *et al.*, 2019; Verma *et al.*, 2025; Meena *et al.*, 2015)<sup>[2, 23, 15]</sup>.

To enhance food and nutritional security while ensuring sustainable agriculture, there is a growing emphasis on integrating grain legumes into cereal based cropping systems to boost productivity and profitability. Considering this, the present study aims to identify effective nutrient management strategies for moong bean cultivation. Specifically, it aims to examine how various sources of nutrients including organic manure, inorganic and biofertilizers affect the growth and yield of moong bean, with the goal of improving both crop performance and farmer's income.

## 2. Materials and Methods

### 2.1 Experiment site and climatic data

The present study was carried out during the *Kharif* 2024 at the Research farm of Guru Kashi University, Talwandi Sabo, located in Bathinda district. The experimental site lies at a latitude of 29.98°N, longitude of 75.09°E, and an elevation of 208 meters above sea level. The soil of the field was classified as loamy sand in texture, slightly alkaline in reaction (pH 7.73) with normal electrical conductivity (0.26 dSm<sup>-1</sup>), and it is characterized by low organic carbon content (0.30%). It was deficient in available nitrogen (114.25 kg ha<sup>-1</sup>), medium in phosphorus (16.9 kg ha<sup>-1</sup>), and medium in available potassium (218.6 kg ha<sup>-1</sup>). Climatic data recorded during the experimental period (July to October 2024) showed that the average maximum temperature peaked at 40.6°C in July, while the minimum temperature dropped to 19.8°C in October. Evaporation rates during this period ranged from 11.0 mm in July to 3.6 mm in October. Rainfall varied considerably, with the lowest rainfall of 3.8 mm recorded in October, and the highest of 115.3 mm observed in July.

### 2.2 Treatments and Agronomic practices

The experiment comprised eight treatment combinations and was set up in a Randomized complete block design (RCBD) with three replicates. Treatments were T<sub>1</sub> Control (no fertilizers or seed inoculation), T<sub>2</sub> Recommended dose of fertilizer (RDF) {12.5 N: 40 P<sub>2</sub>O<sub>5</sub>: 0 K<sub>2</sub>O kg ha<sup>-1</sup>}, T<sub>3</sub> *Rhizobium* inoculation + 75% RDF, T<sub>4</sub> FYM (5 t ha<sup>-1</sup>) + 75% RDF, T<sub>5</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 75% RDF, T<sub>6</sub> *Rhizobium* inoculation + 100% RDF, T<sub>7</sub> FYM (5 t ha<sup>-1</sup>) + 100% RDF, and T<sub>8</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 100% RDF. The moongbean variety 'ML 2056' was sown at 4-6 cm depth with a seed drill at row spacing of 30 cm on 13th July 2024. Seed rates of 20 kg ha<sup>-1</sup> for moongbean was used. Organic and inorganic fertilizers were applied as per treatments. Recommended dose of nitrogen (12.5 kg N ha<sup>-1</sup>) and phosphorus (40 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) were applied through urea (46% N) and SSP (16% P<sub>2</sub>O<sub>5</sub>) fertilizers. The organic manure (well decomposed FYM) was applied at the rate of 5 t ha<sup>-1</sup> five day prior to sowing. Seeds were treated with *Rhizobium* inoculation (25g kg<sup>-1</sup> seeds) as per treatment by making slurry of *Rhizobium* culture using 10% jaggery solution. *Rhizobium* was purchased from Krishi vigyan kendra, Bathinda.

### 2.3 Observation recorded

Observations on growth and yield attributes were recorded at 30 and 60 days after sowing (DAS) and at harvest. Plant height was measured from the base to the tip of the main shoot on five randomly selected plants plot<sup>-1</sup>, and the mean was expressed in centimetres. The number of branches plant<sup>-1</sup> was counted on the same five plants, and averages were computed. Dry matter accumulation was determined by recording the fresh weight of plant samples, followed by shade drying and oven drying at 60°C until constant weight, and expressed in q ha<sup>-1</sup>. Yield attributes including the number of pods plant<sup>-1</sup>, seeds pod<sup>-1</sup> (from 20 randomly selected pods), and pod length were recorded. The 1000-grain weight was measured using a electronic balance. Seed and stover yields were recorded plot wise, sun dried, weighed and expressed in q ha<sup>-1</sup>. Biological yield was calculated as the sum of seed and stover yields, while Harvest index (%) was calculated by dividing economic (grain) yield by the total biological (grain + stover) yield and expressed as percentage.

$$HI (\%) = \frac{\text{Economic yield}}{\text{Biological yield (Grain + Stover)}} \times 100$$

### 2.4 Economics

To determine the most economically beneficial treatment, an economic analysis of the various treatments was conducted based on net return (Rs/ha), using current market prices. This analysis aimed to identify the most profitable option. Net return was calculated by subtracting cost of cultivation from gross return. Additionally, the benefit cost (BC) ratio was computed for each treatment to assess its economic feasibility, using the following formula.

$$B:C \text{ ratio} = \frac{\text{Net Return (Rs)}}{\text{Cost of Cultivation (Rs)}}$$

### 2.5 Statistical analysis

The data collected from the field trials were subjected to statistical analysis using analysis of variance (ANOVA). The analysis was performed using OPSTAT software developed by O.P. Sheoran at CCS HAU, Hisar (Sheoran *et al.*, 1998)<sup>[19]</sup>, specifically designed for agricultural research. To compare treatment means and assess the significance of differences, the critical difference (CD) was calculated at the 5% level of significance.

## 3. Results and Discussion

### 3.1 Growth parameters of moong bean

Plant height of moong bean varied significantly under different combinations of organic manure, inorganic and biofertilizer applications (Table 1). A rapid increase in plant height was observed from 30 to 60 DAS after which the growth rate slowed. The maximum plant height (28.5, 64.5, and 67.3 cm at 30 DAS, 60 DAS, and at harvest respectively) was recorded under treatment T<sub>8</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 100% RDF, which was statistically at par with T<sub>5</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 75% RDF recording heights of 27.5, 63.5, and 66.2 cm at the corresponding stages significantly higher than control. The number of branches plant<sup>-1</sup> increased progressively from 30 DAS to harvest (Table 1). The highest number (5.70) was observed in T<sub>8</sub> *Rhizobium* + FYM (5 t ha<sup>-1</sup>) + 100% RDF, which was statistically at par with T<sub>5</sub> (5.40) and T<sub>6</sub>

(5.06) The lowest were recorded in the control treatment. Dry matter accumulation ( $\text{q ha}^{-1}$ ) increased significantly from 30 DAS to harvest in response to various combinations of organic manure, inorganic and biofertilizers (Table 1). The highest accumulation ( $34.4 \text{ q ha}^{-1}$ ) was recorded under  $T_8$  *Rhizobium* + FYM ( $5 \text{ t ha}^{-1}$ ) + 100% RDF, which was statistically at par with  $T_5$  ( $32.3 \text{ q ha}^{-1}$ ). The lowest ( $20.8 \text{ q ha}^{-1}$ ) were observed in the control. *Rhizobium* with inorganic and organic fertilizer increased the availability of Nitrogen to plant that might help in increased cell size and vegetative growth. Increased dry matter accumulation under these treatments indicates superior photosynthetic efficiency and nutrient uptake, leading to robust biomass production. Similar results showed by Kapoor *et al.*, (2019)<sup>[2]</sup>, Ahmad *et al.*, (2014)<sup>[1]</sup> and Singh *et al.*, (2017)<sup>[22]</sup> that applying various nutrient combinations significantly affected the plant's ability to produce dry matter and increased height.

### 3.2 Yield attributes of moong bean

Significant variation was observed in yield attributes such as pods  $\text{plant}^{-1}$ , seeds  $\text{pod}^{-1}$ , and 1000-grain weight due to different combinations of organic manure, inorganic and biofertilizers (Table 1). The highest number of pods  $\text{plant}^{-1}$  (25.9), pod length (9.6 cm), seeds  $\text{pod}^{-1}$  (13.9), and 1000-grain weight (39.2 g) were recorded in  $T_8$  *Rhizobium* + FYM ( $5 \text{ t ha}^{-1}$ ) + 100% RDF, which was statistically at par with  $T_5$  and  $T_6$ . The lowest values for these traits were observed in the control. Improvements in moong bean yield attributes such as pods  $\text{plant}^{-1}$ , pod length, seeds  $\text{pod}^{-1}$ , and 1000-grain weight under integrated nutrient management can be attributed to enhanced nutrient availability, better root growth and improved physiological processes that promote efficient assimilate partitioning to reproductive organs (Singh *et al.*, 2020; Meena *et al.*, 2015)<sup>[20, 15]</sup>. This study's results align with earlier findings in pulses, where combined use of organic, inorganic, and biofertilizers improved pod formation, seed development, and grain weight (Matkarimov *et al.*, 2019; Yadav *et al.*, 2001)<sup>[14, 25]</sup>. Additionally, increased 1000-grain weight indicates superior seed filling, supported by enhanced micronutrient availability and soil enzyme activity under integrated management (Choudhary *et al.*, 2011)<sup>[6, 7]</sup>.

### 3.3 Productivity of moong bean

Application of different combinations of organic and inorganic

fertilizers with *Rhizobium* significantly influenced seed yield, stover yield, and biological yield of mungbean (Tables 2). The highest seed yield ( $10.7 \text{ q ha}^{-1}$ ), stover yield ( $32.1 \text{ q ha}^{-1}$ ), and biological yield ( $42.5 \text{ q ha}^{-1}$ ) were recorded in  $T_8$  *Rhizobium* + FYM ( $5 \text{ t ha}^{-1}$ ) + 100% RDF which was statistically at par with  $T_5$  and  $T_6$  and significantly higher than control. This enhanced performance can be attributed to the complementary roles played by these inputs. Inorganic fertilizers provide a quick and readily available source of essential nutrients like nitrogen and phosphorus, promoting rapid vegetative growth. FYM acts as a slow release nutrient source that improves soil physical properties, water-holding capacity, and microbial activity (Brar *et al.*, 1995)<sup>[5]</sup>. *Rhizobium* inoculation enhances biological nitrogen fixation and contributing to sustained nitrogen availability throughout the crop cycle (Kalson *et al.*, 2024)<sup>[11]</sup>. The combined use of these inputs not only supplies nutrients more efficiently but also improves soil health, thus creating a favourable environment for moong bean growth. The synergistic interaction might results from improved nutrient use efficiency, better root development, and higher enzymatic and microbial activity in the rhizosphere, which are critical for pulse crops that have relatively short duration and high nutrient demand during reproductive stages (Kumar *et al.*, 2003, 2017)<sup>[13, 12]</sup>. Similar findings were reported by Rana and Singh (2012)<sup>[17]</sup>, who observed that moong bean yield significantly improved with the integrated use of FYM and biofertilizers along with chemical fertilizers.

### 3.4 Economic of moong bean

Economic analysis (Table 2) revealed that the highest cost of cultivation (Rs.27,360  $\text{ha}^{-1}$ ) was incurred in  $T_8$  *Rhizobium* + FYM ( $5 \text{ t ha}^{-1}$ ) + 100% RDF, followed by  $T_7$  (Rs.27,160  $\text{ha}^{-1}$ ), while the lowest was in the control (Rs.20,660  $\text{ha}^{-1}$ ). Gross returns were also highest in  $T_8$  (Rs.93,158  $\text{ha}^{-1}$ ), followed by  $T_5$  (Rs.87,080  $\text{ha}^{-1}$ ), with the lowest in  $T_1$  (Rs.54,349  $\text{ha}^{-1}$ ). Correspondingly, the highest net returns (Rs.65,798  $\text{ha}^{-1}$ ) and benefit cost ratio (2.40) were recorded in  $T_8$ , while the lowest net return (Rs.33,689  $\text{ha}^{-1}$ ) and B:C ratio (1.63) were observed in the control. These results highlight the economic advantage of integrating *Rhizobium*, FYM, and inorganic fertilizers in moongbean cultivation. Similar results were reported by Meena *et al.*, (2015)<sup>[15]</sup>.

**Table 1:** Growth and yield attributes of moong bean as influenced by synergistic effect of inorganic, organic and biofertilizer.

| Treatments                                                                 | Growth attributes |                              |                                                | Yield attributes         |                 |                         |                      |
|----------------------------------------------------------------------------|-------------------|------------------------------|------------------------------------------------|--------------------------|-----------------|-------------------------|----------------------|
|                                                                            | Plant height(cm)  | Branches $\text{plant}^{-1}$ | Dry matter Accumulation ( $\text{q ha}^{-1}$ ) | Pods $\text{plant}^{-1}$ | Pod Length (cm) | Seeds $\text{pod}^{-1}$ | 1000-grain weight(g) |
| T1: Control (no fertilizers or seed inoculation)                           | 57.2              | 3.2                          | 20.8                                           | 12.2                     | 7.4             | 8.6                     | 30.2                 |
| T2: Recommended dose of fertilizer (RDF)                                   | 64.4              | 4.7                          | 27.3                                           | 18.0                     | 8.3             | 12.4                    | 37.3                 |
| T3: <i>Rhizobium</i> inoculation + 75% RDF                                 | 59.4              | 4.4                          | 25.8                                           | 17.1                     | 8.0             | 12.0                    | 37.2                 |
| T4: FYM ( $5 \text{ t ha}^{-1}$ ) + 75% RDF                                | 59.1              | 4.3                          | 24.4                                           | 16.9                     | 7.8             | 11.8                    | 36.8                 |
| T5: <i>Rhizobium</i> inoculation + FYM ( $5 \text{ t ha}^{-1}$ ) + 75% RDF | 66.2              | 5.4                          | 32.3                                           | 24.8                     | 9.1             | 13.6                    | 38.8                 |
| T6: <i>Rhizobium</i> inoculation + 100% RDF                                | 65.1              | 5.1                          | 29.1                                           | 23.8                     | 8.8             | 13.2                    | 38.1                 |
| T7: FYM( $5 \text{ t ha}^{-1}$ ) + 100% RDF                                | 64.9              | 4.9                          | 26.8                                           | 23.2                     | 8.6             | 13.0                    | 37.8                 |
| T8: <i>Rhizobium</i> inoculation + FYM( $5 \text{ t ha}^{-1}$ ) + 100% RDF | 67.3              | 5.7                          | 34.4                                           | 25.9                     | 9.6             | 13.9                    | 39.2                 |
| S.Em $\pm$                                                                 | 0.7               | 0.3                          | 1.1                                            | 0.9                      | 0.5             | 0.3                     | 0.8                  |
| CD ( $p=0.05$ )                                                            | 2.1               | 0.7                          | 4.9                                            | 2.15                     | 1.5             | 0.8                     | 1.1                  |

**Table 2:** Yield and economics of moong bean as influenced by synergistic effect of inorganic, organic and biofertilizer.

| Treatments                                                                | Yield (q ha <sup>-1</sup> ) |              |                  | Harvest index (%) | Economics                                  |                                     |                                   |           |
|---------------------------------------------------------------------------|-----------------------------|--------------|------------------|-------------------|--------------------------------------------|-------------------------------------|-----------------------------------|-----------|
|                                                                           | Seed yield                  | Stover yield | Biological yield |                   | Cost of cultivation (Rs ha <sup>-1</sup> ) | Gross return (Rs ha <sup>-1</sup> ) | Net return (Rs ha <sup>-1</sup> ) | B:C ratio |
| T1: Control (no fertilizers or seed inoculation)                          | 6.3                         | 23.8         | 30.1             | 20.9              | 20,660                                     | 54,349                              | 33,689                            | 1.63      |
| T2: Recommended dose of fertilizer (RDF)                                  | 8.8                         | 27.7         | 37.0             | 23.8              | 23,660                                     | 75,967                              | 52,308                            | 2.21      |
| T3: <i>Rhizobium</i> inoculation + 75% RDF                                | 8.2                         | 26.5         | 36.1             | 23.2              | 23,110                                     | 71,452                              | 48,343                            | 2.09      |
| T4: FYM (5 t ha <sup>-1</sup> ) + 75% RDF                                 | 8.1                         | 25.9         | 34.0             | 23.8              | 26,410                                     | 70,237                              | 43,827                            | 1.66      |
| T5: <i>Rhizobium</i> inoculation + FYM (5 t ha <sup>-1</sup> ) + 75% RDF  | 10.0                        | 31.4         | 41.5             | 24.3              | 26,610                                     | 87,080                              | 60,470                            | 2.27      |
| T6: <i>Rhizobium</i> inoculation + 100% RDF                               | 9.3                         | 29.7         | 39.8             | 24.1              | 23,860                                     | 80,482                              | 56,622                            | 2.37      |
| T7: FYM(5 t ha <sup>-1</sup> ) + 100% RDF                                 | 9.1                         | 27.9         | 36.7             | 24.0              | 27,160                                     | 78,572                              | 51,412                            | 1.89      |
| T8: <i>Rhizobium</i> inoculation + FYM (5 t ha <sup>-1</sup> ) + 100% RDF | 10.7                        | 32.1         | 42.5             | 24.5              | 27,360                                     | 93,158                              | 65,798                            | 2.40      |
| S.Em <sub>±</sub>                                                         | 0.1                         | 0.8          | 1.1              | 0.3               |                                            |                                     |                                   |           |
| CD (p=0.05)                                                               | 0.8                         | 2.6          | 3.1              | 0.8               |                                            |                                     |                                   |           |

#### 4. Conclusion

The results of the study show that the treatment T<sub>8</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 100% RDF significantly enhanced growth and yield attributes of moongbean, including plant height, number of leaves and branches plant<sup>-1</sup>, dry matter accumulation, number of pods plant<sup>-1</sup>, pod length, 1000-grain weight, seed yield, stover yield, and biological yield. However, T<sub>5</sub> *Rhizobium* inoculation + FYM (5 t ha<sup>-1</sup>) + 75% RDF was statistically at par with T<sub>8</sub> across most parameters, suggesting that a 25% reduction in chemical fertilizer application can be achieved without compromising productivity. This finding underscores the potential of integrated nutrient management for promoting sustainable and resource efficient agriculture. Furthermore, T<sub>8</sub> and T<sub>6</sub> *Rhizobium* inoculation + 100% RDF recorded comparable benefit:cost ratios (2.40 and 2.37, respectively), T<sub>6</sub> offering a viable, cost-effective option for small and resource-limited farmers.

#### 5. References

- Ahmad A, Ali A, Aslam Z, *et al.* Growth nodulation and yield components of mungbean (*Vigna radiata*) as affected by phosphorus in combination with *Rhizobium* inoculation. African Journal of Agricultural Research. 2014;9(30):2319-2323.
- Kapoor A, Singh R, Singh VK, Serawat M, Vishwakarma DK. Effect of Organic, Inorganic and Biofertilizers on Growth and Yields of Mungbean. Biological Forum An International Journal. 2023;15(2):929-937.
- Babulkar P, Wandile P, Badole RM, Balpande SS. Residual effect of long-term application of FYM and fertilizers on soil properties (vertisol) and yield of soybean. J. Indian Soc. Soil Sci. 2000;48(1):89-92.
- Bhatt M, Singh AP, Singh V, Kala DC, Kumar V. Long-Term Effect of Organic and Inorganic Fertilizers on Soil Physico Chemical Properties of a Silty Clay Loam Soil under Rice-Wheat Cropping System in Tarai Region of Uttarakhand. J. Pharmacogn. Phytochem. 2019;8:2113-2118.
- Brar BS, Dhillon NS, Chand M. Effect of farmyard manure application on grain yield and uptake and availability of nutrients in rice-wheat rotation. Indian Journal of Agricultural Sciences. 1995;65(5):350-353.
- Choudhary AK, Kumar R, Nadarajan N. Enhancing pulse production through improved agronomic practices. Indian Journal of Agronomy. 2011;56(4):323-328.
- Choudhary HR, Sharma OP, Yadav LR, Choudhary GL. Effect of organic manure and chemical fertilizers on productivity of moong bean. Journal of Food Legume. 2011;24(4):324-326.
- Dahiya PK, Linnemann AR, Van Boekel, Khetarpaul N, Grewal RB, Nout MJR. Mung bean: Technological and nutritional potential. Critical Reviews in Food Science and Nutrition. 2015;55(5):670-688.
- Diwedi BS, Diwedi V. Monitoring soil health for higher productivity. Indian J. of Fertilisers. 2007;3:11-23.
- Fairhurst T. Handbook for Integrated Soil Fertility Management. Wallingford, UK: Africa Soil Health Consortium; 2012.
- Kalson A, Qazizadah NA, Sangin MR, Varsha, Anand SP. Effect of Organic Manures and Biofertilizers on Nodulation, Yield Performance, and Quality Attributes of Mung Bean (*Vigna radiata*). Journal of Experimental Agriculture International. 2024;46(11):747-755. <https://doi.org/10.9734/jeai/2024/v46i113094>.
- Kumar R, Singh AK, Meena MK. Response of green gram (*Vigna radiata* L.) to integrated nutrient management. Legume Research. 2017;40(5):864-868.
- Kumar S, Singh RC, Kadian VS. Performance of moong bean as influenced by seed inoculation. Indian J. Pulses Research. 2003;16:67-68.
- Matkarimov F, Jabborova D, Saidmurot B. Enhancement of Plant Growth, Nodulation and Yield of Mungbean (*Vigna radiata* L.) by Microbial Preparations, International Journal of Current Microbiology and Applied Sciences. 2019;8(8):2382-2388.
- Meena RS, Dhakal Y, Bohra JS, Singh SP, Singh MK, Sanodiya P, Meena H. Influence of bioinorganic combinations on yield, quality and economics of mung bean. American Journal of Experimental Agriculture. 2015;8(3):159-166. <https://doi.org/10.9734/AJEA/2015/17065>.
- Ram K, Meena RS. Evaluation of Pearl Millet. Mung bean intercropping systems in Arid Region of Rajasthan (India). Bangladesh Journal of Botany. 2014;43(3):367-370.
- Rana KS, Singh S. Productivity and economics of mungbean (*Vigna radiata*) as influenced by integrated nutrient management. Indian Journal of Agronomy. 2012;57(3):247-250.
- Rana MM, Chowdhury AKMSH, Bhuiya MSU. Effects of planting density and bio-fertilizer on the growth parameters of three summer moong bean (*Vigna radiata* L.) cultivars. Bangladesh Journal of Agricultural Research. 2011;36(3):537-542.
- Sheoran OP, Tonk DS, Kaushik LS, Hasija RC, Pannu RS. Statistical software package for agriculture research workers. In: Hooda DS, Hasija RC, editors. Recent advances in information theory, statistics and computer application. Hisar, India: Department of Mathematics

- Statistics, CCS HAU; 1998. p. 139-143.
20. Singh D, Verma S, Yadav A. Integrated nutrient management in pulses: a review. *Journal of Food Legumes*. 2020;33(1):11-16.
  21. Singh G, Sekhon S. Role of pulses in agriculture. In: Singh C, Sekhon HS, Kolar JS, editors. *Pulses*. Udaipur: Agrotech Publishing Academy; 2005. p. 33-57.
  22. Singh M, Deokaran, Mishra JS, Bhatt BP. Effect of integrated nutrient management on production potential and quality of summer mung bean (*Vigna radiata* L.). *Journal of Krishi Vigyan*. 2017;5(2):39-45.
  23. Verma AK, Singh AK, Singh A, Kaushik S, Singh D, Yadav V, Singh A. Effect of biofertilizers and variable nutrient sources on physico-chemical properties of soil and yield of black gram (*Vigna mungo* L.). *Research on Crops*. 2025;26:260-267.:  
<https://doi.org/10.31830/2348-7542.2025.ROC-1202>.
  24. Wani SP, Rupela AP, Lee KK. Sustainable agriculture in the semiarid tropic through biological nitrogen fixation in grain legumes. *F! Soil*. 1995;17:29-49.
  25. Yadav OS. Effect of nitrogen sources and bio-fertilizer on growth, yield and quality of cowpea. Bikaner: RAU; 2001.
  26. Yadav RD, Keshwa GL, Yadav SS. Effect of integrated use of FYM, urea and sulphur on growth and yield of isabgol (*Plantago ovata* Forsk.). *J. Med. Aromatic Plant Sci*. 2004;25(3):668-671.