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Effect of organic manure and inorganic fertilizer with bioinoculant on growth and yield of mungbean (*Vigna Radiata* L.)

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ABSTRACT

A field experiment was conducted during the Kharif season of 2022 at Rajoula Agricultural Farm, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Satna (Madhya Pradesh) to study the effect of organic manure, inorganic fertilizer, and bioinoculants on growth and yield of mungbean (*Vigna radiata* L.). The experiment was laid out in a randomized block design with nine treatments replicated thrice. Treatments included combinations of farmyard manure (FYM), vermicompost, recommended dose of fertilizer (RDF: 20:40:20 NPK kg ha⁻¹), and bioinoculants (*Rhizobium* + PSB + *Trichoderma*). The integrated treatment (75% RDF + FYM @ 5 t ha⁻¹ + *Rhizobium* + PSB) recorded the highest plant height (46.5 cm), number of pods per plant (33.8), seed yield (1.23 t ha⁻¹), and harvest index (36.8%). The results indicated that integration of organic, inorganic, and microbial sources synergistically improved mungbean productivity and soil fertility, supporting the concept of sustainable nutrient management under semi-arid conditions.

Keywords: Mungbean, Integrated Nutrient Management, FYM, Bioinoculants, Yield, Soil Fertility, Sustainable Agriculture

Introduction

Pulses are vital components of human nutrition and sustainable agriculture due to their high protein content, ability to fix atmospheric nitrogen, and contribution to soil fertility. They are rich sources of proteins (20–25%), vitamins, fiber, minerals such as iron, zinc, magnesium, and essential amino acids, which play a pivotal role in human health (Ali *et al.*, 2012) [1]. Among food crops, pulses rank second after cereals in importance for food and nutritional security, particularly in developing countries like India, where they serve as the major source of dietary protein for vegetarian populations (Statista, 2022) [2]. In addition to their nutritional value, pulses improve soil health through symbiotic nitrogen fixation, enhancing soil microbial activity and organic matter content (Patel *et al.*, 2020) [3]. Mungbean (*Vigna radiata* L.), also known as green gram, is one of the most important short-duration pulse crops cultivated across arid and semi-arid regions of India. It is widely recognized for its high seed protein content (24–28%), carbohydrate (59–66%), and moderate levels of oil, fiber, and minerals (Bhowalan d & Bhowmik, 2014) [4]. Globally, mungbean is cultivated on approximately 5.5 million hectares, with India contributing nearly 75% of total production (Taunk *et al.*, 2012) [5]. It ranks third among pulses after chickpea and pigeon pea, with major producing states including Madhya Pradesh, Uttar Pradesh, Maharashtra, Karnataka, Andhra Pradesh, and Bihar, which together account for nearly 80% of India's total pulse production (Anonymous, 2015) [6]. Despite its high nutritive value and agronomic potential, mungbean productivity in India remains low compared to its genetic potential. The per capita availability of pulses in India has declined from 69 g/day in 1961 to 37 g/day in 2011 (Ali *et al.*, 2012) [1]. This decline is attributed to the widening gap between pulse production and population growth. India currently accounts for about 25% of global pulse production, with 30.5 million hectares under cultivation and an average productivity of only 0.66 t ha⁻¹ (Statista, 2022) [2]. In Madhya Pradesh alone, mungbean occupies approximately 5.44 lakh hectares with an average productivity of 1179 kg ha⁻¹ (Green Outlook, 2021) [7]. To meet future demand, the country needs to increase total pulse production by 2.2% annually to achieve a projected requirement of 39 million tonnes by 2050. One of the major constraints to higher productivity is nutrient imbalance in soils due to the continuous use of inorganic fertilizers and limited application of organic amendments. The overreliance on chemical fertilizers deteriorates soil structure, reduces microbial activity, and causes nutrient imbalances, leading to lower yields over time (Reddy *et al.*, 2003) [8]. In contrast, organic manures such as farmyard manure (FYM) and vermicompost improve soil physical, chemical, and biological properties by enhancing nutrient retention, microbial biomass, and cation exchange capacity (Latha *et al.*, 2001; Shariff *et al.*, 2017) [9, 10]. FYM, in particular, serves as a slow-release nutrient source, improving root growth and soil aeration (Bhadu *et al.*, 2018) [11]. The integration of organic and inorganic nutrient sources—commonly referred to as Integrated Nutrient Management (INM)—has emerged as a viable approach for sustainable pulse production. Combining organic manures with chemi

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cal fertilizers enhances nutrient-use efficiency and soil fertility while maintaining yield stability (Meena *et al.*, 2015) [12]. Moreover, the inclusion of bioinoculants such as *Rhizobium*, *Trichoderma*, and *Pseudomonas* further enhances crop performance. *Rhizobium* bacteria form symbiotic associations with mungbean roots to fix atmospheric nitrogen, thereby improving soil nitrogen content and seed protein levels (Kumar *et al.*, 2017) [13]. *Trichoderma* spp. and *Pseudomonas* spp. act as plant growth-promoting rhizobacteria (PGPR) by solubilizing phosphorus, producing growth hormones, and protecting plants from soil-borne pathogens (Ahmad *et al.*, 2010; Bhalerao *et al.*, 2014) [14, 15]. Phosphorus, another critical macronutrient, plays a key role in root growth, nodule development, and energy transfer processes in legumes. Its deficiency often limits biological nitrogen fixation and grain yield in pulses (Singh *et al.*, 2017) [16]. Application of phosphorus through both mineral fertilizers and bio-solubilizing microorganisms can markedly improve nodulation and productivity in mungbean (Sahu *et al.*, 2021) [17]. Similarly, potassium contributes to enzymatic activation, water regulation, and nutrient translocation in plants, which are essential for seed filling and stress tolerance (Bagadkar *et al.*, 2020) [18].

2. Materials and Methods

2.1 Experimental site and agro-climatic conditions

The field experiment was conducted during the Kharif season of 2022 at the Rajoula Agricultural Farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (Madhya Pradesh), India. The experimental site is geographically situated at 24°31' N latitude, 80°52' E longitude, and an elevation of approximately 250 meters above mean sea level. The region falls under the semi-arid subtropical agro-climatic zone, characterized by hot summers and moderate rainfall, primarily received during the monsoon months (June to September). The total rainfall during the cropping period was about 890 mm, with a mean maximum temperature of 33–37 °C and a minimum of 22–25 °C. The relative humidity ranged from 65% to 85% during the crop-growing season, which was favorable for mungbean growth and nodulation. Before sowing, a composite soil sample (0–15 cm depth) was collected from the experimental site, air-dried, ground, and passed through a 2-mm sieve for analysis. The initial soil properties were determined using standard procedures (Jackson, 1973) [19] and were as follows:

- Texture: Sandy loam
- Soil pH: 7.5
- Electrical conductivity: 0.24 dS m⁻¹
- Organic carbon: 0.43%
- Available nitrogen: 210.4 kg ha⁻¹ (alkaline KMnO₄ method)
- Available phosphorus: 11.6 kg ha⁻¹ (Olsen's method)
- Available potassium: 218.0 kg ha⁻¹ (Flame photometer method).

These results indicated a low nitrogen, medium phosphorus, and medium potassium soil fertility status typical of alluvial soils of Chitrakoot.

2.2 Experimental design and treatments

The experiment was laid out in a Randomized Block Design (RBD) consisting of nine treatments with three replications, making a total of 27 plots. Each plot measured 3 m × 4 m (12 m²), with a 50 cm spacing between plots and 1.0 m spacing between replications to prevent nutrient interference between treatments.

The treatments were designed to assess the combined and individual effects of organic manure, inorganic fertilizer, and bioinoculants. The details are presented below:

Treatment Code	Treatment Description
T ₁	Control (no fertilizer or manure)

Treatment Code	Treatment Description
T ₂	100% Recommended Dose of Fertilizer (RDF: 20:40:20 NPK kg ha ⁻¹)
T ₃	FYM @ 5 t ha ⁻¹
T ₄	RDF + FYM @ 5 t ha ⁻¹
T ₅	RDF + <i>Rhizobium</i> + PSB
T ₆	RDF + FYM + <i>Rhizobium</i>
T ₇	RDF + Vermicompost @ 2.5 t ha ⁻¹
T ₈	RDF + Vermicompost + <i>Rhizobium</i> + PSB
T ₉	75% RDF + FYM + <i>Rhizobium</i> + PSB (Integrated treatment)

2.3 Crop variety and planting material

The test crop used was mungbean (*Vigna radiata* L.), cultivar 'HUM-16', a high-yielding, short-duration variety developed by IIPR, Kanpur. The variety has a growth duration of 65–70 days and is moderately resistant to Yellow Mosaic Virus (YMV). Healthy seeds were used for sowing after proper cleaning and grading. The seed rate was 15 kg ha⁻¹. Prior to sowing, seeds were surface sterilized with 0.1% mercuric chloride solution for 2 minutes followed by several rinses in distilled water to eliminate microbial contamination.

2.4 Bioinoculant preparation and application

Bioinoculants were applied in the form of *Rhizobium*, Phosphate Solubilizing Bacteria (PSB), and *Trichoderma harzianum*.

1. Seed Inoculation: Mungbean seeds were treated with *Rhizobium japonicum* and PSB @ 25 g kg⁻¹ seed, ensuring uniform coating by using 10% jaggery solution as an adhesive. Treated seeds were shade-dried for 30 minutes before sowing.
2. Soil Application: *Trichoderma harzianum* was incorporated in the soil at 5 kg ha⁻¹ mixed with 100 kg FYM, 7 days before sowing to improve soil microbial activity and control soil-borne pathogens.

2.5 Organic and inorganic nutrient management

Organic Manures: Farmyard manure (FYM) and vermicompost were applied as per treatment at 15 days before sowing and thoroughly incorporated into the soil during field preparation.

- FYM contained: N – 0.52%, P – 0.26%, K – 0.42%.
- Vermicompost contained: N – 1.40%, P – 0.80%, K – 1.20%.

Inorganic Fertilizers: The recommended NPK dose (20:40:20 kg ha⁻¹) was applied in the form of urea (46% N), single super phosphate (16% P₂O₅), and muriate of potash (60% K₂O). The full phosphorus and potassium and half of nitrogen were applied as basal dose at sowing, while the remaining nitrogen was top-dressed at 30 DAS.

2.6 Sowing and crop management

The field was ploughed twice, followed by harrowing and leveling to create a fine seedbed. The crop was sown manually on July 10, 2022, maintaining a row spacing of 30 cm and plant spacing of 10 cm. Thinning was done at 15 DAS to maintain the desired population density. Irrigations were provided at critical growth stages flower initiation and pod development depending on rainfall distribution. Weeding was done manually twice, at 20 DAS and 40 DAS, to minimize weed competition. The crop was protected from insect pests (whitefly and pod borer) by spraying *Imidacloprid* (0.03%) and *Chlorantraniliprole* (0.2%) as per standard recommendations. Harvesting was done manually when 80% pods turned brown.

2.8 Statistical analysis

Data recorded on various growth and yield parameters were subjected to statistical analysis using Analysis of Variance (ANOVA) for RBD as per the method outlined by Panse *et al.* (1985) [20]. The treatment means were compared using the Critical Difference (CD) at 5% probability level ($P = 0.05$) to determine significance. Graphical represen

tations were prepared using MS Excel 2021 for visual interpretation of treatment effects.

Results and Discussion

The experimental findings of the study on the *Effect of Organic Manure and Inorganic Fertilizer with Bioinoculant on Growth and Yield of Mungbean (Vigna radiata L.)* are presented in the following sub-sections.

3.2 Growth attributes

Plant population

Plant population of mungbean crop was recorded per running meter at 20 DAS and at harvest stage of crop and later on it was converted into plants/ha. Plant population of mungbean crop did not significantly in-

fluence due to application of organic manure and inorganic fertilizer with bioinoculants at the stages of crop. A statistically analysed data is presented in (Table 4.1) and their respective mean sum of squares are given in Appendix-I as well as depicted in figure 4.1.

Result showed (Table 4.1) that plant population was observed marginally higher in T₄-FYM @ 4 t ha⁻¹ + *Pseudomonas* @ 2.5 kg ha⁻¹ (622110 & 536999 plants/ha) at 20 DAS & at harvest stage followed by T₆- 50 % NPK + FYM @ 4 t ha⁻¹ + *Pseudomonas* @ 2.5 kg ha⁻¹ (581332 & 514666 plants/ha). Minimum plant population was observed in T₃- FYM @ 4 t ha⁻¹ + *Trichoderma* @ 2.5 kg ha⁻¹ (540666 plants/ha) at 20 DAS. While at harvest stage, it was lowest in T₃- FYM @ 4 t ha⁻¹ + *Trichoderma* @ 2.5 kg ha⁻¹ (540666)

Plant population

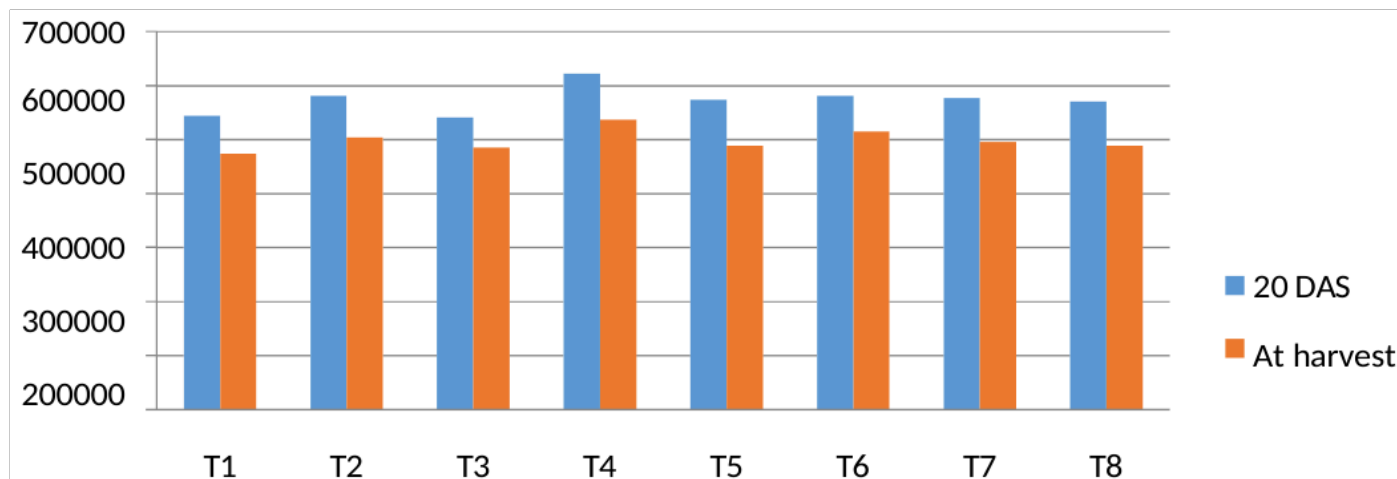


Fig.-4.1: Effect of organic manure, inorganic fertilizer with bio inoculants on plant population of mungbean

3.2.1 Plant height

Plant height of mungbean measured at 20 DAS, 40 DAS, 60 DAS, and at harvest stage and the recorded data have been summarized in table 4.2 and fig. 4.2 At 20 DAS plant height of mungbean did not significantly vary due to application of organic manure and inorganic fertilizers with bio-inoculants. Plant height was recorded numerically higher under T₈-75 % NPK + FYM @ 4 t ha⁻¹ + *Pseudomonas* @ 2.5 kg ha⁻¹ (22.53 cm) followed by T₇-75 % NPK + FYM @ 4 t ha⁻¹ + *Trichoderma* @ 2.5 kg ha⁻¹ (21.27 cm). While, minimum plant height was noted in T₁- Control (No fertilizer) at 20 DAS (19.53 cm). At 40 DAS and harvest, plant height was recorded significantly higher under T₈-75 % NPK + FYM @ 4 t ha⁻¹ + *Pseudomonas* @ 2.5 kg ha⁻¹ (55.27 & 57.13 cm) followed by T₇-75 % NPK + FYM @ 4 t ha⁻¹ + *Trichoderma* @ 2.5 kg ha⁻¹ (54.31 & 56.87 cm). While minimum plant height observed in T₁- Control (No fertilizer) (43.78 & 46.40 cm).

Plant height (cm)

Table 4.1. Effect of organic manure, inorganic fertilizer with bioinoculants on plant population of mungbean

Treatments	Plant population (plants/ha)	
	20 DAS	At harvest
T ₁ - Control (No fertilizer)	544333	473888
T ₂ - RDF (100% NPK)	581332	503666
T ₃ - FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	540666	485666
T ₄ - FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	622110	536999

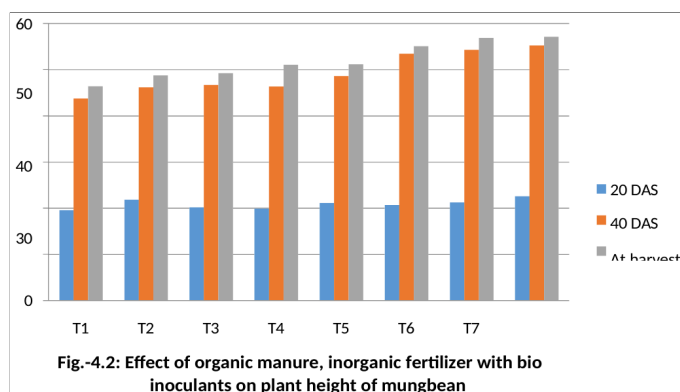
Treatments	Plant population (plants/ha)	
	20 DAS	At harvest
T ₅ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	573999	488777
T ₆ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	581332	514666
T ₇ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	577666	496221
T ₈ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	570221	488777
SEm±	16397	19235
C.D. (P = 0.05)	NS	NS
CV (%)	4.95	6.68

Table 4.2. Effect of organic manure, inorganic fertilizer with bioinoculants on plant height of mungbean

Treatments	Plant height (cm)		
	20 DAS	40 DAS	At harvest
T ₁ - Control (No fertilizer)	19.53	43.78	46.40
T ₂ - RDF (100% NPK)	21.80	46.18	48.73
T ₃ - FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	20.13	46.69	49.20
T ₄ - FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	19.87	46.33	51.07
T ₅ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	21.07	48.67	51.17

(continued on next page)

Treatments	Plant height (cm)		
	20 DAS	40 DAS	At harvest
T ₆ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	20.67	53.47	55.07
T ₇ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	21.27	54.31	56.87
T ₈ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	22.53	55.27	57.13
SEm±	1.00	2.00	2.05
C.D. (P = 0.05)	NS	6.06	6.20
CV (%)	8.34	7.01	46.40



3.3 Yield attributes

The yield-attributing characters of mungbean were significantly influenced by the application of organic manure, inorganic fertilizers, and bioinoculants. The data presented in Table 4.3 clearly indicate that in-

tegrated nutrient management treatments performed better than control across all parameters.

The number of pods per plant was significantly higher under treatment **T₈ (75% NPK + FYM @ 4 t ha⁻¹ + *Pseudomonas* @ 2.5 kg ha⁻¹)**, recording 13.17 pods per plant, which was superior to T₁ (control), T₂, and T₃, while remaining statistically at par with T₄, T₅, T₆, and T₇. The lowest number of pods per plant (11.70) was recorded under control (T₁).

Pod length was also significantly affected by the treatments. The maximum pod length (6.55 cm) was recorded under T₈, which was statistically at par with T₆ (6.28 cm), while the minimum pod length (5.89 cm) was observed under control (T₁).

Similarly, seeds per pod showed a significant increase with integrated nutrient application. Treatment T₈ recorded the highest number of seeds per pod (10.45), which was statistically at par with T₆ (10.05) and T₄ (9.82), whereas the lowest value (8.98) was recorded under control.

Seed weight per plant followed a similar trend, with the highest value observed under T₈ (4.43 g), which was significantly superior to control, T₃, T₄, and T₇, but remained statistically at par with T₆ (4.23 g), T₅ (4.12 g), and T₂ (3.89 g). The minimum seed weight per plant (3.57 g) was recorded under control.

The 1000-seed weight was also significantly influenced by the treatments. The highest test weight (27.63 g) was recorded under T₈, which was significantly superior to control, T₃, and T₅, while remaining statistically at par with T₆ (27.10 g), T₂ (27.00 g), T₇ (26.90 g), and T₄ (26.73 g). The lowest 1000-seed weight (25.23 g) was recorded under control.

Overall, the results clearly indicate that integrated application of reduced levels of chemical fertilizers along with FYM and bioinoculants, particularly *Pseudomonas*, significantly improved all yield-attributing characters of mungbean compared to sole application or control.

Table 4.7. Effect of organic manure, inorganic fertilizer with bioinoculants on yield attributes of mungbean

Treatments	Pods/ plant	Pod length (cm)	Seeds/ pod	Seed wt /plant	1000 grain weight (g)
T ₁ - Control (No fertilizer)	11.70	5.89	8.98	3.57	25.23
T ₂ - Recommended dose of fertilizer (100 %)	11.73	5.97	9.52	3.89	27.00
T ₃ - FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	12.20	6.05	9.63	3.60	25.87
T ₄ - FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	12.43	6.05	9.82	3.68	26.73
T ₅ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	12.53	5.94	9.47	4.12	25.90
T ₆ - 50 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	12.53	6.28	10.05	4.23	27.10
T ₇ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Trichoderma</i> @ 2.5 kg ha ⁻¹	12.40	5.95	9.63	3.67	26.90
T ₈ - 75 % NPK + FYM @ 4 t ha ⁻¹ + <i>Pseudomonas</i> @ 2.5 kg ha ⁻¹	13.17	6.55	10.45	4.43	27.63
SEm±	0.28	0.13	0.21	0.19	0.48
C.D. (P = 0.05)	0.86	0.40	0.65	0.57	1.45
CV (%)	3.99	3.76	3.84	8.42	3.13

3.7 Discussion

The present investigation revealed that integrated application of organic manure, inorganic fertilizers, and bioinoculants plays a crucial role in enhancing the productivity of mungbean. Plant population remained unaffected by different treatments, indicating that nutrient management practices did not interfere with crop establishment due to

proper spacing and uniform agronomic practices. Growth parameters showed limited response at early stages; however, at later stages, treatments combining reduced NPK with FYM and bioinoculants, particularly *Pseudomonas* and *Trichoderma*, improved plant growth. This improvement can be attributed to better nutrient availability, enhanced soil physical properties due to FYM, and plant growth-pro-

moting activities of bioinoculants such as phytohormone production, nutrient solubilization, and induced resistance. Root nodulation was significantly influenced, with maximum nodules observed under recommended dose of fertilizers, while integrated treatments also showed appreciable improvement. This indicates that balanced nutrient supply along with microbial inoculation supports symbiotic nitrogen fixation. Yield attributes such as pods per plant, seed number, and test weight were significantly enhanced under integrated nutrient management, especially with 75% NPK + FYM + *Pseudomonas*. This could be due to improved source-sink relationship, efficient photosynthate translocation, and enhanced metabolic activities. Ultimately, grain yield was highest under integrated application of 75% NPK + FYM + *Pseudomonas*, demonstrating that partial substitution of chemical fertilizers with organic and biological inputs can sustain or even improve productivity. The increase in yield and harvest index reflects the cumulative positive effects of improved growth, nodulation, and yield attributes.

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