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Effect of Phosphorus Fertilization and Organic Manures on Growth, Yield and Economics of Mungbean (*Vigna radiata* L.)

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Abstract

Mungbean (*Vigna radiata*) is an important pulse crop contributing significantly to nutritional security and soil fertility through biological nitrogen fixation. A field experiment was conducted to evaluate the effect of phosphorus levels and organic manures on growth, yield attributes, yield, and economics of mungbean. The experiment consisted of four phosphorus levels (0, 25, 50, and 75 kg ha^{-1}) and three organic manure treatments (control, FYM @ 15 t ha^{-1}, and vermicompost @ 4–5 t ha^{-1}). Results indicated that increasing phosphorus levels significantly improved plant height, dry matter accumulation, number of branches, and nodulation, with maximum values observed at 75 kg P ha^{-1}. Similarly, yield attributes such as number of pods $plant^{-1}$ (29.58), seeds pod^{-1} (11.04), and test weight (44.57 g) were highest under 75 kg P ha^{-1}, resulting in maximum seed yield (1146 kg ha^{-1}) and net return (Rs. 50,562 ha^{-1}). Among organic manures, vermicompost recorded superior growth and yield parameters, with highest seed yield (1196 kg ha^{-1}), biological yield (3680 kg ha^{-1}), and B:C ratio (2.42). The combined application of phosphorus and organic manures enhanced nutrient availability, root development, and microbial activity, leading to improved crop performance. Therefore, application of 50–60 kg P ha^{-1} along with vermicompost proved to be the most efficient and economically viable practice for mungbean cultivation.

Keywords: Mungbean, phosphorus, vermicompost, FYM, growth, yield, nodulation, economics, sustainable agriculture

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Introduction

Mungbean (*Vigna radiata*) is one of the most important pulse crops cultivated in India, particularly in arid and semi-arid regions such as Rajasthan. It is valued for its high protein content (20–25%), digestibility, and short duration, making it an ideal crop for diversified cropping systems. In addition, mungbean plays a vital role in improving soil fertility through symbiotic nitrogen fixation, thereby reducing dependency on synthetic fertilizers.

However, the productivity of mungbean remains low due to poor soil fertility, especially phosphorus deficiency. Phosphorus is a key nutrient involved in energy transfer, root development, nodulation, and reproductive growth. Its adequate supply enhances biological nitrogen fixation and improves overall plant growth and yield (Singh *et al*., 2021). In many Indian soils, phosphorus availability is limited due to fixation, necessitating external application.

Organic manures such as farmyard manure (FYM) and vermicompost have gained importance in sustainable agriculture due to their ability to improve soil physical, chemical, and biological properties. Vermicompost, in particular, enhances microbial activity, nutrient mineralization, and availability of macro- and micronutrients (Kumar *et al*., 2022). The integrated use of organic manures with inorganic fertilizers has been shown to improve nutrient use efficiency and crop productivity. Recent studies emphasize the synergistic effect of phosphorus and organic manures in pulse crops. The combined application not only improves growth parameters such as plant height, dry matter accumulation, and branching but also enhances nodulation and yield attributes, ultimately increasing yield and profitability (Sharma & Yadav, 2023).

Therefore, the present study was undertaken to evaluate the effect of different phosphorus levels and organic manure sources on growth, yield attributes, yield, and economics of mungbean under semi-arid conditions.

Materials and Methods

Experimental Site and Location

A field experiment entitled *"Productivity and Soil Fertility Response of Mungbean (*Vigna radiata*) to Phosphorus Fertilization and Organic Manures"* was conducted during the kharif season of 2025 at the Crop Research Farm, Department of Agronomy, Vivekananda Global University, Jaipur, Rajasthan, India. The experimental site is geographically situated at 26°05′ N latitude and 75°28′ E longitude, with an altitude of 427 m above mean sea level, and falls under the Agro-climatic Zone IIIA (Semi-Arid Eastern Plains) of Rajasthan.

Climate and Weather Conditions

The experimental region is characterized by a semi-arid climate, marked by extreme temperatures during summer and winter. The maximum temperature during the crop season ranged between 30.2°C and 35.2°C, while the minimum temperature varied from 9.9°C to 23.0°C. The total rainfall received during the cropping period was 449.5 mm, mainly contributed by the southwest monsoon during July and August. Relative humidity fluctuated between 35% and 70%, while sunshine hours ranged from 2.9 to 9.7 hours per day. Such climatic conditions are typical for mungbean cultivation in semi-arid ecosystems and influence crop growth, nodulation, and nutrient dynamics.

Soil Characteristics of the Experimental Field

Before the initiation of the experiment, soil samples were collected from five random locations at a depth of 0–15 cm and composited for analysis. The soil of the experimental field was sandy loam in texture, consisting of 70.1% sand, 19.3% silt, and 9.12% clay.

The soil was slightly alkaline in reaction (pH 7.65) with low electrical conductivity (0.24 dS m^{-1}), indicating non-saline conditions. It contained 0.33% organic carbon, suggesting low organic matter status. The available nutrient status of the soil was 156.46 kg N ha^{-1} (low), 20.15 kg P_2O_5 ha^{-1} (medium), and 230.24 kg K_2O ha^{-1} (medium). These soil conditions justify the need for phosphorus fertilization and organic amendments to improve fertility and crop productivity.

Cropping History

The experimental field had a cropping sequence of sesame–mustard (2024), followed by groundnut–wheat (2025), and mungbean was taken as the experimental crop in 2025. This rotation reflects typical cropping systems of semi-arid regions and influences soil nutrient dynamics.

Experimental Design and Treatments

The experiment comprised 12 treatment combinations, laid out in a Factorial Randomized Block Design (FRBD) with three replications. The treatments included:

Factor A: Phosphorus Levels

- P_0: 0 kg ha^{-1}
- P_1: 25 kg ha^{-1}
- P_2: 50 kg ha^{-1}
- P_3: 75 kg ha^{-1}

Factor B: Organic Manures

- OM_0: Control
- OM_1: Farmyard manure (FYM) @ 15 t ha^{-1}
- OM_2: Vermicompost @ 5 t ha^{-1}

A total of 36 plots were maintained, each having a gross plot size of 3.0 m × 5.0 m and a net plot size of 2.4 m × 5.0 m.

Crop Details

The mungbean variety SML-668 was used in the experiment. It is a short-duration, high-yielding variety maturing in about 60–65 days, and well adapted to semi-arid conditions. The crop was sown on 22 July 2025 using a seed rate of 25 kg ha^{-1} with a spacing of 30 cm × 10 cm.

Field Preparation and Treatment Application

The field was prepared by one deep ploughing followed by harrowing and planking to achieve a fine tilth. The land was then leveled and divided into experimental plots as per layout.

Phosphorus Application

Phosphorus was applied as per treatments through single super phosphate (SSP) containing 16% P_2O_5. The full dose was applied as a basal dose at the time of sowing.

Organic Manure Application

- FYM (0.5% N, 0.25% P_2O_5, 0.5% K_2O)
- Vermicompost (1.40% N, 0.80% P_2O_5, 1.00% K_2O)

Organic manures were applied uniformly in respective plots before sowing and thoroughly incorporated into the soil.

Statistical Analysis

The experimental data were analyzed using analysis of variance (ANOVA) through OPSTATas described by Panse and Sukhatme (1985). The significance of treatment effects was tested using the F-test at 5% probability level. The standard error of mean (SEm±) and critical difference (CD) were calculated to compare treatment means.

Results and Discussion

The present investigation evaluated the effect of graded levels of phosphorus and different organic manure sources on growth, yield attributes, yield, and economics of mungbean (*Vigna radiata*). The findings are discussed under major heads with scientific interpretation and literature support.

Effect on Growth Parameters

Plant population at 20 DAS and at harvest was found non-significant under both phosphorus levels and organic manure treatments. This indicates that neither phosphorus nor organic manure had any adverse or stimulatory effect on seed germination and initial plant establishment. Germination is primarily governed by seed viability and soil moisture rather than nutrient availability, which explains the non-significant variation. Similar findings were reported by Singh *et al*. (2021), who observed that phosphorus application did not significantly affect plant stand in pulse crops. Plant height increased progressively with increasing phosphorus levels, reaching a maximum at 75 kg P ha^{-1} (60.11 cm at harvest). Among organic manures, vermicompost recorded the highest plant height (58.78 cm), followed by FYM. The increase in plant height due to phosphorus may be attributed to enhanced cell division, elongation, and energy transfer processes regulated by ATP. Phosphorus also promotes root development, leading to better nutrient and water uptake. Organic manures, particularly vermicompost, improve soil structure, aeration, and microbial activity, which enhances nutrient availability and uptake. These results corroborate the findings of Kumar *et al*. (2022), who reported significant increases in plant height with combined application of phosphorus and vermicompost in mungbean.

Dry matter accumulation increased significantly with phosphorus application, with maximum values recorded at 75 kg P ha^{-1} (60.11 g m^{-1} at harvest). Similarly, vermicompost resulted in higher dry matter (58.78 g m^{-1}) compared to FYM and control. This increase is mainly due to improved photosynthetic efficiency, better nutrient uptake, and enhanced metabolic activities under adequate phosphorus supply. Organic manures improve soil microbial biomass and nutrient mineralization, leading to sustained nutrient availability throughout crop growth. These findings align with Meena *et al*. (2020), who reported enhanced biomass production in mungbean due to integrated nutrient management practices. Number of branches per plant increased significantly with increasing phosphorus levels, with maximum (9.57) at 75 kg P ha^{-1}. Vermicompost also significantly enhanced branching (9.41) compared to FYM and control. Branching is a critical growth parameter influencing yield potential. Adequate phosphorus promotes meristematic activity and lateral bud development. Vermicompost further enhances hormonal activity (auxins and cytokinins), contributing to increased branching. Sharma and Yadav (2023) also reported increased branching in pulse crops with integrated nutrient management practices. Phosphorus significantly increased both total (46.01) and effective nodules (39.34) per plant at 40 DAS. Among organic sources, vermicompost recorded the highest nodulation.

Effect on Yield Attributes

Number of pods per plant increased significantly with phosphorus application, with the highest value (29.58) at 75 kg P ha⁻¹. Among organic manures, vermicompost recorded the maximum number of pods (28.06). The increase in pod number is attributed to improved vegetative growth, better nutrient availability, and enhanced reproductive development. Phosphorus plays a vital role in flowering and pod formation, while vermicompost ensures a continuous nutrient supply. Seeds per pod increased significantly with phosphorus levels, reaching 11.04 at 75 kg P ha⁻¹. Vermicompost also improved seeds per pod (10.74). This improvement may be due to better fertilization and reduced flower drop under improved nutrient conditions. Phosphorus enhances reproductive efficiency and assimilate translocation towards developing seeds. Test weight was not significantly influenced by phosphorus levels but showed a slight increase under higher levels. Vermicompost recorded the highest test weight (44.99 g). Test weight is largely governed by genetic factors; however, better nutrient availability may slightly enhance seed size and weight.

Effect on Yield

Seed Yield

Seed yield increased significantly with phosphorus levels up to 75 kg ha⁻¹ (1146 kg ha⁻¹), which was statistically at par with 50 kg P ha⁻¹ (1122 kg ha⁻¹). Among organic manures, vermicompost recorded the highest seed yield (1196 kg ha⁻¹), followed by FYM. The increase in seed yield is a cumulative effect of improved growth parameters, enhanced nodulation, and better yield attributes. Phosphorus enhances energy transfer and reproductive development, while organic manures improve soil health and nutrient availability.

These findings are supported by Kumar *et al*. (2022), who observed significant increases in mungbean yield with integrated use of phosphorus and vermicompost.

Straw Yield and Biological Yield

Straw yield and biological yield followed trends similar to seed yield. Maximum biological yield was recorded at 75 kg P ha⁻¹ (3523 kg ha⁻¹) and under vermicompost (3680 kg ha⁻¹). This indicates that phosphorus and organic manures not only enhance economic yield but also total biomass production. Harvest index remained non-significant across treatments, indicating proportional increases in both seed and straw yield.

Table 1 Effect of phosphorus and organic manure on growth of mungbean

Treatments	Plant population (m^{-1} row length)		Plant height (cm)			Dry matter accumulation (g m-1 row length)			Number of branches $plant^{-1}$ at harvest	Number of nodules $plant^{-1}$ at 40 DAS	
	At 20 DAS	At harvest	At 25 DAS	At 50 DAS	At harvest	At 25 DAS	At 50 DAS	At harvest		Total	Effective
Phosphorus (kg ha^{-1})											
0	8.68	7.98	13.37	32.36	46.53	1.8	7.49	12.25	8.01	32.44	25.77
25	8.78	8.08	13.58	35.74	54.91	1.85	8.16	14.93	8.71	40.81	34.15
50	8.88	8.18	15.09	38.2	59.37	1.93	8.83	16.59	9.37	45.27	38.60
75	9	8.3	14.11	38.94	60.11	1.92	9.03	16.79	9.57	46.01	39.34
SEm±	0.305	0.305	0.30	0.73	1.21	0.04	0.22	0.27	0.19	1.21	0.95
CD (p=0.05)	NS	NS	NS	2.13	3.55	NS	0.65	0.80	0.56	3.55	2.77
Organic manures											
Control	8.8	8.1	13.52	33.94	50.94	1.84	7.66	13.86	8.24	36.81	31.51
FYM @ 15 t ha^{-1}	8.84	8.14	13.75	36.47	55.97	1.87	8.59	15.57	9.1	41.94	35.14
Vermicompost @ 4 t ha^{-1}	8.87	8.17	15.09	37.77	58.78	1.91	8.89	16	9.41	44.65	36.75
SEm±	0.264	0.264	0.26	0.63	1.05	0.03	0.19	0.24	0.17	1.05	0.82
CD (p=0.05)	NS	NS	NS	1.84	3.08	NS	0.56	0.69	0.49	3.08	2.40
CV (%)	9.16	9.85	7.07	6.23	6.72	6.40	8.08	5.45	6.63	8.83	8.23

NS – Non significant

Table 2 Effect of phosphorus and organic manure on yield attributes and yield of mungbean

Treatments	Yield attributes			Yield (kg ha^{-1})			Harvest index (%)	Economics (Rs. ha^{-1})	
	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)	Seed	Straw	Biological		Net return	B:C ratio
Phosphorus (kg ha^{-1})									
0	22.74	9.3	42.92	871	1919	2791	31.02	33135	2.02
25	26.12	10.18	43.45	1011	2130	3121	31.69	42441	2.29
50	28.58	10.84	43.96	1122	2322	3444	32.54	49705	2.47
75	29.58	11.04	44.57	1146	2377	3523	32.46	50562	2.46
SEm±	0.73	0.22	1.20	31	63	86	0.522	2263	0.07
CD (p=0.05)	2.13	0.65	NS	92	186	252	NS	6636	0.21
Organic manures									
Control	25.05	9.83	42.56	783	1709	2487	31.15	30948	2.13
FYM @ 15 t ha^{-1}	27.16	10.46	43.62	1134	2363	3492	32.27	48770	2.38
Vermicompost @ 5 t ha^{-1}	28.06	10.74	44.99	1196	2489	3680	32.36	52165	2.42
SEm±	0.63	0.19	1.04	27	55	75	0.452	1960	0.06
CD (p=0.05)	1.84	0.56	NS	79	161	219	NS	5747	0.18
CV (%)	8.47	7.17	8.43	9.41	8.69	8.02	4.91	5.23	9.42

NS – Non significant

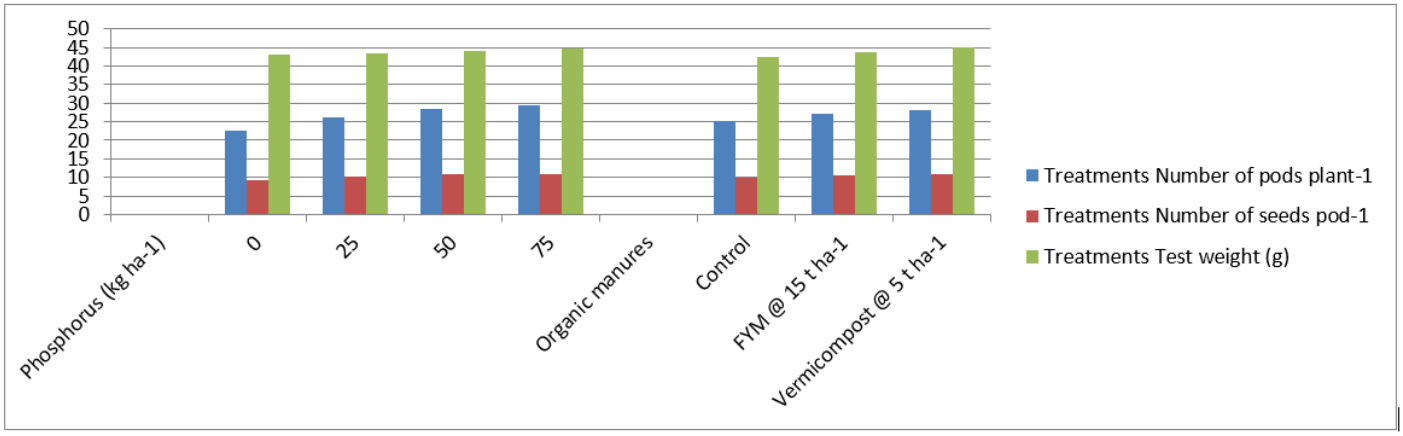

Figure 1 Effect of phosphorus and organic manure on yield attributes of mungbean

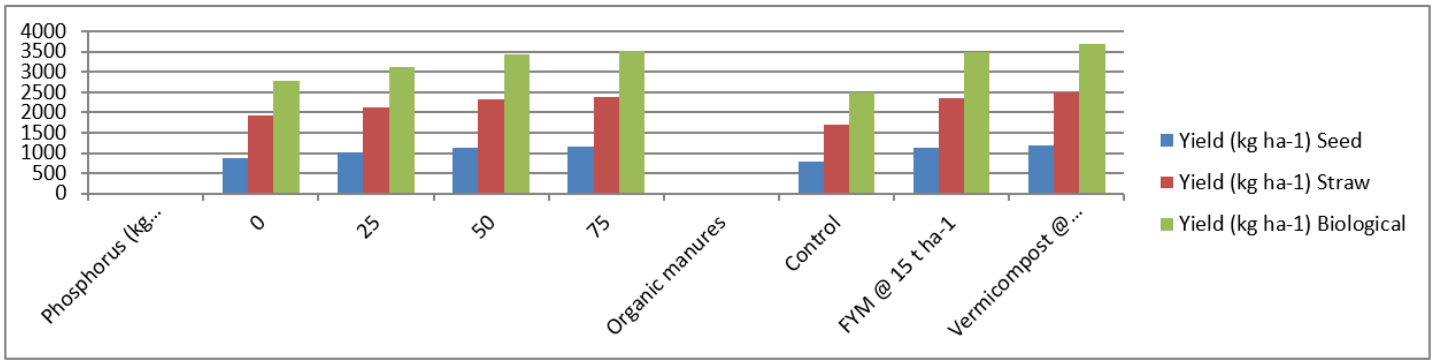

Figure 2 Effect of phosphorus and organic manure on yield of mungbean

Effect on Economics

Economic analysis revealed that higher phosphorus levels significantly increased net returns, with maximum net return (Rs. 50,562 ha^{-1}) and B:C ratio (2.46) at 75 kg P ha^{-1}. However, 50 kg P ha^{-1} showed comparable returns, suggesting it as an economically optimal dose. Among organic manures, vermicompost recorded the highest net return (Rs. 52,165 ha^{-1}) and B:C ratio (2.42), followed by FYM. Higher profitability under vermicompost is due to increased yield and better marketable produce. Integrated nutrient management practices enhance input-use efficiency, thereby improving economic returns. Similar economic benefits of integrated nutrient management were reported by Sharma and Yadav (2023).

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