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Effect of Phosphorus and Bio-Organics on Yield and Nutrient Uptake by Mung bean [Vigna radiata (L.) Wilczek] in an Inceptisol of Varanasi

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Abstract

A pot experiment was conducted to study the effect of phosphorus and bio-organics on yield, and nutrient uptake by mung bean in an Inceptisol. The results showed that application of phosphorus at 40 kg P_2O_5 ha^{-1} significantly increased seed yield by 44.7% and stover yield by 35.9% over control. Similarly, application of poultry manure at 2.5 t ha^{-1} + Rhizobium + PSB increased seed yield by 26.8% and stover yield by 24.5% over control. Phosphorus application also improved nutrient uptake, with maximum nitrogen uptake by seed (69.3%) and stover (86.2%) recorded at 40 kg P_2O_5 ha^{-1}. Bio-organics application also showed significant improvement in nutrient uptake, with poultry manure at 2.5 t ha^{-1} + Rhizobium + PSB recording 39.5% and 49.8% increase in nitrogen uptake by seed and stover, respectively. The study suggests that integrated use of phosphorus and bio-organics can improve mung bean productivity and nutrient use efficiency.

Keywords: Mungbean, Phosphorus, Bio-organics, Yield, Nutrient uptake, Inceptisol

Introduction

Mung bean (Vigna radiata L.) is a vital pulse crop in India, serving as a primary source of protein and nutrients for millions. Beyond its nutritional value, mung bean is valued for its ability to fix atmospheric nitrogen, enhance soil fertility, and provide a valuable income source for farmers. Despite its importance, mung bean productivity in India remains low, largely due to inadequate nutrient management practices. Phosphorus is a crucial nutrient for grain legumes, playing a pivotal role in nodulation, growth, yield, and soil fertility. It is essential for healthy root growth, grain development, and ripening, and participates in various biochemical processes, including energy transfer and oxidation-reduction reactions. Phosphorus application has been shown to promote cell division, leading to increased growth and productivity in legumes. Bio-organics like vermicompost and poultry manure offer a sustainable alternative to chemical fertilizers, enhancing soil fertility, promoting plant growth, and improving crop yields. These organic amendments can help mitigate the environmental impact of chemical fertilizers, making them an attractive option for sustainable agriculture. This study aims to

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investigate the impact of phosphorus and bio-organics on mung bean growth attributes, with the goal of identifying an effective nutrient management strategy for improving productivity and sustainability in mung bean production systems.

Materials and Methods

A pot experiment was conducted during the kharif season of 2017 in a greenhouse at the Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh. The experimental site was located at 25.2677° N latitude, 82.9913° E longitude, and an altitude of approximately 86 meters above mean sea level, falling within the sub-tropical zone. The experiment was conducted on a sandy loam soil with alkaline reaction, low available nitrogen, and medium available phosphorus and potassium. The experiment followed a factorial completely randomized design (CRD) with three replications. The treatments consisted of three levels of phosphorus (0, 20, and 40 kg P_2O_5 ha^{-1}) and five levels of bio-organics: - (Control, Vermicompost (VM) at 2.5 t ha^{-1}, VM at 2.5 t ha^{-1} + Rhizobium + PSB, Poultry manure (PM) at 2.5 t ha^{-1} and PM at 2.5 t ha^{-1} + Rhizobium + PSB). Mung bean was grown in an Inceptisol, and growth attributes were recorded. The crop was sown on July 15, 2017, and irrigated as needed. Weeds were removed regularly, and the crop was harvested at maturity. Seed and stover samples were analyzed for nitrogen content using the Kjeldahl method (Jackson, 1973). Grain and straw samples were digested in di-acid (HNO_3 , $HClO_4$) and analyzed for phosphorus, potassium, and other nutrients using standard methods. The nutrient uptake was calculated using the yield data and respective nutrient contents.

Results and Discussion

Seed yield

Maximum grain yield was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (1174.49 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (1036.54 kg ha^{-1}) as compared to control (811.50 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase grain yield by 44.73% and 27.73% higher over control, respectively (Table 1). Maximum grain yield was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (1102.99 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (1083.82 kg ha^{-1}) as compared to control (870.02 kg ha^{-1}). Application of poultry manure 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 26.78% and 24.57%

Table 1: Effect of phosphorus and bio-organism levels on seed and stover yield, nitrogen uptake by seed and stover of mung bean

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	N uptake by seed (kg ha^{-1})	N uptake by stover (kg ha^{-1})
P_0	811.50	1410.35	24.79	17.49
P_1	1036.54	1679.38	34.96	24.26
P_2	1174.49	1916.91	41.96	32.57
CD (P=0.05)	19.26	47.73	0.89	1.79
Bio-Organics levels				
BO_0	870.02	1467.41	27.66	19.64
BO_1	982.24	1612.81	32.47	22.87
BO_2	1083.82	1791.86	37.56	27.85
BO_3	998.49	1646.16	33.24	24.10
BO_4	1102.99	1826.17	38.59	29.41
CD (P=0.05)	24.86	61.62	1.16	2.51

higher over control, respectively. These findings are consistent with Meena et al (2013), Shukla et al (2016), Meena (2017), and Sharma et al., (2022).

Stover yield

Maximum stover yield was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (1916.91 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (1679.38 kg ha^{-1}) as compared to control (1410.35 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase stover yield by 35.92% and 19.08% higher over control, respectively. Maximum stover yield was observed in treatment BO_4(PM 2.5 t ha^{-1} + Rhizobium + PSB) (1826.17 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (1791.86 kg ha^{-1}) as compared to control (1467.41 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 24.45% and 22.11% higher over control, respectively. These findings are consistent with Singh et al., (2010), Meena et al., (2011), Meena et al (2013), and Sharma et al., (2022).

Nitrogen uptake by seed

Maximum nitrogen uptake by seed was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (41.96 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (34.96 kg ha^{-1}) as compared to control (24.79 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase nitrogen uptake by seed by 69.26% and 41.02% higher over control, respectively (Table 1).

Maximum nitrogen uptake by seed was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (38.59 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (37.56 kg ha^{-1}) as compared to control (27.66 kg ha^{-1}). Applications of poultry manure 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 39.52% and 35.79% higher over control, respectively. These findings are consistent with Meena et al., (2012), Singh et al., (2017), Meena et al., (2017), Yadav et al., (2019) and Sharma et al. (2022).

Nitrogen uptake by stover

Maximum nitrogen uptake by stover was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (32.57 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (24.26 kg ha^{-1}) as compared to control (17.49 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase nitrogen uptake by stover by 86.22% and 38.71% higher over control, respectively.

Maximum nitrogen uptake by stover was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (29.41 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (27.85 kg ha^{-1}) as compared to control (19.64 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 49.75% and 41.80% higher over control, respectively. These findings are consistent with Meena et al., (2013), Shukla et al., (2016), Singh et al., (2017), and Yadav et al., (2019),

Phosphorus uptake by seed

Maximum phosphorus uptake by seed was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (5.14 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (3.95 kg ha^{-1}) as compared to control (2.67 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase phosphorus uptake by seed by 92.51% and 47.94% higher over control, respectively (Table 2). Maximum phosphorus uptake by seed was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (4.70 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (4.51 kg ha^{-1}) as compared to control (3.00 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 56.67% and 50.33% higher over control, respectively. These results are consistent with the findings of Meena et al., (2013), Shukla et al., (2016), Singh et al., (2017), and Yadav et al., (2019),

Phosphorus uptake by stover

Maximum phosphorus uptake by stover was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (4.95 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (3.56 kg ha^{-1}) as compared to control (2.24 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase phosphorus uptake by stover by 120.98% and 58.93% higher over control, respectively. Maximum phosphorus uptake by stover

Table 2: Effect of phosphorus and bio-organism levels on phosphorus and potassium uptake by seed and stover of mung bean

Treatments	P uptake by seed (kg ha^{-1})	P uptake by stover (kg ha^{-1})	K uptake by seed (kg ha^{-1})	K uptake by stover (kg ha^{-1})
Phosphorus levels				
P_0	2.67	2.24	5.07	20.27
P_1	3.95	3.56	7.50	26.78
P_2	5.14	4.95	10.11	33.45
CD (P=0.05)	0.19	0.30	0.52	1.86
Bio-Organics levels				
BO_0	3.00	2.60	5.28	21.47
BO_1	3.60	3.24	7.15	25.16
BO_2	4.51	4.22	8.82	30.32
BO_3	3.79	3.42	7.34	25.94
BO_4	4.70	4.45	9.22	31.28
CD (P=0.05)	0.25	0.59	0.67	0.83

was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (4.45 kg ha^{-1}) followed by BO2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (4.22 kg ha^{-1}) as compared to control (2.60 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 71.15% and 62.31% higher over control, respectively. These results are consistent with the findings of Shukla et al., (2016), Singh et al., (2010), Singh et al., (2017), and Yadav et al., (2019),

Potassium uptake by seed

Maximum potassium uptake by seed was recorded in treatment P_2 (40 kg P_2O_5 ha^{-1}) (10.11 kg ha^{-1}) followed by P_1 (20 kg P_2O_5 ha^{-1}) (7.50 kg ha^{-1}) as compared to control (5.07 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase potassium uptake by grain by 99.41% and 47.93% higher over control, respectively (Table 2). Maximum potassium uptake by seed was observed in treatment BO4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (9.22 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (8.82 kg ha^{-1}) as compared to control (5.28 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost. These results are consistent with the findings of Singh et al., (2010), Meena et al., (2013), Shukla et al., (2016), and Meena (2017),

Potassium uptake by stover

Maximum potassium uptake by stover was recorded in treatment P2 (40 kg P_2O_5 ha^{-1}) (33.45 kg ha^{-1}) followed by P1 (20 kg P_2O_5 ha^{-1}) (26.78 kg ha^{-1}) as compared to control (20.27 kg ha^{-1}). Application of 40 kg P_2O_5 ha^{-1} and 20 kg P_2O_5 ha^{-1} were observed to significantly increase potassium uptake by stover by 65.02% and 32.12% higher over control, respectively. Maximum potassium uptake by stover was observed in treatment BO_4 (PM 2.5 t ha^{-1} + Rhizobium + PSB) (31.28 kg ha^{-1}) followed by BO_2 (VM 2.5 t ha^{-1} + Rhizobium + PSB) (30.32 kg ha^{-1}) as compared to control (21.47 kg ha^{-1}). Application of poultry manures 2.5 t ha^{-1} + Rhizobium + PSB and vermicompost 2.5 t ha^{-1} + Rhizobium + PSB represented an increase of 45.69% and 41.22% higher over control, respectively. These results are consistent with the findings of Meena et al., (2012), Meena et al., (2013), Singh et al., (2017), and Yadav et al., (2019),

Conclusion

The study concludes that phosphorus application at 40 kg P_2O_5 ha^{-1} and bio-organics (poultry manure or vermicompost) with Rhizobium and PSB can significantly improve mung bean yield and nutrient uptake. The integrated use of phosphorus and bio-organics can be recommended as a sustainable and efficient approach for mung bean production. Further research is needed to optimize the rates and combinations of phosphorus and bio-organics for different soil types and agro-climatic conditions.

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