

Different levels of phosphorus and phosphorus solubilizing bacteria (PSB) influence growth, yield and economics of green gram [*Vigna radiata* L.]

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ABSTRACT

An experiment was conducted during *Kharif* 2021-22 to study the effect of phosphorus levels (0, 10, 20, 30, 40, and 50 kg P₂O₅ ha⁻¹) and biofertilizers (without and with 25 ml PSB ha⁻¹) on plant growth characters and yield attributes. A significant increase was documented in plant height (40.82 cm), dry matter accumulation (382.23), the number of leaves (45.1), number and dry weight of nodules (49.15), and the number of primary (6.4) and secondary branches (7.19) plant⁻¹. Also, yield attributes viz., the number of pods plant⁻¹ (13.06), the number of grain pod⁻¹ (35.13), 1000-seed weight (995g), biological yield (2809), seed yield, straw yield, harvest index significantly increased up to the level of 50 kg P₂O₅ ha⁻¹. Higher net returns (68009), and B:C ratio (2.18) were recorded with the application of 40 kg P₂O₅ ha⁻¹ along with 25 ml kg⁻¹ of seed PSB ha⁻¹. However, growth and production attributes were superior at 40 kg P₂O₅ kg ha⁻¹ with PSB but economics of 40 and 50 kg P₂O₅ kg ha⁻¹ with PSB application were at par to each other, thus, application of 40 kg P₂O₅ kg ha⁻¹ together with PSB is advised for enhanced green gram production.

Key words: Economics, Green gram, Phosphorus solubilizing bacteria, Yield attributes.

INTRODUCTION

Green gram (*Vigna radiata* L.) is one of the most important pulses and belongs to the family Leguminosae and subfamily Papilionaceae. The seed is often green, yellow-brown, or sometimes purple-brown in color. The seed germinates epigeal and is a self-pollinated crop (Lambrides and Godwin, 2007). It is a warm-season, short-day crop that is often farmed in semi-arid to sub-humid tropical regions. The optimum climatic conditions include 600 to 1000 mm annual rainfall but can be raised well under both irrigated and non-irrigated conditions. During the germination and growth period, a temperature range of 22 to 35°C is required. Warm weather and well-drained loam or sandy loam soils are ideal for obtaining a higher yield. India ranks first not only in green gram production but also in consumption globally. India has 25 million hectares of land planted with pulses; 16.47 million tonnes are produced with a 652 kg ha⁻¹ productivity (Govt of India, 2021). The crop is mostly grown in the states of Maharashtra, Andhra Pradesh, Rajasthan, Karnataka, Bihar and Madhya

Pradesh (ANGRAU, 2021) which together account for around 70% of the country's total production of pulses.

Proper intake of phosphorus (P) is important for the growth of green gram. In addition to its involvement in metabolic processes and energy conversions, P has a significant impact on root growth, which is the site of biological nitrogen (N) fixation. This allows plants to absorb nutrients from lower layers and, as a result, thrive in environments of moisture stress (Singh and Pareek, 2003).

In India's sustainable agricultural systems, bio-fertilizers, which are a part of integrated nutrient management, are involved as an economical, environmentally responsible, source of non-bulky and sustainable, supplemental plant nutrients that are cheaper. In the current environment of expensive chemical fertilizers, the function of bio-fertilizers has a unique significance. P solubilizers are injected into pulse seeds to increase the quantity of them in the rhizosphere and significantly improve its availability for plant development (Andy *et al.*, 2020).

Thus, the objectives of the present study were to study the effect of Phosphorus solubilizing bacteria (PSB) and different levels of phosphorus on the growth, yield, and economics of green gram (*Vigna radiata* L.).

MATERIALS AND METHODS

The field experiment was conducted at Crop Research Centre, School of Agriculture, ITM University, Gwalior, (M.P.) during the *Kharif* season of 2021-22 (latitude of 26.140° N and longitude of 78.196° E with an altitude of 211 m above the mean sea level). This area is located in the Grid Region of Madhya Pradesh (semi-arid zone). The soil of the test field contains high potassium levels, (235.4 kg ha⁻¹), medium availability phosphorus (14.3 kg ha⁻¹), available N (65 kg ha⁻¹), and organic carbon (0.17%) levels. The total rainfall during May 2021, was 650-700 mm of rainfall overall throughout the trial. During the growing season, the highest temperature recorded was 36.5°C on August 2021.

Six P-levels viz., 0 (P₀), 10 (P₁₀), 20 (P₂₀), 30 (P₃₀), 40 (P₄₀), and 50 kg P₂O₅ kg ha⁻¹ (P₅₀) and bio-fertilizer levels without PSB (B₀), and with 25 ml PSB ha⁻¹ (B₁) were used in the experiment following factorial Randomized Block Design. Recommended agronomical practices and plant protection measures were applied during crop cultivation. The variety PDM-139 (Samrat) of green gram was seeded using a seed rate of 12 kg ha⁻¹ in furrows spaced at 30 cm. Thinning was carried out after full germination (10 days after sowing-DAS) to maintain plant-to-plant spacing of 10 cm and

achieve a consistent plant population. According to the crop's need, three irrigations including one pre-sowing were given. Two hand-weedings were carried out at 20 and 40 DAS. Harvesting was done manually after net plot construction when the plant's colour became yellowish brown. After sun-drying the weight of the whole biological product from each net plot was recorded before threshing. Wooden sticks were used for threshing purposes. The cleaned seed weight of each plot was used to track the grain yield and overall biological yield to get straw yield.

Parameters observed periodically included growth plant height; dry matter accumulation, and number of nodules, leaves, primary branches and secondary branches and yield (number of grains and pods, and grain, and straw yields). Economic analysis of the crop production was based on gross return, net return, and B:C ratio. A factorial randomized block design (two factors-2 x 6) was used to analyse the data statistically (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

The application of 50 kg P₂O₅ ha⁻¹ recorded significantly higher plant height, dry matter accumulation, number of leaves at 60 DAS, number of nodules plant⁻¹, number of primary branches plant⁻¹ and secondary branches/plant¹ at 60 days after sowing (DAS) respectively, while it was statistically at par with (P>0.05) 40 Kg P₂O₅ ha⁻¹ (Table 1). Therefore, P has an impact on activities like photosynthesis (Maqsood *et al.*, 2001), protein and

Table 1. Effect of Phosphorus and Biofertilizer Levels on Growth Attributes at 60 DAS.

| Treatments | Plant height (cm) | Dry matter accumulation (g m ⁻²) | Number of nodules | Number of leaves | Primary branches plant ⁻¹ | Secondary branches plant ⁻¹ |
|--------------------------------------|-------------------|--|-------------------|------------------|--------------------------------------|--|
| A) Phosphorus levels | | | | | | |
| P ₀ (Control) | 26.12 | 235.16 | 31.01 | 27.34 | 4.33 | 4.91 |
| P ₁₀ | 29.8 | 266.69 | 36 | 31.91 | 4.83 | 5.47 |
| P ₂₀ | 33.11 | 297.61 | 40.02 | 35.61 | 5.33 | 6.03 |
| P ₃₀ | 36.32 | 333.57 | 44.7 | 39.88 | 5.86 | 6.61 |
| P ₄₀ | 39.66 | 364.45 | 48.47 | 43.73 | 6.36 | 7.17 |
| P ₅₀ | 40.82 | 382.23 | 49.15 | 45.1 | 6.4 | 7.19 |
| S. Em ± | 1.09 | 10.36 | 1.27 | 1.25 | 0.17 | 0.19 |
| C. D.* | 3.2 | 30.38 | 3.73 | 3.67 | 0.5 | 0.55 |
| B) Bio-fertilizer | | | | | | |
| B ₀ | 32.92 | 295.31 | 40.04 | 35.49 | 5.34 | 6.04 |
| B ₁ | 35.69 | 331.26 | 43.18 | 39.03 | 5.69 | 6.42 |
| SEm ± | 0.63 | 5.98 | 0.73 | 0.72 | 0.09 | 0.11 |
| CD* | 1.85 | 17.54 | 2.15 | 2.12 | 0.29 | 0.32 |
| C) Interaction effect P x PSB | | | | | | |
| S. Em ± | 1.54 | 14.65 | 1.8 | 1.77 | 0.24 | 0.26 |
| C. D. | NS | NS | NS | NS | NS | NS |

* CD at 5%

phospholipid formation, nucleic acid synthesis, and cytoplasmic streaming (Yang *et al.*, 2014). As it was treated in soil with low P content and availability were increased. The increase in the availability of N in the green gram field, therefore strengthening the capacity of the crop to absorb N, P, and K. Increased nutrient uptake may have enhanced photosynthesis, which ultimately promoted metabolite translocation to different parts of the plant, promoting the development of meristematic tissues in apical buds and intercalary meristem resulting root and shoot formation (Kumawat *et al.*, 2014; Vidhyashree *et al.*, 2017; Sudharani *et al.*, 2018). Among the bio-fertilizer levels treatment inoculated with PSB recorded the highest value of plant height at 60 DAS, dry matter accumulation at 60 DAS, number of leaves at 60 DAS, number of nodules plants⁻¹ at 60 DAS, number of primary branches plant⁻¹ at 60 DAS and secondary branches plant⁻¹ at 60 DAS as compared to the treatment without PSB at all the growth attributes. The presence of Phosphate Solubilizing Bacteria (PSB) increased the P availability in the soil. P helps in root nodulation in leguminous crops. Higher crop growth of the plant is improved by the increased nutrient availability (Tyagi *et al.*, 2014; Meena *et al.*, 2015; Sushil *et al.*, 2015; Karnavat *et al.*, 2018).

Application of phosphorus with 50 kg P₂O₅ ha⁻¹ (Table 2) has recorded a higher number of grains per plant, the number of pods plant⁻¹, grain yield, biological yield, which was statistically on

par with (P>0.05) 40 kg P₂O₅ ha⁻¹ over control. As a result, phosphorus uptake was increased. Because of this, photosynthates were moving away from the source and toward the sink rapidly (Maqsood *et al.*, 2001). Among different bio-fertilizer levels B₁ recorded the highest value with the number of grains plant, the number of pods plant⁻¹, grain yield, straw yield over B₀. According to Rekha *et al.*, (2018), inoculating seeds with PSB improved seed output in green gram, which may be associated with the development of root nodules and N fixation.

The treatments were analysed economically using the gross return, net return, and benefit-cost ratio (Table 3). The treatment that received 40 kg P₂O₅ ha⁻¹ + PSB had greater net returns (Rs. 68009.00),

Table 3. Effect of phosphorus and biofertilizer levels on economics

| Treatments | Gross return | Net return | B: C ratio |
|---|--------------|------------|------------|
| 0 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 49440 | 20749 | 0.72 |
| 10 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 68986 | 39670 | 1.35 |
| 20 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 77100 | 47159 | 1.57 |
| 30 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 90710 | 60144 | 1.96 |
| 40 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 99200 | 68009 | 2.18 |
| 50 kg P ₂ O ₅ kg ha ⁻¹ + PSB | 99760 | 67944 | 2.13 |
| 0 kg P ₂ O ₅ kg ha ⁻¹ | 42590 | 14149 | 0.5 |
| 10 kg P ₂ O ₅ kg ha ⁻¹ | 60580 | 31514 | 1.08 |
| 20 kg P ₂ O ₅ kg ha ⁻¹ | 70150 | 40459 | 1.36 |
| 30 kg P ₂ O ₅ kg ha ⁻¹ | 82953 | 52637 | 1.74 |
| 40 kg P ₂ O ₅ kg ha ⁻¹ | 91103 | 60162 | 1.94 |
| 50 kg P ₂ O ₅ kg ha ⁻¹ | 95410 | 63844 | 2.02 |

Table 2. Effect of Phosphorus and bio-fertilizer levels on yield attributes

| Treatments | No. of Grains pod ⁻¹ | No. of. Pods plant ⁻¹ | Grain yield (kg ha ⁻¹) | Biological yield (kg ha ⁻¹) |
|--------------------------------------|---------------------------------|----------------------------------|------------------------------------|---|
| A) Phosphorus levels | | | | |
| P ₀ | 6.51 | 20.59 | 453 | 1430.5 |
| P ₁₀ | 8.25 | 23.7 | 655 | 1886.33 |
| P ₂₀ | 9.5 | 26.75 | 748 | 2123 |
| P ₃₀ | 10.98 | 30.37 | 890 | 2449 |
| P ₄₀ | 12.361 | 33.25 | 976 | 2679 |
| P ₅₀ | 13.06 | 35.13 | 995 | 2809 |
| SEm ± | 0.34 | 0.95 | 26.61 | 75.55 |
| CD* | 1.02 | 2.81 | 78.07 | 221.59 |
| B) Bio-fertilizer | | | | |
| B ₀ | 9.44 | 26.62 | 756 | 2086.61 |
| B ₁ | 10.78 | 29.98 | 816 | 2372.94 |
| SEm ± | 0.2 | 0.55 | 15.36 | 43.62 |
| CD* | 0.59 | 1.62 | 45.07 | 127.93 |
| C) Interaction effect P x PSB | | | | |
| SEm ± | 0.49 | 1.35 | 37.64 | 106.85 |
| CD* | NS | NS | NS | NS |

* CD at 5%

and benefit-cost ratio, it was observed (2.18). This could be because this treatment produces higher economics than other treatments. With increasing levels of phosphorus and PSB, this was justified by a greater increase in grain and straw yield compared to the cost of cultivation. These findings are consistent with those reported by Mitra *et al.*, (2006), who reported both increasing levels of phosphorus and PSB levels increased the benefit-cost ratio and net income.

CONCLUSION

However, growth and production attributes were superior at 40 kg P₂O₅ kg ha⁻¹ with PSB but economics of 40 and 50 kg P₂O₅ kg ha⁻¹ with PSB application were at par to each other, thus, based on these results, applying 40 kg P₂O₅ kg ha⁻¹ together with PSB is advised to produce the highest green gram.

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