Indian Journal of Agronomy **70** (4): 507–511 (December 2025)
DOI: 10.59797/ija.v70.i4.5670

Research Communication

Influence of phosphorus and biofertilizers on the productivity and profitability of summer black gram (*Phaseolus mungo*) under sub-tropical conditions of Nagaland

CHARAN SINGH CHOUDHARY[1], D. NONGMAITHEM[2], A.P. SINGH[3], T. GOHAIN[4], ASHIK KUMAR MEENA[5], GADEKAR KARAN EKNATH[6] AND VIROSANUO SOLO[7]

School of Agricultural Sciences, Nagaland University, Medziphema Campus, Medziphema 797 106, Nagaland

Received: November 2024; Revised accepted: November 2025

ABSTRACT

To study the influence of phosphorus and bio-fertilizers on the productivity and profitability of summer black gram under the sub-tropical conditions of Nagaland a field experiment was conducted at the experimental farm of School of Agricultural Sciences (SAS), Nagaland University during the summer season of 2022. The experiment was conducted by taking 2 factors i.e. phosphorus levels, viz control, 15 kg P/ha, 30 kg P/ha and 45 kg P/ha along with bio-fertilizers i,e (control), *Rhizobium* (20 g/kg seed), Phosphate solubilizing bacteria (20 g/kg seed) and *Rhizobium* (20 g/kg seed) + Phosphate solubilizing bacteria (20 g/kg seed) in factorial randomized block design which were replicated thrice. The black gram variety "Pusa 1" was uniformly fertilized by 20 kg N/ha through Urea. The experimental study revealed that among the phosphorus levels, the application of 45 kg P/ha recorded significantly highest yield attributes and seed yield (724.17 kg/ha). However, among bio-fertilizers, application of *Rhizobium* (20 g/kg seed) + Phosphate solubilizing bacteria (20 g/kg seed) resulted in highest yield attributes and yield of black gram. Among the economic analysis, application of 45 kg/ha phosphorus and combine treatment of *Rhizobium* + Phosphate solubilizing bacteria incurred the highest cost of cultivation, highest gross return, net return and Benefit cost ratio. Therefore, for summer black gram cultivation, application of 45 kg/ha phosphorus and treatment of *Rhizobium* + Phosphate solubilizing bacteria was proved to be profitable.

***Key words*:** Biofertilizers, Black gram, Economics, Phosphorus, Yield

India has become the self-sufficient in the production of cereals. Still, it lags with the production of pulses; hence, a large chunk of various food legumes is imported from other countries. India is the largest producer (2,76,68,511.27 t for 2022; FAOSTAT, 2024) of pulses globally with about 27.44% share in global production. Among the pulses, black gram or urdbean (*Phaselous mungo* L.) is one of the major pulses grown throughout the country during *kharif* (rainy season) and summer season. The total area under black gram is about 4.14 million hectares with an annual production of about 2.23 million tonnes and productivity about 538 kg/ha in country (DPD, 2021). The productivity of pulses is mostly dependent on appropriate nutrient management strategies, particularly phosphorus (P), biofertilizers and balanced nutrient delivery (Gupta *et al*., 2024).

Protein synthesis and energy transfer depend on phosphorus, a critical macronutrient essential to many physiological functions, such as nucleic acid synthesis, cell division and tissue formation (Hasanain *et al.,* 2021). Phosphorus, in particular, has a major impact on root growth, morphological changes in root characteristics, and root hair density, all of which greatly increase crop output. Phosphorus fertilization is therefore an essential agricultural technique to meet plant nutritional needs and maximize crop yield (Elhaissoufi *et al.,* 2022).

By producing organic acid and phosphate enzyme activity, the phosphate solubilizing bacteria (PSB) contribute significantly to the solubilization of inorganic phosphates

Based on a part of M.Sc. Thesis of the first author submitted to School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland in 2022 (unpublished)

[1]Corresponding author's Email: debikanong@gmail.com
[1]Ph.D. Scholar, [2]Assistant Professor, [3]Associate professor, [4]Professor & Head of department, [5,6]Ph.D. Scholar, Department of Agronomy, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Medziphema 797 106, Nagaland; [7]Junior Agronomist, AICRP-Linseed, Medziphema Center, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Medziphema 797 106, Nagaland

in soil and their availability to plants (Kumawat *et al.,* 2022). The crop production will be influenced by phosphate solubilizing bacteria that dissolve entangled phosphates (Yu *et al.,* 2019). By encouraging root growth, enough phosphorus availability makes it easier for Rhizobium to create enough infection sites. Additionally, it helps *Rhizobium* convert ammonium into amino acids and synthesize mitochondrial and symbiosomal membranes inside the nodules. The mineralization and solubilization of fixed organic phosphorus depend heavily on PSB. Furthermore, PSB generates plant growth regulators, especially auxins, which promote plant development and help maximize agricultural output (Shome *et al.,* 2022). Thus, keeping the above fact in view, an experiment was conducted to assess the influence of phosphorus and biofertilizers on the productivity and profitability of black gram under the subtropical conditions of Nagaland.

A field experiment was carried out at the Agronomy experimental research farm of School of Agricultural Sciences, Nagaland University, Medziphema campus, India (25°45´N latitude, 95°53´E longitude and 310 m above MSL) during the summer season 2022. The soil of the experimental field was sandy loam in texture (Sand 68.15%, Silt 22.75% and Clay 9.1%), slightly acidic in reaction (*p*H 4.8), high in organic carbon (1.63 %) and medium in available nitrogen (262.54 kg/ha) available phosphorus (17.21 kg/ha) and potassium (190.54 kg/ha). The study was conducted in factorial randomized complete design with 3 replications and 16 treatment combinations. The treatments comprised of two factors, i.e. phosphorus levels viz., Control, 15 kg P/ha, 30 kg P/ha and 45 kg P/ha along with biofertilizers, viz. Control, *Rhizobium* (20 g/kg seed); Phosphate solubilizing bacteria (20 g/kg seed) and *Rhizobium* (20 g/kg seed) + Phosphate solubilizing bacteria (20 g/kg seed). The black gram crop variety 'Pusa 1' was sown in lines at a spacing of 30 cm between the rows and 10 cm between the plants. Blackgram crop was fertilized with the recommended dose of nitrogen through Urea @ 20 kg/ha which was broadcasted in the field a day before the sowing. However, phosphorus application was made as per the requirement of the treatment and application biofertilizers, i.e. *Rhizobium* and Phosphate solubilizing bacteria (PSB), were applied through seed treatment method just before sowing @ 20 g/kg seeds as per the treatment. Further, the crop was managed as per regional recommendations of the crop.

The data were subjected to analysis as per the methodology provided by Gomez and Gomez, (1984). The analysis of variance procedures was used to analyse the standard error of mean (SEm±) and the value of critical difference (CD) at 5% level of significance to compare the difference between the mean values.

The data on pods/plant (No.), seeds/pod (No.) and pod length of black gram as influenced by levels of phosphorus and bio-fertilizers are presented in Table 1. The maximum number of pods/plant (16.88 and 16.83), number of seeds/pod (6.92 and 6.89), pod length (5.75 cm and 5.74) was recorded under the application of 45 kg P/ha and *Rhizobium* + PSB respectively, where minimum was observed in control. The increase in number of pods/plant and number of seeds/pod might be due to excess assimilates stored in the leaves and later translocated into seeds at the time of senescence. Phosphorus plays a critical role in all biological systems, participating in numerous metabolic pathways and serving as an essential building block for nucleic acids, coenzymes, phosphoproteins and phospholipids. This

Table 1. Effect of levels of phosphorus and bio-fertilizers on yield attributes of black gram

Treatment	Pods/plant (No.)	Seeds/pod (No.)	Pod length (cm)	1,000-grain weight (g)
Phosphorus level (kg/ha)				
Control	10.72	5.00	3.60	34.85
15	12.76	5.69	4.30	36.33
30	14.65	6.23	4.97	38.03
45	16.88	6.92	5.75	39.73
SEm±	0.39	0.17	0.15	_
CD (P=0.05)	1.12	0.49	0.43	_
Bio-fertilizers				
Control	10.96	5.08	3.73	34.96
Rhizobium	12.67	5.68	4.23	36.31
PSB	14.56	6.19	4.92	37.98
Rhizobium + PSB	16.83	6.89	5.74	39.69
SEm±	0.39	0.17	0.15	_
CD (P=0.05)	1.12	0.49	0.43	_

improvement is due to phosphorus application as indicated by studies conducted by Anchra *et al.,* (2024) and Mishra *et al.,* (2010). Phosphorus application plays a crucial role not only in root development and proliferation but also in enhancing nodulation and nitrogen fixation by improving the supply of assimilates to the roots. The beneficial effects of biofertilizers inoculation could be attributed to their multiple actions for synthesizing growth promoting substances and antibiotics which might have been utilized by the plants in the synthesis of protein, carbohydrates, starch and other assimilates, thereby improving the growth and yield of plants. Similarly, Chopra *et al.,* (2016) also reported a significant increase in yield attributes and Virk *et al.,* (2023) also reported significantly increase in productivity and profitability of soybean.

The data on seed and stover yield of black gram are illustrated in Figure 1 was significantly influenced by varying levels of phosphorus and bio-fertilizers. Results revealed that among the different phosphorus levels and biofertilizers, the maximum seed yield (726.75 and 708.08 kg/ha) and stover yield (1,885.93 and 1,876.17 kg/ha) was recorded under the application of 45 kg P/ha and *Rhizobium* + PSB respectively, where minimum was observed in control. This is because the increase in photosynthetic activities of plant and root system enabled the plants to extract more water and nutrients from the soil depth, resulting in better growth and development of plant and ultimately leading to higher yield. Further, the improvement of dry matter was mainly responsible for the increased seed and stover yield in 45 kg P/ha. Similar results were reported by Dudwal *et al*., (2021) in the urdbean. The increase in yield of black gram with bio-fertilizers might be owing to bulk inoculation of beneficial microbes, which plays an important role in improving three major aspects of yield determination, i.e. strong sink development of reproductive structure, formation of vegetative higher photosynthesis and production of assimilates to fill economically to sink as highlighted by Harika *et al.*, (2023), Bhuva and Detroja (2018). These findings also highlight the phosphorus and biofertilizers work together to improve black gram's physiological efficiency. The integration of 45 kg P/ha and *Rhizobium* + PSB not only improves root architecture but also facilitates nutrient mobilization, especially phosphorus, which is often immobile in soil. Higher black gram seed and stover yields are supported by the improved phosphorus solubilization and atmospheric nitrogen fixation caused by the microbial activity induced by the application of biofertilizer. Furthermore, improved transfer of photosynthates from source to sink is facilitated by the increased enzymatic and hormonal activity induced by microbial inoculants. This is essential for achieving the crop's maximum output potential. Nadeem *et al.,* (2018) found similar results in cowpea showing that using 40 kg of P/ha with *Rhizobium* and PSB both 10 ml/kg seed inoculation

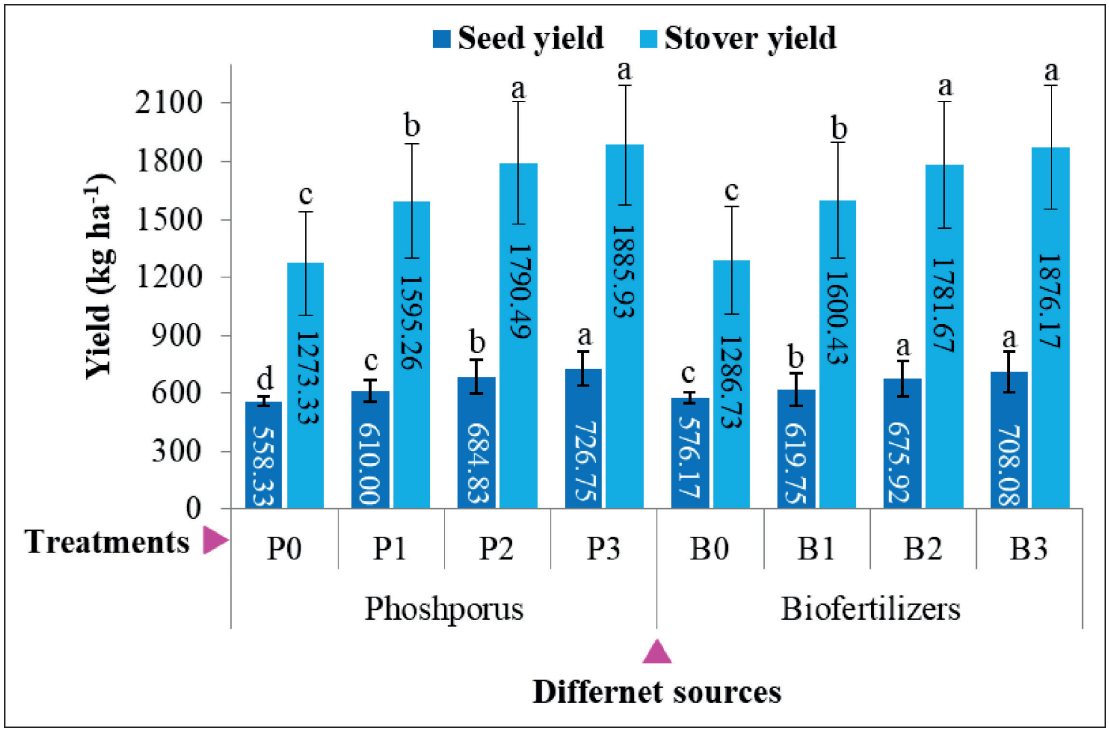

Fig. 1. Effect of levels of phosphorus and biofertilizers on seed yield and stover yield.
(Same letters within column indicates not significant at $p > 0.05$ as per DMRT post hoc-analysis and Error bar indicate standard deviation).

Table 2. Effects of levels of phosphorus and bio-fertilizers on economics

Treatment	Cost of cultivation (× 10^3 ₹/ha)	Gross returns (× 10^3 ₹/ha)	Net returns (× 10^3 ₹/ha)	Benefit: cost ratio
Phosphorus level (kg/ha)				
Control	21.65	36.85	15.19	0.70
15	22.43	40.26	17.82	0.79
30	23.21	45.19	21.97	0.95
45	24.00	47.96	23.96	1.00
SEm±	_	785.75	785.75	0.03
CD (P=0.05)	_	2,269.10	2,269.10	0.10
Bio-fertilizers				
Control	22.71	38.02	15.31	0.67
Rhizobium	22.78	40.90	18.12	0.79
PSB	22.87	44.61	21.73	0.94
Rhizobium + PSB	22.94	46.73	23.79	1.03
SEm±	_	785.75	785.75	0.03
CD (P=0.05)	_	2,269.10	2,269.10	0.10

greatly improved growth and stover yield. These results are in close agreement with the findings reported by Parashar and Sharma (2024) in chickpea.

The data on economics as influenced by different levels of phosphorus and biofertilizers are presented in Table 2 and the highest cost of cultivation in phosphorus levels was recorded in treatment 45 kg/ha phosphorus (₹24.00 thousand/ha) and in biofertlizer treatment, (*Rhizobium* + PSB) recorded the highest (₹22.94 thousand/ha). Under phosphorus levels, The highest gross return, net return and benefit-cost ratio (₹47.96, ₹23.96 thousand/ha and 1.00) respectively were obtained under treatment 45 kg/ha phosphorus while under biofertilizer treatment, highest gross return, net return and benefit-cost ratio (₹46.73, ₹23.79 thousand/ha and 1.03) were recorded in *Rhizobium* + PSB) respectively. The higher yield obtained under these treatments has resulted in higher returns. Similar results were reported by Rabari *et al.,* (2022) and Sharma and Solanki, (2025).

Hence, it can be concluded that the application of phosphorus and biofertilizers significantly affected the yield attributes, yield and economics of black gram. Thus, an effective approach to increase crop productivity and farm profitability in summer black gram in Nagaland could involve applying 45 kg P_2O_5/ha + *Rhizobium* + PSB on black gram crop.

REFERENCES

Anchra, S., Kaushik, M., Choudhary, J., Meena, R.S. and Dhayal, S. 2024. Influence of phosphorus, sulphur and zinc levels on yield, quality and nutrients uptake of lentil (*Lens culinaris*) in sub-humid southern plain of Rajasthan. *Indian Journal of Agronomy* **69**(2): 200–205.

Chopra, R., Sharma, M., Singh, A. and Bali, B. 2016. Impact of organic manures, fertilizers and bio fertilizers on yield and economics of wheat in haplustepts. *Annals of Plant and Soil Research* **18**(4): 333–337.

Bhuva, H.M. and Detroja, A.C. 2018. Influence of nutrient management with organic manures on productivity, profitability and quality of pearl millet (*Pennisetum glaucum*)-chickpea (*Cicer arietinum*) sequence. *Indian Journal of Agronomy* **63**(3): 300–306.

DPD 2021. Ministry of Agriculture & Farmers welfare. Directorate of Pulses Development, Annual Report. Available online at: https://dpd.gov.in/Crop-wise%20Area,%20Production%20and%20Productivity%20of%20Pulses%20from%202010-11%20to%202020-21.pdf

Dudwal, B.L., Bijarniya, V.S., Choudhary, S. and Dudwal, S.K. 2021. Productivity and Growth of Urdbean as Influenced by Thiourea and Phosphorus Fertilization under Rainfed Semi-arid conditions of Rajasthan. *Chemical Science Review and Lettres* **10**(40): 492–495.

Elhaissoufi, W., Ghoulam, C., Barakat, A., Zeroual, Y. and Bargaz, A. 2022. Phosphate bacterial solubilization: a key rhizosphere driving force enabling higher P use efficiency and crop productivity. *Journal of Advanced Research* **38**: 13–28.

FAOSTAT, 2024. Food and Agriculture Organization of the United Nations. FAOSTAT Statistical Database. Accessed on 9th September 2024. https://www.fao.org/faostat/en/#data/QCL

Ghosh, P.K., Bandyopadhyay, K.K., Tripathi, A.K. Hati, K.M., Mandal, K.G. and Mishra, A.K. 2003. Effect of integrated management of farm yard manure, phosphocompost, poultry manure and inorganic fertilizers for rainfed sorghum (*Sorghum bicolor*) in vertisols of Central India. *Indian Journal of Agronomy* **48**(1): 48–52.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedure for Agricultural Research, 2nd Edn. John Willey & Sons, New York.

Gupta, A., Saharan, B.S., Sadh, P.K. and Duhan, J.S. 2024. Green to green: harnessing bio-fertilizers for sustainable pulse production and food security. *Discover Plants* **1**(1): 73.

Harika, D., Debbarma, V. and Thrupthi, M.G. 2023. Influence of phosphorus and bio-fertilizers on growth and yield of black gram (*Phaseolus mungo* L.). *International Journal of Plant and Soil Science* **35**(13): 43–51.

Hasanain, M., Singh, V.K., Rathore, S.S., Shekhawat, K., Singh, R.K., Dwivedi, B.S., Upadhyaya, P.K. and Singh. S. 2021. Effect of site-specific nutrient management in conservation agriculture-based maize in north-western India. *Indian Journal of Agronomy* **66**(2): 136–142.

Kumawat, R., Ram, B., Singh, P., Tetarwal, J.P., Yadav, R.K., Gupta, A.K. and Bijarnia, A. 2022. Response of summer mungbean (*Vigna radiata*) to phosphorus levels, biophosliquid biofertilizer and growth-regulator. *Indian Journal of Agronomy* **67**(2): 170–174.

Mishra, A., Prasad, K. and Geeta, R. 2010. Effect of bio-fertilizers inoculations on growth and yield of dwarf field pea (Pisum sativum L.) in Conjunction with different doses of chemical fertilizers. *Indian Journal of Agronomy* **9**(4): 163–168.

Nadeem, M.A., Singh, V., Dubey, R.K., Pandey, A.K., Singh, B., Kumar, N. and Pandey, S. 2018. Influence of phosphorus and bio-fertilizers on growth and yield of cowpea [*Vigna unguiculata* (L.) Walp.] in acidic soil of NEH region of India. *Legume Research* **41**(5): 763–766.

Parashar, A. and Sharma, J. 2024. Effect of varying levels of phosphorus and bio-fertilizers on growth and yield of chickpea under sub-tropical condition. *Indian Journal of Agronomy* **69**(4): 410–416.

Rabari, K.V., Chaudhary, M.P., Patel, K.M., Sundesha, D.L. and Joshi, D.P. 2022. Effect of Phosphorus and Biofertilizers on Yield and Economics of Blackgram. *International Journal of Agriculture Sciences* **14**(4): 11,234–11,236.

Sharma, K. and Solanki, K. 2025. Nitrogen levels and growth regulators effect on wheat (*Triticum aestivum*) lodging, productivity and profitability under restricted irrigation in a Vertisols of Central India. *Indian Journal of Agronomy* **70**(1): 13–19.

Shome, S., Barman, A. and Solaiman, Z.M. 2022. Rhizobium and phosphate solubilizing bacteria influence the soil nutrient availability, growth, yield and quality of soybean. *Agriculture* **12**(8): 1,136. https://doi.org/10.3390/agriculture12081136

Virk, H.K., Singh, K. and Sharma, P. 2023. Influence of phosphorus and biofertilizers on symbiotic parameters, productivity and profitability of soybean (*Glycine max*). *Indian Journal of Agronomy* **68**(2): 227–231.

Yu, L.Y., Huang, H.B., Wang, X.H., Li, S., Feng, N.X., Zhao, H.M., Huang, X.P., Li, Y.W. Li, H., Cai, Q.Y. and Mo, C.H. 2019. Novel phosphate-solubilising bacteria isolated from sewage sludge and the mechanism of phosphate solubilisation. *Science of The Total Environment* **658**: 474–484.