**Effect of Phosphorus and Vermicompost on Growth and Productivity of Black gram (*Vigna mungo* L.)**

# Abstract

A field experiment was conducted during the Rabi season of 2023–24 at the Experimental Farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University, Gangrar, Chittorgarh, Rajasthan. The study evaluated the effect of phosphorus and vermicompost on the growth and productivity of black gram (variety Pratap Urd-1). The result revealed that the maximum plant height (50.25 cm), dry matter accumulation (13.25/plant), number of nodules per plant (40.15), fresh weight of nodules per plant (71.02 mg/plant), dry weight of nodules per plant (51.02 mg/plant), leaf area index (3.52) and yield parameter such as number of pods per plant (35.15), number of seed per pod (7.15), grain yield (11.85 q/ha), straw yield (22.45 q/ha) and biological yield (34.30 q/ha) with application of T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1. Also, maximum net return (59501/ha) and B:C ratio (1.89) were recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1**.**

**Keywords: - Productivity; Black gram; Vermicompost; Phosphorus; Nutrients**

# 1. Introduction

Our country is predominantly vegetarian and pulses are the main source of quality protein and essential amino acids. Black gram (*Vigna mungo* L.) is an important pulse crop among the grain legumes grown in India. It contains 24 % protein, 60 % carbohydrate, 1.3 % fat and is richest in phosphoric acid among the pulses being five to ten times richer than in others. It is commonly known as “urd” or “urd bean” (Singh *et al.* (2022). Black gram plays an important role in maintaining and improving soil fertility through its ability to fix atmospheric nitrogen in the soil through root nodules which process *Rhizobium* bacteria. This imbalanced nutrient supply adversely affects the seed yield of black gram, soil health, and even the profit to the farmers (Laddha *et al*. 2006). The supply of phosphorus to legumes is more important than of nitrogen because, nitrogen is being fixed by symbiosis with *Rhizobium* bacteria (Singh and Singh, 2021). The beneficial effects of phosphorus on nodulation, growth, yield and general behavior of legume crop have been well established because it plays an important role in root development. Phosphorus application to legumes not only benefits the particular crop but also improves the soil nitrogen content for the succeeding non-legume crops requiring lower doses of nitrogen application (Yadav, 2011). Phosphorus stimulates seed setting, hastens maturity and enhances protein content. It plays an important role in the nutrition of legumes and also improves biological nitrogen fixation and the quality of grains (Kumar *et al.* 2009).

Vermicompost has been emerging as an important source in replacing of chemical fertilizer in agriculture in view of sustainable development after Rio Conference, vermicompost is a biofertilizer enriched with all beneficial soil microbes and also contains all the essential plant nutrients like N, P and K (Patel *et al.* 2017). Vermicompost that is prepared through conventional method has standard values of total nitrogen: 0.94%, Phosphorous: 0.47% and potassium: 0.70% it is also enriched with various micronutrients such as Mg (0.46%), Fe (7563 ppm), Zn (278 ppm), Mn (475 ppm), B (34 ppm), Cu (27 ppm). Thus, eliminate usage of any further artificial chemical inputs. Due to absence of toxic enzymes, it is also eco-friendly and has beneficial effect on the biochemical activities of the soil. It also increases the quality, fertility and mineral content of the soil structure. It enhances soil aeration, texture and silt thereby reducing soil compaction (Serawat *et al.* 2018).

# 2. Materials and Methods

A field experiment was conducted during Rabi season of 2023-24 at the experimental farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan). Soil of the experimental field was sandy loam in texture, saline in reaction with a pH value of 7.6, poor in organic carbon (0.32%), deficient in available zinc (0.48 ppm) and iron (1.2 ppm) low in available nitrogen (176 kg/ha) and phosphorus (20.2 kg/ha) but medium in available potassium (320 kg/ha). The experiment was laid out in randomized block design with three replications consisting of nine treatments *viz.* The experiment was laid out in randomized block design with three replications and nine treatments *i.e.* T1-Control, T2-20 kg P2O5 ha-1, T3-40 kg P2O5 ha-1, T4-1.25 t vermicompost ha-1, T5-2.5 t vermicompost ha-1, T6-20 kg P2O5 ha-1 + 1.25 t vermicompost ha-1, T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1, T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 and T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1. The required quantities of fertilizers as per treatments were applied. The doses of NPK were applied in the form of urea, diammonium phosphate, murate of potash respectively. The half dose of nitrogen gives basal dose and remain two split doses after irrigation and full dose of phosphorus and potassium at basal dose. Vermicompost apply in field at field preparation before sowing.

**3. Results and Discussion**

# 3.1 Growth attributes

Data revealed (Table 1.0) at 35 DAS that the maximum plant height was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (29.85 cm). The minimum plant height recorded with control treatment (23.33 cm). At 50 DAS that the maximum plant height was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (42.78 cm). The minimum plant height recorded with control treatment (35.52 cm). At harvest the maximum plant height was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (50.25 cm). The minimum plant height recorded with control treatment (44.88 cm). Similar findings also reported by Tagore *et al*. (2013), Gajera *et al.* (2014), Jha *et al.* (2015), Meena *et al*. (2016) and Singh *et al.* (2016).

Data revealed (Table 1.0) at 35 DAS that the maximum dry matter accumulation was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (4.89 g). The minimum dry matter accumulation recorded with control treatment (3.15 g). At 50 DAS that the maximum dry matter accumulation was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (9.85). The minimum dry matter accumulation recorded with control treatment (6.36 g). At harvest that the maximum dry matter accumulation was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (13.25 g). The minimum dry matter accumulation recorded with control treatment (9.45 g). this result also confirmed by Saxena *et al.* (2016), Mohammad *et al.* (2017), Kumar *et al*. (2017) and Nissa *et al.* (2017).

Data revealed (Table 2.0) at 40 DAS that the maximum number of nodules per plant was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (40.15), it was at par with T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (38.63). The minimum number of nodules per plant recorded with control treatment (25.12). Data revealed at 40 DAS that the maximum fresh weight of nodules per plant was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (71.02 mg/plant), it was at par with T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (68.63 mg/plant). The minimum fresh weight of nodules per plant recorded with control treatment (52.36 mg/plant). Data revealed at 40 DAS that the maximum dry weight of nodules per plant was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (51.02 mg/plant), it was at par with T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (48.65 mg/plant). The minimum dry weight of nodules per plant recorded with control treatment (34.36 mg/plant). The increase in nodulation due to application of P might be due to P helps in early root development and formation of lateral fibrous and healthy roots. Similar results were reported by Rani *et al.* (2016) revealed that, the application of 40 kg P ha-1 increased the number of nodules per plant-1 over control. This might be due to better root development with increasing levels of P in black gram. Similar findings also reported by Patel *et al.* (2017), Verma *et al.*, (2017), Dubey *et al.* (2018), Masih *et al.* (2020) and Reddy and Dawson (2021).

**3.2 Yield attributes and yield**

Data revealed (Table 3.0) that the maximum number of pods per plant was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (35.15), it was at par with T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 andT8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (33.20 and 32.02). The minimum number of pods per plant recorded with control treatment (20.25). Data revealed that the maximum number of seed per pod was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (7.15), it was at par with T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 andT8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (6.85 and 6.65). The minimum number of seed per pod recorded with control treatment (5.05). These investigate also support by Sharma *et al.* (2012), Singh *et al.* (2015), Tiwari *et al.* (2015) and Rani *et al*. (2016).

Data revealed (Table 3.0 and Figure 1.0) that the maximum grain yield was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (11.85 q/ha), it was at par with T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 andT8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (11.08 and 10.45 q/ha). The minimum grain yield recorded with control treatment (8.75 q/ha). Data revealed that the maximum straw yield was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (22.45 q/ha), it was at par with T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 andT8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (20.12 and 19.86 q/ha). The minimum straw yield recorded with control treatment (16.02 q/ha). Data revealed that the maximum biological yield was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (34.30 q/ha), it was at par with T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 andT8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 (31.20 and 30.31 q/ha). The minimum biological yield recorded with control treatment (24.77 q/ha). Similar results were reported by Choudhary *et al*. (2017) that, the significant increase in straw of black gram due to phosphorus along with vermicompost. Sipai *et al*. (2016) concluded that, the straw yield of black gram increased with levels of P up to 40 kg ha-1. In general, overall improvement in yield attributing characters because of P increased which helps to develop a more extensive root system and thus, enables the plant to extract more water and nutrients from soil depth. Similar data result reported by Khan *et al*. (2017), Mehera *et al.* (2022) and Singh *et al.* (2022).

**3.3 Economics**

Data revealed (Table 4.0) that the maximum cost of cultivation was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (31500 ₹/ha). The minimum cost of cultivation recorded with control treatment (24500 ₹/ha). The maximum gross return was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (91001 ₹/ha). The minimum gross return recorded with control treatment (62414 ₹/ha). The maximum net return was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (59501 ₹/ha). The minimum net return recorded with control treatment (37917 ₹/ha). The maximum B:C ratio was recorded with T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 (1.89). The minimum B:C ratio recorded with control treatment (1.55). Similar result also found by Kumar *et al.* (2017), Venkatarao (2017), Gohain and Jamir (2022) and Singh *et al.* (2022)

# Conclusion

The findings of present investigation revealed that significant effect of phosphorus and vermicompost application on the growth, yield and economics of the black gram. Among different T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 registered the maximum productivity with higher net return. So, it was concluded that the treatment T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 superior among all treatments.

# Table 1.0 Effect of phosphorus and vermicompost on plant height and dry matter accumulation at different days interval of black gram

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant height (cm)** | | | **Dry matter accumulation (g)** | | |
| **35 DAS** | **35 DAS** | **35 DAS** | **35 DAS** | **90 DAS** | **At harvest** |
| T1-Control | 23.33 | 35.52 | 44.88 | 3.15 | 6.36 | 9.45 |
| T2-20 kg P2O5 ha-1 | 24.66 | 36.85 | 45.25 | 3.22 | 7.02 | 10.45 |
| T3-40 kg P2O5 ha-1 | 25.15 | 37.12 | 46.14 | 3.35 | 7.36 | 10.85 |
| T4-1.25 t vermicompost ha-1 | 27.02 | 37.96 | 46.78 | 3.48 | 7.58 | 11.30 |
| T5-2.5 t vermicompost ha-1 | 27.85 | 38.78 | 47.68 | 3.75 | 7.98 | 11.85 |
| T6-20 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 27.52 | 38.52 | 47.02 | 3.58 | 7.75 | 11.45 |
| T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 29.05 | 39.44 | 49.05 | 4.30 | 8.78 | 12.52 |
| T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 28.02 | 39.02 | 48.15 | 4.15 | 8.50 | 11.65 |
| T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 29.85 | 42.78 | 50.25 | 4.89 | 9.85 | 13.25 |
| S. Em. (±) | 0.61 | 1.28 | 0.71 | 0.25 | 0.46 | 0.55 |
| C.D. at 5% | 1.85 | 3.86 | 2.13 | 0.76 | 1.39 | 1.64 |

# Table 2.0 Effect of phosphorus and vermicompost on growth attributes of black gram

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Number of nodules per plant at 40 DAS** | **Fresh weight of nodules per plant at 40 DAS (mg/plant)** | **Dry weight of nodules per plant at 40 DAS (mg/plant)** |
| T1-Control | 25.12 | 52.36 | 34.36 |
| T2-20 kg P2O5 ha-1 | 31.63 | 58.63 | 40.12 |
| T3-40 kg P2O5 ha-1 | 34.96 | 62.14 | 43.25 |
| T4-1.25 t vermicompost ha-1 | 29.36 | 56.78 | 37.12 |
| T5-2.5 t vermicompost ha-1 | 32.25 | 60.45 | 40.74 |
| T6-20 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 33.45 | 61.96 | 42.28 |
| T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 35.15 | 65.74 | 45.96 |
| T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 38.63 | 68.63 | 48.65 |
| T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 40.15 | 71.02 | 51.02 |
| S. Em. (±) | 0.51 | 0.80 | 0.81 |
| C.D. at 5% | 1.55 | 2.39 | 2.45 |

# Table 3.0 Effect of phosphorus and vermicompost on yield attributes and yield of black gram

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Number of pods**  **per plant** | **Number of seed**  **per pod** | **Grain yield**  **(q/ha)** | **Straw yield**  **(q/ha)** | **Biological yield**  **(q/ha)** |
| T1-Control | 20.25 | 5.05 | 8.75 | 16.02 | 24.77 |
| T2-20 kg P2O5 ha-1 | 26.36 | 5.75 | 9.15 | 18.10 | 27.25 |
| T3-40 kg P2O5 ha-1 | 28.02 | 6.00 | 9.45 | 18.40 | 27.85 |
| T4-1.25 t vermicompost ha-1 | 30.15 | 6.15 | 9.52 | 18.85 | 28.37 |
| T5-2.5 t vermicompost ha-1 | 32.32 | 6.32 | 9.84 | 19.18 | 29.02 |
| T6-20 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 31.45 | 6.45 | 9.90 | 19.00 | 28.9 |
| T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 33.20 | 6.85 | 11.08 | 20.12 | 31.20 |
| T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 32.02 | 6.65 | 10.45 | 19.86 | 30.31 |
| T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 35.15 | 7.15 | 11.85 | 22.45 | 34.30 |
| S. Em. (±) | 1.05 | 0.17 | 0.47 | 0.88 | 1.27 |
| C.D. at 5% | 3.17 | 0.53 | 1.42 | 2.65 | 3.80 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Cost of cultivation (₹/ha)** | **Gross return (₹/ha)** | **Net return (₹/ha)** | **B:C ratio** |
| T1-Control | 24500 | 62414 | 37914 | 1.55 |
| T2-20 kg P2O5 ha-1 | 25500 | 65860 | 40360 | 1.58 |
| T3-40 kg P2O5 ha-1 | 26500 | 71770 | 45270 | 1.71 |
| T4-1.25 t vermicompost ha-1 | 27000 | 72333 | 45333 | 1.68 |
| T5-2.5 t vermicompost ha-1 | 29500 | 80638 | 51138 | 1.73 |
| T6-20 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 28000 | 75358 | 47358 | 1.69 |
| T7-20 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 30500 | 82268 | 51768 | 1.70 |
| T8-40 kg P2O5 ha-1 + 1.25 t vermicompost ha-1 | 29000 | 82870 | 53870 | 1.86 |
| T9-40 kg P2O5 ha-1 + 2.5 t vermicompost ha-1 | 31500 | 91001 | 59501 | 1.89 |

**Table 4.0 Effect of phosphorus and vermicompost** **on** **economics**

**Figure 1.0 Effect of phosphorus and vermicompost** **on yields of black gram**

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**References**

Choudhary P, Ghosh G, Neha and Kumari S. 2017. Study the response of different phosphorus levels and frequency of boron levels on growth and yield of green gram. *International Journal of Current Microbiology and Applied Science* **6**(6): 875-883.

Gajera, R. J., Khafi, H. R., Raj, A.D., Yadav, V. and Lad, A. N. (2014). Effect of phosphorus and bio-fertilizers on growth yield and economics of summer green gram [*Vigna radiate* (L.) Wilczek]. Agric. Update, **9** (1): 98-102.

Jha, Digambar Prasad., Sharma, S.K. and Amarawat, T. 2015. Effect of organic and inorganic sources of nutrients on yield and economics of black gram (*Vigna mungo* L.) grown during *kharif*. *Agricultural Science Digest*, **35**(3) : 224-228.

Khan M M S, Singh V P and Kumar A. 2017. Studies on effect of phosphorous levels on growth and yield of *Kharif* mung bean [*Vigna radiata* (L.) Wilczek]. *International Journal of Pure and Applied Bioscience* **5**(4): 800-808

Kumar D, Singh R K, Pareek B, Yadav R S, Anuradha Gaurav R, Shukla M and Dubey S K. 2017. Response of different sources of phosphorus on growth, nodulation and yield on greengram (*Vigna radiata* L.) *International Journal Pure Applied Bioscience* **5**(6): 201-207.

Kumar, V., Dwivedi, V.N. and Tiwari, D.D. 2009. Effect of phosphorus and iron on yield and mineral nutrition in chickpea. *Annals of Plant and Soil Research,* **11** : 16-18.

Laddha, K.C., Sharma, R.K., Sharma, S.K and Jain, P.M. 2006. Integrated nitrogen management in maize and its residual effect on black gram under dry land conditions. *Indian Journal of Dryland Agricultural Research and Development,* **21**(2) : 177-184.

Masih, A., Dawson, J., & Singh, R. E. (2020). Effect of Levels of Phosphorus and Zinc on Growth and Yield of Greengram (*Vigna radiata* L.). *International Journal of Current Microbiology and Applied Sciences*, **9**(10), 3106-3112.

Meena S, Swaroop N and Dawson J. 2016. Effect of integrated nutrients management on growth and yield of greengram (*Vigna radiata* L.). *Agricultural Science Digest* **36** (1): 63-65.

Mehera S. B., Rajendar, G., and Kumar, H. S. (2022). Effect of Bio-fertilizer and zinc levels on growth and yield of green gram (*Vigna radiata* L.). *Applied Sciences* **3**(12): 125-138.

Mohammad R, Yadav B L and Ahamad A. 2017. Effect of phosphorus and bio- organics on yield and soil fertility status of mungbean [*Vigna radiata* (L.) Wilczek] under semi-arid condition of Rajasthan, India. *International Journal of Current Microbiology and Applied Sciences* **6**(3): 1545-1553.

Nissa S U, Bashir S, Dar S A, Baba J A, Hakeem S A, Wani R A, Mughal M N and Basu Y A. 2017. Effect of *rhizobium* and PSB in combination with phosphorus on the enrichment of soil fertility and its effect on yield of greengram (*Vigna radiata* L.). *International Journal of Current Microbiology and Applied Sciences* **6**(11): 3648-3652.

Patel H B, Shah K A, Barvaliya M M and Patel S A. 2017. Response of greengram (*Vigna radiata* L.) to different level of phosphorus and organic liquid fertilizer. *International Journal of Current Microbiology and Applied Sciences 6*(10): 3443-3451.

Rani, M., Prakash, V. and Khan, Khalil. (2016). Response of mung bean [*Vigna radiate* (L.) wilczek] to phosphorus, sulphur and PSB during summer season. *Agric. Sci. Digest*.,**36** (2) 2016: 146-148.

Reddy, Y. V., & Dawson, J. (2021). Effect of biofertilizers and levels of vermicompost on growth and yield of cowpea (*Vigna unguiculata* L.). *The Pharma Innovation Journal*, **10**(6), 985-988.

Saxena J, Saini A, Kushwaha K and Arino A. 2016. Synergistic effect of plant growth promoting bacterium *pseudomonas fluorescens* and phosphate solubilising fungus *Aspergillus awamori* for growth enhancement of chickpea. *Indian Journal of Biochemistry & Biophysics* 53: 135-143.

Serawat A, Sharma Y, Serawat M, Kapoor A and Jakhar R K. 2018. Effect of phosphorus and sulphur on growth attributes and yields of mungbean (*Vigna radiata* L.) in sandy soils of hyper arid western plains of Rajasthan. *International Journal of Current Microbiology and Applied Sciences* **7**(8): 2674-2683.

Sharma A, Rawat U S and Yadav B K. 2012. Influence of phosphorus levels and phosphorus solubilizing fungi on yield and nutrient uptake by wheat under sub-humid region of Rajasthan, India. *International Scholarly Research Network.*

Singh K, Manohar R S, Choudhary R, Yadav A K and Sangwan A. 2015. Response of different sources and levels of phosphorus on yield, nutrient uptake and net returns on mungbean under rainfed condition. *Indian Journal of Agricultural Research* **35**(4): 263-268.

Singh, A. K., Singh, C. K., Singh, R. K., Sarvjeet and Lavanya, G. R. (2016). Effect of phosphorus and bio- fertilizer on growth and yield of green gram (*Vigna radiiata* L.). *Res. Environ. Life Sci*. **9** (2) 223- 225.

Singh, K. K., Gupta, S. K., Das, S., & Kumar, R. (2022). Effect of bio-fertilizer on yield and economics of summer greengram (*Vigna radiata* L.). *The Pharma Innovation Journal*, **11**(4): 188-191.

Singh, V., & Singh, V. (2021). Influence of Spacing and Phosphorus on Growth and Yield of Green Gram (*Vigna radiata* L.) in Prayagraj Condition. In *Biological Forum-An International Journal* **13**(2): 408-412.

Sipai A H, Jat J R and Rathore B S. 2016. Effect of phosphorus, sulphur and biofertilizer on growth, yield and nodulation in mungbean on loamy sand soils of Kutch*. Crop Research* 51: 1.

Tagore G S, Namdeo S L, Sharma S K and Kumar N. 2013. Effect of *rhizobium* and phosphate solubilizing bacterial inoculants on symbiotic traits, nodule leghaemoglobin and yield of chickpea genotypes. *International Journal of Agronomy* (DOI: *10.1155/2013/581627*).

Tiwari S, Kumar S, Maurya D K, Singh S K and Verma P K. 2015. Effect of phosphorus levels on growth, seed yield, quality and nutrient uptake by greengram (*Vigna radiata* L.). *Environment & Ecology* 33: 1731-1733.

Verma G, Kumawat N and Morya J. 2017. Nutrient management in mungbean [*Vigna radiata* (L.) Wilczek] for higher production and productivity under semi-arid tract of Central India. *International Journal of Current Microbiology and Applied Sciences* **6**(7): 488-493.

Yadav B K. 2011. Improvement of mungbean growth and productivity by Phosphate- dissolving fungi *Aspergillus niger* seed inoculation. *Legume Research* **34**(3): 217-221.