E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 683-687
Received: 09-09-2025
Accepted: 14-10-2025

Sneha Bhargava
M.Sc. Scholar, Department of Agronomy, Naini Agricultural institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj Uttar Pradesh, India

Umesha C
Assistant Professor, Department of Agronomy, Naini Agricultural institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj Uttar Pradesh, India

Corresponding Author:
Sneha Bhargava
M.Sc. Scholar, Department of Agronomy, Naini Agricultural institute, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj Uttar Pradesh, India

Response of phosphorus and sulphur on yield and economics of greengram (*Vigna radiata* L.)

Sneha Bhargava and Umesha C

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i11j.4249

Abstract
During the *Zaid* season of 2025, the experiment "Response of Phosphorus and Sulphur on yield and economics of Greengram (Vigna radiata L.)" was carried out at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The experimental field soil had a sandy loam texture, a moderately basic response (pH 7.2), medium levels of available organic carbon (0.310%), low levels of available nitrogen (269.75 kg/ha), and extremely high levels of available potassium (246.4 kg/ha) and phosphorus (18.0 kg/ha). The experiment was laid out in a Randomized Block Design (RBD) with ten treatments and replicated thrice *viz.*, T_1: Phosphorus 30 kg/ha along with Sulphur 20 kg/ha, T_2: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_3: Phosphorus at 50 kg/ha along with Sulphur 40 kg/ha, T_4: Phosphorus 30 kg/ha along with Sulphur 20 kg/ha, T_5: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_6: Phosphorus 50 kg/ha along with Sulphur 40 kg/ha, T_7: Phosphorus 30kg/ha along with Sulphur 20 kg/ha, T_8: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_9: Phosphorus 50 kg/ha along with Sulphur 40 kg/ha and T_{10}: RDF: 20:40:60 NPK kg/ha as control. The result showed that significantly higher yield and yield attributes *viz.*, number of pods/plants (22.93), number of seeds/pod (8.20), test weight (38.22 g), seed yield (1794.66 kg/ha), stover yield (2946.80 kg/ha), maximum gross return (₹125626.13/ha), net return (₹83996.13/ha), and benefit-cost ratio (2.02) were all significantly higher yield and yield attributes.

Keywords: Sulphur, Phosphorus, Yield and Economics, Greengram (Virat)

Introduction

In the global farming system, pulses have a special significance. Protein, vitamins, fiber, minerals (iron, zinc, and magnesium), and essential amino acids are all abundant in pulses and are crucial for human health (Yadav *et al*. 2017) [33]. After cereals, pulses are the second most significant food crop in terms of food security. One of the best sources of protein in the diet is pulses. An important source of protein in the Indian diet is pulses. Through symbiotic nitrogen fixation from the atmosphere and a proliferation of soil microbes, pulses improve soil and human health. With over 35% of the world's land, 25% of its output, and 27% of its consumption, India is the world's biggest producer and consumer of pulses (GOI 2021) [9]. India produces 23.15 million tonnes of pulses annually on 31.04 million hectares of land (Patel *et al*. 2020) [24]. Conversely, pulse production is unable to meet the nation's demand.

One of the major traditional pulse crops planted in India during the Zaid and Kharif seasons is greengram. Between the Rabi and Kharif seasons, it can be planted as a catch crop. Greengram has 334 calories per 100 grams. With crude protein (24.0%), fat (1.3%), carbohydrates (56.6%), minerals (3.5%), lysine (0.43%), methionine (0.10%), and tryptophan (0.04%), it is renowned for having a high nutritious value. A daily minimum of 40 grams is advised by the Indian Council of Medical Research (ICMR). Its short growing time allows it to fit into intercropping systems with a variety of crops, and its high tonnage capacity and versatility exceptional food, feed, and fodder nutritional properties. In underdeveloped nations like India, pulses are frequently referred to as "poor man's meat" since they are less expensive than meat (Patel *et al*. 2017) [20]. In India, green gram is farmed in dry and semi-arid regions. Other names for this plant include golden gram, Mungbean, mung, and mungo. In India, Mungbean farming comes in third place, after the production of chickpeas and pigeon peas. Its roots can be found in Southeast

Asia and Indo-Burma. It is a great source of high-quality protein, riboflavin, and thiamine since it includes 25-28% protein, 1.0-1.4% oil, 3.3% fiber, 4.8-5.6% ash, and 64-66% carbohydrates by dry weight. India is one of the world's leading producers of Greengram, which is grown in almost all the states. Rajasthan, Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, Odisha, Punjab, and Karnataka are major states that produce Mungbean (Singh *et al*. 2015) [3]. In India, Mungbean (Greengram) is grown on an average of 5.1 million hectares, with a yield of 583 kg/ha and a production of about 2.98 million tons. With a productivity of 492 kg/ha, Rajasthan tops the states in both area and output, accounting for almost 48% of the total area and 40% of the overall production. Following Madhya Pradesh, Uttar Pradesh produced over 0.66 lakh tons of Greengram (moong) on an area of about 1.12 lakh hectares, with an average productivity of 590 kg per hectare. Kumar and associates (2023) [16].

Large amounts of phosphorus are required in the early phases of cell division; the first general indication is weak, slow, and stunted growth. Some plants have symptoms of dark to blue-green coloration on their older leaves because phosphorus is relatively mobile in plants and can be moved to areas of new growth. Purpling of the leaves and stems may occur in cases of severe shortage. By restricting plant growth, phosphorus deficit results in delayed maturity and poor seed and fruit development, which lowers production (Singh *et al*., 2015) [3]. The most important nutrient for pulse crops is phosphorus. It promotes the bacterial cell's symbiotic nitrogen fixation to root hair for nodulation. Phosphorus availability in Indian soils ranges from poor to medium. Only around 30% of the phosphorus that is applied can be used by crops, with the other portion becoming insoluble. Continuous replacement of soluble P from inorganic and organic sources is required to meet the crop's phosphorus requirements since the concentration of accessible P in the soil solution is typically insufficient to maintain plant growth. The growth and development of crops, particularly pulses, depend on the element sulfur. For pulse crops to synthesize proteins and vitamins, sulfur is necessary. Additionally, sulfur has been shown to increase nodulation activity in legumes, which increases N2 fixation. Throughout the Greengram growing season, sulfur has an impact on the plant's height, branches, nodulation, number of pods, and grains per pod (Kumar *et al*. 2013) [22]. Sulphur also effects the dry matter accumulation and also influences the phosphorus and Sulphur uptake by the plant. Singh and colleagues (2017) [33]. Since sulfur is a primary source of three amino acids chitin, cysteine, and methionine it is crucial for plants to produce protein. Additionally, sulfur is linked to improved pulse market quality and nutritional value.

Materials and Methods

A field study in alluvial soil was carried out at the Department of Agronomy's Crop Research Farm, SHUATS, Prayagraj, U.P., during the Zaid season of 2025. The experimental field soil had a sandy loam texture, a moderately basic response (pH 7.2), medium levels of available organic carbon (0.310%), low levels of available nitrogen (269.75 kg/ha), and extremely high levels of available potassium (246.4 kg/ha) and phosphorus (18.0 kg/ha). Ten treatments were used in the Randomized Block Design (RBD) experiment, which was repeated three times. On April 5, 2025, greengram seeds (Virat IPM 205-7) were planted at a distance of 30 cm by 10 cm. Nine treatment combinations and three replications were used in the Randomized Block Design trial. Ten treatments were used in the Randomized Block Design (RBD) experiment, which was repeated three times. *viz.*, T_1: Phosphorus 30 kg/ha along with Sulphur 20 kg/ha, T_2: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_3: Phosphorus at 50 kg/ha along with Sulphur 40 kg/ha, T_4: Phosphorus 30 kg/ha along with Sulphur 20 kg/ha, T_5: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_6: Phosphorus 50 kg/ha along with Sulphur 40 kg/ha, T_7: Phosphorus 30kg/ha along with Sulphur 20 kg/ha, T_8: Phosphorus 40 kg/ha along with Sulphur 30 kg/ha, T_9: Phosphorus 50 kg/ha along with Sulphur 40 kg/ha and T_{10}: RDF: 20:40:60 NPK kg/ha as control.

Chemical analysis of soil

Before the experiment was set up, a composite soil sample was gathered to ascertain the initial soil properties. The soil sample was collected at a depth of 0 to 15 cm, allowed to air dry in the shade, pulverized using a wooden pestle and mortar, filtered through a 2 mm screen, and then used for analysis. Jackson (1973) [13] used the black approach to evaluate organic carbon availability, Subbiah and Asija used the alkaline permanganate method to determine available nitrogen, and Olsen *et al*. (1954) [19] used Olsen's colorimeter method to test phosphorus availability.

Statistical analysis

According to Gamez and Gomez (1984), a statistical analysis of variance (ANOVA) was performed on the collected experimental data. Analysis of variance (ANOVA), as it relates to randomized block design, was used to statistically examine the observed data of ten treatments. The 'F' test was significant at the 5% level, and Critical Difference (CD) values were calculated.

Results and Discussions

Yield and yield attributes

Number of pods per plant

The application of phosphorus 50 kg/ha and sulfur 40 kg/ha resulted in the significantly largest number of pods per plant (22.93) in (T_9), which was shown to be statistically comparable to all treatments. But (T_3) 30 kg/ha of phosphorus and 20 kg/ha of sulfur, (T_5) 50 kg/ha of phosphorus and 15 kg/ha of sulfur, and (T_6) 50 kg/ha of phosphorus and 40 kg/ha of sulfur. The maximum number of pods per plant after applying phosphorus may be the result of improved photosynthetic activity, enough light availability, a balanced supply of nutrients during the developing stage, and an increase in branches, which produce more pods per plant. Additionally, the use of sulfur may have increased the number of pods per plant because it is crucial for tissue differentiation, carbohydrate metabolism, and sugar translocation. Bharvi *et al.* (2015) [3] and Singh *et al*. (2015) [3]. One important plant nutrient that affects cell division, seed germination, flowering, fruiting, and the synthesis of fat and carbohydrates is sulfur. Additionally, the nutrient participates in a number of biochemical processes and regulates metabolic pathways, including enzyme reactions (Das *et al*., 2016) [7].

Number of Seeds per pod

The treatment of 50 kg/ha of phosphorus and 40 kg/ha of sulfur resulted in the largest number of seeds per pod (8.20) in T_9. Nonetheless, (T_3) Phosphorus 30 kg/ha and Sulfur 20 kg/ha and (T_6) Phosphorus 50 kg/ha and Sulfur 40 kg/ha were statistically comparable to the highest (T_9) seed. The likely cause of these outcomes is that biofertilizer-inoculated seeds are well-nourished and capable of delivering sufficient nutrients and metabolites to the developing seedling. One important nutrient for plants, phosphorus affects cell division, seed germination, flowering, fruiting, and the synthesis of carbohydrates and fat. Additionally, the nutrient participates in a number of biochemical processes and regulates metabolic pathways, including enzyme reactions (Das *et al*., 2016) [7].

Test weight (g)

The application of 50 kg/ha of phosphorus and 40 kg/ha of sulfur resulted in a higher test weight (38.22 g) in (T_9). The maximum number of pods per plant after applying phosphorus may be the result of improved photosynthetic activity, enough light availability, a balanced supply of nutrients during the developing stage, and an increase in branches, which produce more pods per plant. Additionally, the use of sulfur may have increased the number of pods per plant because it is crucial for tissue differentiation, carbohydrate metabolism, and sugar translocation. Bharvi *et al*. (2015) [3] and Singh *et al*. (2015) [3].

Grain yield (kg/ha)

Table 1 presents statistical data. shown that the application of phosphorus 50 kg/ha and sulfur 40 kg/ha produced the maximum seed production (1794.66 kg/ha) in (T_9), which was statistically comparable to treatments 8 (1365 kg/ha). These outcomes could be attributed to improved seed germination and a larger root system for nutrient uptake. The application of sulfur may also increase seed yield by improving cell walls, tissue differences, sugar transport, maintaining conducting tissue with regulatory effects on other elements, and metabolism of nucleic acids, carbohydrates, auxins, and phenols. Kumar *et al*. (2022) [15] observed similar findings. One important nutrient for plants, phosphorus affects cell division, seed germination, flowering, fruiting, and the synthesis of carbohydrates and fat. Additionally, the nutrient participates in a number of biochemical processes and regulates metabolic pathways, including enzyme reactions. Choudhary and associates (2015) [5].

Stover yield (kg/ha)

The information in Table 1. demonstrated that the application of phosphorus (50 kg/ha) and sulfur (40 kg/ha) produced the greatest stover production (2946.80 kg/ha) at harvest, which was found to be statistically comparable to the highest. Improved development in terms of seedling emergence, plant height, and dry matter accumulation, which increases photosynthetic efficiency, may be the cause of the noticeably higher stover yield following the application of phosphorus and sulfur. Superior vegetative development results from increased photosynthetic accumulation in vegetative components, which raises the stover production. Furthermore, vegetative development may be the cause of the enhanced stover output following the application of sulfur produce too many sites for the larger and noteworthy seed output attained with phosphorus application (20 kg/ha). This could be because of a well-developed root system and increased photosynthate transfer from source to sink. The application of sulfur had the combined impact of increasing plant height, number of leaves per plant, and number of branches per plant that is, enhanced growth parameters which led to an increase in straw yield. This result closely aligns with findings by Arun Raj *et al*. (2018) [2], Parashar *et al*. (2020) [23], Yadav *et al*. (2017) [33], and Gajera *et al*. (2014) [11].

Harvest index (%)

The application of 50 kg/ha of phosphorus and 40 kg/ha of sulfur resulted in a significantly higher harvest index (31.08%) in (T_9). Nonetheless, the minimum harvest index for all treatments was Control (28.14%), and there was no discernible difference between the treatments. When phosphorus levels were applied, there were more branches, which led to more pods. Weight of a thousand grains, which resulted in increased seed production through the optimization of photosynthesis, respiration, energy storage, transfer, cell division, and cell elongation These results were consistent with those of Choudhary *et al*. (2015) [5].

Economics: Phosphorus and sulfur had a substantial impact on the cost of cultivations, gross returns, net returns, and benefit cost ratio in Greengram due to varying levels and treatments, as Table 2 illustrates.

Cost of cultivation (INR/ha)

In comparison to other treatments, the highest cultivation cost (41,630.00 INR/ha) was found in (T_9) with application of phosphorus 50 kg/ha along with sulfur 40 kg/ha, while the lowest cultivation cost (37480 INR/ha) was found in (T_1) with application of phosphorus 30 kg/ha along with sulfur 20 kg/ha.

Gross return (INR/ha)

When compared to other treatments, the highest gross return (125626.13 INR/ha) was found in (T_9) with application of phosphorus 50 kg/ha along with sulfur 40 kg/ha, and the lowest gross return (61184.08 INR/ha) was found in (T_1) with application of phosphorus 30 kg/ha along with sulfur 20 kg/ha.

Net returns (INR/ha)

In comparison to other treatments, the maximum net return (83996.13 INR/ha) was found in (T_9) with the application of phosphorus 50 kg/ha and sulfur 40 kg/ha, while the lowest net return (23704.08 INR/ha) was found in (T_1) with the application of phosphorus 30 kg/ha and sulfur 20 kg/ha.

Benefit cost ratio (B:C)

When compared to other treatments, the highest benefit cost ratio (2.02) was found in (T_9) with the application of phosphorus 50 kg/ha along with sulfur 40 kg/ha, while the lowest benefit cost ratio (0.63) was found in (T_1) with the application of phosphorus 30 kg/ha along with sulfur 20 kg/ha.

Table 1: Effect of Phosphorus and Sulphur on yield attributes and yield of Greengram.

		Post-harvest					
S. No.	Treatments	No. of pods/plants	No. of seed/pod	Test weight (g)	Seed yield (Kg/ha)	Stover yield (kg/ha)	Harvest index (%)
1.	Phosphorus 30 kg/ha + Sulphur 20 kg/ha	16.87	5.93	34.81	874.06	1991.86	30.48
2.	Phosphorus 40 kg/ha + Sulphur 30 kg/ha	17.73	6.20	35.37	972.24	2016.84	32.47
3.	Phosphorus 50 kg/ha + Sulphur 40 kg/ha	21.07	7.20	37.88	1427.84	2793.21	33.86
4.	Phosphorus 30 kg/ha + Sulphur 20 kg/ha	18.07	6.40	35.77	1031.73	2352.13	30.55
5.	Phosphorus 40 kg/ha + Sulphur 30 kg/ha	19.80	6.87	37.28	1268.86	2611.82	32.64
6.	Phosphorus 50 kg/ha + Sulphur 40 kg/ha	21.93	7.87	37.92	1634.30	2792.57	36.98
7.	Phosphorus 30 kg/ha + Sulphur 20 kg/ha	18.40	6.67	36.35	1117.65	2481.45	31.08
8.	Phosphorus 40 kg/ha + Sulphur 30 kg/ha	20.33	7.00	37.86	1354.57	2679.98	33.38
9.	Phosphorus 50 kg/ha + Sulphur 40 kg/ha	22.93	8.20	38.22	1794.66	2946.80	37.84
10.	Control (RDF): 20:60:40 NPK kg/ha	19.73	6.80	37.08	1247.96	2522.39	33.22
	F - Test	S	S	S	S	S	NS
	SEm±	1.01	0.39	0.64	97.56	121.38	2.34
	CD (p=0.05)	3.01	1.15	1.89	289.87	360.65	-

Table 2: Effect of Phosphorus and Sulphur on Economics of Greengram.

Treatments S. No.	Total cost of cultivation (INR/ha)	Gross Return (INR/ha)	Net Return (INR/ha)	B:C ratio
1. Phosphorus 30 kg/ha + Sulphur 20 kg/ha	37480	61184.08	23704.08	0.63
2. Phosphorus 40 kg/ha + Sulphur 30 kg/ha	38110	68056.97	29946.97	0.79
3. Phosphorus 50 kg/ha + Sulphur 40 kg/ha	39430	99948.98	60518.98	1.53
4. Phosphorus 30 kg/ha + Sulphur 20 kg/ha	38580	72221.00	33641.00	0.87
5. Phosphorus 40 kg/ha + Sulphur 30 kg/ha	39210	88820.40	49610.40	1.27
6. Phosphorus 50 kg/ha + Sulphur 40 kg/ha	40530	114400.92	73870.92	1.82
7. Phosphorus 30 kg/ha + Sulphur 20 kg/ha	39680	78235.23	38555.23	0.97
8. Phosphorus 40 kg/ha + Sulphur 30 kg/ha	40310	94820.18	54510.18	1.35
9. Phosphorus 50 kg/ha + Sulphur 40 kg/ha	41630	125626.13	83996.13	2.02
10. Control (RDF): 20:60:40 NPK kg/ha	33330	87357.53	54027.53	1.62

Conclusion

The application of phosphorus 50 kg/ha and sulfur 40 kg/ha (T_9) in Greengram has the maximum grain production, gross return, net return, and benefit cost ratio, according to the results of a one-season trial.

Acknowledgement

The authors would like to express their sincere gratitude to Dr. Umesha C., Assistant Professor, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, India, for his invaluable advice and provision of the necessary research facilities, which were crucial to the successful completion of this study.

Competing Interests

Authors have declared that no competing interests exits.

References

1. Abraham YL, Umesha C, Sanodiya LK. Effect of levels of phosphorus and potassium on growth, yield and economics of black gram. Pharma Innovation Journal. 2021;10(9):109-112.
2. Arun Raj M, Vasanthi D, Mansingh MDI. Effect of sulphur on growth and yield of greengram (*Vigna radiata* L.). International Journal of Science, Environment and Technology. 2018;7(5):1861-1867.
3. Bharvi TK, Vaishali S, Singh N, Deshmukh SP. Effect of summer green gram (*Vigna radiata* L.) varieties, sulphur levels and fertilizer levels on quality, nutrient content and uptake under south Gujarat condition. Journal of Pharmacognosy and Phytochemistry. 2015;9(5):2313-2315.
4. Bouyoucos GJ. Hydrometer Method Improved for Making Particle Size Analysis of Soils. Agronomy Journal. 1927;54:464-465.
5. Choudhary P, Gautam Ghosh N, Kumari S. Effect on yield and benefit-cost ratio of green gram at different phosphorus levels and frequency of boron levels. Int J Curr Microbiol App Sci. 2015;12(6):1095-1103.
6. Choudhary Rohin, Pandey IB, Singh RS, Singh SK, Meena H, Singh K. Effect of phosphorus and sulphur levels on growth and yield of summer greengram (*Vigna radiata* L.) in Middle Indo-gangetic Zone. Legume Research. 2023;46(2):186-190.
7. Das SK. Effect of phosphorus and sulphur on yield attributes, yield, nodulation and nutrient uptake of green gram (*Vigna radiata* L.). Legume Research-An International Journal. 2016;40(1):138-143.
8. Fisher RA. Statistical method for research works. Oliver and Boyd and Co. Inc. Edinburgh, United Kingdom; 1921.
9. Government of India (GOI). Agricultural Statistics at a Glance, Agricultural Statistics Division, Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi. https://eands.dacnet.nic.in; 2021.
10. Gangaraddi Vijaykumar, Brahmaprakash GP. Evaluation of selected microbial consortium formulations on growth of green gram (*Vigna radiata* L.). International Journal of Chemical Studies. 2018;6(6):1909-1913.
11. Gajera RJ, Khafi HR, Raj AD, Yadav V, Lad AN. Effect of phosphorus and bio-fertilizers on growth, yield and economics of summer green gram. Agriculture Update. 2014;9(1):98-102.
12. Jat SR, Patel BJ, Shivran AC, Kuri BR, Jat G. Effect of phosphorus and sulphur levels on growth and yield of cowpea under rainfed conditions. Annals of Plant and Soil Research. 2013;15(2):114-117.
13. Jackson ML. Soil Chemical Analysis. Prentice Hall of India

Pvt. Ltd., New Delhi; 1975. p. 498.
14. Khan MMS, Singh VP, Kumar A. Studies on effect of phosphorus levels on growth and yield of kharif mungbean (*Vigna radiata* L. wilczek). Journal of Pure & Applied Biosciences. 2017;5(4):800-808.
15. Kumar AM, Umesha C, Raju GV. Effect of phosphorus and boron levels on growth and yield of chickpea (*Cicer arietinum* L.). International Journal of Plant & Soil Science. 2022;34(21):266-271.
16. Kumar Shubham, Debbarma V. Effects of phosphorus and boron on growth, yield and economics of green gram (*Vigna radiata* L.). International Journal of Plant & Soil Science. 2023;35(11):1-8.
17. Masih A, Dawson J, Singh RE. Effect of levels of phosphorus and zinc on growth and yield of greengram (*Vigna radiata* L.). International Journal of Current Microbiology and Applied Sciences. 2020;9(10):3106-3112.
18. Mukhtar Tariq, Tariq-Khan M, Aslam MN. Bio efficacy of *Trichoderma* species against Javanese root-knot nematode, *Meloidogyne javanica*, in green gram. Gesunde Pflanzen. 2021;10:1007.
19. Olsen SH, Cole VV, Watanabe FS, Dean LA. Estimation of phosphorus in soil by extraction with sodium bicarbonate. United States Department of Agriculture; 1954.
20. Patel MM, Meena LK, Arvadiya LK, Patel DD, Zinzala MJ. Comparative study on improved organic practices of summer greengram (*Vigna radiata* L.) at Bharuch district of Gujarat. International Journal of Chemical Studies. 2017;9(1):2368-2370.
21. Piper CS. Soil and Plant Analysis. Hans Publishers, Bombay; 1966.
22. Prajapati JP, Kumar S, Singh RP, Kushwaha IK, Yadav PK. Effect of phosphorus and sulfur on growth, yield attributes and yield of green gram (*Vigna radiata* L.). Environment & Ecology. 2013;31(4A):1977-1979.
23. Parashar A, Tripathi L. Effect of phosphorus and sulphur on the growth and yield of black gram (*Vigna mungo* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(5):2585-2588.
24. Patel BK, Patel HK, Makawana SN, Shiyal VN, Chotaliya RL. Effect of various sources of nitrogen and phosphorus on growth, yield and economics of summer green gram (*Vigna radiata* L. Wilczek). International Journal of Current Microbiology and Applied Sciences. 2020;11:745-752.
25. Rakhonde PN, Koche MD, Harne AD. Management of powdery mildew of green gram (*Vigna radiata* L.). Journal of Food Legumes. 2011;24(2):220-222.
26. Raj Suthin Raj, Muthukumar, Charumathi, Renganathan, Sudhagar Rao GB, Ann Suji H. Management of root rot of black gram caused by *Macrophomina phaseolina* (Tassi) Goid using *Trichoderma viride*. J Biopest. 2020;13(2):50-58.
27. Richards LA. Diagnosis and Improvement of Saline Alkali Soils. Agriculture Handbook 60. US Department of Agriculture, Washington DC; 1954.
28. Singh K, Manohar RS, Chaudhary K, Yadav AK, Singh M. Response of different sources and levels of phosphorus on yield, nutrient uptake and net returns of mungbean under rainfed condition. Research in Environment and Life Science. 2015;9(1):19-23.
29. Singh P, Yadav KK, Meena FS, Singh B, Singh R. Effect of phosphorus and sulphur on yield attributes, yield and nutrient uptake of mung bean in central plain zone of Punjab, India. Plant Archives. 2017;17(2):1756-1760.
30. Sindhu SS, Suneja S, Goel AK, Parmar N, Dadarwal KR. Plant growth promoting effects of *Pseudomonas* sp. on inoculation with *Mesorhizobium* sp. Cicer strain under sterile and “wilt sick” soil conditions. Applied Soil Ecology. 2002;1957-1964.
31. Toth SJ, Prince AL. Estimation of Cation-Exchange Capacity and Exchangeable Ca, K, and Na Contents of Soils by Flame Photometer Techniques. Soil Science. 1949;67:439-446.
32. USDA. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Soil Survey Staff, Coord., Soil Conservation Service. Agriculture Handbook 436, US Department of Agriculture, Washington DC; 1975. p. 754.
33. Yadav KV, Singh DP, Sharma SK, Kishor K. Use of phosphorus for maximization of summer mungbean (*Vigna radiata* L.) productivity under sub humid condition of Rajasthan, India. Journal of Pharmacognosy and Phytochemistry. 2017;6(4):01-03.