E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating: 5.20
www.agronomyjournals.com
2025; 8(7): 831-835
Received: 02-04-2025
Accepted: 08-05-2025

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Effect of phosphorus and sulphur on nutient uptake and yield of greengram (*Vigna radiata* L.)

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DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i7k.3290

Abstract
A field experiment was conducted during *Kharif* 2024 at the Research Farm of Vivekananda Global University, Jaipur, to study the effect of phosphorus and sulphur on nutient uptake and yeild of greengram (*Vigna radiata L.*). The experiment included 16 treatment combinations with four levels each of phosphorus (0, 20, 40, and 60 kg P_2O_5 ha^{-1}) and sulphur (0, 20, 40, and 60 kg S ha^{-1}), arranged in a factorial randomized block design with three replications.
Results revealed Application of 60 kg P ha^{-1} recorded higher growth, yield and quality attributes while it was found at par with 40 kg P ha- Therefore it is suggested to apply 40 kg P ha^{-1} as a recommended dose of phosphorus greengram crop. The superior growth, development and yield parameters were recorded due to the application of 60 kg S ha^{-1}. By the application of 60 kg S ha^{-1} but it was at par with 40 kg S ha^{-1}. Hence it is recommended to apply 40 kg S ha^{-1} to greengram crop as a recommended dose.

Keywords: Phosphorus, sulphur, nutrient uptake, yield, greengram

Introduction
Green gram (*Vigna radiata* L.) is a self-pollinated leguminous crop, which is grown during *kharif* as well as summer season in arid and semi-arid regions of India. It is tolerant to drought and can be grown successfully on drained loamy to sandy loam soil in areas of erratic rainfall. It is mainly a rainy season crop and raised without irrigation but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season under irrigated conditions. Being a short duration crop, it suits well in various multiple and intercropping system. After picking of pods, greengram plants may be used as green fodder or green manure. It is also cultivated for its edible seeds and its seed is more palatable, nutritive, digestible and non-flatulent then other pulses grown in country. It is an excellent source of protein (24.5%) with high quality of lysine (460 mg/g) and tryptophan (60 mg/g), 0.6% fat, 0.9% fiber and 3.7% ash (potter and Hotchkiss, 1997). Besides being a rich source of protein, it maintains soil fertility through biological nitrogen fixation in soil and thus plays a vital role in further sustainable agriculture. It also have a remarkable quantity of ascorbic acid and contains riboflavin (0.21 mg/g) and minerals (3.84 g/100 g) when sprouted.
Phosphorus is an important nutrient next to nitrogen for plants. Indian soils are poor to medium in available phosphorus. At present 5% of the Indian soils have adequate available P, 49.3% are under low category, 48.8% under medium and 1.9% under high category (Pattanyak *et al.*, 2009). The P input in Indian agriculture comes from fertilizers, organic manures and to a very small extent from crop residues. The overall uptake of phosphorus in cereals, pulses, oil seeds and tubers varies between 2 and 24 mg kg^{-1}. For the targeted food grains production of 3.01 mt by the year 2020, at least 45 mt of plant nutrients need to be added to the Indian soils, out of which P use will be 5.6 to 8.8 mt. Several workers observed a steady decline in available P status with continuous cropping without P application. Only 25% to 30% of the applied P is available to crops and remaining P is converted into insoluble P (Sharma and Khurana, 1997).
Sulphur, an essential secondary plant nutrient, is required by plant and animals in approximately the same amount as phosphorus. Few years back, it was a neglected element. However, recently sulphur is gaining importance for crop production in the balance fertilization programme. On an

average, the amount of sulphur content in the earth crust is ranged about 0.06 to 0.10 per cent. Sulphur is called the fourth major nutrient. Its requirement per tonne yield can be taken as 3-4 kg for cereals, 8 kg for legumes and 12 kg for oilseeds (Tondon, 1986). It is absorbed by plant in form of sulphates ion. Sulphur content in plant ranges from 0.1-0.4%. The effect of sulphur reported as a synergistic effect on productivity of crops. Sulphur is essential for chlorophyll formation, synthesis of protein, vitamins, thiourea, plant hormones, thiamin, biotin, glutathione and S containing essential amino acids *viz.* methionine, cysteine and cysteine. About 90% of plant sulphur is present in these amino acids. Sulphur also markedly enhanced content of phosphorus, sulphur, protein and gum in grain and ultimately the yield. Sulphur has their role in growth and development of crop in legumes. Sulphur increase crop yields and improve quality of produce, both of which are important for determining the market price. After phosphorus, sulphur nutrition has been found to be a major limiting factor in greengram production. (Saraf, 1988. [13]

Materials and Methods

The experiment was conducted at the Research Farm of Vivekananda Global University, Jaipur, situated in Agro-climatic Zone IIIa (Semi-Arid Eastern Plain Zone) of Rajasthan, at 26°51′ N latitude, 75°47′ E longitude, and 390 m above mean sea level. The climate is semi-arid with extreme temperatures (4°C to 45.5°C) and average annual rainfall of 500-700 mm, mainly during July to September. Pre-sowing soil analysis from a 0-30 cm depth revealed loamy sand texture, alkaline pH, low organic carbon, nitrogen, and zinc, and medium phosphorus and potassium. The experiment followed a factorial randomized block design with 16 treatment combinations—four levels each of phosphorus (0, 20, 40, 60 kg/ha) and sulphur (0, 20, 40, 60 kg/ha)—replicated three times. Mungbean variety RMG 975, suitable for low-rainfall and drought-prone areas, was used due to its moderate resistance to MYMV, root knot nematode tolerance, and yield potential of 8-9 q/ha in 65-70 days.

$$\text{Nutrient uptake (kg ha-1)} = \frac{\text{Nutrient content in grain (\%)} \times \text{Grain yield (kg ha-)} + \text{Nutrient content in straw (\%)} \times \text{Straw yield (kg ha-)}}{100}$$

Nutrient	Method	Reference
Available N (kg ha^{-1})	Alkaline permanganate method	Jackson, 1973
Available P2O5 (kg ha^{-1})	Olsen's method	Subbiah and Asija, 1956
Available K2O (kg ha^{-1})	Flame photometer method	Jackson, 1973

Table 1: Effect of phosphorous and sulphur on N, P and S uptake in seed and straw of greengram

Treatments	Nitrogen uptake (kg/ha)		Phosphorous uptake (kg/ha)		Sulphur uptake (kg/ha)	
Phosphorous levels (kg/ha)	Seed	Straw	Seed	Straw	Seed	Straw
Control	19.61	17.60	2.77	2.58	0.65	1.33
20	25.69	22.51	3.50	2.84	1.07	1.49
40	37.09	25.97	4.42	3.27	1.39	1.78
60	39.68	27.70	4.67	3.42	1.48	1.90
S.Em+	1.58	0.83	0.19	0.12	0.06	0.09
CD (P = 0.05)	4.55	2.41	0.54	0.34	0.17	0.27
Sulphur levels (kg/ha)						
Control	19.75	18.24	2.11	2.27	0.71	1.02
20	30.27	22.55	3.93	2.86	1.09	1.46
40	34.03	25.25	4.53	3.33	1.32	1.90
60	38.02	27.74	4.80	3.65	1.46	2.12
S.Em+	1.58	0.83	0.19	0.12	0.06	0.09
CD (P = 0.05)	4.55	2.41	0.54	0.34	0.17	0.27

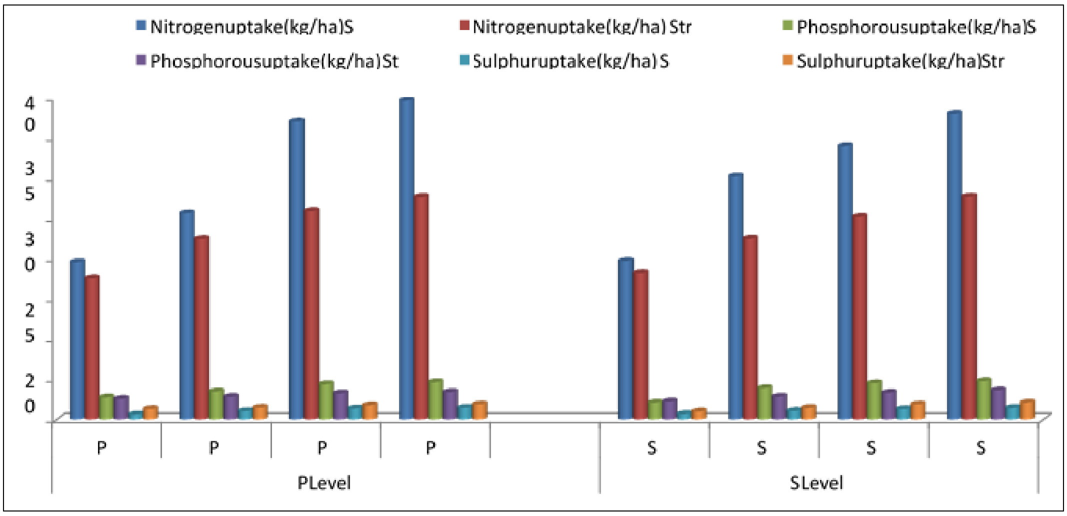

Fig 1: Effect of phosphorous and sulphur on nutrients uptake in seed and straw of greengram

Nitrogen uptake

The uptake of nitrogen by crop exhibited significant increase due to phosphorous fertilization (Table 1). Application of phosphorous at 60 kg ha^{-1} resulted in the highest uptake of 39.68 and 27.70 kg N/ha in grain and straw, respectively which remain at with 40 kg P2O5 ha^{-1} which found superior over 20 kg P2O5 ha^{-1} and control, respectively.

Uptake of N was also improved significantly due to sulphur treatments (Table 1). The highest uptake of 38.02 and 27.74 kg N/ha in grain and straw, respectively was recorded under application of 60 kg S ha^{-1} which found at par with 40 kg S ha^{-1}.

Phosphorus uptake

It is clear from the data presented in table-1 that every addition in graded levels of phosphorous upto 40 kg ha^{-1} resulted in significantly higher uptake of phosphorus over lower levels. It recorded 4.42 in grain and 3.27 kg ha^{-1} in straw uptake of phosphorus, respectively. However, it was found at with 60 kg P2O5 ha^{-1} (4.67 and 3.42 kg ha^{-1}) in grain and straw respectively.

Uptake of phosphorous was also improved significantly due to sulphur treatments (Table 1). The highest uptake of 4.80 and 3.65 kg P/ha in grain and straw, respectively was recorded under application of 60 kg S ha^{-1} which found at par with 40 kg S ha^{-1}.

Sulphur uptake

It is clear from the data presented in table-1 that every addition in graded levels of phosphorous upto 40 kg ha^{-1} resulted in significantly higher uptake of sulphur over lower levels. It recorded 1.39 in grain and 1.78 kg ha^{-1} in straw uptake of sulphur, respectively. However, it was found at with 60 kg P2O5 ha^{-1} (1.48 and 1.90 kg ha^{-1}) in grain and straw respectively.

Uptake of sulphur was also improved significantly due to sulphur treatments (Table-1). The highest uptake of 1.46 and 2.12 kg S/ha in grain and straw, respectively was recorded under application of 60 kg S ha^{-1} which found at par with 40 kg S ha^{-1}.

Table 2: Effect of phosphorous and sulphur on yield of greengram

Treatments			
Phosphorous levels (kg/ha)	**Seed yield (kg/ha)**	**Straw yield (kg/ha)**	**Biological yield (kg/ha)**
Control	632	1568	2200
20	785	1694	2479
40	956	1864	2820
60	995	1917	2912
S.Em+	22	39	55
CD (P = 0.05)	63	112	159
Sulphur levels (kg/ha)			
Control	617	1569	2187
20	851	1746	2598
40	922	1817	2739
60	978	1910	2888
S.Em+	22	39	55
CD (P = 0.05)	63	112	159

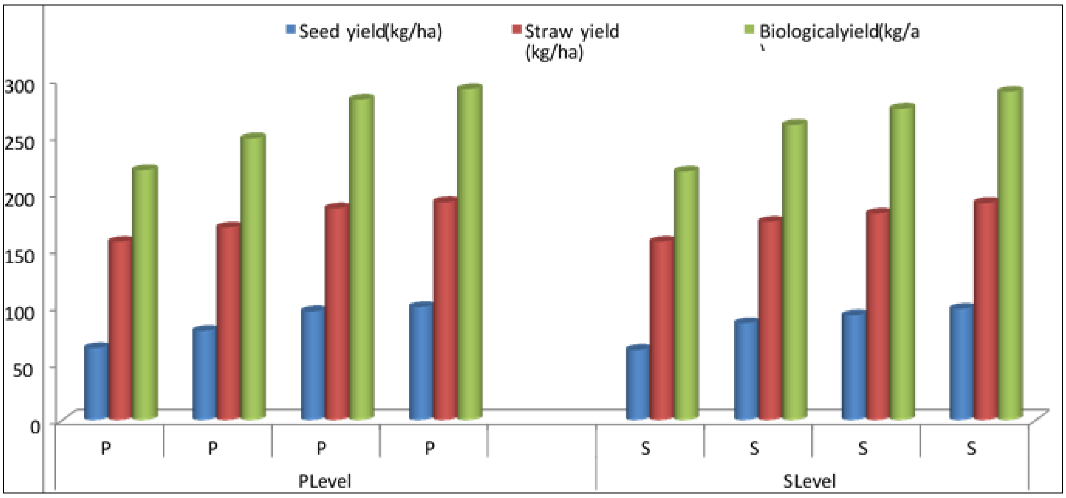

Fig 2: Effect of phosphorous and sulphur on yields of greengram

Grain yield

A critical examination of data (Table 2) indicated that the application of 60 kg P2O5 ha^{-1} was produced maximum grain yield (995 kg ha^{-1}) which was found significantly superior over 20 kg P2O5 ha^{-1} and at par with the application of 40 kg P2O5 ha^{-1}. The significantly lowest grain yield (632 kg ha^{-1}) was obtained in no application of phosphorus.

A perusal of data shows in table-2 that the higher seed yield (978 kg ha^{-1}) was obtained with application of sulphur 60 kg ha^{-1}. This treatment was found significantly superior over other treatments and remains at par with 40 kg S ha^{-1}.

Straw yield

Data presented in table-2 indicated that the mean straw yield of greengram was significantly influenced by different levels of phosphorus and sulphur. Data presented in table 4.5 revealed that the maximum straw yield (1917 kg ha^{-1}) was obtained by the application of 60 kg P2O5 ha^{-1} which was found significantly superior over control and 20 kg P2O5 ha^{-1} and at par with 40 kg P2O5 ha^{-1}.

Further, results indicated that application of 60 kg S ha^{-1} was produced highest straw yield (1910 kg ha^{-1}). It was found at par with 40 S ha^{-1} and significantly superior over without application of sulphur.

Biological yield

Data on biological yield as affected by various treatments are presented in table -2. Results showed that higher biological yield (2912 kg ha^{-1}) received when 60 kg P2O5 ha^{-1} was applied. This treatment was found significantly superior over 20 kg P2O5 ha^{-1} and remains at par with 40 kg P2O5 ha^{-1}.

The application of 60 kg S ha^{-1} recorded highest biological yield (2888 kg ha^{-1}) which was found to be at par with the application of 40 kg S ha^{-1} and both of these levels of sulphur was found significantly superior over no application of sulphur.

Discussion

Effect of phosphorus

Nutrient uptake

A significant increase in N, P and S content was observed due to application of phosphorus up to 40 kg P2O5 ha^{-1}. As stated earlier in preceding chapter that application of phosphorus might have improved the nutritional environment in rhizosphere as well as in plant system, leading to increased uptake and translocation of nutrients especially of N, P and S in reproductive structures which led to higher content and uptake. Further, the significant and positive correlation of seed yield with nutrients uptake also evidenced for higher content of nutrients. Since, uptake of N, P and S is the function of seed and straw yield and their content, the significant increase in content of these nutrients coupled with increased seed and straw yield enhanced the total uptake of N, P and S. These results are in close conformity with the findings of Erman *et al*., (2009) [5]. Nagar and Meena (2004) [10] in clusterbean, Sepat (2005) and Kumawat (2006) in mothbean, Gupta *et al*. (2006) [6] in urdbean and Jain *et al*. (2007) in greengram.

Yield

The effect of different levels of phosphorus on mean seed yield kg ha^{-1} was found to be significant. The application of 60 kg P2O5 ha^{-1} was recorded significantly higher mean seed yield (995 kg ha^{-1}) followed by the application of 40 kg P2O5 ha^{-1} (956 kg ha^{-1}) and 20 kg P2O5 ha^{-1} (785 kg ha^{-1}). Higher seed yield with higher level of phosphorus may be due to higher reproductive growth. These results reported by Sawargoankar *et al.*, (2006) [14] and Deshbhratar *et. al*., (2010) [2]. Straw yield kg ha^{-1} as influenced by different levels of phosphorus was found to be significant. The application of 60 kg P2O5 ha^{-1} recorded maximum straw yield kg ha^{-1} (1917 kg ha^{-1}) which was found significantly superior over lower levels of phosphorus (20 kg P2O5 ha^{-1}) and was at par with 40 kg P2O5 ha^{-1} (1864 kg ha^{-1}). This might be due to phosphorus gives vigorous start to plant and strengthens straw. Rekha *et al*. (2018) [12] and Chaudhari *et al*. (2019) [1] corroborate the similar results. Data on biological yield kg ha^{-1} as influenced by different levels of phosphorus was found significant. The application of 60 kg P2O5 ha^{-1} recorded significantly superior over 20 kg P2O5 ha^{-1} and at par with 40 kg P2O5 ha^{-1}. It may be due to higher the dry matter production by the application of higher level of phosphorus resulted in higher seed and biological yield. Same results were reported Sawargoankar *et al*., (2006) [14].

Effect of sulphur

Nutrient uptake

The significant increase in N concentration in seed and straw/stick of greengram, phosphorus concentration in seed of greengram and in straw of greengram, total uptake of nitrogen and phosphorus by greengram were recorded with increased application of sulphur upto 60 kg ha^{-1}. The nitrogen concentration in seed of greengram, phosphorus concentration in stick of greengram, sulphur concentration in seed and straw/stick and total uptake of sulphur in seed of greengram were recorded significantly higher with increased application of sulphur upto 60 kg ha^{-1}. The positive influence of S fertilization on N, P and S concentration of the crops seems to be due to improved nutritional environment both in the rhizosphere and in the plant system. Thus, increased availability of nutrients in the root zone coupled with increased metabolic activity at the cellular level probably might have increased the uptake of nutrient and their accumulation in vegetative plant parts. Similar result was reported by Meena *et. al*., (2006) [9] and Patel *et. al*., (2010) [11].

Yield

The data on mean seed yield (kg ha^{-1}), straw yield (kg ha^{-1}) and biological yield(kg ha^{-1}) indicated that the application of 60 kg S ha^{-1} recorded highest seed yield, straw yield and biological yield were 978, 1910 and 2888 kg ha^{-1} respectively which was found to be significantly superior over 20 kg S ha^{-1} (851, 1746 and 2598 kg ha^{-1}) and control and at par with 40 kg S ha^{-1} (922, 1817 and 2739 kg ha^{-1}). Maximum seed yield might be due to pivotal role of sulphur in regulating the metabolic and enzymatic processes including photosynthesis, respiration and legume *Rhizobiun* symbiotic nitrogen fixation which reflected in increased yield. The other reasons may be due to the important role of sulphur in energy transformation, activation of enzymes and also in carbohydrate metabolism. This may also be due to optimum availability of available sulphur which consequently resulted in well filled pods resulting in increased seed yield of mung bean. These results are in conformity with those of Dharwe *et al*. (2017 and 2019) [3, 4]. Stover yield increased because of enhancement of vegetative growth under improved fertilizer application. Similar kind of reports on yields has also been given by Karwasra *et al.,* (2006) [7] and Katiyar, (2013) [8].

Conclusion

Results revealed that Application of 60 kg P ha^{-1} recorded higher growth, yield and quality attributes while it was found at par with 40 kg P ha^{-1}. The higher net return and B:C ratio was obtained with 40 kg P ha^{-1}. Therefore it is suggested to apply 40 kg P ha^{-1} as a recommended dose of phosphorus greengram crop.

The superior growth, development and yield parameters were recorded due to the application of 60 kg S ha^{-1}. It was also found superior in respect of gross and net monetary returns but it was at par with 40 kg S ha^{-1}. The higher B:C ratio was obtained by the application of 60 kg S ha^{-1} but it was at par with 40 kg S ha^{-1}. Hence it is recommended to apply 40 kg S ha^{-1} to greengram crop as a recommended dose.

Acknowledgement

I express my heartfelt gratitude to my major advisor, Dr. A. L. Prajapat, for his invaluable guidance and consistent support. I am thankful to Prof. (Dr.) Hoshiyar Singh, Dean, and Mr. Raju Singh Jakhar, Head of Department, for providing necessary facilities. I also extend my thanks to the advisory committee members and all faculty members who supported me throughout the study. Special thanks to my parents and friends for their moral support.

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