International Journal of Plant & Soil Science

Volume 35, Issue 18, Page 1587-1593, 2023; Article no.IJPSS.102855
ISSN: 2320-7035

Effect of Phosphorus and Sulphur on Growth, Protein Content, Yield and Economics of Black Gram (*Vigna mungo* L.)

Aman Parashar [a++*], Yagyavalkya Sharma [b#] and Vishakha Jaiswal [a++]

[a] *Department of Agronomy, School of Agriculture, ITM University, Gwalior, India.*
[b] *Department of Biotechnology and Microbiology, Kalp Laboratories, Mathura, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i183429

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/102855

Original Research Article

Received: 18/05/2023
Accepted: 21/07/2023
Published: 04/08/2023

ABSTRACT

To study the effect of phosphorus and sulphur levels on growth, protein content, yield and economic profitability of black gram production in, a field experiment was conducted during the *kharif* season of 2018-19 at the Research Farm, School of Agriculture, ITM University, Gwalior, (M.P.). The experiment was conducted in factorial in randomized block design with four phosphorus levels (0 kg/ha (P_0), 20 kg/ha (P_1), 40 kg/ha (P_2) and 60 kg/ha (P_3)) along with three Sulphur levels (10 kg/ha (S_1), 20 kg/ha (S_2) and 30 kg/ha (S_3)) which were replicated thrice. The black gram variety "Awasthi" was uniformly fertilized by 20 kg N/ha and 20 kg K_2O / ha using Urea and muriate of potash. However, phosphorus and Sulphur were applied using Single Super Phosphate and

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++ *Ph. D scholar;*
# *Senior Scientist and Head;*
**Corresponding author: E-mail: amanparashar.soag@itmuniversity.ac.in;*

Cossavet as per the requirement of the treatments. The results revealed that the application of phosphorus @ 60 kg/ha recorded significantly highest plant height (37.12 cm) at 60 DAS, the maximum number of branches per plant (6.33), the maximum number of leaves per plant (10.62) at 60 DAS, seed yield (14.12 q/ha), Stover yield (35.42 q/ha). While among the sulphur levels, application of Sulphur @ 30 kg/ha recorded significantly highest plant height (36.19 cm), the maximum number of branches per plant (6.06), the maximum number of leaves per plant (10.01) at 60 DAS, higher seed yield (12.55 q/ha) and Stover yield (31.85 q/ha). Among the economics, the combined application of phosphorus @ 60 kg with the application of Sulphur @ 30 kg/ ha produced significantly the highest net returns and Benefit Cost. Thus, the application of phosphorus @ 60 kg along with the application of Sulphur @ 30 kg/ ha was found to be the most promising treatment in enhancing the growth and yield in black gram.

Keywords: Sulphur; black gram; protein content; yield and phosphorus.

1. INTRODUCTION

India holds the title of the world's largest producer and consumer of pulse crops, making it a vital legume crop in South and Southeast Asia . It contributes a significant 25% to the world's total pulse production, with one-third of the world's total acreage under pulses cultivated in India. The productivity of pulses mainly depends on proper nutrient management practices, particularly phosphorus and sulphur. However, the country's production of pulses falls considerably short of what is needed to meet even the bare minimum level of per capita consumption, leading to malnutrition among the populace. Increased pulse production in India is required to address this malnutrition.

“Black gram (*Vigna mungo* L.) is one of the important kharif pulse crops. It is commonly grown in the summer and rainy seasons in northern India. It is a protein-rich (25 percent) staple food containing almost three times that of cereals. It supplies the protein requirement of the vegetarian population. Black gram accounts for 10 per cent of total pulse production in India” [1]. It is a member of the Leguminosae subfamily Papilionaceae, and because of its extensive foliage and deep root system, it effectively inhibits soil erosion and outcompetes weeds. It increases soil fertility by fixing atmospheric nitrogen into the soil. However, there is a substantial variation between black gram's potential and actual productivity. So proper fertilization is necessary to meet it.. “Although, the crop can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur” [2,3]. Being a leguminous crop, black gram needs sufficient amounts of phosphorus and sulfur in addition to other nutrients because these are crucial for plant growth and development.

“Phosphorus is among the essential macro-nutrients required for plant growth and development. It plays a key role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, cell enlargement, transfer of genetic information, root growth, nodulation and nitrogen fixation in plants. It promotes the development of roots, seed formation, and gives strength to straw, hastens the maturity of crops, and increases the ratio of grain to straw” [1]. It was reported that 80 per cent of the Indian soils need P application [4] at recommended rates, whereas, the application of some quantity of P fertilizers would be essential to arrest P mining from the soils so as to sustain high yield of crops “Sulphur is another essential nutrient that is usually required by leguminous crops in amounts comparable to phosphorus. Sulphur is part of the amino acids cysteine and methionine, hence essential for protein production. It helps in chlorophyll formation, stimulating growth, seed formation and N fixation by enhancing nodule formation. Widespread S deficiency has been observed in larger areas due to the use of high analysis Sulphur free fertilizers like urea and diammonium phosphate (DAP) in high-yielding varieties and intensive cropping, and is more conspicuous in light textured soils low in organic matter” [5].

“The nutrient addition may have asynergistic or antagonistic effect on the availability of other nutrients. Generally, P and S interaction was found to be synergistic on dry matter yields of different crops at their lower levels of application but at their higher levels of application, there was antagonistic interaction” [6,7]. Further, Jaggi [8] observed synergistic interaction between phosphorus and Sulphur at all levels of applied P

(0 to 60 kg P_2O_5 /ha) and S (0 to 90 kg S/ha) on seed and straw yield of Indian mustard. Thus, keeping the above fact in view, an experiment was conducted to assess the effect of phosphorus and Sulphur levels on growth, protein content, yield and economics of black gram.

2. MATERIALS AND METHODS

The experiment was carried out during the *kharif* season year 2018-19 at the Research Farm, School of Agriculture, ITM University, Gwalior, (M.P.). The climate of this place is typically sub-tropical and semi-arid in nature. The soil of the experimental field was sandy clay loam in texture, low in organic carbon (4.0 g/kg) and available nitrogen (183.50 kg/ha) and medium in phosphorus (14.40 kg/ ha) and potassium (243.00 kg/ ha) with electrical conductivity (0.41 dS /m) in the safer range.

The experiment design was a Factorial arranged in a randomized block design with four levels of phosphorus (P_0- 0 kg/ha, P_1- 20 kg/ha, P_2- 40 kg/ha and P_3- 60 kg/ha) and three levels of Sulphur (S_1- 10 kg/ha, S_2- 20 kg/ha and S_3- 30 kg/ha). This was replicated thrice. Blackgram variety "Awasthi" was sown at a spacing of 40 cm x 10 cm. A basal application of 20 kg N/ha and 20 kg K_2O / ha using Urea and muriate of potash was done at ???. However, phosphorus and Sulphur were applied through Single Super Phosphate and Cossavet as per the requirement of the treatments. The crop was managed as per regional recommendations of the crop.

Data pertaining to the growth attributes were taken during different growth periods. For plant height, data was recorded using a a measuring tape.Number of branches per plant, number of leaves per plant and number of root nodules per plant were counted virtually. Yield data was obtained at harvest. For grain and stover yield, the net plot was harvested and weighed for the grain and stover yield which was expressed in q/ ha. protein content in seed was obtained using the formula,

Protein (%) = N (%) x 6.25.

Among economic parameters, net return was calculated by deducting cultivation cost from gross returns. Cost – benefir (C:B) ratio was calculated by dividing net returns with total cost of cultivation to evaluate the economic viability of treatments. The analysis of variance was conducted using OP-Stat developed by CCSHAU, Hisar for all observations.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The data relating to the growth attributes like plant height at 60 DAS, number of branches per plant at 60 DAS, number of leaves per plant at 60 DAS were significantly influenced due to different phosphorus and sulphur levels.

3.1.1 Effect of phosphorus

Data presented in Table 1 revealed that the highest plant height of 37.12 cm at 60 DAS, maximum number of branches per plant (6.33), maximum number of leaves per plant (10.62) at 60 DAS was recorded with the application of phosphorus at 60 kg/ha. The lowest plant height, number of branches per plant and number of leaves per plant were noted with the application of phosphorus applied at 0 kg ha-1 (Control, P0) at 60 DAS. "This might be due to the higher availability of N and P and their uptake that progressively enhanced the plant's vegetative growth". Sharma and Singh (1997). "The fast increase in growth attributes in the early stage of plant growth may be attributed to the higher number of leaves producing higher food material for growth of the plant. In fact, more and large-sized leaves were responsible for preparing more food photosynthates which increased cell division and resulted in rapid growth of the plants" (Karache et al. 2008). Similar results have also been reported by Reddy et al*.* (2003), Ghosh et al*.* (2006), Gajera et al. [9].

3.1.2 Effect of sulphur

The Sulphur also significantly influenced to the plant height at 60 DAS. The highest plant height (36.19 cm), maximum number of branches per plant (6.06), and Maximum number of leaves per plant (10.01) was found under the application of Sulphur @ 30 kg/ha followed by Sulphur @ 20 kg/ha. This is probably due to the fact that the increase in growth might be due to the better nutrition and their utilization under well-fertilized plots as compared to lower levels which could not meet the nutrition requirement of the crop. The results were also found in conformity with those reported by Chaubey et al. [10]; Jat et al. [11] and Akter et al. [12] that application of S significantly increased the growth attributes. Increasing in growth might be due to favourable function of Sulphur being a major structural constituent of cell helps in stimulating the cell division and cell enlargement, which increased growth and in turn yield of black gram.

Table 1. Influence of phosphorus and Sulphur on growth attributes of black gram at 60 DAS

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant
Phosphorus levels			
P_0: 0 kg/ha	33.75	4.99	8.46
P_1: 20 kg/ha	34.63	5.72	9.33
P_2: 40 kg/ha	35.15	5.98	9.67
P_3: 60 kg/ha	37.12	6.33	10.62
S.Em±	0.28	0.05	0.04
CD	0.81	0.15	0.11
Sulphur levels			
S_1: 10 kg/ha	5.39	27.34	9.07
S_2: 20 kg/ha	5.82	29.19	9.47
S_3: 30 kg/ha	6.06	31.85	10.01
S.Em±	0.24	0.04	0.03
CD	0.70	0.13	0.09

3.2 Protein Content

Data on quality characters of black gram as presented in Table 2 revealed that quality characters are significantly affected by phosphorus and sulphur levels.

3.2.1 Effect of phosphorus

The result revealed that protein content was significantly influenced by the different levels of phosphorus. Protein content ranged from 21.05 to 24.71%. The highest protein content of 24.71 % was observed with the application of phosphorus @ 60 kg/ha. This is due to fact that application of the adequate amount of phosphorus influenced the vigour of plants which possibly accelerated the sulphur fixing power of plants by increasing the activity of nodule bacteria, proliferation of root growth resulting in more build-up to Sulphur content in seed and straw ultimately produce a higher concentration of protein. Similar results were found by Dhage et al. [13] and Chesti et al. [14].

3.2.2 Effect of sulphur

The different Sulphur levels also significantly influenced the Protein content (Table 3). It was observed that the highest protein content of 23.14% was recorded with the application of Sulphur @ 30 kg/ha followed by Sulphur @ 20 kg/ha. There was a significant increase in protein content, recorded with a higher dose of Sulphur at this growth stage. This is due to the fact that protein molecules are built up through systematically controlled condensation of amino acid molecules, formed by combining reduced Sulphur with derivatives of carbohydrates obtained within the plant system as a product of photosynthesis. Accumulation of protein in grain and straw under adequate Sulphur supply might be accredited to the continuous availability of sulphur and enhancement in its absorption through increased root cation exchange capacity which results in more protein synthesis. Contrary to this, a limited amount of available sulphur conspicuously associated with a lower rate of Sulphur could not meet the sulphur requirement for protein synthesis, resulting in a low protein percentage. As sulphur is the major constituent of protein, therefore, increasing levels of N increased the protein content and yield. Similar results were reported Yadav et al. [15] and Bhat et al. [16].

Table 2. Effect of phosphorus and sulphur on protein content of black gram

Treatments	Protein content (%)
Phosphorus levels	
P_0: 0 kg/ha	21.05
P_1: 20 kg/ha	21.51
P_2: 40 kg/ha	22.59
P_3: 60 kg/ha	24.71
S.Em±	0.19
CD	0.56
Sulphur levels	
S_1: 10 kg/ha	21.99
S_2: 20 kg/ha	22.27
S_3: 30 kg/ha	23.14
S.Em±	0.17
CD	0.49

Table 3. Effect of phosphorus and sulphur on grain yield, stover yield and economics of blackgram

Treatments	Grain yield per hectare (q/ha)	Stover yield per hectare (q/ha)	Net return (Rs/ha)	B:C ratio
Phosphorus levels				
P_0: 0 kg/ha	9.76	24.87	34971.67	1.86
P_1: 20 kg/ha	10.88	27.79	40265.00	2.04
P_2: 40 kg/ha	11.69	29.75	43801.33	2.12
P_3: 60 kg/ha	14.12	35.42	56162.67	2.61
S.Em±	0.09	0.24	-	-
CD	0.27	0.71	-	-
Sulphur levels				
S_1: 10 kg/ha	10.75	27.34	39804.50	2.04
S_2: 20 kg/ha	11.54	29.19	43375.00	2.14
S_3: 30 kg/ha	12.55	31.85	48221.00	2.29
S.Em±	0.08	0.21	-	-
CD	0.23	0.61	-	-

3.3 Yield and Economics

3.3.1 Effect of phosphorus

The data relating to yield is presented in Table 3 revealed that the seed yield per hectare (14.12 q/ha), stover yield per hectare (35.42 q/ha), net returns (Rs.48221.00/ha) and B: C ratio (2.29:1) were recorded with the application of phosphorus @ 60 kg/ha. lowest yield per plant and economics was noted without application of phosphorus applied @ 0 kg/ha (Control). This might be due to the fact that plants treated with optimum phosphorus doses, resulted in higher yields due to better root development and nodulation which will helps in higher nutrient availability leading to higher flowering, fruiting and grain and stover yield per hectare. Similar findings were reported by Abraham and Lal (2003), Sharma et al. [17], Yadav et al. [18]. Further higher economics is possibly due to proportionately highest net return as compared to the cost involved which contributed to B: C ratio.

3.3.2 Effect of Sulphur

The data presented in Table 3 revealed that seed yield per hectare, Stover yield per hectare net returns and B:C ratio was significantly influenced due to different levels of sulphur. It was observed that highest seed yield per hectare (12.55 q/ha), stover yield per hectare (31.85 q/ha), net returns (Rs.48221.00/ha) and B: C ratio (2.29:1) were recorded with the application of Sulphur @ 30 kg/ha followed by Sulphur @ 20 kg/ha. This is due to fact that the highest yield is obtained due to the maximum production of crop characteristics like plant height, branches/ plant, leaves/ plant, pods/ plant and seeds/ pod. This finding was partly supported by Singh et al. (1995) who stated that application of Sulphur increased the seed yield. Similar findings were reported by Bagayoko et al. [19], Beg and Singh [20], Singh et al. [21], [22-26].

4. CONCLUSION

It can be concluded that among the phosphorus levels, application of phosphorus @ 60 kg/ha recorded significantly higher growth attributes, protein content, grain yield and Stover yield. Among the sulphur levels, application of Sulphur @ 30 kg/ha recorded higher growth attributes and yield of black gram. Thus, the application of phosphorus @ 60 kg with application of Sulphur @ 30 kg/ ha was found to be most promising treatment in enhancing the growth, protein content and yield in black gram for resource-poor farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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