***Original Research Article***

# Effect of Phosphorus and Sulphur on growth, protein content, yield and economics of Blackgram (*Vigna Mungo* L.)


## ABSTRACT

To study the effect of phosphorus and sulphur levels on growth, protein content, yield and economic profitability ~~s~~ of blackgram production in ???, ~~an~~ afield 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 ~~viz.,~~(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~~viz.,~~(10 kg/ha ($S_1$), 20 kg/ha ($S_2$) and 30 kg/ha ($S_3$)) which were replicated thrice. The ~~blackgram~~ black gramvariety "Awasthi" was uniformly fertilized by 20 kg N/ha and~~,~~ 20 kg $K_2O$ /ha using ~~through~~ Urea and muriate of potash. However, phosphorus and Sulphur ~~was~~ wereapplied usingthrough Single Super Phosphate and Cossavet as per the requirement of the treatments. The ~~experimental~~ results revealed that ~~among the phosphorus levels,~~ 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~~ highestplant height (36.19 cm), the maximum number of branches per plant (6.06), the m~~M~~aximum number of leaves per plant (10.01) at 60 DAS, higherseed 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 ~~blackgram~~black gram.



**Keywords**: Sulphur, Black gram, Protein content, Yield and Phosphorus


**Comment [K1]:** The application of 60kg/ha of phosphorus significantly influenced plant height, number of branches, number of leaves, seed yield and Stover yield.

**Comment [K2]:** Similarly, the highest rate of sulphur significantly influenced the growth and yield parameters of black gram.



## 1. Introduction:

India holds the title of the world's largest producer and consumer of pulse ~~crop~~crops, making it a vital legume crop in South and Southeast Asia (Ref?). 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 (Ref). 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.~~However, theproduction of pulses in the country is far below the requirement to meet even the minimum level per capita consumption which is causing malnutrition among the population. To meet this malnutrition, there is need to increase pulse production in India.~~

Black gram (*Vigna mungo* L.) is one of the important kharif pulse ~~crop~~crops. It is commonly grown in the summer and rainy seasons in northern India. It is a ~~protein rich~~protein-rich (25 ~~per cent~~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. 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.~~It belongs to Leguminosae, sub familypapilionaceae,and controls soil erosion and competes with weeds effectively due to its deep root system and foliage cover. It fixes atmospheric nitrogen into the soil and improvedthe soil fertility. But there exists a vast gap between potential productivity and actual productivity of black gram. So to meet it, proper fertilization is essential~~. Although, the crop can meet its nitrogen requirements by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur (Thakur and Negi, 1985; Nandal, *et al*., 1987). 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.~~Black gram being a leguminous crop, requires adequate amount of phosphorus and sulphur as well as apart from other nutrients these are directly involved in growth and development of plant~~.

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. It was reported that~~,~~ 80 per cent of the Indian soils need P application (Motsara, 2002) at recommended rates, whereas, the application of some quantity of P

**Comment [K3]:** Reference

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fertilizers would be essential to arrest P mining from the soils so as to sustain high yield of crops

Sulphur is another essential nutrient ~~which~~ that is usually required by leguminous crops in amounts comparable to phosphorus. Sulphur is ~~a~~ 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. ~~Wide spread~~Widespread S deficiency ~~have~~ has been observed ~~on~~ in larger areas due to the use of high analysis Sulphur free fertilizers like urea and diammonium phosphate (DAP) in ~~high yielding~~high-yielding varieties and intensive cropping, and is more conspicuous in light textured soils low in organic matter (Sinha *et al*., 1995).

The nutrient addition may have a synergistic 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 (Aulakh*et al*., 1990 and Islam *et al.*, 2006). Further, Jaggi (1998) 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 ~~blackgram~~black gram.

**2. Materials and Method**

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 ~~conducted in~~ a Factorial arranged in a randomized block design with four levels of phosphorus ~~as~~($P_0$- 0 kg/ha, $P_1$- 20 kg/ha, $P_2$- 40 kg/ha and $P_3$- 60 kg/ha)~~,~~ and ~~while~~ three levels of Sulphur ~~were tested are~~($S_1$- 10 kg/ha, $S_2$- 20 kg/ha and $S_3$- 30 kg/ha). This was ~~which were~~ replicated thrice. Blackgram variety “Awasthi” was sown at a spacing of 40cm x 10 cm. A basal application of ~~and it was uniformly fertilized by~~ 20 kg N/ha and~~,~~ 20 kg $K_2O$ /ha using ~~through~~ Urea and muriate of potash was done at ???. However, phosphorus and Sulphur ~~was~~ were applied through Single Super Phosphate and

**Comment [K5]:** Provide current literature to support your work

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**Comment [K6]:** The soil analysis must be presented and referenced in the text. No reference was made to the soil fertility status

Cossavet as per the requirement of the treatments. The crop was managed as per regional recommendations of the crop.

Comment [K7]: Any reference????

Data pertaining to the growth attributes were taken during different growth periods. For plant height, data was recorded using a ~~with~~the ~~help of~~a measuring tape.~~scale and numbers~~ Number of branches per plant, number of leaves per plant and number of root nodules per plant were counted virtually. Yield data ~~For data related to yield~~ was obtained at harvest. For grain and stover yield, ~~from the individual plot,~~ the net plot was harvested and weighed for ~~and subsequently,~~ the grain and stover yield which was ~~thus obtained were weighed and~~ expressed in q/ ha.

~~For~~ protein content in seed was obtained using ~~can be calculated by~~ the formula,

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

Comment [K8]: Use Microsoft equation editor for all formula

Comment [a9]: This is a formula, define the parameters and the constant figures

Among economic parameters, net return ~~per ha~~ was calculated by deducting cultivation cost from gross returns. Cost – benefir~~Benefit cost~~ (C:B~~B:C~~) 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 ~~related~~ 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

Comment [K10]: Can you discuss your results based on the experimental design used? Parameters measured could be discussed at the treatment level

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 ~~Whereas~~ lowest plant height, number of branches per plant and number of leaves per plant~~was~~ were noted with ~~without~~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 ~~vegetative growth of the plant~~plant's vegetative growth. This result is similar with the findings of Sharma and Singh (1997) that ??????. 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~~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). ~~The similar~~Similar results have also been reported by Reddy *et al.,* (2003), Ghosh *et al.,* (2006), Gajera*et al.,* (2014).

### 3.1.2 Effect of Sulphur

The Sulphur also significantly influenced to the plant height at 60 DAS. ~~Highest~~ The highestplant 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 thatthe increase in growth might be due to the better nutrition and their utilization under ~~well fertilized~~well-fertilized plots as compared to lower levels which could not meet ~~out~~ the nutrition requirement of the crop. The results were also found in conformity with those reported by Chaubey*et al*. (2000); Jat*et al*. (2012) and Akter*et al*. (2013) 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 inturn yield of blackgram.

**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 |

**Comment [a11]:** You need to look at how you analyzed your data, Did you use the factorial design? The presentation of your results suggest otherwise. What about your interactions if any?

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### 3.2 Protein content

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

**Effect of Phosphorus**

The result revealed that protein content was significantly influenced by ~~due~~the~~to~~ different levels of phosphorus. Protein content ranged from 21.05 to 24.71%. The highest protein ~~content of~~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 ~~has~~ possibly accelerated the sulphur fixing power of plants by increasing the activity of nodule bacteria, proliferation of root growth resulting in more ~~build up~~build-up to Sulphur content in seed and straw ultimately produce a higher concentration of protein. Similar results were found by Dhage*et al*. (2014) andChesti*et al*. (2012).

**Comment [a12]:** Rephrase the whole sentence

**Comment [a13]:** Careful reconsider your reason for the level of protein rise and provide better justification

**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 ~~produce~~ productof photosynthesis. Accumulation of protein in grain and straw under adequate Sulphur supply might be accredited ~~accounted~~ to the continuous availability of sulphur and ~~enhance~~ enhancementin 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 ~~into~~ ina 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 *etal*. (2017) and Bhat *et al*. (2009).

**Comment [a14]:** So is it the N availability that increased protein level and not P? Your work did not look at varying N

**Table 2. Effect of phosphorus and sulphur on protein content of blackgram**

**Comment [a15]:** The presentation of your result in this table form does ot reflect your design for the analysis

| 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 |

### 3.3 Yield andEconomics

**Effect of Phosphorus**

The data ~~related~~ relatingto 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. ~~Whereas~~ lowest yield per plant and economics was noted ~~with~~ without application of phosphorus applied @ 0 kg/ha (Control). This might be due to the fact that ~~plant~~ plantstreated with optimum phosphorus doses, resulted in higher ~~yield~~ yieldsdue 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. (2021), Yadav *et al.* (2016). Further higher economics is possibly due to proportionately highest net return as compared to the cost involved which contributed to B: C ratio.

**Comment [a16]:** ? did you measure yield in kg/ha or quantum?

**Comment [a17]:**

**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 ~~characters~~ characteristicslike 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 ~~finding~~ findings were reported by Bagayoko*et al*. (2000), Beg and Singh (2009), Singh *et al*. (2018).

**Comment [a18]:** You work needs to be looked at again. Discussion needs to be looked at again. Discuss parameters and look at how each was influenced by treatment. Use scientific and statistical approach to present your results and cite current reference

**Table 3. Effect of phosphorus and sulphur on grainyield, 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 | - | - |



## 4. Conclusion

It can be concluded that ~~the~~ among the phosphorus levels, application of phosphorus @ 60 kg/ha recorded significantly highergrowth 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 ~~blackgram~~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 blackgram for ~~resource poor~~resource-poor farmers.

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