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A review of the effects of phosphorus and sulphur levels on growth, yield, and quality of blackgram

Sunkara Sarada Devi, Pramod Tuppad and Awadhesh Kishore

School of Agriculture
ITM University, Gwalior (M.P.), India

Abstract

The paper reviewed the research work on the effects of phosphorus and sulphur levels on growth, yield, and quality of grams and beans published during 2011-2022. Most of the studies concluded that the levels of phosphorus and sulphur administration influenced the growth, yield, and quality of black gram significantly. The studies compared growth, production, and economic parameters to a valid conclusion. However, the findings varied from study to study but most of the authors showed similar trends. The recommended dose of phosphorus and sulphur for black gram varied for different agroclimatic zones, seasons, soil types and varieties.

Keywords: Black gram, Growth, Phosphorus, Quality, Sulphur, Yield.

Introduction

Blackgram (*Vigna mungo.* L) is one of the most cultivated pulse crops in India. It is popularly known as 'Urd Bean'.Blackgram belongs to the family Leguminoceae. In India, the crop is sown in every season viz. Kharif, Rabi, and summer seasons. Black gram is considered to be one of the cheapest sources of protein. The colour of the seeds varies from black, dark brown, green. *Vigna mungo* commenced from central Asia and India from where it was domesticated. It is found in many tropical zones of Asia, Africa, and Madagascar. Based on geography, India is one of the largest producers of black gram accounting for more than 70% of the global production. After Myanmar and Thailand, India ranks next to these countries. India is the world's largest producer as well as consumer of black gram. It produces about 1.5 to 1.9 million tonnes of black gram annually from about 3.5 million hectares of area, with average productivity of 500 kg per hectare. Black gram accounts for about 10% of India's total pulse production**.** In India Madhya Pradesh, Uttar Pradesh and Andhra Pradesh are the major black gram growing states area-wise. The highest yield was recorded by the state of Bihar (898 kg/ha) followed by Sikkim (895 kg/ha) and Jharkhand (890 kg/ha). The national yield average is 585 kg/ha. Black gram occupies an area of 35.53 lakh hectares with a production of 19.64 lakh tonnes and a productivity of 553 kg/ha. In Madhya Pradesh, black gram is grown in an area of 17.52 lakh hectares with a production of 8.85 lakh tonnes and productivity of 500 kg/ha (GOI 2020). In the Gwalior district, black gram occupies an area of 5.07 thousand hectares with a production of 1.54 thousand tonnes and productivity of

303kg/ha during the year (GOI 2020). Sulphur is one of the essential nutrient elements required for growth and development. Irrespective of crops, sulphur is now called the fourth major plant nutrient. Sulphur is necessary for protein production and activation of enzymes. Sulphur deficiency is mostly caused in coarse-textured soils (Pasricha and Aulakh 1986). Some of the reasons that lead to sulphur deficiency are, the increased removal of sulphur by a crop, high yielding fertilizer crop varieties, increased cropping intensity, and extensive use of sulfur-free fertilizers. The application of sulphur helps to improve the growth, nutrient uptake, grain quality, and yield of black grams (Singh and Aggarwal 1998). To maintain the quality of grains the role of sulphur and phosphorous is important. Sulphur and phosphorous are very essential to increase higher yields. Black gram, being a pulse crop, Black gram requires a high amount of phosphorus (P). Phosphorus is one of the essential macronutrients required for plant growth and development. Phosphorous maintains a role in photosynthesis, metabolism of sugars, energy storage and transfer, cell division, flower formation, cell enlargement, transfer of genetic information, root growth, seed production, nodulation, early crop maturity in plants. Phosphorous acts as an “energy unit” within the plants and helps in root development. The application of some quantity of Phosphorous fertilizers would be essential to sustain the high yield of crops. Phosphorus participates in the process from the starting of seedling growth to seed formation and maturity. It may lead to leaching if Phosphorous is not absorbed by the plant roots. Phosphorous fertilization in legume crops can be used in areas having an adequate amount of water-soluble sulphur. Legume crops usually require an almost equal proportion of sulphur and phosphorous. When sulphur content in the soil was below the critical limit both the growth and quality of the plant were adversely affected. The majority of these enzymes are of great importance in the transformation of energy in the carbohydrate metabolism and respiration of plants.

Effects of Phosphorus levels on growth, yield, and quality of black gram

Patil et al (2011) conducted a field experiment at Parbhani (Maharashtra) consisting of four levels of P_2O_5 (0, 25, 50, and 75 kg P_2O_5 ha^{-1}) and revealed that application of P_2O_5 at 50 kg P_2O_5 ha^{-1} significantly increased the growth of green gram over 25 kg P_2O_5 ha^{-1} and control but at par with 75 kg P_2O_5 ha^{-1}. Patil et al (2011) conducted an experiment on the green gram at Marathwada Agricultural University, Parbhani to conclude that the application of P_2O_5 @ 50 kg ha^{-1} was optimum to harvest the highest yield of green gram. Thenua and Ravindra (2011) conducted a field experiment on chickpeas in sandy loam soil at Lakhota. Results revealed that the application of 60 kg P_2O_5 ha^{-1}, recorded a higher plant height (59.6 cm) and the number of branches per plant (6.3) compared to the control (52.2 cm, 5.8, respectively).

Singh et al (2012) reported that the application of 75 kg P_2O_5 ha^{-1} recorded the maximum plant height, branches per plant, dry matter production per plant, chlorophyll content, leaf area, LAI, grain yield, stalk yield, biological yield, and harvest index, which were significantly superior over 25 kg P_2O_5 ha^{-1} and control (without P_2O_5 application) but at par with 50 kg P_2O_5 ha^{-1} during both the years of experiment. Among the bio inoculants, dual inoculation of PSB + PGPR significantly increased higher growth attributes such as plant height, branches plant, dry matter production, chlorophyll content, leaf area, LAI, grain yield, stalk yield, biological yield, and harvest index.

Akter et al (2013) experimented at Sher-e-Bangla Agricultural University Farm, Dhaka, Bangladesh from December 2008 to April 2009 to evaluate the effect of P (0, 15, 30, 50 kg P_2O_5 ha^{-1}) and S (0, 10, 20, 40 kg S ha^{-1}) and their interaction on the growth and yield of soybean (Glycine max L.) and found highest plant height of soybean with 40 kg S ha^{-1} which was statistically at par with that of 20 kg S ha^{-1}.

Kokani et al (2014) found that P_2O_5 applied 40 kg ha^{-1} on summer black gram significantly increase the plant height at 60 DAS and harvest, number of branches, number of pods per plant, number of seeds per pod, length of the pod, grain (1171 kg ha^{-1}) and stover (2667 kg ha^{-1}) yields as well as protein yield (232.10 kg ha^{-1}) of black gram. Gajera et al (2014) reported that the use of 60 kg P_2O_5 ha^{-1}significantly increased the growth parameters, plant height, branches per plant, dry weight of nodules, leaf area index, and dry matter accumulation as well as yield attributes like the number of pods per plant, grain yield per plant, stover yield and test weight as compared to 40 kg P_2O_5 ha^{-1}. Kokani et al (2014) found the use of 40 kg P_2O_5 ha^{-1}. Significantly increased the plant height, number of branches per plant, number of pods per plant, number of seeds per pod, length of the pod, grain yield of stover yield of summer green gram over control.

Kadam et al (2015) revealed that the use of 40 kg P_2O_5 ha^{-1} on summer green gram significantly increased the plant height, number of leaves, number of branches, and aerial dry matter per plant. Further increase in P_2O_5 level resulted in decreased growth rate indicating that the optimum dose of P_2O_5 for summer green gram was 40 kg ha^{-1}. Singh et al (2015) stated a certain use of 40 kg P_2O_5 enhanced significantly higher no. of seed per pod, no. of pods per plant, no. of nodules, test weight, seed yield, and a further increase in P level fail to produce a significant effect on their indices.

Das (2017) observed that with the application of P_2O_5 a higher number of active nodules were recorded with 60 kg P_2O_5 ha^{-1} at 45 DAS in green gram. Due to the role of P_2O_5 in root development and proliferation which ultimately led to the development of more nodules. Khan et al (2017) reported that the use of 45 kg P_20_5 ha^{-1} significantly increased the dry weight at all stages of 40 and 55 days after sowing than the 40 and 60 kg P_2O_5 ha^{-1}. Patel et al (2017) observed that the higher doses of P_2O_5 (40 kg ha^{-1}) recorded a significantly maximum number of nodules per plant in Kharif green gram. Higher levels of P_2O_5 recorded better growth which facilitated more area for nodule formation. Venktarao et al (2017) stated that the use of 40 kg Phosphorus per hectare on summer green gram recorded the highest no. of total and effective nodules per plant, plant height, and LAI.

Effects of sulphur levels on growth, yield, and quality of black gram

Najar et al (2011) observed that the application of 40 kg S ha^{-1} recorded the highest total N, P, K, S, Ca, and Mg uptake by soybean under temperate conditions in the Kashmir valley. However, the highest S -use efficiency and apparent S recovery were recorded with 10 kg S ha^{-1}, followed by 20 kg S ha^{-1}. The maximum N:S, K:S, Ca:S and Mg:S ratio was recorded under the control, whereas the minimum with the application of 40 kg S ha^{-1} in Stover and seed of soybean. Nawange et al (2011) observed that growth parameters viz., plant height (38.34 cm), the number of branches per plant (5.13), and the number of root nodules per plant (60.50) increased significantly with increasing levels of S up to 40 kg ha^{-1} in chickpea under a medium black clay loam soil at Bhopal. Patil et al (2011) conducted an experiment on the green gram at Marathwada Agricultural University, Parbhani to 18 conclude that the application of S 40 kg ha^{-1} was optimum for the growth and yield of green gram. Prajapati et al (2011) observed that application of S up to 30 kg ha^{-1} in mung bean sole and intercropped with sesame significantly increased the number of pods per plant, seeds per pod, and seed and straw yield of mung bean. Trivedi et al (2011) Application of 40 kg S ha^{-1} gave the highest shoot height, root length, number of leaves per plant, number of pods per plant, length of pods, 100 seed weight, and seed protein content in soybean over control. Thenua and Ravindra (2011) observed a field experiment on chickpea in sandy loam soil at Lakhota. Results revealed that the application of 80 kg S ha^{-1} recorded a higher plant height (58.2 cm) and the number of branches per plant (6.4) compared to the control (50.5 cm and 5.6, respectively).

Bairwa et al (2012) observed that, among different levels of S, 45 kg S ha^{-1} gave significantly higher grain yield (743 kg ha^{-1}) and stover yield (1225 kg ha^{-1}) of a green gram over their respective preceding levels (0, 15 and 30 kg S ha^{-1}) on a pooled basis. Kumar et al (2012) observed that increasing levels of S enhanced the growth, plant height, and yield attributes like number of nodules per plant, dry weight of nodules, number of pods per plant, Number of grains per pod, 1000-grain weight, grain yield, and straw yield showed a maximum increase at 30 kg S ha^{-1} respectively. The increase in grain and straw yield with successive increases in S levels was more at 30 kg S ha^{-1}. Overall, the difference between 20 kg and 30 kg S ha^{-1} did not differ significantly.

Murari Lal et al (2013) experimented on chickpea in sandy clay loam soil at Udaipur. Application of 45 kg S ha^{-1} significantly increased the protein content (23.65%) over control (19.86%) and the rest of the doses. Murari Lal et al (2013) experimented on chickpea in sandy clay loam soil at Udaipur. The application of 45 kg S ha^{-1} significantly increased the grain yield (1854 kg ha^{-1}) compared to the control (1134 kg ha^{-1}) and the rest of the doses.

Bera and Ghosh (2015) stated that the use of 60 kg S per hectare on summer green gram undoubtedly increases the plant height, branches, nodules per plant, and grain output than the low amount of 20, 40 kg S per hectare.

Goswami and Singh (2016) found that the use of 25 kg S ha^{-1} on summer green gram enhanced the plant height, branches per plant, pod per plant, grain per pod, and grain output than the control.

Kudi et al (2018) reported that the use of 30 kg S per hectare on summer green gram enhanced the plant height, branches per plant, number of leaves per plant, number of pods per plant, grains per pod, grain yield than the lower dose 15 kg S ha^{-1}.

Singh et al (2019) experimented at CCS Haryana Agricultural University Krishi Vigyan Kendra, Ambala during the summer season of 2014 to study the effect of P_2O_5 levels and varieties on growth, and yield parameters, yield, economics, and nutrient uptake of green gram. Two varieties of green gram viz. MH 421 and SML 668 and four P_2O_5 levels viz. control (no fertilizer), 20, 40, and 60 kg P_2O_5 ha^{-1} were tested. Cv. MH421 produced significantly higher seed yield (1158 kg ha^{-1}), yield attributing parameters, harvest index, attraction index, net returns (Rs 21001 ha^{-1}), B-C ratio (1.60), and nutrient uptake compared to SML 668 during the summer season. Application of 40 kg P_2O_5 ha^{-1} registered significantly higher seed yield (1283 kg ha^{-1}), yield attributing characters, harvest index, attraction index, net returns (Rs 32351 ha^{-1}), B-C ratio (2.08), and nutrient uptake of green gram compared to control and 20 kg P_2O_5 ha^{-1}. However, 40 kg P_2O_5 ha^{-1} and 60 kg P_2O_5 ha^{-1} were at par with the others.

Kumar and Mehra (2022) experimented with different levels of potassium and S the treatment with potassium at 20 kg ha^{-1} and S at 30 kg ha^{-1} produced significantly highest plant height (51.63 cm), a higher number of nodules (29.46), dry weight per plant (25.05 g), highest crop growth rate (12.56), the highest number of pods per plant (45.74), number of seeds per pod (1.88), seed yield (2.03 t ha^{-1}), stover yield (4.45 t ha^{-1}), and Harvest index (31.29%). However, the treatment with potassium at 20 kg ha^{-1} and S at 30 kg ha^{-1} was found to be effective in the highest gross return (1,23,260.4 INR ha^{-1}), net return (87,830.4 INR ha^{-1}), and Benefit-cost ratio (2.47) when compared to the other treatments.

Effects of interaction effects of phosphorous and sulphur levels on growth, yield, and quality of black gram

Jitendra Kumar (2011) studied the effect of graded levels of P_2O_5 (0, 20, 40, and 60 kg ha^{-1}) and S (0, 20, and 40 kg ha^{-1}) on the growth and yield of garden pea applied through SSP and gypsum, respectively. Application of 60 kg P_2O_5 ha^{-1} produced the highest mature green pod yield (73.83 q ha^{-1}). Similarly, the levels of S up to 40 kg ha^{-1} showed a linear increase in plant height, nodulation, and yield of a garden pea. The 23 applications of 40 kg S produced the highest yield (66.51 q ha^{-1}) in sandy loam soil. Tripathi et al. (2011) conducted a field experiment during Kharif 2006 and 2007 at Kanpur to evaluate the response of genotypes of urdbean (*Vigna mungo* L.) to S fertilization in an Inceptisol. Application of S at 25 and 50 kg S ha^{-1}. Uptake of N, K, and S both in grain and Stover increased significantly with increasing levels of S but P_2O_5 uptake was at par with 25 and 50 kg S ha^{-1}. Yadav (2011) conducted a trial at Udaipur to study the effect of P and S on the yield and quality of cluster beans with three levels of P (10, 20, and 40 kg P_2O_5 ha^{-1}) and three levels of S (0, 10, and 20 kg S ha^{-1}). The results indicated that grain and stover yield was increased with an increase in the level of P and S individually as well as in various combinations.

Akter et al (2013) also reported the significant combined effect of different doses of P and S fertilizers on the number of pods per plant in soybean. They recorded the highest number of pods per plant (30.73) with the combined application of 30 kg P ha^{-1} and 40 kg S ha^{-1}. On the other hand, the lowest number of pods per plant (13.00) was recorded at 11 in the P_0S_0 treatment combination.

Kokani et al (2014) conducted a field experiment during the summer of 2013 at the college farm, Navsari Agricultural University, Navsari to study the response of summer black gram (*Vigna mungo* L.) to FYM, P_2O_5, and S. The plant height at harvest (36.73 cm), the number of branches (5.02), seed yield (1149 kg ha^{-1}), and Stover yield (2652 kg ha^{-1}) of black gram was produced significantly higher under the incorporation of 5 t FYM ha^{-1} over control, which was 10.16 and 19.08 per cent higher over control, respectively. Significantly the higher plant height at harvest (37.38 cm), number of branches (5.18), number of pods per plant (20.68), number of seeds per pod (6.26), length of the pod (4.74 cm), grain yield (1171kg ha^{-1}) and Stover yield (2667 kg ha^{-1}) were obtained with the application of 40 kg P_2O_5 ha^{1} over control. Application of S at 20 kg ha^{-1} was also recorded as significantly highest plant height at harvest (37.07 cm), number of branches (5.17), number of pods per plant (20.93), number of seeds per pod (6.30), grain (1153 kg ha^{-1}) and Stover yield (2548 kg ha^{-1}) over control, respectively. Singh et al (2014) conducted a field experiment at Research Farm of BHU, Varanasi to investigate the effect of P x S application on mung beans in sandy loam soil with four levels of P_2O_5 i.e., 0, 15, 30, and 45 kg P ha^{-1} and three levels of S i.e., 0, 10, and 20 kg S ha^{-1} and concluded that mung bean responds well to

PXS fertilization and improves the productivity and the quality of the seeds.

Das et al (2018) Experimental results revealed that yield attributing characters, yield, and protein content of chickpea were significantly influenced by FYM, P_2O_5, S, and interaction effects of these three factors. Application of 60 kg ha^{-1} P_2O_5 and 20 kg ha^{-1} S in a Farmyard manure treated plot (5 t ha^{-1}) along with a recommended dose of nitrogen and potassium proved to be the best treatment combination for increasing the productivity of chickpea and thereby increasing the pulse production of the country.

Das (2017) conducted a field experiment during pre-Kharif 2010, 2011, and 2012 to study the effects of P_2O_5 and S on yield parameters, yield, nodulation, and nutrient uptake of green gram. The experiment was laid out in a factorial randomized block design with three replications having eight treatment combinations viz. four levels of S (0, 20, 40, and 60 kg ha^{-1}) as factor A and two levels of phosphorous (30 and 60 kg ha^{-1}) as factor B. Application of 60 kg P_20_5 ha^{-1} and 40 kg S ha^{-1} proved to be most economic in green gram with NPV 4.59. Singh (2017) conducted a field experiment during the summer season of 2015 at the Crop Research Centre of the Department of Agriculture, Mata Gujri College, Sri Fatehgarh Sahib to study the response of P_2O_5 and S on yield, yield attributes, Number of pods per plant, number of grains per pod, Pod length (cm), 100-grain weight (g), Grain yield (q ha^{-1}), Stover yield (q ha^{-1}), Biological yield (q ha^{1}) and Harvest index (%) nutrient uptake, net returns, and B-C ratio of summer mung bean. The maximum cost of cultivation (Rs28930), net return (Rs38210), and B-C (2.32) ratio were computed under $P_{60}S_{40}$ followed by all other treatment combinations. Singh and Nariya (2017) observed that the dry matter accumulation increased significantly with the progressive increase in P_2O_5 levels up to 60 kg ha^{-1} at 45, 60, 75, and 90 DAS and harvest. An increasing level of P_2O_5 up to 60 kg P_2O_5 ha^{-1} significantly resulted in P_2O_5 and S content and uptake by stover. Further total uptake of nitrogen, potassium and S by chickpea crop was significantly influenced by increasing levels of P_2O_5 up to 60 kg P_2O_5 ha^{-1} and total P_2O_5 uptake by crop was significantly higher with the application of 40 kg P_2O_5 ha^{-1}.

Phogat et al (2020) revealed the utmost concentration and uptake of P_2O_5 in seed (0.376% and 3.59 kg ha^{-1}) and stover (0.266% and 6.38 kg ha^{-1}) and S in seed (0.397% and 3.79 kg ha^{-1}) and stover (0.134% and 3.21 kg ha^{-1}) with the combined application of P_2O_5 60 kg and S 30 kg ha^{-1}, indicating a synergistic effect of P_2O_5 and S on nutrient uptake, respectively. Singh et al (2020) experimental findings revealed that the treatment T_6 (P at 40 kg ha^{-1} + S at 30 kg ha^{-1}) recorded maximum plant height (32.77 cm), number of nodules per plant (18.56), dry weight (11.92 g $plant^{-1}$), crop growth rate (0.703g m^{-2} day^{-1}), number of pods per plant (24.51), number of grains per pod (6.40), test weight (47.60 g), grain yield (2.76 t ha^{-1}) and protein content (24.28%). However, the maximum stover yield (6.22 t ha^{-1}) was obtained with the treatment T_5 (P at 40 kg ha^{-1} + S at 25 kg ha^{-1}). Maximum gross return (Rs 124200 ha^{-1}), net return (Rs 82422.58 ha^{-1}), and B-C ratio (2.97) were recorded with the treatment T_6 (P at 40 kg ha^{-1} + S at 30 kg ha^{-1}).

Sahu et al (2021) observed that application at 60 kg P_2O_5 ha^{-1} being statistically at par with 40 kg ha^{-1} P_2O_5 registered more growth parameters and yield attributes than the lower levels. The seed yield (1079.6 kg ha^{-1}) and stover yield (2025.1 kg ha^{-1}) were also noted with the application of 60 kg P_2O_5 ha^{1} and it remained statistically at par with 40 kg P_2O_5 ha^{-1}. However, 30 kg S ha^{-1} being statistically at par with 45 kg S ha^{-1} resulted in superior growth attributes, yield parameters, and seed (979.2 kg ha^{-1}) and stover yield (1871.8 kg ha^{-1}) to lower levels. Further, the combination of 60 kg P_2O_5 ha^{-1} and 30 kg S ha^{-1} produced significantly more grain yield (1211.3 kg ha^{-1}) than other treatment combinations. The study concludes that rabi green gram can be grown with 60 kg P_2O_5 and 30 kg S ha^{-1} for better productivity.

Chaudhari et al (2022) conducted a field experiment in randomized block design, the treatments comprised three levels of P_2O_5 (20, 40, and 60 kg P_2O_5 ha^{-1}) as one factor and three levels of S (20, 40, and 60 kg S ha^{-1}) as another factor. The results revealed that an application of 60 kg P_2O_5 ha^{-1} recorded significantly higher P_2O_5 content in seed as well as stover and S content in stover, higher uptake of nitrogen, P_2O_5, potassium, and S by seed as well as stover. An application of 60 kg S ha^{-1} recorded significantly higher S content in seed as well as stover, uptake of nitrogen, P_2O_5, potassium, and S by seed and stover. The interaction effect of 40 kg P_2O_5 ha^{-1} + 60 kg S ha^{-1} recorded significantly higher P_2O_5 and S uptake by the seed of green gram.

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