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Effect of Phosphorus and Sulphur Application on Growth, Yield Attributes, Nutrient Uptake, Quality and Economics of Blackgram (*Vigna mungo* L.): A Review

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ABSTRACT

Phosphorus and sulphur is a key element involved in various functions in growth and metabolism of blackgram. It is frequently a major limiting nutrient for plant growth in most Indian soils. Black gram is the major source of protein for the vegetarian diet and important pulse crop both in terms of area and production. Pulses have been in focus in recent times due to the continuous upswing in their prices. The low productivity of blackgram is due to intensive farming practices and use of exhaustive and high yield cultivars and imbalanced external fertilization. Therefore proper fertilization (site specific and balanced fertilization) is needed to increase the production and productivity of blackgram. Blackgram is very much responsive to phosphorus and sulphur application. In crop plants, the nutrient interactions are generally measured in terms of growth response, yield response and changes in concentration and uptake of nutrients. Studies have indicated synergistic effect between phosphorus and sulphur but their relationship depends on their rate of application and crop species *etc*. A better understanding of nutrient interaction is helpful in maximizing fertilizer use efficiency and net profit. The most of the results revealed that different levels of P and S had a significant effect on growth attributes, yield attributes, grain and haulm yield and quality prarameters of blackgram. The conjoint application up to 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} were found to be superior and synergistic in improving the growth and yield attributes of blackgram. The present paper is a critical review from research findings of eminent scientists on sulphur and phosphorus effect over black gram.

Key words: Black gram, Phosphorus, Proper fertilization, Sulphur.

Black gram (*Vigna mungo* L.) belongs to the family Leguminosae and subfamily fabaceae and the origin is India and Central Asia. Blackgram (*Vigna mungo*) is the important pulse crop in India, Japan and other countries. Blackgram seeds are highly nutritious containing higher amount of protein (22-26%) and minerals which are essential for the growth and development of human and animal body (Table 1). In India, blackgram is the most important pulse crop both in terms of area and production. The important states producing blackgram are Maharashtra, Uttar Pradesh, Andhra Pradesh, Orissa, Tamil Nadu, Rajasthan, Chhattisgarh and Madhya Pradesh. Currently, blackgram area in the country stands at 3.47 m ha. with a production of 1.43 mt. In Tamil Nadu, blackgram is a popular pulse crop occupying an area of 4.56 lakh hectares with a production of 2.36 lakh tonnes (Kannaiyan, 2001). Studies have reported that an increasing demand for blackgram in future. In order to achieve this increasing demand, efficient utilization of all the farming inputs are essential for enhancing the productivity of blackgram.

Proper fertilization is essential to improve the productivity of black gram. It can meet its nitrogen requirement by symbiotic fixation of atmospheric nitrogen. The nutrients which need attention are phosphorus and sulphur (Nandal *et al.,* 1987). Phosphorus is the second most critical plant nutrient but for pulse it assumes primary importance owing to its important role in root proliferation and overall plant growth (Thakur and Negi,1985). Phosphorus is the backbone of balanced fertilization in Indian agriculture. Phosphorus is second most critical plant nutrient, but for pulses, it assumes primary importance, owing to its important role in root proliferation and thereby atmospheric nitrogen fixation. The yield and nutritional quality of pulses is greatly influenced by application of phosphorus. It plays a key role in various physiological processes like root growth and dry matter production,

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nodulation and nitrogen fixation and also in metabolic activities especially in protein synthesis. It also helps in establishing seedling quickly and also hastens maturity as well as improves the quality of crop produce. Phosphorus deficiency in soils is widespread and its use efficiency hardly exceeds 20 per cent. Out of 135 districts under pulses, soils in 68 districts are low and 62 districts are medium in available P status (Shweta and Malik, 2014). The application of phosphorus to pulse crop is one of the most important strategies to increase the productivity of pulses in India.

Next most important emerging nutrient that is showing widespread deficiency is sulphur. Black gram also responds well to sulphur fertilization in S deficient soils. Sulphur is one of the sixteen essential nutrient elements required for normal growth and development. Sulphur plays a key role in sustaining higher production of pulse crop and it is highly required for the formation of protein, vitamins and sulphur containing amino acids *viz.,*cystine, cystein and methionine. Besides, it involves in various metabolic and enzymatic process including photosynthesis, respiration and legume-rhizobium symbiotic nitrogen fixation. Sulphur deficiency has been reported over 70 countries worldwide, of which India is one (Srinivasarao *et al.,* 2004). According to FDCO, survey made during the year 2011 noticed deficiency of sulphur in more than 250 districts of India. Over 27000 soil samples from twelve states of India were analysed, of which 40 per cent were found deficient and another 35 per cent were potentially deficient in available sulphur (Biswas *et al*., 2004). More than 70 per cent soil samples taken from Maharashtra, Orissa, Jharkhand, West Bengal Andhra Pradesh and Karnataka were found low to medium in available sulphur. Lack of knowledge and importance about sulphur, use of exhaustive and high yielding cultivars and neglected usage of farm yard manures seems to have terminated to a wide occurrence of sulphur deficiency. Further intensive farming practices and use of sulphur free phosphatic fertilizers and pesticides became popular (Pareek, 2007) which allegedly reported to show sulphur deficiency. Tamil Nadu is one of the agriculturally important states with very little documents on sulphur status. While comparing sulphur with phosphorus, phosphate ion ($H_2PO_4^-$) is more strongly adsorbed than sulphate (SO_4^{2-}) (Hedge and Murthy, 2005). Phosphatic fertilizer application result in increased anion adsorption sites by phosphate, which releases sulphate ions into the soil solution (Tiwari and Gupta, 2006). Since the bonding strength of $H_2PO_4^-$ is higher than SO_4^{2-}

According to lyotrophic series of anion OH^-> $H_2PO_4^-$> SO_4^{2-}> BO_3^- = Cl^-. One $H_2PO_4^-$ = half of SO_4^{2-} with equimolar concentration. Because of higher bonding strength $H_2PO_4^-$ get adsorbed easily than SO_4^{2-}. Though it is a monovalent anion $H_2PO_4^-$ can easily replace SO_4^{2-} from colloidal complex. Thus, it may be subjected to leaching if not taken up by plant roots. Thus, it may be subjected to leaching if it is not taken up by plant roots. Studies have indicated both synergistic and antagonistic relationship between sulphur and phosphorus but their relationship depends on their rate of application and crop species (Sinha *et al*., 1995).

The pulses per capita availability was 69.9 g in 1951, by increasing in 1971, it comes to 50 g and in 1982 remained only 40 g and in 2005, it was estimated as 27 g. The availability of pulses is very low at present as against required 85 g day^{-1} $capita^{-1}$ for balanced diet. To recover this deficit of production, it is high time to cultivate pulse crops scientifically with efficient nutrient management. According to Indian Institute of Pulses Research vision document, India's population is expected to touch 1.68 billion by 2030 and the pulse requirement for the year 2030 is projected at 32 million tonnes with anticipated required annual growth rate of 4.2 per cent. However, about 2-3 million tonnes of pulses are imported annually to meet the domestic consumption requirement (Anonymous, 2011-12). The present review paper emphasizes the effects of phosphorus and sulphur on growth, yield attributes, yield, nutrient uptake, quality and economics on black gram from research investigations carried out by eminent scientists.

Effect of phosphorus on growth and yield of blackgram

Black gram being a pulse crop requires high amount of phosphorus, which is among the essential macronutrients 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 serves as energy currencywithin plants and helps in root development and grain formation.

Kumawat *et al.* (2013) conducted a research trial on black gram in *kharif* season with different sources of phosphorus (DAP, SSP and PROM), levels (20 and 40 kg ha) and with biofertilizers (PSB and Rhizobium) in sandy soil. DAP source of phosphorus supplementation registered significant increase in pod number $plant^{-1}$ (46.02), grain number pod^{-1} (8.20), test weight (40.63 gm) and seed weight pod^{-1} (0.83gm), seed yield (10.20 q ha^{-1}), haulm yield (21.40 q ha^{-1}) and biological yield (31.61 q ha^{-1}). Gayatri and Saravanapandian (2019) conducted a field experiment with different levels of phosphorus application (0, 20, 40, 60 and 80 kg ha^{-1}) in *kharif* season in Madurai district of Tamil Nadu having Vylogam soil series and found that phosphorus application at 60 kg ha^{-1} gave maximum yield (966 kg ha^{-1}) than other levels and control (693 kg ha^{-1}) in black gram. Similarly the haulm yield was higher (1347 kg ha^{-1}) at 60 kg ha^{-1} of phosphorus application as against no application (1059 kg ha^{-1}). The yield increment of grain and haulm was 39.39% and 33.52% over control which could be due to

Table 1: Nutritive value of blackgram.

Protein	24%	Calcium	154 mg/100 g
Fat	1.4%	Phosphorus	385 mg/100 g
Minerals	3.2%	Iron	9.1 mg/100 g
Fiber	0.9%	Calorific value	347 Kcal/100 g
Carbohydrate	59.6%	Moisture	10.9%

increased phosphorus supplementation to blackgram plants. Dhage *et al.* (2014) stated that phosphorus supply leads to increase in growth as well as yield as a result from acceleration in cell division and enlargement, boosting carbohydrate metabolism, fat metabolism and higher respiration activity in black gram. Kokani *et al.* (2014) tried with different levels of phosphorus application (0, 20 and 40 kg ha^{-1}) in summer black gram at Navsari Agricultural University, college farm during 2013 and observed that 40 kg ha^{-1} of phosphorus application significantly gave higher seed yield (1179 kg ha^{-1}) and haulm yield (2667 kg ha^{-1}) as against control treatment (1079 and 2182 kg ha^{-1}) respectively. Phogat *et al.* (2018) conducted a field experiment with different levels of phosphorus application (0, 20, 40 and 60 kg ha^{-1}) in *kharif* season in Jammu and found that phosphorus application at 60 kg ha^{-1} gave maximum yield (895 kg ha^{-1}) than other levels and control (659 kg ha^{-1}) in black gram. Similarly the haulm yield was higher (1347 kg ha^{-1}) at 60 kg ha^{-1} of phosphorus application as against no application (1059 kg ha^{-1}). Yadav *et al.* (2017) conducted a research trial on black gram in *kharif* season with different levels (20, 40 and 60 kg ha^{-1}) of phosphorus and with biofertilizers (PSB and Rhizobium) in loamy sand soil, among thedifferent levels of fertilizer application 60 kg ha^{-1} recorded the highest pods per grain, test weight of grains, grain yield and straw yield which was closely on par with the 40 kg ha^{-1} phosphorus application treatment. The higher crop growth with more supply of phosphorus might have regulated starch/sucrose ratio in source leaves and reproductive organs resulting in better source to sink assimilation. The beneficial effect of phosphorus on fruiting of plants and better translocation of desired metabolites to the yield contributing parts of the plant might attributed to more grain yield. The improvement in straw yield might be due to the fact that phosphorus tends to increased growth and development in terms of plant height, branches and dry matter by improving nutritional environment of rhizosphere and plant system leading to higher plant metabolism and photosynthetic activity. These findings corroborate the results of Tanwar *et al.* (2003) and Tripathi *et al.* (2011). Kumawat *et al.* (2013) conducted the field experiment in *kharif* season used different levels (20 and 40 kg ha^{-1}) and different sources (DAP, SSP and PROM) of phosphorus in sandy soil. Among the different sources of phosphorus DAP produce significantly higher pods per plant (46.02), grain per pods (8.20), 1000 grain weight (40.63 gm) and seed weight per pod (0.83gm), seed (10.20 q ha^{-1}), haulm (21.40 q ha^{-1}) and biological (31.61 q ha^{-1}) yields.

Effect of sulphur on growth and yield of blackgram

Sulphur is one of the essential plant nutrients for all plants and is indispensable for the growth and metabolism. Sulphur has a number of oxidizing function in soil and plant nutrition. It is a constituent of certain amino acids like methionine, cystine and cysteine and also a constituent of Fe-S proteins called ferrodoxin. The acidity produced by oxidation helps to solubilizing plant nutrients and improves alkali soils (Ram and Katiyar, 2013). Sulphur is also known to promote nodulation in legumes thereby enhancing the N fixation. It is a constituent of free amino acid such as methionine, cysteine and plays a vital role in protein synthesis. Gypsum is preferred more as a source of sulphur because of its diverse role in soil especially in saline and alkaline soils; gypsum is used as amendments also.

Kumar *et al.* (2008) conducted the field experiment in summer black gram using different levels of sulphur (20 and 40 kg ha^{-1}) application in sandy loam soil. Among the different treatments application of 40 kg S ha^{-1} recorded highest grain yield of blackgram (980 kg ha^{-1}). Application of 20 kg ha^{-1} sulphur as gypsum synthesized more protein and account as 24.45% and application of sulphur recorded significantly higher number of pods per plant (22.77), pod length (5.10 cm), seed per pod (6.77) and 100 seed weight (4.88 g) also synthesized more protein and accounted as 24.48 per cent. Enhancement in protein content may be due to sulphur which plays a vital role in nodulation and amino acid synthesis (Dhanushkodi *et al.,* 2009). Kumar *et al.* (2009) studied the experiment on conjoined application of sulphur inoculation with rhizobium and micronutrients. In this study recorded the maximum grain yield (11.32 q ha^{-1}) as compared to any other treatment. Yield attributing characters like number of pods per plant (55) and 100 grain weight (4.69 g) were also higher in the treatment comprising rhizobium, sulphur and all the micronutrients applied treatment. Jawahar *et al.* (2013) conductedresearch trial on black gram in kharif season with different levelsof sulphur (0, 20 and 40 kg ha^{-1}) application in sandy soil. Among the different treatments application of 20 kg S ha^{-1} recorded significantly higher seed yield (1088 kg ha^{-1}) compared to without sulphur (824 kg ha^{-1}) applied treatment. The growth components were enhanced by the higher levels of sulphur at 40 kg ha^{-1} leaf area index 2.33 and chlorophyll content 2.42 and number of branches 8.91. This might be due to the high dose of sulphur and increased availability of sulphur along with other major nutrientsas reported by Kumar *et al.* (2012). Gayathri and Saravanapandian (2019) conducted a field experiment with different levels of sulphur application (0, 20, 40, 60 and 80 kg ha^{-1}) in *kharif* season in Madurai district of Tamil Nadu having Vylogam soil series and found that the sulphur application also significantly increased the grain and haulm yield up to S 40 kg ha^{-1}. The magnitude of increase in grain and haulm yield was 29.41 and 22.96 per cent respectively due to application of S 40 kg/ha over control. The magnitude of response was found more in case of phosphorus as compared to sulphur. The application of sulphur might have increased the availability of nutrient to plants due to improved nutritional environment which in turn favourably influenced the energy transformation activation of enzymes, chlorophyll synthesis as well as increased carbohydrate metabolism. These results corroborate the findings of Dhage *et al.* (2014).

Interaction effect of phosphorus and sulphur

Increasing levels of phosphorus and sulphur enhanced the growth, plant height, yield attributes like number of nodules

plant^{-1}, dry weight of nodules, number of pods plant^{-1}, number of grains pods^{-1}, 1000 weight, grain yield and straw yield showed maximum increase at 45 kg P ha^{-1} and 30 kg S ha^{-1}, respectively (Kumar *et al.,* 2012). Gayatri and Saravanapandian (2019) concluded that interaction effect of phosphorus and sulphur have strong synergistic effect and registered the highest grain yield (1118 kg ha^{-1}) and haulm yield (1683 kg ha^{-1}) by combined application of P 60 kg/ha + S 40 kg/ha. This might be due to greater release and uptake of nutrients causing a favourable environment for better growth and development of plants. These results are in conformity with the findings of Niraj and Prakash (2014) in blackgram. The P and S both being anions might have complemented each other for the absorption sites in order to strike a proper balance between cation and anion in producing synergistic effect (Aulakh and Pasricha 1977). Singh *et al*. (1997) reported that nature of P and S interaction depends on their rate of action. Ram and Katiyar (2013) conducted the field experiment in summer mungbean under arid climate and concluded that highest plant height (50.12 cm), number of branches plant^{-1} (12.72), number of nodules plant^{-1} (35.25), number of pods plant^{-1} (21.89), number of seeds pod^{-1} (12.99), test weight (38.73 g) and seed yield (12.51 q ha^{-1}) and protein content (24.07%) was obtained at 40 Kg S ha^{-1} along with phosphorus at60 kg ha^{-1}. Protein in legume was appreciably increased with the application of phosphorus and adequate quantities of sulphur also play an important role in improving the crop quality. Application of 40 kg S ha^{-1} may regarded as beneficial dose of sulphur application from the point of view of increasing the protein content 23.94% seed of blackgram (Singh *et al.,* 2013). Statistical data from investigations on the combined application of sulphur and phosphorus, showed significant increase the highest plant height (43.53 cm), number of branches per plant (5.79), leaf area index (3.97, 4.17 and 4.65 at 20, 40 and 60 DAS) and dry matter content (4.64, 7.63 and 10.65 g plant^{-1} at 20, 40 and 60 DAS, respectively) were observed in treatment (40 kg S ha-^{1} + 60 kg P ha^{-1}). With respect to yield attributes and yield the results indicated that significantly the maximum number of pods per plant (20.47), weight of 100 seeds (4.07 g), seed yield (819 kg ha^{-1}) and straw yield (1551 kg ha^{-1}) were found with the application of 40 kg S ha^{-1} + 60 kg P ha^{-1} Kumawat *et al.* (2014). Gokila *et al.* (2017) conducted the field experiment in two different soil series (Vylogam and Peelamedu) of Madurai district in combined application of phosphorus and sulphur. They conclude the highest growth parameters such as plant height (54.7 cm, 55.9 cm), number of leaves per plant (54.8, 58.8), Number of pods per plant (34.7, 38.8), Number of seed per pod (7.4, 8.4) and grain yield (1145, 1275 kg ha^{-1}) and straw yield (1645, 1990 kg ha^{-1}) and quality parameters *viz*., protein (23, 24.2%) and methionine (8.92, 8.97 mg g^{-1}) were significantly increased by the S @ 20 kg ha^{-1}along with other major nutrient supplement treatment when compared to control in Vylogam and Peelamedu series.

Effect of phosphorus and sulphur application on nutrient uptake of blackgram

The yield of the crop is generally mediated through the absorption of nutrients which is reflected in the nutrient concentration in different parts of the plant. The uptake values of nutrients are particularly useful in determining nutrient use efficiency. The uptake values, in general are governed by the dry matter yield and the nutrient concentrations. The increase in uptake values may be mediated through dry matter production or higher nutrient content.

Yadav *et al.* (2017) studied the field experiment with different levels of phosphorus (0, 20, 40, 60 and 80 kg ha^{-1}) and bio fertilizer application in kharif season in Agronomy Farm, S.K.N. College of Agriculture in loamy sand soil and concluded that application 60 P kg ha^{-1} recorded the maximum total nitrogen uptake (85.87 kg ha^{-1}), total phosphorus uptake (10.07 kg ha^{-1}) and total potassium uptake (55.91 kg ha^{-1}) against control treatment. The beneficial effect of phosphorus on fruiting of plants and better translocation of desired metabolites to the yield contributing parts of the plant might attributed to more grain yield reported by Kumawat *et al.* (2013). Gayatri and Saravanapandian (2019) obtained maximum N uptake in grain (36.34 kg ha^{-1}) and haulm (50.83 kg ha^{-1}), P uptake in grain (4.36 kg ha^{-1}) and haulm (4.54 kg ha^{-1}), K uptake in grain (12.30 kg ha^{-1}) and haulm (24.24 kg ha^{-1}) and S uptake in grain(3.80 kg ha^{-1}) and haulm (4.71 kg ha^{-1}) with conjoint application of 60 kg P_2O_5 ha^{-1} + 40 kg S ha^{-1} and the least NPKS uptake was observed in control plot from the research investigation carried in Vylogam soil series of Madurai district in Tamil Nadu with different levels of phosphorus (0, 20, 40, 60 and 80 kg ha^{-1}) and sulphur (0, 20, 40, 60 and 80 kg ha^{-1}) application in *kharif* season. The phosphorus uptake was found to be more in grain than haulm because absorbed phosphorus might have been translocated from root to shoot and finally in grain and further the applied phosphorus have been effectively utilized by the plants which leads to the formation of certain organophosphorus compounds in the grain (Dwivedi *et al*., 2000). Kachave *et al.* (2018) studied the phosphorus and PSB application of Black gram [*Vigna mungo* (L.)] in Inceptisol during *kharif* season and concluded that 60 kg phosphrous application recorded the maximum N uptake in grain (32.14 kg ha^{-1}) and haulm (48.83 kg ha^{-1}) and P uptake in grain (3.12 kg ha^{-1}) and haulm (3.95 kg ha^{-1}) over the control treatment. Phosphorus stimulates the symbiotic nitrogen fixation because in presence of phosphorus bacterial cell becomes mobile which is pre requisite for migration of bacterial cell to root hair for nodulation (Charel, 2006). Phosphorus helps in proper root development which increases root nodules and consequently increases nitrogen fixation. It also plays an important role in the process of photosynthesis, energy conservation and transportation, cell division.

Effect of phosphorus and sulphur application on quality parameters of blackgram

Various levels of phosphorus and sulphur showed a significant variation with regard to protein content of

blackgram. Niraj and Prakash, (2014) reported the protein content in black gram increased significantly by phosphorus and sulphur application upto 60 kg ha^{-1} of each nutrient. The maximum increase in protein content 17.90 percent was obtained with 60 kg P and 45 kg S ha^{-1} together. The response to applied phosphorus withrespect to protein content in black gram is attributed to more nitrogen fixation. Similar results were also reported by Kumawat *et al*. (2014). Increasing doses of sulphur application resulted in a significant increase in protein content of blackgram. The positive response to added sulphur is assigned tolow status of available sulphur of soil or due to stimulating effect of applied sulphur in the synthesis of protein resultingin greater photosynthetic efficiency which in turn translated in term of increased yield. Yadav *et al*. (2017) conducted a field experiment in different levels of phosphorus application(0, 20, 40 and 60 kg ha^{-1}) and the concluded them application of 60 kg ha^{-1} P significantly increased the protein content (23.63 per cent) of black gram, because the application of phosphorus might have nutritional environment in rhizospheric as well as in plant leading to increased uptake and translocation of nutrients especially of nitrogen in reproductive structures which led to higher content and uptake. Kachave *et al.* (2018) studied the field experiment in different levels of phosphorus application (0, 30, 40, 50 and 60 kg ha^{-1}) in sandy loam soil and concluded that application of 60 kg ha^{-1} P recorded the maximum protein content (23.77) and protein yield (294.46 kg ha^{-1}) compared to the control treatment becausephosphorus helps in root enlargement, better microbial activities therefore more availability and uptake of N thereby, increased protein content ultimately resulted in increased protein yield. Similar results were reported by Dongare *et al.* (2016). Gokila *et al.* (2017) conducted a research trial on black gram in rabi season with different sources of sulphur (Gypsum, Ammonium sulphate and Potassium sulphate) and levels of sulphur (10 and 20 kg ha^{-1}) in Peelamedu (*Typic haplustert*) and Vylogam (*Typic rhodustalf*) soil series. Potassium sulphate source of sulphur supplementation (20 kg ha^{-1}) registered significant increase in quality parameters *viz*., protein (23, 24.2%) and methionine (8.92, 8.97 mg g^{-1}) content in the different S sources when compared to control in Vylogam and Peelamedu series. Application of S serves for several structural, regulation of secondary metabolites and catalytic functions in the sense of proteins, tripeptide glutathione (redox buffer) and certain proteins such as thioredoxin, glutaredoxin and protein disulphide isomerase. This attributing to regulation activity, involved in light reaction (CO_2 fixation) of photosynthesis, which will increase the assimilation of N and S responsible for S containing amino acids, *viz*., methionine and cysteine reported by Singh and Sarkar (2013). Mir *et al*. (2013) tried with different levels of phosphorus (0, 30 and 60 kg ha^{-1}) and sulphur (0, 20 and 40 kg ha^{-1}) applicationin black gram at Allahabad Agricultural Institute- Deemed University, college farm during 2013 and observed that 60 kg ha^{-1} of phosphorus and 40 kg ha^{-1} sulphur application significantly gave higher protein content (22.64%). The highest protein content of black gram was recorded in higher fertilizer supplemented treatment because sulphur increases the nitrogen absorption in plants which ultimately increased the protein content in seeds and sulphur play a important role in synthesis of sulphur containing amino acids and nitrogen uptake.

Benefit cost ratio

Kumawat *et al*. (2013) conducted a research trial on black gram in kharif season with different sources of phosphorus (DAP, SSP and PROM), levels (20 and 40 kg ha) and with biofertilizers (PSB and Rhizobium) in sandy soil. DAP applied recorded the highest net returns Rs. 25112.60 ha^{-1} with benefit cost ratio of 2.77. At the same time different levels of fertilizer application 40 kg ha^{-1} phosphorus applied treatment recorded the highest net returns of Rs 26315.54 ha^{-1} and the benefit cost ratio of 2.80 compare to the other treatments. Gayatri and Saravanapandian (2019) conducted a field experiment with different levels of phosphorus (0, 20, 40, 60 and 80 kg ha^{-1}) and sulphur (0, 20, 40, 60 and 80 kg ha^{-1}) application in *kharif* season in Madurai district of Tamil Nadu having Vylogam soil series and found that the maximum net profit was recorded under the treatment $P_{60}S_{40}$ (Rs 39333) and the lowest under P_0S_0 (Rs 11693). The magnitude of benefit-cost ratio varied from 1.68 to 2.65. The highest B-C ratio of 2.65 was registered in case of P_{60} S_{40}, based on the findings of this study provided a sound base to believe that combined application of phosphorus and sulphur increased the grain and haulm yield of blackgram crop over control and was proved to be the most economical treatment for increasing net profit. Similar findings were made by Das (2017). Kokani *et al.* (2014) tried with different levels of phosphorus (0, 20 and 40 kg ha^{-1}) and sulphur (0, 20 and 40 kg ha^{-1}) applicationin summer black gram at Navsari Agricultural University, college farm during 2013 and observed that 40 kg ha^{-1} of phosphorus along with 20 kg ha^{-1} sulphur application significantly recorded the higher net return (Rs. 58873/ha) and BCR (4.58) whereas, the lowest net return (Rs. 52085/ha) and BCR (4.14) was recorded under control treatment. Increase in the gross and net realization might be due to increase in the seed yield under the same treatment. This is in accordance with the findings of Marko *et al.* (2013).

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