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Influenced of different levels and sources of Sulphur on nodulation and quality of Blackgram [*Vigna mungo* (L.) Hepper]

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Abstract
A field experiment was conducted at Narendra Deva University of Agriculture and Technology Kumarganj Faizabad Uttar Pradesh to study the effect of different levels and sources of sulphur on yield, nodulation and quality of black gram. Therefore, the investigation was assessed with two sources of S as Gypsum and Elemental Sulphur with four levels (S @ 0, 20, 40 and 60 kg ha^{-1}). The result revealed that, the maximum grain (10.92 q $ha^{-1)}$ and straw (26.54 q ha^{-1}) were observed at 60 kg S ha^{-1} which was statistically at par with 40 kg S ha^{-1}. While, gypsum recorded significantly higher grain (10.82 q ha^{-1}) and straw (24.91 q ha^{-1}) yield over elemental Sulphur. Quality parameters *viz.*, protein (24.30 %) methionine (8.82, mg g^{-1}), number of nodules(33.99), fresh weight of nodules(0.88 g $plant^{-1}$) and dry weight of nodules (0.398 g $plant^{-1}$) recorded maximum with application of 60 kg S ha^{-1} which was statistically at par with 40 kg S $ha^{-1.}$ Gypsum recorded significantly highest protein and methionine content over elemental Sulphur. Therefore, it is concluded that the application 40 kg S ha^{-1} through gypsum proved to be beneficial for getting maximum yield and quality of black gram.

Keywords: Grainyield, Elemental Sulphur, Gypsum, Nodulation, Protein and Methionine

Introduction
Black gram is one of the most important pulse crops grown in India. It is mainly grown for human consumption but also used as fodder for cattle and green manure for soil fertility. Seeds are mainly cooked, as 'Dal' in our country. Being a legume crop, black gram has the ability to fix atmospheric nitrogen symbiotically with the nodule producing bacteria Rhizobium sp. Responses of black gram to added fertilizers sulphur have been found to vary with soil conditions. Sulphur being an essential element for plant growth present in major metabolic compounds such as amino acids (methionine and cysteine), glutathione, proteins, are particularly important for legumes. Modern intensive farming has resulted in higher demand for fertilizer because of removal of all the essential nutrients in higher proportions by the crops. Most of our attention for fertilizer use has been restricted to the use of N, P and K, the three primary nutrients required by the crops in large quantities. Sulphur is an important secondary nutrient elements and it is indispensable for the synthesis of certain amino acids like cysteine, cystine and methionine besides being involved in various metabolic and enzymatic processes of plants (Schnug, 1991; McGrath *et al*., 1996 and Zhao *et al*., 1999). Low S levels in Indian soils is regularly the main reason for low yield of cereals, pulses, oilseeds and commercial crops due to its involvement in the assimilation of nitrogen, photosynthesis, in synthesis of proteins and S containing amino acids. The widespread S deficiency in Indian soils depends more on climate, vegetation, parent material, soil texture, and management practices. Sulphur and nitrogen both are required for the synthesis of protein; therefore, the ratio of total N to total S in plant tissue can reflect the ability of N and S in protein synthesis Brunold and Suter, 1984). Hence, the present investigation was undertaken to find out the response of blackgram to different levels and sources of sulphuron nodulation and quality of black gram.

Materials and methods
Field experiments were conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj Faizabad in 1997. The soil of the experimental plot was silty loam having pH 8.25, organic carbon 0.32%, and the available N, P, K and S 124, 18.50, 145.32 and 12.54 kg ha^{-1}, respectively. The experiment was carried out in Factorial Randomized Block Design with four replications.

The treatments consisted four levels of S (0, 20, 40 and 60 kg ha-[1]). Elemental Sulphur and Gypsum was used as a sources of sulphur. Black gram (T-9) was grown as test crop. A uniform dose of N(15 kg ha^{-1}) and P_2O_5 (50 kg ha^{-1}) were applied through urea and DAP, respectively at the time of sowing. Sulphur was applied at the time of sowing as per the treatment. All the agronomic package of practices were performed for growing crops. The number of nodules per plant were recorded at 25 days interval, whereas yield parameters (grain and straw yield qha^{-1}) were recorded at harvesting. Protein content calculated by multiplying factor 6.24 in nitrogen (determined using standard procedure by Jackson, 1973). Methionine was estimated by colorimetric method (Sadasivam, S. and A. Manikam, 1992). Statistical analysis of the data was carried out using standard analysis of variance (Gomez and Gomez 1984). The significance of the treatment effect was determined using the F-test and to determine the significance of the difference between the means of the two treatments, least significant differences (LSD) were estimated at the 5 % probability level.

Results and discussion

Grain yield and Straw Yield of black gram

Sulphur application significantly influenced the grain and straw yield (Table 1) of black gram. Maximum grain yield(10.92 q ha-1) and straw yield (26.54 q ha-1) was observed with the application of 60 kg S ha^{-1}which was statistically at par with application of 40 kg S ha^{-1},while minimum grain yield (7.89 q ha^{-1}) and straw yield (20.12 q ha^{-1}) were recorded in control plot. The maximum biological yield (36.96 q ha^{-1}) was observed at 60 kg S ha^{-1} which was statistically at par with 40 kg S ha^{-1}. The maximum harvest index (30.93 was noticed in the same treatment while, minimum harvest index was recorded in control plot. Gypsum recorded maximum grain yield (10.82 q ha-1) and straw yield (24.91 q ha-1) which was significantly higher than elemental sulphur. Similar trend were observed in biological yield and harvest index. The increase in grain yield might be due to vigorous growth which helped the plants in more absorption of nutrients from the soil (Singh, *et al.*, 1994). The results were in line with those of Dubey, (1996) and Karwasara and Roy, (1984).

Effect of Sulphur on Nodulation of Black gram

The application of 60 kg S ha^{-1}showed significantly (Table 2) more number of nodules per plant (33.99), fresh weight of nodules per plant (0.88 g) and dry weight of nodules per plant (0.398 g) over control and 20 kg S ha^{-1} while, 40 kg S ha^{-1} found at par. Sinha and Sakal (1993) have also reported that a good supply of sulphur helps in proliferation of nodules over the roots of the legumes. Gypsum proved to be the best source of sulphur with 32.63 nodules per plant, 0.85 g fresh weight of nodules per plant and 0.313 g dry weight of nodules per plant over elemental sulphur. This is might be due to application of S as $CaSO_4$ which increase the availability sulphur in sodic soils. These results are corroborated with the finding of Pathak and Pathak1972. Gypsum was recorded to the best one for increasing the dry weight of nodules plant-[1]. The result are parallel to the findings of Raman and Prasad (1983), Ram and Dwedi (1990) and Khandkar and Shinde (1991).

Effect of sulphur application on quality parameters of blackgram

Protein content (Table 2) improved with the increasing levels of sulphur. The maximum protein content (24.30 %) was recorded with the application of 60 kg S ha^{-1} in black gram. The gypsum was found to be the best sources with regard to protein content (23.83 %) followed by elemental sulphur (23.18%). This might be attributed to the fact that sulphur is the best known for its role in the formation of amino acid *i.e.* methionine, cysteine and cysteine and synthesis of protein. S application in respect of protein content was reported by many workers. Dubey and Mishra (1970), Kumar *et al.,* (1981) and Ram and Dwivedi (1992). As in the case of protein, the methionine content of blackgram was also significantly influenced by S application and it varied from7.02 to 8.80 mg g^{-1}. While comparing the treatments, application of 60 kg S ha^{-1} recorded significantly highest methionine content (8.82) mg g^{-1}which was at par (8.80) mg $g^{-1}$with the application of 40 kg S ha^{-1}. The highest methionine content was recorded in application of Gypsum (8.7mg g^{-1}) followed by elemental sulphur (8.3 mg g^{-1}). This was ascribed by application of S regulating nitrate reductase enzyme (Nitrate assimilation pathway), these leads to maintain the N: S (15:1) ratio in blackgram plant tissues. Application of sulphur increases sulphur availability which has a role in regulating nitrate reductase, in addition to its role in regulating ATP-sulphurylase. This result was corroborating with the findings of Josefsson (1970) who found that S fertilization had increased the Scontaining amino acids in rapeseed. On the basis of result achieved during field trial conducted on black gram it may be recommended that 40 kg S ha^{-1} applied through gypsum proved to be beneficial for getting maximum yield, nodulation and quality of black gram.

Table 1: Effect of sources and levels of Sulphur on Grain Yield, Straw Yield, Biological Yield (q/ha), and Harvest Index of Black gram

Treatments	Grain (qha^{-1})	Straw (qha^{-1})	Biological Yield (qha^{-1})	Harvest Index
Sources of Sulphur				
Elemental Sulphur	10.10	24.17	34.27	29.57
Gypsum	10.82	24.91	35.73	30.56
SEM ±	0.13	0.22	0.37	-
C.D. (0.05)	0.39	0.65	1.10	-
Level of Sulphur(kg/ha)				
Control	7.89	20.12	18.01	28.18
20	9.86	23.03	32.89	29.23
40	1080	26.06	36.86	30.54
60	10.92	26.54	36.96	30.93
SEM ±	0.16	0.27	0.45	-
C.D. (0.05)	0.48	0.80	1.35	-

Table 2: Effect of sources and levels of Sulphur on nodulation and quality parameters of black gram

Treatments	No. of nodules plant^{-1}	Fresh weight of nodules plant^{-1}(g)	Dry weight of nodules plant^{-1}(mg)	Protein Content (%)	Methionine (mg g^{-1})
Sources of Sulphur					
Elemental Sulphur	31.52	0.79	274	23.18	8.5
Gypsum	32.63	0.85	313	23.83	8.7
SEM ±	0.27	0.01	8	0.14	0.14
C.D. (0.05)	0.80	0.05	25	0.43	0.30
Level of Sulphur(kg/ha)					
Control	27.25	0.66	21	22.99	7.02
20	30.90	0.77	234	23.08	7.50
40	33.34	0.85	397	24.05	8.80
60	33.99	0.88	398	24.30	8.82
SEM ±	0.33	0.02	10	0.71	0.12
C.D. (0.05)	0.98	0.06	30	0.53	0.32

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