Madras Agric. J., 87(7-9): 456-458 July - September 2000
https://doi.org/10.29321/MAJ.10.A00500

Influence of sulphur application on nodulation and protein content of blackgram

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Abstract : Field trials were conducted during the *kharif* and *rabi* seasons of 1995 and 1996, to evaluate the efficacy of different sources and levels of sulphur on the nodulation and protein content of blackgram. Different sulphur sources viz., elemental sulphur, gypsum and pyrite were tried at 0, 10, 20, 30 and 40 kg S/ha^{-1} levels. Gypsum proved its superiority over other sources by recording highest nodule number/ plant, nodule dry weight and nitrogenase activity. Increasing doses of sulphur increased all the above characters. Protein content was also favourably altered due to gypsum application and higher doses of sulphur. (*Key Words* : Sulphur, Nodulation, Protein content, Blackgram)

Sulphur nutrient is now considered as the fourth major nutrient due to its role played in the growth and metabolism of plants. It has a number of important functions in plant nutrition and is best known for its role in protein synthesis (Singh *et al.* 1994). Nodulation in legumes is a unique character, which is also affected by sulphur application (Khandkar *et al.* 1985). In the recent years sulphur deficiencies are increasingly reported and recognised in India. Intensive cropping with ignorance of replenishing the sulphur removed by crops is considered as the major reason for sulphur deficiency in soils (Singh, 1995). With an objective to find a best source and level of sulphur, this trial was initiated in blackgram.

Materials and Methods

Field trails were conducted at National Pulses Research Centre, Vamban (Pudukottai Dist.,) Tamil Nadu, during the *Kharif and Rabi* seasons of 1995 and 1996 to find out the best sulphur source and level for blackgram. The soil of the experimental field was alfisol with sandy clay loam in texture and with a pH 6.2. The available N.P.K. status was low (186 kg ha^{-1}), low (9.3 kg ha^{-1}) and medium (198 kg ha^{-1}) respectively. Sulphur content of the soil was 11.5 kg ha. Three different sources viz., elemental sulphur (90% S), gypsum (15% S) and pyrite (20% S) were evaluated at 0, 10, 20, 30 and 40 kg. S ha^{-1} levels. The trial was executed in a factorial randomised block design replicated thrice. Sources of sulphur formed one factor while levels of sulphur formed the other factor. The crop was uniformly nourished with 25:50:25 kg NPK ha^{-1}. Plants were uprooted at flowering stage and the total number of pink coloured effective nodules in the roots were separated and counted. Separated nodules were oven dried and weighted for nodule dry weight measurement. Nitrogenase activity was estimated as per the method suggested by Hardy *et al.* (1968) and expressed as µ mole of ethylene/g of nodule/hr. Protein content in the grain was calculated by multiplying the total nitrogen content with the factor 6.25. Short duration variety Vamban 1 was taken for study.

Results and Discussion

Effective nodules / plant

Sulphur application had a significant role in increasing the number of effective nodules/plant during both the seasons (Table 1). Among the different sources gypsum proved its superiority by recording the highest number of root nodules/plant. Elemental sulphur and pyrite were on par in their effect. The superiority of gypsum application might be attributed to the readily available sulphate form of sulphur in gypsum (Pandey, 1989). Increasing levels of sulphur increased the nodule number markedly. Higher levels of sulphur (40 kg ha^{-1}) produced higher number of nodules/plant. Increased nodulation due to sulphur application is due to the involvement of sulphur in the production of ferodoxin and nitrogenase enzyme which is the key factor for increasing the rhizhobium infection sites and nitrogen fixation (Kandpal and Chandel, 1993).

Nodule dry weight

The effect of sulphur was distinct in influencing the nodule dry weight (Table 1). Gypsum application tented to produce significantly higher nodule dry weight than elemental sulphur and pyrite. The effect of elemental sulphur and pyrite were on par during both the seasons. Increased number of nodules/plant was due to increased availability of sulphur from sulphur application. Among the different levels tried sulphur at 40 kg ha^{-1} was significatly superior in producing higher nodule dry weight.

Nitrogenase activity

Positive influence of sulphur on the

nitrogenase activity was observed during both the seasons (Table 1). Comparing the sulphur sources, gypsum was significantly superior in increasing the nitogenase activity. Easily and readily available sulphate form of sulphur in gypsum might have triggered the nitrogenase activity in root nodules. Incremental doses of sulphur also increased the nitrogenase activity. Higher doses of sulphur (40 kg ha^{-1}) recorded the highest nitrogenase activity. Increased nitrogenase activity due to sulphur application was also reported by Kasthuri *et al.* (1992).

Protein content

Various sources and levels of sulphur exhibited substantial influence on the crude protein content of blckgram grains during both the seasons (Table 1). Gypsum application synthesised significantly higher protein content, which contributed for 9.8% and 8.7% increase over elemental sulphur and pyrite. The effect of elemental sulphur and pyrite were similar. Favourable effect of gypsum on the protein content is due to increased nitrogen uptake and its effective translocation to the grains. Increasing levels of sulphur resulted in substantial increases in the crude protein content. Sulphur at 40 kg ha^{-1} synthesised highest crude protein of 21.8% and 20.9% during *kharif* and rabi respectively. Favourable influence of sulphur on protein content is attributed to the role of sulphur in the synthesis of sulphur containing aminoacids and nitrogen uptaks. Similar views were expressed by Surendra Singh *et al.* (1992).

Grain yield

There was significant effect of sources and levels of S on grain yield of blackgram during both the seasons (Table 2). Gypsum yielded 1245 kg ha^{-1} and 979 kg ha^{-1} of grain during *kharif* and rabi seasons respectively which was 25.2 per cent and 19.3 per cent increased yield over pyrite and elemental sulphur. The grain yield varied only marginally between pyrite and elemental S and they were comparable with each other. Positive response to gypsum application might be due to easily available sulphate sulphur in gypsum and due to its higher solubility. Similar findings were reported by Biswas *et al.* (1986) and Hariram and Dwivedi (1992). The poor response to elemental S and pyrite might be due to low oxidation rate of sulphide to sulphide to sulphate form of sulphur (Arora *et al.* 1991). Among the levels of sulphur, 40 kg S ha^{-1} produced significantly higher yield during both the seasons. However, this was on par with 30 kg S ha^{-1}. Progressive yield increase observed due to incremental sulphur doses might be due to the cumulative favourable effect of sulphur on growth attributes, nodulation, yield components and uptake of nutrients.

Economics

Sources and levels of sulphur were found to alter the benefit cost ratio (BCR). Sulphur nutrition through gypsum was more effective in increasing the monetary returns (Table 2). Gypsum gave the highest

Table 1. Effect of sulphur application on nodulation and protein content of blackgram.

Treatments	Nodule number / plant			Nodule dry weight (g/ plant)			Nitrogenase activity*			Protein content (%)		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
Elemental S	13.21	11.50	12.36	28.72	24.42	0.115	0.110	0.113	19.97	19.12	19.55	
Gypsum	20.80	19.79	19.36	43.40	32.88	38.14	0.562	0.481	0.522	21.96	21.00	21.48
Pyrite	14.31	13.32	13.82	30.07	25.54	27.81	0.123	0.118	0.121	20.30	19.20	19.75
SEd	1.16	1.61	-	1.06	0.59	-	0.033	0.034	-	0.23	0.25	-
CD (5%)	2.39	2.65	-	2.19	1.22	-	0.069	0.071	-	0.48	0.52	-
S-levels (kg ha^{-1})												
0	9.12	7.82	8.47	22.12	18.14	20.13	0.125	0.117	0.121	19.10	18.12	18.61
10	12.09	9.56	10.83	26.82	20.68	23.75	0.211	0.204	0.208	19.74	18.51	19.13
20	14.33	13.44	13.89	30.91	25.50	28.21	0.393	0.350	0.371	20.48	19.25	19.13
30	17.36	15.87	16.62	36.65	30.07	33.36	0.517	0.496	0.507	20.92	19.96	20.44
40	20.64	18.20	19.42	41.87	33.91	37.89	0.714	0.679	0.697	21.83	20.97	21.40
SEd	1.34	0.85	-	1.23	0.69	-	0.011	0.020	-	0.27	0.29	-
CD (5%)	2.76	1.72	-	2.53	1.41	-	0.023	0.042	-	0.55	0.61	-

* μ mole of ethylene/g of nodule/hour

BCR of 3.33 and 2.43 during kharif and rabi seasons respectively. Among the levels, 40 kg S/ha^{-1} produced the highest BCR which was comparable with the BCR produced by 30 kg S/ha^{-1}. The reason could be attributed for lower input cost and higher returns in the respective treatments.

From the study it may be concluded that application of sulphur at 30 and 40 kg/ha^{-1} in the form of gypsum enhances nodulation, protein content, yield and economics of irrigated blackgram.

Table 2. Effect of sources and levels of sulphur on yield and economics of blackgram.

Treatments	Grain yield (kg/ha)			Benefit Cost Ratio		
	Kharif	*Rabi*	Mean	*Kharif*	*Rabi*	Mean
S-sources						
Elemental S	946	826	886	2.24	1.83	2.04
Gypsum	1245	979	1112	3.34	2.43	2.89
Pyrite	1009	855	932	2.52	2.64	2.58
SEd	32	27	-	-	-	-
CD (5%)	66	55	-	-	-	-
S-levels (kg ha^{-1})						
0	832	704	768	1.94	1.48	1.71
10	920	756	838	2.22	1.65	1.94
20	1002	843	922	2.48	1.93	2.21
30	1120	938	1029	2.86	2.23	2.55
40	1225	1010	1117	3.26	2.51	2.89
SEd	37	30	-	-	-	-
CD (5%)	76	63	-	-	-	-

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(Received : July 1992; Revised: November 2000)