Environment and Ecology 41 (1B) : 425—431, January—March 2023
ISSN 0970-0420

Effect of Sulfur Fertilization and Foliar Nutrition on Yield Attributes of Blackgram cv ADT 3

G. Baradhan, S. Joyson, S. M. Suresh Kumar, S. Manimaran, G. Sathiya Narayanan

Received 7 October 2022, Accepted 6 January 2023, Published on 6 March 2023

ABSTRACT

Field investigation was carried out to study the effect of sulfur fertilization and foliar nutrition on yield attributes of blackgram cv ADT 3 at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar. The field experiment was laid out in split plot design with 3 replications. The main plot constitutes RDF alone (M_1), RDF + 15 kg S ha^{-1} (M_2), and RDF + 20 kg S ha^{-1} (M_3). In sub plots, foliar nutrition practices viz., control (S_1), two per cent DAP foliar spray on 25 and 45 DAS (S_2), 0.5% MAP foliar spray on 25 and 45 DAS (S_3), two per cent urea foliar spray on 25 and 45 DAS (S_4), two per cent water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS (S_5) and 0.5% chelated micronutrient mixture foliar spray on 25 and 45 DAS (S_6). The result indicated that RDF + 20 kg S ha^{-1} combined with 0.5% chelated micronutrient mixture foliar spray on 25 and 45 DAS (M_3S_6) recorded highest values of above yield attributes such as pod length, number of pods plant^{-1}, number of grains pod^{-1}, grain yield and haulm yield of blackgram cv ADT-3.

Keywords Blackgram, Sulfur, Yield attributes, Chelated micronutrient.

INTRODUCTION

Blackgram (*Vigna mungo* L.), an ancient and well-known leguminous crop of Asia is popular because of its nutritional quality, green manuring value, nitrogen fixing capacity and short duration. Blackgram is a highly priced pulse, rich in protein (24%) and phosphoric acid and used in several south Indian dishes due to its mucilaginous paste property with fermented ground rice. In India it occupies 2.9 million hectares with an annual production of 1.24 million tones and in Tamil Nadu it is grown in 3.41 lakh hectares with a production 1.21 million tones and productivity 354.84 kg ha^{-1} (Muddana and Sanjay-Swami 2020). One of the reasons for low productivity is poor nutrition of the crop as it is grown on low fertile soils and inadequate application of fertilizer. There is scope to enhance the productivity of blackgram by applying nutrients and growth regulators which helps to extend the photosynthetic activity.

G. Baradhani[1], S. Joyson[2], S. M. Suresh Kumar[3], S. Manimaran [4], G. Sathiya Narayanan[5]*
[1,3,4,5]Associate Professors, [2]Research Scholar,
[1,2,3,4]Department of Agronomy, Faculty of Agriculture, Annamalai University, India
[5]Dept of Genetics and Pl Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar 608002, Tamil Nadu, India

Email : sathiyaa2005@gmail.com
*Corresponding author

Table 1. Sulfur fertilization and foliar nutrition on number of pods plant^{-1} of blackgram.

Sub plot treatment	Main plot treatment			
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	Mean
S_1 - (Control)	14.33	16.53	16.82	15.89
S_2 - (2% DAP foliar spray on 25 and 45 DAS)	23.23	34.93	39.14	32.43
S_3 - (0.5% MAP foliar spray on 25 and 45 DAS)	18.91	27.53	28.12	24.85
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	21.11	30.78	32.87	28.25
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS)	19.01	27.98	28.68	28.22
S_6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	25.35	37.07	41.23	34.55
Mean	20.32	29.14	31.45	26.87
	Main	Sub	M × S	S × M
SEd	0.18	0.34	0.56	0.58
CD (p=0.05)	0.49	0.69	1.19	1.19

Sulfur (S) is now being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium (Prasad and Shivay 2018). It is essential for the growth and development of plant, besides stimulating seed formation. It plays key role in protein synthesis, chlorophyll formation and oil synthesis (Vishnu Priya and Manohar 2022). Sulfur application is beneficial for enhancing the productivity of blackgram as it is constituent of several amino acids like methionine, cystine and cysteine where they both occur as free acids and as building blocks of proteins. Sulfur also plays a vital role in plant growth as well as in metabolism of the plant. Sulfur influences plant growth in two ways, firstly by acting as a nutrient and secondly by improving the favorable soil conditions. It also plays vital role in chlorophyll formation, biological nitrogen fixation and affects rhizospheric microbial population in soil. Sulfur requirements and benefit from sulfur fertilization are the maximum for the oilseed crops followed by pulses and are lowest

Table 2. Sulphur fertilization and foliar nutrition on pod length (cm) of blackgram.

Sub plot treatment	Main plot treatment			
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	Mean
S_1 - (Control)	2.18	2.65	2.69	2.51
S_2 - (2% DAP foliar spray on 25 and 45 DAS)	3.81	5.79	6.51	5.37
S_3 - (0.5% MAP foliar spray on 25 and 45 DAS)	3.03	4.62	4.70	4.11
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	3.45	5.07	5.43	4.65
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS)	3.08	4.67	4.72	4.15
S_6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	4.17	6.14	6.88	5.73
Mean	3.29	4.83	5.15	4.42
	Main	Sub	M × S	S × M
SEd	0.27	0.06	0.09	0.10
CD (p=0.05)	0.08	0.12	0.20	0.20

Table 3. Sulfur fertilization and foliar nutrition on number of grains pod^{-1} of black gram.

Sub plot treatment	Main plot treatment			
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	Mean
S_1 - (Control)	2.75	3.18	3.23	3.05
S_2 - (2% DAP foliar spray on 25 and 45 DAS)	4.62	7.19	8.09	6.63
S_3 - (0.5% MAP foliar spray on 25 and 45 DAS)	3.68	5.52	5.63	4.94
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	4.19	6.29	6.75	5.74
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS)	3.74	5.58	5.75	5.02
S6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	5.07	7.66	8.54	7.09
Mean	4.01	5.90	6.33	5.14
	Main	Sub	M × S	S × M
SEd	0.04	0.07	0.11	0.12
CD (p=0.05)	0.10	0.14	0.24	0.24

for cereals (Udayana *et al.* 2021). Sulfur deficiencies in oilseed crops and pulses, have become more prominent. Sulfur induces chlorophyll concentration in leaf, grain yield and protein content. It influences leaf area (Biswas *et al.* 2012). For optimum growth and production, plant tissue must contain sufficient concentration of sulfur, only then the plants can produce carbohydrate, proteins, oils and vitamins to their full potential. However, the availability of sulfur needed for profitable crop production continues to decline. Foliar application is considered to have the advantages of quick and effective nutrient usage, reduction of losses through leaching and fixation and aid in controlling nutrient intake by plants (Thakur *et al.* 2017). The enhancement effect of foliar application of might be attributed to the favorable influence of these nutrients on metabolism and biological activity and its stimulation effect on photosynthetic pigments and enzymes activity which in turn encourage vegetative growth of plants (Thind 2022). Considering the above facts, a field experiment was conducted to study the effect of sulfur fertilization and foliar nutrition on

Table 4. Sulfur fertilization and foliar nutrition on hundred grain weight of blackgram.

Sub plot treatment	Main plot treatment			
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	Mean
S_1 - (Control)	3.92	3.92	3.92	3.92
S_2 - (2% DAP foliar spray on 25 and 45 DAS)	3.96	4.02	4.04	4.01
S_3 - (0.5% MAP foliar spray on 25 and 45 DAS)	3.95	3.98	4.00	3.98
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	3.95	4.00	4.02	3.99
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS)	3.95	3.98	4.00	3.98
S_6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	3.98	4.04	4.08	4.03
Mean	3.95	3.99	4.01	3.98
	Main	Sub	M × S	S × M
SEd	0.03	0.03	0.08	0.08
CD (p=0.05)	NS	NS	NS	NS

Table 5. Sulfur fertilization and foliar nutrition on grain yield (kg ha^{-1}) of blackgram.

Sub plot treatment	Main plot treatment			
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	Mean
S_1 - (Control)	707	789	729	761.88
S_2 - (2% AP foliar spray on 25 and 45 DAS)	1028	1485	1645	1386.00
S_3 - (0.5% MAP foliar spray on 25 and 45 DAS)	866	1212	1220	1099.33
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	955	1312	1399	1222.04
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS)	870	1218	1224	1104.00
S_6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	1123	1580	1775	1489.33
Mean	924.44	1266.00	1342.50	1178.76
	Main	Sub	M × S	S × M
SEd	7.63	18.44	30.14	31.95
CD (p=0.05)	21.18	37.67	62.98	62.25

yield attributes of blackgram ADT 3.

MATERIALS AND METHODS

The field experiment was conducted at the Experimental Farm, Department of Agronomy, Annamalai University, Annamalai Nagar to study the effect of sulfur fertilization and foliar nutrition on growth and yield of blackgram ADT 3. The field experiment was conducted in split plot design with 3 replications. The main plot constitutes RDF alone (M_1), RDF + 15 kg S ha^{-1} (M_2), and RDF + 20 kg S ha^{-1} (M_3). In sub plots, foliar nutrition practices viz., control (S_1), two per cent DAP foliar spray on 25 and 45 DAS (S_2), 0.5% MAP foliar spray on 25 and 45 DAS (S_3), two per cent urea foliar spray on 25 and 45 DAS (S_4), two per cent water soluble fertilizer (19:19:19) foliar spray on 25 and 45 DAS (S_5) and 0.5% chelated micronutrient mixture foliar spray on 25 and 45 DAS (S_6).

The recommended dose of inorganic fertilizer nutrients viz., nitrogen @ 25 kg ha^{-1} through urea, phosphorus @ 50 kg ha^{-1} through single superphosphate and potash @ 25 kg ha^{-1} through muriate of potash were applied to all the plots. As per the treatment schedule sulfur was applied at the rate of 15 kg ha^{-1} and 20 kg ha^{-1} through gypsum. For foliar spray application the required quantities of various foliar spray fluids were calculated plot wise and the quantity of spray fluid required per plot was determined and sprayed. The DAP solution was prepared on the previous day night by dissolving 10 kg of DAP in 10 liters of water and allowed to settle overnight and it was filtered using a muslin cloth and the supernatant solution was taken for spraying after diluting with remaining quality of water (490 ls). The 0.5% MAP was prepared by dissolving 5 grams of MAP in 1 l of water. Stir or shake the mixture until all the contents is dissolved. The 2% urea was prepared by dissolving 20 gs of urea in 1 liter of water. The 2% water soluble fertilizer solution is prepared by dissolving 20 gs of water soluble 19:19:19 in 1 l of water. The 0.5% chelated micronutrient is prepared by dissolving 5 grams of chelated micronutrient in 1 lr of water. The above foliar nutrients were sprayed using knap sack sprayer at 25 and 45 DAS.

Proper irrigation was done at critical stages of flowering and pod formation and five plants from each plot were chosen by simple random sampling method and tagged. These tagged plants were used for recording all crop growth attributes such as the yield components viz., pod length, number of pods $plant^{-1}$, number of grains pod^{-1}, 100 grain weight, grain yield and haulm yield were observations at harvesting stage. The mean values of biometric yield observations were recorded and statistically

Table 6. Sulfur fertilization and foliar nutrition on haulm yield (kg ha^{-1}) of blackgram.

Sub plot treatment	Main plot treatment			Mean
	M_1 (RDF alone)	M_2 (RDF+15 kg S ha^{-1})	M_3 (RDF+20 kg S ha^{-1})	
S_1 - (Control)	1046	1196	1203	1148.50
S_2 - (2% DAP foliar spray on 25 and 45 DAS)	1625	2326	2500	2184.66
S_3 - (0.5% AP foliar spray on 25 and 45 DAS)	1343	1901	1912	1718.55
S_4 - (2% Urea foliar spray on 25 and 45 DAS)	1485	2048	2188	1907.00
S_5 - (2% Water soluble fertilizer (19:19:19) foliar spray on 2_5 and 45 DAS)	1347	1908	1914	1723.00
S_6 - (0.5% Chelated micronutrient mixture foliar spray on 25 and 45 DAS)	1762	2463	2845	2356.33
Mean	1434.75	1973.61	2093.66	1834.17
	Main	Sub	M × S	S × M
SEd	11.43	28.09	45.87	48.66
CD (p=0.05)	31.73	57.38	95.77	99.38

analyzed as per the procedure outlined by (Panse and Sukhatme 1978).

RESULTS AND DISCUSSION

Yield attributes and yield also indirectly depends on growth attributes like plant height, number of branches, number of root nodules, total dry matter production and leaf area index. The higher number of root nodules is due to the fact that nodulation in legumes is stimulated due to sulfur application in soil which leads to production of large, branched and pinkish nodules and ultimately increased number and dry weight of nodules and hence yield. The application of sulfur increases the yield by increasing the sulfur from source (assimilate) to sink (seed) which would have increased the number of pods per plant. Besides, sulphur application increases the photosynthetic activity over all growing environment (rhizohsphere region of roots) and greater partitioning of metabolites and adequate translocation of nutrients to developing structure leads to increase the number of pods per plant in blackgram. This result was corroborated with the findings, that the application of sulfur @ 20 kg ha^{-1} had registered significantly higher number of pods per plant which had been attributed that sulfur improves overall nutritional environment of the rhizosphere as well as in the plant system, which in turn enhanced the plant metabolism and photosynthetic activity resulting in better growth and yield attributes of plant (Kokani *et al.* 2014) (Table 1).

The presence of magnesium in foliar spray found to be promising in obtaining the higher number of pods plant^{-1} which correlates strongest to the yield and this is due to enhanced chlorophyll concentration and photosynthetic rate supplying assimilates to developing pods (Neuhaus *et al.* 2014). The same was also reported by (Howladar *et al.* 2014). While application of nutrient elements through foliar spray at appropriate stages of growth become important for their efficient utilization and better performance of the crop as a balanced fertilization with nutrients in plant nutrition is very important in the production of high yield with high quality seeds. Foliage applied macro and micronutrients at critical stages of the crop were effectively absorbed and translocated to the developing pods, producing more number of pods and better filling in blackgram. The higher number of pods plant^{-1} was recorded in chelated micronutrient foliar spray and it is due to the application of nutrients at reproductive stage thus helping in more translocation of photosynthates to the developing pods resulting in better filling of number of seeds pod^{-1}. Due to increase in number of seeds pod^{-1} leads to increase in pod length (Tables 2–3). Due to increase in yield attributing characters, which finally increased the seed yield over control (S_1).

Interaction of application of RDF+20 kg S ha^{-1} and foliar spray of 0.5% chelated micronutrient mixture resulted in enhanced 100 grain weight (4.08) compared to RDF alone (3.92) (Table 4). The leaf area index is often used as a vital indicator of plant growth for evaluating assimilation, transpiration rates and is a major factor determining solar radiation interception, canopy photosynthesis and therefore yield. The reason behind increased seed yield owing to sulfur application is due to increased metabolic and enzymatic processes including photosynthesis and legume rhizobium symbiotic nitrogen fixation. Successive increase in sulphur level up to RDF +20 kg S ha^{-1} significantly increased seed yield of blackgram (Limbikai *et al*. 2015). Among the foliar sprays, spray of 0.5% chelated micronutrient mixture at 25 and 45 DAS recorded significantly higher seed yield (Table 5). Higher yield attributes and yield were noticed with the foliar spray of chelated micronutrients which contains iron, boron, manganese, magnesium and zinc. The increased yield was also due to added advantage of zinc leading to optimum availability of nutrients for luxurious crop growth and efficient partitioning of assimilates from source to sink (Prasanna *et al.* 2013).

It is an established fact that photosynthesis together with availability of assimilates (source) and storage (sink) exert an important regulative function on the complex process of yield formation. Application of sulfur could have improved the nitrate recovery and diversion of greater proportion of assimilation to developing pods. This result was in association with the findings who reported that the grain and haulm yields of blackgram produced significantly higher with sulfur @ 20 kg ha^{-1} over control (Kokani *et al.* 2014) and (Shubhangi *et al.* 2014) (Table 6). This increase in yield might be due to sulfur availability resulting in better formation of nodule, nitrogenase enzyme, chlorophyll and thereby influencing growth and yield components of the crop which ultimately resulted in highest grain and haulm yield. Further higher crop yield is due to better availability of available nutrients in the soil and higher uptake of nutrients which ultimately led to effectively assimilate partitioning of photosynthesis from sources to sink in post flowering stage and resulted in highest grain and haulm yield.

Interaction of application of RDF+20 kg S ha^{-1} and foliar spray of 0.5% chelated micronutrient mixture at 25 and 45 DAS significantly resulted in enhanced yield attributes viz., higher number of pods per plant (41.23), pod length (6.88 cm) and seed yield (1119 kg ha^{-1}) compared to other treatment combinations. The increase in these yield attributes may be associated with increased growth attributes.

CONCLUSION

On the basis of the result of the field experiment, it may be inferred that in RDF + 20 kg S ha^{-1} along with foliar application of 0.5% chelated micronutrient mixture foliar spray on 25 and 45 DAS had a remarkable effect on the yield components viz., pod length, number of pods $plant^{-1}$ and number of grains pod^{-1}, grain yield and haulm yield of blackgram cv ADT 3. It is an effective practice for augmenting higher yield in blackgram. This practice found to be agronomically good and economically viable and can be recommended to the blackgram growers in Cauvery deltaic areas of Tamil Nadu.

REFERENCES

Biswas BR, Sharmin S, Zakir HM, Chowdhury AK, Talukder NM (2012) Growth and yield of soybean (*Glycine max* L.) as influenced by the application of sulfur and molybdenum. *Bangladesh J Agrofor Environ* 1 : 61—66.

Howladar SM, Osman ASh, Rady MM, Al-Zahrani HS (2014) Magnesium foliar application and phosphorien soil inoculation positively affect *Pisum sativum* L. plants grown on sandy calcareous soil. *World Acad Sci Engg Technol* 8 (5) : 436—440.

Kokani JM, Shah KA, Tandel BM, Nayaka P (2014) Growth, yield and yield of summer blackgram (*Vigna mungo* L.), as influenced by FYM, phosphorus and sulphur. *J Environ Sci* 6 : 429—433.

Limbikai G, Nethravathi B, Patil AM, Math G (2015) Influence of sulfur and foliar spray of nutrients on yield of black gram. *The Ecoscan* : *An Int Quart J Env Sci* 7 (SP) : 325—329.

Muddana SSCS, Sanjay-Swami (2020) Yield and yield attributes of black gram (*Vigna mungo* L. Hepper) as influenced by phosphorus and boron in acid Inceptisol. *Int J Agricult Appl Sci* 1 (2) : 73—78.

Neuhaus C, Geilfus CM, Muhling KH (2014) Increasing root and leaf growth and yield in Mg-deficient faba beans (*Vicia faba*) by $MgSO_4$ foliar fertilization. *J Pl Nutri Soil Sci* 177 (5) : 741—747.

Panse AS, Sukhatme PV (1978) Statistical method for agricultural

works. ICAR, New Delhi, 3rd edn, pp 328.

Prasad R, Shivay YS (2018) Sulphur in soil, plant and human nutrition. *Proc Nat Acad Sci Ind Section B : Biol Sci* 88 (2) : 429—434.

Prasanna KL, Naidu SMM, Sumathi V, Nagamani C (2013) Effect of nitrogen and zinc on growth, yield and economics of clusterbean *Cyamopsis tetragonoloba* (L.) Taub. *Andhra Agric J* 60 (2) : 260—263.

Shubhangi JD, Patil VD, Mamta JP (2014) Effect of various levels of phosphorus and sulfur on yield, plant nutrient content, uptake and availability of nutrients at harvest stages of soybean *Glycine max* (L.). *Int J Curr Microbiol Appl Sci* 3 (12) : 833—844.

Thakur V, Teggelli RG, Meena MK (2017) Influence of foliar nutrition on growth and yield of pulses grown under north eastern dry zone of Karnataka : A review. *Int J Pure Appl Biosci* 5 (5) : 787—795.

Thind VYHS (2022) Effect of rhizobium, foliar spray of nutrients and plant growth regulators on growth and yield of summer Green Gram (*Vigna radiata* L.). *The Pharma Innov J* 11 (2) : 11(2) : 2058—2064.

Udayana SK, Singh P, Jaison M, Roy A (2021) Sulfur : A boon in agriculture. *The Pharma Innov J* 10 (7) : 912—921.

Vishnu Priya KK, Manohar KA (2022) Role of sulfur nutrition in enhancing the productivity of pulses and oil seeds. *Ind J Natural Sci* 13 (72) : 43172—43182.