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Economics and Nutrient Uptake by Blackgram as Influenced by Secondary Nutrients and Zinc Nutrition

E. Jeevana Lakshmi[1*], P.V. Ramesh Babu[2], G. Prabhakara Reddy[1] and P. Kavitha[3]

[1]*Department of Agronomy, S.V. Agricultural College, Tirupati, India*
[2]*Department of Agronomy,* [3]*Department of Soil Science and Agricultural Chemistry, Agricultural College, Mahanandi, India*

**Corresponding author*

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A B S T R A C T

To study the effect of foliar sprays of secondary nutrients and zinc nutrition on nutrient uptake and economics of blackgram, a field experiment was conducted during *rabi*, 2016-17 on sandy loam soils of College Farm, Agricultural College, Mahanandi. The experiment comprised of eight treatments *viz.*, control (T_1), RDF (20-50-0 kg N-P_2O_5-K_2O ha^{-1}) (T_2), RDF + foliar application of one per cent $CaNO_3$ (T_3), RDF + foliar application of one per cent $MgNO_3$ (T_4), RDF + foliar application of one per cent Sulphur (T_5), RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and Sulphur (T_6), RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7), T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8). As per the results, foliar spray of secondary nutrients (Ca, Mg and Sulphur) and zinc at 25 and 45 DAS along with RDF (T_8) recorded the higher values of dry matter, seed yield, haulm yield and nutrient uptake (secondary and zinc) while control treatment recorded the lower values among the treatments tested.

Introduction

Pulses being the cheap source of protein ensure nutritional security in India and also play a vital role in restoring the soil nutrient status through biological nitrogen fixation acting as mini factories for improving soil health (Pooniya *et al.*, 2015). They are cultivated on marginal and sub marginal soils under rainfed situations with marginal inputs. As pulses are legumes, nutrient management aspect is ignored in many situations. However, from the essentiality point of view, all the essential elements are crucial for plant growth (Fageria *et al.*, 2009). In post green revolution era due to intensification of agriculture, soil capacity to supply all the essential nutrients is declining. For producing one ton of biomass pulses generally remove 3-10 kg of Ca, 1-5 kg of Mg and 1-3 kg S along with other major and minor elements (Choudhary *et al.*, 2014).

Sulphur is the fourth essential and most deficient secondary nutrient in Indian soils. It is required nearly in equal quantities as that of P in legumes and it should not be over looked for attaining higher yields and quality produce (Singh, 2004). The most deficient micronutrient in Indian soils is zinc, making it mandatory to include in the nutrient management practices. Appropriate recommendations are needed because of increasing fertilizer costs and awareness of environmental problems. Soil application of nutrients is a common practice for all the major nutrients but, the secondary and micro nutrients are required in relatively smaller quantities than major nutrients. So foliar application may solve the purpose and reduce the impact on dynamic soil system. Foliar application targets the above ground parts where the nutrient is needed and rapid absorption is facilitated. It overcomes the losses such as fixation, leaching, volatilization and decomposition which occur through soil application. As the nutrient needed for foliar sprays is less it is economical in achieving high monetary returns than soil application.

Materials and Methods

A field experiment was conducted at College Farm, Agricultural College, Mahanandi, Andhra Pradesh during *rabi*, 2016-17. The texture of the soil was sandy loam, neutral in reaction, medium in organic carbon and nitrogen, high in phosphorus, potassium and sulphur, medium in calcium, low in magnesium and nearly medium in zinc. The experiment comprised of eight treatments *viz.*, control (T_1), RDF (20-50-0 kg N-P_2O_5-K_2O ha^{-1}) (T_2), RDF + foliar application of one per cent $CaNO_3$ (T_3), RDF + foliar application of one per cent $MgNO_3$ (T_4), RDF + foliar application of one per cent Sulphur (T_5), RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and Sulphur (T_6), RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7), T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8).The test variety was TBG-104. The trail was laid out in RBD replicated thrice. The foliar spray of nutrients was carried out at 25 and 45 DAS @ 500 l ha^{-1}. Five plants in each plot were marked separately for non-destructive sampling. Dry matter production per hectare was worked out by taking the oven dry weight of all the five plants drawn from the gross plot leaving the extreme border row and expressed as kg ha^{-1}. Later these samples were powdered for the chemical estimation.

Diacid digestion was done using 1 gm of powered plant sample and 10 ml of 10:4 mixture of nitric acid (HNO_3) and perchloric acid ($HClO_4$). Pre-digestion was carried out using 25 ml of nitric acid per gram of plant sample to avoid explosion. The digested plant sample was diluted to a known volume (100 ml) with double distilled water and filtered through Whatman No.1 filter paper. Aliquots of this diluted digest were used for the estimation of calcium, magnesium (EDTA titration method by Cheng and Bray, 1951), sulphur (turbidometric method by Tandon, 1998) and zinc (AAS) by adopting the standard procedures.

The uptake of calcium, magnesium and sulphur at 30 and 60 DAS by whole plant and at harvest by seed and haulm samples was calculated as follows.

Uptake of nutrient (kg ha^{-1}) = [Nutrient content (%) / 100] X Dry matter yield (kg ha^{-1})

The uptake of zinc at 30 and 60 DAS by whole plant and at harvest by seed and haulm samples was calculated as follows.

Uptake of nutrient (g ha^{-1}) = [Nutrient content (ppm) / 1000] X Dry matter yield (kg ha^{-1})

The total cost of cultivation and gross returns of blackgram was calculated for all the treatments on the basis of inputs used and prevailing market price of the economic produce. Net returns were obtained by deducting the cost of cultivation of respective treatments from gross returns of the corresponding treatments. Benefit-cost ratio was worked out by dividing gross returns with corresponding cost of cultivation of the respective treatments.

Statistical significance was tested by 'F' value at 5 per cent level of probability and wherever the 'F' value was found significant, critical difference was worked out and the values were furnished.

Results and Discussion

Dry matter production, seed yield and haulm yield

The dry matter production seed yield and haulm yield of blackgram were increased significantly with T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) treatment and the next best treatment was RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6). The control (T_1) treatment recorded lower values of dry matter production and yields. With regard to individual secondary nutrients and zinc foliar sprays, RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment reported higher dry matter production, seed yield and haulm yield and was comparable to RDF + foliar application of one per cent $CaNO_3$ (T_3) treatment (Table 1). While, RDF + foliar application of one per cent sulphur (T_5) and RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7) treatments did not record any significant increase in haulm yields over RDF treatment.

The adequate supply of the nutrients stimulated growth and accelerated metabolic activities like carbohydrate and nitrogen fixation in the combination treatments which contributed to the increased dry matter production and yields (Prasanna *et al.,* 2013). The substantial increase in the growth of the plants leading to higher values of yield parameters might be the reason for higher seed yield in the combination treatments and the results were supported by Veerabhadrappa and Yeledhalli (2005a) and Zafar *et al.,* (2014). In the nutrient combination, zinc might have played a considerable role in the development of functional floral tissues for normal flower and pod development (Hafeez *et al.,* 2013) but the effect was unnoticeable on haulm yield in the present study. Among the individual secondary nutrient foliar sprays, magnesium nitrate was found to be encouraging in achieving higher dry matter and yields. Magnesium, due to its role in the formation of organic compounds and increasing plant metabolism (Howladar *et al.,* 2014), calcium due to its role in regulating cellular functions and the structural support of the plant might have increased the haulm yields.

Nutrient uptake of blackgram

Foliar application of secondary nutrients and zinc have exerted a progressive and significant influence on the nutrient uptake of blackgram at 30, 60 DAS and at harvest. There exist nutrient interactions in plant. The net influence of these interactions and processes produce the final yield from the crop (Fageria, 2001). Among all the treatments control (T_1) treatment recorded the lower nutrient uptake values.

Calcium

As the dry matter increased from 30 days to harvest the uptake of calcium was also increased. The uptake of calcium in seed was lower as compared to haulm due to the reason that calcium is immobile in the plant system (Meena *et al.,* 2007).

The treatment T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) recorded higher calcium uptake at all the stages and was comparable with RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6) treatment at 30 DAS and at harvest by haulm. With respect to individual secondary nutrients and zinc foliar sprays, at all the stages of crop growth even in the haulm and seed, RDF + foliar application of one per cent $CaNO_3$ (T_3) treatment showed greater calcium uptake and was comparable to RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment at 30 and 60 DAS (Table 2).

The calcium uptake varied interestingly at all the growth stages. The combined nutrient treatments recorded higher uptake of calcium and this might be due to increased dry matter production and calcium is one of the elements in the nutrient combination. With reference to individual secondary nutrients and zinc foliar sprays, though magnesium spray had higher dry matter accumulation calcium spray showed an increase in the uptake due to higher nutrient concentration in calcium spray. The binding strengths of calcium are much stronger than magnesium and they easily out-compete magnesium at the exchange sites thus, there existed an antagonism and this was the reason for lower calcium uptake with magnesium foliar spray. The zinc foliar spray also showed a decline in the calcium uptake due to its antagonism with calcium was reported by Ranade and Malvi (2011) and Prasad *et al.*, (2016).

Magnesium

The magnesium uptake was in the treatment that received T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) and was equally effective with RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6) treatment at 30 DAS and at harvest by both seed and haulm. The treatment RDF + foliar application of one per cent $MgNO_3$ (T_4) was greater in recording the magnesium uptake among the individual secondary nutrients and zinc foliar sprays. This particular treatment was comparable to T_6 treatment at all the stages of crop growth and even at harvest (Table 3). On the other hand, RDF + foliar application of one per cent $CaNO_3$ (T_3), RDF + foliar application of one per cent sulphur (T_5) and RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7) treatments not showed any significant increase and were on par with each other at 30 and 60 DAS.

Higher uptake of magnesium in the combination treatments was due to their higher dry matter accumulation and higher root activity for absorption of availability of nutrients even from the soil resulted in positive results with combination treatments. On the other hand synergism between nitrogen-magnesium (Ranade and Malvi, 2011) and magnesium-zinc might have contributed to the present results with combination treatments. Higher calcium concentration inhibits the uptake of magnesium due to decrease in the permeability of cells (Fageria, 2001) owing to this the uptake of magnesium in the calcium foliar spray decreased despite of higher dry matter accumulation. The positive results of magnesium foliar application on uptake of magnesium and zinc was reported by Rady and Osman (2010), Mobarak *et al.*, (2013) and Howladar *et al.*, (2014).

Sulphur

The sulphur uptake by seed was higher in pulses than in cereals due the need of producing seed for synthesis of sulphur containing amino acids in protein formation.

Among all the foliar spray treatments, T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) obtained higher sulphur uptake and was appreciably higher than RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6) treatment (Table 4).

Table.1 Dry matter production (kg ha^{-1}), seed yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) of blackgram as influenced by secondary nutrients and zinc nutrition

Treatments	Dry matter production (kg ha^{-1})		Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
	30 DAS	60 DAS		
T_1: Control	285	1068	508	1210
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	312	1169	639	1336
T_3: RDF + Foliar application of 1 % $CaNO_3$	346	1565	1019	1776
T_4: RDF + Foliar application of 1 % $MgNO_3$	355	1691	1089	1798
T_5: RDF + Foliar application of 1 % Sulphur	319	1419	894	1492
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	377	2011	1187	1906
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	315	1227	782	1377
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	414	2331	1284	2025
SEm±	13	83	48	52
CD (P=0.05)	**40**	**253**	**146**	159

Table.2 Ca uptake (kg ha^{-1}) by blackgram at different growth stages as influenced by secondary nutrients and zinc nutrition

Treatments	Ca uptake (kg ha^{-1})			
	30 DAS	60 DAS	At harvest	
			Haulm	Seed
T_1: Control	3.19	10.92	19.16	**0.71**
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	3.68	12.66	21.45	**0.91**
T_3: RDF + Foliar application of 1 % $CaNO_3$	5.07	20.07	33.52	**2.35**
T_4: RDF + Foliar application of 1 % $MgNO_3$	4.47	19.65	29.64	**1.96**
T_5: RDF + Foliar application of 1 % Sulphur	4.16	17.01	25.43	**1.69**
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	5.17	25.06	33.92	**2.50**
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	3.95	13.90	22.64	**1.39**
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	5.76	29.07	36.42	**2.82**
SEm±	0.216	1.047	1.253	**0.074**
CD (P=0.05)	**0.66**	**3.18**	**3.80**	**0.22**

Table.3 Mg uptake (kg ha^{-1}) by blackgram at different growth stages as influenced by secondary nutrients and zinc nutrition

Treatments	Mg uptake (kg ha^{-1})			
	30 DAS	60 DAS	At harvest	
			Haulm	Seed
T_1: Control	2.56	6.49	7.12	**0.80**
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	2.89	7.39	8.29	**1.16**
T_3: RDF + Foliar application of 1 % $CaNO_3$	3.20	9.69	11.10	**1.78**
T_4: RDF + Foliar application of 1 % $MgNO_3$	3.66	12.88	14.45	**2.38**
T_5: RDF + Foliar application of 1 % Sulphur	2.99	9.01	9.79	**1.73**
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	3.75	14.14	14.68	**2.42**
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	3.00	8.03	9.55	**1.48**
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	4.14	16.30	15.89	**2.66**
SEm±	0.137	0.584	0.465	**0.093**
CD (P=0.05)	**0.42**	**1.77**	**1.41**	**0.28**

Table.4 S uptake (kg ha^{-1}) by blackgram at different growth stages as influenced by secondary nutrients and zinc nutrition

Treatments	S uptake (kg ha^{-1})			
	30 DAS	60 DAS	At harvest	
			Haulm	Seed
T_1: Control	0.61	0.91	1.13	**0.41**
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	0.70	1.35	1.33	**0.59**
T_3: RDF + Foliar application of 1 % $CaNO_3$	0.95	2.10	2.23	**1.04**
T_4: RDF + Foliar application of 1 % $MgNO_3$	0.92	2.43	2.23	**1.15**
T_5: RDF + Foliar application of 1 % Sulphur	1.05	2.31	2.31	**1.12**
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	1.19	3.10	2.81	**1.40**
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	0.97	1.83	1.90	**0.93**
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	1.51	3.87	3.20	**1.72**
SEm±	0.052	0.124	0.079	**0.044**
CD (P=0.05)	**0.16**	**0.38**	**0.24**	**0.13**

Table.5 Zn uptake (g ha^{-1}) by blackgram at different growth stages as influenced by secondary nutrients and zinc nutrition

Treatments	Zn uptake (g ha^{-1})			
	30 DAS	60 DAS	At harvest	
			Haulm	Seed
T_1: Control	19.71	28.08	22.26	**18.32**
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	24.00	35.70	25.36	**27.64**
T_3: RDF + Foliar application of 1 % $CaNO_3$	29.26	53.98	34.14	**45.33**
T_4: RDF + Foliar application of 1 % $MgNO_3$	41.49	67.14	35.15	**52.04**
T_5: RDF + Foliar application of 1 % Sulphur	37.62	54.44	29.17	**48.80**
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	55.40	96.84	44.33	**75.17**
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	129.53	194.32	115.64	**88.01**
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	136.12	249.25	149.29	**124.69**
SEm±	3.243	6.492	1.985	**4.709**
CD (P=0.05)	**9.84**	**19.69**	**6.02**	**14.28**

Table.6 Gross returns, net returns and Benefit cost- ratio of blackgram cultivation as influenced by Secondary nutrients and zinc nutrition

Treatments	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	Benefit-cost ratio
T_1: Control	29464	13784	**1.88**
T_2: Recommended dose of fertilizers (RDF) (20-50-0 kg N, P_2O_5 and K_2O ha^{-1})	37068	18316	**1.98**
T_3: RDF + Foliar application of 1 % $CaNO_3$	59082	39030	**2.95**
T_4: RDF + Foliar application of 1 % $MgNO_3$	63142	43190	**3.16**
T_5: RDF + Foliar application of 1 % Sulphur	51877	30925	**2.48**
T_6: RDF + Foliar application of 1 % each of $CaNO_3$, $MgNO_3$ and Sulphur	68852	45400	**2.94**
T_7: RDF + Foliar application of $ZnSO_4$ @ 0.2%	45368	26536	**2.41**
T_8: T_6 + Foliar application of $ZnSO_4$ @ 0.2%	74484	50952	**3.17**
SEm±	2796	2796	**0.17**
CD (P=0.05)	**8481**	**8481**	**0.51**

Regarding the individual foliar sprays of secondary nutrients and zinc treatments, RDF + foliar application of one per cent sulphur (T_5) achieved greater values of sulphur uptake at 30 DAS and by haulm at harvest. While at 60 DAS and by seed at harvest, RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment recorded higher sulphur uptake. But all the individual secondary nutrient foliar sprays were on par with each other at 30, 60 DAS and at harvest.

Higher uptake of sulphur with combination of secondary nutrients and zinc might be due to application of sulphur as well as zinc sulphate and due to higher dry matter accumulation by the crop. Both the synergism and antagonism was possible between sulphur and zinc (Prasad, 2016). While in the present study, positive interaction was observed and this might have contributed to higher uptake in the combination treatment *i.e*. foliar spray of secondary nutrients along with zinc. Though dry matter accumulation was not considerable in the zinc sulphate foliar spray, sulphur uptake was relatively increased due to the presence of sulphur in the fertilizer. Increased sulphur uptake with foliar spray of sulphur was inferred by Devi and Pillai (2000), Veerabhadrappa and Yeledhalli (2005b) and Choudhary *et al.,* (2014).

Zinc

The treatment T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) recorded significantly higher uptake of zinc at all the crop growth stages. The next best treatment was RDF + foliar application of $ZnSO_4$ @ 0.2 per cent (T_7) which was equally effective with higher treatment at 30 DAS. RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6) treatment also recorded notable zinc uptake at all the stages of crop growth. Regarding individual secondary nutrients foliar sprays, RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment recorded higher values (Table 5).

Higher uptake of zinc was found in the treatments that contained zinc foliar spray in its nutrient management practices. Though individual spray of zinc along with RDF recorded comparatively lesser dry matter accumulation than combination treatments, higher zinc uptake was due to its higher zinc concentration. The zinc uptake by seed was greater than the haulm uptake due to the translocation of zinc to the reproductive structures (Puniya *et al.,* 2014). Among the individual secondary nutrient foliar sprays, magnesium foliar spray increased the zinc uptake because of synergism between the two elements (Prasad *et al.,* 2016).

Economics

Any recommendation to reach the farmers and its adoption depends on the profitability. Such is the importance of economics for the success of any technology.

Among all the treatments, T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) treatment realized higher gross and net returns and was equally profitable with the treatment RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6).

With respect to individual secondary nutrients and zinc foliar sprays, RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment achieved higher gross and net returns and was on par with T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) treatment in achieving higher net returns.

While, RDF + foliar application of one per cent $CaNO_3$ (T_3) treatment was equally effective with RDF + foliar application of one per cent $MgNO_3$ (T_4) treatment in recording higher gross and net returns (Table 6).

Higher B: C ratio was obtained with T_6 + foliar application of $ZnSO_4$ @ 0.2 per cent (T_8) and was on par with RDF + foliar application of one per cent $MgNO_3$ (T_4), RDF + foliar application of one per cent $CaNO_3$ (T_3) and RDF + foliar application of one per cent each of $CaNO_3$, $MgNO_3$ and sulphur (T_6) treatments.

Higher gross and net returns with both the combination treatments (T_8 and T_6) and magnesium foliar spray were due to higher seed yields in the corresponding treatments. Lower B: C ratio in the treatments with combination of secondary nutrients and individual foliar spray of sulphur was due to higher cost of sulphur. Similar results with respect to magnesium were recorded by Yedukondalu *et al.,* (2007). The results of increase in B: C ratio with calcium treatment over control was reported by Kundu and Sarkar (2009), zinc treatment over control was revealed by Anitha *et al.,* (2005), Ramaprasad *et al.,* (2011) and Prasanna *et al.,* (2013).

Among all the foliar sprays tested, the treatment with combined application of secondary nutrients and zinc resulted in higher gross returns, net returns and B: C ratio. Interestingly, B: C ratio of magnesium treatment was also higher due to its lower price. Over all it can be concluded that foliar application of one per cent each of calcium, magnesium, sulphur and 0.2 per cent $ZnSO_4$ at 25 and 45 DAS along with RDF increased the growth, productivity, net returns and nutrient uptake by blackgram

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