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Screening of Blackgram Genotypes for Sulphur Utilization Potential in *VerticUstropept*

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Abstract

A microplot study was conducted on a medium black soil to screen improved sulphur (S) utilizers among blackgram genotypes. For this experiment, four different S sources including Gypsum, SSP, $FeSO_4$, and $ZnSO_4$, were applied at four levels (S @ 0, 20, 30, and 40 kg ha^{-1}). With the application of high levels of sulphur (40 kg S ha^{-1}), growthand yield parameters (plant height, root length and the number of pods per plant) of black gram increased significantly. Sulphur application in the form of SSP enhanced root length and number of pods per plant. Application of sulphur as $FeSO_4$ recorded maximum consumption by plants (3.17 kg ha^{-1}) followed by $ZnSO_4$ (2.88kg ha^{-1}). Blackgram genotypes VBN 11, CO 6, and VBN 8 were categorized as efficient S utilizers, while CO 7 and MDU 1 were considered inefficient S utilizers.

Key words: *SSP; $ZnSO_4$; Sulphur uptake; Blackgram genotypes*

Introduction

Pulses occupy the second most important position in the global food chain, behind cereals. India accounts for about 70 percent of world blackgram production. India is the world's largest producer as well as consumer of blackgram. In 2020-21, about 24.5 lakh tonnes of Urad was produced from about 4.6 million hectares of land, at average productivity of 533 kg per hectare (agricoop.nic.in).About 19 percent of the area is under production, blackgram contributes to India's pulse production, accounting for 23 percent. As a legume crop, blackgram can fix atmospheric nitrogen using nodule-producing bacteria *Rhizobium* species. Sulfur is one of the important secondary nutrients in plants, and about 90% of plant sulphur is present in amino acids *viz.*,methionine, cystine, and cysteine.These amino acids are the building blocks of protein.Sulphur also has a role in the production of chlorophyll, the activation of enzymes, and other processes. Sulphur is also found in the vitamins biotine and thiamine (B1) and ferrodoxins, which are iron-sulphur proteins. Sulphur is linked to the production of high-quality crops, both nutritionally and commercially. This is the reason for the essentiality of sulphurto improve the quality of pulse crops. Over 70 countries around the world, including India, have reported sulphur deficiency. Sulphur deficiency has been reported frequently for a variety of causes, including greater sulphur removal by the crop, high yielding fertiliser responsive crop varieties, higher cropping intensity, and widespread usage of sulphur free fertilizers (Ramdevputra *et al*.,2010). Sulphur nutrition has an impact on blackgram by improving the quality and yield. In this context, the current study was conducted to determine how blackgram genotypes responded to various sulphur sources and levels.

Materials and methods

In this present investigation, a microplot (1 m x 1 m) experiment was carriedout at Coimbatore, Tamil Nadu. The soil of the experimental plot was medium black, clay loam in texture belonged to Perianaickenpalayam soil series (*VerticUstropept*). The soil werealkaline in reaction (8.12), with 4.80 g kg^{-1} organic carbon, and 196, 12.60, 440 kg ha^{-1} and 9.80 mg kg^{-1} available N, P, K, and S, respectively. The experiment was conducted in factorial randomized block design with three replications. The treatments consisted of different blackgram genotypes *viz*., VBN 11, CO 6, MDU 1, VBN 8, and CO 7, four sulphur sources namely SSP, gypsum, iron sulphate, and zinc sulphate and S levels @ 0, 20, 30, and 40 kg ha^{-1}. The prescribed NPK of 25:50:25 kg NPK ha^{-1}were applied as urea, DAP, and MOP respectively. Biometric observations on plant height, root length andnumber of pods per plant were all measured. The available sulphur in soil samples was determined using $BaCl_2$ turbidity method (Williams and Steinberg's,1959). Plant samples were randomly selected and air-dried before being oven- dried for 48 hours at 70°C. Nitric acid and perchloric acid in the ratio of 5:2 were used to digest the seeds. The sulphur concentration was evaluated spectrophotometrically at 420 nm wave lengths after digestion. Plant sulphur concentration was multiplied by DMP to compute sulphur assimilation. The statistical analysis was performed by ANOVA using SPSS®20.0 software for Windows (Snedecor and Cochran, 1994).

Results and Discussion

Effect of Sulphur on growth parameters

Application of different sources of sulphur differed significantly for growth and yield attributes of blackgram *viz.,* plant height, root length, number of pods per plant, available S and S uptake (Table 1&2). Plant height measurements revealed that $FeSO_4$ application resulted in maximum plant height of 82.50 cm followed by $ZnSO_4$ application (78.07). The use of iron sulphate aids in synthesizing chlorophyll that acts as a plant growth regulator (Jin *et al*., 2008). SSP was found to be significantly higher (22.50 cm) than other sources pertaining to the root length. Growth and yield parameters *viz*., plant height, root length, number of pods per plant of blackgram increased significantly with higher levels of sulphur application (Table 1).In comparison to control, sulphur @ 40 kg ha^{-1} significantly increased the plant height (82.50 cm) and root length (22.50 cm) of blackgram (Kumar and Singh, 2008)&(Khatkar *et al*., 2007). The genotype VBN 11 recorded the maximum plant height and root length (70.01 cm& 19.75 cm). Sulphur's contribution to increased growth and yield could be attributed to its role in chlorophyll synthesis (Arunachalam *et al*., 1995).

Effect of Sulphur on number of pods plant^{-1}

The data recorded for number of pods per plant of blackgram genotypes are summarized in table 1. In terms of the number of pods per plant, application of S @ 40 kg ha^{-1} as SSP (39.12) produced the highest pods per plant in blackgram which was in line with the work of Konthoujam Nandini Devi *et al*. (2012). This was supplemented by the fact that increasing S from source (assimilate) to sink (seed) enhances yield, which would have increased the number of pods per plant. This result was supported by the findings of Kokani *et al*. (2014), who reported that sulphur application resulted in a significantly higher number of pods per plant, which was attributed to sulphur improving the overall nutritional environment of the rhizosphere as well as in the plant system, which in turn enhanced plant metabolism and photosynthetic activity, resulting in improved plant growth and yield attributes. The supply of sulphur in adequate amounts also helps develop reproductive parts, which results in the development of pods in plants (Patel *et al*., 2009). In the case of blackgram genotypes, VBN 11 (29.26), CO 6(26.64), and VBN 8(23.60), the number of pods per plant was much higher than the CO7(22.51) and MDU1(21.17) genotypes.

Effect on available and uptake of Sulphur

Application of S @ 40 kg ha^{-1} recorded the highest availability and uptake of sulphur among the varied sulphur levels (Table 2). With increasing amounts of S, available S in post-harvest soil and sulphur consumption in blackgram grains increased (Kothari and Jethra,2002).The following genotypes recorded more available sulphur in post- harvest soil: VBN 8> MDU 1> CO6> CO7> VBN 11. Among the S sources, gypsum significantly enhanced available sulphur (20.50 mg kg^{-1}) over other sources. Availability of sulphur was considerably influenced by the gypsum application, followed by SSP. Application of S significantly enhanced the available S content in the soil, according to Jawahar *et al*. (2003) and Yadav. (2011). Increased availability of available sulphur, resulting in well-filled pods and higher seed yields (Ghosh and Sarkar, 2000). Comparied to the control, sulphur application at 40 kg ha^{-1} resulted in the highest nutritional consumption of sulphur in grains. Higher sulphur content in grains with fertiliser application could be due to greater nutrient absorption as the pool of available nutrients increases in the soil. Sulphur addition, according to Dubey *et al*. (1999) resulted in plants with high nitrogen and sulphur content. VBN 11 and CO 6 absorbed significantly more sulphur than VBN 8 intotal sulphur intake. Sulphur absorption was found to be lower in CO7 and MDU 1 blackgram genotypes. The application of $FeSO_4$ resulted in the highest sulphur uptake (3.17 kg ha^{-1}), followed by $ZnSO_4$ (2.88 kg ha^{-1}).

Conclusion

Ssource and levels had a significant positive effect on blackgram genotyes growth and yield-related metrics. VBN 11, CO 6, and VBN 8 were determined to be efficient sulphur utilizers based on sulphur absorption and uptake, but CO 7 and MDU 1 were found to be ineffective sulphur utilizers. Compared to alternative sources, S @ 40 kg ha^{-1} as $FeSO_4$ exhibited a much higher sulphur absorption in all genotypes. The amount of sulphur uptake in blackgram increases as sulphur levels increase up to 40 kg ha^{-1}.

Ethics statement

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication

All the authors agreed to publish the content.

Competing Interests

The authors declare no conflict of interest in publication of this content

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Table 1. Effect of sulphur source and levels on growth and yield attributing characteristics of blackgram genotypes

Geno types	Ssources	Plant height (cm)				Root length (cm)				No of pods per plant			
		S_{20}	S_{30}	S_{40}	Mean	S_{20}	S_{30}	S_{40}	Mean	S_{20}	S_{30}	S_{40}	Mean
VBN 11	Control	45.00				8.50				18.44			
	$FeSO_4$	75.63	78.89	82.50	79.01	13.53	17.88	21.05	17.49	24.59	26.74	29.98	27.10
	$ZnSO_4$	72.86	75.01	78.07	75.31	12.59	16.86	20.13	16.52	21.62	23.45	27.09	24.05
	SSP	68.22	70.46	73.56	70.75	16.98	19.76	22.50	19.75	34.06	36.15	39.12	36.44
	Gypsum	64.03	66.65	70.09	66.92	15.06	18.63	21.65	18.45	26.88	29.07	32.37	29.44
	Mean	70.18	72.75	76.06	73.00	14.54	18.28	21.33	18.05	26.79	28.85	32.14	29.26
CO 6	Control	37.50				6.54				15.54			
	$FeSO_4$	69.01	72.03	75.50	72.18	7.03	10.69	13.61	10.44	21.81	24.12	27.29	24.41
	$ZnSO_4$	66.55	68.55	71.46	68.85	6.35	9.98	12.86	9.73	19.19	21.47	24.75	21.81
	SSP	61.74	63.82	67.17	64.24	10.09	12.51	15.10	12.57	31.03	33.31	36.24	33.53
	Gypsum	58.07	60.51	63.82	60.80	8.45	11.51	14.17	11.38	24.54	26.35	29.58	26.82
	Mean	63.84	66.23	69.49	66.52	7.98	11.17	13.93	11.03	24.15	26.31	29.47	26.64
VRI 8	Control	30.68				7.00				15.00			
	$FeSO_4$	62.05	64.86	68.20	65.04	10.66	14.55	17.72	14.31	19.27	21.44	24.79	21.83
	$ZnSO_4$	59.68	61.55	64.50	61.91	10.01	13.89	16.84	13.58	15.80	18.61	22.30	18.91
	SSP	55.54	57.49	60.41	57.81	13.81	16.34	19.10	16.42	27.55	29.66	32.79	30.00
	Gypsum	51.71	53.98	57.18	54.29	12.17	15.41	18.29	15.29	20.95	23.66	26.38	23.67
	Mean	57.24	59.47	62.57	59.76	11.66	15.05	17.99	14.90	20.89	23.34	26.57	23.60
CO 7	Control	30.28				6.25				14.13			
	$FeSO_4$	67.83	70.78	74.20	70.94	8.99	12.02	15.11	12.04	17.95	20.29	23.60	20.61
	$ZnSO_4$	65.25	67.21	70.28	67.58	8.41	11.44	14.34	11.40	14.93	17.73	21.13	17.93
	SSP	61.11	63.15	66.06	63.44	11.53	13.99	16.60	14.04	26.06	28.59	32.20	28.95
	Gypsum	57.55	59.93	62.76	60.08	10.43	12.83	15.81	13.02	19.84	22.22	25.62	22.56

	Mean	62.94	65.27	68.33	65.51	9.84	12.57	15.47	12.63	19.69	22.21	25.64	22.51
MDU 1	**Control**	30.88				6.06				13.17			
	$FeSO_4$	58.10	60.75	64.00	60.95	6.36	9.91	12.94	9.73	16.92	19.19	22.45	19.52
	$ZnSO_4$	55.59	57.37	60.55	57.84	5.72	9.25	12.09	9.02	15.21	17.44	21.02	17.89
	SSP	51.88	53.74	56.60	54.07	9.58	11.97	14.70	12.08	23.73	24.94	27.80	25.49
	Gypsum	48.39	50.55	53.45	50.80	8.09	11.12	13.92	11.05	19.64	21.32	24.39	21.78
	Mean	53.49	55.60	58.65	55.91	7.44	10.56	13.41	10.47	18.87	20.72	23.91	21.17
		SE d		**CD (P=0.05)**		**SE d**		**CD (P=0.05)**		**SE d**		**CD (P=0.05)**	
V		1.39		1.65		0.30		0.59		0.55		1.07	
S		1.25		1.48		0.27		0.53		0.49		0.96	
L		1.08		2.12		0.24		0.46		0.43		0.83	

Table 2. Effect of sulphur source and levels on available and uptake sulphur of blackgram genotypes

Genotypes	S sources	Available sulphur (mg kg^{-1})				Sulphur uptake (kg ha^{-1})			
		S $_{20}$	S $_{30}$	S $_{40}$	Mean	S $_{20}$	S $_{30}$	S $_{40}$	Mean
VBN 11	Control	6.50				1.04			
	$FeSO_4$	9.13	10.67	15.37	11.72	2.33	2.80	3.17	2.77
	$ZnSO_4$	8.62	10.08	14.83	11.18	2.14	2.58	2.88	2.53
	SSP	9.45	11.35	15.86	12.22	1.81	2.22	2.59	2.21
	Gypsum	9.87	11.85	16.30	12.67	1.61	1.93	2.37	1.97
	Mean	9.27	10.99	15.59	11.95	1.97	2.38	2.75	2.37
CO 6	Control	7.32				0.82			
	$FeSO_4$	10.05	12.31	17.12	13.16	2.07	2.28	2.69	2.35
	$ZnSO_4$	9.53	11.69	16.57	12.59	1.61	1.98	2.45	2.01
	SSP	10.93	13.02	17.63	13.86	1.35	1.79	2.20	1.78
	Gypsum	11.36	13.55	18.09	14.33	1.19	1.61	2.03	1.61
	Mean	10.47	12.64	17.35	13.49	1.56	1.91	2.34	1.94
VRI 8	Control	9.44				0.66			
	$FeSO_4$	12.07	14.55	19.50	15.37	1.57	1.81	2.18	1.85
	$ZnSO_4$	11.53	13.90	18.92	14.78	1.27	1.58	2.01	1.62
	SSP	13.01	15.31	20.02	16.11	1.05	1.43	1.81	1.43
	Gypsum	13.46	15.87	20.50	16.61	0.91	1.28	1.67	1.29
	Mean	12.52	14.91	19.73	15.72	1.20	1.53	1.92	1.55
CO 7	Control	7.03				0.52			
	$FeSO_4$	9.62	11.81	16.59	12.68	1.38	1.53	1.83	1.58
	$ZnSO_4$	9.10	11.20	16.04	12.12	1.09	1.37	1.71	1.39

	SSP	10.49	12.52	17.09	13.37	0.86	1.20	1.52	1.19
	Gypsum	10.91	13.04	17.55	13.83	0.72	1.02	1.34	1.03
	Mean	10.03	12.14	16.82	13.00	1.01	1.28	1.60	1.30
MDU 1	**Control**	8.55				0.47			
	$FeSO_4$	11.10	13.44	18.14	14.23	1.09	1.23	1.56	1.29
	$ZnSO_4$	10.57	12.81	17.58	13.65	0.82	1.06	1.34	1.07
	SSP	11.87	14.01	18.65	14.84	0.64	0.91	1.18	0.91
	Gypsum	12.29	14.54	19.10	15.31	0.54	0.77	1.04	0.78
	Mean	11.46	13.70	18.37	14.51	0.77	0.99	1.28	1.01
		SE d		**CD (P=0.05)**		**SE d**		**CD (P=0.05)**	
V		0.30		0.59		0.05		0.12	
S		0.27		0.53		0.04		0.07	
L		0.23		0.46		0.03		0.06	