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ORIGINAL ARTICLE **OPEN ACCESS**

Effect of Sources and Levels of Sulphur on Uptake of Major Nutrients by Sesame (*Sesamum indicum* L.) and Post Harvest Nutrient Status in Soil

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ABSTRACT

A field experiment was conducted during the kharif season of 2012 on farmer's field at Marewad village of Dharwad district to study the effect of sources and levels of sulphur on nutrient uptake of sesame and post harvest nutrient status in soil. The experiment was laid out in RCBD with factorial concept with three replications. It consists of 13 treatments combinations comprised of three sources of sulphur (Single super phosphate, Gypsum and Elemental sulphur) and four levels of sulphur (10, 20, 30 and 40 kg ha^{-1}) and with one control treatment without sulphur. The uptake of major nutrients i.e., Nitrogen (74.59 kg ha^{-1}), Phosphorous (5.19 kg ha^{-1}), Potassium (36.22 kg ha^{-1}) and Sulphur (4.82 kg ha^{-1}) were highest with application of single super phosphate across all the sulphur levels. Among the levels of sulphur application of higher level of sulphur at 40 kg ha^{-1} recorded higher N, P, K and S uptake (77.04, 5.29, 37.02 and 5.03 kg ha^{-1}). Available nitrogen status of soil decreased progressively with increased levels of sulphur from 10 to 40 kg ha^{-1} (227.8 to 206.7 kg ha^{-1}). Among the levels, significantly lower available nitrogen was recorded with application of 40 kg S ha^{-1} (206.7 kg ha^{-1}) indicating higher uptake of nitrogen.

Keywords: *Sulphur, Nutrient uptake, Sesame, Single super phosphate, Gypsum*

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INTRODUCTION

Sesame seed, commonly known as Til in India is largely produced for its oil and is also used as a flavoring agent. The seeds come in several colours like red, white, black, yellow, depending upon the variety of the seeds. The seeds have high oil content around 55%. They are also a good source of magnesium, calcium, iron, phosphorus, vitamin B1, selenium, and zinc. In addition, sesame seeds are a good source of both dietary fiber and monounsaturated fats.

At present, national average yields of sesame is 303 kg ha^{-1}, which needs to be increased to at least 1.2 and 1.5 tonnes by 2025 as reported by Hedge [5]. However, the gap between the potential achievable yield and the average yield of sesame is wide. Therefore it requires a dedicated and an integrated agronomic effort to find appropriate strategies that would be beneficial to all the stakeholders. The main reason for low productivity of sesame is its cultivation in marginal and sub marginal lands under poor management and input starved rainfed conditions.

Sulphur plays a key role in the plant metabolism, indispensable for the synthesis of essential oils, chlorophyll formation, required for development of cells and it also increases cold resistance and drought hardiness of crops especially for oilseed crops. Use of high analysis sulphur free fertilizers, heavy sulphur removal by the crops under intensive cultivation and neglect of sulphur replenishment contributed to widespread sulphur deficiencies in arable soils. Sulphur has become one of the major limiting nutrients for oilseeds in recent years due to its widespread deficiency [4].

Sulphur-deficiency symptoms are more frequently observed in crops at early stages of growth, because sulphur can be easily leached from the surface soil [6]. In acute deficiency of sulphur flowering and seed formation is greatly reduced, resulting in poor yield and oil content. Sulphur also plays an important role in the chemical composition of seeds. Sulphur is the component of the amino acids, cystine, cysteine and methionine, needed for chlorophyll. It increases the percentage of oil [3]. Keeping those aspects in view, a field experiment was planned to study the effect of sources and levels of sulphur on nutrient uptake and post harvest nutrient status in soils.

MATERIAL AND METHODS

A field experiment was conducted during the *kharif* season of 2012 on farmer's field at Marewad village of Dharwad district to study the "Effect of sources and levels of sulphur on growth, yield and uptake of sesame". The soil of the experimental site was black clay loam in texture (Vertisol), slightly alkaline in reaction (7.9) with medium organic carbon (0.78%), low available nitrogen (257.5 kg ha^{-1}), high available phosphorus (31.6 kg ha^{-1}), high available potassium (554 kg ha^{-1}) and low in available sulphur (9.6 ppm) contents.

The experiment was laid out in RCBD with factorial concept with three replications. There were 13 treatments combinations comprised of three sources of sulphur (Single super phosphate, Gypsum and Elemental sulphur) and four levels of sulphur (10, 20, 30 and 40 kg ha^{-1}) and with one control treatment without sulphur application. Variety DS – 5 was sown at 30 x 10 cm spacing. The full dose of sulphur was applied from different sources of sulphur i.e. single super phosphate, gypsum and elemental sulphur at 10, 20, 30 and 40 kg S ha^{-1} at the time of sowing as per treatment combinations. The recommended dose of nitrogen, phosphorus and potassium were applied at the rate of 50:25:25 kg N, P_2O_5 and K_2O per hectare in the form of urea, diammonium phosphate and muriate of potash after taking into consideration of the contribution of N from DAP and contribution of P_2O_5 from single super phosphate. FYM was incorporated 15 days before sowing in the respective plots as per recommended dose (5 t ha^{-1}). All the cultural practices were followed as per the recommended package of practices for sesame. Thinning was done after 15 days of sowing, Hand weeding was carried out twice at 30 and 45 days after sowing. The soil samples were collected from each treatment after harvest of sesame crop to assess the change in nutrient status.

RESULTS AND DISCUSSION

Effect of different sources and levels of sulphur on sulphur uptake (kg ha^{-1}) by seed and stalk at harvest.

Application of different sources induced significant effect on sulphur uptake at harvest. Sulphur uptake by seed (1.59 kg ha^{-1}) and stalk (3.23 kg ha^{-1}) was significantly higher in single super phosphate treatment compared to elemental sulphur (2.76 and 1.38 kg ha^{-1}) and was on par with gypsum (2.95 and 1.54 kg ha^{-1}) respectively by stalk and seed (Table - 1) . It is an established fact that plant removes more nutrients from the soil, as its availability increased by addition of fertilizers. In the present investigation, native available soil sulphur (9.6 ppm) status was lower than the critical value and the application of single super phosphate and gypsum increased the availability and uptake of sulphur coupled with higher dry matter production lead to higher sulphur uptake. The lowest sulphur uptake at harvest was observed in control (2.24 and 1.11 kg ha^{-1} respectively by stalk and seed). The results are corroborated the findings of Kalaiyarasan *et al*. [8] who revealed that the addition of 45 kg S ha^{-1} through gypsum recorded the highest uptake of N, P, K and S.

Significantly higher sulphur uptake (1.67 kg ha^{-1}) by seed and stalk (3.36 kg ha^{-1}) was recorded with application of higher level (40 kg ha^{-1}) of sulphur compared to preceding lower levels of 20 kg S ha^{-1} and 10 kg S ha^{-1} and found on par with the 30 kg S ha^{-1}(1.65 and 3.23 respectively in seed and stalk) (Table - 1). It might be due to higher sulphur content in seed and stalk together with higher seed and stalk yield resulted in higher uptake of sulphur. Similar results were reported earlier by Pati *et al*. [10], who reported that sulphur concentration in seed and stack increased due to graded levels.

Effect of different sources and levels of sulphur on nitrogen, phosphorous and potassium uptake (kg ha^{-1})

Different sulphur sources exerted pronounced effect on uptake and available nutrient status of soil with respect to nitrogen, phosphorous and potassium after harvest of the crop. The uptake of N, P and K was significantly higher with single super phosphate (74.56, 5.19 and 36.22 kg ha^{-1}) and gypsum (73.04, 5.99 and 35.63 kg ha^{-1}) application compared to elemental sulphur (66.54, 4.41 and 32.69 kg ha^{-1}), which may be attributed to higher seed and stalk production with single super phosphate and gypsum . Similar results were reported earlier by Dayanand *et al*. [2]

The uptake of nutrients (N, P and K) by grain and straw as well as total uptake by sesame were significantly affected by the levels of sulphur. A marked increase in the total nitrogen (75.12 and 77.04 kg ha^{-1}), phosphorus (5.12 and 5.29 kg ha^{-1}) and potassium (36.17 and 37.02 kg ha^{-1}) uptake was recorded with the application of 30 kg S ha^{-1} and 40 kg respectively (Table -1). It might be due to the higher biomass production lead to higher uptake of nutrients from soil at higher sulphur levels. Indira *et al.* [7], also reported that the uptake of N, P, K and S increased with increasing levels of sulphur.

Effect of different sources and levels of sulphur on available nutrient status in soil after harvest of sesame

Among the sulphur sources, available nitrogen (210.0 kg N ha^{-1}) and phosphorous (26.58 kg P_2O_5 ha^{-1}) status was significantly lower under single super phosphate treatment compared to elemental sulphur (221.4 kg N ha^{-1} and 29.20 kg P_2O_5 ha^{-1}, respectively). Gypsum (216.0 kg N ha^{-1} and 26.37 kg P_2O_5 ha^{-1}) was intermediate between single super phosphate and elemental sulphur (Table -2). It might be due to the uptake of N, P and K was significantly higher with single super phosphate and gypsum application than elemental sulphur, which may be attributed to higher seed and stalk production. Chaurasia *et al.* [1] who reported that the treatment of 40 kg S ha^{-1} gave significantly higher uptake of N, P, K and S in soybean and increased the available N, P_2O_5, K_2O and S in the soil Available K_2O status of soil after harvest of sesame crop was not significant due to initial high status of soil available K_2O (554 kg ha^{-1}).

Available N, P_2O_5 and K_2O of soil after harvest of crop was significantly influenced by graded levels of sulphur. Available nitrogen status of soil decreased progressively with increased levels of sulphur from 10 to 40 kg ha^{-1} (227.8 to 206.7 kg ha^{-1}). Among the levels, significantly lower available nitrogen was recorded with application of 40 kg S ha^{-1} (206.7 kg ha^{-1}) indicating higher uptake of nitrogen (Table - 2). Similar trend was observed with respect to phosphorous and potassium, because of synergistic interaction of sulphur with N, P, and K and higher stalk and seed yield at higher levels of sulphur lead to higher uptake of N, P and K. Added N, P_2O_5 and K_2O responded well with higher levels of applied sulphur (40 and 30 kg S ha^{-1}) that reflected in available N, P_2O_5 and K_2O status of soil after harvest. This is in line with Chaurasia *et al.* [1] and Vaghani *et al*. [11], who reported 40 kg S ha^{-1} recorded significantly higher available N, P_2O_5, K_2O and S in the soil after harvest of crop.

Available sulphur (kg S ha^{-1})

Significantly higher available soil sulphur (S) status was noticed under elemental sulphur treatment (30.12 kg ha^{-1}) as compare to gypsum treatment (25.57 kg ha^{-1}) and single super phosphate (24.88 kg ha^{-1}). Fertilization of sulphur at 40 kg S ha^{-1} recorded significantly higher available sulphur (30.16 kg S ha^{-1}) status in soil after harvest compared to 30 kg S ha^{-1} (27.13 kg S ha^{-1}), 20 kg S ha^{-1} (25.36 kg S ha^{-1}) and 10 kg S ha^{-1} (24.0 kg S ha^{-1}) respectively . While the lowest available sulphur (S) was noticed in control (16.10 kg ha^{-1}) (Table -2)

Table 1: Nitrogen, phosphorus, potassium and sulphur uptake by sesame as influenced by different sources and graded levels of sulphur at harvest stage of sesame crop

Sulphur levels	Nitrogen uptake (kg/ha)				Phosphorous uptake (kg/ha)				Potassium uptake (kg/ha)				Sulphur uptake (kg/ha)			
	Sulphur sources				Sulphur sources				Sulphur sources				Sulphur sources			
	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean
L_1 (10 kg ha^{-1})	65.22	68.35	61.93	65.16	4.40	4.66	3.92	4.33	32.80	32.10	31.58	32.16	3.62	4.02	3.41	3.68
L_2 (20 kg ha^{-1})	68.54	71.65	64.56	68.25	4.78	4.91	4.45	4.71	34.15	35.12	32.83	34.03	4.36	4.82	3.86	4.35
L_3 (30 kg ha^{-1})	79.08	78.74	67.52	75.12	5.34	5.49	4.53	5.12	37.36	38.64	32.53	36.17	4.93	5.20	4.49	4.88
L_4 (40 kg ha^{-1})	79.32	79.63	72.15	77.04	5.42	5.71	4.75	5.29	38.22	39.02	33.82	37.02	5.05	5.23	4.82	5.03
Mean	73.04	74.59	66.54		4.99	5.19	4.41		35.63	36.22	32.69		4.49	4.82	4.15	
Control	60.31				3.90				28.72				3.35			
For comparison of means	**S.Em ±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**		**S.Em ±**		**CD (0.05)**		**S.Em ±**			**CD (0.05)**
Sources (S)	1.939		5.688		0.10		0.30		0.796		2.335		0.10			0.31
Levels (L)	2.240		6.568		0.12		0.35		0.919		2.696		0.12			0.35
S x L (Interaction)	3.879		NS		0.21		NS		1.592		NS		0.21			NS
Control Vs Treatments	3.86		11.27		0.20		0.59		1.57		4.57		0.20			0.58

SSP- Single super phosphate G-Gypsum ES- Elemental Sulphur

Higher values of available soil sulphur under elemental sulphur treatment indicate comparatively small fraction of applied sulphur was utilized by sesame compared to single super phosphate and gypsum. Elemental sulphur has higher concentration of sulphur and comparatively minimum leaching losses and it releases sulphur slowly into soil solution resulted in higher cumulative sulphur status in soil compared to single super phosphate and gypsum. Available soil sulphur status was significantly higher under elemental sulphur treatment (30.12 kg ha^{-1}) compared to single super phosphate (24.88 kg ha^{-1}) and gypsum (25.57 kg ha^{-1}) indicating reduced leaching losses of sulphur and higher residual effect due to elemental sulphur could not be directly used by plants. It must first be converted to sulphate-sulphur ($SO4^{-2}$ -S) by soil microorganisms, which ultimately improves the native soil sulphur status for succeeding crop. The results are in conformity with those obtained by Pati *et al*. [10]. Who reported that an increase in available S in soil over the control was observed with all levels and sources of sulphur.

Availability of S in soil was significantly increased with the application sulphur. This might be ascribed to adsorption of part of applied sulphur on organic matter and thereby reducing the leaching losses of sulphur. The increasing level of S fertilization from 10 to 40 kg/ha (30.61 kg S ha^{-1}) significantly improved available S content in the soil after harvest of the crop (Table 2). The increase in available S content in the soil after harvest of the crop might be attributed to the fact that only a small fraction of the applied S was utilized by the sesame compared to 10 (24.0 kg S ha^{-1}), 20 (25.36 kg S ha^{-1}) and 30 (27.46 kg S ha^{-1}). Kumar and Trivedi [9], also reported that increased soil available S status after harvest of the mustard crop with increased levels of sulphur.

Table 2: Effect of different sources and levels of sulphur on available nutrient status (kg ha^{-1}) of soil after harvest of sesame crop

Sulphur levels	Nitrogen (kg /ha)				Phosphorous (kg P_2O_5 /ha)				Potassium (kg K_2O ha^{-1})			Sulphur (kg ha^{-1})				
	Sulphur sources				Sulphur sources				Sulphur source			Sulphur sources				
	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean	S_1 (G)	S_2 (SSP)	S_3 (ES)	Mean
L_1 (10 kg ha^{-1})	228.6	222.8	232.0	227.8	29.10	28.10	30.88	29.36	538.2	536.9	537.4	537.5	23.04	22.23	26.74	24.00
L_2 (20 kg ha^{-1})	221.2	212.0	223.2	218.8	25.92	27.29	30.08	27.76	526.9	523.9	526.2	525.6	24.81	23.45	27.81	25.36
L_3 (30 kg ha^{-1})	207.7	203.2	218.8	209.9	25.03	25.43	28.60	26.35	513.6	510.4	516.5	513.5	25.62	25.12	31.65	27.46
L_4 (40 kg ha^{-1})	206.6	201.9	211.8	206.7	25.43	25.40	27.23	26.02	511.8	510.0	514.2	512.0	28.82	28.72	34.28	30.61
Mean	216.0	210.0	221.4		26.37	26.56	29.20		522.6	520.3	523.6		25.57	24.88	30.12	
Control	236.5				30.77				545.28			16.1				

For comparison of means	S.**Em ±**	**CD (0.05)**	**S.Em ±**	**CD (0.05)**	**S.Em ±**	**CD (0.05)**	S.**Em ±**	**CD (0.05)**
Sources (S)	2.39	7.00	0.60	1.75	5.41	NS	0.37	1.07
Levels (L)	2.75	8.08	0.69	2.02	6.25	18.32	0.42	1.24
S x L (Interaction)	4.77	NS	1.19	NS	10.82	NS	0.73	NS
Control Vs Treatments	4.65	13.58	1.15	3.36	10.39	NS	0.71	2.08

SSP- Single super phosphate G-Gypsum ES- Elemental Sulphur

CONCLUSIONS

Sulphur application at 40 kg ha^{-1} through single super phosphate in addition to a recommended dose of other nutrients was found optimum for sesame crop for higher nutrient uptake and long-term availability of sulphur to crop.

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