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Effect of Sources and Levels of Sulphur on Growth of Sesame (*Sesamum indicum* L.)

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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 growth of sesame. 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. Among the sources of sulphur, single super phosphate recorded significantly higher plant height (122 cm), number of primary branches (2.93), leaf area plant^{-1} (4.54 dm^2), Leaf are index (1.51), Leaf area duration (79) at harvest compared to all other treatments. Among the levels of sulphur, application of 40 kg/ha sulphur recorded higher plant height (125.36 cm), number of primary branches (3.0), leaf area plant^{-1} (4.63), Leaf are index (1.55) and Leaf area duration (80.75). The treatment receiving 30 kg ha^{-1} sulphur recorded on par results with 40 Kg ha^{-1} sulphur application. Among the combinations, application of single super phosphate at 40 kg ha^{-1} proved significantly superior for growth of sesame.
***Keywords**: Growth, Sulphur, Sesame, Leaf area index , Single super phosphate*

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INTRODUCTION
Sesame (*Sesamum indicum* L.) is believed to be one of the most ancient crops cultivated by humans. Sesame seed has higher oil (around 50 %) and protein (25 %) content Sesame oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as the queen of oilseeds. At present, national average yields of sesame is 303 kg/ha, which needs to be increased to at least 1.2 and 1.5 tonnes by 2015 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 [7]. 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 use was also reported to be very remunerative in many crop sequences involving oilseeds [9].
Since adequate information is lacking on the choice of sulphur fertilizers for sesame, this study was undertaken to know the suitability of various sources and levels of sulphur for sesame grown in Northern Transition Zone (Zone-8) of Karnataka.

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 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 in available nitrogen (257.5 kg ha^{-1}), high in available phosphorus (31.6 kg ha^{-1}), high in 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}). For recording growth observations of the crop, five plants were selected randomly from the net plot area of each treatment and tagged. These tagged plants were used for recording observations at 30 DAS, 60 DAS and at harvest.

RESULTS AND DISCUSSION

Growth attributes of sesame:

Plant Height (cm): At 60 DAS, among the sources, single super phosphate (113.05 cm) recorded significantly higher plant height compared to gypsum and elemental sulphur .Among the levels application of 40 kg S ha^{-1} recorded significantly higher plant height (115.89 cm) and which was on par with 30 kg S ha^{-1} (113.92 cm). The lowest plant height (100.9 cm) was recorded with control. Similar trend was followed in harvest (Table 1). Higher plant height ascribed to addition of single super phosphate and gypsum might be due to higher availability of sulphur compared to elemental sulphur. Kalaiyarasan *et al.* [6] and Vaiyapuri *et al*. [10] also reported that revealed that application of 45 kg S ha^{-1} as gypsum recorded the highest plant height in sesame.

Number of primary branches plant $^{-1}$: Sources of sulphur and levels had a significant effect on number of primary branches $plant^{-1}$ at 60 DAS and at harvest. Single super phosphate produced higher number of primary branches $plant^{-1}$ (2.81 and 2.93 at 60 DAS and at harvest, respectively) and 40 kg S ha^{-1} at both 60 DAS and at harvest (2.89 and 3.0 respectively) recorded higher number of primary branches $plant^{-1}$ (Table 1). The increase in number of branches by sulphur application is attributed to the stimulatory effect of sulphur in cell division. The importance of sulphur in cell division cell elongation and setting of cell structure has been reported by Hadvani *et al.* [3].

Leaf area (dm^2): Sources of sulphur had significant effect on leaf area. At 60 DAS, single super phosphate recorded significantly higher leaf area $plant^{-1}$ (11.19 dm^2) as compared to elemental sulphur (10.45 dm^2) but on par with gypsum (11.00 dm^2) (Table 2). At harvest single super phosphate (4.54 dm^2) and gypsum (4.47 dm^2) recorded significantly higher leaf area $plant^{-1}$ compared to elemental sulphur (4.22 dm^2). Application of 40 kg S ha^{-1} recorded significantly higher leaf area $plant^{-1}$ at 60 DAS and at harvest (11.52 and 4.63 dm^2 respectively). It was on par with 30 kg S ha^{-1} at, 60 DAS and at harvest (11.32 and 4.61dm^2 respectively). This might be ascribed to adequate supply of sulphur that resulted in higher production of photosynthates and their translocation to sink, which ultimately increased the leaf area of plants. The results obtained were also confirmed by Dev and Sarawgi [1] in sunflower. Higher dose of sulphur (40 kg ha^{-1}) enhanced the plant metabolism and photosynthetic activity resulting into better growth and development of plants and ultimately the yields. Similar results were also reported by Ghosh and Joseph [2].

Leaf area index (LAI)

At 60 DAS, higher LAI was recorded with single super phosphate (3.73) application compared to elemental sulphur (3.48) and on par with gypsum (3.67). Among the levels, sulphur application at 40 kg S ha^{-1} recorded higher LAI (3.84) and was statistically on par with 30 kg S ha^{-1} (3.77). Lowest LAI was noticed in control (3.02) (Table 2). At harvest, single super phosphate (1.51) and gypsum (1.49) recorded significantly higher LAI compare to elemental sulphur (1.41). Application of 40 kg S ha^{-1} recorded significantly higher LAI (1.55).The LAI (1.30) under control recorded lowest at harvest compared to other treatments.

Leaf area duration (LAD): Between 30-60 DAS, a higher LAD (72.24) was associated with single super phosphate application compared to elemental sulphur (67.94) followed by gypsum (71.05). Among the sulphur levels, 40 kg S ha^{-1} recorded significantly higher LAD (74.78) and on par with 30 kg S ha^{-1} (73.43) (Table 2). Between 60 DAS - harvest, significantly higher LAD (78.66) was associated with single super phosphate application as against elemental sulphur (73.36) but was on par with gypsum (77.34). Among the sulphur levels, application of 40 kg S ha^{-1} recorded significantly higher LAD (80.75) followed by application of 30 kg S ha^{-1} (79.64). It might be due to role of sulphur in chlorophyll formation. Similar results were reported by Shekhawat and Shivay [8].

CONCLUSION

Sulphur application had significant effect on growth of sesame grown in Vertisols. In neutral pH soils, application of single super phosphate at 40 kg ha^{-1} recorded higher growth parameters.

Table 1: Effect of different sources and levels of sulphur on plant height (cm) and number of primary branches of sesame at different growth stages

Sulphur levels	Plant height (cm)								No of primary branches							
	60 DAS				At harvest				60 DAS				At harvest			
	Sulphur sources				Sulphur sources				Sulphur sources				Sulphur sources			
	S1 (G)	S2 (SSP)	S3 (ES)	Mean	S1 (G)	S2 (SSP)	S3 (ES)	Mean	S1 (G)	S2 (SSP)	S3 (ES)	Mean	S1 (G)	S2 (SSP)	S3 (ES)	Mean
L_1 (10 kg ha^{-1})	101.3	103.1	105.7	103.4	114.9	114.7	117.5	115.7	2.20	2.50	2.04	2.25	2.42	2.62	2.32	2.45
L_2 (20 kg ha^{-1})	104.8	110.1	102.1	105.7	117.7	121.6	116.5	118.6	2.64	2.90	2.17	2.57	2.81	3.05	2.58	2.81
L_3 (30 kg ha^{-1})	116.3	119.4	106.1	113.9	123.8	127.0	118.8	123.2	2.79	2.90	2.70	2.80	2.93	3.10	2.86	2.96
L_4 (40 kg ha^{-1})	117.2	119.6	110.8	115.9	125.4	128.1	122.5	125.4	2.96	2.94	2.76	2.89	3.15	2.95	2.91	3.00
Mean	109.9	113.1	106.2		120.5	122.8	118.8		2.65	2.81	2.42		2.83	2.93	2.67	
Control	100.9				107.1				2.06				2.42			

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)	1.7	5.1	2.1	NS	0.09	0.27	0.07	0.19
Levels (L)	2.0	5.8	2.3	6.9	0.11	0.31	0.08	0.22
S x L (Interaction)	3.4	NS	4.06	NS	0.19	NS	0.13	NS
Control Vs Treatments	3.3	9.7	3.3	9.7	0.18	0.53	0.13	0.38

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

Table 2: Effect of different sources and levels of sulphur on leaf area per plant (dm ^{2}), Leaf area index (LAI) and leaf area duration (LAD) of sesame at different growth stages

Parameter	Stage	Sulphur sources	L_1 (10 kg ha^{-1})	L_2 (20 kg ha^{-1})
leaf area (dm ^{2})	60 DAS	S_1 (G)	10.21	10.87
		S_2 (SSP)	10.26	10.69
		S_3 (ES)	9.88	10.14
		Mean	10.12	10.57
	At harvest	S_1 (G)	4.18	4.42
		S_2 (SSP)	4.23	4.40
		S3 (ES)	3.90	4.07
		Mean	4.10	4.30
leaf area index (LAI)	60 DAS	S_1 (G)	3.40	3.62
		S_2 (SSP)	3.42	3.56
		S_3 (ES)	3.29	3.38
		Mean	3.37	3.52
	At harvest	S_1 (G)	1.39	1.47
		S_2 (SSP)	1.41	1.47
		S_3 (ES)	1.30	1.36
		Mean	1.37	1.43
leaf area duration (LAD)	60 DAS - harvest	S_1 (G)	72	76
		S_2 (SSP)	72	75
		S_3 (ES)	69	71
		Mean	71	74

L_3 (30 kg ha^{-1})	L_4 (40 kg ha^{-1})	**Mean**	Control	**For comparison of means**	Sources (S)	Levels (L)	S x L (Interaction)	Control Vs Treatments
11.33	11.58	11.00	9.07	**S.Em ±**	0.15	0.18	0.31	0.29
11.84	11.98	11.19						
10.80	10.99	10.45		**CD (0.05)**	0.45	0.52	NS	0.86
11.32	11.52							
4.63	4.65	4.47	3.90	**S.Em ±**	0.07	0.08	0.13	0.15
4.74	4.78	4.54						
4.45	4.46	4.22		**CD (0.05)**	0.19	0.22	NS	0.43
4.61	4.63							
3.78	3.86	3.67	3.02	**S.Em ±**	0.05	0.06	0.10	0.10
3.95	3.99	3.73						
3.60	3.66	3.48		**CD (0.05)**	0.15	0.17	NS	0.29
3.77	3.84							
1.54	1.55	1.49	1.30	**S.Em ±**	0.02	0.02	0.04	0.05
1.58	1.59	1.51						
1.48	1.50	1.41		**CD (0.05)**	0.06	0.07	NS	0.14
1.54	1.55							
80	81	77	65	**S.Em ±**	72	76	80	81
83	84	79						
76	77	73		**CD (0.05)**	72	75	83	84
80	81							

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

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