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Effect of Different Levels and Sources of Sulphur on Growth and Productivity of Sesame under Sandy Soils of Western Rajasthan

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A B S T R A C T

An experiment was carried out at the Instructional farm, College of Agriculture, Bikaner during *Kharif* 2017-18 on loamy sand soil. The experiment comprising of four sources (Gypsum, ES, SSP + Gypsum and SSP+ES) and four levels of sulphur (30, 45, 60 and 75 kg ha^{-1}) along with an absolute control (no sulphur) making 17 treatment combinations. These 17 combinations were replicated three times in factorial randomized block design. Results showed that application of sulphur through SSP + gypsum, significantly increased the dry matter accumulation at 30, 60 DAS and at harvest. These sources @ 60 kg S ha^{-1} except plant stand at 30 DAS and at harvest. gave significantly higher dry matter accumulation at 30, 60 DAS and at harvest, plant height at harvest over control and which was statistically at par with 75 kg S ha^{-1}. Application of sulphur up to 60 kg S ha^{-1} increased the biological yield of sesame significantly over preceding levels. The increase in biomass with this level was 12.51 and 7.88 percent over 30 and 45 kg S ha^{-1}, respectively. Maximum biological yield was recorded in 75 kg S ha^{-1} treatment which was statistically at par with 60 kg S ha^{-1}. Application of sulphur through SSP + gypsum produced significantly higher biological yield (3647.7 kg ha^{-1}) which was 8.48, 7.66 and 6.60 percent higher over ES, ES+SSP and gypsum, respectively. Application of SSP + gypsum significantly increased the plant height and dry matter accumulation and crop productivity over ES+SSP, gypsum and ES. Among the sources and levels of sulphur application, SSP + gypsum recorded higher total biomass up to 75 kg S ha^{-1}.

Introduction

Sesame (*Sesamum indicum* L.) also called as “Queen of oil seeds” has been known to be one of the earliest domesticated edible oilseeds used by the mankind. It is an important edible oil seed crop next to groundnut and rapeseed-mustard. It`s oil content generally varies from 46 to 52 percent and protein content 18-20 percent. Globally, sesame is grown on more than 7.0 million hectares with production of 4.0 million tonnes and productivity of 535 kg ha^{-1}. India is the largest producer of sesame in the world. It is cultivated on 2.0 mha with total production of 0.81 mt. The average productivity of the crop is 405.5 kg ha^{-1} (Anonymous, 2014-15). In Rajasthan, it is successfully cultivated in Pali, Sirohi, Karauli, Sawaimadhopur, Hanumangarh, Bhilwara, Nagaur, Jodhpur and Jhunjhunu districts. Despite of being such an important sesame growing state, the average productivity in Rajasthan is very low in comparison to global as well as national level. Cultivation of crop on marginal and sub-marginal lands of poor fertility under rain fed condition, low and scanty rainfall, poor agronomic practices and inadequate or even no use of fertilizers are the major factors responsible for low productivity. Sulphur is an essential plant nutrient. Research work done in different parts of the country indicates that application of sulphur is highly profitable and seems to be essential for boosting the crop production. Available sulphur in soil is frequently ranged between 5-10 ppm in light textured soils of Rajasthan. In such soils, each unit of sulphur applied can augment the supply of edible oil by 3.5 units (Tandon, 1995). It has been reported that, on an average, production of one tonne of oilseed requires 12 kg sulphur (Jamal *et al.*, 2010). This suggests that economic crop production cannot be expected from the fertilizers devoid of sulphur.

Sulphur plays an important role in many physiological processes of plant like synthesis of sulphur containing amino acids (cystine, cystein and methionine), vitamins (biotin and thiamine), co-enzyme-A and chlorophyll and metabolism of carbohydrates, protein and fats. It also helps in synthesis of glucosides in sesame oil and increasing the oil quality in oilseed crops. Sulphur also has an important role in development of root system and increases drought and cold tolerance in crops due to disulphide linkage. It helps in control of diseases and pests and hastens the decomposition of crop residues. A number of substances supplying sulphur are available in the market. The direct source of sulphur is elemental sulphur (ES) which is somewhat costlier. Gypsum is another material, containing 18 per cent sulphur, huge deposits of which are found in the state of Rajasthan and being excavated at large scale. Single super phosphate (SSP) is another source containing 12 per cent sulphur in addition of phosphorus. Thus, it is wise to select a relatively cheaper and more effective source of sulphur. Taking into consideration the above facts, the present investigation was planned to evaluate effect of different levels of sulphur and its sources on productivity of sesame in sandy soils of western Rajasthan.

Materials and Methods

The experiment was conducted at research farm of College of Agriculture, Bikaner during *kharif* 2017-18. Geographically, it is situated at 28.01^0 N latitude and 73.22^0 E longitude at an altitude of 234.7 m above mean sea level. The relative humidity of the locality fluctuates between 16.7 to 85.9 percent, total rainfall was 168.3 mm and average maximum and minimum temperature 47.1^oC and 16.8^oC respectively in *kharif* 2017-18.

The experiment comprises four sources of sulphur (Gypsum, Elemental Sulphur, Single Super Phosphate + Gypsum and Single Super Phosphate + Elemental Sulphur) and four levels of sulphur (30, 45, 60 and 75 kg ha^{-1}) along with an absolute control (no sulphur) making 17 treatment combinations. Dry matter accumulation calculate by randomly selected spots from each plot was recorded at 30, 60 DAS and at harvest stage. Plants were uprooted randomly from 3 spots of each plot. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^0 C till a constant weight was achieved. The weight was recorded and expressed as average dry matter $plant^{-1}$ (g). At maturity, crop was harvested separately from each plot. The harvested produce of each plot was tied up in bundles, tagged and allowed to sun dry on threshing floor. After drying, the bundles were weighed for biological yield. Threshing and winnowing was done manually. After cleaning, the final biomass per plot was recorded and converted into kg ha^{-1}.

Experimental data recorded in various observations were statistically analysed with the help of Fisher's analysis of variance technique (Fisher, 1950). The critical difference (CD) for the treatment comparisons were worked out wherever the variance ratio (F test) was found significant at 5% level of significance.

Results and Discussion

Effect of sulphur levels on growth parameters

Results showed that the effect of different levels of sulphur application significantly influenced all experiment traits except plant population at 30 DAS and at harvest stages. Progressive increase in level of sulphur significantly improved the plant height of sesame up to 60 kg S ha^{-1} and was at par with 75 kg S ha^{-1}. Application of 60 kg S ha^{-1} increased the plant height by 23.70 and 08.77 percent over 30 and 45 kg S ha^{-1}, respectively. Progressive increase in level of sulphur significantly also improved the dry matter accumulation of sesame up to 75 kg S ha^{-1} at 30, 60 DAS and harvest stages, but this level was statistically at par with 60 kg S ha^{-1} at 30 and 60 DAS over preceding level. The percent increase due to 75 kg S ha^{-1} was 7.60, 3.65 and 1.19 per cent at 30 DAS and 8.58, 6.54 and 3.56 per cent at 60 DAS and 16.59, 10.03 and 3.92 percent at harvest stages, respectively over 30, 45 and 60 kg S ha^{-1}. Significant increase in plant height and dry matter accumulation was observed due to the application of sulphur upto 60 kg ha^{-1} (Table 1), however and plant population was not influenced by the sulphur levels. It is because of the fact that application of sulphur has been reported to improve not only the availability of sulphur itself but of other nutrients too, which are considered important for the growth and development of plant. Sulphur has also been reported to help in lowering the soil pH, which is the main reason for greater availability and mobility of nutrients especially P, Fe, Mn, and Zn (Hilal *et al.*, 1992). Sulphur in the form of sulphate is involved in various metabolic and enzymatic activities of plant. It is also a constituent of glutathione, a compound supposed to play part in plant respiration and synthesis of oils (Jordon and Reisenaur, 1957). The profound influence of sulphur fertilization on plant height could be attributed to increased metabolic processes in plants which seem to have promoted meristematic activities causing higher apical growth and expansion of photosynthetic surface. Thus, it is obvious that the improved growth and development of the crop plants in the present investigation might be the result of enhanced metabolic activities and photosynthetic rate resulting in improvement in plant height and ultimately the accumulation of dry matter at the successive growth stages. The higher content of sulphur in plants is known to have role in better development and thickening of xylem and collenchymas tissues. The similar results were also reported by Sarkar and Saha (2005), Chaudhari and Patel (2007), Murmu *et al.*, (2015) and Kumar *et al.*, (2017).

Effect of Sulphur levels on crop productivity

A perusal of data (Table 1) showed that application of sulphur up to 60 kg S ha^{-1} increased the biological yield of sesame significantly over preceding levels. The increase in biomass with this level was 12.51 and 7.88 percent over 30 and 45 kg S ha^{-1}, respectively. Maximum biological yield was recorded in 75 kg S ha^{-1} treatment which was statistically at par with 60 kg S ha^{-1}. Every increase in level of sulphur upto 60 kg ha^{-1} recorded significant improvement in total biomass. The improvement in total biomass seems to be due to the balanced nutritional environment. Another probable reason could be efficient and greater partitioning of metabolites and adequate translocation of nutrients towards the developing reproductive structures i.e. sinks.

Effect of sulphur sources on growth parameters

Effect of different sources of sulphur application significantly influenced all treatments except plant population at 30 DAS and at harvest stages. Application of sulphur through SSP + gypsum was found as the most effective source in enhancing plant height of sesame. This source of sulphur increased the plant height by 6.42, 5.90 and 5.05 percent over ES, SSP+ES and gypsum, respectively. A further perusal of data (Table 1 and Fig. 1) showed that there was non-significant effect of different sources of sulphur on dry matter accumulation at 30 DAS, but, different sources of sulphur significantly affected the dry matter accumulation at 60 DAS and at harvest. The maximum dry matter of 9.59 and 12.77 g plant^{-1} was obtained under SSP + gypsum which was 5.50 and 3.74 per cent more than gypsum, 6.44 and 4.76 per cent more than ES and 5.73 and 4.24 per cent more than SSP+ES at 60 DAS and harvest stage, respectively. It is apparent from data (Table 1) that plant height and dry matter accumulation significantly increased under SSP + gypsum treated plots at all the growth stages over control, ES, SSP+ES and gypsum. Higher plant height ascribed to addition of SSP + gypsum might be due to higher availability of sulphur as compared to other sources. It was probably due to successive increase in cell multiplication, elongation and expansion throughout the entire period of crop upto maturity. This might also be ascribed to adequate supply of sulphur that resulted in higher production of photosynthates which ultimately increased the plant growth and growth attributes. Another reason for enhancement of growth parameters might be due to increased uptake of nitrogen, sulphur and phosphorus which have resulted into larger photosynthesizing surface and accelerated the process of formation and translocation of photosynthates and hence overall development of the plant.

Fig.1 Effect of sulphur levels and its sources on dry matter accumulation at 30, 60 DAS and at harvest

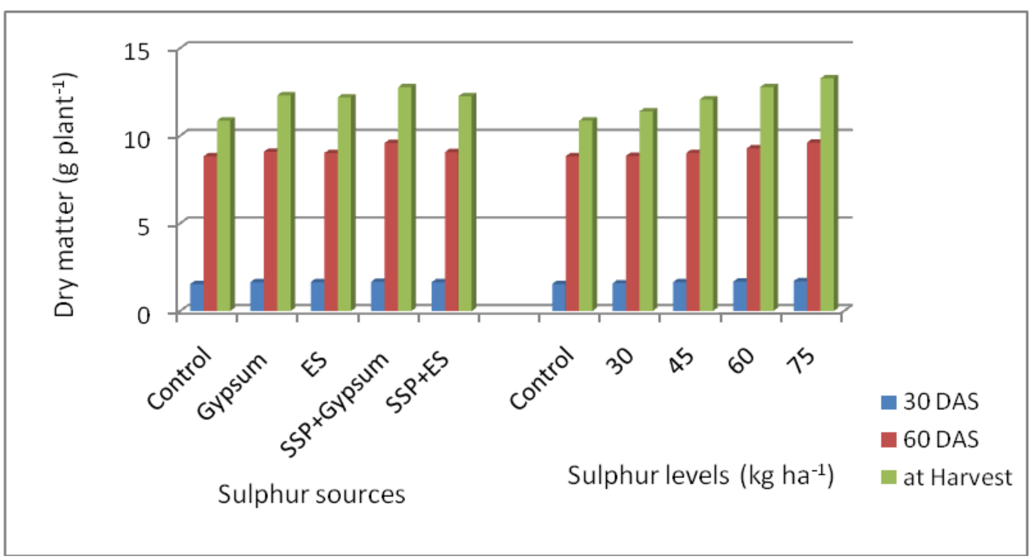

Table.1 Effect of sulphur levels and its sources on plant population m^2 (30 DAS and at harvest), plant height at harvest, dry matter accumulation (30, 60 DAS and at harvest) and total biomass

Treatments	Plant population		Plant height (cm)	Dry matter (g $plant^{-1}$)			Total Biomass (kg ha^{-1})
	30 DAS	Harvest		30 DAS	60 DAS	Harvest	
Sulphur sources							
Gypsum	32.50	30.00	159.63	1.65	9.09	12.31	3421.7
ES	30.00	29.50	157.56	1.65	9.01	12.19	3362.6
SSP+Gypsum	33.25	30.00	167.69	1.67	9.59	12.77	3647.7
SSP+ES	31.51	29.00	158.36	1.64	9.07	12.25	3388.1
SEm ±	0.905	0.672	1.355	0.027	0.156	0.145	51.5
CD at 5 %	NS**	NS**	3.903	NS**	0.450	0.419	148.3
Sulphur levels (kg ha^{-1})							
30	31.58	29.42	139.19	1.58	8.85	11.39	3192.3
45	31.84	29.67	158.30	1.64	9.02	12.07	3329.6
60	31.87	29.75	172.18	1.68	9.28	12.78	3591.7
75	31.98	29.67	173.57	1.70	9.61	13.28	3706.5
SEm ±	0.905	0.672	1.355	0.027	0.156	0.145	51.5
CD at 5 %	NS**	NS**	3.903	0.078	0.450	0.419	148.3
Control	31.00	29.00	132.84	1.54	8.83	10.86	2973.0
Sulphur treatments	31.82	29.63	160.81	1.65	9.19	12.38	3455.0
F test	NS**	NS**	S*	S*	S*	S*	S*

*Significant, **Non-Significant

Higher dry matter accumulation with gypsum source was also reported by Kumar *et al.,* (2011) in sunflower, Yadav and bohra (2008), Rani *et al.,* (2009) and higher plant height with gypsum by Rao *et al.,* (2013) in groundnut, Shinde *et al.,* (2011), and Tripathi *et al.,* (2007) along with SSP.

Effect of sulphur sources on crop productivity

A perusal of data (Table 1) showed that application of sulphur through SSP + gypsum produced significantly higher biological yield (3647.7 kg ha^{-1}) which was 8.48, 7.66 and 6.60 percent higher over ES, ES+SSP and gypsum, respectively. The significant increase in total biomass under SSP + gypsum might be attributed to the higher solubility and easy availability of SO_4^{-2} sulphur present in SSP + gypsum as compared to only gypsum and "sulphide" form of sulphur present in elemental sulphur which essentially requires its oxidation to be converted into SO_4^{-2} form of sulphur prior to be finally absorbed by the plant. Results of Pati *et al.,* (2011) also revealed that total biomass of sesame increased significantly with the source supplying SO_4^{-2} -S.

Sulphur fertilization over control

Results revealed that different levels as well as sources of sulphur could not bring significant variation in plant population of sesame at 30 DAS and at harvest stages (Table 1). Average of different of sources and levels of sulphur significantly increased the plant height by 21.05 per cent over control, dry matter accumulation varied significantly at 7.14, 4.07 and 14.00 per cent over control respectively at 30, 60 DAS and harvest and total biomass of sesame by 16.21 per cent over control.

Application of SSP + gypsum significantly increased the plant height and dry matter accumulation at harvest over ES+SSP, gypsum and ES. The increasing levels of sulphur up to 60 kg S ha^{-1} significantly increased the plant height at harvest and dry matter accumulation per plant at all the stages. However, the higher level was found at par with 60 kg S ha^{-1}. The plant stand at 30 DAS and at harvest was observed non-significant. Among the sources and levels of sulphur application, SSP + gypsum recorded higher total biomass up to 75 kg S ha^{-1}.

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