Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 1397-1399
Received: 01-11-2020
Accepted: 03-12-2020

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Effects of different sources and level of sulphur on growth, yield attributes and yield of *kharif* sesamum (*Sesamum indicum* L.)

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Abstract
The field experiment was conducted at the experimental farm, Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS) India during the 2015 to study the response of *kharif* Sesamum (*Sesamum indicum* L.) to different sources and level of Sulphur. The experiment consisted of eight treatment combinations of different sources and levels of Sulphur in Factorial Randomized Block Design replicated thrice. The results of study revealed that use of Bensulf as a source of sulphur recorded significantly higher growth, yield and yield attributes as compared to gypsum as source. Among the levels of Sulfur, application of 40 kg S ha^{-1} recorded significantly enhanced growth, yield and yield attributes than the application of 10 and 20 kg S ha^{-1} but it was at par with 30 kg S ha^{-1} for *kharif* Sesamum.

Keywords: Bensulf, sulphur, growth, yield and yield attributes

Introduction

Sesamum indicum L., is one of the most important oilseed crop grown extensively in India. Sesamum is having quality food, nutrition, edible oil, biomedicine and health care, all in one. Sesamum seed is rich source of linoleic acid, vitamins E, A, B_1, B_2 and niacin and minerals including calcium and phosphorus.

Lack of suitable varieties, lack of production inputs, improper management practices and inappropriate cultural operations are the main reasons for poor sesamum yield. Sulphur requirement of sesamum is more being an oilseed crop. Sulphur application significantly improves the quality of sesamum oil in terms of free fatty acids, like linolic acids and oleic acids. It plays a very vital role in the nutrition of oilseed crops particularly as it is a key element of S containing amino acids (Takkar, 1987) [13]. Sulphur as a plant nutrient can play a key role in augmenting the production and productivity of oilseeds in the country as it has a significant influence on quality and development of oilseeds.

Some reports earlier elucidated the positive effects of S application in improving the productivity and oil quality of sesame but still comprehensive study is needed to evaluate the effect of sulphur levels and efficacy of different sulphur sources in improving the yield and oil quality of sesame under rainfed conditions. Considering the above discussed factors, present investigation was undertaken with a view to study the response of *kharif* Sesamum (*Sesamum indicum* L.) to different sources and level of sulphur.

Material and Methods

The field experiment was conducted during *kharif*, 2015 at Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (MS). Parbhani. The soil of the experimental field was medium deep black and well drained. The topography of the experimental field was fairly uniform and levelled. The experiment was comprised of a total of eight treatment combinations comprising two sources of sulphur (S_1 Gypsum and S_2 Bensulf) and four levels of sulphur *viz.* L_1 10 kg S ha^{-1}, L_2 20 kg S ha^{-1}, L_3 30 kg S ha^{-1} and L_4 40 kg S ha^{-1}, to sesamum assigned in a Factorial Randomized Block Design with three replications. Sulphur application was made to the respective plots at the rate of 10 kg, 20 kg, 30 kg and 40 kg ha^{-1} according to the allocation of treatments at the time of sowing. The source of the material used was gypsum and bensulf analyzing 20% and 13% sulphur respectively. The sulphur per hectare was worked out from the percentage of sulphur present in the gypsum and bensulf. A common dose of 50 kg N ha^{-1}, 25 kg P_2O_5 ha^{-1} and 25 kg K_2O ha^{-1} through DAP (Diammonium phosphate) and Urea were applied as basal dose and FYM was also spread uniformly and mixed immediately in the soil before sowing to the all treatment plots.

The sesamum crop was sown at a spacing of 45 × 15 cm on 24 June 2015 and harvested on 20 September 2016. The various biometric observations were recorded on five randomly selected sesamum plants from net plots, which were tied tags for their easy identification.

Results and Discussion
Growth parameters
Plant height, number of branches plant^{-1} and dry matter accumulation plant^{-1} differed with the different treatments. Differential effect due to different sources and levels of sulphur on height of plant was observed at all stages of crop growth. The source bensulf recorded significantly plant height over gypsum at all stages of crop growth except 45 DAS. It was probably due to successive increase in cell multiplication, elongation and expansion throughout the entire period of crop up to maturity. This might be ascribed to adequate and ready 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. Higher dry matter accumulation with gypsum source was also reported by Kumar *et al*. (2011) [4].
The height of plant was significantly influenced by different levels of sulphur. The application of 40 kg S ha^{-1} recorded significantly more plant height than 10 and 20 kg S ha^{-1} whereas it was at par with 30 kg S ha^{-1} except 60 DAS. Increase in plant height with increasing sulphur level might be resulted from synthesis of sulphur containing amino acids, proteins and activity of proteolytic enzymes. Similar results were obtained by Pavani *et al.*, (2013) [6], Duary and Mandal (2006) [1] and Sarkar and Saha (2005) [10].
The data revealed (Table 1) that the rate of increase in mean number of branches was observed during 30 to 60 DAS and thereafter slowly increased up to harvest. The source bensulf recorded significantly more number of branches over the gypsum at all stages of crop growth. Among the levels of sulphur application, 40 kg S ha^{-1} found significantly superior over 10 and 20 kg S ha^{-1} whereas it was at par with 30 kg S ha^{-1}. This might be the result of enhanced metabolic activities and photosynthetic rate resulting in improvement branches per plant. Similar results were obtained by Sarkar and Banik (2002) [9] and Subrahmaniyam *et al.,* (1999). Number of functional leaves per plant was increased continuously up to 60 days. After 60 days the number of leaves was decreased up to harvest. The differences in the numbers of leaves in different sources were found significant. The source bensulf recorded significantly more number of leaves and leaf area over gypsum as a source, while among the levels of sulphur, Application of 40 kg S ha^{-1} recorded significantly more number of leaves and leaf area as compared to lower levels and it was at par with 30 kg S ha^{-1}. Similar was the trend in case of total dry matter accumulation per plant. The profound influence of S fertilization on these parameters could be attributed to its participation in the primary and secondary metabolism as constituent of various organic compounds that are vital for functioning of plant processes, which seems to have promoted meristematic activities causing higher apical growth and expansion of photosynthetic surface that is leaf and leaf area (Sharma, 2011) [11]. These results were corroborating the findings of Pavani *et al.*, (2013) [6] and Saren *et al.,* (2004) [8].
The application of 40 kg S ha^{-1} recorded significantly superior over 10 and 20 kg S ha^{-1} whereas it was at par with 30 kg S ha^{-1}. The increase in total dry matter with application of higher dose of S was due to better crop growth which gave maximum plant height, LAI and ultimately produced more dry matter. Application of sulphur significantly increased the production of more dry matter due to availability of nutrient, absorption and utilization by the plant. These results were in conformity with the findings of Poonia (2000) [7], and Daniela *et al.,* (2008).

Yield attributes
Different sources and levels of sulphur under study influenced significantly the yield attributes and seed yield of sesamum crop (Table 2). Data presented in Table 2 shows that weight of seeds per plant, weight of capsules per plant as well as number of capitula per plantthe increased due to application of sulphur source bensulf as compared to gypsum. Among the levels of sulphur application, 40 kg S ha^{-1} was found significantly superior over 10 and 20 kg S ha^{-1} in recording yield attributes of sesamum, where as it was at par with 30 kg S ha^{-1}.

Yield studies
The seed yield of sesamum differed significantly among the sources and levels of sulphur. Source of sulphur, bensulf was proved significantly superior over gypsum source and among the sulphur levels 40 kg S ha^{-1} was significantly superior over 10 and 20 kg S ha^{-1} whereas it was at par 30 kg S ha^{-1}. An increase in number of capsules per plant, number of seeds per capsule and seed index as a result of sulphur application through gypsum might have resulted into higher seed yield of sesame. The sulphur fertilization played a vital role in improving the formation of vegetative structure there by photosynthesis, strong sink strength through development of reproductive structure and production of assimilates to fill economically important sink. Thus cumulative influence of S application maintained balance source-sink relationship and ultimately resulted in increased seed yield. The results were in line with the findings of Ganeshmurthy (1996) [2] and Hussain *et al.,* (2011) [3].
The data on stover yield and biological yield (kg ha^{-1}) and harvest index of sesamum also followed similar trend of variation as influenced by different sources and levels of sulphur. The increased stalk yield may be the result of greater accumulation of dry matter under gypsum as a source of sulphur. Application of sulphur 40 kg ha^{-1}, owing to availability of more nutrients for plant growth parameters like plant height, branching and leaf area index ultimately dry matter accumulation per plant. These findings are coinciding with the findings of Singh (2001) [12]. It might be owing to beneficial effect of sulphur on crop growth and development, which affects yield attributing characters.

Conclusion
It is concluded from the studies on response of sesamum to the sources and different sulphur levels that, the application of Bensulf was found productive as compared to gypsum. Among the levels of sulphur, application of 30 kg S ha^{-1} was found optimum and productive as compared to other levels.

Table 1: Growth attributes of sesamum as influenced by different treatments

Treatments	Plant height at harvest (cm)	No. of branches plant $^{-1}$	No. of functional leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Total dry matter plant^{-1} (gm)
Sources of sulphur					
S_1- Gypsum	116.00	3.45	13.67	5.98	26.00
S_2- Bensulf	129.00	3.76	14.69	6.79	30.00
S.E. ±	2.36	0.09	0.31	0.24	0.82
C. D. (P=0.05)	7.16	0.28	0.94	0.72	2.48
Levels of sulphur					
L_1- 10kg S ha^{-1}	113.30	3.30	11.50	5.80	25.00
L_2- 20kg S ha^{-1}	119.90	3.50	13.83	5.84	27.00
L_3- 30kg S ha^{-1}	128.80	3.65	15.16	6.51	29.00
L_4- 40kg S ha^{-1}	134.30	3.96	16.18	7.38	31.30
S.E. ±	3.34	0.13	0.44	0.34	1.16
C. D. (P=0.05)	10.12	0.40	1.33	1.02	3.51
Interaction					
S.E. ±	4.72	0.18	0.62	0.48	1.64
C. D. (P=0.05)	NS	NS	NS	NS	NS
General Mean	124.00	3.60	14.17	6.39	28.01

Table 2: Yield attributes and yields of sesamum as influenced by different treatments

Treatments	No. of capitula plant^{-1}	Weight of capitula plant^{-1}	Weight of seed plant^{-1} (g)	No. seed plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Sources of sulphur						
S_1- Gypsum	34.85	14.14	4.04	1775	476	1448
S_2- Bensulf	37.98	15.74	4.43	1892	533	1604
S.E. ±	0.83	0.41	0.11	36	15	44
C. D. (P=0.05)	2.52	1.26	0.34	109	44	133
Levels of sulphur						
L_1- 10kg S ha^{-1}	33.63	13.78	3.71	1746	421	1291
L_2- 20kg S ha^{-1}	35.00	14.28	4.03	1779	490	1474
L_3- 30kg S ha^{-1}	36.68	15.05	4.45	1836	539	1611
L_4- 40kg S ha^{-1}	40.00	16.65	4.75	1973	567	1728
S.E. ±	1.18	0.59	0.16	51	21	62
C. D. (P=0.05)	3.57	1.76	0.49	154	63	188
Interaction						
S.E. ±	1.68	0.83	0.23	72	29	88
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS
General Mean	36.42	14.94	4.24	1834	504	1526

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