International Journal of Research in Agronomy 2024; 7(5): 149-151

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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www.agronomyjournals.com
2024; 7(5): 149-151
Received: 07-03-2024
Accepted: 19-04-2024

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Response on growth and yield of Linseed (*Linum usitatissimum* L.) to different sources and levels of Sulphur

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i6c.822

Abstract
A field experiment was conducted during the Rabi session of 2021-22 in Jaunpur district which lies Indo-Gangetic plains of Central Uttar Pradesh to "Response on growth and yield of Linseed (*Linum usitatissimum* L.) to different sources and levels of Sulphur". The experiment consisted of ten treatment combinations including three sources of sulphur (Gypsum, Phasal samriddhi and Elemental sulphur) and four levels of sulphur (0, 15, 30 and 45 kg S ha^{-1}). The experiment was laid out in Randomized Block Design (FRBD) each replicated three times. The result showed that Phasal samriddhi @ 45 kg ha^{-1} recorded highest growth characters *viz.,* plant population, Plant height (cm), Number of primary and secondary branches $plant^{-1}$ and yield attributing characters *viz.,* number of capsules $plant^{-1}$, number of seeds $capsule^{-1}$, test weight (g), biological yield (q ha^{-1}), seed yield (q ha^{-1}), straw yield (q ha^{-1}), harvest index (%). Among the sources of sulphur, Phasal Samriddhi, being at par with gypsum, proved significantly superior to other.

Keywords: Level of sulphur, sources of sulphur, growth and yield of linseed

Introduction

Linseed (*Linum usitatissimum* L.) is one of the most important oil seed crops in India. It`s belongs to the family linaceae and the genus *Linum* that has 100 species is an important oilseed crop has been grown from ancient times. It is grown for its seed as well as fibre (flax) which is used for manufacture of linin. Seed is directly used for edible purpose. Oil contains in linseed 33-46% which is used for edible and industrial purpose (paint, varnishes, soaps etc.). Sulphur is now diagnosed as the fourth major nutrient in addition to N, P and K. Global reports of sulphur deficiency and resultant crop response, particularly in oil seed crops are quite ostensible (Pandey and Ali 2012) [5]. High yielding varieties of linseed crop demand considerably higher amount of sulphur (Dwivedi *et al.,* 2001) [3]. Sulphur is besmeared in the formation of chlorophyll, amino acids, activation of enzymes for improvement in crop yield (Tandon, 1995) [12]. Sulphur deficiency can be revised by application of sulphur inclusive fertilizers *viz.,* gypsum, phasal samriddhi, ammonium sulphate, single super phosphate etc. The choice of the most suitable fertilizer should be made on the basis of total nutrient content, price, easiness of availability. In view of importance of sulphur for linseed, a field experiment was under taken to study the response on growth and yield of Linseed (*Linum usitatissimum* L.) to different sources and levels of sulphur, grown under Indo-Gangetic plains of eastern Uttar Pradesh.

Materials and Methods

The field experiment was conducted at Agronomic Experimental Farm of Sri Ganesh Rai PG College, Dobhi, Jaunpur (U.P.) during March 2021, located in sub-humid subtropical climatic zone of Indo-Gangetic plains of Eastern Uttar Pradesh. The experiment was laid out into factorial randomized block design with three replications and treatment in concert of two factors first factor is levels of sulphur *viz.* D_0 (0 Kg S ha^{-1}), D_1 (15 Kg S ha^{-1}), D_2 (30 Kg S ha^{-1}), D_3 (45 Kg S ha^{-1}) and second factor is source of sulphur *viz.* S_1 (Gypsum), S_2 (Phasal Samriddhi), S_3 (Elemental Sulphur).

The soil of the experimental plot was silt loam with pH 7.6, organic carbon 0.37%, Available N content 136.10 kg ha^{-1}, available P_2O_5 content 13.15 kg ha^{-1} and available K_2O content 230.10 kg ha^{-1}. The crop was timely sowing, plot size of 5.00 × 4.00 m. Standard culture practices followed uniformly in each experimental plot. The data regarding growth parameters, yield parameters and yield were analysed with statistical analysis and significance of treatments were tested with the help of 'F' test.

Results and Discussion

Plant growth parameters

Application of sulphur through gypsum, phasal samriddhi, and elemental sulphur found to be equally effective in respect of plant population at initial and harvest stage. Application of sulphur to linseed through gypsum, phasal samriddhi and elemental sulphur was found to be equally effective in respect of plant height at 30 DAS and at harvest stage. Phasal samriddhi significantly increased the plant height over gypsum and elemental sulphur at 60 DAS (Table-1). It may be due to the presence of additional nutrients in phasal samriddhi. Gypsum and phasal samriddhi contain the sulphur in easily available SO_4^{-2} form. At the initial and harvest stage, all the sources were at par. This indicates that sulphur at initial stage did not affect the plant height while at harvest stage all the sulphur sources was equally effective as elemental sulphur releases sulphur slowly which effects were visible at latter stage. Similar results were obtained by Jagtap *et al.*, (2003) [4] and Benerjee *et al.* (2001) [1]. Satish *et al.*, (2011) [10] also made similar results however, in sunflower. Plant population was not significantly affected by application of various levels of sulphur. All the applied levels of sulphur also did not show significant difference over control in this respect. Plant height was not affected with application of various levels of sulphur at 30 DAS and at harvest stage, while at 60 DAS it significantly increased upto 45 kg S ha^{-1} being at par with 30 kg S ha^{-1}. It may be due to the fact that sulphur application improved the nutritional environment and hence could result in more nutrient uptake and increase in dry matter production. Jagtap *et al.*, (2003) [4] and Sune *et al.*, (2006) [7] also reported that 30 kg S ha^{-1} increased plant height along with other growth parameters.

Yield attributing characters and yield

Number of primary and secondary branches $plant^{-1}$ significantly increased with the application of gypsum and phasal samriddhi over elemental sulphur. The difference between phasal samriddhi and gypsum was statistically non-significant. Number of primary and secondary branches plant significantly increased with increasing level of sulphur upto 45 kg S ha^{-1} (Table-2). All the levels of sulphur produced significantly more primary and secondary branches $plant^{-1}$ over control. It might be due to vigorous cell growth, cell division (Steffenson, 1954) [9], enlargement and cell elongation induced by sulphur number of branches plant also increased with the advancement of the crop age. Sune *et al*. (2006) [7] and Singh *et al*., also reported similar results. Effect due to sources and levels of sulphur was found to be significant for number of capsules plant. Application of 45 kg S ha^{-1} through phasal samriddhi, produced significantly maximum number of capsules $plant^{-1}$ being at par with 30 kg S ha^{-1} applied through gypsum. Number of capsules directly correlated with the number of flowers initiated on the inflorescence. Sulphur causes greater tissue differentiation, ensures higher number of flowers, which in turn developed into capsules. Jagtap *et al.*, (2003) [4] and Benerjee *et al.* (2001) [1] also made similar results. Number of seed $capsule^{-1}$ significantly increased with the application of phasal samriddhi as compared to gypsum and elemental sulphur. Number of seed $capsule^{-1}$ increased significantly with the increasing levels of sulphur upto 45 kg S ha^{-1}. All the applied levels of sulphur also produced significantly maximum number of seed $capsule^{-1}$ over control. It may be due to the better role of readily available SO_4^{-2}, present in phasal samriddhi and gypsum. Plants absorb the sulphur in form of SO_4^{-2}, both sources of sulphur contain sulphur in form of SO_4^{-2}, The presence of macro and micro nutrients in phasal samriddhi positively affects the seed setting. Increase in yield attributes by sulphur application and sulphur is involved in greater production of pollen grain and their efficient use in fertilization. Increase in yield attributes by sulphur application had also been observed by Duhoon *et al*. (2005) [2] and Singh *et al.* (2006) [11]. The sources of sulphur could not bring significant difference among themselves in respect to test weight. It was maximum with phasal samriddhi (7.57 g) and minimum (7.26 g) with gypsum. Application of various levels of sulphur also could not bring significant difference in test weight. It was recorded at maximum at 45 kg S ha^{-1} and minimum at 15 kg S ha^{-1} with a value of 7.58 g and 7.04 g, respectively. All the applied levels of sulphur *viz.*, 15, 30 and 45 kg S ha^{-1} could not cross the level of significance when compared with control in respect to test weight. Interaction effects of various levels and sources of sulphur were also found to be non-significant. It might be due to the fact that N and Zn found in phasal samriddhi increased the photosynthates, which accumulated into seeds consequently increasing test weight. Sulphur is closely associated with seed containing constituents such as greater accumulation of sulphur containing amino acids, higher synthesis of proteins and glucosides, related to the higher test weight of seeds (Singh and Singh, 2007) [8].

Biological yield, grain yield increased significantly with the application of phasal samriddhi and gypsum over elemental sulphur. However, the difference in biological yield between phasal samriddhi and gypsum was found to be non-significant. All the sources of sulphur were equally effective for straw yield. Biological yield, grain yield and straw yield increased with increasing levels of sulphur up to 45 kg S ha^{-1}. Application of 15 kg S ha^{-1} being at par with 30 kg S ha^{-1}, produced maximum biological grain and straw yield, which was significantly more over 15 kg S ha^{-1}. All the applied levels of sulphur produced significantly more biological, grain and straw yield over control. Maximum harvest index was recorded with phasal samriddhi which was significantly higher over gypsum and elemental sulphur. Except 15 kg S ha^{-1} all the levels of sulphur recorded significantly higher harvest index over control. It might be due to fact that yield is directly correlated with primary and secondary branches $plant^{-1}$, number of capsules $plant^{-1}$, number of seed $capsules^{-1}$, test weight and other yield attributing traits which increased in the presence of phasal samriddhi and gypsum. Plants mainly absorbed in the form of SO_4^{-2} ions from soil. In phasal samriddhi and gypsum both, sulphur is present in the SO_4^{-2} form which needs no further transformation in the soil and plants readily absorb it phasal samriddhi also contains other macro and micro nutrients such as nitrogen, phosphorus, potash, zinc, organic carbon etc. Similar results were obtained Prasad and Prasad (2002) [6] and Singh and Singh (2007) [8]. It may also be due to enhanced rates of photosynthesis and carbohydrates metabolism as influenced by sulphur application. Sulphur augmented the translocation of photosynthates to the sink site. Similar findings were also reported by Sune *et al*. (2006) [7] and Singh *et al.* (2007) [8].

Table 1: Effect of Sources and Levels of sulphur on Growth attribute characters of linseed.

Treatments	Plant population running m^{-1}		Plant height (cm)		
	Initial	At Harvest	30 DAS	60 DAS	At Harvest
Sources of sulphur					
S_1 (Gypsum)	38.97	36.75	5.65	29.71	49.40
S_2 (Phasal samriddhi)	41.64	38.75	5.51	33.01	50.65
S_3 (Elemental sulphur)	36.75	32.97	5.25	29.18	48.18
C.D. (P=0.05)	NS	NS	NS	2.04	NS
Levels of sulphur					
D_0 (0 kg S ha^{-1})	32.98	30.31	4.45	27.86	47.61
D_1 (15 kg S ha^{-1})	36.42	32.75	5.39	29.00	47.80
D_2 (30 kg S ha^{-1})	37.76	35.31	5.50	31.02	50.03
D_3 (45 kg S ha^{-1})	43.19	40.42	5.53	31.88	50.66
C.D. (P=0.05)	NS	NS	NS	2.04	NS
Interaction effect					
C.D. (P=0.05)	NS	NS	NS	NS	NS

Table 2: Effect of Sources and Levels of sulphur on yield attributing characters and yield of linseed.

Treatments	No of branches $Plant^{-1}$		No. of capsule $Plant^{-1}$	No. of seed $capsule^{-1}$	Test weight (g)	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
	Primary	Secondary							
Sources of sulphur									
S_1 (Gypsum)	4.63	35.13	40.33	5.56	7.26	27.36	12.49	14.89	45.36
S_2 (Phasal samriddhi)	4.50	33.63	42.39	7.21	7.57	28.85	14.53	14.33	50.08
S_3 (Elemental sulphur)	3.90	28.89	34.28	6.43	7.27	25.99	11.51	14.48	44.13
C.D. (P=0.05)	0.27	2.28	2.30	0.51	NS	2.34	0.61	NS	2.46
Levels of sulphur									
D_0 (0 kg S ha^{-1})	3.39	23.38	26.34	4.42	6.79	20.02	8.69	11.32	43.42
D_1 (15 kg S ha^{-1})	3.84	30.15	33.68	5.22	7.04	23.52	10.36	13.16	43.92
D_2 (30 kg S ha^{-1})	4.44	33.12	40.73	6.59	7.48	29.00	13.90	15.11	47.70
D_3 (45 kg S ha^{-1})	4.74	34.38	42.61	7.40	7.58	29.69	14.29	15.41	47.96
C.D. (P=0.05)	0.26	2.28	2.30	0.51	NS	2.34	0.61	0.79	2.46
Interaction effect									
C.D. (P=0.05)	NS	NS	4.21	NS	NS	NS	NS	NS	NS

Conclusion

It is concluded from the study, Application of sulphur through Phasal samriddhi proved to be the best source of sulphur for linseed crop. Application of sulphur @ 45 kg S ha^{-1} appeared to be the optimum dose for obtaining higher seed yield of linseed crop. Among the various levels and sources of sulphur, 45 kg S ha^{-1} through Phasal samriddhi proved to be better on growth and yield of linseed. In order to make recommendations these findings need to be further confirmed.

Acknowledgment

Authors have deep regard for those who were directly or indirectly involved in this study. Special thanks is owed to Dr. A.K. Singh SMS (Animal husbandry) Krishi Vigyan Kendra, Amhit for this guidance in directly this work.

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