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Hezaki Jimo
MSc. (Agronomy) Scholar, SHUATS, Allahabad, Uttar Pradesh, India

Rajesh Singh
Assistant professor, Department of Agronomy, SHUATS, Uttar Pradesh, India

Correspondence
Hezaki Jimo
MSc. (Agronomy) Scholar, SHUATS, Allahabad, Uttar Pradesh, India

Effect of sources and doses of Sulphur on yield attributes, yield and quality of Linseed (*Linum usitatissimum* L.)

Hezaki Jimo and Rajesh Singh

Abstract

A field experiment was conducted during *rabi* season of 2016-17 at Crop Research Farm, Department of Agronomy, SHUATS, Allahabad, (U.P.) to study the effect of different sources and doses of sulphur on yield, yield attributes and quality of Linseed (*Linum usitatissimum* L.). The experiment consisted of ten treatment combinations comprising of three sources of sulphur (gypsum, Single Super phosphate and Ammonium sulphate) and four doses of sulphur (0, 20, 40 and 60 kg S ha^{-1}). The experiment was laid out in Randomized Block Design each replicated thrice. The result showed that ammonium sulphate @ 40 kg ha^{-1} recorded maximum number of capsule $plant^{-1}$ (124.73), seed $capsule^{-1}$ (8.93) seed yield (1262.33 kg ha^{-1}), stover yield (2830.40 kg ha^{-1}), harvest index (30.81 %), test weight (5.94 g) and oil content (39.46 %), Each successive increase in the level of sulphur up to 40 kg ha^{-1} significantly increased the number of capsule $plant^{-1}$, seeds $capsules^{-1}$, seed yield, stover yield, harvest index, test weight and oil content. Among the sources of sulphur, ammonium sulphate, being at par with gypsum, proved significantly superior to other sources for number of capsule $plant^{-1}$, seed $capsules^{-1}$, seed yield, stover yield, harvest index, test weight and oil content.

Keywords: Linseed, Source of sulphur, Sulphur levels, Yield attributes, Yield

Introduction

Linseed (*Linum usitatissimum* L.) is one of the most important oil seed crop in India. It is grown both for its seed as well as fibre which is used for manufacture of linin. Seed is directly used for edible purpose. Seed contain 33-47% oil which is used for both edible and industrial purpose (paint, varnishes, printing ink, pad ink, soaps etc.) Sulphur is now recognised as the fourth major nutrient in addition to nitrogen, phosphorus and potassium. High yielding cultivars of linseed crop require considerably higher amount of sulphur (Dwivedi *et al.*, 2001) [2]. Sulphur is involved in the formation of chlorophyll, amino acids, activation of enzymes and improvement in crop yield and oil % (Tandon, 1995) [9]. Sulphur deficiency can be corrected by application of sulphur containing fertilizers viz., gypsum, ammonium sulphate, single super phosphate etc. The choice of the most suitable fertilizer should be made on the basis of total nutrient content, price, ease of availability and crop in question. Keeping in view the importance of sulphur for linseed, a field experiment was under taken to study the suitability of various sources and levels of Sulphur for linseed grown in agro-climatic conditions of Allahabad region.

Materials and method

A field experiment was conducted during *rabi* season of 2016-17 at Crop Research Farm, Department of Agronomy, Nani Agricultural Institute, Sam Higginbottom university of Agriculture, Technology and Sciences, Allahabad (U.P.) which is located at 25º24'41.27" N latitude, 81°51'3.42" E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and south east side of Allahabad City. The soil of experimental field was sandy loam, *p*H 7.39 with 0.39 (%) organic carbon. The experiment consisted of ten treatment combinations comprising three sources of sulphur (gypsum, Single Super phosphate and Ammonium sulphate) and four doses of sulphur (0, 20, 40 and 60 kg S ha^{-1}). The experiment was laid out in Randomized Block Design with three replications basal dose of 80kg N, 40 kg P_2O_5 and 40 kg K_2O ha^{-1} was supplemented through di-ammonium phosphate and murate of potash in all plots. Urea and di-ammonium were also applied in single super phosphate treated plots for compensation of nitrogen and phosphorous. The required quantity of sulphur was calculated as per treatment and applied as basal dose. Linseed (*Linum usitatissimum* L.) variety Garima was sown on 11th November 2016 keeping row to row distance of 30 cm and plant to plant distance of 10 cm, with seed rate of 30 kg ha^{-1}. The crop duration was 135 days. During the crop season, light irrigation was done at 25 and 60 days after sowing. Inter culture operation was done to remove weeds. After harvesting, the data on yield attributes *viz*., capsules $plant^{-1}$, seeds $capsule^{-1}$, seed yield, stover yield, harvest index, test weight, and oil content were statistically analysed and critical differences were calculated.

Result and discussion

Yield attributes

The effect of source of sulphur on number of capsule $plant^{-1}$ and number of seed $capsule^{-1}$ was found significant when ammonium sulphate and gypsum was applied (Table 1). The maximum number of capsule $plant^{-1}$ (124.73) and seeds $capsule^{-1}$ (8.93) was observed with ammonium sulphate which showed statistical parity with gypsum and these sulphur sources was found significantly superior over single super phosphate. Minimum number of capsule $plant^{-1}$ (115.87) and seeds $capsule^{-1}$ (7.93) was recorded from the control plot which was statistically inferior to the rest of sulphur sources. Sulphur is mainly responsible for enhancing the reproductive growth and the proportion of the reproductive tissues (inflorescence and capsules) (Grath and Zhao, 1996) [3]. Application of different dose of sulphur significantly affects the number of capsule $plant^{-1}$ and seed $capsule^{-1}$. There was significant increase in number of capsule $plant^{-1}$ and number of seed $capsule^{-1}$ with increasing doses of sulphur up to 40 kg S ha^{-1}. The maximum number of capsules $plant^{-1}$ (124.73) and number of seeds $capsule^{-1}$ (8.93) was recorded under sulphur @ 40 kg ha^{-1} (Table 1), while minimum number of capsule $plant^{-1}$ and seed $capsule^{-1}$ were recorded from control (0 kg S ha^{-1}) plot which showed inferiority over rest of sulphur dose. Higher dose of sulphur was responsible for increased leaf area and chlorophyll content of leaves causing higher photosynthesis and assimilation, metabolic activities which were responsible for overall improvement in vigour and yield attributes and finally seed yield Chaubey and Dwivedi *(*1995) [1]. Similar results were also obtained by Upadhyay *et al*., (2012) [10] in linseed with sulphur application.

Seed and stover yield

The seed and stover yield of linseed increased significantly when sulphur was applied through ammonium sulphate compared to other sources of sulphur (Table 1). The highest seed yield (1262.33 kg ha^{-1}) and stover yield (2830.40 kg ha^{-1}) was recorded under T_9 (Sulphur @ 40 kg ha^{-1} through Ammonium sulphate). However, Ammonium sulphate and gypsum proved equally effective in increasing the yield of linseed. This increase in yield might be attributed to easy availability of SO_4 sulphur present in ammonium sulphate and gypsum compared to other source of sulphur which essentially requires its oxidation to be converted into SO_4^{2-} prior to its absorption by the plants (Singh and Singh, 2007) [8]. The seed yield and stover yield increased significantly with increasing level of sulphur up to 40 kg ha^{-1}. The highest seed yield (1262.33 kg ha^{-1}) and stover yield (1.760 t ha^{-1}) was recorded with sulphur @ 40 kg ha^{-1} (Table 1) and this was significantly superior to other dose of sulphur. Sulphur plays a vital role and promotes metabolic activities in chlorophyll formation, amino acid and protein synthesis. These results confirm the findings of Prasad and Prasad (2002) [5] and Singh and Singh (2007) [8]. Similarly the harvest index and test weight (1000 seed weight) were found to be significant with the application of ammonium sulphate and gypsum over other single super phosphate and control plot. The highest harvest index (41.84 %) and test weight (5.94 g) was obtained with sulphur @ 40 kg ha^{-1} through ammonium sulphate being stastically at par to gypsum (sulphur @ 40 kg ha^{-1}). This may be due to large amount of sulphur found in the seed which is considered essential for seed formation Ramaswami Manickam (1985) [6] and Singh and Kumar (1996) [7]. The oil yield increased significantly with increasing level of sulphur up to 40kg ha^{-1} (Table 1). The highest oil content (39.56 %) was recorded with sulphur @ 40 kg ha^{-1} through ammonium sulphate being stastically at par to gypsum (sulphur@40 kg ha^{-1}). The beneficial effect of sulphur levels on oil may be due to cation exchange capacity of root which enabled the plant to extract more nutrients from soil. Kumar *et al*., (2011) [4] and Dwivedi *et al*., (2001) [2] reported similar findings.

Economics

A persual of the table 2 clearly reveals that T_3 (40 kg Sulphur ha^{-1} through Gypsum) recorded maximum net return (₹ 33250.35), followed by treatment T_9 (40 kg Sulphur ha^{-1} through Ammonium sulphate) giving a B:C ratio of 1.97 and 1.87 respectively.

Table 1: Effect of sources and doses of sulphur on No. of capsule $plant^{-1}$, seed $capsule^{-1}$ and test weight (g), seed yield, stover yield, harvest index and oil content of linseed.

	Treatments	Capsule $plant^{-1}$	Seed $capsule^{-1}$	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)	Test weight (g)	Oil content (%)
T_1	Control (0 kg Sulphur ha^{-1})	115.87	7.93	926.00	2332.88	28.41	5.45	37.15
T_2	20 kg Sulphur ha^{-1} through Gypsum	118.93	8.47	1099.00	2580.38	29.87	5.70	38.71
T_3	40 kg Sulphur ha^{-1} through Gypsum	123.93	8.87	1241.67	2798.04	30.74	5.93	39.45
T_4	60 kg Sulphur ha^{-1} through Gypsum	123.33	8.60	1155.33	2616.56	30.63	5.92	39.06
T_5	20 kg Sulphur ha^{-1} through SSP	117.67	8.40	1155.67	2788.29	29.31	5.68	38.62
T_6	40 kg Sulphur ha^{-1} through SSP	120.60	8.60	1184.00	2787.27	29.82	5.73	38.73
T_7	60 kg Sulphur ha^{-1} through SSP	119.87	8.60	1129.33	2639.43	29.97	5.72	38.88
T_8	20 kg Sulphur ha^{-1} through AS	119.33	8.53	1125.67	2546.95	30.65	5.71	38.72
T_9	40 kg Sulphur ha^{-1} through AS	124.73	8.93	1262.33	2830.40	30.84	5.94	39.46
T_{10}	60 kg Sulphur ha^{-1} through AS	123.67	8.80	1152.67	2588.60	30.81	5.92	39.45
	F test	S	S	S	S	S	S	S
	S.Ed. (±)	1.69	0.15	26.35	65.04	0.22	0.07	0.05
	CD (P= 0.05)	3.55	0.31	55.35	136.65	0.47	0.15	0.11

- SSP- Single Super Phosphate , AS- Ammonium Sulphate

Table 2: Economics of different treatment combinations of linseed.

	Treatments	Gross return (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
T_1	Control (0 kg Sulphur ha^{-1})	50965.75	32845.90	18119.85	1.55
T_2	20 kg Sulphur ha^{-1} through Gypsum	60110.75	33762.56	26348.19	1.78
T_3	40 kg Sulphur ha^{-1} through Gypsum	67679.57	34429.22	33250.35	1.97
T_4	60 kg Sulphur ha^{-1} through Gypsum	62999.79	35095.88	27903.91	1.80
T_5	20 kg Sulphur ha^{-1} through Single Super Phosphate	63359.92	34700.20	28659.72	1.83
T_6	40 kg Sulphur ha^{-1} through Single Super Phosphate	64774.54	35408.51	29366.03	1.83
T_7	60 kg Sulphur ha^{-1} through Single Super Phosphate	61745.54	36116.81	25628.73	1.71
T_8	20 kg Sulphur ha^{-1} through Ammonium Sulphate	61377.23	34929.16	26448.07	1.76
T_9	40 kg Sulphur ha^{-1} through Ammonium Sulphate	68777.47	36762.50	32014.97	1.87
T_{10}	60 kg Sulphur ha^{-1} through Ammonium Sulphate	62810.53	38584.68	24225.85	1.63

- Sale rate of linseed seed @ ₹ 5000 q^{-1} Sale rate of linseed stover @ ₹ 200 q^{-1}

Conclusion

It can be concluded that treatment T_9 (40 kg Sulphur ha^{-1} through Ammonium sulphate) revealed superior performance in most of the parameters, *viz*., Number of capsule $plant^{-1}$ (124.73), Number of seed $capsule^{-1}$ (8.93), Test weight (5.94 g), Seed yield (1262.33 kg ha^{-1}), Stover yield (2830.40 kg ha^{-1}), Harvest Index (30.84%) and Oil content (39.46 %). As the experiment is based on one year trial, further research has to be done for conformity and recommendation.

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