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Effect of sulphur fertilization and date of sowing on yield and yield attributes of linseed

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Abstract

A field experiment was conducted during the rabi season of 2024 at the Crop Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India, to evaluate the response of linseed to different sulphur sources and application levels. The study included three sulphur levels (15, 30, and 45 kg ha⁻¹) and three sowing dates (6, 13, and 20 November) arranged in a factorial design with three replications. The results revealed significant improvements in plant height, number of branches, and dry matter accumulation with the application of ammonium sulphate compared to the other sulphur sources. Among the sulphur levels tested, the highest values for plant height, branch number, and dry matter production were recorded with 60 kg S ha⁻¹, which was statistically at par with 45 kg S ha⁻¹. A similar trend was observed for both seed yield and stalk yield.

Keywords: Sulphur, date of sowing, linseed

1. Introduction

Linseed (*Linum usitatissimum* L.), commonly known as flax, tisi, or linum, is one of the most important oilseed crops cultivated in India. It is a self-pollinated annual herbaceous plant belonging to the Linaceae family and is widely grown for its valuable oil and fibre. Sulphur has emerged as the fourth major plant nutrient after nitrogen, phosphorus, and potassium due to its critical role in crop growth and productivity (Chaurasiya *et al.*, 2023) [6]. Linseed is considered one of the richest plant-based sources of *omega*-3 fatty acids, making it particularly beneficial for nonfish consumers. Besides its nutritional importance, linseed oil has extensive industrial applications in the manufacture of paints, varnishes, printing inks, and other commercial products.

India occupies a prominent position in global linseed cultivation, ranking first in area and third in production. The crop is cultivated on approximately 4.68 lakh hectares, producing about 1.63 lakh tonnes annually (Maurya *et al.*, 2017) [7]. Flaxseed contains approximately 41% oil, 20% protein, 28% dietary fibre, 7.7% moisture, and 3.4% ash. The protein content generally decreases with increasing oil content in the seed (Mahesh *et al.*, 2020) [8].

Globally, linseed is cultivated over an area of about 2.62 million hectares with a production of 2.65 million tonnes and an average productivity of 1,011 kg ha⁻¹. In contrast, India produces nearly 0.10 million tonnes from 0.28 million hectares, with an average productivity of 541 kg ha⁻¹ (AICRP Annual Report on Linseed, 2024-25) [9]. India ranks fourth in area and third in production after major linseed-producing countries such as Canada, Russia, and China (Anonymous, 2022-23) [10].

At present, linseed occupies approximately 4.36 lakh hectares and contributes around 1.67 lakh tonnes to the country's annual oilseed production. The crop is predominantly grown under rainfed conditions (63%), while 25% is cultivated under the utera cropping system and only 12% under irrigated conditions. Low productivity in India is mainly attributed to cultivation under marginal and sub-marginal lands, inadequate irrigation facilities, poor crop management practices, limited input use, and the continued cultivation of traditional low-yielding varieties.

Considering the importance of optimum sowing time and sulphur nutrition in enhancing linseed productivity, the present investigation entitled "Effect of Date of Sowing and Levels

of Sulphur on Growth and Yield of Linseed” was conducted at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, during the Rabi season of 2024-25.

2. Materials and Methods

The field experiment was conducted during the Rabi season of 2024 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh. The experimental site is geographically situated at 25°24'42" N latitude, 81°50'56" E longitude, and an altitude of 98 m above mean sea level.

The experiment was laid out in a Randomized Block Design (RBD) with nine treatment combinations and three replications. The treatments consisted of three sowing dates (6 November, 13 November, and 20 November 2024) combined with three levels of sulphur (15, 30, and 45 kg ha⁻¹). The treatment details were as follows: -

- T₁: 6 November + 15 kg S ha⁻¹
- T₂: 6 November + 30 kg S ha⁻¹
- T₃: 6 November + 45 kg S ha⁻¹
- T₄: 13 November + 15 kg S ha⁻¹
- T₅: 13 November + 30 kg S ha⁻¹
- T₆: 13 November + 45 kg S ha⁻¹
- T₇: 20 November + 15 kg S ha⁻¹
- T₈: 20 November + 30 kg S ha⁻¹
- T₉: 20 November + 45 kg S ha⁻¹

The linseed crop was sown on the respective dates as per treatment specifications. Sulphur fertilizer was applied according to the assigned treatment levels. Harvesting was carried out from a net plot area of 1 m² in each treatment plot. Five plants were randomly selected from each plot for recording growth and yield attributes.

Observations were recorded on plant height, dry matter accumulation, crop growth rate, number of capsules per plant, number of seeds per capsule, test weight, seed yield, and stover yield. The experimental data were statistically analyzed using the analysis of variance (ANOVA) technique as described by Gomez and Gomez (1976), and treatment means were compared at the appropriate level of significance.

2. Result and discussion

2.1 Growth parameters

Plant Height

At Harvest, significant and taller plant height (63.97 cm) was recorded in treatment 3 [6 of November + Sulphur at 45 kg/ha]. Additionally, a noteworthy aspect is the interdependence among various growth traits. For instance, studies have indicated that an increase in plant height is often positively associated with higher dry weight and seed yield (Filho *et al.*, 2013)^[11].

Dry Weight/plant

At harvest, the maximum and significantly higher dry weight (7.67 g plant⁻¹) was observed in - Treatment 3 (6 November sowing + 45 kg S ha⁻¹). The increase in dry matter accumulation may be - attributed to the beneficial effect of sulphur on various metabolic and physiological processes within the plant. Adequate sulphur nutrition

enhances photosynthetic activity, promotes vegetative growth, and improves the development of both above-ground and below-ground plant parts, including plant height, number of branches, and leaf production. These factors collectively contribute to greater biomass accumulation and dry matter production. Similar findings were reported by Mallick *et al.* (2015)^[12].

Crop growth rate

At 80- At Harvest interval DAS, significant and higher crop growth rate (5.000g/m²/day) was recorded in treatment 3 [6 of November + Sulphur at 45 kg/ha]. However, treatment 6 [13 of November + Sulphur at 45 kg/ha] were found statistically at par with Treatment 3 [6 of November + Sulphur at 45 kg/ha].

Adequate sulphur levels enhance metabolic and physiological processes and stimulate photosynthesis, thereby promoting plant growth. This results in increased plant height, a greater number of branches and leaves, and improved development of both above- and below-ground plant structures, which likely contributed to the observed increase in crop growth rate, as reported by Mallick *et al.* (2015)^[12].

Relative growth rate (g/g/plant)

At 40-60 DAS the maximum relative crop growth rate (0.137g/g/day) is observed in treatment- 3 (6 of November + Sulphur at 45 kg/ha). CGR and RGR are the growth indices which are calculated from the change in dry matter accumulation to study the growth of the plant within a particular time interval. The findings suggest that sulphur application affects plant growth dynamics and influences canopy formation, which is crucial for optimal light interception and biomass accumulation (Soni & Singh, 2023)^[13].

2.2 Yield attributes

1.3.1 Number of capsules /plants

The number of pods/plants was significantly recorded (31.87) in treatment (6 of November + Sulphur at 45 kg/ha). Sulphur plays vital and important role in energy storage and transformation, carbohydrate metabolism and activation of enzymes also increase the photosynthetic activity of plant. Similar, results were also agreed by Banu *et al.* (2017)^[14].

1.3.2 Number of seed /capsules

The significantly higher number of seed/ capsules (7.33) was recorded in treatment-3 (6 of November + Sulphur at 45 kg/ha). Significantly increased number of kernels/pod with application of sulphur (45 kg/ha) which might be due to the sufficient sulphur was accessible throughout the entire time of crop growth for improving vegetative growth and development of the plant, which may have caused the increase in number of kernels/pods. The results were found to be ilar with Deepika *et al.* (2023)^[15].

1.3.3 Test weight (g)

Significantly higher test weight (9.15) was recorded in treatment-3 (6 of November + Sulphur at 45 kg/ha). Sulphur works synergistically with nitrogen and other nutrients, enhancing their efficiency in plants. Singh *et al.* (2019) observed that sulfur application increased nitrogen use efficiency, leading to improved plant growth and better nutrient allocation to the developing grains.

1.3.4 Seed yield (kg/ha)

Significantly higher seed yield (0.9458 t/ha) was observed in treatment 3 (6 of November + Sulphur at 45 kg/ha). Reddy *et al.* (2019) ^[1] demonstrated that sulfur fertilization at a rate of 40-45 kg/ha significantly increased the seed yield of linseed by improving plant vigor, seed formation, and oil content.

Stover yield (kg/ha): The significantly higher Stover yield (1.5606 t/ha) was observed in treatment-3 (6 of November + Sulphur at 45 kg/ha). Sharma and Verma *et al.* (2016) ^[5]

reported, sulphur application not only improved seed yield but also significantly enhanced stover yield in linseed under different agro-climatic zones in India.

1.3.5 Harvest index (%)

Significantly higher in Harvest Index (30.64%) was observed in 6 of November + Sulphur at 45 kg/ha Kumar *et al.* (2020) ^[4] found that linseed crops receiving sulphur fertilization under timely sown conditions recorded significantly higher stover and biological yields.

Table 1: Effect of Sources and level of Sulphur on growth attributes of Linseed.

Sr.No.	Treatment combinations	Growth attributes			
Plant height(cm)(At harvest)	Plant dry weight (g)(At harvest)	RGR (g/g/ day)(At Harvest)	CGR(g/ m2/ day)(At Harvest)		
1	6 of November + Sulphur at 15 kg/ha	59.1	6.23	0.028	4.467
2	6 of November + Sulphur at 30 kg/ha	57.2	6.58	0.026	4.467
3	6 of November + Sulphur at 45 kg/ha	63.97	7.67	0.030	5.000
4	13 of November + Sulphur at 15 kg/ha	58.37	5.82	0.025	4.383
5	13 of November + Sulphur at 30 kg/ha	62.17	6.81	0.026	4.600
6	13 of November + Sulphur at 45 kg/ha	56.9	6.47	0.027	4.483
7	20 of November + Sulphur at 15 kg/ha.	60.1	6.15	0.026	4.217
8	20 of November + Sulphur at 30 kg/ha.	59.37	6.68	0.024	4.300
9	20 of November + Sulphur at 45 kg/ha.	60.80	6.31	0.024	4.050
	F-test	S	S	S	S
	SEm (±)	0.11	0.05	0.003	0.001
CD (P=0.05)				0.003	
	0.34	0.16	0.001		

Table 2: Effect sources and levels of Sulphur on yield and yield attributes of Linseed.

Sr.No.	Treatment combinations	Number of capsules/plant	Number of Seeds/capsules	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest Index (%)
1.	6 of November + Sulphur at 15 kg/ha	27.46	6.3	7.86	0.6063	1.2098	40.09
2.	6 of November + Sulphur at 30 kg/ha	28.09	6.96	7.84	0.6389	1.3539	37.6
3.	6 of November + Sulphur at 45 kg/ha	30.88	8.11	9.61	0.9458	1.5607	45.87
4.	13 of November + Sulphur at 15 kg/ha	28.31	5.79	8.5	0.7631	1.3511	38.52
5.	13 of November + Sulphur at 30 kg/ha	27.82	5.93	8.37	0.6741	1.1897	40.8
6.	13 of November + Sulphur at 45 kg/ha	29.85	6.02	7.93	0.7941	1.4494	40.45
7.	20 of November + Sulphur at 15 kg/ha.	27.96	7.06	9.34	0.6488	1.3577	35.19
8.	20 of November + Sulphur at 30 kg/ha.	30.34	7.91	8.93	0.8297	1.4067	37.17
9.	20 of November + Sulphur at 45 kg/ha.	27.67	7.56	7.9	0.8552	1.5496	35.45
	F-Test	S	S	S	S	S	NS
	S.Em (±)	0.69	0.51	0.43	66.86	87.49	3.63
	CD (P=0.05)	2.07	1.52	1.28	198.68	259.95	10.79

Conclusion

It is concluded that with 6 of November + Sulphur at 45 kg/ha (Treatment-3), has performed positively and improved growth and yield parameters. Higher grain yield, gross returns, net returns and benefit cost ratio were also recorded with application of with 6 of November + Sulphur at 45 kg/ha (Treatment-3).

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