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# Effect of sulphur level and date of sowing on growth, yield and quality of linseed (*Linum usitatissimum* L)

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**Abstract**
A field experiment was conducted during *rabi* season in 2021-2022 at the Research farm, Department of Agronomy, AKS University, Satna (M.P.), to evaluate the effect of sulphur level and date of sowing on growth, yield and quality of linseed (*Linum usitatissimum* L.). The experiment was laid out in Factorial Randomized Block Design comprising four Sulphur levels *viz.* 00 kg $S_0$ ha$^{-1}$, 20 kg $S_1$ ha$^{-1}$, 30 kg $S_2$ ha$^{-1}$, 40 kg $S_3$ ha$^{-1}$ and three Date of sowing levels, 29$^{th}$ october D1, 5$^{th}$ November D2, 12$^{th}$ November D3 and treatments were replicated thrice. Results revealed that different levels of sulphur affected the growth parameters as well as yield attributes and yield of linseed. Incorporation of 40 kg $S_3$ ha$^{-1}$ recorded maximum plant height at 90 DAS (56.24 cm), number of branches per plant at 90 DAS (7.67), Number of capsules per plant (59.89), grain yield (17.85 q ha$^{-1}$), straw yield (47.47 q ha$^{-1}$), and oil content (43.39%), however, number of seeds per capsule (7.31) and harvest index (27.25%) were higher with incorporation of 30 kg S2 ha$^{-1}$. Among different Date of sowing, number of branches per plant at 90 DAS (7.18), number of seeds per capsule (6.63), grain yield (16.10q ha$^{-1}$), harvest index (26.33%), and oil content (42.63%) were observed when crop was sown on 29 October.

**Keywords:** Sulphur level and Date of Sowing, linseed, growth, yield, quality

## Introduction
Indian mustard (*Brassica juncea* L.) is an important *Rabi* oilseed crop extensively grown as rainfed crop in India. Mustard oil meets the one third of edible oil requirement of the country, to meet these needs the country highly depends on imports of vegetable oil. Import of vegetable oils during July 2019 is up by 26% to 14.12 lakh tones as compared to 11.19 lakh tones in July 2018, according to data compiled by the Solvent Extractors' Association of India (SEA). There is a need to decrease the Import of vegetable oils by expanding the area under oil seed crops. It is important to increase the yields of mustard crop by improving the available germplasm lines, for that we need to know various yield contributing characters and the relationship among them and with the seed yield. In this experiment, we studied correlation or mutual association among different yield contributing characters and the direct and indirect effects also estimated through path coefficient analysis. The inter-relationship between the yield components will be helpful to a breeder to assess the nature, extent and direction of selection pressure on characters.

## Material and Methods
Linseed is considered as the most important industrial oil seed crop of India stands next to rapeseed-mustard in Rabi oil seed in terms of area and production. It is grown either for oil extracted from seed or fiber from the stem. The oil content of linseed varies from 37-43% and very part of the plant is utilized commercially either directly or after processing. Linseed contains 20-25% protein and sufficient oil along with mineral elements like phosphorus. Most of the oil is used in the industry for manufacturing of paints, varnishes, ink, soaps and small fraction of used for edible purposes. To sustain the linseed production, there is need to develop appropriate agronomic practices to obtain the higher crop yield. Its importance is further increased due to presence of omega-3 factor in oil. Linseed, due to its high iodine value and quick drying property value, its use in industrial application is promising. It is an important source of essential fatty acids for human diets and has several human health benefits (Millis, 2002). Thus, the interest in linseed for food, feed and industrial products is growing and more attention is now being given to meet the increased demand for this crop.

Sulphur is the fourth major plant nutrient after nitrogen, phosphorus and potassium for Indian agriculture. It is essential for synthesis of amino acids, proteins, oils, a component of vitamin A and activates enzyme system in plant. Three amino acids *viz*. methionine (21% S), cysteine (26% S) and cystine (27%S) contain S which are the building blocks of proteins. About 90% of Sulphur is present in these amino acids. Sulphur is also involved in the formation of chlorophyll, glucosides and glucosinolates (mustard oils), activation of enzymes and sulphydryl ($SH^-$) linkages that are the source of pungency in oilseeds. Adequate Sulphur is therefore very much crucial for oilseed crops. Sulphur is also a constituent of vitamins biotine and thiamine ($B_1$) and also of iron Sulphury proteins called ferrodoxins. Sulphur is associated with the production of oilseed crops of superior nutritional and market quality.

Production potentiality of linseed can be fully exploited with suitable agronomic practices. Among the different practices, optimum sowing time is one of the most important agronomic factors and non-monetary input which play an important role to fully exploit the genetic potentiality of a linseed variety as it provides optimum growth conditions such as temperature, light, humidity and rainfall. It is also important in deciding the environmental conditions of crop, timing and rate of organ appearance while in crop growth analysis, predicting of phenology is of prime importance. Since the temperature and solar radiation play an important role in partitioning of biomass between various organs of plant which is related to, and often governed by phenological phase of the plant and the way in which a crop develops can affect the yield and this therefore, an aspect with which agronomists are much concerned.

Optimum sowing time is one of the most important agronomical factor and non-monetaey input but has noticeable impact on productivity of crop. Planting dates significantly affect growth character, yield and its components as well as oil yield in flax. Sowing dates have been shown to provide differential Groeth conditions such as temperature, precipitation and growth periods. The appropriate sowing date is very important since it ensures good seed germination, as well as timely appearance of seedling and optimum development of root system.

## Materials and Methods

The present investigation was carried out during 2021-2022 in *rabi* season at the Research farm, Department of Agronomy, AKS University, Satna (M.P.). Mean temperature and humidity ranged from 21.20º C (min) to 23.90.ºC (max) and 75.00% (morning) to 55.00% (evening), respectively. The soil of experimental field was silty clay loam with low level of organic carbon (0.39%), available nitrogen (150.4 kg $ha^{-1}$), available phosphorus (16.8 kg $ha^{-1}$) and medium level of available potassium (279.50 kg $ha^{-1}$) having 7.9 pH and 0.14 ds/m EC.

Twelve treatment combinations ($S_0D_1$, $S_0D_2$, $S_0D_3$, $S_1D_1$, $S_1D_2$, $S_1D_3$, $S_2D_1$, $S_2D_2$, $S_2D_3$, $S_3D_1$, $S_3D_2$, $S_3D_3$) of four levels of Sulphur *viz*. $S_0$ = 00 kg $S_1$ = 20 kg/ha, $S_2$ = 30 kg/ha, $S_3$ = 40 kg/ha and three Date of sowing *vi*:- $D_1$ = 29th October, $D_2$ = 5th November, $D_3$ = 12 November were laid out in Factorial Randomized Block Design and replicated thrice.

### JLS-66 (Jawahar Linseed Sagar- 66)

The variety of 'JLS-66' developed by Jawaharlal Nehru Krishi Vishwa Vidhyalaya (JNKVV), Jabalpur. It matures in 107-114 days, short in height with white flowers and seed are light brown in colour. Moderately resistant to powdery mildew, alternaria blight, rust and major insect pests. Oil content 40.5% and yield potential is 20.0 q/ha.

## Results and Discussion

**Experimental results on the effect of treatments are explained as under:** The beneficial effect of different levels of sulphur on mean plant height at 90 DAS, number of branches per plant at 90- DAS, number of capsule per plant, number of seed per capsule, Seed yield (q $ha^{-1}$), strover yield (q $ha^{-1}$), harvest index, oil content were evident during active growth and maturity period of linseed crop.

Incorporation of 40 kg $S_3$ $ha^{-1}$ ($S_3$) produced significantly higher mean plant height at 90 DAS (56.24cm), number of number of branches per plant at 90- DAS (7.67), followed by incorporation of 30 kg S $ha^{-1}$($S_3$), however, maximum number of number of capsule per plant (59.89) was observed with application of 30 kg S $ha^{-1}$ followed by 40 kg S $ha^{-1}$ (Table 1).

Data on yield and yield contributing traits *viz.*, number of capsule per plant (cm), grain yield (q $ha^{-1}$), straw yield (q $ha^{-1}$), harvest index as influenced by different sulphur levels was found to be significant and have been presented. Incorporation of 40 kg S $ha^{-1}$($S_3$) produced maximum, number of capsule per plant (59.89 cm), seed yield (17.85q $ha^{-1}$), straw yield (47.47q $ha^{-1}$), number of seed per capsule (7.31g), followed by incorporation of 30 and 20 kg S $ha^{-1}$, respectively. However, harvest index (27.25%) was highest when crop was supplied 30 kg S $ha^{-1}$. All above mentioned yield and yield attributes were recorded to be lowest with control treatments. The results are in conformity with those of Jat *et al.* (2012) [7], Singh *et al*. (2013) [13], Vishal *et al*. (2017) [19] and Sharma *et al*. (2018).

Protein content also influenced by different levels of sulphur. Highest oil content (43.39%) was noted with application of 40 kg /$ha^{-1}$ followed by 30, 20 kg Zn $ha^{-1}$, respectively.

The beneficial effect of different Date of sowing on plant height at 90 DAS, number of branches per plant at 90- DAS, number of capsule per plant, number of seed per capsule, grain yield (q $ha^{-1}$), straw yield (q ha), harvest index, oil content were evident during active growth and maturity period of linseed crop. Crop sown on 29 October produced maximum, number of branches per plant at 90- DAS (7.18), number of capsule per plant (58.42), however, highest plant height (54.63 cm) at 90 DAS was recorded.

The yield and yield contributing traits like, number of seed per capsule, grain yield (q $ha^{-1}$), straw yield (q $ha^{-1}$), Harvest index were also significantly influenced by different date of sowing. Highest grain yield (16.10 q $ha^{-1}$) was obtained with (29th October) which was statistically. In addition to that crop sown on 29 October also gave harvest index (26.33%), however, number of capsule per plant (58.42 cm), and straw yield (44.36 q $ha^{-1}$) were recorded higher when crop was sown on 29 October.

Protein content was also influenced by different Date of sowing. Crop sown on 29 October had more oil content (42.63%) than rest of the sowing dates. This might be due to the fact that late sowing delayed the peak growth of linseed crop and sulphur concentration decreases in the plant from the late reproductive period to harvest. The results are in conformity with that of Kadam *et al*. (2015), Jana *et al*. (2018) and Bughrbee *et al*. (2020).

**Table 1:** Plant height of linseed at 90 DAS as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 50.81 | 53.20 | 56.17 | 58.35 | 54.63 |
| $D_2$ (5th Nov) | 45.96 | 53.18 | 54.96 | 55.93 | 52.51 |
| $D_3$ (12th Nov) | 45.87 | 52.70 | 53.50 | 54.45 | 51.63 |
| Mean | 47.55 | 53.03 | 54.88 | 56.24 | |

**Table 2:** Number of branches per plant of linseed at 90 DAS as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 5.80 | 6.47 | 7.07 | 9.40 | 7.18 |
| $D_2$ (5th Nov) | 5.60 | 6.20 | 6.80 | 6.93 | 6.38 |
| $D_3$ (12th Nov) | 5.07 | 5.93 | 6.60 | 6.67 | 6.07 |
| Mean | 5.49 | 6.20 | 6.82 | 7.67 | |

**Table 3:** Number of capsules per plant of linseed as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 51.60 | 56.07 | 61.73 | 64.27 | 58.42 |
| $D_2$ (5th Nov) | 51.40 | 55.60 | 57.87 | 58.33 | 55.80 |
| $D_3$ (12th Nov) | 48.60 | 52.93 | 56.73 | 57.07 | 53.83 |
| Mean | 50.53 | 54.87 | 58.78 | 59.89 | |

**Table 4:** Number of seeds per capsule of linseed as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 4.47 | 5.20 | 7.53 | 9.33 | 6.63 |
| $D_2$ (5th Nov) | 3.93 | 5.07 | 6.00 | 6.87 | 5.47 |
| $D_3$ (12th Nov) | 3.27 | 4.60 | 5.47 | 5.73 | 4.77 |
| Mean | 3.89 | 4.96 | 6.33 | 7.31 | |

**Table 5:** Seed yield (q/ha) per hectare of linseed as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$** (0 kg/ha) | **$S_1$** (20 kg/ha) | **$S_2$** (30 kg/ha) | **$S_3$** (40 kg/ha) | **Mean** |
| $D_1$ (29th Oct) | 11.69 | 13.94 | 19.19 | 19.56 | 16.10 |
| $D_2$ (5th Nov) | 11.28 | 13.64 | 16.94 | 18.97 | 15.21 |
| $D_3$ (12th Nov) | 10.39 | 13.03 | 14.19 | 15.03 | 13.16 |
| Mean | 11.12 | 13.54 | 16.78 | 17.85 | |

**Table 6:** Stover yield (q/ha) per hectare of linseed at as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 39.02 | 41.62 | 48.37 | 48.41 | 44.36 |
| $D_2$ (5th Nov) | 36.72 | 41.18 | 46.05 | 48.04 | 43.00 |
| $D_3$ (12th Nov) | 36.45 | 40.43 | 42.10 | 45.96 | 41.24 |
| Mean | 37.40 | 41.08 | 45.51 | 47.47 | |

**Table 7:** Harvest index (%) of linseed as influenced by different levels of Sulphur, date of sowing and their interactions.

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 23.03 | 25.10 | 28.40 | 28.78 | 26.33 |
| $D_2$ (5th Nov) | 23.45 | 24.87 | 26.90 | 28.31 | 25.88 |
| $D_3$ (12th Nov) | 22.18 | 24.36 | 25.21 | 24.66 | 24.10 |
| Mean | 22.89 | 24.78 | 26.84 | 27.25 | |

**Table 8:** Oil content (%) of linseed as influenced by different levels of Sulphur, date of sowing and their interactions

| Date of sowing | Sulphur levels | | | | |
|---|---|---|---|---|---|
| | **$S_0$ (0 kg/ha)** | **$S_1$ (20 kg/ha)** | **$S_2$ (30 kg/ha)** | **$S_3$ (40 kg/ha)** | **Mean** |
| $D_1$ (29th Oct) | 39.69 | 42.06 | 44.15 | 44.63 | 42.63 |
| $D_2$ (5th Nov) | 39.47 | 42.04 | 42.55 | 43.20 | 41.82 |
| $D_3$ (12th Nov) | 38.61 | 39.75 | 42.24 | 42.35 | 40.74 |
| Mean | 39.26 | 41.28 | 42.98 | 43.39 | |

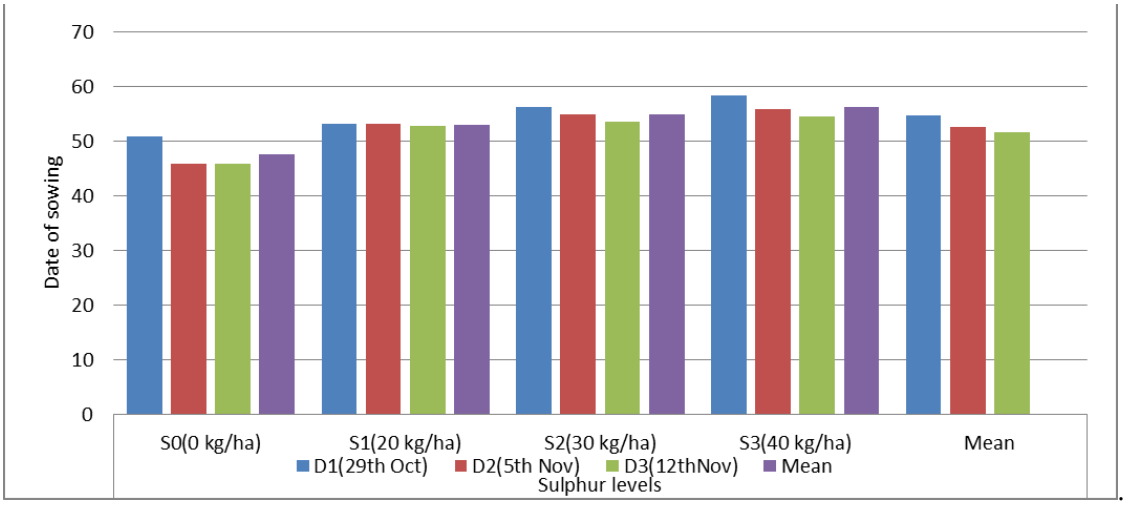


**Fig 1:** Plant height of linseed at 90 DAS as influenced by different level of sulphur and date of sowing (cm)

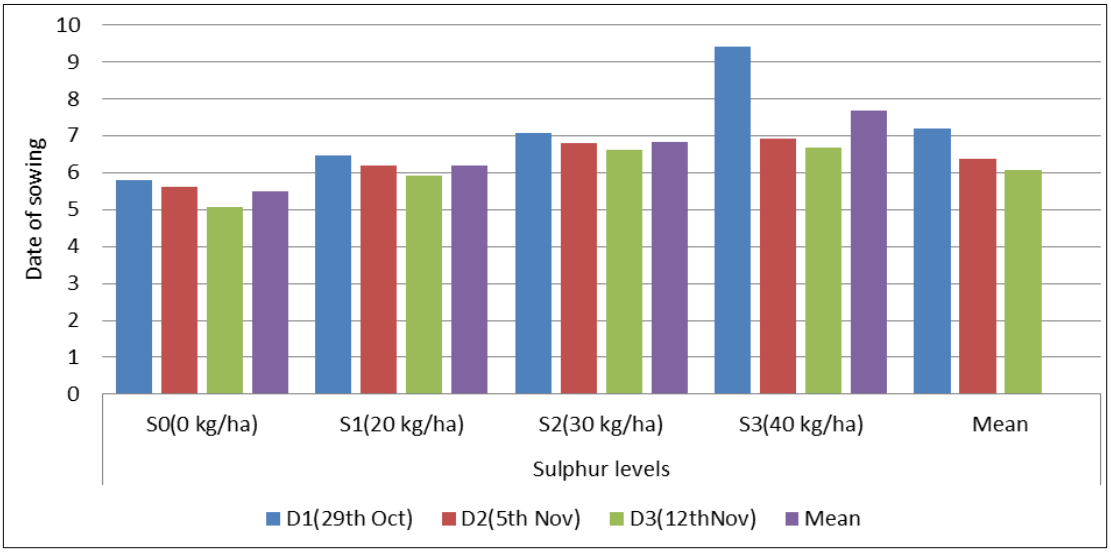


**Fig 2:** Number of branches per plant of linseed at 90 DAS as influenced by different levels of sulphur and date of sowing

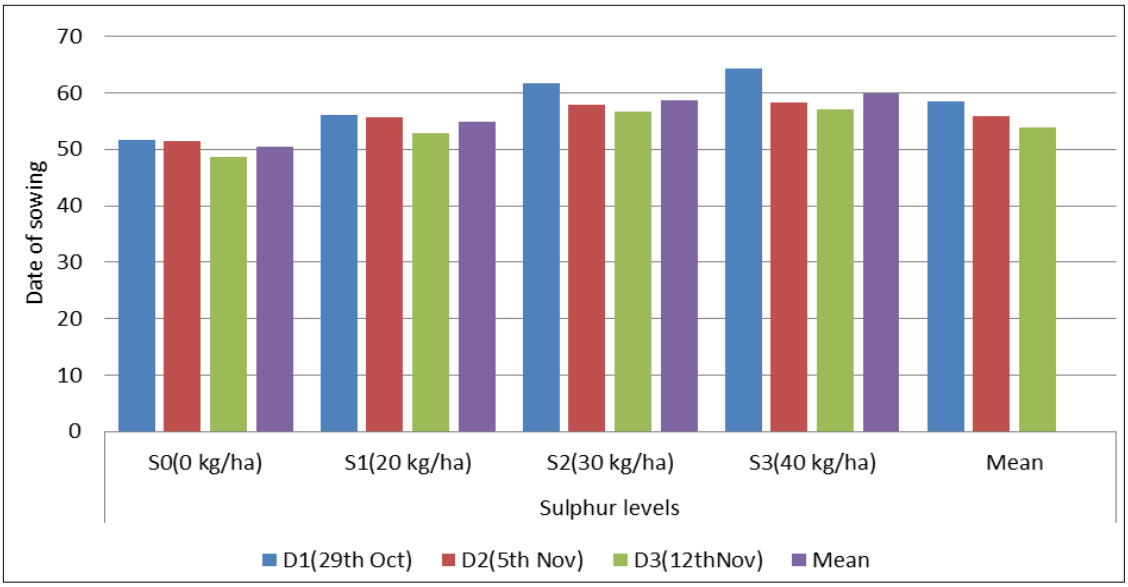


**Fig 3:** Number of capsules per plant of linseed as influenced by different levels of sulphur and date of sowing

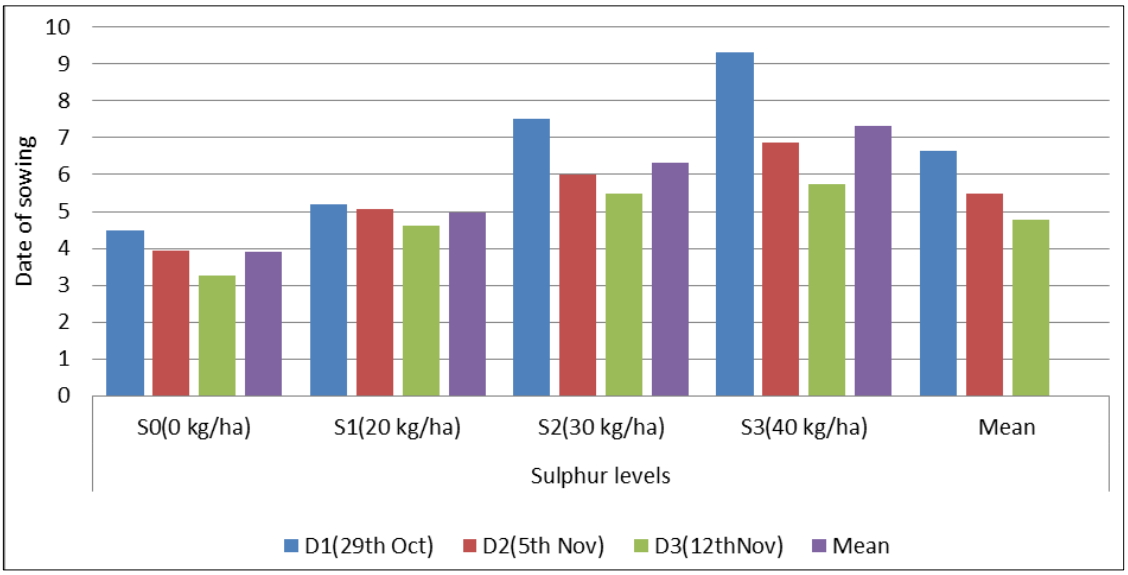


**Fig 4:** Number of seeds capsules linseed as influenced by different levels of sulphur and date of sowing

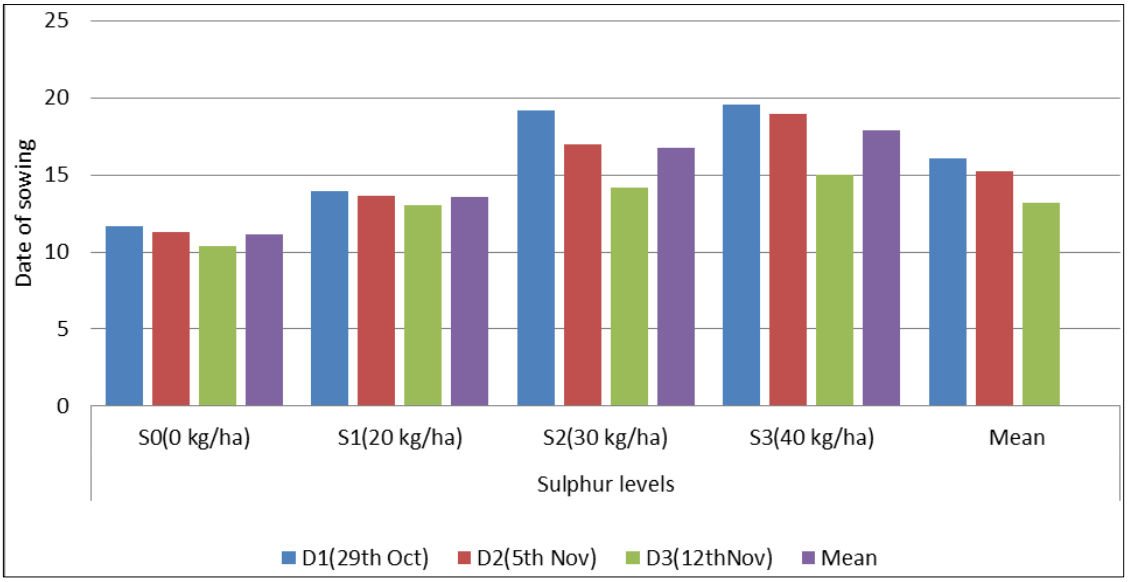


**Fig 5:** Grain yield per hectare (q/ha) of linseed as influenced by different levels of sulphur and date of sowing and their interaction

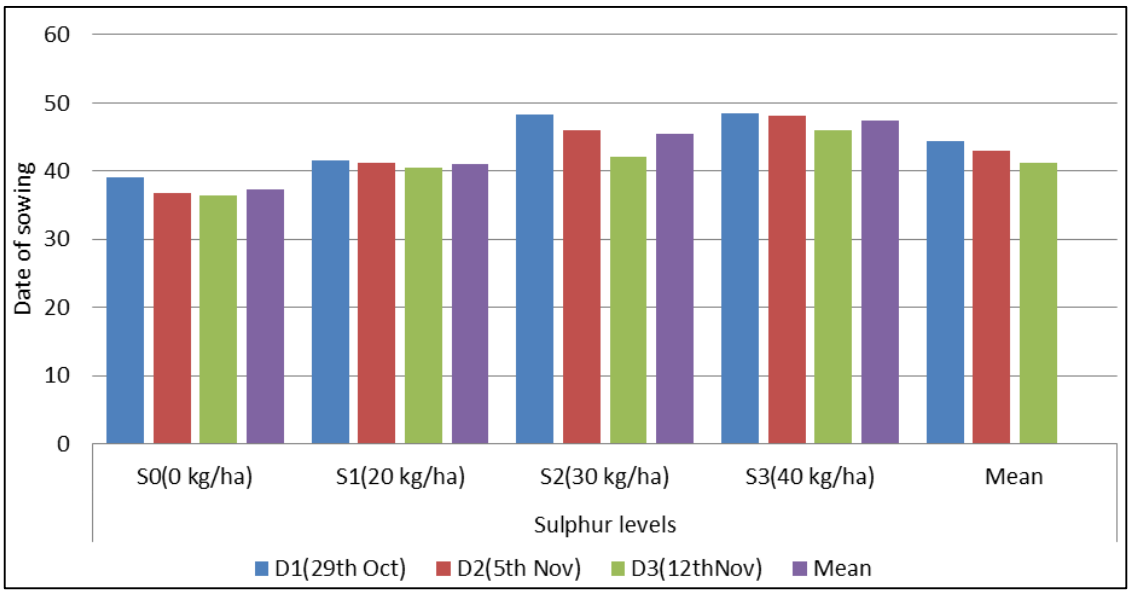


**Fig 6:** Stover yield per hectare (q/ha) of linseed as influenced by different levels of sulphur and date of sowing and their interaction

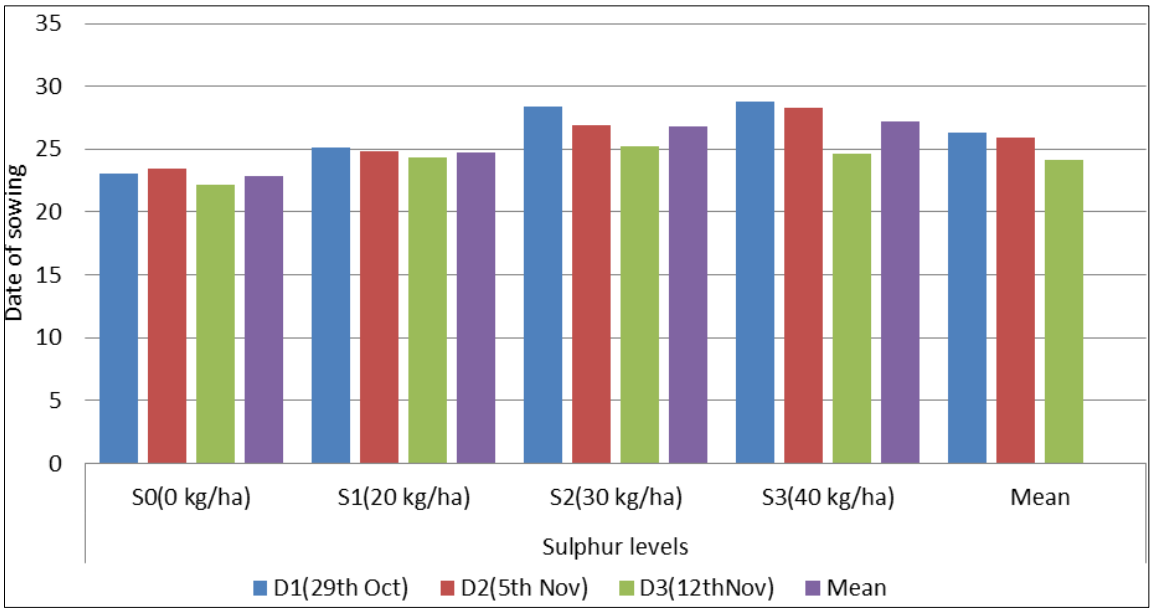


**Fig 7:** Harvest index (%) of linseed as influenced by different levels of sulphur and date of sowing and their interaction

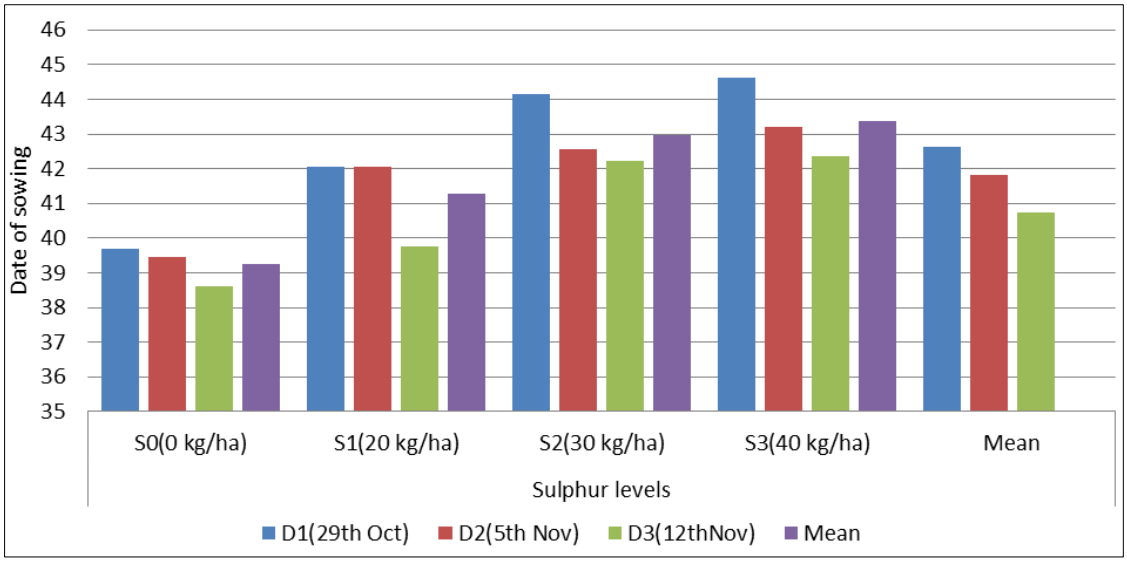


**Fig 8:** Oil content (%) of linseed as influenced by different levels of sulphur and date of sowing and their interaction

## Summary and Conclusion

All growth parameters except number of branches per plant at 90 DAS were highest with the application of 40 kg S $ha^{-1}$. Crop sown on 12 November produced maximum number of capsules per plant and whereas highest plant height was obtained when crop was sown on 12 November. Yield attributes *viz.* Number of seeds per capsule and Test weight were higher with the incorporation of 40 kg S $ha^{-1}$ and sowing of crop on 12 November. The significant higher grain yield per hectare, and Oil content of Linseed was recorded with the incorporation of 40 kg S $ha^{-1}$and with the sowing of Linseed crop on 29 October, 5, 12 November.

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