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Response of sulphur level and varieties on growth, yield and quality of linseed (*Linum usitatissimum* L.)

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Abstract
A field experiment was conducted on "Response of Sulphur level and varieties on growth, yield and quality of linseed (*Linum usitatissimum* L.)", an experiment was conducted at Instructional Farm of Department of Agronomy, Faculty of Agriculture, AKS University, Sherganj, Satna (M.P.) during *Rabi* season of 2021-22. The experiment consisted of randomize block design with factorial concept having with three replications. The results showed that higher plant height (56.99 cm), number of branches (8.8), seed yield (18.53 q/ha), stover yield (46.31 q/ha), harvest index (28.58%) and oil content (44.25%) was recorded under T_{10} S_3V_1 Application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 which was at par T_{12} S_3V_3 Application of Sulphur @ 75 kg/ha with linseed variety of JLS-79. The lower seed yield (10.53 q/ha), stover yield (31.24 q/ha) was recorded under T_2 S_0V_2 Application of Sulphur @ 0 kg/ha with linseed variety of JLS-67.

Keywords: Linseed, response of sulphur level and varieties on growth, yield and quality components

Introduction
Linseed (*Linum usitatissimum* L.) is considered as the most important edible as well as 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. The oil is rich in linolenic acid (>66%) and it is a perfect drying oil. Linseed seeds contain high levels of dietary fiber as well as lignin, an abundance of micronutrient and omega-3 fatty acids (Alpha Linolenic Acid).

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.

Varieties play an important role in determining the yield of any crop, the potential yield of cultivars within its genetic makeup is set by its environment. The release of new varieties of linseed is major breakthrough in achieving increased production per unit area. Yield of these varieties can be further improved by providing optimum environment by manipulating agronomic practices. Varieties differ in their yield potential depending upon many physiological processes which are controlled by both genetic makeup and the environment.

The growth phase of the crop should synchronize with optimum environmental conditions for better expression of plant growth, yield and its ancillary characters. It is the fact that a specified genotype does not exhibit the same phenotypic characteristics under all environmental conditions and different genotypes respond differentially to a specified environment and their relative ranking usually differ and ultimately decides the selection of varieties for stabilize or to get higher yields. Different genotypes may respond differently to changing climate and exhibit marked variation in the growth, development and yield of a particular variety.

Materials and Methods

"Response of Sulphur level and varieties on growth, yield and quality of linseed (*Linum usitatissimum* L.)" was carried out in the research farm, Faculty of Agriculture, AKS University, Sherganj, Satna (M.P.) during the year 2021-22. The details of the experimental site, climatic conditions, material used, procedures and techniques. Soil of the experimental site was clayey in texture (clay 29.94%) estimated by using Standard international Pipette method (Piper, 1966) [4], low in available nitrogen (150.4 kg ha^{-1}) estimated by using alkaline potassium per magnate method (Subbiah and Asija, 1956) [6], low in available phosphorus (16.8 kg ha^{-1}) estimated by using Olsen's method (Jackson, 1973) [1], very high in available potash (279.50 kg ha^{-1}) estimated by using flame photometer (Jackson, 1973) [1], available sulphur (33.0 mg/kg) estimated by using spectrophotometry (Lindsay and Norvell, 1978), organic carbon content was medium (0.39%) estimated by using Walkey and Black method (Jackson, 1973) [1] and soil reaction was slightly alkaline (pH 7.96) estimated by using glass electrode pH mater (Jackson, 1973) [1]. The experiment was laid out in Randomized Block Design with Factorial concept and 12 treatments with net plot of 4.0 m x 3.0 m.

Results and Discussion

Plant height (cm) at 90 DAS

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in plant height at 90 DAS. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T_{10}, S_3V_1) produced significantly highest plant height (56.99 cm) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 54.80 cm which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest plant height (44.67 cm) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Number of branches at 90 DAS

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in number of branches per plant at 90 DAS. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T_{10}, S_3V_1) produced significantly highest number of branches per plant (8.8) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 6.60 which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest number of branches per plant (5.0) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Seed yield (q/ha)

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in seed yield per hectare. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T_{10}, S_3V_1) produced significantly highest seed yield per hectare (18.53 q/ha) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 17.92 q/ha which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest seed yield per hectare (10.53 q/ha) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Stover yield (q/ha)

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in stover yield per hectare. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T10, S_3V_1) produced significantly highest stover yield per hectare (46.31 q/ha) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 44.96 q/ha which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest stover yield per hectare (31.24 q/ha) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Harvest index (%)

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in harvest index. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T10, S_3V_1) produced significantly highest harvest index (28.58%) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 28.50% which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest harvest index (25.21%) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Oil content (%)

The interaction effect between different levels of Sulphur and linseed varieties was found to be significant for variation in oil content. The treatment combination consisting that application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 (T_{10}, S_3V_1) produced significantly highest oil content (44.25%) which was statistically at par under the application of Sulphur @ 75 kg/ha with linseed variety of JLS-79 (T_{12}, S_3V_3) by 43.77% which was proved significantly superior as compared to all the remaining varieties and Sulphur interaction. The lowest oil content (38.73%) was noticed under the without application of Sulphur @ 0 kg/ha with linseed variety of JLS-67 (T_2, S_0V_2) treatment combination.

Table 1: Plant height (cm) of linseed at 90 DAS as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	51.40	51.88	53.61	56.99	53.47
V_2 (JLS-67)	44.67	49.52	52.17	54.57	50.23
V_3 (JLS-79)	44.70	51.87	53.11	54.80	51.12
Mean	46.92	51.09	52.96	55.45	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	1.11	3.26
Variety (V)	1.28	3.77
Interaction (S x V)	0.64	1.33

Table 2: Number of branches per plant of linseed at 90 DAS as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	5.80	6.27	6.47	8.87	6.85
V_2 (JLS-67)	5.07	5.73	6.33	6.53	5.92
V_3 (JLS-79)	5.60	6.07	6.40	6.60	6.17
Mean	5.49	6.02	6.40	7.33	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	0.63	1.85
Variety (V)	0.73	2.14
Interaction (S x V)	0.36	0.76

Table 3: Seed yield (q/ha) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	12.72	13.64	16.58	18.53	15.37
V_2 (JLS-67)	10.53	12.22	13.83	16.64	13.31
V_3 (JLS-79)	11.08	13.31	14.69	17.92	14.25
I IMean	11.44	13.06	15.04	17.69	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	0.44	1.28
Variety (V)	0.50	1.48
Interaction (S x V)	0.25	0.52

Table 4: Stover yield (q/ha) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	35.19	38.48	43.15	46.31	40.78
V_2 (JLS-67)	31.24	33.87	40.22	44.24	37.39
V_3 (JLS-79)	31.34	37.17	41.60	44.96	38.77
Mean	32.59	36.51	41.66	45.17	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	0.84	2.46
Variety (V)	0.97	2.83
Interaction (S x V)	0.48	1.00

Table 5: Harvest index (%) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	26.55	26.17	27.76	28.58	27.26
V_2 (JLS-67)	25.21	26.52	25.59	27.34	26.16
V_3 (JLS-79)	26.14	26.35	26.10	28.50	26.77
Mean	25.96	26.35	26.48	28.14	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	0.78	2.29
Variety (V)	0.90	2.65
Interaction (S x V)	0.45	NS

Table 5: Oil content (%) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

Varieties	Sulphur levels				
	S_0 (0 kg/ha)	**S_1 (25 kg/ha)**	**S_2 (50 kg/ha)**	**S_3 (75 kg/ha)**	**Mean**
V_1 (JLS-66)	39.46	41.74	42.20	44.25	41.91
V_2 (JLS-67)	38.73	39.40	41.91	42.84	40.72
V_3 (JLS-79)	39.21	41.72	42.01	43.77	41.68
Mean	39.13	40.95	42.04	43.62	

	S. Em±	C.D. (P= 0.05)
Sulphur level (S)	0.39	1.15
Variety (V)	0.45	1.32
Interaction (S x V)	0.23	0.47

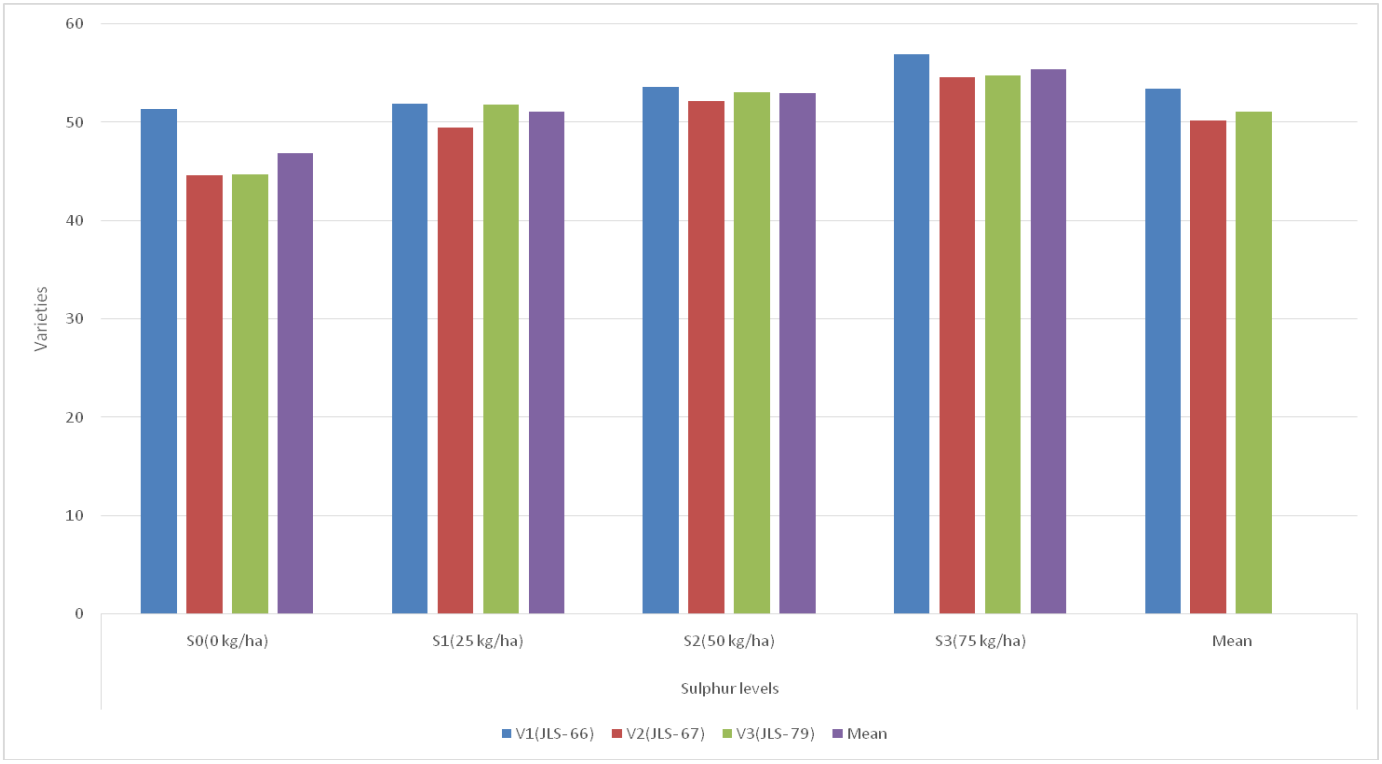

Fig 1: Plant height (cm) of linseed at 90 DAS as influenced by different levels of Sulphur, varieties and their interaction.

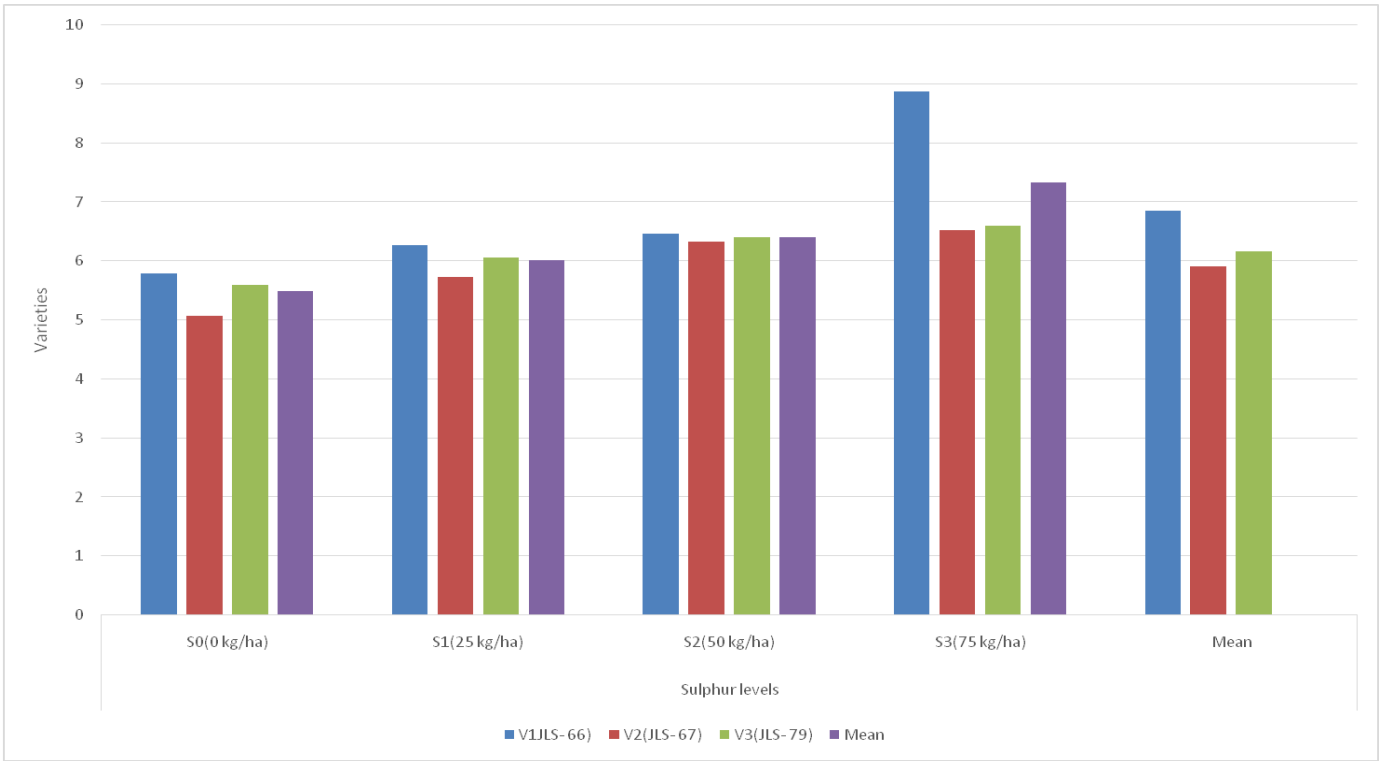

Fig 2: Number of branches per plant of linseed at 90 DAS as influenced by different levels of Sulphur, varieties and their interaction.

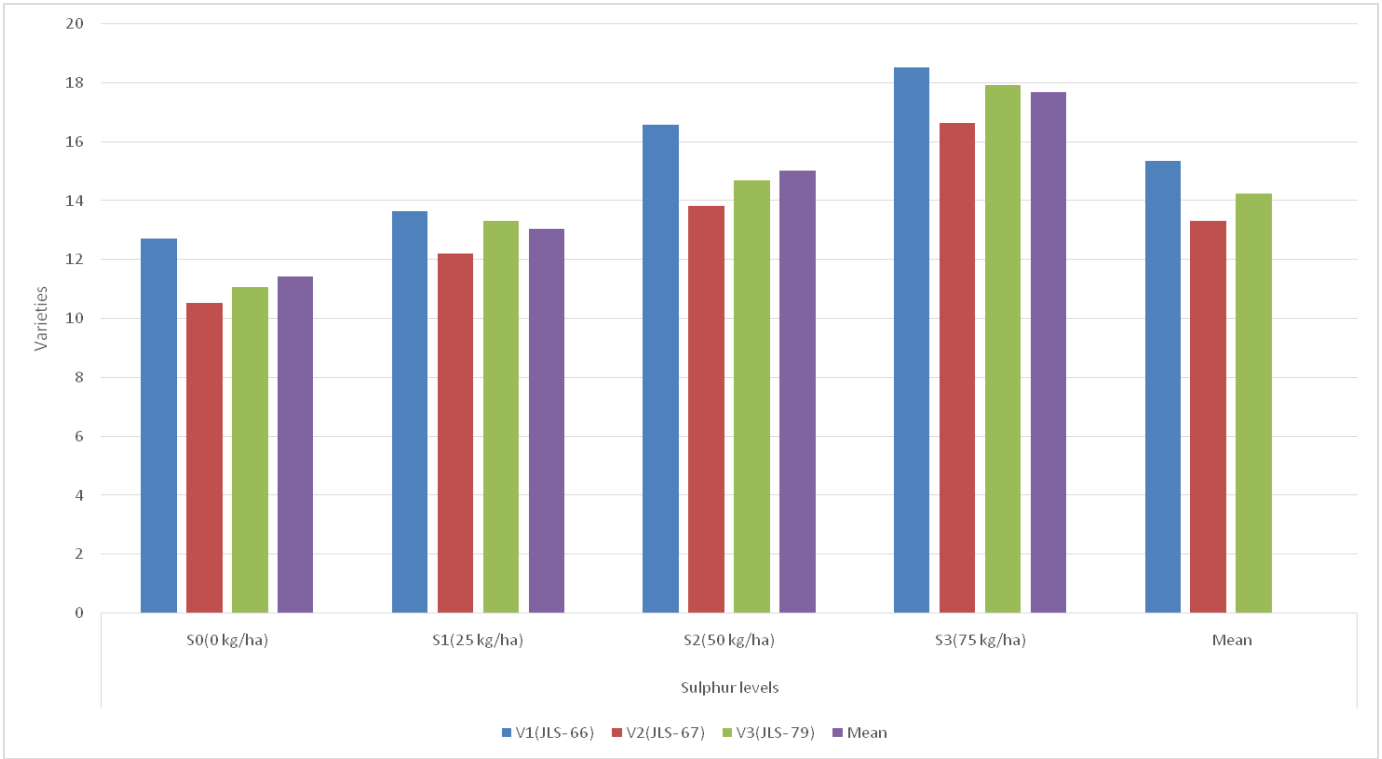

Fig 3: Seed yield per hectare (q/ha) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

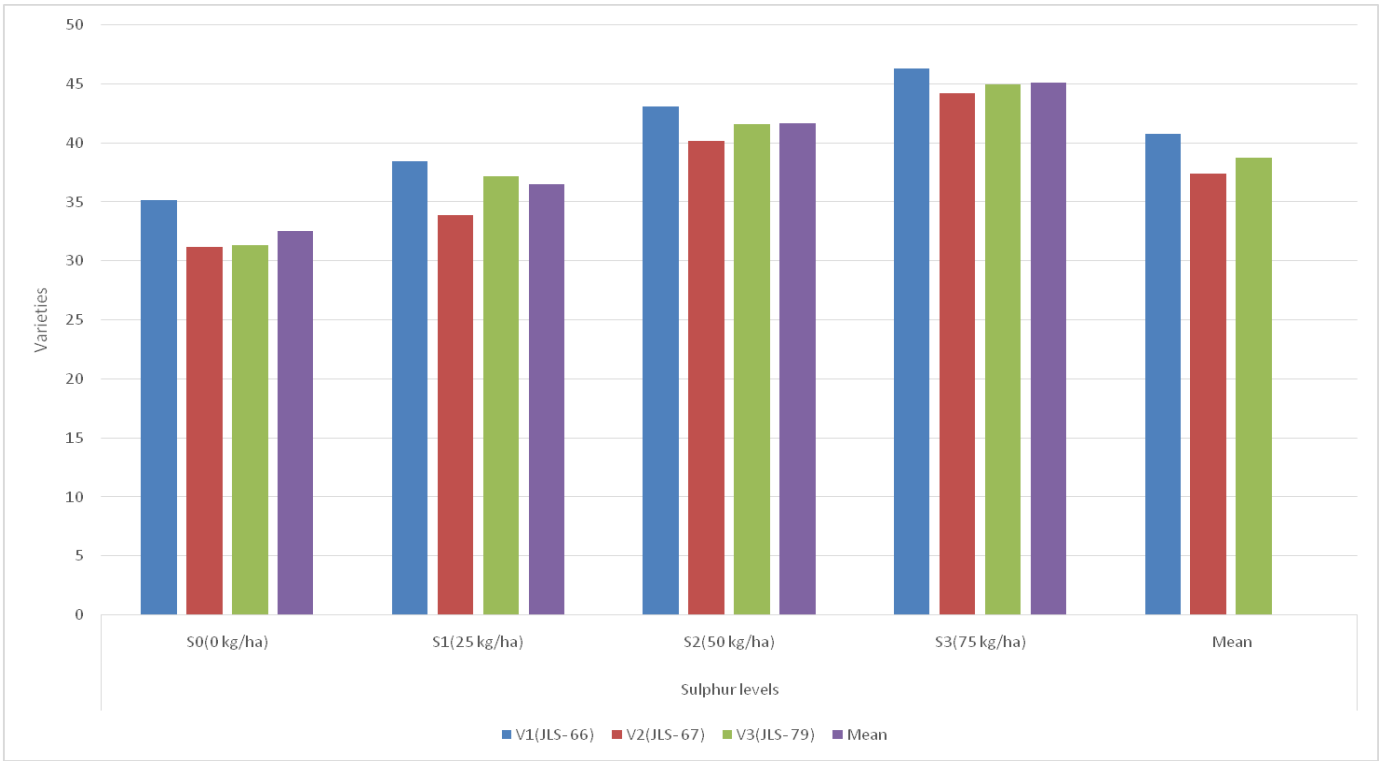

Fig 4: Stover yield per hectare (q/ha) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

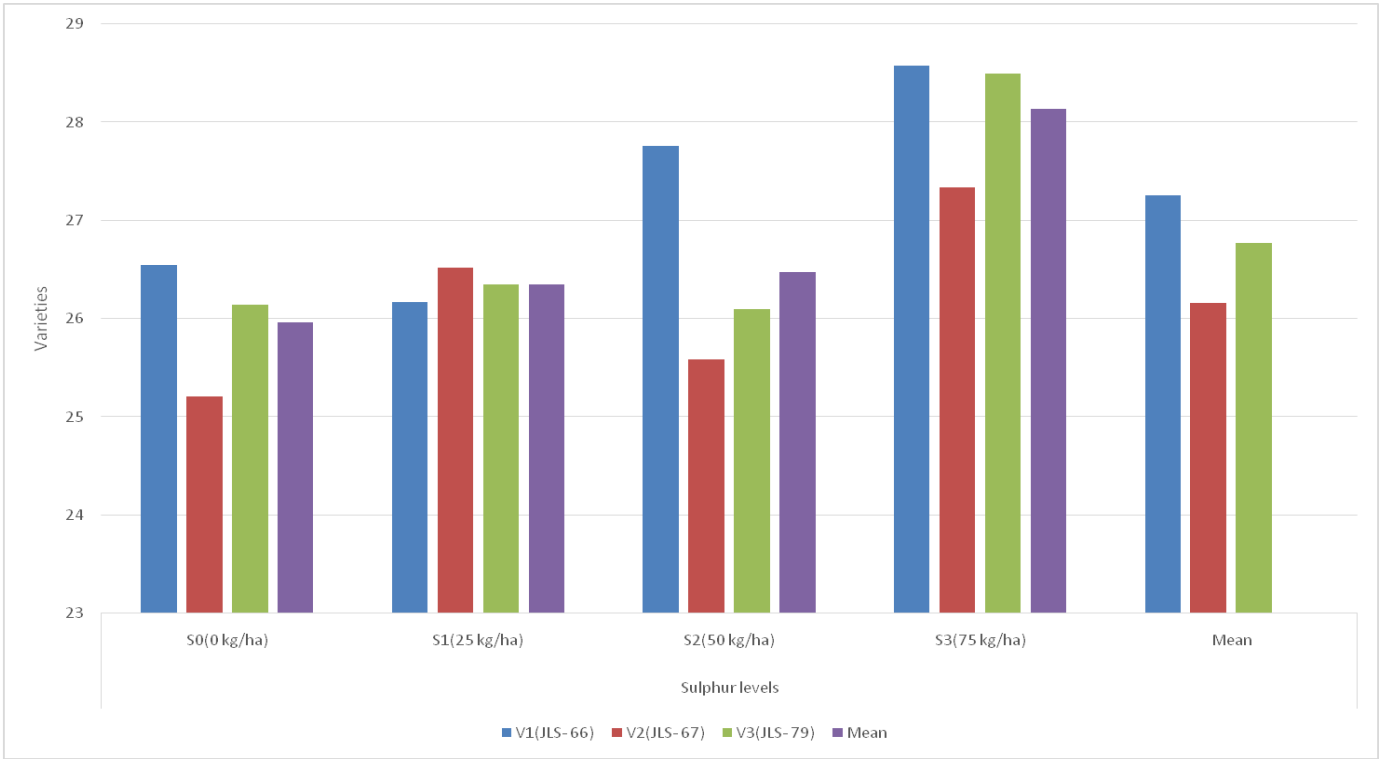

Fig 5: Harvest index (%) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

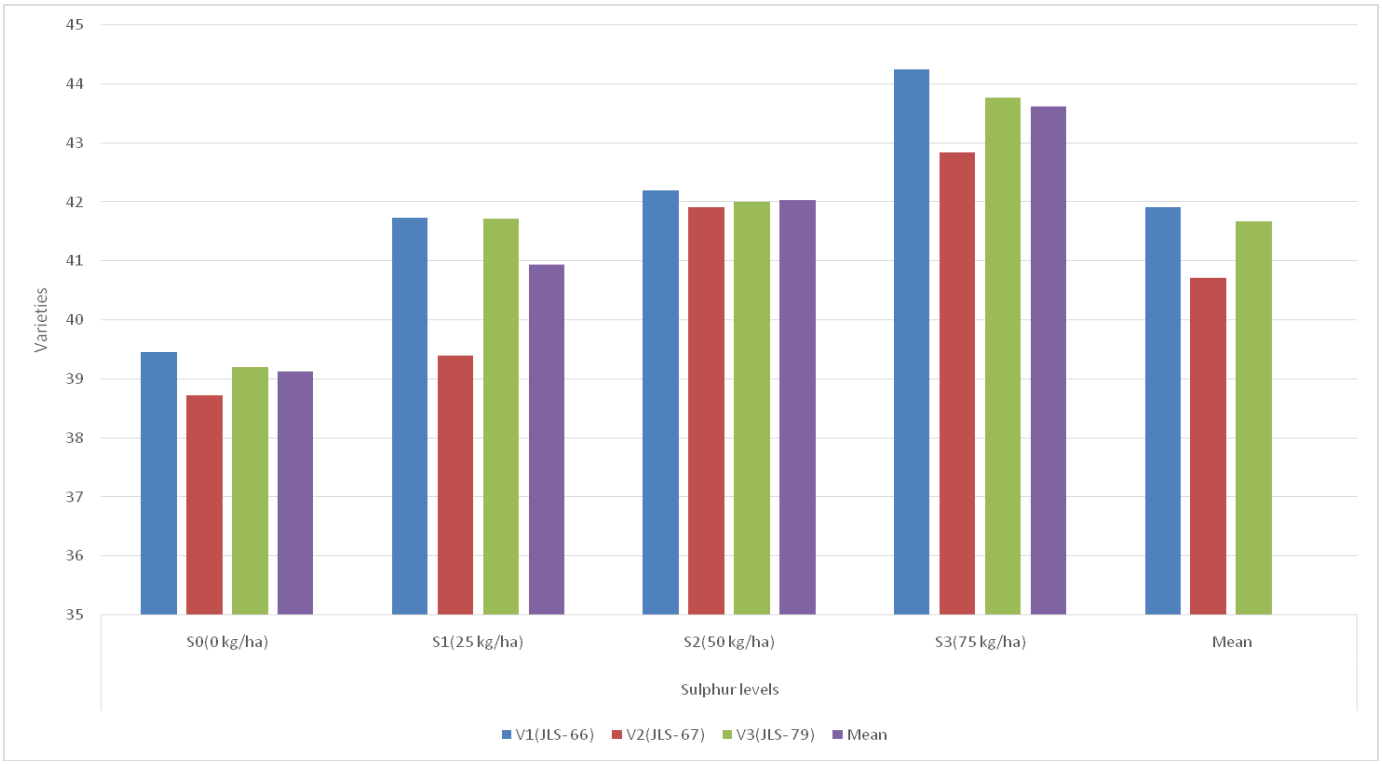

Fig 6: Oil content (%) of linseed as influenced by different levels of Sulphur, varieties and their interaction.

Conclusion

The higher plant height, number of branches, seed yield, stover yield, harvest index and oil content was recorded under T_{10} S_3V_1 Application of Sulphur @ 75 kg/ha with linseed variety of JLS-66 which was at par T_{12} S_3V_3 Application of Sulphur @ 75 kg/ha with linseed variety of JLS-79. The lower seed and stover yield was recorded under T_2 S_0V_2 Application of Sulphur @ 0 kg/ha with linseed variety of JLS-67.

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