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The interaction effect of sulphur and zinc on yield of linseed crop

Divya Diwan, Pawan Sirothia and Anup Kumar Dwivedi

Divya Diwan
Department of Soil Science, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India

Pawan Sirothia
Department of Soil Science, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India

Anup Kumar Dwivedi
Department of Soil Science, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India

Correspondence
Pawan Sirothia
Department of Soil Science, Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India

Abstract
The present experiment was conducted at Rajoula agriculture farm of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M.P.) during *Rabi* 2017-18. The soil of experiment field was sandy loam having 0.32% organic carbon, 10.55 kg/ha DTPA sulphur and 0.31 ppm available sulphur. The treatment comprised 9 combinations of 3 sulphur levels (0%, 0.5% and 1%kg S/ha) and 3 levels of Zinc (0, 5 and 7.5 kg Zn/ha). Sulphur was applied through w.p. All 9 treatment combination was tested in a factorial Randomized block design with 3 replications. The N, P and K fertilizers applied uniformly @ 30kg N + 15kg K_2O/ha as urea, DAP and MOP respectively. Crop variety 'Shekhar' was shown on 07.10.2017 and harvested on 03.04.2018. Crop in its life period received no winter rain as winter season was totally dry. It is observed that the effect of sulphur was found significant on growth and yield of linseed where seed yield responded up to 0.5% kg/ha sulphur application. Zinc application has significant effect on growth and linseed yield. However, 7.5 kg /ha Zinc produced numerically higher seed yield over no application of Zinc. Interaction effect of S × Zn was significant on any crop character. However, the combined application of 0.5% kg S/ha plus 7.5 kg Zn/ha proved to be better than from crop production point of view.

Keywords: Fertilizer, linseed, nutrients, sulphur, zinc

Introduction
Linseed (*Linum usitatissimum* L.) is an oilseed and fiber crop. It is grown for both seed as well as fiber for the manufacture of linen. Seed contains a good percentage of oil which varies from 33 to 47 per cent in different varieties. The oil is edible and also due to its quick drying property, it is used for the preparation of paints, varnishes, printing ink, oil cloth, soap and waterproof fabrics. The oilcake left after the oil is pressed out is a most valuable feeding cake perhaps the most favorite cattle feed. It is good in taste and contains 36 percent protein. It is fed to both milch and fattening animals. It is also used as organic manure. It contains about 5 per cent nitrogen. 1.4 per cent phosphorus and 1.8 per cent potash. Flax seeds contain 23% 18:3 Omega-3 fatty acids (mostly ALA) and 6% 18:2 Omega-6 fatty acids. Flaxseed oil contains 53% 18:3 Omega-3 fatty acids (mostly ALA) and 13% 18:2 Omega-6 fatty acids. One of the main components of flax is lignan, which has plant estrogen as well as antioxidants (flax contains up to 800 times more lignans than other plant foods contain).

India is the second largest (21.21 %) linseed growing country in the world after Canada and production-wise it ranks fourth (8.20 %) in the world after Canada (40.51 %), China (18.68 %), and USA (10.89 %). The world linseed average productivity is 852 kg/ha. However, the productivity of linseed in India is lower than the world linseed average productivity and is only 395 kg/ha. Among the *Rabi* oilseed crops in India, linseed happens to occupy the second position i.e., next to rapeseed-mustard in areas as well as production. At present, linseed is cultivated on about 4.36 lakh ha with the contribution of 1.67 lakh tonnes to the annual oilseed production of the country. Presently, linseed is under cultivation in as many as 16 states of the country viz., Madhya Pradesh, Maharastra, Chhattisgarh, Uttar Pradesh, Jharkhand, Bihar, Orissa, Karnataka, Nagaland, Assam, Jammu and Kashmir, West Bengal, Andhra Pradesh, Himachal Pradesh, Rajasthan and Punjab. Area under linseed cultivation has remained almost static between 2.85 to 2.98 lakh ha (2013-14 to 2015-16). Productivity of linseed has declined from 541 kg/ha (2014-15) to 442 kg/ha (2015-16).

The use of sulphur is one of the most important factors in increasing yields. Sulphur plays an important role in the formation of amino acids, synthesis of proteins, chlorophyll and oil (Singh and Singh 2007) [10]. Balanced use of sulphur commensurate with crop needs and soil nutrient status is indispensable for sustained production of high yield level. Experimental evidences indicate that sulphur is most essential plant nutrient which is generally lacking in Indian soils.

To, fulfill the necessities for sulphur nutrient, it is necessary to supply these to the hungry soil in concentrated and readily available from i.e. fertilizers. It is also essential to know optimum level of sulphur. Though many workers have worked on this aspect but requirement of sulphur vary from soil to soil and place to place. Even agro-climatic conditions have great influence on the sulphur requirement of a crop. Therefore, it was necessary to find out the most beneficial sources and level of sulphur from the point of view of yield, nutrient uptake and quality of linseed.

Materials and Methods

The experiment was conducted, during the *Ravi* season of 2017-18. The field experiment will be conducted in Agriculture farm (Rajoula) of Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna (M. P.) This farm is situated in Bundelkhand Zone of northern Madhya Pradesh. The place of experiment Chitrakoot is located at $25^0 10'$ N latitude and $80^0 85'$ E longitude at an elevation of about 200 meter above mean sea level. The climate of the region is semi-arid and sub-tropical having extreme winter and summer. During the winter months, the temperature drops down to as low as 2°C while in the summer the temperature reaches above 47°C. During the experimental period, weather was generally warm but pleasant due to pre-monsoon and monsoon showers, followed by beginning of winter season. The average rainfall in this area is approximately 90 - 100 cm, with maximum concentration during the monsoon i.e. Nov.-April, with a few occasional showers during the winter months.

Soil samples were collected separately from each plot of the experimental field to a depth of 0-15 cm prior to sowing of Linseed crop. The samples were analyzed for its physico-chemical properties. The soil of experimental site was sandy loam in texture, low in organic carbon, nitrogen and phosphorus and medium in available potassium.

The experiment was laid out in randomized block design with three replications. The field experiment was conducted with 9 different treatments *viz*. S_0 Zn_0, S_0Zn_1, S_0 Zn_2, S_1Zn_0, S_1Zn_1, S_1Zn_2, S_2Zn_0, S_2Zn_1 and S_2Zn_2, where S_0 mean 0% level of sulphur spray, S_1 means 0.5% level of sulphur spray and S_2 means 1% level of sulphur spray and Zn_0 means 0 kg level of zinc, Zn_1 means 5 kg level of zinc and Zn_2 means 7.5 kg level of zinc per hectare in three replications. The size of plots was 8.2 m^2. The linseed variety "Shekhar" was sown on 7th October, 2017.

The capsules were picked from all the five tagged plants of each plot. After counting the capsules of each plant, their average was recorded. Ten capsules were taken from five tagged plants. Capsules were shallow carefully by hand. Seeds were separated from stalk and then they were counted and an average was worked out. Seed samples from each treatment of every plot were taken. Later on counting of 1000 seeds was carried out for each treatment separately and was weighed on an electric balance. The weight was recorded in gram. From the recorded data of yield per plot (seed yields and straw yield) were computed per hectare on multiplying the yield per plot by conversion factor.

The raw data collected was subjected to statistical analysis using the analysis of variance technique. The critical difference (at 5 % level of probability) was computed for comparing treatment mean in cases where effect came out to be significant by F- test as follows.

$$CD = SEm \pm x\ t$$

Where, CD= Critical difference at 5% level of probability

SEm± = Standard error of mean

t = Table value of "t" at error degree of freedom.

EMSS= Error mean sum of square.

r = number of replication on which observation is based.

Result and Discussion

Application of sulphur at each increased level enhanced biological yield of linseed significantly with up to 0.5 kg S/ha Table-1. The margin of increase with 0.5% and 1% kg S/ha level over control were found to be 3.50 and 3.38, respectively. Highest dose of 0.5% kg S/ha yielded highest biomass which was not found significantly higher over 0.5% kg S/ha. Effects of zinc application or S × Zn interaction were found significant on biological yield. However numerically boron treatment similarly the treatment combination of 0.5% kg S + 7.5 kg Zn produced numerically highest biological yield of (3.50 kg) 35.0 q/ha.

The data for total biomass yield for different treatments are presented in Table-1. Mean effect of treatment is also exhibited in fig. 1.

The data clearly indicate that seed yield of linseed was significantly influenced only by increasing levels of sulphur application while Zinc levels or S × Zn interaction seed yield significantly. Increasing levels of sulphur increased seed yield with up to 0.5 kg S/ha, but difference between 0.5% and 1% kg S levels and between 0.5% kg S levels was significant. However application of 0%, 0.5% and 1% kg S/ha increased seed yield over control by the margins of 0.36 0.44 and 0.38 seed/ha respectively. Though interaction effect of S × Zn was significant, the highest numerical yield of 4.4 q/ha was recorded under treatment combination of 0.5 kg S /ha 7.5 kg Zn/ha. The data regarding seed yield under different treatment are furnished is Table- 2 and mean effect of treatment are also demonstrated in fig. 2.

The application of sulphur increased, but difference between sulphur does was found significant. The dosses of 0%, 0.5% and 1% kg/ha or 29.7, 30.2 and 29.9 (q/ha) higher Stover yields, respectively over no application of Zinc. Neither Zinc levels nor S X Zn interaction could influence Stover yield significantly. However, the treatment of 0.5% kg S/ha+7.5 kg/ha Zn application recorded numerically highest Stover yield of 30.2 q/ha. The pertinent data under different treatments are performed in Table-3 while the values of mean sum of squares have been provided fig.3.

Seed yield and Stover yield increased with increasing levels of sulphur application significantly with up to 0.5 kg S/ha. It might be attributed to growth characters and yield attributed of linseed which application. Sulphur application has been reported to favor yield due to proper partitioning of photo syntheses from source to sink (Singh *et. al*, 2006) [11]. These results corroborated the findings of Jaggi *et al.* (1993) [6], Chaubey and Dwivedi (1995) [2], Kulhare *et al.* (1995) [8], Dubey *et al.* (2000) [4], Banerjee (2001) [1], Pandey (2003) [9], Sune *et al.* (2006) [12] and Singh and Singh (2007) [10].

The application of Zinc could influence the yields of linseed in present study significantly. Although yield attributes improved due to Zinc but these could be reflected in seed yield perhaps because of narrow margin of increase. As crop faced dry weather in its reproduction phase it could betake expected advantage of Zinc in seed yield. Significantly affect all Zinc application on Stover yield might be attributed to growth characters which also responded to application of Zinc. Significant effect of Zinc application on the yield of oilseed crop has also be observed by Kalia and Sharma (1988) [7] and Chaurasia *et al.* (1992) [3].

Table 1: Effect of Sulphur, Zinc and S x Zn interaction on biological yield (q/ha) of linseed.

Treatment	**Zn-Levels (kg/ha)**			
	0	**5**	**7.5**	**Mean**
S-levels (kg/ha)				
0 %	2.50	3.03	3.34	2.95
0.5 %	2.68	3.16	3.50	3.11
1 %	2.88	3.25	3.38	3.17
Mean	2.68	3.15	3.40	
Factors	S	Zn	S x Zn	
S. E m. ±	0.02	0.02	0.03	
C.D. (P=0.05)	0.06	0.06	0.11	

Table 2: Effect of Sulphur and Zinc interaction on seed yield (q/ha) of linseed.

Treatment	**Zn-Levels (kg/ha)**			
	0	**5**	**7.5**	**Mean**
S-levels (kg/ha)				
0 %	0.28	0.31	0.36	0.32
0.5 %	0.30	0.32	0.44	0.35
1 %	0.30	0.33	0.38	0.34
Mean	0.29	0.32	0.39	
Factors	S	Zn	S x Zn	
S. E m. ±	0.002	0.002	0.004	
C.D. (P=0.05)	0.007	0.007	0.01	

Table 3: Effect of sulphur and Zinc interaction on Stover yield (q/ha) of linseed.

Treatment	**Zn-Levels (kg/ha)**			
	0	**5**	**7.5**	**Mean**
S-levels (kg/ha)				
0 %	2.22	2.71	2.97	2.63
0.5 %	2.37	2.83	3.02	2.74
1 %	2.51	2.89	2.99	2.79
Mean	2.37	2.81	2.99	
Factors	S	Zn	S x Zn	
S. E m. ±	0.02	0.02	0.04	
C.D. (P=0.05)	0.07	0.07	N/A	

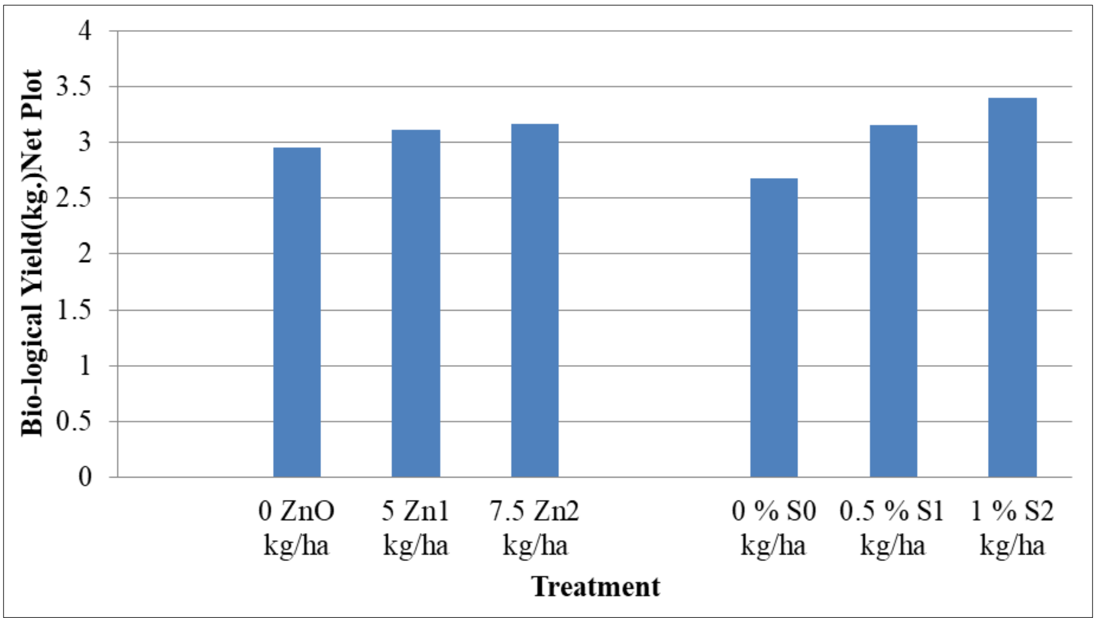

Fig 1: Effect of Sulphur, Zinc and S × Zn interaction on biological yield (q/ha) of linseed.

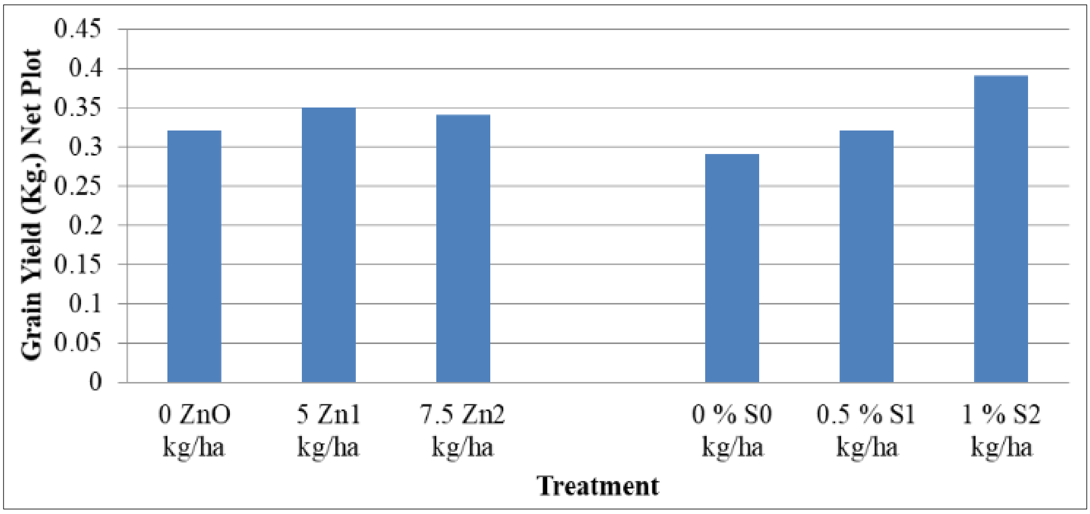

Fig 2: Effect of Sulphur and Zinc interaction on seed yield (q/ha) of linseed.

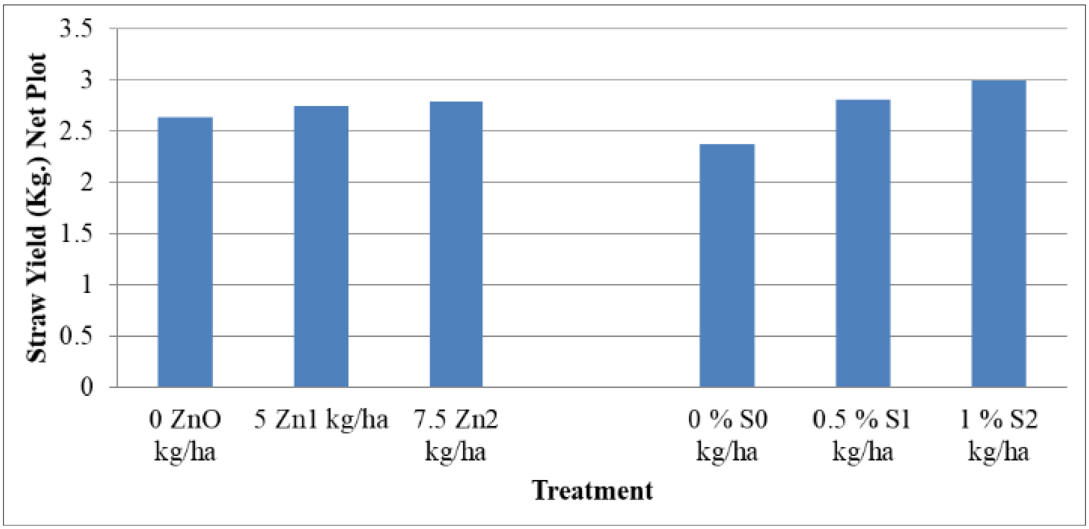

Fig 3: Effect of sulphur and Zinc interaction on Stover yield (q/ha) of linseed.

Conclusion

The overall conclusion may be drawn that 0.5% kg S/ha plus 7.5 kg Zn/ha along with recommended rates of NK is a better fertilizer schedule for higher production of rainfed linseed under the condition of present experiment.

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