TITLE

INFLUENCE OF SULPHUR AND ZINC ON YIELD AND ECONOMICS OF LENTIL (*Lens culinaris* Medikus.)

Article type: *Original Research Article*

ABSTRACT

A field experiment was conducted during *Rabi* season of 2022-23 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of Sulphur and Zinc on growth and yield of Lentil. The treatments consist of Sulphur 20, 30, 40 kg/ha and Zinc 5.0, 6.0, 7.0 kg/ha. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%). Results revealed that the higher plant height (37.68 cm), higher number of nodules (19.25), higher plant dry weight (18.83 g/plant), higher crop growth rate (15.7 g/m^2/day, higher number of pods/plant (148.77), higher number of seeds/pod (1.80), higher 1000 seed weight (25.27 gm), higher seed yield (1.78 t/ha) and higher stover yield (3.05 t/ha) were significantly influenced with application of Sulphur 40 kg/ha + Zinc 7.0 kg/ha. Higher gross return (INR 1,06,980/ha), higher net return (INR 74,445/ha) and higher B:C ratio (2.29) were also recorded in treatment-9 (Sulphur 40 kg/ha + Zinc 7.0 kg/ha).

Keywords: *Lentil, Sulphur, zinc, growth parameters, and yield attributes.*

INTRODUCTION

Lentil (*Lens culinaris* L. Medikus), commonly known as 'masoor' in India, has all the features to become the food of future. The nutritional content of lentils is of great interest to consumers, who are more focused on health and wellness than ever before.

The nitrogen-fixing, drought-resistant lentil is a very affordable, delicious, and incredibly healthy meal. Lentils help to improve soil quality by collaborating with soil microbes and requiring little watering. Carbon may be kept out of the atmosphere by healthy soil. where it traps heat, hastening the warming process. Due to its high capacity for fixing nitrogen, which results in the addition of 32.8 kg/ha of nitrogen and 4-5 t/ha of organic matter to the soil, lentil is very important in systems of cereal-based cropping. The protein content of lentil grains ranges from 22.0 to 34.6 percent, and 100 g of dried lentil seeds have the following nutritional values: 340–346 kcal, 20.2 g protein, 0.6 g fat, 65.0 g total carbs, around 4 g fibre, 2.1 g ash, 68 mg Ca, 325 mg P, and 7 mg Fe. Furthermore, because of its high lysine and tryptophan content, it provides a balance in amino acid uptake when consumed with wheat or rice, as these amino acids are scarce in cereals **(Deep *et al.*, 2022).**

Sulphur is the fourth most crucial nutrient for plants, behind nitrogen, phosphorus, and potassium.Sulphur has a variety of roles in plant growth, including affecting a number of physiological processes and a plant's ability to withstand abiotic stress as well as serving as a structural component of macro macromolecules. Despite the fact that sulphur has long been recognised as an important component of nutrition, agriculture has paid it little attention. As food, fibre, and energy production are intensified to support the expanding human population, a severe problem with sulphur has just come to light. Additionally, animal output is rising. Sulphur can assist in supplying the rising demand for premium pulse and oilseed crops. Sulphur is a crucial component in raising the calibre of oilseed crop oil extraction. Protein, vitamin, and chlorophyll production are all facilitated by Sulphur. All live cells require sulphur because it contains 21 amino acids that are important for the synthesis of protein. Pulses are particularly vulnerable to sulphur deficiency, which reduces yields and quality. Sulphur is only ingested by plants as sulphate (SO42-), which decomposes into sulphate. a combination of chemicals, including amino acids. Utilising Sulphur improves the use of nitrogen. The efficiency of N, P, and K is significantly impacted by sulphur deficiency. In addition to the authorised dosage, the application of 30 and 40 kg S/ha-1 was shown to be successful in pulses. The Contribution of Sulphur Nutrition to Increasing Oilseed and Pulse Productivity.

Zinc is a crucial micronutrient for humans, animals, and plants. Zn is a crucial component of many enzymes that catalyse several metabolic reactions in plants.In addition to aiding in photosynthesis, cell membrane integrity, protein synthesis, pollen development, and plant immunity to disease, zinc also helps to increase the levels of antioxidant enzymes and chlorophyll in plant tissues. **(Azhar Hussain 2015)** More than 3 billion people worldwide suffer from Fe and Zn deficiencies, and this condition is particularly common in areas where the population is heavily dependent on an unvarying diet of cereal-based foods. Zinc deficiency not only slows down plant growth and yield, but it also affects human beings. **(B. Hafeez 2013)** Nearly half of the world's population now suffers from a significant Zn deficiency. This is really caused by the crop's low Zn content, which was cultivated on soils with low Zn levels. As the most significant nutritional issue influencing the bulk of agricultural output in India, zinc deficiency affects nearly 50% of the country's soils. Keeping these points in view, the present study entitled “**Influence of Sulphur and Zinc on Growth and Yield of Lentil (*Lens culinaris* medik.)”** was conducted at Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh during *rabi* season of 2022-23.

Materials and Methods

The experiment was conducted during *Rabi* of 2022-23, Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. Which is located at 25.24’ 42’’ N latitude, 81.50’ 56” E longitude and 98m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. Factors are three levels of Sulphur (20, 30 and 40 kg/ha) and three levels of Zinc (5, 6 and 7 kg/ha). The S and Z were supplied, both are applied as basal at the time of sowing. The lentil variety KLS-0903 was sown on 26 November 2022 by maintaining a spacing of 30cm × 10cm. Harvesting was done taking $1m^2$ area from each plot. And from it three plants were randomly selected for recording growth and yield parameters. The treatment details are as follows, T_1 -(Sulphur 20 kg/ha + Zinc 5 kg/ha), T_2 -(Sulphur 20 kg/ha + Zinc 6 kg/ha), T_3 – (Sulphur 20 kg/ha + Zinc 7 kg/ha), T_4 -(Sulphur 30 kg/ha + Zinc 5 kg/ha), T_5 -(Sulphur 30 kg/ha + Zinc 6 kg/ha), T_6 -(Sulphur 30 kg/ha + Zinc 7 kg/ha), T_7 -(Sulphur 40 kg/ha + Zinc 5 kg/ha), T_8 -(Sulphur 40 kg/ha + Zinc 6 kg/ha), T_9 -(Sulphur 40 kg/ha + Zinc kg/ha), T_{10}-(N 20 Kg/ha + P 40 kg/ha +k 20 kg/ha) Control. The observations were recorded for plant height, nodules/plant, dry weight, grain yield and stover yield. The data were subjected to statistical analysis by analysis of variance method **(Gomez and Gomez, 1976)**.

Results and Discussion

<u>YIELD ATTRIBUTES:</u>

Number of Pods/plant - The significant and higher number of pods/plant (148.77) were observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). The significant and higher number of pods/plant (148.77) were recorded with the application of Sulphur and zinc. Improved availability of Sulphur and favorable nutritional environment might have helped the plants at the peak growth period and flowering stages which ultimately increased the number of pods per plant **(Mourya *et al.*, 2021)**. Further, increase in pods per plant might be due to application of Zinc. Zinc has a greater role in the production of auxin and indole acetic acid, which helps in increased plant growth which resulted in more pods per plant similar result were reported by **Upadhyay (2016).**

Number of seeds/pod - The significant and higher number of seeds/pod (1.80) were observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). Number of seeds per pod had increased with application of Sulphur, which leads to transfer of photosynthates and it's accumulating from growing parts of plant to seeds which make them plump and bold and also effects the seed size and weight. These results were close with **Choubey et al., 2013,** and also with the application of zinc has also significant improvement was observed might be due to Zinc improved translocation of photosynthates towards reproductive system and thereby enhancing the yield of the crop. Better photosynthetic activity also may have resulted in better translocation of photosynthates from source to sink due to less crop competition between the plants which might have led to higher yield attributes. These finding are similar to those reported by **Krishna reddy and Ahlawat (1996).**

Test Weight (gm)

The significant and higher Test weight (25.27 gm) was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha).

The Sulphur application increased the test weight significantly up to 40 kg S ha-1 over control. This improvement in the growth and yield attributing characters might be due to lowering soil pH with elemental Sulphur addition which was slightly on higher side and improving physical condition of the soil **(Choudhary and Das 1996)**. The results so obtained get support with those of **Deo and Khaldelwal (2009).**

Seed Yield (t/ha) - The significant and higher seed yield (1.78 t/ha) was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). The synergistic effect of Sulphur and Zinc may be due to utilization of large quantities of nutrients through their well-developed roof system and nodules which might have resulted in better plant development and ultimate yield at low initial status of available Sulphur and Zinc content in the experimental soil. The seed yield of lentil is a function of the product of number of pods per plant, number of seeds per pod and test weight. The increase in the number of pods per plant and number of seeds per pod increased the seed yield of lentil. Similar results are conformity with **Mourya Teja *et al.* (2021).** Increase in these attributes due to the involvement of the zinc in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhanced accumulation of assimilate in the grains resulting in heavier grains. These results are in agreement with the findings of **Krishna *et al.*, (2022)**.

Stover Yield (t/ha) - The significant and higher stover yield (3.05 t/ha) was observed in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha), was found to be statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). The increase in straw yield due to Sulphur application might be attributed to its low availability in experimental soils. The synergistic effect of S may be due to utilization of large quantities of nutrients through well-developed root system which might have resulted in better plant development and ultimate yield at low initial status of available Sulphur in the experimental soil. Similar results reported by **Sahay *et al.*, (2015).**

Harvest Index (%) - The significant and higher Harvest Index (37.17 %) was observed in treatment-8 with (Sulphur 40 kg/ha + Zinc 6 kg/ha), which was significantly superior over rest of the treatments. However, treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha), was found to be statistically at par with treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha). The significant and higher Harvest Index (37.17 %) was observed with the application of Sulphur 40 kg/ha. Increase in harvest index due to better translocation of photosynthesis from growing parts to storage parts which increases the economical yield of the plant. These results are supported by **Chaubey *et al.*, 2019 and Shukla *et al.*, 2014**.

ECONOMIC ANALYSIS:

Gross Returns

Highest gross return (1,06,980 INR/ha) was obtained in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha) as compared to other treatments.

Net Returns

Net return (74,445 INR /ha) was found to be highest in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha) as compared to other treatments.

Benefit Cost Ration

Benefit Cost ratio (2.29) was found to be highest in treatment-9 with (Sulphur 40 kg/ha + Zinc 7 kg/ha) as compared to other treatments.

Conclusion:

I t was concluded that with the application of Sulphur 40 kg/ha along with Zinc 7.0 kg/ha (Treatment-9), has performs positively and improves growth and yield parameters. Maximum grain yield, gross returns, net returns and benefit cost ratio were also recorded with application of Sulphur 40 kg/ha along with Zinc 7.0 kg/ha (Treatment-9). These findings are based on one season therefore; further trials may be required for further confirmation.

Table 1. Influence of Sulphur and Zinc on yield attributes of lentil.

S. No.	Treatments	Pods/plant	Seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Sulphur 20 kg/ha + Zinc 5kg/ha	106.83	1.29	21.97	1.29	2.55	33.64
2.	Sulphur 20 kg/ha + Zinc 6kg/ha	111.27	1.35	22.18	1.34	2.66	33.56
3.	Sulphur 20 kg/ha + Zinc 7kg/ha	117.30	1.50	23.12	1.42	2.72	34.27
4.	Sulphur 30 kg/ha + Zinc 5kg/ha	121.17	1.53	22.18	1.46	2.72	34.96
5.	Sulphur 30 kg/ha + Zinc 6kg/ha	125.54	1.61	22.71	1.55	2.80	35.70
6.	Sulphur 30 kg/ha + Zinc 7kg/ha	131.60	1.67	24.18	1.64	2.82	36.75
7.	Sulphur 40 kg/ha + Zinc 5kg/ha	136.83	1.64	23.00	1.57	2.69	36.79
8.	Sulphur 40 kg/ha + Zinc 6kg/ha	142.54	1.72	24.21	1.68	2.84	37.17
9.	Sulphur 40 kg/ha + Zinc 7kg/ha	148.77	1.80	25.27	1.78	3.05	36.95
10.	Control	118.73	1.38	20.63	1.26	2.70	31.87
	F-Test	**S**	**S**	**S**	**S**	**S**	**S**
	SEm±	2.19	0.04	0.69	0.03	0.05	0.67
	CD (P=0.05)	6.50	0.11	2.05	0.10	0.15	1.98

Table 2. Influence of Sulphur and Zinc on economic analysis of lentil.

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
Sulphur 20 kg/ha + Zinc 5kg/ha	31374.72	77580	46205.28	1.47
Sulphur 20 kg/ha + Zinc 6kg/ha	31524.72	80580	49055.28	1.56
Sulphur 20 kg/ha + Zinc 7kg/ha	31674.72	85200	53525.28	1.69
Sulphur 30 kg/ha + Zinc 5kg/ha	31804.82	87600	55795.18	1.75
Sulphur 30 kg/ha + Zinc 6kg/ha	31954.82	93180	61225.18	1.92
Sulphur 30 kg/ha + Zinc 7kg/ha	32104.82	98160	66055.18	2.06
Sulphur 40 kg/ha + Zinc 5kg/ha	32234.93	93960	61725.07	1.91
Sulphur 40 kg/ha + Zinc 6kg/ha	32384.93	100800	68415.07	2.11
Sulphur 40 kg/ha + Zinc 7kg/ha	32534.93	106980	74445.07	2.29
Control	29914.5	75960	46045.5	1.54

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