Original Research Article

EFFECT OF SULPHUR AND ZINC ON GROWTH AND YIELD OF LENTIL (*Lens culinaris* L.)

ABSTRACT

A field experiment was conducted during *Rabi* season of 2022 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), number of nodules (19.25), plant dry weight (18.83 g/plant), crop growth rate (15.7 g/m^2/day, number of pods/plant (148.77), number of seeds/pod (1.80),1000 seed weight (25.27 gm), seed yield (1.78 t/ha) and stover yield (3.05 t/ha) were significantly influenced with application of Sulphur 40 kg/ha + Zinc 7.0 kg/ha.

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

INTRODUCTION

The second-most significant cold season legume crop in India is lentil (*Lens culinaris* L.) **(Ram and Punia, 2018)**. It has a 1.32 million hectares surface area and a 1.18 million tonnes of production were produced, and each hectare produced 894 kg of output **(Directorate of Economics and Statistics, 2020)**. Uttar Pradesh (38.47%), Madhya Pradesh (29.95%), Bihar (10.26%), and West Bengal (13.88%) are the biggest producing states. A crucial component of the diets of developing nations is lentil. About twice as much protein than cereal is found in lentil. Additionally, it provides every important amino acid that cereal grains typically lack **(Elias *et al.*, 1986; Thavarajah *et al.*, 2011).** After soybeans, lentils offer the second-highest protein-to-calorie ratio of any type of legume. A person may get a number of critical nutrients from lentil crops, which are abundant in protein (20–30%), minerals (2–5%), and vitamin B9. Especially for iron (Fe), zinc (Zn), and selenium (Se), lentil is generally rich in micronutrients and has the ability to offer appropriate dietary quantities.

Sulphur is a crucial secondary plant nutrient that is essential for several physiological processes in plants, including the production of amino acids (methionine, cysteine, and cysteine), the synthesis of proteins, and the production of chlorophyll. It engages in the metabolic processes of vitamins (such as biotin and thiamine) and a portion of coenzyme A and pyrophosphate. It also stimulates enzymes. Lack of Sulphur may be the cause of poor fruiting, poor blooming, and stunted development. According to reports, when it comes to Sulphur requirements, pulses come in second place behind oil seeds **(Parashar 2022)**. Increased Sulphur deficit was caused by the use of Sulphur-free fertilizers and the cultivation of high yielding cultivars under intensive cropping systems. Since the lentil crop is farmed with insufficient irrigation, Sulphur treatment may be necessary to improve the water usage efficiency **(Aditya 2021)**.

Intense agricultural activities due to the burgeoning human population have resulted into micronutrient deficiencies in soil. Zinc deficiency is prevalent worldwide, especially in calcareous soils. In India, 51.2 and 19.2% of soils were found to be deficient in Zn and Fe, respectively **(Shukla *et al.*, 2021)**. Micronutrient deficiencies in soils and crops have led to severe consequences, including reduced yield and low micronutrient concentration in crops, thus resulting in micronutrient malnutrition in humans and animals. Worldwide, Zn and Fe deficiencies have affected one-fifth and one-third of the population, respectively **(Chaudhari *et al.*, 2021)**. Zinc deficiency has been observed mainly in developing countries **(Bailey *et al.*, 2012)**. It is essential for optimum growth and functioning of immune system, enzyme catalyzed biochemical reactions, neurobehavioral development, protein and DNA synthesis **(Allen 2006)** and its deficiency results in adverse health conditions such as diarrhea, stunted physical and mental growth, loss of appetite, etc. Iron deficiency results into anemia, which globally has affected 40.0 and 42.0% of pregnant women and children, respectively, and even resulted to 20.0% of maternal deaths. Inadequate Fe intake causes the increased mortality of pregnant women and newborns and compromises the immune system.

Keeping these points in view, the present study entitled "**Effect of Sulphur and Zinc on Growth and Yield of Lentil (*Lens culinaris* L.)"** 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, 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 PL-406 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

Growth parameters

Plant height (cm):

The significantly higher plant height (37.68 cm) was observed in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha) was statistically at par with treatment- 9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). Significant and higher plant height may be owing due to Sulphur application in the soil might be due to increase availability and uptake of soil nutrients by the crop contributed by Sulphur fertilization. Availability of Sulphur to plants has helped in better development and thickening of xylem and collenchyma tissue which might have resulted into increased plant height. Similar results are reported with **Teja *et al.*, (2021).** Further, increase in plant height might be due to with the application of zinc activation of several enzymes which are zinc dependent viz. carbonic anhydrase, ribulose bis phosphate carboxylase, aldolase fructose 1 to 6 bis phosphatase, starch synthetase and sucrose synthetase. Zinc is known to produce the growth hormones and precursor of auxins i.e., tryptophan (**Pramanik.k and Bera A.K. (2012) and Debnath (2018).**

Nodules/plant:

The significantly higher number of nodules per plant (7.93 cm) was observed in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha) was statistically at par with treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). The increase of number of root nodules with increasing levels of Zn might be because Zn helps to improve more nodulation and leghemoglobin formation. Proper nutrition of plants with S increases the amount of glucose flowering to the roots and ATP biosynthesis. These are in conformity with the present findings of **Valenciano *et al.* (2011), Singh *et al.* (2012).**

Plant dry weight (g):

The significantly higher plant dry weight (18.83 gm/plant) was observed in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha) was statistically at par with treatment- 9 (Sulphur 40 kg/ha + Zinc 7 kg/ha).

The significantly higher plant dry weight

(18.83 gm/plant) was observed with the application of Sulphur. Sulphur plays major role in photosynthetic process which has a direct bearing on plant growth and development, increasing levels of Sulphur application resulted in increment in dry weight of lentil, the results were found to be similar with **Singh *et al.* (2000).** Further, increase in dry matter might be due to with the application Zinc. Zinc is an important element for the synthesis of tryptophan, which is the pioneer for the synthesis of IAA (Indole acetic acid), a growth hormone, involved in stem elongation **(Patel *et al*., 2007; Shahram and Gholamreza 2012)**. It is also considered to be a precursor for auxin synthesis, involved in nitrogen metabolism and several oxidation reduction reactions, stability of RNA and starch formation. Thus, it's suitable supply effects in higher dry matter production, ultimately growth and development of plants. Parallel results were found by **Meena *et al*., (2012).**

Crop Growth Rate (g/m^2/day):

The significantly higher crop growth rate (15.7 g/m^2/day) was observed in treatment-9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). However, treatment-8 (Sulphur 40 kg/ha + Zinc 6 kg/ha) was statistically at par with treatment- 9 (Sulphur 40 kg/ha + Zinc 7 kg/ha). Zinc plays a major role in photosynthesis, enzymes activation, fertilization and translocation of assimilates which are responsible for the increase in seed yield. The better crop growth and development might be due to the combined application of Zinc. The results of the present investigation are in close conformity with the findings of **Tiwari *et al*. (2018).**

YIELD AND YIELD ATTRIBUTES

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 **Reddy and Ahlawat (1996).**

Test Weight (g):

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 **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**.

CONCLUSION:

It is 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.

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Table 1. Influence of Sulphur and Zinc on growth parameters of lentil.

S. No.	Treatment combinations	Plant height	Number of nodules/plants	Plant Dry weight	Crop growth rate ($g/m^2/day$)
1.	Sulphur 20 kg/ha + Zinc 5 kg/ha	33.24	15.77	15.80	13.4
2.	Sulphur 20 kg/ha + Zinc 6 kg/ha	34.10	16.44	16.34	13.5
3.	Sulphur 20 kg/ha + Zinc 7 kg/ha	34.35	17.03	16.73	14.2
4.	Sulphur 30 kg/ha + Zinc 5 kg/ha	35.06	17.59	16.31	14.6
5.	Sulphur 30 kg/ha + Zinc 6 kg/ha	35.43	18.19	16.45	15.8
6.	Sulphur 30 kg/ha + Zinc 7 kg/ha	35.77	17.78	17.14	16.3
7.	Sulphur 40 kg/ha + Zinc 5 kg/ha	36.32	18.72	17.47	15.6
8.	Sulphur 40 kg/ha + Zinc 6 kg/ha	37.27	18.61	18.48	15.4
9.	Sulphur 40 kg/ha + Zinc 7 kg/ha	37.68	19.25	18.83	15.7
10.	Control (NPK 20-40-20kg/ha)	33.64	16.50	15.07	13.2
	F test	S	S	S	S
	S Em.(±)	0.45	0.37	0.13	0.33
	CD (p=0.05)	1.32	1.10	0.38	0.97

Table 2. Influence of Sulphur and Zinc on yield attributes and yield 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 (NPK 20-40-20kg/ha)	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