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# EFFECT OF SULPHUR AND ZINC NUTRITION ON YIELD, UPTAKE OF NUTRIENTS AND QUALITY OF LENTIL IN ALLUVIAL SOIL

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## ABSTRACT

*In a field experiment on alluvial soil, the effects of sulphur and zinc nutrition were studied on lentil for yield, quality and uptake of nutrients. Application of S upto 30 kg ha$^{-1}$ enhanced the average yield of grain and straw by 34.8 and 28.4 % over control, respectively. Application of Zn up to 4 kg ha$^{-1}$ increased the lentil grain and straw yield over control. The mean uptake of S by grain and straw increased from 4.2 to 7.3 and from 3.6 to 6.6 kg ha$^{-1}$, respectively with the increase of S levels. The uptake of Zn also increased with the levels of Zn from 27.0 to 64.1 and 24.0 to 61.7 g ha$^{-1}$, respectively. The uptake of N and K increased up to 30 kg S ha$^{-1}$ and 6 kg Zn ha$^{-1}$ level. Phosphorus uptake by straw increased up to 2 kg Zn ha$^{-1}$ followed by reduction at higher levels of Zn. Zinc and sulphur showed a synergistic effect on the uptake of N, K and Zn and ultimately on the grain and straw production of lentil. Significantly higher grain and straw yields of lentil were recorded in the treatment where 4 kg Zn was applied along with 30 kg S ha$^{-1}$. Protein content in lentil increased significantly with the increase of S and Zn over control.*

**Keywords:** Sulphur, zinc, nutrition, yield, nutrients, uptake, lentil, alluvial soil

## INTRODUCTION

Lentil (*Lens culinaris* L.) is primarily a rabi season crop and it is usually grown on marginal lands with poor fertility status. Sulphur and zinc have their role in growth and development of crop plants. The use of S-free fertilizers has created wide spread deficiency of sulphur in soils. Zinc deficiencies in Agra region soils and responses to its application on crops have been reported by Singh and Singh (1996). In legumes, sulphur being the constituent of some amino acids, promotes the biosynthesis of protein. Likewise, zinc also plays a vital role in the synthesis of protein and nucleic acids and helps in the utilization of nitrogen and phosphorus by plant. These nutrients play a vital role in bio-synthesis of protein and amino acids. Application of S and Zn, therefore, has shown significant effects on yield, uptake of nutrients and quality of the crop (Tripathi *et al.* 1997). The interaction of these nutrient elements may affect the critical levels of available Zn and S below which response to their application could be observed. Information of Zn and S on yield, quality and uptake of each other by lentil is rather limited. Thus, the present study was undertaken to evaluate the effects of graded doses of sulphur and zinc on yield, uptake of nutrients and quality of lentil.

## MATERIAL AND METHODS

A field experiment was undertaken at R.B.S. College research farm Bichpuri (Agra) with graded levels of S (0, 10, 20 and 30 kg S ha$^{-1}$) through elemental sulphur and zinc (0, 2, 4 and 8 kg Zn ha$^{-1}$) through zinc chloride in randomized block design with three replications using lentil as test crop. The experimental soil was sandy loam in texture and had pH 7.6, EC 0.24 dSm$^{-1}$, organic carbon 3.5 g kg$^{-1}$, available N 160 kg ha$^{-1}$, available P 8.4 kg ha$^{-1}$, available K 115 kg ha$^{-1}$, available S 18.5 kg ha$^{-1}$ and available (DTPA) Zn 0.46 mg kg$^{-1}$. Nitrogen, P and K were applied to lentil at the rate of 20 kg N, 60 kg $P_2O_5$ and 40 kg $K_2O$ ha$^{-1}$ through urea, di-ammonium phosphate and muriate of potash, respectively. Seeds of lentil were treated with rhizobium culture. Lentil (variety T 36) was sown using 40 kg seed ha$^{-1}$. At harvest, grain and straw yields were recorded. Plant samples (grain + straw) were collected for chemical analysis of nitrogen, phosphorus, potassium, sulphur and zinc. The grain and straw samples were digested in $HNO_3$ and $HClO_4$ mixture and sulphur and zinc were determined by turbidimetric method (Chesnin and Yien 1951) and atomic absorption spectrophotometer, respectively. Phosphorus and potassium in the acid extract was determined by vanadomolybdate yellow colour method and flame photometer, respectively. The nitrogen was determined by Kjeldahl method (Jackson 1973). The protein content is calculated by multiplying N content with 6.25.

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## RESULT AND DISCUSSION

### Grain and Straw yield

Increase in level of zinc from 0 to 6 kg $ha^{-1}$ resulted in a significant increase in the grain yield of lentil from 17.22 to 18.85 q $ha^{-1}$. Straw yield followed similar trend. Singh *et al.* (1995), Singh and Yadav (2004) and Singh and Singh (2012) reported similar effects of Zn on grain and straw yield of mungbean and chickpea, respectively. Application of varying doses of S had significant effect on the grain yield of lentil. The grain yield increased from 15.13 to 20.40 q $ha^{-1}$ progressively with increase in the level of S from 0 to 30 kg $ha^{-1}$. The corresponding increase in straw yield was from 18.93 to 24.30 q $ha^{-1}$. The finding is in agreement with those of Singh and Singh (2004) and Deo and Khaldelwal (2009), Tripathi *et al.* (2011). Further synergistic effect of zinc and sulphur interaction on grain and straw yield was significantly highest at 6 kg Zn + 30 kg S $ha^{-1}$ followed by 4 kg Zn + 20 kg S $ha^{-1}$ in grain and straw yield.

Table 1: Effect of S and Zn levels on lentil grain and straw yield (mean of 2 years)

| Sulphur (kg $ha^{-1}$) | Zinc levels (kg $ha^{-1}$) | | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 4 | 6 | Mean |
| | Grain yield ( q $ha^{-1}$) | | | | |
| 0 | 13.04 | 15.02 | 16.22 | 16.24 | 15.13 |
| 10 | 16.20 | 17.19 | 18.30 | 18.44 | 17.53 |
| 20 | 19.49 | 19.77 | 19.93 | 20.11 | 19.82 |
| 30 | 20.15 | 20.33 | 20.51 | 20.63 | 20.40 |
| Mean | 17.22 | 18.07 | 18.74 | 18.85 | |
| CD (P=0.05) | S 0.41 | Zn 0.41 | | SxZn 0.82 | |
| | Stover yield (q $ha^{-1}$) | | | | |
| 0 | 15.51 | 19.46 | 20.10 | 20.66 | 18.93 |
| 10 | 21.91 | 23.24 | 23.45 | 23.54 | 23.03 |
| 20 | 23.25 | 24.19 | 24.31 | 24.43 | 24.04 |
| 30 | 24.29 | 24.59 | 24.64 | 24.75 | 24.30 |
| Mean | 21.24 | 22.87 | 23.12 | 23.34 | |
| CD (P=0.05) | S 0.25 | Zn 0.25 | | S x Zn 0.49 | |

The magnitude of increase in grain and straw yield was 58.7 and 59.6% due to combined application of Zn and sulphur (6 kg Zn + 30 kg S $ha^{-1}$) over control, respectively. The synergistic effect of Zn and S 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 Zn and S content in the experimental soil. Zinc plays an important role in the production of indole acetic acid, a growth hormone where results in higher value of auxin content which helps in increased growth and yield of the crop. These results confirm the findings of Singh *et al.* (1995) who have shown that nature of Zn and S interaction depends on their rates of application.

### Protein Content

The protein content in lentil grain increased significantly from 23.80 to 24.30% with increasing zinc levels from 0 to 6 kg $ha^{-1}$. Increased doses of sulphur also resulted in a significant increase in protein content of lentil. The positive response to added sulphur is assigned to low status of available sulphur of soil or due to stimulating effect of applied sulphur in the synthesis of chloroplast protein resulting in greater photosynthetic efficiency which in turn translated in terms of increase in yield. Singh *et al.* (1997) and Deo and Khaldelwal (2009) reported similar results in summer moong and chickpea, respectively. Maximum increase of 24.8% in protein content was obtained when 6 kg Zn and 30 kg S $ha^{-1}$ were applied together; the increase was 7.1% over control (23.21%). Similar results were also reported by Tripathi *et al.* (1997). In the untreated plots, protein yield was 356.93 kg $ha^{-1}$. It was observed that as the levels of S increased from 0 to 30 kg $ha^{-1}$, there was a significant increase in the protein yield in grain. These findings are in confirmation with those of Singh and Singh (2004). Zinc application also increased the protein yield significantly over control. Maximum protein yield was recorded with 30 kg S applied in combination with 6 kg Zn $ha^{-1}$.

### Uptake of nutrients

The nitrogen uptake by grain and straw increased significantly with increased levels of S and Zn upto 30 kg and 6 kg $ha^{-1}$ application (Table 3). Deo and Khaldelwal (2009) reported similar results in chickpea. Nitrogen uptake by grain and straw at 0 to 30 kg S $ha^{-1}$ applied were 57.3 and 80.7 and 29.2 and 49.9 kg $ha^{-1}$, whereas at 0 and 6 kg Zn $ha^{-1}$ it was 65.9 and 73.6 and 36.0 and 43.1 kg $ha^{-1}$, respectively. The S x Zn interaction indicated that nitrogen uptake by grain and straw increased which suggests a positive effect of S and Zn on N absorption by lentil crop. Application of sulphur significantly increased the uptake of P by lentil crop over control. The increase in P uptake by grain and straw due to sulphur application was from 12.3 to 20.2 kg $ha^{-1}$ and 12.3 to 9.1 kg $ha^{-1}$, respectively with the highest level of S i.e. 30 kg S $ha^{-1}$ (Table 3). Results corroborate the findings of Singh and Singh (2004) for black gram and Deo and Khaldelwal (2009) for chickpea. As regards the P uptake by grain and straw, application

Table 2: Effect of S and Zn level on protein content and yield in lentil grain (mean of 2 years)

| Sulphur (kg ha$^{-1}$) | Zinc levels (kg ha$^{-1}$) | | | | |
|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | Mean |
| | | | Protein Content (%) | | |
| 0 | 23.21 | 23.43 | 23.71 | 23.93 | 23.57 |
| 10 | 23.62 | 23.81 | 23.93 | 24.12 | 23.87 |
| 20 | 23.87 | 24.06 | 24.18 | 24.31 | 24.10 |
| 30 | 24.50 | 24.62 | 24.75 | 24.87 | 24.68 |
| Mean | 23.80 | 23.98 | 24.14 | 24.30 | |
| CD (P=0.05) | S 0.03 | | Zn 0.03 | S x Zn 0.06 | |
| | | | Protein yield (kg ha$^{-1}$) | | |
| 0 | 302.65 | 351.91 | 384.57 | 388.62 | 356.93 |
| 10 | 354.94 | 409.29 | 437.91 | 444.77 | 411.72 |
| 20 | 453.14 | 475.66 | 481.90 | 488.87 | 474.89 |
| 30 | 487.44 | 500.52 | 507.62 | 513.06 | 502.66 |
| Mean | 400.04 | 434.34 | 453.00 | 458.83 | |
| CD (P=0.05) | S 14.5 | | Zn 14.5 | Sx Zn 29.0 | |

of 6 kg Zn ha$^{-1}$ decreased the P uptake from 16.7 to 15.8 kg ha$^{-1}$ while in straw it increased from 15.4 to 16.7 kg ha$^{-1}$ with 2 kg Zn ha$^{-1}$. The decrease in P uptake with higher levels of Zn might be due to antagonistic effect between P and Zn. Islam *et al.* (2005) reported similar results in mungbean. Interactive effect of zinc and sulphur was found to be significant. Among the different treatment combinations, application of no Zn along with 30 kg S ha$^{-1}$ resulted in highest uptake of phosphorus.

Table 3: Effect of S and Zn levels on uptake N, P, K, S and Zn by lentil grain and straw (mean of 2 years)

| Sulphur (kg ha$^{-1}$) | Zinc (kg ha$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | Mean | 0 | 4 | 8 | 12 | Mean |
| | Grain | | | | | Straw | | | | |
| | | | | | Nitrogen (kg ha$^{-1}$) | | | | | |
| 0 | 48.4 | 56.5 | 61.8 | 62.7 | 57.3 | 22.6 | 29.4 | 1.5 | 33.5 | 29.2 |
| 10 | 61.4 | 65.5 | 70.2 | 71.4 | 67.1 | 34.5 | 38.3 | 39.7 | 40.3 | 38.2 |
| 20 | 74.5 | 74.5 | 76.3 | 78.4 | 75.9 | 39.4 | 42.9 | 43.8 | 45.2 | 42.8 |
| 30 | 79.2 | 80.3 | 81.3 | 82.0 | 80.7 | 47.5 | 48.9 | 49.5 | 53.6 | 49.9 |
| Mean | 65.9 | 69.2 | 72.4 | 73.6 | | 36.0 | 39.9 | 41.1 | 43.1 | |
| CD (P=0.05) | S 0.65 | Zn 0.65 | | SxZn 1.32 | | S 0.27 | Zn 0.27 | | SxZn 0.54 | |
| | | | | | Phosphorus (kg ha$^{-1}$) | | | | | |
| 0 | 12.2 | 12.2 | 12.6 | 12.1 | 12.3 | 10.9 | 12.9 | 12.8 | 12.7 | 12.3 |
| 10 | 14.6 | 14.9 | 15.3 | 14.6 | 14.8 | 12.6 | 16.8 | 16.3 | 16.1 | 16.3 |
| 20 | 19.0 | 18.6 | 18.3 | 17.5 | 18.3 | 18.4 | 18.5 | 18.3 | 17.3 | 18.1 |
| 30 | 21.2 | 20.6 | 19.8 | 19.2 | 20.2 | 20.1 | 19.5 | 18.6 | 18.1 | 19.1 |
| Mean | 16.7 | 16.6 | 16.5 | 15.8 | | 16.4 | 16.9 | 16.5 | 16.1 | |
| CD (P=0.05) | S 0.24 | Zn 0.24 | | SxZn 0.49 | | S 0.24 | Zn 0.30 | | SxZn 0.60 | |
| | | | | | Potassium (kg ha$^{-1}$) | | | | | |
| 0 | 15.1 | 19.1 | 20.8 | 21.3 | 19.1 | 40.3 | 51.6 | 33.8 | 55.5 | 43.3 |
| 10 | 19.6 | 21.1 | 22.7 | 23.1 | 21.6 | 50.2 | 62.0 | 63.1 | 63.4 | 59.7 |
| 20 | 24.2 | 24.8 | 25.5 | 25.9 | 25.1 | 62.1 | 65.1 | 65.9 | 66.8 | 64.9 |
| 30 | 25.7 | 26.2 | 26.7 | 26.7 | 6.3 | 65.3 | 66.6 | 67.2 | 67.8 | 66.7 |
| Mean | 21.1 | 22.8 | 23.9 | 24.3 | | 54.0 | 61.3 | 57.5 | 63.4 | |
| CD (P=0.05) | S 0.16 | Zn 0.16 | | SxZn 0.32 | | S 0.34 | Zn 3.4 | | SxZn 6.8 | |
| | | | | | Sulphur (kg ha$^{-1}$) | | | | | |
| 0 | 4.0 | 4.3 | 4.4 | 4.1 | 4.2 | 3.2 | 3.8 | 3.7 | 3.6 | 3.6 |
| 20 | 5.7 | 5.8 | 5.8 | 5.7 | 5.7 | 5.3 | 5.5 | 5.3 | 5.0 | 5.3 |
| 40 | 7.2 | 7.0 | 6.9 | 6.5 | 6.9 | 5.9 | 5.9 | 5.5 | 5.2 | 5.6 |
| 60 | 7.6 | 7.4 | 7.3 | 7.1 | 7.3 | 6.9 | 6.7 | 6.4 | 6.3 | 6.6 |
| Mean | 6.1 | 6.1 | 6.1 | 5.8 | | 5.3 | 5.4 | 5.2 | 5.0 | |
| CD (P=0.05) | S 0.28 | Zn NS | | S x Zn NS | | S 0.32 | Zn NS | | SxZn NS | |
| | | | | | Zinc (g ha$^{-1}$) | | | | | |
| 0 | 22.4 | 38.5 | 49.3 | 59.8 | 42.5 | 19.3 | 51.4 | 59.3 | 65.8 | 48.9 |
| 20 | 26.0 | 40.4 | 52.0 | 63.7 | 45.5 | 25.7 | 60.1 | 67.8 | 75.0 | 57.1 |
| 40 | 30.1 | 43.6 | 54.6 | 66.8 | 48.8 | 25.9 | 59.5 | 67.0 | 74.5 | 56.7 |
| 60 | 29.7 | 43.3 | 54.1 | 66.1 | 48.3 | 25.2 | 59.2 | 65.5 | 71.5 | 55.3 |
| Mean | 27.0 | 41.4 | 52.5 | 64.1 | | 24.0 | 57.5 | 64.9 | 71.7 | |
| CD (P=0.05) | S 0.26 | Zn 0.26 | | SxZn 0.52 | | S 1.20 | Zn 1.20 | | SxZn 2.40 | |

Successive levels of S increased the potassium uptake by lentil grain and straw significantly from 19.1 to 26.3 kg $ha^{-1}$ and f50.3 to 66.7 kg $ha^{-1}$ at 30 kg S $ha^{-1}$ (Table 3). Similarly, K uptake was also affected significantly by Zn application up to 6 kg $ha^{-1}$. The combined treatment of 30 kg S and 6 kg Zn $ha^{-1}$gave the highest (26.7 and 67.8kg $ha^{-1}$) potassium uptake by the crop. Sulphur uptake increased significantly with increasing levels of S up to 30 kg $ha^{-1}$ over control. This increase in S uptake might be attributed to increased content of S and grain and straw yield of lentil with sulphur application. The result of the present investigation is in corroboration with those of Deo and Khaldelwal (2009). There was a non significant effect of zinc levels on the utilization of S by lentil crop. The S uptake tended to reduce at higher level (6 kg Zn $ha^{-1}$) of zinc. The combined application of S and Zn was not found to have any significant effect on the utilization of S by lentil crop. The uptake of Zn by lentil grain and straw increased significantly with S application and maximum values were recorded at 20 kg S $ha^{-1}$. Application of zinc up to 6 kg $ha^{-1}$ gradually and significantly increased the uptake of Zn by lentil grain and straw. The Zn uptake by grain and straw with 6 kg Zn $ha^{-1}$ increased from 27.0 to 64.1 and 24.0 to 61.7 g $ha^{-1}$, respectively. The uptake of Zn was in accordance with grain and straw yield and its content. The maximum values of Zn uptake recorded in lentil grain and straw were 66.8 and 64.5 g $ha^{-1}$ at 20 kg S $ha^{-1}$ in combination with 6 kg Zn $ha^{-1}$.

On the basis of results, it is concluded that the application of 30 kg S and 4 kg Zn $ha^{-1}$ may be recommended for lentil in alluvial soil. Application of 30 kg S and 4 kg Zn $ha^{-1}$ gave higher values of uptake of nutrients and protein content.

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