

Original Research Article

Zn and B mediated effect on yield attribute, yield, and nutrient uptake in Lentil (*Lens culinaris* Medick.)

Abstract

A field experiment was conducted during *rabi* season 2020-21 at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) to evaluate the Effect of Zn and B application. Ten treatments comprising control, RDF, Zn and B in a different combination were tested in randomized block design with three replications. The experimental results revealed that yield attributing traits *viz.* number of pods plant⁻¹, number of grain plant⁻¹, grain yield plant⁻¹, test weight and biological yield, grain yield, straw yield and content and uptake of N, P, K, Zn, S and B in lentil differed significantly among different treatments. Growth parameters were significantly better in the treatment T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹). The highest grain yield was recorded in T₁₀ RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹ was applied with Zn and B and was statistically at par with T₈. From the study it may be concluded that the application of RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹ with Zn and B (T₁₀) gave best results (Grain yield increased by 26.7%, 25.7%, 21%, 22.9%, 17.2% and 59.1% over T₁, T₃, T₄, T₅, T₆ and T₁, respectively) and proved to be beneficial for *rabi* lentil followed by RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹ (T₉) ~~also gave better results~~. The balanced and combined use of Zn and B along with N, P, K and S in lentil improved the yield attribute ~~yield~~, yield, and total uptake of nutrients along with maintaining the soil fertility.

Keywords: Micronutrient, Boron, Zinc, Sulphur, Lentil

INTRODUCTION

Lentil (*Lens culinaris* Medick.), belonging to Fabaceae family often known as an ancient crop for modern times, is a nutritious food legume. It is a nutrient-dense grain legume grown in temperate regions whose seed has relatively higher contents of dietary protein (340- 346 g), carbohydrate (65.0%) and calories (340-346 g) compared to other legumes, besides, seed is a good source of fiber (4 g), ash (2.1 g), Ca (68 mg), P (325 mg), Fe (7.0 mg Fe), Na (29 mg), K (780 mg), thiamine (0.46 mg), riboflavin (0.33 mg) and niacin (1.3 mg). Lentil is the richest source of important amino acids (lysine, arginine, leucine, and other S- containing amino acids) among all the winter season legumes (Sharma *et al.* 2014). Pulses contribute about 10 % of the daily protein intake and 5 % of energy intake and hence are of particular importance for food security in low income countries. Pulses (Neacsu *et al.* 2017). Globally, in 2017, pulses accounted for 85.40 million hectares of global crop area producing 87.40 million tonnes of grain

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with an average productivity of 1023 kg ha⁻¹. However, still the production of pulses is not keeping pace with a minimum requirement of 60 g of protein per day (Anonymous 2018). The total area under lentil crop worldwide was about 6.58 million ha with the production of about 7.59 million tonnes with an average yield of 1153 kg ha⁻¹ during 2017-18 (FAO, 2019). India is the world's largest grower, producer and consumer of pulses accounting 34% of total acreage, 26 % of the total production and about 30 percent (23-24 million tonnes) of the total consumption in the world with the area under pulses was >29 million ha with the total production of 25.23 million tonnes at a productivity of 841 kg ha⁻¹ during 2017-18 (Anonymous, 2018). India stands second in production of lentil after Canada. The major lentil-growing countries of the world include India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria (Ahlawat, 2012). In India, lentil recorded an ever-highest production of 1.61 million tonnes from area of 1.55 million ha at a productivity level of 1034 kg ha⁻¹, the ever-highest yield level (Anonymous, 2018). Lentil is the third most important pulse crop of North India (Singh *et al.*, 2014) which is mainly grown as rainfed crop in Uttar Pradesh, Uttarakhand, Madhya Pradesh, Jharkhand, Bihar and West Bengal. Lentil plays an important role in the diet of developing world and have the second highest pulse of protein per calorie of any legume, after soybean (Mudryj *et al.*, 2014). Micronutrients play an important role in increasing yield of pulses through their effect on the plant itself and on the nitrogen fixing by symbiotic process. There is a great need for micronutrients nowadays, because of their deficiency in soil mainly through micronutrient removal from long-term crop production increased use of only high analysis fertilizers, higher micronutrient requirements accompanying higher crop yields, less use of animal manures in crop production and use of high P concentrations from long-term applications. Zinc is an essential trace element which is required in about 200 enzymes and transcription factors (Kabata, 2004). Zn plays a major role in auxin metabolism, nitrogen metabolism, influence on the activities of enzymes (e.g. dehydrogenase and carbonic anhydrase, proteinases and peptidases) and cytochrome C synthesis, stabilization of ribosomal fractions and protection of cells against oxidative stress (Obata *et al.*, 1999). Zn deficiency in field crops leads to poor growth interveinal chlorosis and necrosis of lower leaves. Plants emerged from seeds with low concentrations of Zn could be highly sensitive to biotic and abiotic stress (Mishra *et al.*, 2018). Boron is non-mobile in plant therefore; continuous supply of boron from soil is required for all plant meristems. It is essential for cell wall synthesis, lignification, as well as the structural integrity of bio membranes and also maintains stable balance between sugars and starches, pollination and seed production (Kumar *et al.*, 2018). Boron is very important in cell division and in pod and seed formation (Singh *et al.*, 2015). These micronutrients can be added to crop through soil fertilization, foliar sprays and seed treatment. Each method has the potential to affect plant micronutrient nutrition both in the treated plant directly and in the progeny plants through enrichment of the seeds by micronutrient treatment of the parent.

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MATERIALS AND METHODS

A field experiment was conducted during *rabi* season 2020-21 at Sardar Vallabh bhai Patel University of Agriculture and Technology, located in Indo-Gangetic plains of Western Uttar Pradesh: $29^{\circ} 5' 34''$ N latitude, $77^{\circ} 41' 58''$ E longitudes and at an elevation of 230 meters above the mean sea level. The weekly maximum temperature ranged between 18.70 °C to 32.99 °C, while mean weekly minimum temperature ranged between 4.9 °C to 16.63 °C. The mean relative humidity varied between 94.86 to 32.86 %. Whereas, total amount of rainfall received during crop period was 39.8 mm. Before start of the experiment, a composite soil sample (0-15

cm depth) was drawn from experimental field and analyzed for physico-chemical properties. The soil of the experimental field was sandy clay loam in texture and slightly alkaline in reaction. The soil was medium in organic carbon, available phosphorus and potassium but low in available nitrogen.

Variety and nutrient

(Pusa Vaibhav) variety ~~selected~~ was selected for this experiment which was released from IARI New Delhi in 1996 and suitable for NWPZ (Punjab, Haryana, Delhi, West UP.) with seed rate of @50 kg ha⁻¹ approximately. 5 cm furrowed depth was opened manually at a row distance of 30 cm with the help of a furrow opener. ~~The variety~~ has a yield potential of 20- 24 q ha⁻¹ and resistant to rust & tolerant to wilt, small seeded and it generally matures in 130-135 days. Recommended dose of N, P, K and S @ 20, 50, 20 and 40 kg ha⁻¹ ~~in this experiment~~ was applied through DAP, MOP, Urea and bentonite. Zinc and boron were applied through zinc sulphate monohydrate and borax as a basal dose according to treatments.

Yield attributes study

In yield and yield attributing Characters, for number of pods plant⁻¹ five randomly selected plants per plot were counted and their average was calculated. For number of seeds pod⁻¹ total number of pods from each five ~~sample~~ plants were threshed and average number of seeds pods⁻¹ was recorded. For test-weight (1000 seed weight) from the lot threshed clean seeds of each plot, randomly seed sample was taken and one thousand seeds were counted from the samples of each plot and weight of seeds was recorded on an electronic balance.

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Yield Study

Biological yield, seed yield and straw yield obtained from each plot was added to obtain biological yield in kilogram from each plot and converted to quintal per hectare. For seed yield the weight of clean seeds obtained from each plot was recorded on double pan balance. Finally, the seed yield plot⁻¹ was converted into yield ha⁻¹ by multiplying with appropriate value. Stover yield was determined by subtracting the seed yield from the biological yield of each net plot under a particular treatment. Then, the value was converted into Stover yields ha⁻¹ by using the appropriate value for each plot, which was used in case of conversion of seed yields ha⁻¹. Harvest Index (%) refers to the ratio of economic yield (seed yield) to the biological (seed + stover) yield under a particular treatment and expressed in percentage. It was ~~be~~ computed by using the following formula (**Donald (1962)**).

$$\text{Harvest index} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

Plant analysis

Preparation of samples:

The plant samples were dried in an oven at 60 ± 2 °C for about 48-72 hours and then grounded by a grinding mill and passed through a 20-mesh sieve. The grinded plant materials (grain and straw) ~~in paper bags~~ were stored in paper bags and kept into the desiccators. The grain and straw samples were analyzed for determination of N concentrations. The method was as follows:

Digestion of plant samples for N determination:

~~Amount of~~ 100 mg oven dry ground sample were taken into a digestion flask. ~~Into the flask,~~ 1.1g catalyst mixture (K_2SO_4 : $CuSO_4 \cdot 5H_2O$: Se = 10: 1: 0.1), 2 ml 30% H_2O_2 and 3 ml conc. H_2SO_4 was be added in the flask. The flask was swirled and allowed to stand for about 10 minutes followed by heating at 200 °C. Heating was continued until the digest became clear and colorless. After cooling, the content was taken into a 100 ml volumetric flask and the volume was made with de-ionized water.

Total nitrogen:

The total nitrogen content was determined by modified kjeldahl method as described by (page *et al.*, 1982). For determination of N, plant samples were digested in sulphuric acid at a temperature between 360-410°C. At a temperature below 360°C, the digestion procedure is either slow or incomplete, but above 410°C some of the ammonia may be lost. To accelerate digestion rate, the use of copper sulphate as a catalyst is done. Unlikely, to raise the boiling temperature of H_2SO_4 , anhydrous sodium sulphate or potassium sulphate is used. Alternatively, commercially available potassium sulphate – copper sulphate tablets (e.g. Kjeltab) may be used for convenience and uniformity. For better, uniform and complete digestion of the plant samples, temperature of the digestion is carefully regulated, which normally takes less than 2 hours. Completely digested samples are cooled and diluted, as concentrated alkali is added to H_2SO_4 digest for distillation. The distilled ammonia is quantitatively absorbed in boric acid and titrated against standard acid.

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Digestion of plant samples for P, K and micronutrients determination:

For the release of mineral elements from plant tissues, dry ashing and wet oxidation are two widely adopted methods. Dry ashing is carried out usually at an ignition temperature of 550-660°C followed by its extraction in dilute $HClO_4$ or H_2SO_4 for determining various elements. Ashing at temperature exceeding 600 °C leads to considerable volatilization loss of P and K volatilization loss of S also takes place during ignition. A part of P and micro nutrients also get occluded, causing a lot of error. For these reasons and for being comparatively more time taking, dry ashing is only occasionally adopted. Wet oxidation employs oxidizing acid like HNO_3 - H_2SO_4 - $HClO_4$ tri acid mixture or HNO_3 - $HClO_4$ di-acid mixture. Use of $HClO_4$ avoids the volatilization loss of K and provides a clear solution while H_2SO_4 helps completing oxidation.

Determination of P:

Phosphorous in an aliquot, was determined using the method based on vanado-molybdo phosphoric yellow colour method. Phosphorous content in seed and straw of mung bean (expressed in percent) was analysed by Vanado-molybdo phosphoric yellow colour method. Plant sample of 1g was weighed and 10 ml of di-acid mixture (3:1 Nitric acid: Per chloric acid) was added to the sample in a volumetric flask. Sample was placed on hot plate for digestion. The solution was filtered in 100 ml conical flask and was diluted with distil water. 0, 1, 2, 3, 4, 5 ml of 50 ppm P solution was transferred to 50 ml volumetric flask to get 0, 100, 150, 200 and 250µg

P. Ten millilitre of vanad-omolybdate reagent was added and content was mixed thoroughly. Readings of transmittance and absorbance were taken at 420 m μ and standard curve was plotted. Further, 10 ml of dilute solution was transferred in 50 ml volumetric flask and 10 ml of ammonium molybdate vandate solution was added and readings were recorded.

Determination of K:

Potassium in the acid-digest of plant samples were determined using flame photometer exactly in the same manner as described for available K in soil. Potassium content in seed and straw (expressed in percent) was analysed by wet digestion method. Plant sample of 1 gm was weighed in 100 ml of digestion flask. Add 20 ml of di acid mixture to the sample. Sample was heated slowly on hot plate and temperature was raised gradually until sample turned colourless. After digestion of sample, 20 ml of water was added and filtered through ~~Whatman no. 40~~ filter paper (Whatman no. 40) into 100ml of volume flask. Aliquot was taken and reading of K was noted in flame photometer using red filter.

Determination of Zn:

~~These~~ ~~THIS~~ micronutrients ~~were~~ ~~was~~ determined in the di-acid or acid digest of plant tissues using AAS. Atoms of metallic elements (Zn) absorb energy when subjected to radiations of specific wavelength. The absorption of radiation is proportional to the concentration of atoms of that element. Atomic adsorption spectrophotometer (AAS) has distinct advantage over flame emission spectroscopy, as the absorption of radiation by the atoms is independent of the wavelength of radiations and temperature of the atoms. AAS also have greater sensitivity and accuracy.

Determination of B:

Boron was determined through colorimetric method. Total boron (B) in plant material is determined by ashing of the plant sample following dissolution of the ashed material and its analysis with spectrophotometer. The Azomethine-H method is perhaps the most commonly used spectrophotometric method of B determination. This method is fast, simple, and sensitive and does not require concentrated acids, which make it desirable for automation. In this approach, the sample is commonly ashed in a muffle furnace using suitable containers (e.g. quartz or platinum crucibles) by a spectroscopic azomethine-H method described by Gaines and Mitchell (1979) and Wolf (1971) ~~whwre~~ in dry-ashed samples are dissolved in dilute acid (usually HCl/ HNO₃) for analysis.

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RESULTS AND DISCUSSION

Yield attributes

Yield attributing characters

The yield attributes viz. number of pods per plant⁻¹, number of grain per pod⁻¹ and test weight (1000 grains weight in gram) as affect by Zn and B application were recorded at harvest stage and data are presented in Table 1. The data regarding number of pods per plant⁻¹ of lentil as

influenced by Zn and B application was significantly influence by Zn and B application. At harvest higher number of pods (144.6 plant^{-1}) found with RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) was significantly higher to (T_1) control and statistically at par than the rest of treatments, while minimum (109.6 plant^{-1}) in control (T_1). From the table it is clear that number of grains per pod⁻¹ differed significantly due to application of Zn and B ranged from 1.36 to 1.81 grains per pod⁻¹. Maximum number of grains (1.81 pod^{-1}) statically at par to the all treatments, except T_1 , which was significantly higher than remaining treatments were found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}), while minimum ($1.36 \text{ grains pod}^{-1}$) number in T_1 (control). The number of grains pod⁻¹ increased by 33.1% in T_{10} and 26.5% in T_9 over control due to application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} and RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1} respectively. The data on test weight did not differed significantly under the influence of different treatments. The maximum (25.73g) 1000 grains weight was found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) while minimum (23.8g) in control (T_1). The favorable effect of nitrogen, Zinc and Boron on the size of cell, which is expressed morphologically in terms of increased plant height, number of branches etc. The improvement in growth attributing parameters directly supports the development of yield attributing characters. Therefore, the better assimilation of photosynthetic and their partitioning into developing pod clusters might have taken place that improved yield attributing characters like pods plant⁻¹ and seeds pod⁻¹. Similarly, (Singh and Singh, 2014), (Mohammad *et al.*,2015) and (Singh *et al.*,2017) also reported the improved yield attributes of lentil with synthetic fertilizers.

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Yield

Grain yield of lentil under different treatments ranged from 10.5 to 16.7 q ha^{-1} . Maximum grain yield (16.7 q ha^{-1}) was noticed in T_{10} statistically at par to T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}), T_8 (RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1}) and significantly higher than remaining treatments was found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}). Minimum grain yield (10.5 q ha^{-1}) was observed under T_1 . Significantly higher yield was obtained with Zn and B application of RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1} and RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} . Grain yield in T_9 and T_{10} was higher by 46.66% and 59.0%, respectively over control. Result revealed that the grain yield increase by Zn and B application. Straw yield varied from 11.6 to 16.8 q ha^{-1} under different treatments. Maximum straw yield (16.8 q ha^{-1}) statistically at par to T_9 , T_8 , T_7 and T_6 and significantly higher than remaining treatments was found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}), while minimum (11.6 q ha^{-1}) in control (T_1). In comparison to T_1 (Control) straw yield increased by 44.8% in T_{10} . Biological yields ranged from 22.0 to 33.4 q ha^{-1} under different treatments. Maximum biological yield (33.4 q ha^{-1}) register with T_{10} which was statistically at par to the treatments T_9 (RDF+ Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}), T_8 (RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1}), T_7 (RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}) and T_6 (RDF + Zinc 5 kg ha^{-1}) and significantly higher than remaining treatments was found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}), while minimum significantly lower than the rest of treatments in control (T_1). Harvest index express proportion of economic yield in total biological yield did not differ significantly by the Zn and B application during the experimentation. Numerically maximum harvest index value (49.9%) was observed in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) than rest of the treatments during year of study. Lowest harvest index (47.5%) was recorded in control (T_1). The proper mobilization of dry matter production towards the sink (seed yield) is an important factor for economic yield. The variation

in seed yield of different lentil cultivars has been reported by various researchers like (Zike *et al.*, 2017), (Iliger and Alagundagi, 2017) and (Biswas *et al.*, 2018).

Nutrient content in plant and their uptake

Nitrogen Content (%)

It is clear from the data that grain N content at harvest differed significantly from 3.52 to 4.6 % under the influence of different treatments. Maximum grain N content (4.6%) was found in T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) was significantly higher than the N content found in treatments T₁ and T₂ and statistically at par to rest of treatments. Minimum grain N content was found in T₁ (control). The N content in lentil straw under different treatments ranged from 0.86 to 1.23 %. The maximum nitrogen content in straw (1.23) was significantly higher to T₁ and T₂ and statistically at par to rest of treatments was found in T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹), while minimum (0.86%) in control (T₁). Similar kind of trend was also observed by (Karmegam *et al.*, 1999) who reported that with the application of 30 kg N, 26.20 kg P and 60 kg S ha⁻¹ in green-gram the content was significantly higher.

Phosphorus content (%)

Application of Zn and B significantly enhance the phosphorus content over the control. Grain P content ranged from 0.37 to 0.44 % under different treatments. The treatment T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher phosphorus content (0.44%) in grains which did not differ significantly by the Zn and B application during the experimentation. Numerically minimum phosphorus content (0.37%) in grains was recorded under the control (T₁). Straw P content under different treatments varied from 0.2 to 0.25 %. Treatment T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the highest phosphorus content (0.25%) which was statistically at par with the treatments T₉ (RDF + Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹) and T₈ (RDF + Boron 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) and significantly higher than the rest of treatments. The minimum phosphorus content (0.2%) in straw was recorded under the control (T₁). Similar kind of trend was also observed by (Rajesh *et al.*, 2006) who evaluated the effect of nitrogen, potassium + phosphorus under varying Boron level (40, 80, 120, kg ha⁻¹) on the yield and nutrient uptake in lentil

Potassium content (%)

Application of Zn and B significantly enhanced the potassium content over the control. Reveled that in plant potassium content was significantly affected by different treatments. Grain K content ranged from (0.83 to 0.87%) differs significantly under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher potassium content in grain which was found to be at par with the treatments T₉ (RDF + Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹) and T₈ (RDF + Boron 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) and significantly higher than the remaining treatments. The minimum potassium content in grains was recorded under control treatment (T₁). K content in straw which was differed significantly under different treatments ranged from 1.43 to 1.49 %. The treatment T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded higher potassium content in straw which was found to be at par with the treatment T₉ (RDF +

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Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹). The minimum potassium content in straw was recorded under the control treatment (T₁).

Zinc content (g ha⁻¹)

Grain zinc content ranged from 36.94 to 39.72 g ha⁻¹ under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher zinc content (39.72 g ha⁻¹) in grain which did not differ significantly by the application of Zn and B during the experimentation. The minimum (36.94 g ha⁻¹) zinc content was observed in (T₁) control. Straw zinc content ranged from 24.44 to 26.04 g ha⁻¹ under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher zinc content (26.04 g ha⁻¹) in grain which ~~was~~ did not differ significantly by the application of Zn and B during the experimentation. The minimum (24.44 g ha⁻¹) zinc content was observed in (T₁) control. The results were in conformity with the findings of (Arya *et al.*,2007) and (Sahu *et al.*,2017).

Boron content (g ha⁻¹)

Grain B content ranged from 20.45 to 32.68 g ha⁻¹ under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher boron content (32.68 g ha⁻¹) in grain which was boron content in grain which was found to be at par with the treatments, T₉ (RDF + Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹), T₈ (RDF + Boron 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹), T₇ (RDF + Boron 1 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹), while the minimum (20.45 g ha⁻¹) boron content was observed in (T₁) control. Straw boron content ranged from 9.76 to 10.34 g ha⁻¹ under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher B content (10.34 g ha⁻¹) in grain which ~~was~~ did not differ significantly by the application of Zn and B during the experimentation. The minimum (9.76 g ha⁻¹) B content was observed in (T₁) control. Similar result was also found by (Ram *et al.*, 2014).

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Sulphur content (%)

Result presented in Table 2 clearly indicates that plant sulphur content was significantly affected by different treatments. Grain S content (ranged from 0.409 to 0.418%) differs significantly under different treatments. The treatment, T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded the higher (0.418%) sulphur content in grain which was found ~~to be~~ at par with the treatments T₉ (RDF + Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹) and T₈ (RDF + Boron 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹) and significantly higher than the remaining treatments. The minimum (0.409%) B content in grains was recorded under control treatment (T₁). B content in straw which was differed significantly under different treatments ranged from 0.821 to 0.871 %. The treatment T₁₀ (RDF + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹) recorded higher (0.871%) sulphur content in straw which was found ~~to be~~ at par with the treatment T₉ (RDF + Boron 1 kg ha⁻¹ + Zinc 5 kg ha⁻¹) and T₈ (RDF + Boron 2 kg ha⁻¹ + Zinc 2.5 kg ha⁻¹), while the minimum (0.821%) sulphur content in straw was recorded under the control treatment (T₁). Similar finding was also found by (Upadhyay, 2013).

Table. 1 Zn and B mediated effect on yield attribute and yield on Lentil

Symbol	Treatments	Yield attribute			Yields (q/ha)			Harvest Index (%)
		No. of Pods plant ⁻¹	No. of Grains pod ⁻¹	1000 grains weight (g)	Grain	Straw	Biological	
T ₁	Control	109.6	1.36	23.8	10.5	11.6	22.0	47.5
T ₂	RDF (N:P:K:S)	130.4	1.62	24.3	13.9	14.9	28.7	48.2
T ₃	RDF + Boron 1 kg ha ⁻¹	132.2	1.65	24.6	14.0	14.9	28.9	48.4
T ₄	RDF + Boron 2 kg ha ⁻¹	136.5	1.7	24.8	14.5	15.2	29.7	48.8
T ₅	RDF + Zinc 2.5 kg ha ⁻¹	135.4	1.69	24.9	14.3	15.1	29.4	48.5
T ₆	RDF + Zinc 5 kg ha ⁻¹	141.8	1.71	25.1	14.9	15.5	30.4	49.0
T ₇	RDF + Boron 1 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹	142.6	1.72	25.7	15.1	15.8	31.0	49.1
T ₈	RDF + Boron 2 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹	143.8	1.74	25.733	15.4	15.8	31.2	49.5
T ₉	RDF + Boron 1 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	143.5	1.72	25.7	15.4	15.9	31.4	49.2
T ₁₀	RDF + Boron 2 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	144.6	1.81	25.733	16.7	16.8	33.4	49.8
	SEm (±)	4.89	0.17	0.89	0.5	0.5	1.0	1.7
	C.D. (P=0.05)	14.65	0.58	NS	1.5	1.6	3.1	NS

Table: 2 Zn and B mediated effect on Nutrient uptake in Lentil

Sym bol	Treatments	N content (%)		P content (%)		K content (%)		Zn content (g ha ⁻¹)		B content (g ha ⁻¹)		S content (%)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T ₁	Control	3.52	0.86	0.37	0.2	0.83	1.43	36.94	24.44	20.45	9.76	0.409	0.821
T ₂	RDF (N:P:K:S)	4.15	1.09	0.41	0.22	0.84	1.44	37.15	24.47	23.74	9.95	0.413	0.834
T ₃	RDF + Boron 1 kg ha ⁻¹	4.42	1.14	0.43	0.22	0.85	1.44	37.86	25.65	27.64	9.95	0.414	0.842
T ₄	RDF + Boron 2 kg ha ⁻¹	4.52	1.16	0.41	0.23	0.85	1.45	38.58	25.82	29.68	9.96	0.415	0.845
T ₅	RDF + Zinc 2.5 kg ha ⁻¹	4.49	1.15	0.42	0.23	0.84	1.45	38.49	25.72	21.41	9.95	0.414	0.844
T ₆	RDF + Zinc 5 kg ha ⁻¹	4.53	1.18	0.41	0.23	0.85	1.45	38.64	25.84	21.61	9.98	0.415	0.846
T ₇	RDF + Boron 1 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹	4.55	1.19	0.42	0.23	0.85	1.46	38.71	25.87	30.42	10.05	0.416	0.847
T ₈	RDF + Boron 2 kg ha ⁻¹ + Zinc 2.5 kg ha ⁻¹	4.58	1.22	0.43	0.24	0.86	1.48	39.45	26.02	31.45	10.24	0.417	0.853
T ₉	RDF + Boron 1 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	4.56	1.21	0.42	0.24	0.86	1.47	38.82	25.95	30.48	10.12	0.417	0.868
T ₁₀	RDF + Boron 2 kg ha ⁻¹ + Zinc 5 kg ha ⁻¹	4.6	1.23	0.44	0.25	0.87	1.49	39.72	26.04	32.68	10.34	0.418	0.871
	SEm (±)	0.15	0.04	0.04	0.008	0.04	0.06	1.35	0.90	0.95	0.35	0.016	0.040
	C.D. (P=0.05)	0.45	0.119	NS	0.024	0.02	0.03	2.71	NS	2.85	NS	0.002	0.019

Conclusion

In the light of results summarized above, it may be concluded based on the present study that for higher grain yield with better nutrient uptake in western U.P. condition, (T₁₀)- RDF (N:P:K:S @ 20, 50, 20 and 40 kg ha⁻¹) + Boron 2 kg ha⁻¹ + Zinc 5 kg ha⁻¹ should be preferred over other combination nutrients. The observations are based on one season data, to get more precise information, it is suggested that the experiment should be repeated in future on the same soil with same lay-out.

Comment [A17]: Rewrite clearly.

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