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 the 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 a 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 T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}). The highest grain yield was recorded in T_{10} RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} which were statistically at par with T_8. It is concluded based on the study that the application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} with Zn, and B (T_{10}) gave best results (Grain yield increased by 26.7%, 25.7%, 21%, 22.9%, 17.2% and 59.1% over T_1, T_3, T_4, T_5, T_6 and T_1, respectively) and proved to be beneficial for *rabi* lentil followed by RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_9). The balanced and combined use of Zn, and B along with N, P, K and S in lentil improved the yield attribute, yield, and total uptake of nutrients along with maintaining the soil fertility.

Keywords: Micronutrient, Boran, Zinc, Lentil quality, Lentil yield

INTRODUCATION

“Lentil (*Lens culinaris* Medick.), belong 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 (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 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 to human beings" (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). The area under pulses was >29 million ha with a total production of 25.23 million tonnes at a productivity of 841 kg ha^{-1} during 2017-18. India is the world's largest producer, consumer, and grower of pulses, accounting for 34% of total acreage, 26% of total production, and approximately 30% (23-24 million tonnes) of the total consumption worldwide" (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. 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.

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. At 29^0 5′ 34″ N latitude, 77^0 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 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} was applied through DAP, MOP, Urea and bentonite. Zinc and boron were applied through zinc sulphate monohydrate and borox as a basal dose according to treatments.

Yield attributes study

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 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.

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).**

$$\boldsymbol{Harvest\ index\ = \frac{Economic\ yield\ (kg\ ha^{-1})}{Biological\ yield\ (kg\ ha^{-1})} X100}$$

Plant analysis

Preparation of samples:

The plant samples were dried in an oven at 60±2 ^{0}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) 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:

100 mg oven dry ground sample were taken into a digestion flask. 1.1g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_2O$: 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 ^{0}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 (Subbiah and Asija, 1956). 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 in H_2SO_4 digest for distillation. The distilled ammonia is quantitatively absorbed in boric acid and titrated against standard acid.

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^{0}C followed by its extraction in dilute $HCIO_4$ or H_2SO_4 for determining various elements. Ashing at temperature exceeding 600 ^{0}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- $HCIO_4$ tri acid mixture or HNO_3- $HCIO_4$ di-acid mixture. Use of $HCIO_4$ avoids the volatilization loss of K and provides a clear solution while H_2SO_4 helps completing oxidation.

Digestion of the Sample for Sulphur.

Weigh accurately an amount of plant material ranging from 300- 500 mg and transfer it into the digestion flask. Add 2 ml of perchloric acid (s.g. 1.67) and 4 ml of H202 (30 ~). Connect the digestion flask with the condenser part (a few drops of water can be used as a lubricant). The stopcock remains closed. Start heating. After the quick initial reaction of H_20_2, the remnants of hydrogen peroxide and water are distilled over into the condenser part. The digest becomes brownish to black. When perchloric acid starts to react, the digest becomes yellowish and finally colourless. At this point, the digestion should be continued for another hour in order to convert organically-bound Sulphur (methionine) into the sulphate. The heating should be regulated in such a way, that the perchlorie acid vapours condense in the side arm of the condenser (to about 2/3 of its height). The temperature of the digest is then about 203 ~ C. This procedure prevents the drying out of the sample. If this same temperature is maintained throughout the whole digestion, the upper part of the condenser remains relatively cool and practically no vapours leave the system. After cooling, the liquid in the condenser is transferred into the digestion flask by opening the stopcock and repeated washings. The solution is transferred quantitatively to 100 ml volumetric flasks and made up to volume with water (Novozamsky *et al.,* 1977).

Determination of P:

Phosphorous in an aliquot was determined using the method based on vanado-molybdo phosphoric yellow colour method (Olsen *et al.,* 1954). 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 mµ 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 (Hanway and Heidel, 1952). 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 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:

This micronutrient was determined in the di-acid or acid digest of plant tissues using AAS (Lindsay and Norvell, 1978). 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) where in dry-ashed samples are dissolved in dilute acid (usually HCl/ HNO_3) for analysis.

Sulphate Determination.

Pipette 15-ml aliquot of sample solutions and standards into 25-ml graduated flasks. To each flask add approximately 1 g of the graded barium chloride crystals from a standard cup and gently mix the reagent by inverting the flask several times. Add 2 ml of gum accacia solution and dilute to 25 ml. Again invert the flask several times and measure directly the turbidity at 440 nm.

RESULTS AND DISCUSSION

Yield attributes

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 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 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 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 improved yield attributes of lentil with synthetic fertilizers.

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 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 T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) was significantly higher than the N content found in treatments T_1 and T_2 and statistically at par to rest of treatments. Minimum grain N content was found in T_1 (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 T_1 and T_2 and statistically at par to rest of treatments was found in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}), while minimum (0.86%) in control (T_1). 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 T_{10} (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 (T_1). Straw P content under different treatments varied from 0.2 to 0.25 %. Treatment T_{10} (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 T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}) and T_8 (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 (T_1). 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. Grain K content ranged from (0.83 to 0.87%) differs significantly under different treatments. The treatment, T_{10} (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 T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}) and T_8 (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 (T_1). K content in straw which was differed significantly under different treatments ranged from 1.43 to 1.49 %. The treatment T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5kg ha^{-1}) recorded higher potassium content in straw which was found at par with the treatment T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}). The minimum potassium content in straw was recorded under the control treatment (T_1) Similar trend was also observed by (Rajesh *et al.*,2006).

Zinc content (g ha^{-1})

Grain zinc content ranged from 36.94 to 39.72 g ha^{-1} under different treatments. The treatment, T_{10} (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 (T_1) control. Straw zinc content ranged from 24.44 to 26.04 g ha^{-1} under different treatments. The treatment, T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) recorded the higher zinc content (26.04 g ha^{-1}) in grain which 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 (T_1) 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, T_{10} (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 at par with 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}), while the minimum (20.45 g ha^{-1}) boron content was observed in (T_1) control. Straw boron content ranged from 9.76 to 10.34 g ha^{-1} under different treatments. The treatment, T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) recorded the higher B content (10.34 g ha^{-1}) in grain which 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 (T_1) control. Similar result was also found by (Ram *et al.,* 2014).

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, T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) recorded the higher (0.418%) sulphur content in grain which was found at par with the treatments T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}) and T_8 (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 (T_1). B content in straw which was differed significantly under different treatments ranged from 0.821 to 0.871 %. The treatment T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}) recorded higher (0.871%) sulphur content in straw which was at par with the treatment T_9 (RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}) and T_8 (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 (T_1). 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

Symbol	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	Grains	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

It is concluded based on the present study that for higher grain yield with better nutrient uptake in western U.P. conditions farmers can adopt, (T_{10})- RDF (N:P: K:S @ 20, 50, 20, and 40 kg $ha^{-1)}$ + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} combination. The observations are based on one-season data, to get more precise information, it is suggested that the experiment should be repeated in the future on the same soil with the same layout.

REFRENCES

Ahlawat, I. P. S. (2012) Agronomy – *rabi* crops, Lentil. Division of Agronomy Indian Agricultural Research Institute, New Delhi – 110 012 Agronomy.

Anonymous, (2018). Economic Survey of India. annual report.

Arya, R.L., Varshney J.G. and Kumar Lalit (2007). Effect of integrated nutrient application in chickpea+mustard intercropping system in the semi-arid tropics of North India. *Communication in Soil Science and Plant Analysis*38 (1/2): 229-240.

Biswash, M.R., Rahman, M.W., Haque, M.M., Sharmin, M. and Barua, R. (2014). Effect of Potassium and Vermicompost on the Growth, Yield and Nutrient Contents of Mungbean (BARI Mung 5). *Open Science Journal of Bioscience and Bioengineering.* 1(3): 33-39.

DONALD, C. M. (1962). In search of yield. *Journal of the Australian Institute of Agricultural Sciences* 28, 171- 178.

FAO, (2019) FAOSTAT statistical database of the United Nations Food and Agriculture Organization (FAO).

Gaines, T. P., & Mitchell, G. A. (1979). Boron determination in plant tissue by the azomethine H method. *Communications in Soil Science and Plant Analysis*, *10*(8), 1099-1108.

Hanway,J.J. and Heidel ,H. 1952. Soil analysis methods as used in Iowa State College Soil Testing Laboratory.

Iliger, M. D., Alagundagi, S. C., Patil, M. B., & Vijayakumar, A. G. (2017). Influenceof seed rate and fertilizer levels on growth and yield of lentil (*Lens culinaris* Medik.) genotypes under dry land situation. *Journal of Pharmacognosy and Phytochemistry*, 6(6), 2019-2022.

Kabata-Pendias, A. (2004). Soil–plant transfer of trace elements—an environmental issue. *Geoderma*, *122*(2-4): 143-149.

Karmegam, N. Alagumalai, K. and Daniel, T. (1999). Effect of N.P.S on the growth and yield of greengram (*Phaseolus aureus* Roxb.) *Tropical Agriculture*. 76(2): 143-146.

Kumar, J., Gupta, S., Gupta, D. S., & Singh, N. P. (2018). Identification of QTLs for agronomic traits using association mapping in lentil. *Euphytica*, *214*(4), 1-15.

Lindsay, W. L., & Norvell, W. A. 1978. Development of a DTPA soil test for zinc, iron, manganese, and copper. *Soil science society of America journal*, 42(3): 421-428.

Mishra, U. S., Sharma, D., &Raghubanshi, B. P. S. (2018). Effect of zinc and boron on yield, nutrient content and quality of blackgram (*Vigna mungo* L.). *Research on Crops*, *19*(1), 34-37.

Mohammadi, M., Abas, M., Syed, A.S. and Meysam B. (2015). The effect of zinc and potassium on the quality yield of wheat under drought stress conditions. *International Journal of Agriculture and Crop Sciences,* 16(1):1164-1170.

Mudryj, A. N., Yu, N., and Aukema, H. M. (2014).Nutritional and health benefits of pulses. *Applied Physiology, Nutrition, and Metabolism*, 39(11): 1197-1204.

Neacsu, M., McBey, D., & Johnstone, A. M. (2017). Meat reduction and plant-based food: replacement of meat: nutritional, health, and social aspects. *Sustainable protein sources*, 359-375.

Novozamsky, I., van Eck, R. (1977). Total sulphur determination in plant material. *Z. Anal. Chem.* 286, 367–368.

Obata, H., S. Kawamura, K. Senoo and A. Tanaka (1999). Changes in the level of protein and activity of Cu/Zn superoxide dismutase in zinc deficient rice plant, *Oryza sativa L. Soil Sci. Plant Nutr*. 45: 891-896.

Olsen, S. R. 1954. *Estimation of available phosphorus in soils by extraction with sodium bicarbonate* (No. 939). US Department of Agriculture.

Rajesh P., Singh, A.K. and Malik, S.P. (2006). Growth pattern in relation to yield in mungbean (*Vigna radiata* (L.) Wilczek). *Indian Journal of Genetics & Plant Breeding*. 60(2): 237-238.

Ram, B., Singh, S. K., Latare, A. M., & Kumar, O. (2014). Effect of sulphur, zinc and boron application on growth and yield of hybrid rice (*Oryza sativa* L.). *Journal of the Indian Society of Soil science*, 62(2), 184-188.

Sahu Gayatri, Nitin Chatterjee and Goutam Kumar Ghosh (2017) Integrated Nutrient Management In Lentil *(Lens culinaris Medikus)* In Red And Lateritic Soils Of West Bengal, *Bull. Env.Pharmacol. Life Sci*., 6(4): 55-62.

Sharma, V., & Shukla, V. A. N. D. A. N. A. (2014). Scenario of Lentil in India–A review. *Advances in Life Sciences*, *3*(1), 01-06.

Singh, A.K., Khan, M.A. and Srivastava, A. (2014) Effect of boron and molybdenum application on seed yield of mungbean. *Asian Journal of Biological Science*, 9, 169–172.

Singh, D, Khare, A., Sharma, R., & Chauhan, S. S. (2015). Effect of boron on yield qwuailty and uptake of nutrients by lentil. *Annals of Plant and Soil Research*, *17*(4), 385-387.

Singh, D. and Singh, R.P. (2014). Effect of integrated nutrient management on growth, physiological parameters and productivity of lentil (*Lens culinaris* Medik.). I*nternational Journal of Agricultural Sciences*, 10(1): 175-178.

Singh, N. (2017). Pulses: an overview. *Journal of Food Science and Technology*, 54(4), 853- 857.

Subbiah, B. V. and Asija, G.C. 1956. A rapid method for the estimation of nitrogen in soil. *Current Science*, 25: 259 - 260.

Upadhyay, A. K. (2013). Effect of sulphur and zinc nutrition on yield, uptake of nutrients and quality of lentil in Alluvial soil. *Annals Plant and Soil Research*, 15(2), 160-163.

Wolf, B. (1971). The determination of boron in soil extracts, plant materials, composts, manures, water and nutrient solutions. *Communications in Soil Science and Plant Analysis*, *2*(5), 363-374.

Zike, T., Abera, T. and Hamza, I. (2017). Response of improved lentil (*Lens culinaris* Medik) varieties to phosphorus nutrition on vertisols of West Showa, Central Highlands of Ethiopia. *Advances in Crop Science and Technology*, 5(6): 315.