Application of Zinc, Boron and Molybdenum in Soil Increases Lentil Productivity, Nutrient Uptake and Apparent Balance

<table>
<thead>
<tr>
<th>Journal:</th>
<th>Canadian Journal of Soil Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manuscript ID</td>
<td>CJSS-2019-0141.R1</td>
</tr>
<tr>
<td>Manuscript Type:</td>
<td>Article</td>
</tr>
<tr>
<td>Date Submitted by the Author:</td>
<td>04-Mar-2020</td>
</tr>
<tr>
<td>Complete List of Authors:</td>
<td>Hossain, M.A.; Bangladesh Agricultural Research Institute, Soil Science Quddus, M.A.; Bangladesh Agricultural Research Institute, Soil Science Alam, Md. Khairul; Murdoch University, Agriculture Discipline; Bangladesh Agricultural Research Institute, Soil Science Naser, H.M.; Bangladesh Agricultural Research Institute, Soil Science Anwar, Babul; Bangladesh Agricultural Research Institute, Soil Science Khatun, Firoza; Bangladesh Agricultural Research Institute, Soil Science Rashid, Md Harunur; The University of Newcastle Faculty of Science, Global Centre for Environmental Remediation (GCER) Khatun, Fatima; Bangladesh Agricultural Research Institute, Soil Science Siddiky, M.A.; Bangladesh Agricultural Research Institute, Soil Science</td>
</tr>
<tr>
<td>Keywords:</td>
<td>Lentil yield; micronutrient; nodulation; nutrient uptake and balance; soil properties</td>
</tr>
<tr>
<td>Is the invited manuscript for consideration in a Special Issue?:</td>
<td>Not applicable (regular submission)</td>
</tr>
</tbody>
</table>

https://mc.manuscriptcentral.com/cjss-pubs
Application of Zinc, Boron and Molybdenum in Soil Increases Lentil Productivity, Nutrient Uptake and Apparent Balance

Running title: Micronutrients increase lentil yield and quality

Md. Ashraf Hossain\textsuperscript{a}, Md. Abdul Quddus\textsuperscript{b}, Md. Khairul Alam\textsuperscript{c}, Habib Mohammad Naser\textsuperscript{c}, Md. Babul Anwar\textsuperscript{d}, Firoza Khatun\textsuperscript{e}, Md. Harunur Rashid\textsuperscript{f}, Mst. Fatima Khatun\textsuperscript{g} and Md. Alamgir Siddiky\textsuperscript{b}

\textsuperscript{a}Training and Communication Wing, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
\textsuperscript{b}Soil and Water Management Section, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
\textsuperscript{c}Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh
\textsuperscript{d}Regional Agricultural Research Station, Bangladesh Agricultural Research Institute, Jashore-7403, Bangladesh
\textsuperscript{e}Plant Pathology Division, Bangladesh Agricultural Research Institute, Gazipur1701, Bangladesh
\textsuperscript{f}Global Centre for Environmental Remediation (GCER), Faculty of Science, University of Newcastle, Callaghan 2308, NSW, Australia
\textsuperscript{g}Plant Growth Genetic Resources Centre, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

Number of tables: 6

Number of figures: 9

Corresponding author: Dr. Md. Khairul Alam; khairul.krishi@gmail.com
Application of Zinc, Boron and Molybdenum in Soil Increases Lentil (*Lens culinaris* Medic) Productivity, Nutrient Uptake and Apparent Nutrient Balance

**Abstract**

In severely deficit soil, lentil (*Lens culinaris* Medic) crop requires micronutrients for increased production. Micronutrient management is, therefore, very important for lentil productivity but mostly ignored. This study was carried out from 2014-2015 to 2016-2017 to understand the effects of zinc (Zn), boron (B) and molybdenum (Mo) on lentil productivity, nodulation and nutrient uptake and how these elements improve soil micronutrient fertility. The experiment was laid out in randomized complete block design and the treatments were replicated thrice. Different combinations of Zn, Mo and B were contrasted with no application of micronutrients. The treatments were Zn alone (Zn), B alone (B), Mo alone (Mo), Zn combined with B (ZnB), Zn with Mo (ZnMo), B with Mo (BMo) and Zn combined with B and Mo (ZnBMo). Doses of Zn, B and Mo were 3, 2 and 1 kg hectare\(^{-1}\), respectively. In this trial, the highest average seed yield (1807 kg ha\(^{-1}\)) and yield increment (44%) was obtained in ZnBMo combined application with macronutrients. Single, dual and combined application of Zn, B and Mo had significant effects on yield parameters and yield of lentil (p<0.05). The highest nutrient uptake, maximum nodulation (63.5 plant\(^{-1}\)) and the highest protein content (26.6 %) in seed was recorded from the treatment receiving all three micronutrients. The increased lentil yield might be associated with increased nodulation and nutrient uptake by the crop under micronutrient applied treatments. The results suggest that combination of Zn, B and Mo could be applied for increased lentil production in micronutrient deficit soils.

**Keywords:** Lentil yield; micronutrient; nodulation; nutrient uptake and balance; soil properties
Introduction

Lentil (Lens culinaris Medic) is a very important source of nutritional security (Togay et al. 2015; protein content around 18 to 30% and Bhatti 1988; contains several essential micronutrients, e.g. Fe, Zn, β-carotene) for improving health of humans and domestic animals. About 6.3 million tonnes of lentil was produced in 2016 worldwide, while lentil in the Asia-Pacific region covers more than 50 % of area cultivated globally and accounts for almost 50 % of world’s lentil (FAOSTAT 2017). However, lentil area and production in the Eastern Gangetic deltaic Bangladesh was about 154.7 thousand ha and 168.8 thousand tonnes with an average yield of 753 kg ha$^{-1}$ which contributed about 35 % to the total pulses production in Bangladesh (BBS 2017). In Eastern Gangetic deltaic Bangladesh, the demand for pulses are quite high and have to import about 1.82 million tonnes of lentil worth US $ 135.1 million from abroad in 2014-2015 (BBS 2016). The huge demand and demand gap of the crop should make up by increasing domestic production which can be achieved through judicious nutrient management in already depleted soils (BARC 2012).

The Eastern Gangetic Plains and Bangladesh is now dominant in growing triple crops in a year rotation (Alam et al. 2016). On the other hand, growing grain crops which are input-intensive have been reported to deteriorate soil health (Salahin 2017; Alam 2018), to cause yield decline (Alam et al. 2016) and consequently not to result in good economic return. Pulses help to diversify rice-based cropping systems predominant in Bangladesh, while promoting healthy soils and enhancing economical crop production in a cropping system (Balasubramanian et al. 2012; Alam et al. 2014). Yadav et al. (2007) found that improved soil physical, chemical and biological properties were associated with growing lentils in intensively crop growing soils. They attributed to increase yield and improve soil health by biological N fixation or other rotational effects (Nulik et al. 2013). However, soils in the Gangetic plains including Bangladesh are now reported to be deficient in micronutrients (BARC 2012). The management
of the micronutrients should, therefore, be taken into account to increase the production of the important crops.

Lentil yield in Bangladesh is generally low but rising demographic pressure require augmented production for minimizing the demand. Introduction of appropriate nutrient (macro and micronutrients) management practices and high yielding lentil variety may, therefore, play a key role in increasing the production of lentil. Sing et al. (2014) reported that micronutrients helped to achieve higher production by fixing increased amount of atmospheric N by legume-rhizobium symbiosis and by increasing uptake of different plant nutrients. Singh and Bhatt (2013) also reported that micronutrients required in small amount but contributed significantly on yield of lentil (16.2 %) by increasing the growth and uptake of nutrients. Though requires in small amount, the micronutrients take part in many important physiological activities and processes. Combined use of different micro- and macronutrients can augment seed yield by 55 to 60%, of which 20 to 25% could be ascribed to the micronutrients (Islam et al. 2018). Valenciano et al. (2011) found that in combination with Mo and B, Zn efficiently contribute on chickpea yield. Quddus et al. (2017) reported that poor crop yield in the eastern Gangetic Bangladesh were associated with widespread micronutrient deficiencies like Zn, B, and Mo. The positive impacts of these three micronutrients (Zn, B and Mo) on several crops like chickpea, mungbean, groundnut etc. have already been discovered. On the other hand, their effects on lentil productivity, nutrient uptake and balance in soil have not been explored properly. The present study was, therefore, undertaken (i) to find out the effects of micronutrients on lentil seed yield and nutrient uptake, and (ii) to study on nutrient balance and properties of soil after three years.

Materials and Methods

Site description and soils

The experiment was conducted at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Jashore during November to March (rabi season) of
consecutive three years (from 2014 to 2017). Geographically the experiment was located at 23° 11' 15" N latitude and 89° 11' 06" E longitude. The soil was silt loam in texture and calcareous in nature under the Gopalpur soil series. The sub-order of the soil was Aquic Eutrochrepts under the order Inceptisols. The area fell in the High Ganges River Floodplain Agro-Ecological Zone (AEZ-11). Particle size distribution of initial soil was measured by hydrometer method (Black 1965). The textural class of the soil was then determined with the textural triangle. The chemical properties of initial soil are presented in Table 1.

The climate of the experimental location is subtropical. The cropping season stretches from October to March and experiences the lowest precipitation, low humidity, low temperature, and short days. During the growing season, rainfall varied from 1.7 to 65 mm and the mean minimum and maximum air temperatures were 8.91 and 30.6 °C, respectively. Average air temperatures ranged from 16.6 to 24.5 °C during 2014-2015, 17.1 to 25.3 °C during 2015-2016 and 17.9 to 24.7 °C during 2016-2017 (Figure 1).

**Land preparation, experimental design, treatment and layout**

The land was prepared by ploughing with a power tiller, followed by land leveling with ladder attached to a tractor. Randomized complete block design (RCBD) was assigned to set up the experiment with three replications of each treatment. The treatments were as follows:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient name and dose (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zn</td>
</tr>
<tr>
<td>T₁: Control</td>
<td>0</td>
</tr>
<tr>
<td>T₂: Only Zinc (Zn)</td>
<td>3</td>
</tr>
<tr>
<td>T₃: Only Boron (B)</td>
<td>0</td>
</tr>
<tr>
<td>T₄: Only Molybdenum (Mo)</td>
<td>0</td>
</tr>
<tr>
<td>T₅: Zn and B</td>
<td>3</td>
</tr>
<tr>
<td>T₆: Zn and Mo</td>
<td>3</td>
</tr>
<tr>
<td>T₇: B and Mo</td>
<td>0</td>
</tr>
<tr>
<td>T₈: Zn, B and Mo</td>
<td>3</td>
</tr>
</tbody>
</table>
The unit plot size was 6 m × 4 m while each plot was separated by an alley of 50 cm wide. Three replicated blocks were separated by the space of 1 m width. Basal doses of nutrients were 20 kg N, 22 kg phosphorus (P), 30 kg potassium (K), and 10 kg sulfur (S) ha⁻¹, respectively, applied at the rate of full amount in the respective treatment plot. The sources of N, P, K, S, Zn, B and Mo were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate (ZnSO₄·7H₂O), boric acid (H₃BO₃), and sodium molybdate (Na₂MoO₄·2H₂O), respectively. The sulphur applied through ZnSO₄·7H₂O is deducted from the actual dose applied through gypsum. The rate of fertilizer application was calculated on the basis of soil test results (BARC 2012).

**Seed sowing and agronomic practices**

After treated by the fungicide Provax 200, the seeds of lentil (cv. BARI Masur-7) (at the rate of 30 kg ha⁻¹) were sown continuously in rows maintaining row to row distance 30 cm on 10 November 2014, 12 November 2015 and 11 November 2016. Hands weeding as well as thinning of seedlings were done at 25 days after sowing (DAS). Again, hand weeding was carried out at 55 DAS. The disease stemphylium blight was controlled by spraying Rovral® at 2 g L⁻¹ three times at an interval of 10 days begun at flowering stage. Insects (pod borer and aphid) were controlled by spraying insecticide of Karate (Lambda-cyhalothrin) @ 2 ml L⁻¹ two times at pod setting stage at an interval of 10 days. Irrigation was not applied. Mature crop was harvested on 20 March 2015, 22 March 2016 and 25 March 2016.

**Data collection, soil and plant analyses**

Lentil nodulation data was recorded at seedling stage (32 DAS), vegetative stage (50 DAS), flowering stage (68 DAS) and pod setting stage (86 DAS). Five plants from each treatment were selected from preset quadrates (1.5 m²) for nodule calculation. Uprooting of plants was done by a root sampler which was then washed under slow releasing tap water. The nodules per plant were then counted. The active nodules of light-pink or red colored were selected by slicing them
and were recorded. The number of pods plant$^{-1}$ was recorded from 10 plants of lentil selected randomly from each quadrats during harvesting. Pods were detached from every plant for recording number of pods plant$^{-1}$ and averaged. Mature plants were brought to the laboratory for oven drying for 48 hours at 65 °C. The seeds were then separated. Then treatment-wise seeds collected from each quadrate were preserved in polythene bags (20 cm × 30 cm). Lentil seed yield was calculated per quadrate (1.5 m$^2$) which was then converted to per m$^2$. Thousand seed weight (g) was also determined. The straws were oven-dried (70 °C for 48 hours), weighed and recorded. The day after the crop harvest, soil samples were collected from three spots plot$^{-1}$ at 0-15 cm depth. The soil samples from each plot were air-dried. After grinding and sieving soil samples, the samples were preserved in plastic containers with proper label for analysis. A glass electrode pH meter was used to analyze the pH of soil samples (a soil-water ratio 1:2.5 was used) (Page et al. 1982). Organic carbon was determined following the wet oxidation method (Page et al. 1982) and the organic matter content was calculated by Using Van Bemmelen factor 1.73. Total N determined by Microkjeldahl method (Bremmer and Mulvaney 1982). In line with Thomas (1982), K and Ca in their exchangeable forms were extracted with NH$_4$OAc solution. Atomic absorption spectrophotometer (Chemito AA 203) was used to directly measure exchangeable K and Ca (Chemito AA 203). Available P was determined by Olsen and Sommers (1982) method. Available S was determined in line with method of Page et al. (1982) (by extracting the soil sample with 0.15 % CaCl$_2$). Zinc and B in their available forms were determined by DTPA (Lindsay and Norvell 1978) and azomethine-H method (Page et al. 1982). Plant samples (straw and seed) was analysed for N (Kjeldahl method; Persson et al. 2008) P (spectrophotometer method), K (atomic absorption spectrophotometer) and S (turbidity method using BaCl$_2$ by spectrophotometer; Chapman and Pratt 1961). Zinc concentration in the digested plant samples was directly measured by AAS (VARIAN SpectrAA 55B, Australia). Boron concentration was determined by spectrophotometer following azomethine-H method (Page et al. 1982).
Protein content in lentil seed was measured by using the pulses food factor of 5.30 (FAO 2018). Uptake of nutrients by the lentil crop was calculated from the results of crop yield and nutrient concentration in seed and stover (BARC 2012).

Physiological efficiency (PE) was calculated according to Equation: 
\[
PE = \frac{Y - Y_0}{U - U_0}
\]

Where, Y is the economic yield of the micronutrient fertilized plot, \(Y_0\) is the yield of the micronutrient unfertilized plot, U is the nutrient uptake by lentil with micronutrient fertilized plot and \(U_0\) is the nutrient uptake by lentil with micronutrient unfertilized plot (Paul et al. 2014).

All inputs of nutrients and their outputs (only from the crop uptake) were calculated to make an apparent nutrient balance (BARC 2012). It was also assumed that lentil fixes 14 kg N ha\(^{-1}\) by Biological Nitrogen Fixation (BNF) process (Montanez 2000).

Statistical analysis

Data on produce quality, yield and yield contributing characters and soil properties were statistically analyzed through analysis of variance procedure using a randomized complete block design. The LSD method was used for multiple comparisons (all-pairwise comparisons) at 5% significance level by running data into SPSS (Statistical Package for the Social Sciences) software package version 21 (SPSS Inc., Chicago, IL, USA).

Results

Yield attributes, seed yield and functional relationship

Lentil seed yield varied due to application of Zn, B and Mo (Table 2). The average seed yield of lentil varied from 1253 to 1807 kg ha\(^{-1}\), while the lowest yield was recorded in control treatment and the highest yield in the range was recorded from ZnBMo treatment (T8; Table 2). Among single application of Zn, B or Mo; the highest seed yield was obtained from only B treatment in 2\(^{nd}\) and 3\(^{rd}\) year. However, in all seasons, the maximum significant increase in seed yield was observed in the combined application of Zn, B, and Mo. The ZnBMo treatment consistently
produced the highest seed yield all over the three years (2075 kg ha\(^{-1}\) in 1\(^{st}\) year, 1667 kg ha\(^{-1}\) in 2\(^{nd}\) year and 1680 kg ha\(^{-1}\) in 3\(^{rd}\) year). The lowest seed yield was observed in T\(_1\) in all experimental years (Table 2). The wide yield variation in 1\(^{st}\) year might be associated with the well climatic condition having low temperature.

Application of micronutrients had varied yield attributes (number of pods plant\(^{-1}\) and 1000-seed weight of lentil) (Table 2). Among the single application of Zn, B and Mo in the experiment, the highest number of pods plant\(^{-1}\) (67.8) was obtained from B (2 kg B ha\(^{-1}\)) treatment and the lowest (63.5) was found in Zn treatment (3 kg Zn ha\(^{-1}\)). However, the highest number of pods plant\(^{-1}\) (81.2) and 1000-seed weight (24.6 g) were recorded from ZnBMo treatment, while the lowest pods plant\(^{-1}\) (55.9) and 1000-seed weight (16.3 g) were recorded from control (T\(_1\)) treatment where no micronutrient was applied (Table 2).

A significant positive linear relationship was observed between number of pods per plant and seed yield of lentil (Figure 2). The coefficient of determination of the regression equation was 0.874, which implies that the seed yield of tested crop governed by number of pods per plant by 87.4\%. In this experiment, the relationship between 1000-seed weight and seed yield of lentil appeared to be statistically significant, that is, seed yield of lentil was dependent on seed weight by 67.7 \%, indicating that a significant (67.7 \%) variability in seed yield of lentil could be attributed by 1000-seed weight (Figure 2).

**Number of nodules plant\(^{-1}\)**

The application of micronutrients had varied number of nodules plant\(^{-1}\) of lentil (Table 3). The application of Zn, B and Mo significantly increased nodules plant\(^{-1}\) of lentil from 32 DAS to 68 DAS which afterwards decreased regardless of treatment. The results also indicated that every micronutrient has an important role in nodule formation. At 32 DAS, the number of nodules varied from 15.9 to 21.3, at 50 DAS, nodules ranged from 31.7 to 50.6, at 68 DAS from 42.2 to 63.5 and at 86 DAS, nodulations plant\(^{-1}\) varied from 26.2 to 32.3 (Table 3). At all sampling
dates, the highest number of nodules plant\(^{-1}\) was recorded from ZnBMo treatment, while the lowest number nodules plant\(^{-1}\) were recorded in control treatment (Table 3). From the results of different dates, we observed that the nodule formation was less in 32 DAS and 86 DAS, while more nodules plant\(^{-1}\) were recorded between 50 and 68 DAS (early to mid-flowering stage).

**Uptake of N, P, K, S, Zn and B by lentil (seed+straw)**

The application of micronutrients increased the uptake of N, P, K, S, Zn and B by lentil seed and straw (Table 4). The highest N uptake (124 kg ha\(^{-1}\)) was found in ZnBMo treatment. The lowest amount of N uptake (65.9 kg ha\(^{-1}\)) was recorded in control plot where no micronutrients were applied (Table 4). In case of P and S uptake by lentil (seed+ straw), the highest amount of P uptake (9.98 kg ha\(^{-1}\)) and S uptake (16.0 kg ha\(^{-1}\)) were recorded from the T\(_8\) treatment. The lowest uptake amount of both P (4.80 kg ha\(^{-1}\)) and S (7.06 kg ha\(^{-1}\)) was found in control treatment (Table 4). Regarding K uptake by lentil, however, the uptake varied between 16.5 kg ha\(^{-1}\) to 30.4 kg ha\(^{-1}\) due to application of micronutrients. The highest K uptake (30.4 kg ha\(^{-1}\)) was observed in ZnBMo treatment which was significantly different from other treatments, while the lowest amount of K uptake (16.5 kg ha\(^{-1}\)) was found in control (T\(_1\)) treatment. The Zn, B and Mo significantly increased both the Zn and B uptake by lentil which ranged from 0.13 to 0.22 kg ha\(^{-1}\) and 0.07 to 0.13 kg ha\(^{-1}\), respectively. The highest uptake of Zn and B (0.22 kg Zn ha\(^{-1}\) and 0.13 kg B ha\(^{-1}\)) by lentil was found in ZnBMo treatment. The lowest uptake of Zn and B (0.128 kg Zn ha\(^{-1}\) and 0.071 kg B ha\(^{-1}\)) were found in control (T\(_1\)) plot (Table 4).

Micronutrient application along with macronutrients increased the protein content in lentil seed (Figure 3). The seed protein content ranged from 21.5 to 26.6 % of which the highest protein content (26.6 %) was found in ZnBMo treatment and the lowest protein content (21.5 %) was found in control treatment (Figure 3).

**Physiological efficiency (PE) of N, P, K, S, Zn and B in lentil**
Micronutrient application increased PE of nutrients in lentil (Figures 4). Physiological efficiency of N in lentil ranged from 7.81 to 10 kg kg$^{-1}$ among treatments. Among the treatments, PE of N was the highest (10 kg kg$^{-1}$) in ZnB treatment followed by ZnBMo, BMo, ZnMo and B treatments, respectively. The lowest PE of N value (7.81 kg kg$^{-1}$) was found in Mo treatment. The PE of P value ranged from 81.5 to 134 kg kg$^{-1}$ due to variable micronutrient treatments. The highest PE of P value (134 kg kg$^{-1}$) was obtained from ZnMo treatment followed by (119 kg kg$^{-1}$) ZnB treatment, while the lowest PE of P value (81.5 kg kg$^{-1}$) was found in Zn treatment. The highest PE of K value (56.7 kg kg$^{-1}$) was recorded in Zn treatment followed by (45.8 kg kg$^{-1}$) B treatment, although the lowest PE of K value (33.2 kg kg$^{-1}$) was achieved in Mo treatment. The PE of S value in lentil varied between 61.9 kg kg$^{-1}$ to 77.8 kg kg$^{-1}$ among the treatments having the highest PE of S value (77.8 kg kg$^{-1}$) obtained from Zn treatment followed by B (77.7 kg kg$^{-1}$) treatment, while the lowest PE of S value (61.9 kg kg$^{-1}$) was found in ZnBMo treatment (Figure 4). Physiological efficiency of Zn and B in lentil was varied among treatments. The highest PE of Zn value (6.43 kg g$^{-1}$) was recorded from the B treatment followed by ZnMo; however, the lowest value (4.29 kg g$^{-1}$) was obtained from Zn treatment. The PE of B value was the highest (13.5 kg g$^{-1}$) in Zn, followed by Mo (11.8 kg g$^{-1}$) treatment. The lowest PE of B value (8.24 kg g$^{-1}$) was obtained from B treatment (Figure 4).

**Apparent nutrient balance**

Apparent balances of N, P, K, S, Zn and B were positively influenced by the application of Zn, B and Mo either alone or in combination (Figures 5 and 6). The balance of N was negative in all the treatments, while the depletion values varied from -31.9 to -90.0 kg N ha$^{-1}$. The balance of N was comparatively less negative in control treatment. The highest N negative balance (-90.0 kg ha$^{-1}$) was occurred in ZnBMo treatment (Figure 5). The P balance was positive in all the treatments; however, the highest P positive balance (17.2 kg ha$^{-1}$) was recorded from control treatment and the lowest P positive balance (12.0 kg ha$^{-1}$) was from ZnBMo treatment. The K
balance was positive in all the treatments except ZnBMo treatment. The balance result of K was found negative (-0.4 kg ha\(^{-1}\)) in ZnBMo treatment. The highest positive balance of K (13.5 kg ha\(^{-1}\)) was observed in control (T\(_1\)) treatment. Micronutrients demonstrated positive effect on apparent balance of S, although the positive S balance varied from 2.54 to 5.44 kg ha\(^{-1}\) across the Mo, B, Zn and control treatments. On the other hand, negative S balance ranged from -0.1 to -3.5 kg ha\(^{-1}\) across the ZnBMo, BMo, ZnMo and ZnB treatments. The highest negative S balance was recorded from ZnBMo treatment and the highest positive S balance was recorded from control treatment (Figure 5). The balance for Zn showed negative value in control, B, Mo and BMo treatments, while the Zn, ZnB, ZnMo and ZnBMo treatments were observed positive. The highest negative Zn balance (-0.196 kg ha\(^{-1}\)) was obtained from BMo treatment and the lowest (-0.128 kg ha\(^{-1}\)) was obtained from control treatment. The highest positive Zn balance (1.83 kg ha\(^{-1}\)) was obtained from T\(_2\) treatment and the lowest (1.78 kg ha\(^{-1}\)) was obtained from ZnBMo treatment. The negative B balance varied from -0.071 to -0.109 kg ha\(^{-1}\) and positive B balance ranged from 1.10 to 1.38 kg ha\(^{-1}\), respectively across the treatments. The highest negative B balance (-0.109 kg ha\(^{-1}\)) was, however, observed in ZnMo treatment and the highest positive B balance was found (1.38 kg ha\(^{-1}\)) in BMo and ZnB treatments (Figure 6).

**Postharvest soil properties**

Postharvest soil properties were affected by the application of Zn, B and Mo (Table 5). It has been mentioned that the available Mo was not determined. Initially the soil pH was 8.1. After three years, the available Zn and B content of the soil decreased when they were not applied (p<0.05), while the concentrations were increased in soils after three years, when applied (p<0.05) (Table 5).

**Discussion**
The application of Zn, B and Mo either single or in combination contributed significantly to increase the seed yield of lentil. This might be attributed to the combination of micronutrient (Zn, B and Mo) which might enhance N-fixation (increased nodules), uptake of nutrients and assimilation of available nutrients by the plants during the whole growth period (Kumar et al. 2009; Valenciano et al. 2011). According to Liebig’s law of minimum, balance nutrition with micronutrients might ensure the growth of lentil and consequently increased yield. These explanations could be well-understood when seed yield increment (%) over control were compared according to the treatments. Combined application of Zn, B and Mo (Zn @ 3 kg ha\(^{-1}\) + B @ 2 kg ha\(^{-1}\) + Mo @ 1 kg ha\(^{-1}\)) contributed to the highest yield increment (44 %) over control (T\(_1\)). In case of couple application, micronutrients have been contributed to obtain moderate yield increment (32% for ZnB, 29% for ZnMo and 33% for BMo treatments) over control (T\(_1\)) (Figure 7). But single application for Zn, B and Mo contributed to achieve only 14%, 16% and 15% yield increment over control (T\(_1\)) (Figure 7). It is, therefore, categorical that application of micronutrients either separately or in combination appreciably enhanced the seed yield of lentil. This result is in agreement with the findings of Islam et al. (2018) and Yang et al. (2009). Yang et al. (2009), for example, reported that the combined application of B with Mo or Zn resulted in higher seed yield than the application of B, Mo, or Zn alone, while the combined application of B, Mo, and Zn increased the seed yield by 68.1% compared to the controls. The yield increase by 44 % with the ZnBMo combined application could reduce the dependency on import of the pulse crop.

Yield attributes viz. number of pods plant\(^{-1}\) and thousand seed weight varied by the application of Zn, B and Mo either alone or in combination. The results indicated that Zn, B and Mo applied alone or in combination positively increased number of pods plant\(^{-1}\) and thousand seed weight of lentil. Micronutrient (Zn, B and Mo) might assist in translocation of photosynthates, increasing N fixation resulting better pod and seed formation as well as thousand seed weight which might
be associated with higher yield. Togayet al. (2008) found that Mo increased plant height, number of pods plant$^{-1}$, seeds pod$^{-1}$ and seeds yield in lentil. Hatwar et al. (2003) reported application of micronutrients viz., Zn, iron and B in combination resulted in improvement of growth, yield parameters and yield of chilli.

Every micronutrient has a vital role in nodule formation. However, used either single or in combination of Zn, B and Mo along with macro (N, P, K and S) nutrient contributed significantly to ensure the effective number of nodules plant$^{-1}$ of lentil. Our observation noticed that single or combined application of Zn, B and Mo demonstrated significantly to increase the number of nodules plant$^{-1}$ in all nodule collection dates. These results are in agreement with Alam et al. (2015) and they reported that Mo with other nutrient significantly increased the number of active nodules in hairy vetch. From the results of different dates, nodule formations were less in 32 DAS and 86 DAS but, the formation were maximum between the dates of 50 to 68 DAS. It seems that the highest numbers of nodule formation were early to mid-flowering stage. After flowering, nodule efficiency was reduced and began to shut down. These findings were supported by Zaychuk (2006). Gupta and Gangwar (2012) reported nodule number increase plant$^{-1}$ was associated with adequate Mo with rhizobium, phosphate solubilizing bacteria and recommended dose of fertilizers. Gad and Kandil (2013) also recorded increased number of nodules plant$^{-1}$ of cowpea, fresh and dry weights of nodules due to different Mo levels. Patel et al. (2011), on the other hand, recorded increased nodules and N-fixation by applying Zn in soil. Our observation indicated that combined applications of Zn, B and Mo were more effective for nodule formation than that of their single or couple application.

The combined application of Zn, B and Mo increased the uptakes of both the macro- and micro-nutrients (N, P, K, S, Zn and B) by lentil over single micro-nutrient application and control treatment. Results clearly indicated that the highest nutrients (N, P, K, S, Zn and B) uptakes were found in the treatment of combined ZnBMo (T$_8$) application, while combined application of ZnB (T$_5$), ZnMo (T$_6$) and Bmo (T$_7$) contributed increased uptake of nutrients over control.
Even single application of Zn, B and Mo increased uptakes of N, P, K, S, Zn and B by lentil over control. The variations recorded in the present study in terms of uptake of essential nutrients could be attributed to increased seed yield and concentration of nutrients in seed and straw of lentil. The results, therefore, stated that the combined application of Zn, B and Mo were more efficient in accumulating major essential nutrients in lentil than that of their paired or single applications. Islam et al. (2018) conducted a similar study and stated that Zn, B and Mo application alone or in combination demonstrated increased concentration of N, P, K, S, Zn and B in lentil. The results are in agreement with the findings of Ziaeyana and Rajaiea (2009); Bhagiya et al. (2005).

Protein synthesis in lentil has been increased by the application of Zn, B and Mo in combination at the rate of 3, 2 and 1 kg ha\(^{-1}\). The study also denoted that every micronutrient has an important role for protein synthesis. Some evidence supported that protein content of legume was significantly affected by the application of Mo (Nasar and Shah 2017). Hidoto et al. (2017) reported that that Zn application increased carbohydrates and protein synthesis in plant, while translocation of sugar, fixation of N, synthesis of protein and sucrose were influenced by B application to soil (Singh et al. 2014).

The application of Zn, B and Mo either singly or in combination in this study ensures increased uptake by the crop. Under the different treatments, a removal of N by the crop as uptake is substantial. The present study showed that the highest negative balance of N was found in ZnBMo treatment plot, while the lowest was was observed in control plot where no micronutrients were used. Hence, the highest N use efficiency might be attained by the combined micronutrient application. The highest yield and biomass performed by the ZnBMo treatment might be due to the soil N use efficiency. The result is in agreement with the finding of Islam et al. (2018) and Valenciano et al. (2011).
Phosphorus balance was positive in all micronutrient treated plots, while the highest positive value was found in control (T₁) treatment. Positive P balance was the lowest in case of higher P uptake by test crop from ZnBMo treated plot. The P amount observed medium in soil but plant tissue showed inadequate level even under positive balance of P. Constraints for achieving adequate P concentration in tissue and uptake could include unavailability of the applied P (due to chemical fixation, or inadequate moisture in the fertilizer zone). The calcareous soil which contained large amounts of calcium (Ca) may have favored the long-term sorption of P by Ca compounds (Saleque et al. 2006). However, combined application of ZN, B and Mo could increase the use of P in soil. The balance of K was found positive in most of the treatments except ZnBMo that showed negative K balance. The negative K balance depends on highest crop uptake, however, combined micronutrient led to increased yield of test crop which built up maximum K uptake. The control and single practice of micronutrient resulted in positive S balance, while paired ZnB or ZnMo or BMo or ZnBMo maintained a negative S balance. The combined micronutrient either couple or in combination along with recommended dose of S contributed to get higher yield as well as maximum S uptake by lentil, although negative S balance was found. The result is in agreement with the findings of Kihara et al. (2017). Zinc balance was positive in combined application of Zn with other micronutrients that indicated increased use of this Zn fertilizer in deficient soil. In case of B, the balance was positive in the combined application of micronutrients with B that pointed to the use of the B containing fertilizer in the present study. The negative balance of both Zn and B showed in either Zn or B untreated plot. Similar result was reported by Jahan et al. (2015) in a mono crop cultivation of mungbean. The plant tissue analysis results were detected with the deficiency of Zn and B in lentil (data not present) which recommended for increasing of Zn and B fertilization.

The results of postharvest soils in this study indicated that application of Zn, B, and Mo at the rate of 3, 2 and 1 kg ha⁻¹ had remarkable effect on soil micronutrient contents. Increased biomass and activity of microbes in soil are obtained with the incorporation of pulse crops in intensive
cropping systems. Nourishing those microbes by growing pulses enhances soil structure improvement and availability of nutrients (Singh et al. 2018). The present study substantiated that application of micronutrients can, therefore, increase crop performance, uptake and soil micronutrient status.

The manuscript lacks in Mo results because methods of Mo analyses in soil and plant samples are not well developed.

**Conclusions**

From three years’ study, it is clear that combined micronutrient application at 3 kg Zn ha\(^{-1}\), 2 kg B ha\(^{-1}\) and 1 kg Mo ha\(^{-1}\) significantly increased the seed yield of lentil. The employment of micronutrients (Zn, B and Mo) created an opportunity for having more pods setting and seed weight, which ultimately enhanced the seed yield (44 % increase over control). The increased yield might also be associated with the maximum number of nodules plant\(^{-1}\) and the highest protein content in seed obtained with the conjunctive use of the three micronutrients. In addition, the agronomic fortification of these nutrients (3 kg Zn ha\(^{-1}\), 2 kg B ha\(^{-1}\) and 1 kg Mo ha\(^{-1}\)) resulted in increased uptake of N, P, K, S, Zn and B uptake (N uptake increase by 88 %, P by 108 %, S by 128 %, K by 84, Zn by 69 % and B by 86 %). Based on the experiment, joint application of Zn, B and Mo helped to obtain higher results than that of their single or couple application. Application of Zn, B and Mo showed encouraging effects on Zn and B concentration in post-harvest soils. Results of the current study suggested that the combination of Zn, B and Mo applied at 3, 2 and 1 kg ha\(^{-1}\) along with N, P, K and S applied at 20, 22, 30 and 10 kg ha\(^{-1}\) might be recommended for yield maximization of lentil and sustenance of the fertility of calcareous soils in the Eastern Gangetic plains and Bangladesh.

**Acknowledgement:** This research work was conducted by the financial support of Pulses Research Centre in Bangladesh Agricultural Research Institute. Authors acknowledge to Head of...
Soil Science Division, BARI for providing laboratory facilities to analyze the plant and soil samples.

**Declarations of interest:** The authors have no conflicts of interests.

**References**


FAO. 2018. Analysis of Protein. Food and agriculture Origination publication, FAO Food and Nutrition Paper 14/7, Centre for Food Safety, UN.


Table 1. Fertility status of initial soil sample of the experimental field

<table>
<thead>
<tr>
<th>Location</th>
<th>pH</th>
<th>OM(%)</th>
<th>Total N (%)</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>P</th>
<th>S</th>
<th>Zn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jessore</td>
<td>8.1</td>
<td>1.65</td>
<td>0.073</td>
<td>18.0</td>
<td>1.75</td>
<td>0.13</td>
<td>15</td>
<td>15.5</td>
<td>0.48</td>
<td>0.16</td>
</tr>
<tr>
<td>Critical level</td>
<td>-</td>
<td>-</td>
<td>0.12</td>
<td>2.0</td>
<td>0.5</td>
<td>0.12</td>
<td>10</td>
<td>10</td>
<td>0.60</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Interpretation**

- Slightly alkaline
- Low
- Very low
- Very high
- High
- Low
- Medium
- Medium
- Low
- Low

*BARC (2012)*
Table 2. Effect of Zn, B and Mo on pods plant\(^{-1}\), seed weight of lentil (pooled data of 3-years) and seed yield of lentil during three years

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of pods plant(^{-1})</th>
<th>1000 seeds wt. (g)</th>
<th>Seeds yield (kg ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1(^{st}) yr.</td>
</tr>
<tr>
<td>(T_1) (Control)</td>
<td>55.9f</td>
<td>16.3f</td>
<td>1481c</td>
</tr>
<tr>
<td>(T_2) (Zn @ 3 kg ha(^{-1}))</td>
<td>63.5e</td>
<td>18.6e</td>
<td>1656c</td>
</tr>
<tr>
<td>(T_3) (B @ 2 kg ha(^{-1}))</td>
<td>67.8cde</td>
<td>20.3cd</td>
<td>1603c</td>
</tr>
<tr>
<td>(T_4) (Mo @ 1 kg ha(^{-1}))</td>
<td>65.8de</td>
<td>19.4de</td>
<td>1575c</td>
</tr>
<tr>
<td>(T_5) (Zn @ 3 kg ha(^{-1}) + B @ 2 kg ha(^{-1}))</td>
<td>71.5bcd</td>
<td>18.8e</td>
<td>1942ab</td>
</tr>
<tr>
<td>(T_6) (Zn @ 3 kg ha(^{-1}) + Mo @ 1 kg ha(^{-1}))</td>
<td>72.3bc</td>
<td>21.9b</td>
<td>1896b</td>
</tr>
<tr>
<td>(T_7) (B @ 2 kg ha(^{-1}) + Mo @ 1 kg ha(^{-1}))</td>
<td>77.0ab</td>
<td>20.7bc</td>
<td>1862b</td>
</tr>
<tr>
<td>(T_8) (Zn @ 3 kg ha(^{-1}) + B @ 2 kg ha(^{-1}) + Mo @ 1 kg ha(^{-1}))</td>
<td>81.2a</td>
<td>24.6a</td>
<td>2075a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.95</td>
<td>3.46</td>
<td>5.72</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>6.02</td>
<td>1.22</td>
<td>176</td>
</tr>
</tbody>
</table>

Values within the same column with a common letter do not differ significantly (P<0.05)
Table 3. Effect of Zn, B and Mo on number of nodules plant\(^{-1}\) in different dates (pooled data of 3- years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>No. of nodules plant(^{-1}) at 32 DAS</th>
<th>No. of nodules plant(^{-1}) at 50 DAS</th>
<th>No. of nodules plant(^{-1}) at 68 DAS</th>
<th>No. of nodules plant(^{-1}) at 86 DAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>T(_1)</td>
<td>15.9c</td>
<td>31.7e</td>
<td>42.2e</td>
<td>26.2e</td>
</tr>
<tr>
<td>T(_2)</td>
<td>16.8c</td>
<td>39.5d</td>
<td>48.2d</td>
<td>28.4cd</td>
</tr>
<tr>
<td>T(_3)</td>
<td>16.5c</td>
<td>38.9d</td>
<td>47.6d</td>
<td>27.7de</td>
</tr>
<tr>
<td>T(_4)</td>
<td>19.6b</td>
<td>46.7bc</td>
<td>57.9bc</td>
<td>30.2bc</td>
</tr>
<tr>
<td>T(_5)</td>
<td>18.9b</td>
<td>44.9c</td>
<td>56.4c</td>
<td>30.4ab</td>
</tr>
<tr>
<td>T(_6)</td>
<td>19.8b</td>
<td>48.4ab</td>
<td>60.7ab</td>
<td>31.2ab</td>
</tr>
<tr>
<td>T(_7)</td>
<td>19.9b</td>
<td>47.5b</td>
<td>60.4ab</td>
<td>30.2bc</td>
</tr>
<tr>
<td>T(_8)</td>
<td>21.3a</td>
<td>50.6a</td>
<td>63.5a</td>
<td>32.3a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>3.90</td>
<td>3.00</td>
<td>3.27</td>
<td>3.68</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>1.27</td>
<td>2.28</td>
<td>3.13</td>
<td>1.90</td>
</tr>
</tbody>
</table>

Values within the same column with a common letter do not differ significantly (P<0.05)

**Note:** T\(_1\) (Control), T\(_2\) (Zn @ 3 kg ha\(^{-1}\)), T\(_3\) (B @ 2 kg ha\(^{-1}\)), T\(_4\) (Mo @ 1 kg ha\(^{-1}\)), T\(_5\) (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)), T\(_6\) (Zn @ 3 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)), T\(_7\) (B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)) and T\(_8\) (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)).
Table 4. Effect of Zn, B and Mo on uptake of N, P, K, S, Zn and B by lentil (seed+straw) (pooled data of 3-years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>S</th>
<th>Zn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg ha(^{-1})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T(_1)</strong></td>
<td>65.9d</td>
<td>4.80e</td>
<td>16.5e</td>
<td>7.06d</td>
<td>0.128e</td>
<td>0.071e</td>
</tr>
<tr>
<td><strong>T(_2)</strong></td>
<td>88.1c</td>
<td>6.96d</td>
<td>19.6d</td>
<td>9.32c</td>
<td>0.169cd</td>
<td>0.084de</td>
</tr>
<tr>
<td><strong>T(_3)</strong></td>
<td>88.2c</td>
<td>7.10d</td>
<td>21.0cd</td>
<td>9.71c</td>
<td>0.160d</td>
<td>0.096cd</td>
</tr>
<tr>
<td><strong>T(_4)</strong></td>
<td>90.1c</td>
<td>6.59d</td>
<td>22.2c</td>
<td>9.96c</td>
<td>0.162d</td>
<td>0.087d</td>
</tr>
<tr>
<td><strong>T(_5)</strong></td>
<td>106b</td>
<td>8.16bc</td>
<td>26.7b</td>
<td>12.6b</td>
<td>0.200b</td>
<td>0.117b</td>
</tr>
<tr>
<td><strong>T(_6)</strong></td>
<td>105b</td>
<td>7.50cd</td>
<td>25.4b</td>
<td>12.8b</td>
<td>0.185bc</td>
<td>0.109bc</td>
</tr>
<tr>
<td><strong>T(_7)</strong></td>
<td>110b</td>
<td>8.61b</td>
<td>26.6b</td>
<td>13.3b</td>
<td>0.196b</td>
<td>0.117b</td>
</tr>
<tr>
<td><strong>T(_8)</strong></td>
<td>124a</td>
<td>9.98a</td>
<td>30.4a</td>
<td>16.0a</td>
<td>0.218a</td>
<td>0.133a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>4.06</td>
<td>7.43</td>
<td>5.21</td>
<td>9.49</td>
<td>5.44</td>
<td>7.74</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>6.90</td>
<td>0.97</td>
<td>2.15</td>
<td>1.89</td>
<td>0.02</td>
<td>0.014</td>
</tr>
</tbody>
</table>

Values within the same column with a common letter do not differ significantly (P<0.05)

**Note:** T\(_1\) (Control), T\(_2\) (Zn @ 3 kg ha\(^{-1}\)), T\(_3\) (B @ 2 kg ha\(^{-1}\)), T\(_4\) (Mo @ 1 kg ha\(^{-1}\)), T\(_5\) (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)), T\(_6\) (Zn @ 3 kg ha\(^{-1}\)+ Mo @ 1 kg ha\(^{-1}\)), T\(_7\) (B @ 2 kg ha\(^{-1}\)+ Mo @ 1 kg ha\(^{-1}\)) and T\(_8\) (Zn @ 3 kg ha\(^{-1}\)+ B @ 2 kg ha\(^{-1}\)+ Mo @ 1 kg ha\(^{-1}\)).
Table 5. Effect of Zn, B and Mo on Zn and B concentrations in soil (average data of 3 years) with reference to initial soil

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Zn</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>T₁ (Control)</td>
<td>55.9f</td>
<td>16.3f</td>
</tr>
<tr>
<td>T₂ (Zn @ 3 kg ha⁻¹)</td>
<td>63.5e</td>
<td>18.6e</td>
</tr>
<tr>
<td>T₃ (B @ 2 kg ha⁻¹)</td>
<td>67.8ede</td>
<td>20.3cd</td>
</tr>
<tr>
<td>T₄ (Mo @ 1 kg ha⁻¹)</td>
<td>65.8de</td>
<td>19.4de</td>
</tr>
<tr>
<td>T₅ (Zn @ 3 kg ha⁻¹ + B @ 2 kg ha⁻¹)</td>
<td>71.5bed</td>
<td>18.8e</td>
</tr>
<tr>
<td>T₆ (Zn @ 3 kg ha⁻¹ + Mo @ 1 kg ha⁻¹)</td>
<td>72.3bc</td>
<td>21.9b</td>
</tr>
<tr>
<td>T₇ (B @ 2 kg ha⁻¹ + Mo @ 1 kg ha⁻¹)</td>
<td>77.0ab</td>
<td>20.7bc</td>
</tr>
<tr>
<td>T₈ (Zn @ 3 kg ha⁻¹ + B @ 2 kg ha⁻¹ + Mo @ 1 kg ha⁻¹)</td>
<td>81.2a</td>
<td>24.6a</td>
</tr>
</tbody>
</table>

CV (%) 4.95  3.46

LSD (0.05) 6.02  1.22

Note: T₁ (Control), T₂ (Zn @ 3 kg ha⁻¹), T₃ (B @ 2 kg ha⁻¹), T₄ (Mo @ 1 kg ha⁻¹), T₅ (Zn @ 3 kg ha⁻¹ + B @ 2 kg ha⁻¹), T₆ (Zn @ 3 kg ha⁻¹ + Mo @ 1 kg ha⁻¹), T₇ (B @ 2 kg ha⁻¹ + Mo @ 1 kg ha⁻¹) and T₈ (Zn @ 3 kg ha⁻¹ + B @ 2 kg ha⁻¹ + Mo @ 1 kg ha⁻¹).
List of figures
Figure 1. Weather condition during the experiment period
Figure 2. Relationship between number of pods plant$^{-1}$ and seed yield (left); 1000-seed weight and seed yield of lentil (right)
Figure 3. Effect of Zn, B and Mo on protein content (%) in lentil seed (pooled data of 3-years)
Figure 4. Effects of Zn, B and Mo on the physiological efficiency (PE) of N, P, K, S, Zn and B in lentil.
Figure 5. Effects of Zn, B and Mo on the apparent balance of N, P, K and S in lentil plot.
Figure 6. Effects of Zn, B and Mo on the apparent balance of Zn and B in lentil plot.
Figure 7. Effect of Zn, B and Mo on % seed yield increment over control (mean of three years)
Figure 1. Weather condition during the experiment period
Figure 2. Relationship between number of pods plant$^{-1}$ and seed yield (left); 1000-seed weight and seed yield of lentil (right)
Figure 3. Effect of Zn, B and Mo on protein content (%) in lentil seed (pooled data of 3-years)

Means followed by uncommon letter (S) are significantly different from each other at 5% level of significance. Errors bars represent the Standard error mean (SEM). Note: T1 (Control), T2 (Zn @ 3 kg ha\(^{-1}\)), T3 (B @ 2 kg ha\(^{-1}\)), T4 (Mo @ 1 kg ha\(^{-1}\)), T5 (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)), T6 (Zn @ 3 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)), T7 (B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)) and T8 (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)).
Figure 4. Effects of Zn, B and Mo on the physiological efficiency (PE) of N, P, K, S, Zn and B in lentil. Errors bars represent the SEM. Note: T1 (Control), T2 (Zn @ 3 kg ha\(^{-1}\)), T3 (B @ 2 kg ha\(^{-1}\)), T4 (Mo @ 1 kg ha\(^{-1}\)), T5 (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)), T6 (Zn @ 3 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)), T7 (B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)) and T8 (Zn @ 3 kg ha\(^{-1}\)+B @ 2 kg ha\(^{-1}\)+Mo @ 1 kg ha\(^{-1}\)).
Figure 5. Effects of Zn, B and Mo on the apparent balance of N, P, K and S in lentil plot. Errors bars represent the SEM. Note: T₁ (Control), T₂ (Zn @ 3 kg ha⁻¹), T₃ (B @ 2 kg ha⁻¹), T₄ (Mo @ 1 kg ha⁻¹), T₅ (Zn @ 3 kg ha⁻¹+B @ 2 kg ha⁻¹), T₆ (Zn @ 3 kg ha⁻¹+ Mo @ 1 kg ha⁻¹), T₇ (B @ 2 kg ha⁻¹+ Mo @ 1 kg ha⁻¹) and T₈ (Zn @ 3 kg ha⁻¹+B @ 2 kg ha⁻¹+ Mo @ 1 kg ha⁻¹).
Figure 6. Effects of Zn, B and Mo on the apparent balance of Zn and B in lentil plot. Errors bars represent the SEM. Note: T\textsubscript{1} (Control), T\textsubscript{2} (Zn @ 3 kg ha\textsuperscript{-1}), T\textsubscript{3} (B @ 2 kg ha\textsuperscript{-1}), T\textsubscript{4} (Mo @ 1 kg ha\textsuperscript{-1}), T\textsubscript{5} (Zn @ 3 kg ha\textsuperscript{-1}+B @ 2 kg ha\textsuperscript{-1}), T\textsubscript{6} (Zn @ 3 kg ha\textsuperscript{-1}+ Mo @ 1 kg ha\textsuperscript{-1}), T\textsubscript{7} (B @ 2 kg ha\textsuperscript{-1}+ Mo @ 1 kg ha\textsuperscript{-1}) and T\textsubscript{8} (Zn @ 3 kg ha\textsuperscript{-1}+B @ 2 kg ha\textsuperscript{-1}+ Mo @ 1 kg ha\textsuperscript{-1}).
Figure 7. Effect of Zn, B and Mo on % seed yield increment over control (mean of three years)

Errors bars represent the SEM. **Note:** T1 (Control), T2 (Zn @ 3 kg ha⁻¹), T3 (B @ 2 kg ha⁻¹), T4 (Mo @ 1 kg ha⁻¹), T5 (Zn @ 3 kg ha⁻¹+B @ 2 kg ha⁻¹), T6 (Zn @ 3 kg ha⁻¹+Mo @ 1 kg ha⁻¹), T7 (B @ 2 kg ha⁻¹+Mo @ 1 kg ha⁻¹) and T8 (Zn @ 3 kg ha⁻¹+B @ 2 kg ha⁻¹+Mo @ 1 kg ha⁻¹).