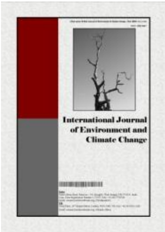

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Effect of Zn and B on Lentil (*Lens culinaris*) Growth Characteristics, Yield, and Available Nutrients in the Soil

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To assess the effects of Zn and B treatment, a field experiment was carried out during the rabi seasion 2020–21 at the Crop Research Center of the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). Ten treatments, each with a different combination of control, RDF, Zn, and B, were examined using a randomised block design with three replications. The experimental results revealed that growth attributing traits *viz.* Plant population (ha^{-1}), Plant height (cm), Number of branches $plant^{-1}$, Dry matter accumulation (g m^{-2}), Effective nodules (No. $plant^{-1}$), Nodules dry weight (mg $plant^{-1}$), yield *viz.* grain yield, straw yield, biological yield and harvest index and Available nutrient in soil N, P, K, Zn, S and B in lentil differed significantly among different treatments. Growth parameters and yield 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}

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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. Zn and B, together with N, P, K, and S, were used in lentils in a balanced manner to preserve soil fertility while also improving growth characteristics and yield.

Keywords: Micronutrient; boran; zinc; sulphur; lentil.

1. INTRODUCTION

A nutrient-rich food legume, lentil (*Lens culinaris* Medic.), is a member of the *Fabaceae* family and is frequently referred to as an old crop in modern times. It is a grain legume with a high nutrient content that is grown in temperate climates. Its seed is a good source of fibre (4 g), ash (2.1 g), calcium (68 mg), phosphorus (325 mg), iron (7.0 mg), sodium (29 mg), potassium (780 mg), thiamine (0.46 mg), riboflavin (0.33 mg), and niacin (1.3 mg). It also has a relatively higher content of dietary protein (340–346 g). Among all the winter season legumes, lentil is the most abundant supply of vital amino acids (lysine, arginine, leucine, and other S-containing amino acids) [1]. Pulses are particularly significant for food security in low-income nations since they provide 5% of the daily energy intake and 10% of the daily protein intake, respectively [2]. Pulses produced 87.40 million tonnes of grain with an average productivity of 1023 kg ha^{-1} on 85.40 million hectares of worldwide cropland in 2017. Still, though, the output of pulses is not keeping up with the daily minimum protein requirement of 60 g [3]. Around 6.58 million ha of land were planted with lentils globally in 2017, producing 7.59 million tonnes with an average yield of 1153 kg ha^{-1} [4]. 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 [3]. After Canada, India is the second-largest producer of lentils. India, Canada, Turkey, Bangladesh, Iran, China, Nepal, and Syria are among the biggest lentil-producing nations in the world [5]. Lentil output in India reached an all-time high of 1.61 million tonnes from an area of 1.55 million ha at the all-time high yield level of 1034 kg ha^{-1} [3]. According to Singh et al. [6], lentils are the third-most significant pulse crop in North India and are mostly farmed as a rainfed crop in the states of Uttar Pradesh, Uttarakhand, Madhya Pradesh, Jharkhand, Bihar, and West Bengal. Lentil, which ranks second among all legumes in terms of protein content per calorie behind soybean, is a key component of the diets of developing nations [7]. By influencing the plant itself and the symbiotic nitrogen fixation process, micronutrients have a significant impact on the yield of pulses. Due to their deficiency in soil, which is primarily caused by the removal of micronutrients from long-term crop production, increased use of only high analysis fertilizers, higher micronutrient requirements associated with higher crop yields, decreased use of animal manures in crop production, and use of high P concentrations from long-term applications, there is a great need for micronutrients today. About 200 enzymes and transcription factors require zinc, a crucial trace metal [8]. Zn is essential for the metabolism of auxin, nitrogen, and other nutrients as well as for the production of cytochrome C, stabilising ribosomal fractions, protecting cells from oxidative stress, and influencing the activities of many enzymes [9]. Field crops with a zinc shortage develop interveinal chlorosis and lower leaf necrosis with poor growth. Low-Zn seeds may have produced plants that are extremely vulnerable to biotic and abiotic stress [10]. All plant meristems need a constant supply of boron from the soil since it is non-mobile in plants and necessary for the synthesis of cell walls, lignification, and structural integrity of bio membranes, stabilizing the ratio of sugars to starches, pollination, and seed generation [11]. The production of pods and seeds, as well as cell division, depends greatly on boron [12]. Through seed treatment, foliar sprays, and soil fertilization, these micronutrients can be supplied to crops. Each technique has the potential to have an impact on the micronutrient nutrition of plants, both directly in the treated plant and in the offspring plants through nutrient enrichment of the parent plant's seeds.

2. MATERIALS AND METHODS

In the Indo-Gangetic plains of Western Uttar Pradesh, during the *rabi* season of 2020–21, a field experiment was carried out at Sardar Vallabh bhai Patel University of Agriculture and Technology. At an altitude of 230 metres above mean sea level, 290 5′ 34″ N latitude, 770 41′ 58″ E longitudes. While the mean weekly low temperature varied from 4.9°C to 16.63°C, the weekly maximum temperature ranged from 18.70°C to 32.99°C. Between 94.86 and 32.86%, the mean relative humidity ranged. Whereas, 39.8 mm of rain fell overall during the crop period. Before the experiment began, a composite soil sample (0–15 cm depth) was taken from the test site and examined for its physico-chemical composition. The soil in the test field was a sandy clay loam with a mildly alkaline response. The soil had a low amount of nitrogen readily available but a medium amount of available phosphorus and potassium as in Table 1 given.

2.1 Variety and Nutrient

The experiment used the (Pusa Vaibhav) variety, which was released from IARI New Delhi in 1996 and is suitable for NWPZ (Punjab, Haryana, Delhi, and West UP), with a seed rate of @50 kg ha^{-1} and a furrow depth of approximately 5 cm that was manually opened at a row distance of 30 cm using a furrow opener. It has a production potential of 20–24 q ha^{-1}, is small-seeded, rust- and wilt-tolerant, and typically matures in 130–135 days. In this experiment, the recommended doses of N, P, K, and S were administered using DAP, MOP, urea, and bentonite, respectively, at 20, 50, 20, and 40 kg ha^{-1}. According to the treatments, zinc and boron were applied by zinc sulphate monohydrate and borax as a basal dose.

2.2 Growth Attribute

2.2.1 Plant population

Plant populations per meter row length were recorded at harvest stages in all plots and then averaged.

2.2.2 Plant height (cm)

The height of five randomly selected plants were measured from the ground level to the base of apical bud with the help of a meter scale at harvest and mean height was computed.

Table 1. Physico-chemical composition of the experimental soil

S. No.	Particular	Values	Method adopted
1	**Physical properties**		
1.	Soil texture	Sandy loam	Bouyoucos hydrometer method [13]
1.1	Sand (%)	62.2	Triangle method
1.2	Silt (%)	20.5	
1.3	Clay (%)	17.3	
2.	Bulk density	1.36	Core sampler method [14]
2.1	Particle density	2.63	Pycnometer Method Danielson and Sutherland [15]
3.	Soil pH (1:2.5)Soil water Suspension)	7.8	Glass electrode pH meter [16]
4.	EC(ds/m) 1:2.5,Soil water Suspension	0.34	Solbridge conductivity meter method [16]
2	**Chemical properties**		
5.	Organic carbon (%)	0.45	Modified Walkley and Black method [17]
6.	Available nitrogen (kg ha^{-1})	191.5	Alkaline potassium permanganate method [18]
7.	Available phosphorus (kg ha^{-1})	12.5	[19]
8.	Available potassium (kg ha^{-1})	193.6	1N NH_4OAc Extraction method [20]
9.	DTPA extractable Zinc ppm	0.78	DTPA extractant and estimated on atomic Absorption spectrophotometer [21]
10.	Boron (mg kg^{-1})	30	Hot water extractable [22]
11.	Sulphur (mg kg^{-1})	8.4	$CaCl_2$ extractable Sulphur [23]

2.2.3 Number of branches per plant

The number of basal branches arising from main shoot were counted in all five randomly marked plants at harvest and then mean were determined for each stage.

2.2.4 Number of nodules and dry weight of nodules

Five plants from each plot were uprooted thoroughly and kept in a tub filled with water. The roots of the plants was be washed in the tub and then nodules per plant was counted. All the nodules from the roots were detached and kept for drying in hot air oven at 60^0C. At that the dry weight per plant were recorded.

2.2.5 Dry matter accumulation (g m^{-2})

The plant samples were cut close to the ground at harvest. The plant samples was sun dried and then dried in oven at 70^0C till the constant weight obtained. Therefore, final weight was recorded.

2.3 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" [24].

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

2.4 Soil Analysis

2.4.1 Available nitrogen

Available nitrogen in soil was determined by the procedure outlined by [18].

2.4.2 Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 [19]. Phosphorus in the extract was determined by developing blue colour with reduction of phospho-molybdate complex and the colour intensity was measured calorimetrically at 660 nm wave lengths.

2.4.3 Available potassium

Exchangeable K content of soil was determined on 1 N NH_4OAC (pH 7.0) extract of the soil by using flame photometer [20].

2.4.4 Available Zinc

Available Zn in soil was estimated by using DTPA as an extractant [21] and its concentration were read on Atomic Absorption Spectrophotometer (GBC- Avanta PM Model).

2.4.5 Available Sulphur

Available sulphur is present in mineral soil in the form of adsorbed SO_4-ion. To replace this adsorbed SO_4- ions calcium chloride was used. Then SO_4 content of the extract was determined by turbidimetric method as proposed by [23].

2.4.6 Available Boron

Available B in soil was estimated by extraction with water directly on a hot plate. Use of azomethine-H in place of carmine or curcumin has further simplified the determination of hot-water soluble B [22].

2.5 Statistical Analysis

Statistical analysis was done with the help of window-based SPSS (Statistical Product and Service Solutions)Version 10.0, SPSS, Chicago, IL. The SPSS technique was used for the analysis of variance to define the statistical significance of the treatment effect at a 5 % probability level. Further, F- test and the significance of the difference between the treatments were examined by critical difference (CD) as described by [25].

3. RESULTS AND DISCUSSION

3.1 Growth Attribute

3.1.1 Plant population

Plant population of lentil as influenced by different nutrient management at maturity

Table 2 with the application of (T_{10}) RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} was significantly higher than the rest of treatment, while minimum plant population (280014 ha^{-1}) was recorded under (T_1 control). Higher plant stand may be due to better management of micronutrients. Similar type of result was obtained by [26].

3.1.2 Plant height

At harvest of lentil, the plant height (Table 2 and Fig. 1) was ranged from 38.5 to 47.9 cm. The maximum plant height (47.9 cm) found in T_{10} was significantly superior to control and statistically at par with rest of treatments, and increased by 24.4 % over control (T_1), while minimum (38.5 cm) was observed in control (T_1). The basal application of chemical fertilizers meets the nutritional requirement of crop for proper establishment and growth during the initial period. “The increased plant height might be due to the involvement of nutrients in cell wall development and cell differentiation which resulted in elongation of shoot and root in plants”. Similar results were obtained by [27] who had reported that an appropriate supply of nutrients through inorganic sources increased the plant height of lentil through active photosynthesis. The results are in agreement with the findings of [28] and [29].

3.1.3 Number of branches

At harvest branches decreased slightly and ranged from 2.8 to 4.1 $plant^{-1}$ (Table 2). The highest number of branches $plant^{-1}$ (4.1) recorded in T_{10} RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} T_8 has same value which was statistically at par to T_8 while significantly higher than rest of treatments and lowest were 2.8 $plant^{-1}$ T_1 in (control). The increase in branches in (T_{10}) per plant over (T_1) control was 46.4%. The increased number of branches could be attributed to nutritional participation in cell wall formation and cell differentiation, which resulted in plant shoot and root elongation. The findings are consistent with those of [30] and [8].

3.1.4 Dry matter accumulation

At harvest dry matter accumulation ranged from 177.1 to 269.7 (g m^2) (Table 2 and Fig. 1). The highest dry matter accumulation recorded in T_{10} RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}which was significantly higher to (T_1) control while statistically at par to rest of treatments and lowest were in T_1 (control). The dry matter accumulation in (T_{10}) RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (g m^2) over (T_1) control was 52.3%. Similar kind of trend was observed by (Kumari and Ushakumari, 2002) who reported that the application of @ 30 kg P_2O_5 in cow pea significantly improved the dry matter [31] also reported the application of RDF + nitrogen + @ 26 P_2O_5 kg ha^{-1} and S @ 40 kg ha^{-1} in lentil, significantly increased dry matter accumulation in lentil. The results reported by (Meena, 2013) are also in close conformities with these findings.

3.1.5 Effective nodules (No. $plant^{-1}$) and nodules dry weight (mg $plant^{-1}$)

The number of effective nodules $plant^{-1}$ and nodules dry weight in lentil was significantly influence by Zn and B application on effective nodules at 45 DAS (Table 2 and Fig. 1). The maximum number of effective nodules $plant^{-1}$ was recorded under T_{10} (37.7) which was statistically at par to treatment T_8 RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1} and significantly higher than the rest of treatment. While minimum (25.3 $plant^{-1}$) in control (T_1). Number of effective nodules $plant^{-1}$ increased by 49% in T_{10} RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} over control (T_1) 45 DAS. The nodules dry weight of lentil was did not differ significantly under the influence of different treatments. The maximum nodules dry weight (67.1 mg $plant^{-1}$) observed with the application of (T_{10}) RDF + Boron 2 kg ha^{-1} + Zinc 5 kg $ha^{-1}$and minimum (55.3 mg $plant^{-1}$) in control. Effective nodule and nodule dry weight may be increased due to customized management of micronutrients. Similar type of results was also found by [32] and (Singh, 2017).

3.2 Yield

The data pertaining to yield presented in Table 3 and Fig. 2 *ie*. Grain, straw, biological yield and harvest index. 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 [33,34] and [28].

3.3 Available Nutrients in Soil

Available nutrients in soil as present in Table 4 and Fig. 3 Shows that available nitrogen revealed that numerically value of available nitrogen was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. After crop harvest available nitrogen in soil ranged from 175.2 to 210.5 kg ha^{-1}. Maximum available nitrogen (210.5 kg ha^{-1}) was observed in T_{10} (RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}), while minimum (210.5 kg ha^{-1}) in control (T_1). For available phosphorus the data presented revealed that numerical value of available phosphorus was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. It is clear from the data available soil phosphorus at harvest differed significantly under the influence of different treatments. After crop harvested available P in soil ranged from 11.5 to 14.9 kg ha^{-1} under different treatments. Maximum available phosphorus (14.9 kg ha^{-1}) statistically at par in 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 the rest treatments was found in RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}), while minimum (11.5 kg ha^{-1}) in control (T_1). For available potassium the data presented revealed that numerical value of available potassium was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. It is clear from the data available soil potassium at harvest differed significantly under the influence of different treatments. After crop harvested available K in soil ranged from 180.7 to 210.8 kg ha^{-1} under different treatments. Maximum available potassium (210.8 kg ha^{-1}) was did not differed significantly by the application of Zn and B during experimentation. The available potassium minimum (180.7 kg ha^{-1}) in control (T_1). For available zinc the data presented revealed that numerically value of available zinc was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. It is clear from the data available soil zinc at harvest differed significantly under the influence of different treatments. After crop harvested available Zn in soil ranged from 0.77 to 0.80 g ha^{-1} under different treatments. Maximum available zinc (0.80 g ha^{-1}) was did not differed significantly by the application of Zn and B during experimentation. The available zinc minimum (0.77 g ha^{-1}) in control (T_1). For available Sulphur the data presented revealed that numerically value of available sulphur was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. It is clear from the data available soil sulphur at harvest differed significantly under the influence of different treatments. After crop harvested available S in soil ranged from 7.6 to 10.6 kg ha^{-1} under different treatments. Maximum available sulphur (10.6 kg ha^{-1}) statistically at par in 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}) and T_7 (RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}) and significantly higher than the rest treatments was found in RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}), while minimum (7.6 kg ha^{-1}) in control (T_1). For available boron the data presented revealed that numerically value of available boron was observed with in application of RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}) over remaining treatments. It is clear from the data available soil boron at harvest differs significantly under the influence of different treatments. After crop harvested available B in soil ranged from 28.2 to 32.4 g ha^{-1} under different treatments. Maximum available boron (32.4 g ha^{-1}) statistically at par in 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}) and T_7 (RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}) and significantly higher than the rest treatments was found in RDF + Boron 2 g ha^{-1} + Zinc 5 kg ha^{-1} (T_{10}), while minimum (28.2 g ha^{-1}) in control (T_1). Increased availability of N, P, K, S, Zn and B in the soil might be due to balanced combined application of Zn and B. The combination of Zn and B customized fertilizer also facilitated more availability of N, P, K, S, Zn and B in soil and also more uptakes by crop. Results of similar kind have also been reported by [35]. "This might be due to its increased availability with the supplementation of these nutrients in soil". Increase in Zn and B content in soil by its application in soil has also been reported by [31] and [36].

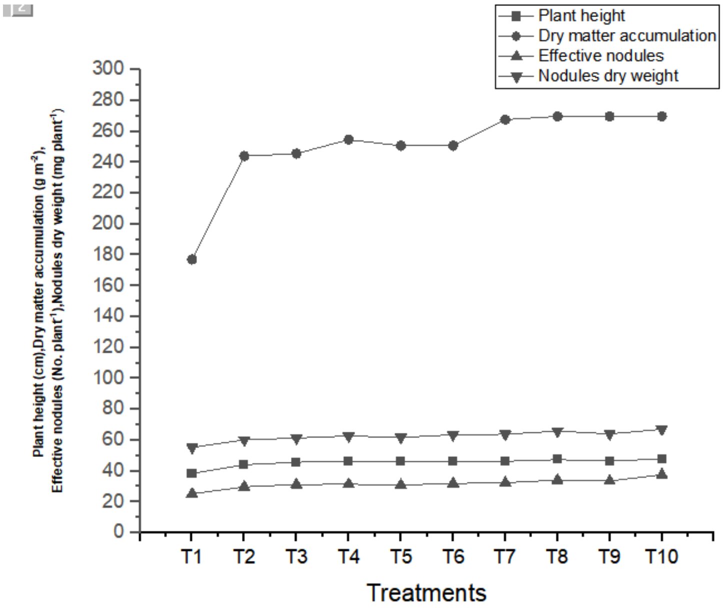

Fig. 1. Effect of Zn and B on, Plant height (cm), Dry matter accumulation (g m^{-2}), Effective nodules (No. $plant^{-1}$), Nodules dry weight (mg $plant^{-1}$) at harvest

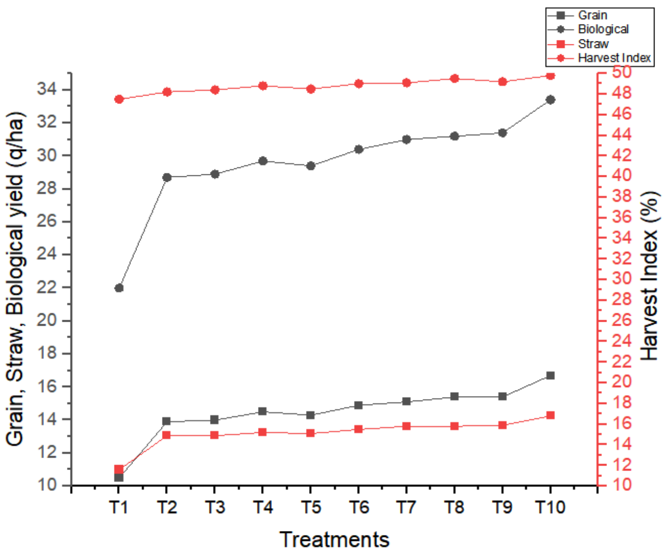

Fig. 2. Effect of Zn and B on yield on Lentil

Table 2. Effect of Zn and B on Lentil Plant population (ha^{-1}), Plant height (cm), Number of branches $plant^{-1}$, Dry matter accumulation ($g\ m^{-2}$), Effective nodules (No. $plant^{-1}$), Nodules dry weight (mg $plant^{-1}$) at harvest

Symbol	Treatments	Plant population (ha^{-1})	Plant height (cm)	Number of branches $plant^{-1}$	Dry matter accumulation ($g\ m^{-2}$)	Effective nodules (No. $plant^{-1}$)	Nodules dry weight (mg $plant^{-1}$)
T_1	Control	280014	38.5	2.8	177.1	25.3	55.3
T_2	RDF (N:P:K:S)	286518	44.1	3.3	244.0	29.8	60.2
T_3	RDF + Boron 1 kg ha^{-1}	287290	45.8	3.4	245.6	31.3	61.4
T_4	RDF + Boron 2 kg ha^{-1}	288340	46.3	3.4	254.6	31.5	62.8
T_5	RDF + Zinc 2.5 kg ha^{-1}	287801	46.2	3.4	250.7	31.0	61.8
T_6	RDF + Zinc 5 kg ha^{-1}	289380	46.2	3.5	250.7	32.0	63.5
T_7	RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	291104	46.4	3.5	267.6	32.5	63.9
T_8	RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	295589	47.4	4.1	269.7	34.2	65.9
T_9	RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}	292475	46.6	3.5	269.7	33.6	64.1
T_{10}	RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}	296590	47.9	4.1	269.7	37.7	67.1
	SEm (±)	**1948**	**1.6**	**0.11**	**9.08**	**1.17**	**2.24**
	C.D. (P=0.05)	**5476**	**4.8**	**0.35**	**27.18**	**3.51**	**NS**

Table 3. Effect of Zn and B on yield on Lentil

Symbol	Treatments	Yields (q/ha)			Harvest Index (%)
		Grain	**Straw**	**Biological**	
T_1	Control	10.5	11.6	22.0	47.5
T_2	RDF (N:P:K:S)	13.9	14.9	28.7	48.2
T_3	RDF + Boron 1 kg ha^{-1}	14.0	14.9	28.9	48.4
T_4	RDF + Boron 2 kg ha^{-1}	14.5	15.2	29.7	48.8
T_5	RDF + Zinc 2.5 kg ha^{-1}	14.3	15.1	29.4	48.5
T_6	RDF + Zinc 5 kg ha^{-1}	14.9	15.5	30.4	49.0
T_7	RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	15.1	15.8	31.0	49.1
T_8	RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	15.4	15.8	31.2	49.5
T_9	RDF + Boron 1 kg ha^{-1} + Zinc 5 kg_{ha}-1	15.4	15.9	31.4	49.2
T_{10}	RDF + Boron 2 kg ha^{-1} + Zinc 5 kg_{ha}-1	16.7	16.8	33.4	49.8
	SEm (±)	**0.5**	**0.5**	**1.0**	**1.7**
	C.D. (P=0.05)	**1.5**	**1.6**	**3.1**	**NS**

Table 4. Effect of Zn and B on available Nitrogen, Phosphorus, Zinc, Sulphur, Boron in Lentil at harvest

Symbol	Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Zinc (g ha^{-1})	Sulphur (kg ha^{-1})	Boron (g ha^{-1})
T_1	Control	175.2	11.5	180.7	0.77	7.6	28.2
T_2	RDF (N:P:K:S)	192.5	12.6	195.6	0.77	9.3	29.4
T_3	RDF + Boron 1 kg ha^{-1}	193.5	12.8	190.8	0.73	9.3	32.7
T_4	RDF + Boron 2 kg ha^{-1}	195.4	12.9	192.4	0.77	9.2	34.8
T_5	RDF + Zinc 2.5 kg ha^{-1}	195.5	13.2	198.2	0.80	9.4	29.8
T_6	RDF + Zinc 5 kg ha^{-1}	198.2	13.6	200.1	0.83	9.5	28.5
T_7	RDF + Boron 1 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	206.8	13.7	204.7	0.77	10.2	31.4
T_8	RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1}	209.5	13.6	207.4	0.77	10.5	33.2
T_9	RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}	208.5	14.1	208.7	0.83	10.4	31.4
T_{10}	RDF + Boron 2 kg ha^{-1} + Zinc 5 kg ha^{-1}	210.5	14.9	210.8	0.80	10.6	32.4
	SEm (±)	**7.12**	**0.48**	**7.10**	**0.037**	**0.34**	**1.14**
	C.D. (P=0.05)	**NS**	**1.43**	**NS**	**NS**	**1.02**	**3.42**

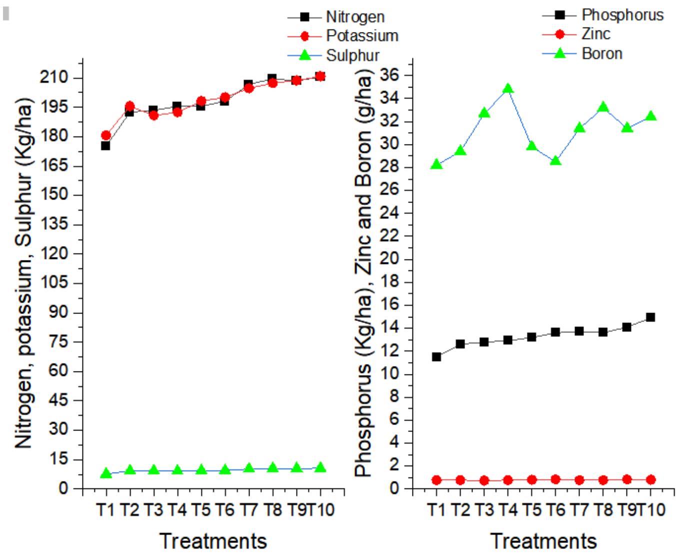

Fig. 3. Effect of Zn and B on available Nitrogen, Phosphorus, Zinc, Sulphur, Boron in Lentil at harvest

4. CONCLUSION

- Based on the results of this study, it can be stated that farmers can use the (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, followed by either the (T_8) - RDF + Boron 2 kg ha^{-1} + Zinc 2.5 kg ha^{-1} or the (T_9)- RDF + Boron 1 kg ha^{-1} + Zinc 5 kg ha^{-1}. The observations are based on data from one season, so it is advised that the experiment be repeated in the future on the same soil with the same layout to obtain more precise information.

- During the experiment it was also monitoring available nutrients in the soil. Because the data is taken just from one planting season, to get more precise results, the experiment will be repeated in the future in similar field conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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