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Foliar application of micronutrients improves the lentil (*Lens culinaris* M.) yield and net economic return

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Abstract
A field experiment was conducted during winter (*Rabi*) season of 2019-20 at Agricultural Research Farm, Department of Agronomy, Dolphin (PG) College of Science and Agriculture, Chunni Kalan, a campus of Punjabi University, Patiala, and Punjab. The experiment used a randomized block design with eight treatments T_1- RDF(40:40:20), T_2-RDF + Zn @ 5 kg ha^{-1}, T_3- RDF + Zn @ 10 kg ha^{-1}, T_4- RDF + Fe @ 5 kg ha^{-1}, T_5- RDF + Fe @ 10 kg ha^{-1}, T_6- RDF + B @ 5 kg ha^{-1}, T_7-RDF + B @ 10 kg ha^{-1}, and T_8- RDF + Zn + Fe+ B @ 5 kg ha^{-1} and three replications. Result revealed that Effect of foliar application of Zinc, Iron, Boron, and RDF was found best in terms of growth, yield and economic returns of lentil crop under irrigated conditions. Among all the treatments of, T_4 (RDF + Fe @ 5 kg ha^{-1}) was better in growth attributes and yield attributes. On the basis of maximum B: C ratio T_4 (RDF + Fe @ 5 kg ha^{-1}) should be suggested for the farmers of Punjab Region.

Keywords: Economic yield, fortification, growth and lentil

Introduction
India is the world's largest pulse-growing country, accounting for almost one-third of total pulse acreage and one-fourth of overall production. India, Canada, Turkey, Bangladesh, Iran, China, Nepal, and Syria are the world's largest lentil-growing countries (Ahlawat, 2012) [1]. Canada leads the globe in production, producing 2.87 million metric tons (MMT), or over 44% of the 6.54 MMT total anticipated in 2020. With 1.18, 0.53, 0.37, and 0.34 MMT, respectively, Australia, Turkey, the United States, and India are next. These five countries generated 82% of global output (FAO, Food and Agriculture Organization, 2021) [3]. Although lentil (*Lens culinaris* M.) contain around 60% carbohydrates, it is important to note that those carbohydrates are absorbed rather slowly in the stomach, resulting in a low glycemic index of around 30, compared to a reference 100 for white wheat bread (Dhull *et al.*, 2022) [2]. Lentil (*Lens culinaris* M.) is often high in micronutrients and has the ability to meet dietary requirements for iron (Fe), zinc (Zn), and selenium (Se) (Thavarajah *et al.*, 2015) [8].

Zinc is important in auxin metabolism, nitrogen metabolism, enzyme activity (e.g., dehydrogenase and carbonic anhydrase, proteinases and peptidases), cytochrome C production, ribosomal fraction stability, and cell defense against oxidative stress (Tisdale *et al.*, 1997: Obata *et al.*, 1999) [11, 6]. There are 200 enzymes and transcription factors that need zinc, making it a crucial trace element (Kabata-Pendias and Pendias, 1999) [5]. Boron is crucial in cell division as well as pod and seed development (Vitosh *et al.*, 1997) [10]. Boron is required for the formation of cell walls, lignification, and the structural integrity of bio membranes. Boron also regulates the balance of sugars and starches, as well as pollination and seed formation (Gupta *et al*., 1985) [4]. Iron enters various plant enzymes that perform important roles in photosynthesis and respiration oxidation-reduction processes.

Materials and Methods
The experiment was carried out at the Agronomy Research Farm of Dolphin (PG) college of Science and Agriculture, Chunni Kalan, a campus of Punjabi University in Patiala, Punjab, during the *Rabi* season 2019-2020. The soil in the experimental field had a slightly alkaline response (7.8 pH), was low in accessible nitrogen (244.5 kg ha^{-1}), low in organic carbon (0.48 percent), and medium in phosphorus (16.57 kg ha^{-1}) and potassium (260.5 kg ha^{-1}).

The test crop was Lentil LL 699, which was tested in a randomized block design with eight treatments T_1- RDF(40:40:20), T_2-RDF + Zn @ 5 kg ha^{-1}, T_3- RDF + Zn @ 10 kg ha^{-1}, T_4- RDF + Fe @ 5 kg ha^{-1}, T_5- RDF + Fe @ 10 kg ha^{-1}, T_6- RDF + B @ 5 kg ha^{-1}, T_7-RDF + B @10 kg ha^{-1}, and T_8- RDF + Zn + Fe+ B @ 5 kg ha^{-1} and three replications. The different treatments were applied at the time of sowing as a basal dressing through single superphosphate (SSP), urea, and MOP, respectively, and two foliar applications for time 50% flowering and 50% pod formation through Fe at 5 kg/h, Zn at 5 kg/ha, and B at 5 kg/ha.

Results and Discussion

Growth and developmental

The data pertaining to the germination percentage, number of nodules per plant plant height and Dry matter accumulation was given in the Table-1. The highest germination percentage (95.8%) was recorded by T_4 (RDF + Fe @ 5 kg ha^{-1}), while the lowest germination percentage (87.3%) was noted for RDF. Compared to the T_4 (RDF + Fe @ 5 kg ha^{-1}), the RDF had the highest (13.3%) and the lowest (4.8%) percentage of unterminated seeds.

Table 1: Effect of foliar application Zinc, Iron, Boron, and RDF in lentil

Treatments	Germination (%)	Number of Nodules/plant	Plant heights At harvest (cm)	Dry matter (g) at 90 DAS
T_1 = RDF(40:40:20)	87.3	4.02	17.67	1.633
T_2 = RDF + Zn @ 5 kg/ha	92.3	8.35	20.12	1.998
T_3 = RDF + Zn @ 10 kg/ha	91.8	3.75	19.02	1.878
T_4 = RDF + Fe @ 5 kg/ha	95.8	10.62	21.86	2.504
T_5 = RDF + Fe @ 10 kg/ha	92.8	6.68	18.88	1.609
T_6 = RDF + B @ 5 kg/ha	91.8	10.02	21.36	2.145
T_7 = RDF + B @ 10 kg/ha	89.3	8.15	19.87	2.131
T_8 = RDF + RDF + Zn + Fe +B 5 kg/ha	89.8	7.55	18.3	1.529
S.Em±	1.94	0.27	0.65	0.08
C.D (P=0.05)	5.68	0.78	1.90	0.29

Treatment T_4 recorded the maximum number of nodules per plant whereas the lowest was recorded by the RDF. Treatment T_2, T_4 and T_6 recorded the significantly higher number of nodules per plant than the T_3, T_5 and T_7. There was a significant difference in plant height due to the micronutrient treatments at harvest of the crop. The highest plant height was recorded in T_4 at all the four stages compared to the RDF, followed by T_6. Both T_4 and T_6 registered significantly higher plant height compared to the RDF at the harvest. Dry matter accumulation was adversely affected by the increase in micronutrient concentration as well as combination. The effect of T_4 (2.504g), T_6 (2.145g) and T_7 (2.131g) were statistically on par with each other in relation to dry matter accumulation and significantly higher than the RDF (1.633) at 90 DAS.

Yield and economic study

Seed yield of lentil and straw yield were presented in the Table-2. The data revealed that RDF + micronutrient treatments had a statistically significant effect on seed yield and straw yield, in lentil crop. T_4 (1545.7 kg ha^{-1}) recorded significantly higher seed yield followed by T_6 (1481.3 kg ha^{-1}), T_2 (1303.6 kg ha^{-1}), T_5 (1239.9 kg ha^{-1}), T_7 (1301.2 kg ha^{-1}), T_3 (1221.5 kg ha^{-1}) and T_8 (1193.7 kg ha^{-1}). The lowest seed yield was recorded under T_8 (119307 kg ha^{-1}). Application of T_4 and T_6 along with RDF recorded 33.0% and 27.5% increase in seed yield respectively. Maximum Straw yield was recorded in T_8 (5508.7 kg ha^{-1}) and minimum was recorded in T_2 (4886.7 Kg ha^{-1}). T_4, T_8 and RDF recorded significantly higher straw yield than T_2.

Table 2: Effect of foliar application of Zinc, Iron, Boron, and RDF in yield and economic study lentil

Treatments	Seed yield (Rs/acre)	Straw yield (Rs/acre)	Gross Returns (Rs/acre)	Net Returns (Rs/acre)	B:C Ratio
T_1 = RDF(40:40:20)	1163.7	5474.6	44802.45	38482.45	1.16
T_2 = RDF + Zn @ 5 kg/ha	1303.6	4886.7	50188.60	42747.60	1.17
T_3 = RDF + Zn @ 10 kg/ha	1221.5	4890.5	47027.75	35708.75	1.32
T_4 = RDF + Fe @ 5 kg/ha	1545.7	5466.9	59509.45	52003.45	1.38
T_5 = RDF + Fe @ 10 kg/ha	1239.9	4997.7	47736.15	36295.15	1.32
T_6 = RDF + B @ 5 kg/ha	1481.3	4943.8	57030.05	49584.05	1.15
T_7 = RDF + B @ 10 kg/ha	1301.2	5276.7	50096.20	38675.20	1.30
T_8 = RDF + RDF + Zn + Fe + B (5 kg/ha)	1193.7	5508.7	45957.45	33413.45	1.14
S.Em±	23.99	140.04	2268.76	2158.86	0.012
C.D (P=0.05)	70.18	409.69	6754.32	5967.32	0.042

The economic feasibility of different agronomic practices is usually a deciding factor for its adoption by the farmers for commercialization of any crop production programme. It is, therefore, of common interest to calculate the effect of different treatments taken in this study on the yield of Lentil. The maximum gross returns of Rs. 57030.05 Rs. /acre is found under treatment T_6. The minimum gross returns are Rs. 44802.45 (Rs/acre) under treatment T_1, because of no nutrient application. The Table-2 under reference shows that the highest net return of (Rs. 52003.45) Rs./acre was obtained from application of T_4-RDF + Fe @ 5 kg ha^{-1} with followed by T_6-RDF + B @ 5 kg ha^{-1} (49584.05). As the benefit over per rupee invested is concern the maximum B: C ratio (1.38) was noted with the application of T_4- RDF + Fe @ 5 kg ha^{-1} followed by T_7-RDF + B @ 10 kg ha^{-1} (1.30).

Conclusion

Effect of foliar application of Zinc, Iron, Boron, and RDF was found best in terms of growth, yield and economic returns of lentil crop under irrigated conditions. Among all the treatments of, T_4 (RDF + Fe @ 5 kg ha^{-1}) was better in growth attributes and yield attributes. On the basis of maximum B: C ratio T_4 (RDF + Fe @ 5 kg ha^{-1}) should be suggested for the farmers of Punjab Region.

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