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Effect of boron and phosphorus on yield and economics of lentil

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Abstract
A field experiment was conducted on lentil during *rabi* season of 2023-24 at Crop Research Farm Department of Agronomy. The treatment consisted of 3 levels of boron (1, 2 and 3 kg/ha) and 3 levels of phosphorus (20, 40 and 60 kg/ha) along with recommended doses of nitrogen and potash and a control (20-40-20 N-P-K/ha). The experiment was laid out in a Randomized Block Design with 10 treatment and replication thrice. The treatment details are as follows: T_1: Boron 1 kg/ha + Phosphorus 20 kg/ha, T_2: Boron 1 kg/ha + Phosphorus 40 kg/ha, T_3: Boron 1 kg/ha + Phosphorus 60 kg/ha, T_4: Boron 2 kg/ha + Phosphorus 20 kg/ha, T_5: Boron 2 kg/ha + Phosphorus 40 kg/ha, T_6: Boron 2 kg/ha + Phosphorus 60 kg/ha, T_7: Boron 3 kg/ha + Phosphorus 20 kg/ha, T_8: Boron 3 kg/ha + Phosphorus 40 kg/ha, T_9: Boron 3 kg/ha + Phosphorus 60 kg/ha, T_{10}: Control (20:40:20) NPK kg/ha. Application of boron 3 kg/ha along with phosphorus 40 kg/ha (treatment 8) recorded maximum number of pods/plant (150.86), maximum number of seeds/plant (1.80), higher seed yield (1.92 t/ha), higher Haulm yield (3.43t/ha). The aforesaid treatment also recorded maximum gross return Gross returns (126921.83 INR/ha), Net return (83961.63 INR/ha) and B:C (1.95).

Keywords: Boron, economics, lentil, phosphorus, yield

Introduction

Lentil (*Lens culinaris* L.) is one of the earliest domesticated crops in the world (Dhuppar *et al*. 2012). It was possibly the first grain legume to be domesticated. The seeds of lentils are known by different names, as *Adas* (Arabic), *Mercimek* (in Turkey), *Messer* (in Ethiopia), *Heramame* (in Japan), and *Masser or Masoor* (India, Pakistan) (Joshi *et al.*, 2017) [8]. Lentils serve as a vital source of human nutrition, primarily consumed as dry seeds, processed into "Dal" by removing outer skins and separating cotyledons, or used in snacks and soup preparations. Their ease of cooking, high digestibility, and impressive biological value render them a dietary staple, particularly for patients. Beyond their utility as a food source, lentil plants offer additional value through their dry leaves, stems, empty pods, and broken pods, which serve as valuable cattle feed. Lentils exhibit a rich nutrient profile, encompassing protein content (24-26%), carbohydrates (57 60%), fats (1.3%), fibre (3.2%), phosphorus (300 mg/100 g), iron (7 mg /100 g), vitamin C (10-15 mg/100 g), calcium (69 mg/100 g), calorific value (343 Kcal/100g), and vitamin A (450 IU).

Lentils are cultivated on approximately 5.57 million hectares globally, with an annual production of 6.82 million tonnes. The average global productivity of lentils stands at around 1225 kg/ha (FAOSTAT 2022). Lentil production of India was 1.28 million tonnes in 2022 from an acreage of 1.42 million ha. with a productivity of 904 kg/ha. as per fourth advanced estimate from DES, MoAF&W, Govt. of India. Canada was the top exporting nation for lentil in 2021, whereas India was the top importer. Uttar Pradesh is the leading lentil producing state in India (0.47 million tonnes from 0.49 ha. acreage, 36.43% of national production), followed by Madhya Pradesh (0.44 million tonnes from 0.49 million ha. acreage, 34.55% of national production), West Bengal (10.53%), Bihar (8.84%) and Jharkhand (4.50%) depending on their contribution in the national production of lentil (GOI, 2023). Lack of appropriate management techniques is one of the main factors limiting the production of pulses because it contributes to the ongoing loss of micronutrients caused by over-mining via intense cropping and the ongoing application of major nutrients (NPK) alone. B deficiency affects lentil reproductive growth more seriously than vegetative growth, particularly in relation to flowering, fruiting, and seed set. Cell division, as well as the development of pods and seeds, depend heavily on boron. A lack of boron altered the ideal balance of those three macronutrients as it influences the absorption of N, P, and K. Farmers usually grow lentil without any fertilizer. Lentil suffering from P deficiency stimulates the length of the primary root, length and number of lateral roots and root hairs (Sarker and Karmoker, 2009) [14] the increment in lateral roots was more than the primary root and resulted to increase in root surface area. The increase in the root surface area enhances the phosphorus acquisition from phosphorus-deficient soils, however, the varieties having prolific root hair formation are better in the acquisition of those nutrients (P, K, Fe, Mn, Cu, Zn, Mo) which are less available in soil (Gahoonia *et al.*, 2006) [5].

Boron is an essential micronutrient indispensable for the normal growth and development of plants. It plays an important role in flowering and fertilization process, boosting yield and quality of crop produce (Kanwar and Randhawa, 1974) [9]. According to Ahmad *et al.* (2009) [1] boron plays structural roles in the growth of cell walls, cell division, seed development, and the stimulation or inhibition of particular metabolic pathways for the production of hormones and sugars.

Phosphorus is the key element for successful pulse production because it is involved in root development, stalk and stem strength, flower and seed formation, crop maturity and production, N-fixation, crop quality and resistance to plant diseases by enhancing the physiological functions. It plays an important role to stimulate biological activities like nodulation, nitrogen fixation, and nutrient uptake in soil and rhizosphere environment resulting in a higher yield of legume crops (Khanam *et al.*, 2016) [11]. Legumes play a significant role in sustainable agriculture through their ability to improve soil fertility and health. Legumes, with a mutual symbiotic relationship with some bacteria in soil, can improve nitrogen (N) amount through biological N-fixation (BNF). But to maximize such functions, legumes need more phosphorus (P) as it is required for energy transformation in nodules. Besides, P also plays a significant role to root development, nutrient uptake, and growth of legume crops. But most of the agricultural soils have inadequate amounts of P to support efficient BNF as it exists in stable chemical compounds which are least available to plants.

Keeping in view of the above fact, the experiment was conducted to find out "Effect of Boron and Phosphorus on Growth and Yield of Lentil".

Materials and Methods

The experiment was conducted during rabi season of 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, with soil (pH - 7.7), organic carbon (0.57%), available N (172.48 kg/ha), available P (27.01 kg/ha) and available K (291.3 kg/ha). The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The treatment details are as follows: T1: Boron 1 kg/ha + Phosphorus 20 kg/ha, T2: Boron 1 kg/ha + Phosphorus 40 kg/ha, T3: Boron 1 kg/ha + Phosphorus 60 kg/ha, T4: Boro 2 kg/ha + Phosphorus 20 kg/ha, T5: Boron 2 kg/ha + Phosphorus 40 kg/ha, T6: Boron 2 kg/ha + Phosphorus 60 kg/ha, T7: Boron 3 kg/ha + Phosphorus 20 kg/ha, T8: Boron 3 kg/ha + Phosphorus 40 kg/ha, T9: Boron 3 kg/ha + Phosphorus 60 kg/ha, T10: Control (20:40:20) NPK kg/ha. The observations were recorded for Number of pods/plant, Number of seeds/pod, Test weight (g), Seed yield (t/ha), Haulm yield (t/ha).

Results and Discussion

Yield Parameters

Number of pods/plant

At harvest, treatment 8 with application of boron 3 kg/ha along with Phosphorus 40 kg/ha recorded significantly higher number of pods/plant (150.87). However, treatment 6 Boron 2 kg/ha + Phosphorus 60 kg/ha, treatment 7 Boron 3 kg/ha + phosphorus 20 kg/ha and treatment 9 Boron 3 kg/ha + phosphorus 60 kg/ha were statistically at par with treatment 8 boron 3 kg/ha + Phosphorus 40 kg/ha. Significantly increased in number of pods/plant was recorded with the application of Boron (3 kg/ha) might be due to due to its critical function in sugar translocation, carbohydrate metabolism, and tissue differentiation. Similar results were observed by Satya (2021) [15]. Further, significantly increased in number of pods/plant was recorded with the application of phosphorus (40 kg/ha) might be due to crucial role of phosphorus in photosynthesis, rapid energy transfer may have improved photosynthetic efficiency and, in turn, the availability of photosynthesis, which in turn raised total biomass output and the translocation of plant parts. Similar results were also reported by Hangsing *et al*. (2020) [7].

Number of seeds/pod

At harvest, significant and maximum number of seeds/pod (1.87) were recorded in treatment 8 with application of boron 3 kg/ha along with Phosphorus 40 kg/ha. However, which is statistically at par with treatment 2 Boron 1 kg/ha + Phosphorus 40 kg/ha, treatment 5 Boron 2 kg/ha + phosphorus 40 kg/ha and treatment 7 Boron 3 kg/ha + Phosphorus 20 kg/ha. Significantly increased in number of seeds/pod was recorded with the application of Boron (3 kg/ha) might be due to the translocation of photosynthesis, pollen viability, and pollen tube growth. Similar results were noticed by Chena *et al.* (2017) [2]. Further, significantly increased in number of seeds/pod was recorded with the application of phosphorus (40 kg/ha) might be due to increase in vegetative growth and reproductive traits under appropriate phosphorus availability and improved soil physical conditions. These results are in close conformity with Masih *et al.* (2020) [12].

Test weight (g)

At harvest, significantly higher test weight (23.14 g) was recorded in treatment 8 with application of boron 3 kg/ha along with Phosphorus 40 kg/ha. However, which is statistically at par with treatment 2 Boron 1 kg/ha + Phosphorus 40 kg/ha, treatment 5 (Boron 2 kg/ha + phosphorus 40 kg/ha) and treatment 9 Boron 3 kg/ha + Phosphorus 60 kg/ha.

Seed Yield (t/ha)

At harvest, significant and higher seed yield (1.92 t/ha) was recorded in treatment 8 with application of boron 3 kg/ha along with Phosphorus 40 kg/ha. However which is statistically at par with treatment 7 boron 3 kg/ha +

phosphorus 20 kg/ha, treatment 9 boron 3 kg/ha + phosphorus 40 kg/ha. Significantly increased in seed yield was recorded with the application of Boron (3 kg/ha) may have increased seed yield because it improved the cell wall, caused tissue differences, sugar transport, maintained conducting tissue that had a regulatory effect on other elements, and promoted the metabolism of phenols, carbohydrates, nucleic acids, and auxins. Similar results were observed by Praveena *et al.* (2018) [13]. Further, significantly increased in seed yield was recorded with the application of phosphorus (40 kg/ha) might might be produced by enhanced root growth, greater nutrient availability, better root proliferation, absorption energy conversion, and plant metabolic processes. These results are in close conformity with Yadav *et al.* (2017) [18].

Haulm yield (t/ha)

At harvest, treatment 8 with application of boron 3 kg/ha along with Phosphorus 40 kg/ha recorded significantly higher haulm yield (3.43 t/ha), however which is statistically at par with treatment 7 boron 3 kg/ha + phosphorus 20 kg/ha. Significantly increased in haulm yield was recorded with the application of Boron (1 kg/ha) might be due to vegetative growth generating an excessive number of photosynthetic translocation sites. Similar results were observed by Karthik *et al.* (2021) [10]. Further, significantly increased in haulm yield was recorded with the application of phosphorus (40 kg/ha) may have improved nitrogen fixation in addition to nodulation, and increased nitrogen fixation will increase crop output. These results are in close conformity with Singh *et al.* (2011) [16].

Harvest index (%)

At harvest, no significant difference was recorded among all the treatments in harvest index. Statistically highest Harvest Index was recorded in treatment 9 (boron 3 kg/ha + phosphorus 60 kg/ha).

Economics: The result showed that maximum gross return (126921.83 INR/ha), maximum net return (84106.43 INR/ha) and highest benefit cost ratio (1.96) was recorded in treatment 8 [Boron (3 kg/ha) + Phosphorus (40 kg/ha)] as compared to other treatments. Higher gross return, net return and benefit cost ratio were recorded with the application of Boron (3 kg/ha) along with phosphorus (40 kg/ha) might be due to higher growth and yield attributes resulting in higher seed and stover yields. These results line up with those that Singh *et al.* (2020) [17] observed.

Table 1: Response of Boron and Phosphorus on yield attributes at harvest of lentil

	Treatment Combinations	Seed yield (t/ha)	Harvest index (kg/ha)
1.	Boron 1 kg/ha + Phosphorus 20 kg/ha	1.41	35.84
2.	Boron 1 kg/ha + Phosphorus 40 kg/ha	1.39	37.19
3.	Boron 1 kg/ha + Phosphorus 60 kg/ha	1.48	35.47
4.	Boron 2 kg/ha + Phosphorus 20 kg/ha	1.67	38.03
5.	Boron 2 kg/ha + Phosphorus 40 kg/ha	1.68	37.04
6.	Boron 2 kg/ha + Phosphorus 60 kg/ha	1.76	38.20
7.	Boron 3 kg/ha + Phosphorus 20 kg/ha	1.82	37.37
8.	Boron 3 kg/ha + Phosphorus 40 kg/ha	1.92	35.98
9.	Boron 3 kg/ha + Phosphorus 60 kg/ha	1.83	38.78
10.	Control RDF (20-40-20 kg/ha)	1.36	38.54
	F test	S	NS
	SEm(±)	0.05	1.62
	CD (p=0.05)	0.14	-

Table 2: Response of Boron and Phosphorus on economics of lentil

	Treatment Combinations	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	Boron 1 kg/ha + Phosphorus 20 kg/ha	42196.60	93211.50	51014.90	1.21
2.	Boron 1 kg/ha + Phosphorus 40 kg/ha	42341.40	91728.42	49387.02	1.17
3.	Boron 1 kg/ha + Phosphorus 60 kg/ha	42486.20	97694.33	55208.13	1.30
4.	Boron 2 kg/ha + Phosphorus 20 kg/ha	42433.60	110073.67	67640.07	1.59
5.	Boron 2 kg/ha + Phosphorus 40 kg/ha	42578.40	110849.50	68271.10	1.60
6.	Boron 2 kg/ha + Phosphorus 60 kg/ha	42723.20	116096.58	73373.38	1.72
7.	Boron 3 kg/ha + Phosphorus 20 kg/ha	42670.60	120237.25	77566.65	1.82
8.	Boron 3 kg/ha + Phosphorus 40 kg/ha	42815.40	126921.83	84106.43	1.96
9.	Boron 3 kg/ha + Phosphorus 60 kg/ha	42960.20	120563.17	77602.97	1.81
10.	Control RDF (20-40-20 kg/ha)	41214.80	89439.58	48224.78	1.17

Conclusion

It is concluded that with the application of Boron 3 kg/ha along with Phosphorus 40 kg/ha (Treatment 8), was observed with higher yield and yield attributes and benefit-cost ratio in lentil.

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