Interaction Effect of Phosphorus and Boron on yield components, productivity parameters and quality traits of Lentil (*Lens culinaris* L.)

Abstract

A field trial was conducted on sandy loam soil having low status of organic carbon and accessible nitrogen, medium in accessible phosphorous and high in accessible potassium at pot house of department of Soil Science and Agricultural Chemistry of C.S.A.U.A&T, Kanpur (campus) under Indo-Gangetic Plain zone of Uttar Pradesh, amid Rabi season of 2021-22. The experiment comprised of 16 treatment combinations in Factorial randomized block design with three replications. Lentil variety Lentil Shekhar 2 (KLB-303) was grown with the recommended agronomic practices. On the premise of the comes about exuded from the present investigation, it might be concluded that application of 60 kg P_2O_5 ha^{-1}+ 2.5 kg Boron ha^{-1} significantly recorded maximum yield components viz. no. of pod plant $^{-1}$ (71), Seed pod $^{-1}$ (1.84) and Seed Index (3.23 g). Similarly, among the productivity parameters such as grain yield (15.67 q ha^{-1}), straw yield (28.22 q ha^{-1}), biological yield (43.89 q ha^{-1}) and harvest index (35.70%) was also associated with the application of 60 kg P_2O_5 ha^{-1}+ 2.5 kg Boron ha^{-1}. Among the quality traits maximum protein content (22.40%) and protein yield (351.00 kg ha^{-1}) was also associated with the application of 60 kg P_2O_5 ha^{-1}+ 2.5 kg Boron ha^{-1}. The present experiment clearly points out the significance of balanced use of Phosphorus and Boron nutrients in Lentil for improving the yield components, yield and quality of Lentil crop.

Key Words: Boron, Lentil, Phosphorus, Protein and Yield.

INTRODUCTION

Lentil, like other pulse crops, has a unique position in cropping systems and sustainable agriculture production because it restores soil fertility. The lentil (*Lens culinaris* L. Medik) often known as masoor in India, is one of the most important Rabi season legumes. It's one of the most nutrient-dense cool-season legumes that can also withstand drought. Its origin is South-West Asia and Mediterranean region. It includes between 24 to 26% protein, 1.3% fat, 2.1%minerals, 3.2% fiber, and 57% carbohydrate **(Ali *et al.*, 2017 and *Singh et al.*, 2013)**. It is also rich in Calcium, Iron, Vitamin B, Folate and Niacin. Red (or pink) lentils have a lower fiber content than green lentils (11% rather than 31 %). Lentils, after soybeans and hemp, have the greatest protein content of any plant, at 26% and as a result, they are an essential element of the diet in many regions of the world, particularly in Nepal and India, where a big vegetarian population exists. Lentil uses atmospheric N_2 to meet its nitrogen needs via biological nitrogen fixing **(Badarneh and Ghawi 1994).** Several factors influence nitrogen fixation in legumes, including rhizobial strains and soil N and P availability. In the symbiotic N_2-fixation mechanism, phosphorus (P) and nitrogen (N) play distinct roles. Indirectly, symbiotic nitrogen fixation has a high P demand because it requires a lot of energy **(Schulze *et al.*, 2006),** and energy-generating metabolism is highly dependent on energy availability **(Israel, 1987).**

Lentil ranks second only to chickpea in terms of total pulse output in India, occupying 1.59 million hectares and contributing 1.6 million tonnes to pulse production and productivity of 1.01 tonne ha^{-1} **(Anonymous, 2020).** India ranks 1st in the world in respect of production as well as acreage of lentil followed by Turkey. In India Uttar Pradesh has largest acreage and production of lentil. In Uttar Pradesh, the area, production and yield of lentils are 495 thousand hectares, 441 thousand tonnes, and 891 kg/ha (2012-13) respectively. M.P., U.P., Bihar, West Bengal, Haryana, Rajasthan, Punjab, and Assam are the most prominent lentil-growing states.

Among the key nutrients, phosphorus is one of the most important nutrient elements in the production of Lentil in India. **Hussain *et al.* (2002)** found that the lentil crop responded well to phosphorus fertilizer. Phosphorus is vital in legume agriculture because it promotes grain formation and root growth, as well as nodulation, seed yield, and seed crude protein content **(Singh *et al.*, 2014).** Plants use only a small percentage of the phosphorus provided through synthetic or chemical fertilizer, but a considerable portion of it is converted into insoluble fixed forms, making it inaccessible for crop uptake. Crop phosphorus recovery efficiency is only between 10% to 30% **(Swarup, 2002).** The overall growth and production of the crop can be boosted by increasing the availability of phosphorus.

The production of nodules on legume roots requires the presence of Boron. Lentil reproductive growth, particularly blooming, fruit, and seed set, is more susceptible to Boron shortage. Boron is essential for cell division, as well as the production of pods and seeds. Boron has an effect on N, P, and K absorption, and it’s lack alters the ideal balance of those three macronutrients. The B treatment had a significant impact on the N and B concentrations of lentil grain, showing that the B played a positive effect in lentil growth and production of proteins. In comparison to most other field crops, legumes have a higher need for Boron.

Boron is essential for glucose transport, cell wall metabolism, cell membrane permeability and stability, and phenol metabolism, with lignin production being the most important. It also helps to improve the quality of goods. Boron was proven to be beneficial in increasing plant growth and yield when applied to the soil or as a foliar spray.

METHOD AND MATERIAL

2.1 Geographical Situation of Experimental Site:

The field experiment was conducted at pot culture house of the department Soil Science and Agricultural Chemistry of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur for year 2021. Kanpur is located in the Gangetic plains of Central Uttar Pradesh, at a height of around 125.9 meters above sea level, in the central part of Uttar Pradesh's subtropical tract of North India, between latitudes of $25^0 26'$ to $28^0 58'$ North and longitudes of $79^0 3'$ to $80^0 34'$ East. The average annual rainfall is 816 mm, with most of it falling between the second and first weeks of June and mid-October, with a few showers in the winter.

2.2 Soil of the experimental material

The soil of the experimental field had originated from alluvial deposits. Soil is sandy loam in texture neutral in reaction (pH 7.28), low inorganic carbon (0.45%), available N (180.20 kg ha^{-1}), available P (11.10 kg ha^{-1}), available K (170.02 kg ha^{-1}).

2.3 Layout and Design of the Experiment

The experiment was laid out in Factorial Randomized Block design with three replications. The total numbers of unit plots were 48. The size of a unit plot was 1 m × 1 m. The width of the main irrigation channel is 1 m.

2.4 Details of Treatment

Table 1 : Treatment used for the study

Phosphorous Levels	Symbol	Boron Levels	Symbol
0 kg ha^{-1}	P_0	0 kg ha^{-1}	B_0
30 kg ha^{-1}	P_{30}	1.0 kg ha^{-1}	B_1
45 kg ha^{-1}	P_{45}	1.5 kg ha^{-1}	$B_{1.5}$

60 kg ha^{-1}	**P_{60}**	2.5 kg ha^{-1}	**$B_{2.5}$**

2.5 Observation recorded

a.) Number of pods $plant^{-1}$

Number of pods of the five randomly selected plants was counted and their means were computed to express as number of pods $plant^{-1}$.

b.) Number of seeds pod^{-1}

Number of grains per pod were recorded at harvest by counting the grains of five randomly selected pods from five tagged plants of each plot and average was worked out.

c.) Seed Index (g)

One hundred seed were counted from samples of each plot and their weight was recorded as seed index (g).

d.) Grain yield (kg ha^{-1})

After threshing and winnowing, the clean grains obtained from the produce of individual net plot, were weighed and weight was recorded as grain yield. The grain yield recorded under each plot was converted into kg per hectare (kg ha^{-1}).

e.) Straw yield (kg ha^{-1})

Straw yield was obtained by subtracting the grain yield (kg ha^{-1}) from biological yield (Kg ha^{-1})

f.) Biological yield (kg ha^{-1})

Above ground harvestable total biomass produce of each plot tied in bundles was weighed with spring balance after complete sun drying. These results obtained in kg $plot^{-1}$ area were converted in kg ha^{-1} by multiplying factor.

g.) Harvest Index (%)

It is the ratio expressed in percentage of economic yield in relation to biological yield. It was estimated by the formula proposed by Donald and Hamblin (1976).

$$\text{Harvest index (\%)} = \frac{\text{Economical yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \times 100$$

RESULT AND DISCUSSION

Yield Attributes

The observation regarding yield attributes viz. no. of pod plant^{-1}, no. of seed pod^{-1} and seed index (g) were shown in Table 2. Significantly higher number of pod plant^{-1} (71.00) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Significantly higher number of seed pod^{-1} (1.84) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Significantly higher seed index (3.22) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. From the (Table 2) the results were observed that increasing levels of phosphorus from 0 kg ha^{-1} to 60 kg ha^{-1} and boron levels from 0 kg ha^{-1} to 2.5 kg ha^{-1} has significant effect on all the productivity parameters viz. no. of pod plant^{-1}, no. of seed pod^{-1} and seed index (g). The consequences of the current investigation are additionally in concurrence with the investigation of **Datta *et al.*, (2013), Chauhan and Raghav (2017) and Yumnam *et al.*, (2018)**

Table 2: Effect of yield attributes of lentil as influenced by phosphorous and Boron Levels

Symbol	Treatment combination	No. of Pods plant^{-1}	No. of Seed Pod^{-1}	Seed Index (g)
T_1	P_0B_0	31	1.54	3.02
T_2	P_0B_1	34	1.57	3.05
T_3	$P_0B_{1.5}$	36	1.59	3.07

T_4	$P_0B_{2.5}$	39	1.60	3.08
T_5	$P_{30}B_0$	45	1.63	3.11
T_6	$P_{30}B_1$	48	1.64	3.13
T_7	$P_{30}B_{1.5}$	50	1.66	3.14
T_8	$P_{30}B_{2.5}$	56	1.69	3.16
T_9	$P_{45}B_0$	53	1.67	3.15
T_{10}	$P_{45}B_1$	58	1.70	3.17
T_{11}	$P_{45}B_{1.5}$	62	1.71	3.18
T_{12}	$P_{45}B_{2.5}$	63	1.75	3.19
T_{13}	$P_{60}B_0$	60	1.72	3.18
T_{14}	$P_{60}B_1$	66	1.78	3.20
T_{15}	$P_{60}B_{1.5}$	68	1.81	3.22
T_{16}	$P_{60}B_{2.5}$	71	1.84	3.23
C.D. at 5 %	**P**	**1.42**	**2.62**	**0.10**
	B	**1.42**	**2.62**	**0.10**
	P×B	**2.92**	**2.83**	**0.22**
S.E(m)±	**P**	**0.49**	**0.87**	**0.03**
	B	**0.49**	**0.87**	**0.03**
	P×B	**0.97**	**0.94**	**0.07**

Symbol	Treatment combination	Grain Yield (q ha^{-1})	Straw Yield (q ha^{-1})	Biological Yield (q ha^{-1})	Harvest Index (%)

Fig. 1: Effect of yield attributes of lentil as influenced by phosphorous and Boron Levels

Productivity Parameters

T_1	P_0B_0	8.19	20.42	28.61	28.62
T_2	P_0B_1	8.48	20.83	29.31	28.93
T_3	$P_0B_{1.5}$	8.90	21.10	30.00	29.66
T_4	$P_0B_{2.5}$	9.22	21.52	30.74	29.99
T_5	$P_{30}B_0$	9.89	21.80	31.69	31.20
T_6	$P_{30}B_1$	10.66	21.11	31.77	33.55
T_7	$P_{30}B_{1.5}$	11.02	22.51	33.53	32.86
T_8	$P_{30}B_{2.5}$	12.10	22.82	34.92	34.65
T_9	$P_{45}B_0$	11.56	22.68	34.24	33.76
T_{10}	$P_{45}B_1$	12.55	23.05	35.60	35.25
T_{11}	$P_{45}B_{1.5}$	13.12	23.67	36.79	35.66
T_{12}	$P_{45}B_{2.5}$	14.22	25.32	39.54	35.96
T_{13}	$P_{60}B_0$	13.83	24.82	38.65	35.78
T_{14}	$P_{60}B_1$	14.81	25.88	40.69	36.39
T_{15}	$P_{60}B_{1.5}$	15.08	26.19	41.27	36.53
T_{16}	$P_{60}B_{2.5}$	15.67	28.22	43.89	35.70
C.D. at 5 %	**P**	**1.12**	**1.27**	**1.68**	**1.49**
	B	**1.12**	**1.27**	**1.68**	**1.49**
	P×B	**1.57**	**2.04**	**1.86**	**2.62**
S.E(m)±	**P**	**0.37**	**0.42**	**0.56**	**0.49**
	B	**0.37**	**0.42**	**0.56**	**0.49**
	P×B	**0.52**	**0.68**	**0.62**	**0.87**

Significantly higher seed yield (15.67 q ha^{-1}) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Significantly higher Stover yield (28.22 q ha^{-1}) was observed in T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Seed yield and stover yield that is biological yield of lentil increases with increase in phosphorus, this increase is due to significant increase in vegetative characters such as no. of pods, seed weight etc. availability of high doses of phosphorus results in higher photosynthetic activity as phosphorus is major constituent of ATP and ATP is utilized in dark reactions of photosynthesis, phosphorus increases production of carbohydrates, sugars, starch, amino acids and proteins, which enhances pod and seed yield these eventually play role in enhancing biological yield. Higher levels of boron resulted in greater uptake of nutrients by seed and stover, boron also enhances chlorophyll content in leaf and thereby bio mass and phosynthates production is increased, which are effectively transferred towards the roots for its development and to provide required energy for nutrient

Table 3: Effect of productivity parameters of lentil as influenced by phosphorous and Boron Levels

uptake this uptake results in higher biological yields. From the (Table 3) the results were observed that increasing levels of phosphorus from 0 kg ha^{-1} to 60 kg ha^{-1} and boron levels from 0 kg ha^{-1} to 2.5 kg ha^{-1} has significant effect on all the productivity parameters viz. seed yield, stover yield, and harvest index. The results of the present investigation are also in agreement with the findings of **Navsare *et al.* (2018), Chauhan and Raghav (2017) and Kumar *et al.* (2017).**

Fig. 2: Effect of productivity parameters of lentil as influenced by phosphorous and Boron Levels

Quality Parameters

Protein Content and Protein Yield

The observation regarding quality parameters viz. protein content and protein yield were shown in Table 3. Significantly higher protein content (22.40 %) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Significantly higher protein yield (351.00 kg ha^{-1}) was observed in treatment T_{16} with application of phosphorus 60 kg ha^{-1} and boron 2.5 kg ha^{-1} and treatment T_{15} with application of phosphorus 60 kg ha^{-1} and boron 1.5 kg ha^{-1} was statistically at par. Result will also agreement with the finings of **Sentimenla *et al.* (2012), Kalyani and Math (2021) and Yadav *et al.*, (2022).**

Table 4: Effect of quality parameters of lentil as influenced by phosphorous and Boron Levels

Symbol	Treatment combination	Protein Content (%)	Protein Yield (kg ha^{-1})
T_1	P_0B_0	19.00	155.61
T_2	P_0B_1	19.55	165.78
T_3	$P_0B_{1.5}$	19.76	175.86
T_4	$P_0B_{2.5}$	19.88	183.29
T_5	$P_{30}B_0$	20.08	198.59
T_6	$P_{30}B_1$	20.24	215.75
T_7	$P_{30}B_{1.5}$	20.56	226.57
T_8	$P_{30}B_{2.5}$	20.92	253.13
T_9	$P_{45}B_0$	20.76	239.98
T_{10}	$P_{45}B_1$	21.20	266.06
T_{11}	$P_{45}B_{1.5}$	21.46	281.55
T_{12}	$P_{45}B_{2.5}$	21.92	311.70
T_{13}	$P_{60}B_0$	21.80	301.49
T_{14}	$P_{60}B_1$	22.10	327.30
T_{15}	$P_{60}B_{1.5}$	22.22	335.07
T_{16}	$P_{60}B_{2.5}$	22.40	351.00
C.D. at 5 %	**P**	**2.62**	**2.47**
	B	**2.62**	**2.47**
	P×B	**3.10**	**2.95**
S.E(m)±	**P**	**0.87**	**0.82**
	B	**0.87**	**0.82**
	P×B	**1.03**	**0.98**

Fig. 3: Effect of quality parameters of lentil as influenced by phosphorous and Boron Levels

CONCLUSION

Based on one year of experiment it may be inferred that application of treatment T_{16} (P 60 kg ha^{-1} + B 2.5 kg ha^{-1}) gave the highest grain and stover yield value of lentil crop showed good potential for sustainable production. Maximum protein content are also associated with the same treatment combination described as above. It is strongly recommended that farmer of the U.P adopt the dose of T_{16} [P 60 kg ha^{-1} + B 2.5 kg ha^{-1}] doses for better crop yield.

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