Original Research Article

Effect of bio fertilizers and boron on growth and yield of lentil (*Lens culinaris* L.)

ABSTRACT

A field Study on the the topic "Effect of bio fertilizers and boron on growth and yield of lentil (*Lens culinaris* L.)" was conducted during*Rabi* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.) to examine treatments consisting of three types ofBiofertilizers*viz.* Rhizobium, PSB and VAM and three levels of Boron*viz*. 1, 1.5, and 2 kg/ha. The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.28 %), available N (225 kg/ha), available P (19.50 kg/ha) and available K (92 kg/ha). There were 10 treatments each being replicated thrice and laid out in Randomized Block Design. The findings showed that treatment 3 (Rhizobium - 20 g/kg seeds + Boron - 2.0 kg/ha) had significantly higher growth characteristics at 60 DAS, including plant height (26.83 cm), dry weight (6.61 g), and yield characteristics at harvest, including number of pods per plant (112.07), number of seeds per pod (2.00), test weight (29.60 g), seed yield (1.75 t/ha), stover yield (2.17 t/ha), maximum gross return (INR 87,666.67), net return (INR 60,184.45) and b:c ratio (2.19) as compared to other treatments.

Keywords:*Bio fertilizers, Boron, growth, lentil,yield, economics.*

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Introduction

India is world's largest homeland of vegetarian population and world leader in pulses production. Pulses serve as a cost-effective and nutritionally balanced rich source of protein to the people of India. Among the many pulse species, Lentil (*Lens culinaris* L.) is one of the most nutritious cool season food legumes. Humans have known lentils since the beginning of civilization. It is widely cultivated in temperate, subtropical and tropical climate, as a winter crop. It can be grown on a wide range of soils from light loams to black cotton soils. It is one of the prominent sources of vegetable protein in the Indo-Gangetic plain (IGP) region. Lentils contain important components of human nutrition, such as 25% protein, 1.1% fat, 59% carbohydrate, and are also rich in important vitamins, minerals, and soluble and insoluble dietary fiber. Their water-soluble vitamin content (except vitamin C) is also relatively high, while the amounts of carotenes and retinols are low, as with most other legumes Especially in South Asia and the Middle East lentils occupy an important place in the daily diet. Worldwide production of lentils was 6.3 Mt in

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2018. In India, it is produced in an area of 1.424 M ha and production is 1.217 M t with an average productivity of 855 kg/ha **(www.dpd.gov.in).**The lentil sometimes known as "Masoor," is a significant annual leguminous crop in the Fabaceae family. Lentil is a pulse that can be eaten. It is around 40cm (16in) tall and produces seeds in pods with two seeds in each. Lentils, one of the first crops domesticated in the Near East, have been a part of human nutrition since the aceramic (pre-pottery) Neolithic period. They were eaten 9,500 to 13,000 years ago, according to archaeological findings. Lentils are available in a variety of colours, ranging from yellow to red-orange to green, brown, and black. Lentils come in a variety of sizes and shapes, with or without skins, whole or split **(Singh *et al.,* 2014).**

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Rhizobium offer a new eco-friendly technology which would overcome shortcomings of the conventional chemical based farming and showed positive influence on both soil sustainability and plant growth. They gradually improve the soil fertility by fixing atmospheric nitrogen. They can also help in restoring the depleted nutrients of the soil and improve plant root proliferation **(GebrekidanFelekeMekuria, 2019).**

The use of phosphorous solubilizing bacteria (PSB) as an inoculant simultaneously enhances P availability to plants and crop yield.Certain micro-organisms such as phosphate solubilizing bacteria (*Pseudomonas* sp, *Bacillus* sp, etc.), actinomycetes mostly those associated with the plant rhizosphere are known to convert insoluble inorganic P into soluble form that can be utilized by plants **(Vikram, 2007; Fankem*et.al,* 2006).**

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Biofertilizers like (PSB) create plant development ingredients in the soil by saturating insoluble soil phosphates like tri-calcium phosphate. Rhizobium is among the different bio-fertilizers of utmost significance. With the help of legumes, rhizobium fixes atmospheric nitrogen symbiosis. More phosphorus was readily accessible in the soil after PSB inoculation, which encouraged improved root development and produced a positive nodulation effect with higher PSB bacterial activity .Increased nitrogen fixation might increase output if a productive strain of Rhizobium is introduced to a nitrogen-deficient soil. As inoculants in the root zone of crop plants, phosphorus-solubilizing bacteria partially solubilize the insoluble phosphate and increase phosphorus usage productivity**(Charles and Joy,2023)**

Although improvement of plant nutrition status and enhancement of growth are the most widely believed roles of VAM fungi in natural ecosystem but it seems that under drought stress conditions it only thrives to survival needs of plants **(Varma and Hock,1999).**

Micronutrients like boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development" **(Ahmad *et al.*, 2009).** "Furthermore, boron deficiency causes decrease in pollen grain count, pollen germination etc. It also influences growth parameters and filling up of seeds. It is usually accepted that boron availability is decreased under dry soil conditions. Thus, boron deficiency is often associated with dry weather and low soil moisture conditions. This behaviour may the related to restricted release of boron from organic complexes which ultimately impaired ability of plants to extract B from soil due to lack of moisture in the rhizosphere**(Myageri*et al.*, 2022).**

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Keeping in view the above facts, the present experiment was undertaken to find out **"Effect of bio fertilizers and boron on growth and yield of lentil (*Lens culinaris* L.)"**

MaterialsandMethods

A Field study carried out during the *Rabi*season 2022, at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj (U.P.) which is located at25^{o} 39' 42''N latitude, 81^{o} 67' 56" E longitude and 98 m altitude above the mean sea level (MSL). This area is situated on the right side of the *Yamuna* River by the side of Prayagraj - Rewa road about 12 km from thecity. The experimental plot's soil had a sandy loam texture, a pH of 7.1 thatwasalmostneutral,mediumlevelsofavailablenitrogen(225kg/ha),lowlevelsofphosphorous (19.50 kg/ha) and available potash (92.00 kg/ha). It alsoincluded medium levels of organic carbon (0.28%). Thetreatmentscompriseoftypes of Bio fertilizersviz.,Rhizobium, PSB and VAM and three levels of Boron*viz.* 1, 1.5, and 2 kg/ha.whoseeffectisobservedonLentil(var.PL406).Theexperimentwas executed in Randomized Block Design with ten treatments replicated thrice. The experimentcomprisingtentreatmentpossiblecombinationofabovefactor,*viz.*,T_1:Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha,T_2:Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha,T_3:Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha,T_4:PSB - 20 g/kg seeds + Boron – 1.0 kg/ha,T_5:PSB - 20 g/kg seeds + Boron – 1.5 kg/ha,T_6:PSB - 20 g/kg seeds + Boron – 2.0 kg/ha, T_7: VAM - 20 g/kg seeds + Boron – 1.0 kg/ha, T_8: VAM - 20 g/kg seeds + Boron – 1.5 kg/ha, T_9: VAM - 20 g/kg seeds + Boron – 2.0 kg/ha, T_{10}: 10. Control (RDF-20:40:20 NPK kg/ha). Observations regarding growth

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ResultandDiscussion

Effectofbio fertilizersandborononngrowthparametersoflentil

Plant height (cm)

Based onrecorded and tabulated data pertaining to growth parameters, significantlyhighest plantheight(42.03 cm)wasrecorded in treatment with Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/haHowever, treatment with Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha (41.30 cm)was statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the minimum plant height (37.53 cm) was recorded with Control (RDF - 20:40:20 NPK kg/ha).

Increase in plant height might be the involvement of boron in different physiological processes like enzyme activation, electron transport, chlorophyll formation, stomatal regulation, etc. With the increase in levels of boron the plant height gradually increased, which might be attributable to greater photosynthetic activity and chlorophyll synthesis due to boron fertilization resulting into better vegetative growth**(Myageri*et al.*, 2022).**Similar results were reported by **Shil*et al.*, 2007.**

Dry Weight (g/plant)

Based on recorded and tabulated data pertaining to growth parameters, significantly highest plant dry weight (16.17 g) was recorded in treatment with Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha However, treatments with Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha (16.09 g), Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha (15.92 g) and PSB - 20 g/kg seeds + Boron – 2.0 kg/ha(15.63 g) were statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the minimum plant dry weight (12.17 g) was recorded with Control (RDF - 20:40:20 NPK kg/ha).

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Rhizobium bacteria establish a symbiotic relationship with lentil plants, forming nodules on their roots. Within these nodules, nitrogen fixation occurs, where atmospheric nitrogen is converted into a usable form (ammonium) for the plant. The increased nitrogen availability through Rhizobium-mediated nitrogen fixation contributes to enhanced plant growth and biomass production**(Kumar *et al.*,2019).**

Dry weight was increased significantly with increasing levels of Boron. As boron generally influences cell division and nitrogen absorption from the soil might enhance plant growth which reflects in terms of plant dry weight**(Myageri*et al.*, 2022).** These findings are in harmony with those obtained by**Tekale*et al.*, 2009.**

Crop Growth Rate(g/m^2/day) and Relative Growth Rate (g/g/day)

Basedon recorded and tabulated data pertaining to growth parameters, significantly highest Crop growth rate (5.97 g/m^2 /day), Relative growth rate (0.0134 g/g/day) was recorded in treatment with Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. However, treatments withRhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha (5.92 g/m^2/day) and (0.0134 g/g/day), Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha (5.81 g/m^2 /day)and (0.0133 g/g/day), PSB - 20 g/kg seeds + Boron – 2.0 kg/ha (5.59 g/m^2/day) and (0.0129 g/g/day) respectivelywere statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the minimum Crop growth rate (2.26 g/m^2 /day) and Relative growth rate (0.0061 g/g/day) was recorded in treatment with Control (RDF - 20:40:20 NPK kg/ha).

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Rhizobium bacteria have the ability to fix atmospheric nitrogen and convert it into a usable form for plants. This symbiotic nitrogen fixation increases the nitrogen availability in the soil, promoting higher crop growth rates in lentils **(Yadav *et al.*, 2019)**.

Boron plays a role in various enzymatic processes within plants, including phenolic compound metabolism, lignin synthesis, and cell wall-related enzyme activity. These enzymatic processes are vital for plant growth and development, contributing to the overall crop growth rate**(Brown *et al.*, 1997).**

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Effectofbio fertilizersandboron onyieldattributesoflentil

Number of pods/plant

According to the yield attributes data that was collected and analyzed at harvest,maximum number of pods per plant (112.07) was recorded in treatment with Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/haHowever, treatments with PSB - 20 g/kg seeds + Boron – 2.0 kg/ha (109.00) and VAM - 20 g/kg seeds + Boron – 2.0 kg/ha(108.33) were statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the minimum number of pods/plant (90.47) was recorded with treatment Control (RDF - 20:40:20 NPK kg/ha).

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Rhizobium inoculation enhances the plant's nutrient uptake efficiency, including the uptake of phosphorus and potassium. These essential nutrients play a crucial role in the reproductive phase of plants, contributing to flower and pod development. By improving nutrient uptake, Rhizobium inoculation can positively impact the number of pods per plant**(Saleem *et al.*, 2018).**

Seed yield (t/ha)

According to the yield attributes data that was collected and analyzed at harvest, highest seed yield (1.75 t/ha). However, treatments with PSB - 20 g/kg seeds + Boron – 2.0 kg/ha(1.65 t/ha) and VAM - 20 g/kg seeds + Boron – 2.0 kg/ha(1.61 t/ha) were statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the lowest seed yield (1.15

t/ha) was recorded with treatment Control (RDF - 20:40:20 NPK kg/ha).

Effect of rhizobium may be due to better availability of nitrogen to plants it will play an important role in increasing the crop production. Rhizobium produce growth hormones which stimulates root morphology. It increases the number of such microorganisms which accelerates the microbial process which in turn augment the extent availability of nutrient in the form which is easily assimilated by the plant**(Mounika *et al.*, 2022).**

Boron plays a vital role in increasing seed yield because boron takes place in many physiological process of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhance seed yield. Boron is a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops**(Myageri*et al.*, 2022).** These results are in confirmatory with the work of **Tekaleet al. 2009.**

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Stover yield (t/ha)

According to the yield attributes data that was collected and analyzed at harvest, highest stover yield (2.17 t/ha). However, treatments with PSB - 20 g/kg seeds + Boron – 2.0 kg/ha(2.07 t/ha) and VAM - 20 g/kg seeds + Boron – 2.0 kg/ha (2.03) were statistically at par with the treatment Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha. While the lowest was stover yield (1.57 t/ha) was recorded with treatment Control (RDF - 20:40:20 NPK kg/ha).

Higher straw yield was recorded due to better growth of plant in terms of plant height, number of branches, and dry weight of plant as a result of nutrient uptake**(Myageri*et al.*, 2022).**

EffectofBio fertilizers andborononeconomicsoflentil

The economic return of lentil was scrutinized after harvesting the crop based on marketpricing,theresultindicatedagrowingtrendinwiththeincreasingyieldtrendacrosstreatment.

The maximum Gross returns (INR 87,666.67/ha), Net returns (INR 60,184.45/ha) andBenefit cost ratio (2.19) was evaluated in treatment with the application of Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha.

Conclusion

It can be concluded that better production and economic returns in lentil were observed with the application of Rhizobium - 20 g/kg seeds and Boron – 2.0 kg/ha. Since the findings are based on one season, further trails are needed to confirm the results.

Table1.Effectof Bio fertilizersandboronongrowth parametersoflentil.

Comment [HT14]: Add the graph of Table 1.

Treatments	PlantHeight(cm)	Plant DryWeight(g)	CGR(g/m^2/day)	RGR(g/g/day)
Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha	40.97	15.92	5.81	0.0133
Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha	41.30	16.09	5.92	0.0134
Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha	42.03	16.17	5.97	0.0134
PSB - 20 g/kg seeds + Boron – 1.0 kg/ha	40.20	14.53	4.48	0.0108
PSB - 20 g/kg seeds + Boron – 1.5 kg/ha	40.53	14.73	4.65	0.0111
PSB - 20 g/kg seeds + Boron – 2.0 kg/ha	40.77	15.63	5.59	0.0129
VAM - 20 g/kg seeds + Boron – 1.0 kg/ha	38.83	13.17	3.17	0.0081
VAM - 20 g/kg seeds + Boron – 1.5 kg/ha	39.03	13.53	3.48	0.0087
VAM - 20 g/kg seeds + Boron – 2.0 kg/ha	39.23	13.87	3.80	0.0094
Control (RDF-20:40:20 NPK kg/ha)	37.53	12.17	2.26	0.0061
F - Test	S	S	S	S
SEm(±)	0.29	0.29	0.34	0.0007

CD(p=0.05)	0.85	0.87	1.00	0.0022

Table2.Effectofbio fertilizersandborononyieldattributes oflentil

Comment [HT15]: Add the graph of Table 2.

Treatments	No. of pods/plant	No. of Seeds/Pod	Seed Index(g)	Seed yield (t/ha)	Stover Yield (t/ha)	Harvest Index (%)
Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha	96.80	1.47	26.13	1.39	1.81	43.42
Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha	103.47	1.53	28.13	1.54	1.96	43.98
Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha	112.07	2.00	29.60	1.75	2.17	44.65
PSB - 20 g/kg seeds + Boron – 1.0 kg/ha	96.47	1.33	26.13	1.28	1.70	42.93
PSB - 20 g/kg seeds + Boron – 1.5 kg/ha	98.67	1.53	27.80	1.53	1.95	43.97
PSB - 20 g/kg seeds + Boron – 2.0 kg/ha	109.00	1.80	28.87	1.65	2.07	44.36
VAM - 20 g/kg seeds + Boron – 1.0 kg/ha	93.80	1.13	26.07	1.21	1.63	42.62
VAM - 20 g/kg seeds + Boron – 1.5 kg/ha	97.67	1.53	26.20	1.47	1.89	43.76
VAM - 20 g/kg seeds + Boron – 2.0 kg/ha	108.33	1.53	28.80	1.61	2.03	44.23
Control (RDF-20:40:20 NPK kg/ha)	90.47	1.07	26.00	1.15	1.57	42.27
F-Test	S	NS	NS	S	S	NS
SEm(±)	1.66	0.26	1.11	0.06	0.06	1.57
CD (p=0.05)	4.94	--	--	0.18	0.19	--

Table3.Effectofbio fertilizersandborononeconomicsof lentil.

Treatments	Total cost of cultivation	Gross Returns	Net Returns	B:C ratio
Rhizobium - 20 g/kg seeds + Boron – 1.0 kg/ha	27362.22	69333.33	41971.11	1.53
Rhizobium - 20 g/kg seeds + Boron – 1.5 kg/ha	27422.22	76833.33	49411.11	1.80
Rhizobium - 20 g/kg seeds + Boron – 2.0 kg/ha	27482.22	87666.67	60184.45	2.19
PSB - 20 g/kg seeds + Boron – 1.0 kg/ha	27354.22	63833.33	36479.11	1.33
PSB - 20 g/kg seeds + Boron – 1.5 kg/ha	27414.22	76666.67	49252.45	1.80
PSB - 20 g/kg seeds + Boron – 2.0 kg/ha	27474.22	82666.67	55192.45	2.01
VAM - 20 g/kg seeds + Boron – 1.0 kg/ha	27378.22	60666.67	33288.45	1.22
VAM - 20 g/kg seeds + Boron – 1.5 kg/ha	27438.22	73666.67	46228.45	1.68
VAM - 20 g/kg seeds + Boron – 2.0 kg/ha	27498.22	80500.00	53001.78	1.93
Control (RDF-20:40:20 NPK kg/ha)	27178.22	57500.00	30321.78	1.12

Comment [HT16]: Add the graph of Table 3. Also.
Addition of graphs of table will improve the quality of paper.

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