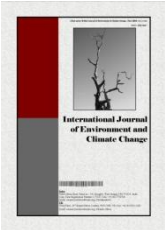

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Influence of Bio Fertilizers and Zinc on Growth and Yield of Lentil (*Lens culinaris* L.)

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted in Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj, (U.P), during the *rabi* season of 2021-22 with the objective to study the "Influence of bio fertilizers and zinc on growth and yield of Lentil (*Lens culinaris* L.)". The soil in the experimental plot was sandy loam in texture, pH (7.2), low in organic carbon (0.82%), available N (274.48 kg/ha), available P (26.80 kg/ha) and available K (230.24 kg/ha).The layout of the experiment was done in a Randomized block design with nine treatments which is replicated thrice. The bio fertilizers (Rhizobium, Phosphate solubilizing bacteria (PSB) and Vesicular arbuscular mycorrhiza (VAM)) @ 25 g/kg of seeds and three levels of zinc (4,5,6 kg/ha).Growth and yield parameters namely plant height, number of nodules/plant, dry weight, pods/plant, number of seeds/pod, test weight, seed yield, Stover yield, harvest index were collected from this experiment. Results revealed that significantly higher plant height (35.24 cm), dry weight (25.64), number of nodules (8.33/plant), pods/plant (160.32), seeds/pod (1.89), seed yield (1.79 t/ha), Stover yield (2.60 t/ha) were recorded with treatment combination of Rhizobium at 25 g/kg seeds + Zinc at 6 kg/ha (treatment 3). Maximum gross return (91290.00 INR/ha), net returns (62405.65 INR/ha), and benefit cost (2.16) were obtained highest in the treatment combination of Rhizobium at 25 g/kg seeds + Zinc at 6 kg/ha (treatment 3).

Keywords: Economics; bio fertilizers rhizobium; PSB; VAM; zinc.

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1. INTRODUCTION

Lentil (*Lens culinaris or Lens esculenta*) is an edible legume. It is about 40 cm (16 inch) tall, and the seeds grow in pods, usually with two seeds in each. Lentil is a self-pollinated crop with very low percentage of natural out crossing. It belongs to the family Leguminosae, sub family papillionaceae. Lentil is also known as a "poor man's meat" because of its rich protein content [1]. It contain about water 11%, protein 22 to 25%and carbohydrates 43.4-74.9 g, fat 0.3-3.5 g. It is also rich in iron, calcium, phosphorus and magnesium, niacin and high lysine and tryptophan content [2]. A significant amount of vitamin A and B is also provided by lentil [3].

Lentil is the fifth most important pulse crop in India. India ranked first in area and second in lentil production with 39.79% and 22.79% of world area and production respectively. Canada rank first in production (41.16%) due to very high level of productivity (1633 kg/ha) as compared to India (611 kg/ha).

Bio fertilizers are gaining importance as they are eco-friendly, non-hazardous and non-toxic. The increasing demand for production of crops and food for such a vast population has led to an interest and necessity for the use of biofertilizers for the betterment of the crops and even for the health of soil [4,5]. Rhizobium inoculation is essential for all the pulse crops to increase the yield of pulses. Rhizosphere, seed inoculation of legumes with an efficient rhizobial strain is necessary. It is a biofertilizer which increase symbiotic nitrogen fixation and ultimately it increases the yield [6,7]. The presence of efficient and specific strains of rhizobium in the rhizosphere is one of the most important requirement for proper establishment of growth of grain legume plant [8].

Microorganisms belongs to Phosphate solubilizing bacteria (PSB) can produce bioactive molecules and organic acids as inoculants in soil increase the phosphorous uptake by the plants and also improve the crop yield. These organisms also helpful to contribute phytate activity in plants that can produce phosphorous in plant by mineralization [9]. The ability of phosphate solubilizing bacteria to convert insoluble form into soluble one. It increases crops yield particularly of pulse crop.

The word mycorrhiza is given to a mutualistic association between a fungus (Myco) and the roots (rhizo of the plants). Vesicular arbuscular mycorrhiza improve plant nutrition, mycorrihizal colonization of roots occurs in all agro ecosystem [10,11]. The hyphae of fungus are able to take up nutrients such as phosphorous, zinc, copper and transport to host plant, thereby improving plant nutrition.Vam fungi improved nodulation in both lentil and black gram. Vesicular arbuscular mycorrhiza produce moisture requirement and increase the drought resistance of the crops. The fungus uses the carbon provided by the plant for its physiological function, growth and development. They improve soil structure, enhance plant health and vigor and minimize stress caused by pathogenic fungi, weed & pollution from heavy metals [12].

Zinc regulates auxin concentration in plants and helps in the synthesis of protein, chlorophyll etc. [13]. Zinc plays a greater role during reproductive phase especially during fertilization Remarkably pollen grain contains zinc in very high quantity. At the time of fertilization most of zinc is diverted to seed only [14]. Zinc deficiency occurs plant growth and development by reduce enzyme activity, disturbing ribosomal stabilization, and decreasing the rate of protein. It induces reducing flowers ovule infertility, low seed set and yield reduction.

2. MATERIALS AND METHODS

The experiment was carried out during *rabi* season of 2021 at the CRF (Crop Research Farm) SHIATS, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The crop Research Farm is situated at 25.750 N latitude, 87.190 E longitude and at an altitude of 98m above mean sea level. This area is situated on the right side of the river Yamuna and by the opposite side of Prayagraj City. Treatments *viz* T1: Rhizobium 25 g/kg seeds+ 4 Kg/ha $ZnSo_4$, T2: Rhizobium 25 g/kg seeds + 5 Kg/ha $ZnSo_4$, T3:Rhizobium 25 g/kg seeds+ 6 Kg/ha $ZnSo_4$,T4: PSB 25 g/kg seeds + 4 Kg/ha $ZnSo_4$, T5: PSB 25 g/kg seeds + 5 Kg/ha $ZnSo_4$, T6: PSB 25 g/kg seeds + 6 Kg/ha $ZnSo_4$, T7: VAM 25 g/kg seeds + 4 Kg/ha $ZnSo_4$,T8: VAM 25 g/kg seeds + 5 Kg/ha $ZnSo_4$, T9: VAM 25 g/kg seeds + 6 Kg/ha $ZnSo_4$. Before sowing the field is irrigated and ploughed and after which levelling is done. The seed rate of KLS-0903 (Krishi) lentil variety is 40-45 kg/ha. The healthy seed of lentil were inoculated with 25 grams of Rhizobium, Phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizal (VAM) per one

kg of seeds. The inoculated seeds were mixed separately in 10 percent jaggery solution. The seed were mixed thoroughly with solution till the culture formed a layer around the seed. Then the treated seed was dried in shade for about 2 hours before sowing all nutrients NPK were applied in the form of Urea, Single super phosphate (SSP) and Murate of potash (MOP). Entire dose of P and K was applied basal for respective plots, half dose of N (as urea) was applied as basal, one-fourth at 30 days after sowing and remaining one-fourth at the time of flowering. Zinc levels are (4,5,6 kg/ha) was applied as soil application along with NPK fertilizers before sowing. In order to minimize weed competition hoeing cum weeding was done 20days after sowing. To maintain uniform plant stand at an intra-row spacing of 20cm, extra plants were thinned out. Weeding and hoeing was done with hand hoe at 30&45 days after sowing to facilitate aeration and to remove weeds. Neem oil 2% was sprayed to control insect pest particularly aphids. The lentil crop was harvested treatment wise at maturity stage. Growth parameters *viz*. plant height, dry matter accumulation were recorded manually on five randomly selected representative plants from each plot of each replication separately and after harvesting, seeds were separated from each net plot and were dried under sun for seven days. Later threshed, cleaned and seed yield, stover yield from each net plot was recorded and expressed in tonnes per hectare. The benefit cost ratio was worked out after price value of seed with straw and total cost included in crop cultivation. The growth parameters were recorded at periodical intervals of 20,40,60, 80DAS and at harvest stage from the randomly selected five plants in each treatment. Statistically analysis was done for all the parameters in one way Anova and mean compared at 5% probability level of significant results.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

It is noticed Table 1, the Influence of Biofertilizers and Zinc on growth and yield of Lentil the result revealed that maximum plant height (35.24 cm), number of nodules/plant (25.64), Plant dry weight (8.33/plant was observed with application of Rhizobium 25 g/kg seeds + 6kg/ha $ZnSo_4$ (treatment 3) as compared to other treatments statistically at par to Rhizobium 25 g/kg seeds + 5 kg/ha $ZnSo_4$ (treatment 2). Rhizobium inoculation significantly increased seed yield by 35%. It may be due to increase in the availability of soil nitrogen to the plants for increased growth and development as rhizobium present in root nodules fixes atmospheric nitrogen. Zinc can help in the nodulation activity due to enzymatic activity and nitrogen fixation which ultimately increase nodulation. Higher dry matter accumulation depends upon the photosynthesis and respiration rate, which finally increases the plant growth with respect to increased plant height, number of nodules etc. The favourable effect of plant growth regulator and zinc might influence the metabolism of the plant, effect on photosynthetic pigments and activity of enzymes which in turn helps to increase in the vegetative growth. An enhanced growth and higher dry matter accumulation due to application of zinc. Zinc produce the growth hormones and precusor of auxins i.e. tryptophan. The results on higher crop growth was also reported by Debnath et al*.* [15], Singh, N et al*.* [16].

3.2 Yield Attribute

It is observed in Table 2, the Influence of Biofertilizers and Zinc on growth and yield of Lentil the result revealed that higher number of pods/plant (160.32), number of seeds/ pod (1.89), seed yield (1.76t/ha), stover yield (2.60t/ha) was observed with application of Rhizobium 25 g/kg seeds +6 kg/ha $ZnSo_4$ (treatment 3) compared to other treatments statistically at par to PSB 25g/kg seeds + 6 kg/ha $ZnSo_4$(treatment 6).The combination of Rhizobium and Zinc play a vital role in increases the yield. 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. Zinc has a greater role in the production of auxin and indole acetic acid, which helps in increased plant growth which resulted in more pods per plant [17,18]. Another reason is that zinc helps in more number of branches due to formation of stamens and pollens. Zinc play a major role in photosynthesis, enzymes activation, fertilization and translocation of assimilates which are responsible for the increase in seed yield. The better crop growth and development might be due to the combined application of Rhizobium and Zinc. The results of the present investigation are in close conformity with the findings of Amit Kumar Tiwari et al*.* [19] and Abid Ali et al*.* [20].

Table 1. Influence of biofertilizers and zinc on growth parameters of lentil

Treatments	Plant height (cm)	No. of nodules/ plant	Plant dry weight (g/plant)	Crop growth rate (g/m^2/day)	Relative growth rate (g/g/day)
1. Rhizobium 25g/kg seeds + 4 Kg/ha $ZnSo_4$	34.82	7.663	25.36	9.93	0.0140
2 Rhizobium 25g/kg seeds + 5 Kg/ha $ZnSo_4$	35.15	8.00	25.55	9.96	0.0140
3.Rhizobium 25g/kg seeds + 6 Kg/ha $ZnSo_4$	35.24	8.333	25.64	10.00	0.0140
4. PSB 25g/kg seeds + 4 Kg/ha $ZnSo_4$	32.78	6.67	24.12	9.63	0.0143
5. PSB 25g/kg seeds + 5 Kg/ha $ZnSo_4$	33.02	7.00	24.26	9.73	0.0140
6. PSB 25g/kg seeds + 6 Kg/ha $ZnSo_4$	33.28	7.333	24.48	9.63	0.0143
7. VAM 25g/kg seeds + 4Kg/ha $ZnSo_4$	30.88	6.00	22.92	10.03	0.0153
8. VAM 25g/kg seeds + 5Kg/ha $ZnSo_4$	31.20	6.33	23.16	10.13	0.0150
9. VAM 25g/kg seeds + 6Kg/ha $ZnSo_4$	31.46	6.663	23.34	10.20	0.0150
F test	S	S	S	S	S
SEm (±)	0.03	0.30	0.03	0.08	0.001
CD (5%)	0.09	0.89	0.09	0.25	0.001

Table 2. Influence of biofertilizers and zinc on yield parameters of lentil

Treatments	No. of pods/plant	No. of Seeds/pod	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1. Rhizobium 25g/kg seeds + 4 Kg/ha $ZnSo_4$	155.84	1.49	18.84	1.58	2.32	40.51
2 Rhizobium 25g/kg seeds + 5 Kg/ha $ZnSo_4$	157.76	1.71	18.82	1.68	2.46	40.58
3.Rhizobium 25g/kg seeds + 6 Kg/ha $ZnSo_4$	160.32	1.89	18.82	1.79	2.60	40.77
4. PSB 25g/kg seeds + 4 Kg/ha $ZnSo_4$	155.62	1.39	18.86	1.55	2.28	40.47
5. PSB 25g/kg seeds + 5 Kg/ha $ZnSo_4$	157.42	1.66	18.84	1.65	2.43	40.44
6. PSB 25g/kg seeds + 6 Kg/ha $ZnSo_4$	160.20	1.85	18.84	1.76	2.56	40.74
7. VAM 25g/kg seeds + 4Kg/ha $ZnSo_4$	155.34	1.28	18.93	1.51	2.24	40.26
8. VAM 25g/kg seeds + 5Kg/ha $ZnSo_4$	156.64	1.56	18.88	1.62	2.41	40.20
9. VAM 25g/kg seeds + 6Kg/ha $ZnSo_4$	159.44	1.82	18.82	1.71	2.51	40.52
F test	S	S	NS	S	S	NS
SEm (±)	0.04	0.02	0.03	0.02	0.02	1.08
CD (5%)	0.12	0.07	-	0.06	0.06	-

Table 3. Influence of biofertilizers and zinc on economics of lentil

S. No	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1	Rhizobium 25g/kg seeds + 4 Kg/ha $ZnSo_4$	28610.35	80580.00	51969.65	1.82
2	Rhizobium 25g/kg seeds + 5 Kg/ha $ZnSo_4$	28747.35	85680.00	56932.65	1.98
3	Rhizobium 25g/kg seeds + 6 Kg/ha $ZnSo_4$	28884.35	91290.00	62405.65	2.16
4	PSB 25g/kg seeds + 4 Kg/ha $ZnSo_4$	28538.35	79050.00	50511.65	1.77
5	PSB 25g/kg seeds + 5 Kg/ha $ZnSo_4$	28675.35	84150.00	55474.65	1.93
6	PSB 25g/kg seeds + 6 Kg/ha $ZnSo_4$	28812.35	89760.00	60947.65	2.12
7	VAM 25g/kg seeds + 4Kg/ha $ZnSo_4$	28502.35	77010.00	48507.65	1.70
8	VAM 25g/kg seeds + 5Kg/ha $ZnSo_4$	28639.35	82620.00	53980.65	1.88
9	VAM 25g/kg seeds + 6 Kg/ha $ZnSo_4$	28776.35	87210.00	58433.65	2.03

3.3 Economics

It is noticed in Table 3, the influence of Biofertilizers and Zinc on growth and yield of lentil the result revealed that higher cost of cultivation, gross return and net return increased with Rhizobium and Zinc. Application of Rhizobium at 25g/kg seeds +6kg/ha $ZnSo_4$(treatment 3) recorded highest gross return (91290.00 INR/ha), net returns (62405.65 INR/ha) and B:C ratio (2.16) This was attributed to increase in grain and straw yield as comparatively less cost than additional income under these treaments. Similarly results were also reported by Rasool, S., & Singh, J. [21].

4. CONCLUSION

From the present study it can be concluded that for better crop growth and productivity of lentil, the seeds must be inoculated with rhizobium at 25g/kg seeds and crop must be fertilized with 6kg/ha $ZnSo_4$ recorded highest growth and yield parameter, which may be more preferable for farmers since it is economically more profitable and hence, can be recommended to the farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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