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Effect of Bio-Fertilizers and Sulphur on Growth and Yield of Lentil (*Lens culinaris* M.)

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Authors' contributions

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

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ABSTRACT

A field experiment was conducted during *Rabi* season (2021-2022) at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P.). The soil of experimental plot was sandy loam in texture. The treatments consisted of *Rhizobium* 20 g/kg + Sulphur 10 kg/ha, *Rhizobium* 20 g/kg + Sulphur 20 kg/ha, *Rhizobium* 20 g/kg + Sulphur 20 kg/ha, PSB 15 g/kg + Sulphur 10 kg/ha, PSB 15 g/kg + Sulphur 20 kg/ha, PSB 15 g/kg + Sulphur 30 kg/ha, VAM 15 g/kg +Sulphur 10 kg/ha, VAM 15 g/kg +Sulphur 20 kg/ha, VAM 15 g/kg +Sulphur 30 kg/ha. The experiment was laid out in Randomized Block Design, with 9 treatments replicated thrice. Results revealed that the highest plant height (34.03 cm), number of nodules (11.10), plant dry weight (12.25 g/plant), number of pods per plant (163.1), number of seeds per pod (2.00), test weight (23.95g), seed yield (1.97 t/ha) and stover yield (3.75 t/ha) were significantly influenced with application of PSB 15 g/kg + Sulphur 30 kg/ha. Higher gross returns (INR 108455.00/ha), net returns (INR 75505.00/ha) and B:C ratio (2.29) were also recorded with application of PSB 15 g/kg + Sulphur 30 kg/ha.

Keywords: Lentil; bio-fertilizers; sulphur; growth parameters and yield attributes.

1. INTRODUCTION

The lentil (*Lens culinaris*), sometimes known as "Masoor," is a significant annual leguminous crop in the Fabaceae family. Lentil (*Lens culinaris*) 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

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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 [1].

Rhizobium provides a new environmentally friendly technique that addresses the drawbacks of traditional chemical-based farming while also improving soil sustainability and plant development. By fixing atmospheric nitrogen, they gradually enhance soil fertility. They can also help replenish depleted soil nutrients and promote plant root multiplication [2].

The use of phosphorous solubilizing bacteria (PSB) as an inoculant increases P availability to plants while also increasing crop production. Phosphate-solubilizing bacteria (*Pseudomonas sp., Bacillus sp*., etc.) and actinomycetes, most of which are found in the plant rhizosphere, are known to convert insoluble inorganic P into a soluble form that plants may use [3,4].

Although the most widely accepted roles of VAM fungi in natural ecosystems are to increase plant nutrition and growth, it appears that under drought stress situations it only thrives to meet the survival demands of plants [5].

Sulphur is the key component of balanced nutrient application for higher yields and superior quality. In legumes, sulphur being the constituent of some amino acids, promotes the biosynthesis of protein.

Sulphur is an important macronutrient for plant growth and development. Sulphur in agricultural soils is a major source of concern for farmers throughout the world because it is generally negative. As sulphur levels in the soil have declined, rigorous environmental controls on industrial emissions have been implemented [6].

As lentil crop is grown with poor irrigation assurance, it may need sulphur application to increase the water use efficiency also. Sulphur is an important secondary plant nutrient, playing a vital role in various physiological processes in the plant including the formation of amino acid (methionine, cystein, and cystyne), synthesis of proteins and chlorophyll. It activates enzymes and involves in the metabolic activities of vitamins (biotin and thiamine) and part of co-enzyme A and pyrophosphate. Sulphur deficiency can be responsible for poor flowering, fruiting and stunted growth. Pulses are reported to be second after oil seeds in requirement of sulphur [7].

2. MATERIALS AND METHODS

The experiment was conducted during *Rabi* season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.7), low in organic carbon (0.52%), available N (247 kg/ha), available P (35 Kg/ha) and available K (352.00 Kg/ha). The crop was sown on 19th November 2021 using variety KLS-09-03. The experiment was laid out in Randomized Block Design comprised of 9 treatments each replicated thrice viz. T_1: Rhizobium 20 g/kg + Sulphur 10 kg/ha, T_2: Rhizobium 20 g/kg + Sulphur 20 kg/ha, T_3: Rhizobium 20 g/kg + Sulphur 30 kg/ha, , T_4: PSB 15 g/kg+ Sulphur 10 kg/ha, T_5: PSB 15 g/kg + Sulphur 20 kg/ha, T_6: PSB 15 g/kg + Sulphur 30 kg/ha, T_7: VAM 15 g/kg + Sulphur 10 kg/ha , T_8: VAM 15 g/kg + Sulphur 20 kg/ha, T_9: VAM 15 g/kg + Sulphur 30 kg/ha. The growth parameters of the randomly selected five plants in each treatment were measured at intervals of 20,40,60,80 DAS and at harvest stage. A statistical analysis was performed, and the mean was compared at a 5% probability threshold of significance. Data on qualitative parameters was tabulated and statistical analysis was performed as directed [8].

3. RESULTS AND DISCUSSION

3.1 Effect of BioFertilizers and Sulphur on Growth Parameters

Effect of Bio Fertilizers and Sulphur on growth parameters of lentil are given in Table 1.

3.2 Growth Parameters

3.2.1 Plant height

At Harvest, significantly maximum plant height was recorded in the treatment-6 with PSB 15 g/kg +Sulphur 30 kg/ha (34.03 cm). However, treatment- 3 (Rhizobium 20 g/kg +Sulphur 30 kg/ha) 33.22 cm and treatment- 9 (VAM 15 g/kg +Sulphur 30 kg/ha) 32.76 cm was noticed

Table 1. Effect of Bio Fertilizers and Sulphur on growth parameters of Lentil

Treatments	Plant Height (cm)	Dry weight(g)	No. of Nodules	CGR	RGR
1. Rhizobium 20 g/kg + Sulphur 10 kg /ha	31.05	11.20	8.44	8.19	0.0233
2. Rhizobium 20 g/kg + Sulphur 20 kg /ha	31.39	11.35	9.55	6.92	0.0173
3. Rhizobium 20 g/kg + Sulphur 30 kg/ha	33.22	11.89	10.55	6.18	0.0137
4. PSB 15 g/kg + Sulphur 10 kg/ha	32.24	11.47	9.77	7.13	0.0179
5. PSB 15 g/kg + Sulphur 20 kg/ha	33.51	12.14	10.01	6.31	0.0137
6. PSB 15 g/kg + Sulphur 30 kg /ha	34.03	12.25	11.10	6.17	0.0131
7. VAM 15 g/kg + Sulphur 10 kg /ha	31.62	11.17	8.88	7.61	0.0207
8. VAM 15 g/kg + Sulphur 20 kg /ha	32.12	11.59	10.22	6.97	0.0171
9. VAM 15 g/kg + Sulphur 30 kg/ha	32.76	11.74	10.33	6.46	0.0148
F test	S	S	S	S	S
SEm(±)	0.44	0.05	0.14	0.27	0.27
CD (P=0.05)	0.31	0.17	0.42	0.83	0.83

Table 2. Effect of BioFertilizers and Sulphur on yield attributes and yield of Lentil

Treatments	Yield and Yield Attributes					
	Pods/Plant	seeds/pod	Test weight	Seed Yield (kg/ha)	Stover Yield(kg/ha)	Harvest Index
1. Rhizobium 20 g/kg + Sulphur 10 kg /ha	112.6	1.0	22.50	1349.03	2806.43	32.45
2. Rhizobium 20 g/kg + Sulphur 20 kg /ha	120.4	1.4	22.83	1414.56	2948.03	32.51
3. Rhizobium 20 g/kg + Sulphur 30 kg/ha	141.1	1.8	23.37	1684.95	3412.13	33.05
4. PSB 15 g/kg + Sulphur 10 kg/ha	126.6	1.6	23.07	1374.27	2885.89	32.38
5. PSB 15 g/kg + Sulphur 20 kg/ha	152.1	1.9	22.93	1820.28	3583.13	33.68
6. PSB 15 g/kg + Sulphur 30 kg /ha	163.1	2.0	23.95	1971.92	3756.27	34.43
7. VAM 15 g/kg + Sulphur 10 kg /ha	118.4	1.2	22.73	1595.61	3075.36	34.13
8. VAM 15 g/kg + Sulphur 20 kg /ha	127.4	1.7	22.40	1450.34	3169.74	31.44
9. VAM 15 g/kg + Sulphur 30 kg/ha	138.4	1.6	23.37	1508.50	3380.37	30.82
F test	S	S	NS	S	S	NS
SEm(±)	2.47	0.09	0.76	55.06	91.52	1.00
CD (P=0.05)	7.40	0.27	-	165.06	274.39	-

statistically at par with above treatment-6. The significantly highest plant height was observed with the application of Sulphur 30kg/ha because the presence of Sulphur plays a vital role in photosynthetic process of plant which has a direct bearing on plant growth and development. The results were found similar to Arunraj et al. [9].

3.2.2 Number of nodules /plant

At Harvest, significantly higher number of nodules per plant was recorded in treatment-6 (PSB 15 g/kg +Sulphur 30 kg/ha) 11.10/plant. However, treatment-3 (Rhizobium 20 g/kg + Sulphur 30 kg/ha) 10.60 was recorded statistically at par to the above treatment-6. Increase in nodule number with increasing levels of sulphur was due to increase in amount of ferredoxin [10].

3.2.3 Dry weight

At Harvest, significantly maximum dry weight was observed in the treatment-6 (PSB 15 g/kg + Sulphur 30 kg/ha) 12.25 g, whereas treatment-5 (PSB 15 g/kg +Sulphur 20 kg/ha) 12.14 g was statistically at par to the treatment-6. The dry weight is the resultant effects of growth of the plant influenced significantly more by seed inoculation through PSB than soil application [11] because seed inoculation with PSB boosted nutrient availability while also adding other plant growth promoting bacteria to the soil, increased macro and micronutrient availability, and increased phosphorous availability [12].

3.2.4 CGR & RGR

At 80-Harvest, significantly highest CGR was observed in the treatment-1 (Rhizobium 20g/kg + Sulphur 10 kg/ha) 8.19 g/m^2/day, whereas treatment-7 (VAM 15 g/kg + Sulphur 10 kg/ha) 7.61 g/m^2/day, was statistically at par to the treatment-1.

At 80-Harvest, significantly highest relative growth rate was observed in the treatment-1 (Rhizobium 20 g/kg + Sulphur 10 kg/ha) 0.0233g/g/day, whereas treatment-7 (VAM 15 g/kg + Sulphur 10 kg/ha) 0.0207 g/g/day, was statistically at par to the treatment-1.

3.3 Effect of Bio Fertilizers and Sulphur on Yield Attributes and Yield

Effect of Bio Fertilizers and Sulphur on yield attributes and yield of lentil are presented in Table 2.

3.3.1 Yield attributes and yield

Number of pods/plant (163.1), Seeds/pod (2.0), Test weight (23.95 g), Seed yield (1971.92 kg/ha), Stover yield (3756.27 kg/ha), Harvest index (34.43%) was recorded higher in treatment-6 (PSB 15 g/kg + Sulphur 30 kg/ha). In case of Seed yield treatment-6 was recorded significantly higher. However, treatment-5 is statistically at par with treatment-6. And stover yield was recorded significantly higher in the treatment-6 however, treatment-5 is statistically at par with treatment-6. Improved availability of Sulphur and favourable nutritional environment might have helped the plants at the peak growth period and flowering stages, the improved growth characters might have also resulted into the improved source sink relationship and sink size, which ultimately increased the number of pods/plant [13]. The higher N intake in the presence of Sulphur might be linked to increased crop vigour, greater consumption, and translocation into the plant, resulting in increased seed yield [14]. The positive effect of sulphur on stover yield may be due to the pronounced role of sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll. It also promotes the root nodules in legumes, which cause the more sulphur available during vegetative growth period and development of plant occurs. It resulted in higher plant height and number of branches per plant and ultimately helped in realization of higher stover yield [15].

4. CONCLUSION

Based on the results of a single season of study, it was shown that using PSB 15 g/kg + Sulphur 30 kg/ha resulted in significantly greater pods/plant, seeds per pod, seed yield, and stover yield of the lentil crop. As a result, farmers are advised to use it in order to increase their output.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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