Original Research Article

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

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.

Comment [H1]: Please state the background and purpose of the study in the summary section.

Comment [H2]: 30 kg/ha?

Key words: *Lentil, bio-fertilizers, Sulphur, growth parameters and yield attributes.*

INTRODUCTION

Lentil (*Lens culinaris*) is an important annual leguminous crop which is locally called "Masoor" belongs to the family Fabaceae. Lentil (*Lens culinaris*) is an edible pulse. It is about 40cm(16in) tall and the seeds grow in pods, usually two seeds in each. Lentils have been part of human diet since the aceramic (before pottery) Neolithic times, being one of the first crops domesticated in the near East. Archeological evidence shows they were eaten 9,500 to 13,000 years ago. Lentils colors range from yellow to red-orange to green,

brown and black. Lentils also vary in size, and are in many forms, with or without the skins, whole or split (**singh, K.M and singh A.K, 2014**) [9].

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 (**Gebrekidan Feleke Mekuria,2019**)[5].

The use of phosphorous solubilizing bacteria (PSB) as an inoculant simultaneously enchances P availability to plants and crop yield. Certain micro-organisms such as phosphate solubilizing bacteria (Pseudomonas sp, Bacillus sp, e.t.c), 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) [14], Fankem et.al., (2006**) [4].

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**) [13].

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 essential macro nutrient required for the plant growth and development of plants. Sulphur in agricultural soils have important concern for the agriculturists all over the world because they are mostly negative, due to the decline of sulphur levels in the soil have been changed to strict environmental rules on industrial emissions. **(Lewandowska M and Sirko A., 2008)[8].**

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 (**Tandon,1991**) [11].

Comment [H3]: Please state the purpose of the study at the end of the introduction.

MATERIALS AND METHODS: -

The experiment was carried out during *Rabi* season of 2021 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P). which is located at 25° 39' 42" N latitude, 81° 67' 56" E longitude and 98 m altitude above the mean sea level. The soil of the experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.7), low in organic carbon (0.57%), available N (230 Kg/ha), available P (32.10 Kg/ha) and available K (346.00 Kg/ha). The crop was sown on 19th November 2021 using variety Shekhar. The experiment was laid out in Randomized Block Design comprised of 3 replications and total 9 treatments 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 were recorded at periodical intervals of 20,40,60,80 DAS and at harvest stage from the randomly selected five plants in each treatment. Statistically analysis was done and mean compared at 5% probability level of significant results. Data recorded on qualitative parameters were tabulated and subjected to statistical analysis as per **Gomez and Gomez, 1976**[6].

Comment [H4]: It can be more descriptive and understandable if you express the applications in a table.

RESULTS AND DISCUSSION: -

Effect of BioFertilizers and Sulphur on growth parameters

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

Growth parameters

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 combination of Rhizobium 20 g/kg +Sulphur 30 kg/ha (33.22 cm), VAM 15 g/kg +Sulphur 30 kg/ha (32.76 cm) was noticed statistically at par with above treatment. The significantly highest plant height was observed with the application of Sulphur 30kg/ha because the presence of Sulphur plays a vital role in

Comment [H5]: Briefly describe it as T_1 application.

photosynthetic process of plant which has a direct bearing on plant growth and development. The results were found similar to **Arunraj et al. (2018)** [1].

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. Increase in nodule number with increasing levels of sulphur was due to increase in amount of ferredoxin (**Suman Kumar Dey 2021**) [10].

Dry weight

At Harvest, significantly highest 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 (**EI Sayed,1998**) [3] because seed inoculation through PSB improved the availability of nutrient and also added other plant growth promoting bacteria in the soil and increased the availability of macro and micro nutrient along with greater availability of phosphorous in the soil. (**Jat and Ahlawat 2004**) [7].

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), where as treatment 7 VAM 15 g/kg + Sulphur 10 kg/ha (7.61 g/m^2/day) was statistically at par to the treatment 5.

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), where as treatment 7 VAM 15 g/kg + Sulphur 10 kg/ha (0.0207 g/g/day) was statistically at par to the treatment 5.

Comment [H6]: Edit the text academically using Word formatting tools

Comment [H7]: Using a single pattern in expressions strengthens the text. (For example T_1 application, T_2 Application)

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.

Yield attributes and Yield

Number of pods/plant (163.1), Seeds/pod (2.0), Test weight (23.95 g), Seed yield (1971.92 t/ha), Stover yield (3756.27 t/ha), Harvest index (34.43%) was recorded higher in treatment 6 with PSB 15 g/kg + Sulphur 30 kg/ha. In case of Seed yield treatment 6 was recorded significantly higher, however treatment 5 is stastistically 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, (**Bagadi Mourya Teja 2021**)[2]. In the presence of Sulphur, the increase in N uptake could be attributed to enhanced vigour of crop growth with increased utilization and translocation in to plant resulting in the enhancement of yield (**Tripathi *et al* 2011**) **[12]**.

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

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 (t/ha)**	**Stover Yield(t/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	-

Conclusion

Comment [H8]:

Based on findings of experimentation in one season, it is concluded that application of PSB 15 g/kg + Sulphur 30 kg /ha produced significantly higher pods/plant, seeds per pod and seed yield and stover yield of lentil crop. Therefore it is recommended for the farmers for receiving higher yield.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Comment [H9]: Giving more references on the subject can increase the narration and the importance of the subject.

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