Original Research Article

Influence of Biofertilizers and Phosphorus on Growth and Yield of Lentil(*Lens culinaris* Medik)

ABSTRACT

The Experiment was conduct atin Crop Research Farm, in Department of Agronomy during *Rabi* season of 2022 on Lentil crop. The treatment consisted of three level of Biofertilizer *Rhizobium*,PSB and*Rhizobium*+ PSB and three level of Phosphorus (30, 40 and 50 kg/ha) and control. The experiment was layout in RandomizedBlock Design (RBD) with 10 treatment and replicated thrice. The soil in the experimental area was sandy loam with pH (8.0), EC (0.56 dS/m), Organic Carbon (0.62%), aAvailable N (225 kg/ha), aAvailable P (38.2 kg/ha), and aAvailable K (240.7 kg/ha). The resultsrevealed that the treatment-9 [*Rhizobium* + PSB + phosphorus(50kg/ha)] produces higher plant height (36.60cm), plant dry weight (6.64 g), maximum number of pods/plant (158.66), maximum number of seeds/pod (1.89), higher seed yield (2018.04kg/ha), straw yield (3530.60kg/ha).

Keywords: Lentil, Biofertilizer, Phosphorus, growth and yield.

Introduction

Lentil (*Lens culinaris*Medik), crop is grown throughout northern and central India, with 85% of total production coming from Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. Locally known as masoor, is one of the most important *Rabi* season season legume grown in India. Lentil is one of the oldest annual grain legumes consumed and cultivated in the world. Originating from South western Asia as early as 6000 B.C. It ranks next to chickpea amongst *rabi* pulse crops and is considered the most nutritious among pulse crops. It contains carbohydrates, mainly starches (55-65%), proteins, including essential amino acids (24-28%) and fat (1-4%). These are rich source of protein in vegetarian diet which contains around 20-30% protein which is nearly 2.0-2.5 times higher than that in the cereals. lentil is rich in proteins and contains high concentrations of essential amino acids like isoleucine and lysine, as well as other nutrients like dietary fiber, folate, vitamin B_1 and minerals **(Rozan*et al*., 2001).**

Uttar Pradesh (1026 kg/ha) productivity. The National yield average was (1032 kg/ha). The lowest yield was observed in the state of Assam (712 kg/ha), Jharkhand (882 kg/ha) **(GOI, 2021-22).**

The importance of bio-fertilizers, which provide the macro and micronutrients required for plant growth, is also well acknowledged. By preserving soil fertility, soil physical qualities, ecological balance and providing stability to the production without contaminating soil, water,air, bio-fertilizers also help to establish a sustainable agriculture system. Crop productivity and nutrient use efficiency are increased when biofertilizers are used in conjunction with chemical fertilizers, organic manures and crop wastes **(Mahajan *et al*., 2003)**. The efficient use of fertilizers is greatly improved by the use of biofertilizers. *Rhizobium*-inoculated pulse seeds are seeded in such soils, which boosts the rhizosphere's population. *Rhizobium* and pulse plants work together to increase soil fertility.Living microorganisms are present in bio-fertilizers, which improve soil biochemistry and reduce pathogens.

Rhizobium is special because it is the only nitrogen-fixing bacterium that coexists symbiotically with legumes. *Rhizobium* inoculation may increase the production of leguminous crops grown on dry soil **(Abdelgani*et al.* 2003)**. Use of biofertilizers plays an important role in increasing fertilizers use efficiency. When seeds of pulses are inoculated with *Rhizobium* and sown in such soils, it increases their numbering the rhizosphere. The association of *Rhizobium* and pulse plants helps in improving fertility of soil. The culture can hence prove broad spectrum biofertilizers which may increase yield of crops (Legumes, vegetables etc.) by 10-30%. Use of PSB culture increases nodulation, crop growth, nutrient uptake and crop yield. Bio-fertilizers contains living micro-organisms, it augments the biochemical processes in soil and pathogen control. Production of the lentil enhanced by optimum use of nutrients **(Singh *et al*., 2010; Singh *et al*., 2011).**Phosphorus (P) is one of the major essential primary nutrients after nitrogen for better crop growth and development. Pulses are heavy feeders of P because it is constituent of all living organism. Especially in the early stages of plant development, adequate supply of P is required for development of the reproductive parts and has a positive effect on root growth, early maturity and reduced disease incidence. The phosphorus requirement is greater for healthy crop growth with efficient root system and profuse nodulation. Phosphorus also plays a key role in pod

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filling and ultimately enhances the grain yield. The nitrogen-fixing capability of legumes can be enhanced by the supply of adequate amounts of nutrients, especially phosphorus (P) and sulphur (S) **(Islam *et al.* 2011)**. Phosphorus is one the macronutrients for biological growth and development. It is considered to be one of the major nutrient elements limiting agricultural production in India. Phosphorus fertilization to legumes is more important than that of nitrogen. The cultivation of pulses without phosphatic fertilizers is one of the important factors responsible for their low productivity. Phosphorus is an essential nutrient for grain legumes, as it helps in improving nodulation, seed yield and seed protein **(Singh *et al.* 2014).**

MATERIALS AND METHODS

This experiment was laid out during the *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25^0 39" 42" N latitude, 81^0 67" 56" E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design Which consisting of ten treatments with T_1–(*Rhizobium*) + (Phosphorus 30 kg/ha), T_2–(*Rhizobium*) + (Phosphorus 40 kg/ha), T_3– (*Rhizobium*) + (Phosphorus 50 kg/ha), T_4 - (PSB) + (Phosphorus 30 kg/ha), T_5 -(PSB) + (Phosphorus 40 kg/ha), T_6 - (PSB + (Phosphorus 50 kg/ha), T_7 - (*Rhizobium*+ PSB) + (Phosphorus 30 kg/ha), T_8 - (*Rhizobium*+ PSB) + (Phosphorus 40 kg/ha), T_9 -(*Rhizobium*+ PSB) + (Phosphorus 50 kg/ha), T_{10} - Control (RDF 20-40-20).The soil in the experimental area was sandy loam with pH (8.0), Organic Carbon (0.42%), aAvailable N (180.58 kg/ha), aAvailable P (15.54 kg/ha), and aAvailable K (198.67 kg/ha). Seeds are sown at a spacing of $30\times10cm^2$ to a seed rate of 50 kg/ha. The recommended dose of nitrogen (20 kg/ha), phosphorus (40 kg/ha) and potassium (20 kg/ha) and Biofertilizer and phosphorus were applied as per the treatments. Nitrogen, Pphosphorus and Ppotash was applied as basal at the time of sowing. One hand weeding was done manually with *Khurpi* at 25 DAS followed by second manual weeding was done at 45 DAS. This was done to control grass as well as broad leaf weeds.Two irrigation was applied to field.Data recorded on different aspects of crop, *viz.*, growth, yield attributes were subjected to statistically analysis by analysis of variance method. (**Gomez and Gomez, 1976)** and economic data analysis mathematical method.

RESULT AND DISCUSSION:

Growth parameters

Plant height (cm)

At 80 DAS, significantly and higher plant height (36.60cm) was recorded in treatment 9 [*Rhizobium* + PSB+ Phosphorus (50 kg/ha)]. However, the treatment 8 [*Rhizobium* + PSB+ Phosphorus (40 kg/ha)] (35.56 cm), treatment 7 [*Rhizobium* + PSB+ Phosphorus (30 kg/ha)] (34.02 cm) and treatment 6 [PSB+ Phosphorus (50 kg/ha)] (34.00 cm) were found to be statistically at par with treatment 9 [*Rhizobium* + PSB+ Phosphorus (50 kg/ha)].The significant higher plant height increases application of *Rhizobium* and PSB might be due to increase in uptake of N and P by the plants, which might be due to more N-fixation and P-solubilization through micro-organisms **Singh *et al*. (2018).** Futher significant and higher plant height was with application of phosphorus (50 kg/ha) might be due to with increased levels of P function in most of the physiological and metabolic processes resulting in increased growth and development, resulting in higher plants height. Similar result was also reported by **Yumnam*et al*. (2018).**

Plant dry weight

The data revealed, significant and maximum plant dry weight (6.64g) was recorded in treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)]. However, the treatment 8 [*Rhizobium* + PSB+ Phosphorus (40kg/ha)] (6.11 g), was statistically at par with treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)].The significant and maximum plant dry weight was with application of *Rhizobium*, increase the dry matter by availability of nitrogenase enzyme PSB increasing the Dry matter production from advanced growth stages to at harvest in which seed treatment with *Rhizobium* had fixed atmospheric nitrogen in the soil into available forms and PSB increased availability of phosphates to plants by mineralizing organic phosphorus compounds" **Singh *et al*. (2014)**.Further application of phosphorus (50 kg/ha) being an energy bond compound andits major role is transformation of energy essential for almost all metabolic processes photosynthesis, respiration, cell elongation and cell division, activation of amino acids for synthesis of protein and carbohydrate metabolism which ultimately increase all the growth attributes and dry weight of plants**Kumar *et al*. (2023)**.

Number of pods/plant

The data revealed that Treatment 9[*Rhizobium* + PSB+ Phosphorus (50kg/ha)] was recorded significant and maximum number of pods/ plant (158.66) which was superior over all other treatments.However,the treatment 8[*Rhizobium* + PSB+ Phosphorus (40kg/ha)] (149) and treatment 7[*Rhizobium* + PSB+ Phosphorus (30kg/ha)] (146.66)were found to be statistically at par with the treatment 9[*Rhizobium* + PSB+ Phosphorus (50kg/ha)].Significant and maximum number of nodules/plant was with application of *Rhizobium* might be increase the number of nodules by availability of nitrogenase enzyme PSB facilitates the nodule formation by proper development of nodules by increasing availability of phosphorus through the mobilizing the unavailable phosphorus present in soil **Singh *et al.* (2018).** Further Significant and higher number of pods/plants was with the application of phosphorus which it might be the reason of moderate plant nutrients availability due to which the plant produces more pods/plant as compare to other treatments and also phosphorus strongly increases the reproduction of the plants *i.e*., flowering and fruiting. These results were similar with that of **Abid *et al*., (2017).**

Number of seeds/pod:

The data revealed that Treatment 9[*Rhizobium* + PSB+ Phosphorus (50kg/ha)] was recorded significant and maximum number of seeds/pod (1.89) which was superior over all other treatments.However, the treatment 8 [*Rhizobium* + PSB+ Phosphorus (40kg/ha)] (1.75), treatment 7 [*Rhizobium* + PSB+ Phosphorus (30kg/ha)] (1.70) and treatment 6 [PSB+ Phosphorus (50kg/ha)] (1.67) were found to be statistically at par with the treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)].

The significant and higher number of seeds/plant was with the application of phosphorus (50 kg/ha) which may be the reason of moderate plant nutrients availability due to which the plant producesmore number of seeds/pod is a genetically controlled character and the difference among genotypes was due to their different genetic ability for this parameter**Rahman *et al.* (2013)**.

Seed Yield (kg/ha):

The data revealed that Treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)] was recorded significantly maximum Seed yield (2018.04kg/ha) which was superior over all other treatments.However, the treatment 8[*Rhizobium* + PSB+ Phosphorus (40kg/ha)] (1796.59 kg/ha) and treatment 7[*Rhizobium* + PSB+ Phosphorus (30kg/ha)] (1718.97 kg/ha) were found to be statistically at par with the treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)].Significant increase in seed yield might be due to the Dual inoculation of *Rhizobium* can increase seed yield in pulse crop up to 10 to 15% while PSB increase availability of insoluble phosphorous into soil. Results were similar to **Singh *et al*. (2018)**. Further Significant and higher seed yield was with application of phosphatic fertilizer therefore provided balance nutrition to the crop which resulted in higher seed yield of lentil. Phosphorus also increased the photosynthesis and translocation of assimilates to different plant parts for enhanced growth and yield attributing characters of the crop as observed in number of pods per plant and number of seeds per pod. In the later stage, the excess assimilates stored in the leaves was translocated towards sink development which ultimately contributed to higher seed yield. These findings were supported by **Choubey *et al*., (2013)** in lentil.

Stover yield (kg/ha):

The data revealed that Treatment 9 [*Rhizobium* + PSB+ Phosphorus (50kg/ha)] was recorded significantly maximum Stover yield (3530.60kg/ha) which was superior over all other treatments.However,the treatment-8 [*Rhizobium* + PSB+ Phosphorus (30kg/ha)] (3364.40 kg/ha) was found to be statically at par with treatment-9[*Rhizobium* + PSB+ Phosphorus (50kg/ha)].Significant increase in stover yield with Dual inoculation of Rhizobium, PSB increase in nitrogen availability in soil leads to increase in content of nitrogen in seed and increase in P availability through solubilization of insoluble native P and production of plant growth promoting substances. Results were similar to **Singh *et al*. (2014)**. Further higher stover yield was with application of phosphorus might have contributed for better growth of plant as expressed in terms of plant height, number ofnodules/plants, dry weight, which improved nutrient uptake, resulted increased in stover yield. Similar findings were reported by **Choubey *et al*., (2013) and Kumar *et al.* (2023)**.

CONCLUSION:

Based on the above findings it can be concluded that lentil with the application of *Rhizobium* + PSB along with the application of Phosphorus50 kg/ha (Treatment 9) recorded highest plant height, dry weight, no. of pods/plant, no. of seeds/pod,seed yield and stover yield.

Table: 1 Effect ofBiofertilizer and Phosphorus on growth of Lentil.

S.No.	Treatment combinations	At 80 DAS	
		Plant height (cm)	**Dry weight (g)**
1.	*Rhizobium* + Phosphorus 30kg/ha	30.60	4.77
2.	*Rhizobium* + Phosphorus 40kg/ha	31.31	4.90
3.	*Rhizobium* + Phosphorus 50kg/ha	31.66	4.96
4.	PSB + Phosphorus 30kg/ha	32.58	5.18
5.	PSB + Phosphorus 40kg/ha	33.26	5.26
6.	PSB + Phosphorus 50kg/ha	34.00	5.27
7.	*Rhizobium* + PSB + Phosphorus 30kg/ha	34.02	5.29
8.	*Rhizobium* + PSB + Phosphorus 40kg/ha	35.56	6.11
9.	*Rhizobium* + PSB + Phosphorus 50kg/ha	36.60	6.65
10.	Control (NPK 20-40-20 kg/ha)	29.76	4.53
	F-test	S	S
	SEm(±)	1.04	0.35
	CD (p=0.05)	3.08	1.05

Table: 2 Effect of Biofertilizer and Phosphorus on yield attributes and yieldofLentil.

S.No.	Treatment combination	Number of pods /Plant	Number of seeds/pod	Seed Yield (kg/ha)	Stover Yield (kg/ha)
1.	*Rhizobium* + Phosphorus 30kg/ha	129.66	1.33	1150.56	2505.80
2.	*Rhizobium* + Phosphorus 40kg/ha	130.00	1.49	1304.34	2540.20
3.	*Rhizobium* + Phosphorus 50kg/ha	132.66	1.52	1439.03	2574.60
4.	PSB + Phosphorus 30kg/ha	134.33	1.63	1458.15	2731.00
5.	PSB + Phosphorus 40kg/ha	136.00	1.65	1498.94	2813.40
6.	PSB + Phosphorus 50kg/ha	136.33	1.67	1649.16	3046.00
7.	*Rhizobium* + PSB + Phosphorus 30kg/ha	146.66	1.70	1718.97	3083.40
8.	*Rhizobium* + PSB + Phosphorus 40kg/ha	149.00	1.75	1796.59	3364.40
9.	*Rhizobium* + PSB + Phosphorus 50kg/ha	158.66	1.89	2018.04	3530.60
10.	Control (NPK 20-40-20 kg/ha)	128.66	1.36	1132.16	2156.40
	F-test	S	S	S	S
	SEm(±)	6.15	0.08	103.30	123.28
	CD (p=0.05)	18.28	0.24	306.88	366.23

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