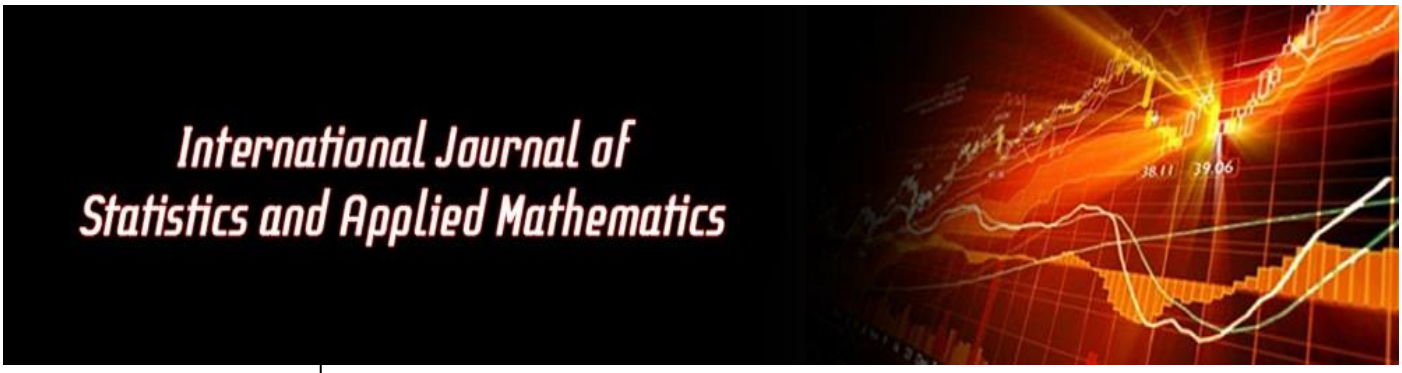

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Effect of phosphorous and biofertilizer application on yield and quality of lentil (*Lens culinaris* M.) under middle zone of U.P.

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Abstract
The present experiment entitled "Effects of phosphorous and biofertilizer application on yield and quality of Lentil (*Lens culinaris M.*) under middle zone of U.P." was carried out at Shradheya Bhagwati Singh Agriculture Research Farm, Chandra Bhanu Gupta Agriculture PG college, (BKT, Lucknow) during the rabi season of 2021-22. The experiment consisted with four levels of phosphorous i.e., (0, 30, 60 and 90 Kg/ha) and three biofertilizers *viz*., Rhizobium, PSB and Rhizobium + PSB thus, having 12 treatments combinations was planned in randomized block design (Factorial experiment). Application of phosphorous from 0 to 90 kg/ha caused significant impact on yield attributes, yield and quality of Lentil. Maximum number of branches, number of grains per pods, number of seeds per pod, grain weight per plant, grain yield, straw yield, protein content and protein yield were noted under the influence of 90 kg P_2O_5 ha^{-1} which was significantly superior to that of 30 kg and 0 kg P_2O_5 $ha^{-1.}$ Among biofertilizer treatments Rhizobium + PSB showed its superiority on above traits over PSB and rhizobium treatments.

Keywords: Biofertilizer, lentil, phosphorous and rhizobium

Introduction
Lentil (*Lens culinaris* Medik.) is a crucial cool season grain legume crop in India, which is that the second major winter legume after chickpea. Lentil (*Lens culinaris* Medik.) belongs to the sub-family Papilionaceae under the legume family (Leguminosae). Being a legume, it fixes nitrogen from the atmosphere through root nodules by Rhizobium bacteria (Humprey *et al*. 2001) [3], which helps in reducing the pressure of nitrogenous fertilizers application. It occupies a unique position in the world of agriculture by its high protein content i.e. 20.6-31.4% (Urbano *et al*. 2007) [6]. The major Lentil (*Lens culinaris* Medik.) growing countries in the world are Canada, India, Australia, Turkey, the United States, and Nepal Lentil (*Lens culinaris* Medik.) is grown in different eco-systems under irrigated (10%) as well as rainfed conditions (90%) in most regions of the world. It is grown as mono- cropping, mixed cropping, intercropping, and relay cropping. As intercropping better exploits, the resources than sole crop and also provides "Biological Insurance" i.e. when one crop fails then the second crop provides some returns. Works well with wheat, barley, mustard and flax. Lentil (*Lens culinaris* Medik.) is valued for its high protein content, which is double that in cereals. It is also called "A poor man's meat" because of the cheapest and most concentrated source of dietary protein. It contains 23.25% protein, 59% carbohydrates, 1.8% oil, 0.2% ash, and traces of iron, calcium, phosphorus, and magnesium.

The role of different bio-fertilizers like Rhizobium, BGA, Azotobactor, PSB, VAM, PGPR etc. have been established in the economical nutrition of various crops; apart from this the micro-organisms secrete the phytohormones and build up organic status of the soil due to which the availability of other nutrients also increases. Growing fertilizer need of the country and increasing fertilizer prices have emphasized on the use of bio-fertilizer in Indian agriculture. Phosphate solubilizing bacteria (PSB) are known to mobilize the unavailable P in soil and make it available to crop.

Phosphorus increases the resistance of plants, and a sufficient supply of phosphorus leads to rapid growth.

Phosphorus is resistant to plant diseases by improving root development, stem and stem strength, flower and seed formation, crop maturation and production, N fixation, crop quality, and the physiological functions involved. Because of its involvement, it is an important factor in the successful production of legumes. It performs a crucial position to stimulate organic sports like nodulation, nitrogen fixation, and nutrient uptake in soil and rhizosphere environments ensuing in a better yield of legume crops. Phosphorus utility ameliorates the bad outcomes of drought on physiological parameters and might enhance yield below water strain conditions (Singh *et al*. 2005) [7]. Phosphorus is discovered in all residing plant cells and is critical for plant growth. It is used by the plant for the formation of nucleic acids [Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA)], phospholipids, the coenzymes Nicotinamide adenine dinucleotide (NAD) and Nicotinamide adenine dinucleotide phosphate (NADP), Adenosine triphosphate (ATP) and different excessive strength compounds. Phosphorus is concerned in more than one plant features which include strength switch, photosynthesis, sugar and starch conversion, nutrient switch inside plants, and transmission of genetic developments from one era to the next. This is necessary for the most important processes. H. Phosphorylation.

Scanty work in middle zone of U.P. for lentil on phosphorous and biofertilizer requirement have done. Keeping the above facts in view present investigation was undertaken to see the effects of biofertilizer and phosphorous levels on yield attributes, yield and quality of Lentil.

Materials and Methods

A field experiment on lentil entitled "Effect of phosphorus and biofertilizers on to see the effects of biofertilizer and phosphorous levels on yield attributes, yield and quality of Lentil." was carried out at Shradheya Bhagwati Singh Agriculture Research Farm, Chandra Bhanu Gupta Agriculture PG college, (BKT, Lucknow) during the rabi season of 2021-22. The college is located 17 kilometers towards west from district headquarter Lucknow. The texture of soil was silty-loam having organic carbon 0.71% available nitrogen 266 Kg/Ha, available Phosphorous 26.2 Kg/Ha, available Potassium 260.1 Kg/Ha with soil pH of 7.9. The experiment consisted with four levels of phosphorous i.e., (0, 30, 60 and 90 Kg/ha) and three biofertilizers *viz*., Rhizobium, PSB and Rhizobium+PSB thus, having 12 treatments combinations was planned in randomized block design (Factorial experiment). Observations on number of branches per plant, number of pods per plants, number of grains per pod, weight of grain per plant, seed yield, straw yield and protein content and protein yield were recorded and subjected to statistical analysis to draw valid conclusions for the effect of treatments tested.

Results and Discussion

Number of branches per plant

Application of phosphorus from 0 to 90 kg/ha increased the number of branches per plant significantly. However, the maximum number of branches per plant (6.95), (9.83), (12.08) and (12.55) at 30, 60, 90 DAS and harvesting stage, respectively was recorded with 90 kg P_2O, ha^1). The lowest number of branches per plant (4.67), (6.55), (8.24) and (8.64) at 30, 60, 90 DAS and harvesting stage, respectively was recorded with no phosphorus treatment at all the stages. These findings are in close conformity with the findings of Biswas and Patra (2007) [1].

Crop treated with Rhizobium + PSB recorded significantly the highest number of branches per plant (6.48), (9.30), (11.00) and (11.93) at 30, 60, 90 DAS and harvesting stage, respectively over PSB and Rhizobium applied alone. Data further revealed that lentil seed treated with PSB observed the highest number of branches per plant as compared to Rhizobium treated seed at all the stage of crop growth. Similar findings were reported by Hussain *et al.* (2011) [2].

Table 1: Effect of phosphorus and biofertilizers on number of branches per plant at different growth stages

Treatments	Number of branches per plant			
Levels of P_2O_5 (kg/ha)	Days after sowing			
	30	60	90	At Harvest
0	4.67	6.55	8.24	8.64
30	5.71	8.19	10.19	10.49
60	6.67	9.42	11.50	11.93
90	6.95	9.83	12.08	12.55
S.Em±	0.133	0.166	0.221	0.225
CD (P=0.05)	0.382	0.478	0.637	0.648
Biofertilizers				
Rhizobium	5.52	7.10	9.10	9.46
PSB	6.00	8.50	10.50	11.31
Rhizobium + PSB	6.48	9.30	11.00	11.93
S.Em±	0.115	0.155	0.202	0.195
CD (P=0.05)	0.331	0.446	0.581	0.562

Yield attributes

Application of phosphorus from 0 to 90 kg/ha increased the number of pods per plant significantly. However, the maximum number of pods per plant (64.65), number of grains per pod (119.57), weight of grain per plant (2.42 g) respectively was recorded with 90 kg P_2O, ha^1). The lowest values above mentioned traits were associated with control plots where phosphorous was not applied. These findings are in close conformity with the findings of Biswas and Patra (2007) [1].

Crop treated with Rhizobium + PSB recorded significantly the highest number of branches per plant (60.47), (109.04), and (2.10 g) respectively over PSB and Rhizobium applied alone. The lowest values of these traits were noted where Rhizobium alone was applied. Similar findings were reported by Hussain *et al.* (2011) [2].

Table 2: Effect of phosphorus and biofertilizers on Number of Pods Per Plants, Number of Grains Per Pod and Weight of Grain Per Plant

Treatments	Yield Attributes		
Levels of P_2O_5 (kg/ha)	Number of Pods Per Plants	Number of Grains Per Pod	Weight of Grain Per Plant
0	55.86	96.28	1.69
30	58.42	103.3	1.91
60	61.43	115.42	2.14
90	64.65	119.57	2.42
S.Em±	0.032	0.20	0.006
CD (P=0.05)	0.094	0.59	0.018
Biofertilizers			
Rhizobium	59.75	106.05	1.98
PSB	60.06	107.83	2.04
Rhizobium + PSB	60.47	109.04	2.10
S.Em±	0.028	0.172	0.005
CD (P=0.05)	0.082	0.51	0.016

Table 3: Effect of phosphorus and biofertilizers on grain yield, straw yield protein content and protein yield

Treatments	Yield and Quality attributes			
Levels of P_2O_5 (kg/ha)	Grain Yield (q/ha)	Straw Yield (q/ha)	Protein Content (%)	Protein yield (kg/ha)
0	9.64	20.67	19.38	264.34
30	11.64	24.24	21.63	338.29
60	14.83	29.59	22.50	401.17
90	15.81	31.47	23.25	453.60
S.Em±	0.014	0.166	0.529	0.547
CD (P=0.05)	0.042	0.490	1.521	1.642
Biofertilizers				
Rhizobium	10.33	22.12	20.31	331.66
PSB	12.92	27.14	21.63	365.98
Rhizobium + PSB	15.51	30.21	23.13	405.01
S.Em±	0.012	0.144	0.458	0.521
CD (P=0.05)	0.036	0.424	1.317	1.565

Yield and Quality attributes

Application of phosphorus from 0 to 90 kg/ha increased the seed yield, straw yield, protein content and protein yield significantly. However, the maximum seed yield (15.81 q/ha), straw yield (31.47 q/ha), protein content (23.25%) and protein yield (453.60 kg/ha) respectively was recorded with 90 kg P_2O, ha^1). The minimum values above parameters were associated with control plots where phosphorous was not applied. These findings are in close conformity with the findings of Choudary *et al.* (2011) [4].

Crop treated with Rhizobium + PSB recorded significantly the maximum seed yield (15.51 q/ha), straw yield (30.21 q/ha), protein content (23.13%) and protein yield (405.01 kg/ha) respectively over PSB and Rhizobium applied alone. The lowest values of these traits were recorded under Rhizobium treatment alone. Similar findings were reported by Gupta *et al.* (2006) [5].

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