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Effect of spacing and phosphorus levels on yield and economics of lentil (*Lens culinaris* Medikus)

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Abstract
A field experiment was conducted during *Rabi* 2020 at CRF (Crop Research Farm), Department of Agronomy, SHUATS, Prayagraj, (UP.). The soil of the experimental field is sandy loam in texture, low in organic carbon and medium available nitrogen, phosphorus and low in potassium. The treatments consisted Spacing *viz.*, 25 cm x 10 cm, 30 cm x 10 cm and 35 cm x 10 cm and Phosphorus levels *viz*., 40 kg P/ha, 50 kg P/ha and 60 kg P/ha whose effect is observed in lentil (K-75). The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. Study revealed that the treatment of 30 cm x 10 cm + P at 60 kg/ha was recorded highest grain yield (1519.75 kg/ha) and Stover yield (3241.65 kg/ha) as compared to all treatments. The economic analysis clearly indicate that maximum gross returns (79128.25 Rs/ha), net returns (53153.25 Rs./ha) and B: C (2.05) was recorded with treatment of 30 cm x 10 cm + P at 60 kg/ha.

Keywords: Lentil, spacing, phosphorus, yield and economics

Introduction
Lentil (*Lens culinaris* Medikus) is an important cool season grain legume crop in India, which is second major winter sown legume after chickpea. Lentil is an important food legume grown during winter season throughout Indian continent under varied agro-ecological conditions, soil types and cropping system, in areas where winters are extremely cold. It is considered as poor man's meat as well as cheapest source of protein for under privileged group of people who cannot afford to buy animal protein (Gowda and Kaul, 1982) [6]. The primary product of the cultivated lentil is the seed, which is a valuable human food product containing a high amount of protein (22.0-34.5%), carbohydrates (65%) and other minerals and vitamins (Yadav *et al.*, 2007) [19] since, 2008. In many countries lentils are used as a meat substitute (Duke, 1981) [3]. The seeds are mostly eaten as dal in soups and the flour can be mixed with cereal flour and used in cakes, breads and some baby food (Muehlbauer *et al.*, 1995) [11].

Spacing is one of the important character which can be manipulated to attain the maximum production from per unit land area. With an increase in spacing the total population decreases but with more nutrients the individual plant grows better and yield more vice-versa. On the other hand, very small population will also reduce the yield (Pookpakdi and Pataradilok, 1993) [13]. Adequate spacing ensures less competition for sunlight, space, water and nutrition and gives a greater yield under favourable moisture conditions. The optimum spacing favours the plants to grow in their both aerial and underground parts through efficient utilization of solar radiation and nutrients and thus increase grain yield (Miah *et al.*, 1990) [10].

Phosphorus is important macro elements for growth of legumes. Phosphorus is critical in plant metabolism which plays an important role in several plant functions, including energy storage and transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Phosphorus is a constituent of ATP, nucleic acid, phospholipids, ADP, sugar phosphate, phytin, protein and several co-enzymes. Phosphorus enhances the root proliferation, nodulation and nitrogen fixation in legume crops, increases dry matter production and seed yield (Sepetoglu, 2002; Sharma and Sharma, 2004; Balyan and Singh, 2005) [14, 15, 1]. It increases the hardness of crop and also improves the crop quality and enhances the crop resistance to diseases (Mann, 1968) [9].

Materials and Methods
The experiment was conducted during the *Rabi* season of 2020 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj.

The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitudes and at an altitude of 98 m above mean sea level. This area is situated on the proper side of the river Yamuna and by the other side of Allahabad City. All the facilities required for crop cultivation were available. The experiment was laid out in Randomized Block Design with nine treatments replicated thrice. The treatments consisted Spacing *viz.*, 25 cm x 10 cm, 30 cm x 10 cm and 35 cm x 10 cm and Phosphorus levels *viz.*, 40 kg P/ha, 50 kg P/ha and 60 kg P/ha whose effect is observed in lentil (K-75). The treatment combination are as follow (T_1) 25 cm x 10 cm + Phosphorus 40 kg/ha, (T_2) 25 cm x 10 cm + Phosphorus 50 kg/ha, (T_3) 25 cm x 10 cm + Phosphorus 60 kg/ha, (T_4) 30 cm x 10 cm + Phosphorus 40 kg/ha, (T_5) 30 cm x 10 cm + Phosphorus 50 kg/ha, (T_6) 30 cm x 10 cm + Phosphorus 60 kg/ha, (T_7) 35 cm x 10 cm + Phosphorus 40 kg/ha, (T_8) 35 cm x 10 cm + Phosphorus 50 kg/ha, (T_9) 35 cm x 10 cm + Phosphorus 60 kg/ha. The Recommended dose of fertilizer is 20:40:20 kg/ha NPK. Fertilizer was applied at the time of sowing in the form of urea, SSP and MOP. The growth parameters were recorded at periodic intervals 20,40,60,80,100 DAS and at harvest from randomly selected plants from each treatment.

Chemical analysis of soil

Composite soil samples are collected before the layout of the experiment to work out the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried under shade, powdered with wooden pestle and mortar, passed through 2 mm sieve and were analyzed for organic carbon by rapid titration method (Nelson, 1975) [12], available nitrogen was estimated by alkaline permanganate method by Subbiah and Asija (1956) [17], available phosphorus by Olsen's method as outlined by Jackson, available potassium was determined by using the flame photometer normal ammonium acetate solution and estimating by using flame photometer (ELICO Model) as outlined by Jackson (1973) [7].

Statistical analysis

The data recorded were different characteristics were subjected to statistical analysis by adopting Fishers the method of analysis of variance (ANOVA) as described by Gomez and Gomez (1984). Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

Results and Discussion

Yield: Observations regarding grain yield and Stover yield are given in Table 1. The maximum grain yield (1519.75 kg/ha) was observed in treatment T_6 (30 cm x 10 cm + P at 60 kg/ha). However, 1450.69 kg/ha was recorded in treatment T_9 (35 cm x 10 cm + P at 60 kg/ha) and 1353.23 kg/ha was recorded in treatment T_3 (25 cm x 10 cm + P at 60 kg/ha) which was statistically at par with T_6 (30 cm x 10 cm + P at 60 kg/ha). The maximum Stover yield (3241.65kg/ha) was observed in treatment T_6 (30 cm x 10 cm + P at 60 kg/ha). However, 3017.94 kg/ha was recorded in treatment T_9 (35 cm x 10 cm + P at 60 kg/ha) which was statistically at par with treatment T_6 (30 cm x 10 cm + P at 60 kg/ha).

While spacing of 30 x 10 cm recorded significantly higher seed yield and stover yield as compared to 35 x 10 cm spacing. It is may be due to higher number of plants per hectare in case of 30 x 10 cm row spacing. 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 of the crop. In the later stage, the excess assimilates stored in the leaves was translocated towards sink development which ultimately contributed to higher seed yield. These results are also in agreement with findings of Choubey *et al.* (2013) [2], Singh, D. *et al.* (2017) [16], Kalsaria *et al.* (2017) [8] and Tophia Yumnam *et al.* (2018) [18] in lentil.

Table 1: Effect of spacing and phosphorus levels on yield of lentil

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)
25 cm x 10 cm + P at 40 kg/ha	1034.63	2720.40
25 cm x 10 cm + P at 50 kg/ha	1273.39	2809.20
25 cm x 10 cm + P at 60 kg/ha	1353.23	2998.33
30 cm x 10 cm + P at 40 kg/ha	961.59	2836.88
30 cm x 10 cm + P at 50 kg/ha	1256.05	2964.88
30 cm x 10 cm + P at 60 kg/ha	1519.75	3241.65
35 cm x 10 cm + P at 40 kg/ha	1020.31	2810.36
35 cm x 10 cm + P at 50 kg/ha	1320.08	2861.10
35 cm x 10 cm + P at 60 kg/ha	1450.69	3017.94
F- Test SEm (±)	S63.04	S74.74
CD (P=0.05)	189.00	224.06

Economic Analysis

Observations regarding the economics of treatments are given in table 2. Higher gross return (79128.25 Rs./ha) was obtained in treatment T_6 (30 cm x 10 cm + P at 60 kg/ha). However, the minimum gross returns (50459.53 Rs./ha) was found to be in treatment T_4 (30 cm x 10 cm + P at 40 kg/ha) as compared to other treatments. Net returns (53153.25 Rs./ha) was found to be highest in treatment T_6 (30 cm x 10 cm + P at 60 kg/ha), and the minimum net returns (25609.53 Rs./ha) was found to be in treatment T_4 (30 cm x 10 cm + P at 40 kg/ha) as compared to other treatments. Benefit Cost ratio (2.05) was found to be highest in treatment with T_6 (30 cm x 10 cm + P at 60 kg/ha), and the minimum benefit cost ratio (1.03) was found to be in treatment T_4 (30 cm x 10 cm + P at 40 kg/ha) as compared to other treatments. Dwivedi *et al.*, (2018) [4] also reported that increased economic values may be ascribed to higher grain yield leading to higher net return and Benefit Cost ratio.

Table 2: Effect of spacing and phosphorus levels on economics of lentil

Treatments	Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)	Net returns (Rs./ha)	B:C ratio
25 cm x 10 cm + P at 40 kg/ha	25,050.00	54126.16	29076.16	1.16
25 cm x 10 cm + P at 50 kg/ha	25,612.50	66347.49	40734.99	1.59
25 cm x 10 cm + P at 60 kg/ha	26,175.00	70513.89	44338.89	1.69
30 cm x 10 cm + P at 40 kg/ha	24,850.00	50459.53	25609.53	1.03
30 cm x 10 cm + P at 50 kg/ha	25,412.50	65540.99	40128.49	1.58
30 cm x 10 cm + P at 60 kg/ha	25,975.00	79128.25	53153.25	2.05
35 cm x 10 cm + P at 40 kg/ha	24,650.00	53440.99	28790.99	1.17
35 cm x 10 cm + P at 50 kg/ha	25,212.50	68754.63	43542.13	1.73
35 cm x 10 cm + P at 60 kg/ha	25,775.00	75494.33	49719.33	1.93

Conclusion

The present study clearly showed that 30 cm x 10 cm + 60 kg P /ha has got higher seed yield (1519.75 kg/ha), Stover yield (3241.65 kg/ha), gross return (79128.25 Rs./ha), net returns (53153.25 Rs./ha) and benefit cost ratio (2.05) in Lentil. It can be concluded that for obtaining higher yield and higher gross returns of Lentil optimum spacing and phosphorus was found more effective.

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