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Effect of sulphur levels and spacing on growth and yield of lentil (*Lens culinaris* M.)

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Abstract
A field experiment was conducted during *Rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available Nitrogen (171.48 kg/ha), available Phosphorus (15.2 kg/ha) and available Potassium (232.5 kg/ha). The treatments were are Spacing's of 20x10, 30x10 and 40x10 cm and Sulphur at 10, 20 and 30 kg/ha. The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The results showed that viz: maximum plant height (45.80 cm), nodules per plant (1.67), dry weight (26.08 g), were recorded significantly in the treatment of T_6 which is with spacing of 30x10 cm + Sulphur at 30 kg/ha. The maximum Pods/plant (199.26), Seeds/pod (1.99), Test weight (25.82 g), higher seed yield (1.67 t/ha), stover yield (2.49 t/ha) and Harvest index of (40.12 %) were recorded in the treatment T_6 is with the spacing of 30x10 cm+ Sulphur at 30 kg/ha as compared to all other treatments. However, the maximum gross returns (10,0200.00 INR/ha), net returns (54154.00) and B:C ratio (1.17) was significantly recorded in the T6 with Spacing's of 30x10 cm and Sulphur at 30, kg/ha as compared to all other treatments.

Keywords: Lentil, sulphur, spacing, yield and economics

Introduction
Lentil is one of the oldest food crop and is relatively tolerant to drought and grown throughout the world. Lentil has 26% protein. Legumes usually require almost equal amount of Phosphorus and Sulphur, and below critical amount in the soil adversely affect both plant growth and quality of produce. Lentil is a protein/calorie crop. Protein content ranges from 22 to 35%, but the nutritional value is low because lentil is deficient in the amino acid's methionine and cystine. Lentil is an excellent supplement to cereal grain diets because of its good protein/carbohydrate content (Delu and Brar 2021) [2].

Lentil is the important legume crop mainly grown in residual soil moisture in Eastern part of India and prominent source of vegetable protein. It is a valuable human food, mostly consumed as dry seeds (whole decorticated, seed decorticated and split). In Indian sub-continent mostly consumed as 'Dal' by removal of outer skin and separation of cotyledons, snacks and soup preparation etc. It is easy to cook and easily digestible with high biological value, hence also referred to patient. Dry leaves, stems, empty and broken pods are used as valuable cattle feed. Lentils have high nutritional value: high protein, high fiber, low fat, and a variety of minerals. The addition of lentils to other foods could enhance their health benefits. Additionally, there is no decrease in the amino acid content in lentils when cooked; rather, the amino acids increased and the phytic acids decreased. Lentils are generally known to have biomedical functions including antioxidative, anti-cancer, anti-inflammatory, antihypertensive, and thrombolytic properties (Singh and Singh 2014) [10].

During seed development in pulses, enormous quantities of proteins are accumulated over a short period of time. These accumulated proteins are of less diversity but constitute a major proportion of total seed protein in mature seeds. The globulin and albumins of pea, soybean, French bean, chickpea etc. have been extensively studied both qualitatively and quantitatively (Roy *et al*., 2010) [8].

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, Sirko A., 2008) [5].

Spacing by maintaining plant population to an optimum level, play an important role in growth

and development by affecting plant density and in turn moisture, nutrients and space availability (Panwar and Sharma, 2004) [6]. Advantage of optimum spacing under irrigated conditions is due to reduced competition for light because when the moisture is lacking, light is no longer limiting factor and the advantage of uniform spacing is lost (Ihsanullah *et al.* 2002).

Materials and Methods

The experiment was conducted during the *rabi* season of 2020-21 at the Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Allahabad. 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. Just before the layout preparation and sowing, 5 samples of soil from the various spot of the allotted research plot was collected randomly from a depth of 0 to 15 cm for analysing the soil sample. The soil texture of the experimental site was sandy loam having available N (110.8 kg/ha) P (6.9 kg/ha), potassium (119.2kg/ha) and organic carbon of soil was of 0.34% with 6.8 available pH of soil. the experimental plot was a randomized block design with having nine treatments which replicated three times with a suitable plot size was of 3m×3m. There were nine treatments combination used for this experiment which are T: 10 kg/ha Sulphur+ 20 kg/ha Spacing, T_2: 20kg/ha Sulphur + 30 kg/ha Spacing, T_3: 30 kg/ha Sulphur + 20 cm x 10 cm, T_4: 10 kg/ha Sulphur + 30 cm x 10 cm T_5: 20 kg/ha Sulphur + 30 cm x 10 cm, T_6: 30 kg/ha Sulphur + 30 cm x 10 cm, T_7 10 kg/ha Sulphur + 40 cm x 10 cm, T_8:20 kg/ha Sulphur + 40 cm x 10 cm, T_9; 30 Kg/ha Sulphur + 40 cm x 10 cm. The Recommended dose of fertilizer is 20:40:20kg/ha NPK. The growth parameters were recorded at periodic intervals 20, 40, 60, 80, 100 DAS and at harvest from randomly selected plants from each treatment.

Results and Discussion

Growth Attributes

Data present in the present table 1. The results of the present investigation revealed that T_6 (30 kg/ha Sulphur and 30 cm x 10 cm) significantly increased the plant height (45.80 cm) at harvest stage and T_9 (30 Kg/ha Sulphur + 40 cm x 10 cm) and T_3 (30 kg/ha Sulphur + 20 cm x 10 cm) are statistically at par with T_6 (30 kg/ha Sulphur + 30 cm x 10 cm). At harvest the maximum dry weight was observed in T_6 (30 kg/ha Sulphur + 30 cm x 10 cm) (26.08 g). However, 25.93 g was recorded in T_9 (30 Kg/ha Sulphur + 40 cm x 10 cm), 25.83 g was recorded in T_3 (30 kg/ha Sulphur + 20 cm x 10 cm) and 25.73 g T_5 (20 kg/ha Sulphur + 30 cm x 10 cm) which were statistically at par with T_6 (30 kg/ha Sulphur + 30 cm x 10 cm). At harvest the maximum number of nodules per plant was significantly higher in treatment T_6 (30 kg/ha Sulphur + 30 cm x 10 cm) having 1.67 nodules per plant. Treatments T_9 (30 Kg/ha Sulphur + 40 cm x 10 cm) (1.56) and T_3 (30 kg/ha Sulphur + 20 cm x 10 cm) (1.39) were statistically at par with T_6 (30 kg/ha Sulphur + 30 cm x 10 cm).

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*. (2018) [1] The spacing practices had significant effects on plant height (cm); however, an increasing trend with closer geometry level could be noticed. This may be due to the competition between the inter and intra plants for sun light, water, nutrients and space at closer spacing, whereas optimum spacing helped in significantly highest plant height. Significant results were obtained due to the optimum spacing of 30x10 cm and similar results were obtained by Singh *et al.* (2009) [9]. Sulphur plays major role in photosynthetic process which has a direct bearing on plant growth and development, increasing levels of Sulphur application resulted in increment in dry weight of lentil, the results were found to be similar with Singh *et al.* (2000) [11]. Higher dry matter production is observed in 30x10 cm spacing due to better photosynthetic activity due to greater exposure to light and increased availability of nutrients to plants have also resulted in higher dry weight, the treatment showed the increasing trend in dry weight up to harvest stage, Khan *et al*. (2017) also reported similar results.

Yield Attributes

Observations regarding yield attributes are given in Table 2. Treatment T_6 (30 kg/ha Sulphur + 30 cm x 10 recorded maximum number of pods per plant (199.26), number of seeds per pod (1.47) and test weight (25.82g). Higher number of pods plant-1 might have been possible due to more vigor and strength attained by the plants as a result of better photosynthetic activities with sufficient availability of light, and supply of nutrients in balanced quantity of the plants at growing stages the results were similar to Jitendra *et al*. (2015) [3]. Observations regarding grain yield, Stover yield and harvest index are given in Table 2. The maximum grain yield was observed in treatment T_6 (30 kg/ha Sulphur + 30 cm x 10 cm) (1.67 t/ha). However, 1.64 t/ha was recorded in treatment T_9 (30 Kg/ha Sulphur + 40 cm x 10 cm) and 1.60 t/ha was recorded in treatment T_3 (30 kg/ha Sulphur + 20 cm x 10 cm) which was statistically at par with T_6 (30 kg/ha Sulphur + 30 cm x 10 cm). The maximum Stover yield was observed in treatment T_6 (30 kg/ha Sulphur + 30 cm x 10 cm) (2.49 t/ha). However, 2.46 t/ha was recorded in treatment T_9 (30 Kg/ha Sulphur + 40 cm x 10 cm) and 2.41 t/ha treatment T_3 (30 kg/ha Sulphur + 20 cm x 10 cm) which was statistically at par with treatment T_6 (30 kg/ha Sulphur + 30 cm x 10 cm). This indicated the synergistic effects of sulphur application in improving productivity of Lentil. Similar, increase in yield due to the application of sulphur was also reported by Khurana *et al*. (2002) [4] in lentil also Higher seed yield under S application @ 30 kg/ha might be due to significant expansion in entire yield related. The similar results observed by Prajapati *et al.* (2013) [7], Togay and Parsak (2014) [12]. The optimum spacing 30x10 cm helped plant to receive sufficient amount of heat, water and nutrients from soil which the increased number of pods/plant, seeds/pod and test weight which directly helped in increase of seed yield in lentil. The results were similar to Singh *et al.* (2009) [9].

Conclusion

The present study clearly showed that 30 kg/ha Sulphur + 30 cm x 10 cm has got higher seed yield (1.67 t/ha) and Stover yield (2.49 t/ha) and also found more productive and effective. The conclusion drawn are based on one season data which requires further confirmation for recommendation.

Table 1: Effect of Spacing and Phosphorus levels on yield attributes and yield of Lentil

Treatments	Plant height (cm) at harvest	Number of nodules/plant at harvest	Dry weight (g) at harvest
10 kg/ha Sulphur + 20 cm x 10 cm	43.19	0.74	24.89
20 kg/ha Sulphur + 20 cm x 10 cm	44.21	0.93	25.48
30 kg/ha Sulphur + 20 cm x 10 cm	45.04	1.39	25.83
10 kg/ha Sulphur + 30 cm x 10 cm	43.67	0.91	25.34
20 kg/ha Sulphur + 30 cm x 10 cm	44.71	1.24	25.73
30 kg/ha Sulphur + 30 cm x 10 cm	45.80	1.67	26.08
10 kg/ha Sulphur + 40 cm x 10 cm	43.50	0.84	25.14
20 kg/ha Sulphur + 40 cm x 10 cm	44.44	1.07	25.62
30 Kg/ha Sulphur + 40 cm x 10 cm	45.48	1.56	25.93
S.Em(±)	0.33	0.11	0.12
C D (P=0.05)	1.00	0.32	0.35
	3.59	1.47	1.83

Table 2: Effect of Spacing and Phosphorus levels on yield attributes and yield of Lentil

Treatments	Pods/plant	Seeds/pod	Test weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
10 kg/ha Sulphur + 20 cm x 10 cm	182.89	1.38	23.43	1.41	2.22	38.83
20 kg/ha Sulphur + 20 cm x 10 cm	190.12	1.66	24.21	1.51	2.30	39.65
30 kg/ha Sulphur + 20 cm x 10 cm	194.32	1.92	25.27	1.60	2.41	39.44
10 kg/ha Sulphur + 30 cm x 10 cm	187.64	1.59	23.95	1.48	2.28	39.43
20 kg/ha Sulphur + 30 cm x 10 cm	192.09	1.81	24.68	1.55	2.39	39.33
30 kg/ha Sulphur + 30 cm x 10 cm	199.26	1.99	25.82	1.67	2.49	40.12
10 kg/ha Sulphur + 40 cm x 10 cm	185.70	1.49	23.57	1.43	2.26	38.78
20 kg/ha Sulphur + 40 cm x 10 cm	191.30	1.76	24.53	1.53	2.34	39.55
30 Kg/ha Sulphur + 40 cm x 10 cm	196.50	1.95	25.45	1.64	2.46	39.94
S.Em(±)	1.79	0.02	0.34	0.02	0.03	0.45
C D (P=0.05)	5.36	0.07	1.01	0.07	0.08	-

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