



Effect of phosphorus and sulphur levels on growth and yield of lentil (*Lens culinaris* L.)

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ARTICLE INFO	ABSTRACT
<p>Received : 19 November 2021 Revised : 08 April 2022 Accepted : 29 May 2022</p> <p>Available online:</p> <p>Key Words: Lentil Phosphorus Sulphur Yield Economics</p>	<p>A field experiment was carried for the duration of <i>Rabi</i> 2020-21 at crop research farm of SHUATS, Prayagraj (U.P.). The soil of experimental site was sandy loam in texture, almost impartial in soil reaction (P^H 7.4), specified in randomized block design. It includes of two factors, Phosphorus levels i.e., P₁- (30 kg/ ha), P₂-(40 kg/ ha), P₃-(50 kg/ ha) and Sulphur levels i.e., S₁- (15 kg/ ha), S₂-(20 kg/ ha), and S₃ (25 kg/ ha) which was replicated thrice. Results shown significantly increase in growth parameters viz. , plant height (44.97 cm), number of number of nodules (10.26), dry weight (15.63g), yield attributes viz., number of pods per plant (90.67), number of seeds per pod (1.93), test weight (18.53g) and yield viz., seed yield (1986.66 kg/ ha), straw yield (3450.00 kg/ ha), harvest index (35.98 %). Higher gross returns (₹ 118536/ha), net returns (₹ 84360.50) and B:C ratio (2.46) Therefore, concluded that combination of phosphorus 50 kg/ ha + sulphur 25 kg/ ha recorded significantly in all parameters.</p>

Introduction

Lentil (*Lens culinaris* L.) is one in all the oldest and maximum nutritious leguminous crop. It cultivation back to beginning of agriculture itself. It is used as cowl crop to test the soil erosion in hassle areas. It is mainly used as dal and consumed as whole decorticated or decorticated and split. The cotyledons are orange red in colour. The whole seeded grain which is commonly known as "Masoor" is used in some of the dishes. India occupies 2nd in role in lentil manufacturing with inside the international after Canada and is the 5th maximum critical pulse crop in India in phrases of manufacturing after chick pea, pigeon pea, mungbean and urdbean (Singh *et al.*, 2015). In the country, lentil is cultivated in a place approximately 1.27 million hectares with manufacturing of 0.97 million tonnes and common productiveness of 765 kg/ ha.(Report.,2015-2016). Lentil is a leguminous crop, fixes atmospheric nitrogen via root nodules via way of means of rhizobium bacteria where in

atmospheric nitrogen is transformed right into a plant usable form in presence of nitrogenase enzyme. It restores soil fertility and improves soil health. Lentil is known for maximum protein content, that is double than cereals. It is likewise called "A poor man meat" because of cheapest and nutritional protein. It contain 23.25% protein, 59% carbohydrates, 1.8% oil, and lines of iron, calcium, phosphorus and magnesium.

Phosphorus is the important thing detail for a success pulse manufacturing. Phosphorus complements the foundation proliferation and nodulatin in legume crops, will increase dry count manufacturing and seed yield (Sharma and Sharma, 2004, Balyan and Singh, 2005). Phosphorus concerned in lots of plant functions, along with energy storage and transfer, photosynthesis, transformation of sugars and starches, nutrient motion in the plant and switch of genetic traits from one generation to the next. Phosphorus may be an

element of ATP, nucleic acid, phospholipid, ADP, sugar phosphate, phytin, protein and various co-enzyme.

Sulphur is the fourth predominant nutrient and essential element for plant growth particularly for legumes crops which play an important role in plant metabolism. Sulphur is a component of a few critical amino acids namely cystine, cysteine and methionine. Sulphur is important for boom and improvement, play a key function in plant metabolism, chlorophyll formation needed for improvement of cells and its increases bloodless resistance and drought hardiness.

The productivity of Lentil in U.P. is totally low because of several limitation like nutrient deficiencies in macro (nitrogen, phosphorus and sulphur) and micro (copper, manganese, zinc and iron) nutrients (EnviStats India, 2019), imbalance fertilizer management practices and infestation of great disease and pests furthermore as lack of latest agro techniques like proper sowing time, plant population and inadequate supply of fertilizer and lack of fine seeds etc. Legumes usually require almost equal amount of phosphorus and sulphur. Phosphorus (<12.5 kg/ha) and sulphur (< 10 mg/kg) below critical amount within the soil adversely affect both plant growth and quality of produce. Present study was conducted to study the phosphorus and Sulphur ranges for maximizing growth and yield of lentil in these climatic conditions.

Material and Methods

Site Selection

The experiment entitled “Effect of Phosphorus and Sulphur levels on growth and yield of lentil (*Lens culinaris* L.)” modified into accomplished at some stage of *Rabi*-season 2020, on the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The Crop Research Farm is located at 25°.750 N latitude, 87°.190 E line of longitude (Google-2021) and at an altitude of ninety eight m higher than sea level. The experimental field soil texture changed into sandy loam.

Experimental Design

The experiment was carried out in a randomized block layout and ten treatments has been replicated three times every on KLS 9-3 variety of lentil. The

lentil was sown on 7th December 2020 with plant geometry 20×10 cm. The treatments were T₁-control (N,K), T₂-Phosphorus 30 kg/ ha + Sulphur 15 kg/ ha, T₃-Phosphorus 30 kg/ ha + Sulphur 20 kg/ ha, T₄-Phosphorus 30 kg/ha + Sulphur 25 kg/ ha, T₅-Phosphorus 40 kg/ ha + Sulphur 15 kg/ ha, T₆-Phosphorus 40 kg/ ha + Sulphur 20 kg/ ha, T₇-Phosphorus 40 kg/ ha + Sulphur 25 kg/ ha, T₈-Phosphorus 50 kg/ ha + Sulphur 15 kg/ ha, T₉-Phosphorus 50 kg/ ha + Sulphur 20 kg/ ha and T₁₀-Phosphorus 50 kg/ ha + Sulphur 25 kg / ha.

Statistical analysis

The experimental data recorded for statistical evaluation via way of means of by adopting Fishers approach of evaluation of variance (Anova) as described by Gomez and Gomez (1984). The statistics accrued from the test turned into subjected to statistical evaluation using ICAR WASP software. Critical difference (CD) values had been calculated the ‘F’ check turned into discovered drastically at 5% level.

Results and Discussion

Growth Parameters

Plant height (cm)

Perusal of data present in Table.1 regarding plant height of lentil was recorded during different stages of crop of growth which turned into substantially better with the utility of Phosphorus 50 kg/ ha + sulphur 25 kg/ ha. During different intervals from 80, 100 DAS to harvest there was significant increase in plant height (42.63 cm, 43.81 cm, and 44.97 cm respectively) with the application of treatment T₁₀. Treatment combination T₉ and T₇ were statistically at par with treatment T₁₀. Above results showed that plant height continued to increase with advancement in crop age and this increase was high during early growth period. However, a slow growth was observed after 80 days of sowing. Increment in plant height might due to stimulation of biological activities in the presence of balanced supply of phosphorus. Similar outcomes on the increased plant height with the increased level of phosphorus application have also been reported by other researchers Maqsood *et al.*, 2000, Barua *et al.*, 2011 and Singh *et al.*, 2016.

Number of nodules per plant

Nodule production per plant was significantly influenced by different phosphorus levels. The highest number of nodules per plant was recorded

Table 1: Effect of Phosphorus and Sulphur levels on Plant height, Number of nodules per plant and Dry weight of lentil.

SN	Treatments	Plant height (cm)			Number of nodules per plant			Dry weight (g/plant)		
		80 DAS	100 DAS	At harvest	40 DAS	60 DAS	80 DAS	80 DAS	100 DAS	At harvest
1	Control (N,K)	34.33 ^f	36.26 ^f	37.74 ^f	25.4 ^h	27.2 ^g	6.00 ^h	3.53 ^c	5.23 ^c	7.26 ^f
2	Phosphorus 30 kg/ha+Sulphur 15 kg/ha	36.23 ^c	38.02 ^c	39.16 ^c	27.93 ^g	29.70 ^f	6.66 ^g	4.03 ^{cd}	5.90 ^{de}	8.86 ^{ef}
3	Phosphorus 30 kg/ ha+Sulphur 20 kg/ ha	36.84 ^c	39.01 ^{de}	40.48 ^d	28.93 ^{fg}	30.53 ^{ef}	7.00 ^g	4.23 ^{cd}	5.93 ^{de}	9.46 ^c
4	Phosphorus 30 kg/ha+Sulphur 25 kg/ha	37.78 ^{cd}	39.48 ^{cd}	40.54 ^d	29.93 ^{ef}	31.26 ^{def}	7.73 ^f	4.46 ^{cd}	7.20 ^{cde}	10.06 ^{de}
5	Phosphorus 40 kg/ha+Sulphur 15 kg/ha	38.51 ^c	39.82 ^{cd}	41.38 ^{cd}	30.6 ^{ce}	32.06 ^{cde}	8.2 ^e	4.60 ^{cd}	7.56 ^{cde}	10.40 ^{de}
6	Phosphorus 40 kg/ha+Sulphur 20 kg/ha	39.90 ^b	41.08 ^b	42.55 ^b	32.0 ^{bc}	33.87 ^{bc}	9.06 ^c	5.23 ^{bc}	9.16 ^{bc}	11.80 ^{cd}
7	Phosphorus 40 kg/ ha+ Sulphur 25 kg/ha	41.43 ^a	42.68 ^a	43.83 ^a	32.96 ^{ab}	35.66 ^{ab}	9.73 ^b	6.23 ^{ab}	10.40 ^{ab}	12.93 ^{bc}
8	Phosphorus 50 kg/ ha+ Sulphur 15 kg/ha	38.96 ^{bc}	40.48 ^{bc}	42.49 ^{bc}	31.2 ^{cd}	33.20 ^{cd}	8.66 ^d	4.83 ^c	7.86 ^{bcd}	10.86 ^{cde}
9	Phosphorus 50 kg/ ha+ Sulphur 20 kg/ha	41.58 ^a	42.80 ^a	43.87 ^a	33.06 ^{ab}	35.93 ^{ab}	10.06 ^{ab}	6.73 ^a	12.80 ^a	14.06 ^{ab}
10	Phosphorus 50 kg/ha+ Sulphur 25 kg/ha	42.63 ^a	43.81 ^a	44.97 ^a	34.0 ^a	37.06 ^a	10.26 ^a	6.90 ^a	12.86 ^a	15.63 ^a
	SEm(±)	0.44	0.41	0.39	0.40	0.80	0.13	0.42	0.87	0.72
	CD(P=0.05)	1.32	1.21	1.17	1.20	2.38	0.39	1.24	2.57	2.13

Table 2: Effect of Phosphorus and Sulphur levels on yield and yield components of lentil.

SN	Treatments	Number of pods per plant	Number of seeds per pod	Seed yield (kg/ ha)	Straw yield (kg/ ha)	Harvest index (%)
1	Control (N,K)	61.73 ^f	1.33 ^g	995.00 ^e	2085.00 ^f	32.47 ^e
2	Phosphorus 30 kg/ ha+ Sulphur 15 kg/ ha	65.00 ^{ef}	1.48 ^f	1130.00 ^d	2270.00 ^{ef}	33.32 ^{cd}
3	Phosphorus 30 kg/ ha+ Sulphur 20 kg/ ha	67.46 ^c	1.51 ^{ef}	1205.00 ^{cd}	2350.00 ^{ef}	33.93 ^{cd}
4	Phosphorus 30 kg/ ha+ Sulphur 25 kg/ ha	72.26 ^d	1.63 ^{de}	1233.33 ^{cd}	2383.33 ^e	34.11 ^{bcd}
5	Phosphorus 40 kg/ ha+ Sulphur 15 kg/ ha	74.86 ^d	1.70 ^{cd}	1278.33 ^c	2420.00 ^e	34.56 ^{abc}
6	Phosphorus 40 kg/ ha+ Sulphur 20 kg/ ha	86.16 ^b	1.73 ^{bcd}	1586.66 ^b	2983.33 ^{cd}	34.71 ^{abc}
7	Phosphorus 40 kg/ ha+ Sulphur 25 kg/ ha	87.26 ^{ab}	1.83 ^{abc}	1871.66 ^a	3368.33 ^{bc}	35.73 ^{ab}
8	Phosphorus 50 kg/ha+ Sulphur 15 kg/ha	80.53 ^c	1.73 ^{bcd}	1488.33 ^b	2810.00 ^d	34.62 ^{abc}
9	Phosphorus 50 kg/ha+ Sulphur 20 kg/ha	88.00 ^{ab}	1.85 ^{ab}	1895.00 ^a	3405.00 ^{ab}	35.77 ^{ab}
10	Phosphorus 50 kg/ha+ Sulphur 25 kg/ha	90.66 ^a	1.93 ^a	1986.66 ^a	3540.00 ^a	35.98 ^a
	SEm(±)	1.26	0.05	42.91	106.57	0.59
	CD(P=0.05)	3.76	0.14	127.50	316.63	1.74

Table 3: Effect of Phosphorus and Sulphur levels on economics of lentil.

SN	Treatment combination	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C Ratio
1	Control (N,K)	29470.4	61170	31699.6	1.07
2	Phosphorus 30 kg/ ha+ Sulphur 15 kg/ ha	32236.7	68980	36743.3	1.13
3	Phosphorus 30 kg/ ha+ Sulphur 20 kg/ ha	32686.7	73205	40518.3	1.23
4	Phosphorus 30 kg / ha+ Sulphur 25 kg/ ha	33136.7	74798	41661.3	1.25
5	Phosphorus 40 kg/ ha+ Sulphur 15 kg/ ha	32756.4	77278	44521.6	1.35
6	Phosphorus 40 kg/ ha+ Sulphur 20 kg/ ha	33206.4	95801	62594.6	1.88
7	Phosphorus 40 kg/ ha+ Sulphur 25 kg/ ha	33656.4	112261	78604.6	2.33
8	Phosphorus 50 kg/ ha+ Sulphur 15 kg/ha	33275.5	89938	56662.5	1.70
9	Phosphorus 50 kg/ha+ Sulphur 20 kg/ha	33725.5	113670	79944.5	2.37
10	Phosphorus 50 kg/ha+ Sulphur 25 kg/ha	34175.5	118536	84360.5	2.46

at 60 DAS (37.06) with treatment combination T₁₀. However lowest were recorded in control (6.00). Highest number of nodules was recorded during 80 DAS (10.26) with application of phosphorus 50 kg/ ha + sulphur 25 kg/ ha and it was statistically at par with treatment T₉. More availability of phosphorus plays an important role in use of sugar and starch, nucleus formation, cell division, photosynthesis and root growth that improves nodulation (Dhingra *et al.*, 1988). The number of nodules increases as plant grows, and normally reaches maximum at the mid flowering stage. So proper application of phosphorus facilitates the earlier formation of nodules, increasing their which enhances the nitrogen fixation (Gahoonia *et al.*, 2006). Thus phosphorus increases the yield of lentil by stimulating physiological functions and root development that improve nodulation (Sharma and Sharma.2004). Similar results are found with Datta *et al.*, 2013, Pandey *et al.*, 2016, Singh and Singh., 2016.

Plant dry weight (g/ plant)

Plant dry weight (g/ plant) was recorded with different intervals are tabulated Table 1 at various growth stages during plant growth. Dry weight was significantly increased (6.90, 12.86 g/plant) with the treatment combination T₁₀. The harvest and highest dry weight (15.63 g/ plant) was recorded in treatment T₁₀ and lowest was with control (7.26 g/plant). Increment in plant dry weight due to increase in dry weight in photosynthetic ability of different metabolites to various parts which in the

end increased the shoot development. These findings are familiar with those of Tophia *et al.*, 2018.

Yield and Yield attributes

Observations regarding the yield and yield attributes viz., number of pods per plant, number of Seeds per pod, Seed yield (kg/ ha), Straw yield (kg/ ha) and harvest index (%) of Lentil were depicted in Table 2.

Yield attributes

Number of pods per plant

The data in Table indicate that the pods per plant were significantly affected by the effect of different rates of phosphorus application. The minimum number of pods were found in control plot (61.73). The maximum number of Pods per plant (90.66) were recorded with treatment T₁₀. Datta *et al.*, (2013) mentioned that number of pods per plant in lentil significantly varied due to different levels of phosphorus. Increase in number of pods per plant because of availability of other nutrients which boosted carbohydrate metabolism and their translocation to reproductive parts of the plant. Phosphorus encourage flowering and fruiting which have stimulated the plants to produce more number of pods and it encourages more number of seeds per pods. These effects had been pronounced with of Maqssod *et al.*, 2000, Togay *et al.*, 2008 and Fatima *et al.*, 2013.

Number of seeds per pod

The average number of seeds per pod have an effect ultimately on the lentil crop. The data in table 2

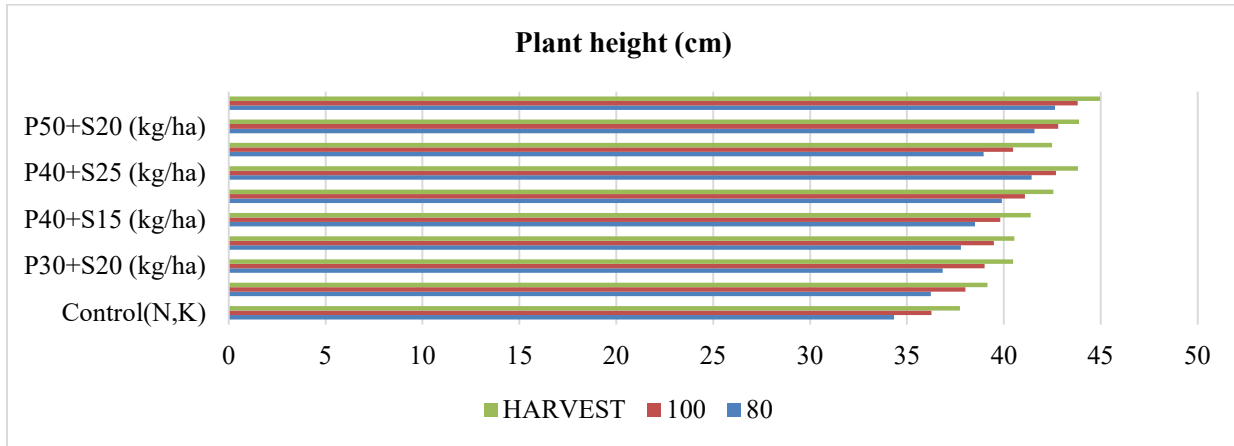


Figure 1: Plant height (cm) of lentil due to different treatment combinations.

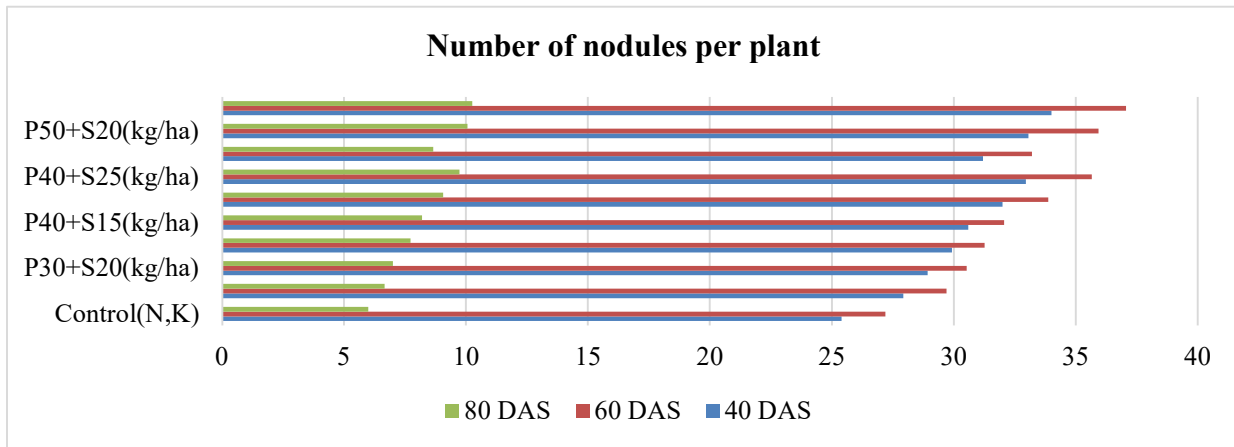


Figure 2: Number of nodules in lentil due to different treatment combinations.

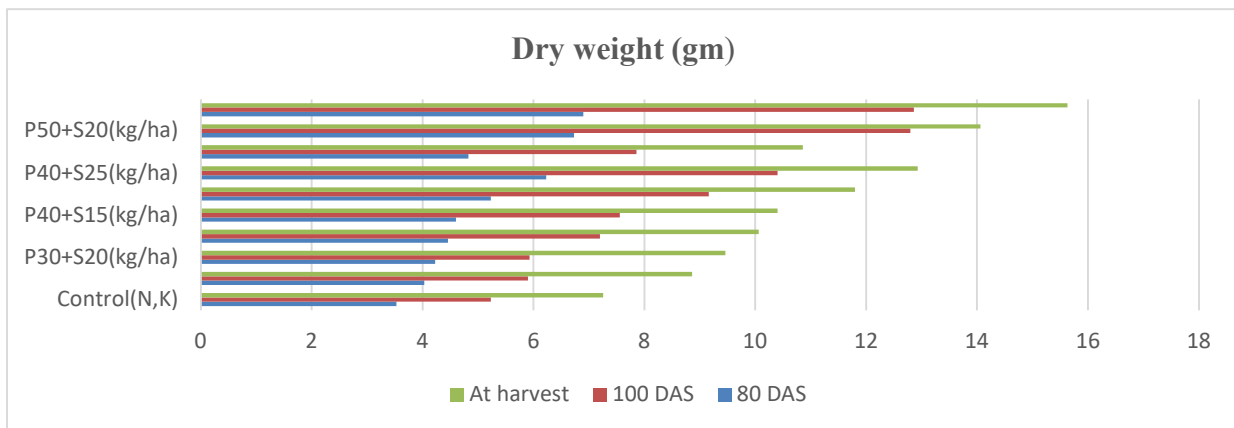


Figure 3: Dry weight (gm) of lentil in different treatment combinations.

reveals that there are significant differences regarding various treatment combinations. Significant growth in number seeds of pod (1.93) have been recorded in T₁₀. However treatment

combination T₉ and T₇ are statistically at par with treatment T₁₀. It is conformed from the above results that due to availability of nutrients by increasing the level of phosphorus increased the number of

seeds per pod. Number of seeds per pod had increased with application of phosphorus and Sulphur, which leads to transfer of photosynthates and its accumulates from growing parts of plant to seeds which make them plump and bold and also effects the seed size and weight. These results were close with Choubey *et al.*, 2013, Sonet *et al.*, 2000 and Upadhyay 2013.

Yield

Seed yield (kg/ ha)

Seed yield is the economic output of different applied treatments as well as the effect of different agronomic practices and environment. The higher supply of phosphorus enhances the grain yield by improving the yield components (Singh *et al.*, 2005). Data related to seed yield was depicted in table 2 higher seed yield was resulted in treatment T₁₀ (1986.66 kg/ ha) and lower seed yield recorded in control (995.00 kg/ha). Application of phosphorus improved the nutrient availability which results greater uptake might have increased the photosynthesis and translocation of assimilates to different parts for enhanced growth and yield. In later stages more assimilates are produced than used in growth and development and the excess assimilates are diverted to storage compounds resulting into increase in seed yield. Similar results were observed with Biswas *et al.*, 2015, Sahey *et al.*, 2015, and Chaubey *et al.*, 2019.

Straw yield (kg/ha)

Results associated with straw yield was recorded and tabulated in table 2 revealed that with treatment T₁₀ had produced maximum straw yield (3540.00 kg/ ha), and minimum straw yield recorded in control (2085 kg/ha). Numerous straw yield was attained by the enlargement of plant in terms of height, more spread number of branches, maximum dry weight of plant was the result of nutrient uptake. These outcomes had been supported by Singh *et al.*, 2000.

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Harvest index (%)

Data related to harvest index represents in table 3. Highest harvest index (35.98 %) was recorded in treatment combination T₁₀. However lowest harvest index recorded in control (32.47%) Increase in harvest index due to better translocation of photosynthesis from growing parts to storage parts which increases the economical yield of the plant. These results are supported by Chaubey *et al.*, 2019 and Shukla *et al.*, 2014.

Economics

Data revealed that experiment economics of lentil was presented in table 3. Cost of cultivation varied from ₹ 29470.40/ha to ₹ 34175.50/ha for different inputs used during research. Among all treatments, highest net returns ₹ 84,360.50/ha, gross returns ₹ 1,18,536/ ha and B:C-ratio (2.46) also found in treatment T₁₀.

Conclusion

This study concluded that the lentil variety (KLS 9-3) were found more productive in terms of maximum plant height, number of nodules per plant, dry weight of plant, yield attributes like number of pods per plant, number of seeds per pod and biological yield as well as in B: C ratio. The treatment combination of 50 kg/ha P₂O₅+ 25 kg/ha S was highly effective in terms of all the growth, yield parameters like seed yield (1986.66 kg/ha) and harvest index (35.98%).

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Conflict of interest

The authors declare that they have no conflict of interest.

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