PHOSPHORUS AND SULPHUR'S IMPACT ON LENTIL GROWTH AND YIELD (*Lens culinaris medik.*)

ABSTRACT

During the Rabi season of 2022–2023, a field experiment was carried out at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. to research how the nutrients phosphorus and sulphur affect the productivity and growth of lentil. The treatments consist of Phosphorus 20, 30, 40 kg/ha and Sulphur 10, 20, 30 kg/ha. The soil in the experimental plot had a sandy loamy texture, a pH of 7.8 that was virtually neutral, and just 0.35 percent organic carbon. The results showed that the application of phosphorus 40 kg/ha + Sulphur 30 kg/ha significantly influenced the higher plant height (39.81 cm), higher number of nodules (6.07), higher plant dry weight (14.40 g/plant), higher number of pods/plant (158.77), higher number of seeds/pod (1.94), higher 1000 seed weight (24.94 gm), higher seed yield (1.t/67 ha), and higher stover yield (2.92 t/ha). Treatment 9 (Phosphorus 40 kg/ha + Sulphur 30 kg/ha) likewise achieved greater net return (INR 68,600/ha), higher gross return (INR 1,00,200/ha), and higher B:C ratio (2.17).

Keywords: *Lentil, Phosphorus, Sulphur, growth parameters, yield attributes and Economics*

INTRODUCTION

Lens, a Latin term that precisely defines the form of the seed of a cultivated legume now known as Lens culinaris and named by the German botanist Medikus in Cubero (1787), has been one of the world's oldest agricultural crops resistant to drought. The plant known as Masoor is a member of the Fabaceae family. As a cool-season pulse crop, lentils are also comparatively drought-resistant. It is a useful source of protein from vegetables for humans. Along with iron, calcium, phosphorus, and magnesium, lentils also include protein, carbs, oils, and ash with percentages of 23.25%, 59%, 1.8%, and 0.2%, respectively. Lentils also contain a considerable quantity of vitamins A and B.

Plant nutrition is an important factor in increasing lentil crop productivity. Phosphorus (P), the second-most significant macronutrient and a non-renewable resource, is needed for developing cells and serves a variety of purposes for plant growth, development, and metabolism. Because it controls numerous biochemical processes in plant life, it is also known as "the secret to life." Phosphorus makes crops more resilient, and a sufficient amount of phosphorus causes crops to develop quickly. For vegetation to be healthy and vigorous, phosphorus is necessary. It promotes more uniform floral development and early fruit maturity. helps plants grow throughout their full life span and also provides disease resistance **(Singh *et al*. 2016).**

Sulphur is a crucial secondary plant nutrient that is essential for several physiological processes in plants, including the production of amino acids (such as methionine, cystein, and cystyne), the synthesis of proteins, and the production of chlorophyll. In addition to activating enzymes, it participates in the metabolism of vitamins (such as biotin and thiamine) as well as a portion of coenzyme A and pyrophosphate. Poor blooming, poor fruiting, and stunted development may be caused by a sulphur shortage. According to reports, pulses require more sulphur than oil seeds. **Parashar A, and Tripathi (2020).**

These factors were taken into consideration when the current study, titled "Effect of Phosphorus and Sulphur on Growth and Yield of Lentil (Lens culinaris medik.)," was conducted in Prayagraj, Uttar Pradesh, during the rabi season of 2022–2023 at the Crop Research Farm of the Department of Agronomy at the Naini Agriculture Institute of Sam Higginbottom University of Agriculture Technology and Sciences.

Materials and Methods

At the Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, the experiment was carried out during Rabi of 2022–2023. It is situated 98m above mean sea level (SL) at 25.24' 42" N latitude, 81.50' 56" E longitude. Ten treatments, each duplicated three times, were used in the experiment's Randomized Block Design. Each treatment's plot was 3m x 3m in size. Factors include three phosphorus values (20, 30, and 40 kg/ha) and three Sulphur levels (10, 20, and 30 kg/ha). When seeds were sown, P and S were given, and both were administered as basal. On November 26, 2022, KLS-0903, a type of lentils, was sowed at a spacing of 30cm × 10cm. Harvesting was done taking $1m^2$ area from each plot. And from it three plants were randomly selected for recording growth and yield parameters. The treatment details are as follows, T_1 -(RDP 20 kg/ha+ Sulphur 10 kg/ha), T_2 -(RDP 20 kg/ha+ Sulphur 20 kg/ha), T_3 – (RDP 20 kg/ha+ Sulphur 30 kg/ha), T_4 -(RDP 30 kg/ha+ Sulphur 10 kg/ha), T_5 -(RDP 30 kg/ha+ Sulphur 20 kg/ha), T_6 -(RDP 30 kg/ha+ Sulphur 30 kg/ha), T_7 -(RDP 40 kg/ha+ Sulphur 10 kg/ha), T_8 -(RDP 40 kg/ha+ Sulphur 20 kg/ha), T_9 -(RDP 40 kg/ha+ Sulphur 30 kg/ha), T_{10}-(N 20 Kg/ha + P 40 kg/ha +k 20 kg/ha) Control. Plant height, nodules per plant, dry weight, grain production, and stover yield were all observed and reported. By using the analysis of variance approach, the data were statistically analyzed **(Gomez and Gomez, 1976).**

Results and Discussion

Growth parameters:

Plant height – the significantly higher plant height (39.81cm) was observed in treatment-9 (RDP 40 kg/ha+ Sulphur 30 kg/ha). However, treatment-8 (RDP 40 kg/ha+ Sulphur 20 kg/ha) was statistically at par with treatment-9 (RDP 40 kg/ha+ Sulphur 30 kg/ha). Due to increased availability and crop absorption of soil nutrients brought on by phosphorus fertilisation, there may be a significant rise in plant height as a result of phosphorus application in the soil. "Higher nutrient availability may have improved photosynthetic capacity and metabolite translocation to various regions, which eventually improved root and shoot growth of the crop". **Tophia Yumnam *et al.* (2018)**, in lentil. And also, with the increased availability of sulphur to plants has helped in better development and thickening of xylem and collenchyma tissue which might have resulted into increased plant height. Similar results are reported with **Mourya Teja**

***et al*., (2021).**

Nodules/plant – Treatment-9 (Nitrogen 30/ha+ Phosphorus 50kg/ha) reported a significantly greater number of nodules/plant (37.44) [Table 1]. Nevertheless, it was discovered that treatment 8 (Nitrogen 30 kg/ha + Phosphorus 40 kg/ha) was statistically equivalent to treatment 9 (Nitrogen 30 kg/ha + Phosphorus 50 kg/ha). With the application of (Nitrogen 30kg/ha phosphorus 50kg/ha), a significant and higher number of nodules/plants were produced, which may have aided in the efficient utilisation of nutrients, improved crop canopy, and increased absorption and utilisation of radiant energy, all of which led to a higher effective and total number of nodules/plants. According to **Patel et al. (2017),** phosphorus treatment enhanced the number of nodules and plants in green gramme. Furthermore, the injection of more nitrogen may have favoured the quick development and tissue expansion. **Fatima *et al.* (2013).**

Dry weight/plant- Treatment 9 (RDP 40 kg/ha+ Sulphur 30 kg/ha) had the considerably greater plant dry weight (14.40 g/plant). Treatment 8 (RDP 40 kg/ha + 20 kg/ha Sulphur) was statistically comparable to Treatment 9 (RDP 40 kg/ha + 30 kg/ha Sulphur). With the application of phosphorus, a significant and increased dry weight is seen. Increases in dry weight brought on by an improvement in photosynthetic capacity and the distribution of metabolites, which eventually led to an improvement in crop shoot growth and conformance with **Unni and Debbarma (2022).** Sulfur's dry weight has also significantly improved. Sulphur plays a significant part in the photosynthetic process, which has a direct impact on the growth and development of plants. Increasing levels of Sulphur application led to an increase in the dry weight of lentils, and the results were similar to those of other crops. **Singh *et al.* (2000).**

YIELD

Number of Pods/plant - Treatment 9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha) had a much larger number of pods per plant (158.77), making it significantly better than the other treatments. Treatment 8 (RDP 40 kg/ha + 20 kg/ha Sulphur) was shown to be statistically equivalent to Treatment 9 (RDP 40 kg/ha + 30 kg/ha Sulphur). Phosphorus administration significantly and significantly increased the number of pods/plants, which may be because phosphorus considerably promotes the reproduction of plants, i.e., blooming and fruiting. These outcomes matched those of **Abid *et al.* (2017).** Improvements in Sulphur availability and a favourable nutritional environment may have aided the plants during their peak growth and flowering stages, which ultimately increased the number of pods per plant. Similar outcomes have been reported with the application of Sulphur. **Mourya Teja *et al.*, (2021).**

Number of seeds/pod - Treatment 9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha) had a much larger number of seeds per pod (1.94), making it significantly better than the other treatments. However, it was discovered that treatment-8 (RDP 40 kg/ha + Sulphur 20 kg/ha) was statistically equivalent to treatment-9 (RDP 40 kg/ha + Sulphur 30 kg/ha). A much greater number of seeds or pods may be the result of enhanced phosphorus fertilisation, which ensures the availability of other plant nutrients, increasing carbohydrate buildup and their re-mobilization to reproductive sections of the plant, which are the closest sink. It is well known that phosphorus promotes blooming and fruiting, which may have encouraged the plants to produce more pods per plant and more seeds per pod. Similar results were disclosed by **Shah *et al.* (2000).**

Test Weight (gm)

Treatment 9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha) had the substantial and higher Test Weight (24.94 gm), which was considerably better than the other treatments. Treatment 8 (RDP 40 kg/ha + 20 kg/ha Sulphur) was shown to be statistically equivalent to Treatment 9 (RDP 40 kg/ha + 30 kg/ha Sulphur). The plants may have benefited from higher Sulphur availability and a nutrient-friendly environment throughout the peak development and blooming periods, which eventually led to an increase in the number of pods per plant, the number of seeds per pod, and test weight. Source sink relationships and sink sizes may have improved as a result of enhanced growth characteristics. Similar outcomes have been validated with **Anil Kumar Singh *et al.* (2012).**

Seed Yield (t/ha) - Treatment 9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha) had a much greater seed production (1.67 t/ha), outperforming the other treatments by a large margin. Treatment 8 (RDP 40 kg/ha + 20 kg/ha Sulphur) was shown to be statistically equivalent to Treatment 9 (RDP 40 kg/ha + 30 kg/ha Sulphur). With the application of phosphorus, a significantly higher seed yield was observed. "This was due to the increased photosynthesis and translocation of nutrients to various plant parts, which improved plant growth and yield-attributing characteristics of the crop as seen in the number of pods/plant and number of seeds/pod. The extra assimilates that had been stored in the leaves were later transferred to sink development, which helped to increase seed output". **Tophia Yumnam *et al.* (2018)**. The large growth in all yield-related parameters, such as the number of branches (primary and secondary), capsules/plant, seeds/capsule, and test weight (1000-seed weight), may also account for the higher seed production under the 30 kg/ha sulphur treatment. The same outcomes were seen by **Prajapati *et al.* (2013).**

Stover Yield (t/ha) - Stover yield of 2.92 t/ha, which was substantially greater than that of the other treatments, was seen in treatment 9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha). However, it was discovered that treatment-8 (RDP 40 kg/ha + Sulphur 20 kg/ha) was statistically equivalent to treatment-9 (RDP 40 kg/ha + Sulphur 30 kg/ha). A significant and greater output of stover was produced after adding phosphorus, which may have helped the plant develop more effectively in terms of plant height, the quantity of nodules or plants, and dry weight. This improved nutrient absorption led to the increased yield of stover. Similar results were disclosed by **Choubey *et al.* (2013)**. Additionally, the use of Sulphur contributes to an increase in The plant was grown taller, had more branches spread out, and produced more straw thanks to nutrient intake. The plant's maximum dry weight was also a result of this growth. These results has been corroborated by **Singh et al., (2000).**

Economic Analysis

Gross returns (INR/ha) - Highest gross return (1,00,200.00 INR/ha) was obtained in treatment-9 (RDP 40 kg/ha+ Sulphur 30 kg/ha) as compared to other treatments.

Net Returns – "Net return (68,600.00 INR /ha) was found to be highest in treatment-9 (RDP 40 kg/ha+ Sulphur 30 kg/ha) as compared to other treatments. With increasing levels of phosphorus, the grain and straw yield increased this attributed to a higher Net return". **Mitra *et al.* (2006).**

Benefit Cost Ration - Benefit Cost ratio (2.17) was found to be highest in treatment-9 with (RDP 40 kg/ha+ Sulphur 30 kg/ha) as compared to other treatments.kg/ha) as compared to other treatments [Table 2].

Conclusion:

It was determined that Treatment 9 (the application of 40 kg/ha of phosphorus and 30 kg/ha of Sulphur) had improved growth and yield metrics. With the application of phosphorus 40 kg/ha and Sulphur 30 kg/ha (Treatment-9), the highest seed production, gross returns, net returns, and benefit cost ratio were also noted. Further studies may be necessary to corroborate these results as they are based on only one season.

Table 1. Influence of phosphorus and Sulphur on growth parameters of lentil.

S. No.	Treatment combinations	Plant height	Number of nodules/plant	Plant Dry weight
1.	RDP 20 kg/ha+ Sulphur 10 kg/ha	35.67	15.65	11.13
2.	RDP 20 kg/ha+ Sulphur 20 kg/ha	35.91	15.78	11.60
3.	RDP 20 kg/ha+ Sulphur 30 kg/ha	36.77	16.47	11.73
4.	RDP 30 kg/ha+ Sulphur 10 kg/ha	37.35	16.81	12.40
5.	RDP 30 kg/ha+ Sulphur 20 kg/ha	37.61	17.89	12.73
6.	RDP 30 kg/ha+ Sulphur 20 kg/ha	38.14	18.63	13.20
7.	RDP 40 kg/ha+ Sulphur 10 kg/ha	37.24	18.47	13.67
8.	RDP 40 kg/ha+ Sulphur 20 kg/ha	38.97	19.44	13.73
9.	RDP 40 kg/ha+ Sulphur 30 kg/ha	39.81	20.83	14.40
10.	Control	35.61	15.90	11.56
	F test	S	S	S
	S Em.(±)	0.36	0.54	0.25
	CD (P=0.05)	1.08	1.59	0.75

Table 2. Influence of phosphorus and Sulphur on yield attributes of lentil.

S. No.	Treatment combinations	No. of Pods/Plant	No. of seeds/pods	Test weight	Grain yield	Straw yield	Harvest index
1.	RDP 20 kg/ha+ Sulphur 10 kg/ha	115.17	1.31	19.37	1.10	2.57	29.98
2.	RDP 20 kg/ha+ Sulphur 20 kg/ha	125.60	1.53	20.27	1.23	2.60	32.17
3.	RDP 20 kg/ha+ Sulphur 30 kg/ha	129.97	1.60	20.45	1.26	2.67	32.11
4.	RDP 30 kg/ha+ Sulphur 10 kg/ha	136.83	1.57	21.03	1.33	2.57	34.08
5.	RDP 30 kg/ha+ Sulphur 20 kg/ha	142.21	1.64	22.04	1.37	2.71	33.55
6.	RDP 30 kg/ha+ Sulphur 20 kg/ha	147.60	1.75	22.18	1.49	2.82	34.54
7.	RDP 40 kg/ha+ Sulphur 10 kg/ha	145.83	1.67	20.67	1.52	2.76	35.56
8.	RDP 40 kg/ha+ Sulphur 20 kg/ha	153.54	1.81	23.81	1.61	2.87	35.90
9.	RDP 40 kg/ha+ Sulphur 30 kg/ha	158.77	1.94	24.94	1.67	2.92	36.39
10.	Control	133.73	1.63	19.63	1.19	2.70	30.47
	F test	S	S	S	S	S	S
	S Em.(±)	3.09	0.05	0.88	0.04	0.05	0.76
	CD (P=0.05)	9.19	0.14	2.61	0.12	0.16	2.25

Table 3. Influence of phosphorus and Sulphur on economic analysis of lentil.

Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
RDP 20 kg/ha+ Sulphur 10 kg/ha	29406	66000	36594	1.24
RDP 20 kg/ha+ Sulphur 20 kg/ha	29936	73800	43864	1.47
RDP 20 kg/ha+ Sulphur 30 kg/ha	30456	75780	45324	1.49
RDP 30 kg/ha+ Sulphur 10 kg/ha	29982	79560	49578	1.65
RDP 30 kg/ha+ Sulphur 20 kg/ha	30512	81960	51448	1.69
RDP 30 kg/ha+ Sulphur 20 kg/ha	31032	89160	58128	1.87
RDP 40 kg/ha+ Sulphur 10 kg/ha	30550	91380	60830	1.99
RDP 40 kg/ha+ Sulphur 20 kg/ha	31080	96600	65520	2.11
RDP 40 kg/ha+ Sulphur 30 kg/ha	31600	100200	68600	2.17
CONTROL	30030	71160	41130	1.37

REFERENCES:

Aditya Delu and BS Brar. Effect of different level of sulphur on growth and yield of lentil crop: A review. *International Journal of Chemical Studies* 2021; 9(1): 193-197.

Ali, Abid, Ahmad, Bashir, Hussain, Iqbal, Ali, Akhtar, Shah and Ali, Fawad (2017). Effect of phosphorous and zinc on yield of lentil. *Pure Applied Biology* 6(4):1397-1402.

Anil Kumar Singh., Gade, R.M., Bharati, R.C., Santosh Kumar and Pravesh Kumar. 2012. Influence of sulphur and zinc nutrition on incidence of disease and performance of rice. *J. Pl. Dis. Sci.* 7(2): 239-242.

Anpur Saikiran Goud, Rajesh Singh and Punnam Chhetr. Effect of Spacing and Phosphorus Levels on Growth and Yield of Lentil (*Lens culinaris* Medikus). *Biological Forum – An International Journal* 13(4): 181-184(2021).

Arathi Unni and Victor Debbarma (2022). Response of Nitrogen and Phosphorus on Growth and Yield of Lentil (*Lens culinaris* medik.) *International Journal of Plant & Soil Science* 34(21): 328-334.

Bagadi Mourya Teja VS, George SG. Effect of sulphur and zinc on growth and yield of lentil (Lens culinaris M.); 2021.\ 10(11):370-372.

Choubey, S.K., Dwivedi V.P. and Srivastava, N.K (2013). Effect of different levels of phosphorus and sulphur on growth, yield and quality of lentil. *Indian Journal Science and Research* 4(2):*149-150.*

Cubero JI. Origin, taxonomy and domestication. In: Webb C, HawtinGC, editors. Lentils. Slough, England: Commonwealth Agricultural Bureau; 1981.

Gomez, K. A and Gomez, A. A (1976). Three or more factor experiment. In: Statistical Procedure for Agricultural Research 2nd edition, p. 139 -141.

Guriqbal Singh, Hari Ram, H.S. Sekhon, Navneet Aggarwal and Veena Khanna. Effect of Nutrient Management on Nodulation, Growth and Yield of Lentil (*Lens culinaris* Medik.) Genotypes. *American-Eurasian Journal of Agronomy*, 4 (3): 46-49, 2011

Mitra, A.K., Banerjee, K and Pal A.K (2006). Effect of different levels of phosphorus and Sulphur on yield attributes, seed yield, protein content of seed and economics of summer green gram. *Research on crops* 7(2):404-405.

Niranjan Reddy Yadavalli, Umesha Chil, Umesha Chil, L.K. Sanodiya. Effect of phosphorus and sulphur levels on growth and yield of lentil (*Lens culinaris* L.). September 2022

Environment Conservation Journal 23(3):313-319. DOI: 10.36953/ECJ.9792221.

Prajapati, J. P., Kumar, S., Singh, R. P., Kushwaha, I. K. and Yadav, P. K. 2013. Effect of Phosphorous and Sulphur on growth and yield attributes and yield of green gram (*Vigna radiate* L.). *Environment and Ecology* 31(4); 1977 - 1979.

Parashar A, Tripathi L. Effect of phosphorus and sulphur on the growth and yield of black gram (Vigna mungo L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(5):2585-2588.

Patel HB, Shah KA, Barvalya MM, Patel SA. Response of green gram (Vigna radiata L.) to different level of Phosphorus & organic liquid fertilizer. International Journal of Current Microbiology and Applied Sciences. 2017;6(10):3443-51.

Shah, S. H., Mahmood, M.Y. and Zamir, M.S.I. 2000. Qualitative and quantitative response of three cultivars of lentil (*Lens culinaris* Medic) to phosphorus application. *Int. J. Agri. Biol*., 2(3): 248-250.

Singh, Nariendar and Singh, Guriqbal, (2016). Response of lentil (Lens culinaris Medikus) to phosphorus. *Agricultural Reviews* 37(1):27-34.

Singh, Y. P., Chauhan, C. P. S. and Gupta, R. K. 2000. Effect of Sulphur, Phosphorous and inoculation on growth, yield and Sulphur utilization by lentil (*Lens culinaris*). *Indian Journal of Agricultural Sciences* 70(7); 491-493.

Togay, Y. Togay, N. and Dogan, Y. (2008). Research on the effect of phosphorus and molybdenum applications on the yield and yield parameters in lentil (*Lens culinaris* Medic.) *African Journal of Biotechnology* 7 (9): 1256-1260.

Yumnam, Tophia, Luikham, Edwin, Singh and Herojit, A (2018). Influence of phosphorous on growth and yield of promising varieties of lentil (*Lens Culinaris* L.M). *International Journal of Current Microbiology and Applied Sciences* 7(8):162-170.