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Effect of Phosphorus and Zinc on Growth and Yield of Lentil (*Lens culinaris* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

A field experiment was conducted during *Winter* season of 2022 at Crop Research Farm (CRF). Department of Agronomy, SHUATS, Prayagraj (UP) to investigate the effect of phosphorus and zinc levels on growth and yield of lentil. The treatments consist of three phosphorus doses viz., 20, 30, 50 kg/ha and three foliar zinc doses i.e., 0.25%, 0.5%, 0.75% whose effect is observed on Lentil (var. PL 406). The experiment was laid out in RBD with Ten treatments replicated thrice. The treatment with application of Phosphorous 50 Kg/ha + Zinc 0.75% recorded significantly higher plant height (45.28 cm) and plant dry weight (12.15 g), number of pods per plant (123.67), number of seeds per pod (1.80), test weight (24.77 g), seed yield (1.72 t/ha) and straw yield (3.36 t/ha) compared to other treatment combinations. It is concluded that Phosphorous 50 Kg/ha + Zinc

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0.75% execute better growth parameters, yield attributes and higher seed yield in lentil crop under eastern Uttar Pradesh conditions.

Keywords: Lentil yield; phosphorus effect; zinc effect.

1. INTRODUCTION

With a quarter of global production and more than one-third of the world's total area under cultivation, India is the world's top producer of pulses. Due to its excellent drought tolerance, the lentil (*Lens culinaris* Medikus) is third most important legume crop planted in India during the Rabi season. It belongs to the Papilionaceae subfamily of the Fabaceae family. The lentil was given the scientific name *Lens culinaris* M. by German botanist Medikus. The vitamins riboflavin, thiamine, niacin, and iron are all abundant in pulses. According to Chandra and Lal [1], there should be a particular amount of fibre in the average person's diet. Pulses range in average protein content from 18 to 24%.

Phosphorus is one of the most crucial nutrients for plants in the soil [2]. It is a part of plant cells and is essential for cell division as well as the expansion of the growing tip [3]. It becomes crucial for young plants and seedlings because of this. As its presence is essential for the storage and transfer of energy required for metabolic activities, phosphorus also has an enhancing effect on growth and biological yield [4]. According to Himani B. Patel et al. [5], phosphorus application not only boosts the dry matter and seed yield of lentils but also improves the N and P content of the seed by promoting nodulation and root development. Increased phosphorus treatment lengthens the plant's main and lateral roots, allowing it to draw significant amounts of water from deeper soil layers. A crucial structural component or regulatory cofactor of numerous enzymes and proteins, zinc is an essential micronutrient that is involved in numerous critical biochemical processes, including the metabolism of carbohydrates, photosynthesis, the conversion of sugars to starch, proteins, auxin (a growth regulator) metabolism, the formation of pollen, the integrity of biological membranes, and resistance to infection by specific pathogens [6]. Because pollen grains contain a large amount of zinc, the majority of the zinc is transferred to seeds during fertilization, making zinc an essential element in reproductive processes like fertilization and pollen grain formation [7].

Plant growth is hampered when phosphorus is absent. Stunted and spindly plants also have stunted roots. Other indications of a shortage include withering leaves, red pigment in the leaf bases, and dull, greyish-green leaves. A phosphorus shortfall can be difficult to identify and, by the time it is, it can already be too late. Plants that were deficient in phosphorus as seedlings may not recover when phosphorus is later provided. Zinc deficiencies can effect plant by stunting its growth, chlorosis, smaller leaves increasing crop maturity period and inferior quality of harvested products [8].

2. MATERIALS AND METHODS

At the Department of Agronomy, SHUATS, Crop Research Farm (CRF), Prayagraj (UP), a field experiment was run from December 2022 to March 2023. The Crop Research Farm is located 98 meters above mean sea level at 25.4137 degrees north latitude and 81.8491 degrees east longitude. The experimental plot's soil had a sandy loam texture, a pH of 7.4 that was almost neutral, medium levels of available nitrogen (278.93 kg/ha), low levels of phosphorous (19.03 kg/ha), and medium levels of available potash (238.1 kg/ha). It also included medium levels of organic carbon (0.48%), available nitrogen, and phosphorus. The treatments comprise of three phosphorus doses viz., 20, 30, 50 kg/ha and three foliar zinc doses i.e., 0.25%, 0.5%, 0.75% whose effect is observed on Lentil (var. PL 406). The experiment was laid out in RBD with ten treatments replicated thrice. The experiment comprising ten treatment possible combination of above factor, *viz.,* T_1: Phosphorus - 20 kg/ha + Zinc 0.25%, T_2: Phosphorus - 20 kg/ha+ Zinc 0.5%, T_3: Phosphorus - 20 kg/ha+ Zinc 0.75%, T_4: Phosphorus - 30 kg/ha+ Zinc 0.25%, T_5: Phosphorus - 30 kg/ha+ Zinc 0.5%, T_6: Phosphorus - 30 kg/ha+ Zinc 0.75%, T_7: Phosphorus - 50 kg/ha+ Zinc 0.25%, T_8: Phosphorus - 50 kg/ha+ Zinc 0.5%, T_9: Phosphorus - 50 kg/ha+ Zinc 0.75%, T_{10}: 10. Control with RDF (N: P: K 20:40:20). Observations regarding growth and yield attributes was recorded during the field experiment.

3. RESULTS AND DISCUSSION

3.1 Effect of Phosphorous and Zinc on Growth Parameters of Lentil

According to the study data pertaining to growth parameters, the significantly higher plant height (45.28 cm) and higher plant dry weight (12.15 g) was recorded in treatment with application of Phosphorous 50 Kg/ha + Zinc 0.75%.

The application of phosphorus may have enhanced plant photosynthetic activity and helped the plant build a more extensive root system, allowing the plant to take more water and nutrients from deeper soil, leading to a significant rise in plant growth. These findings support the findings of Himani et al. [5] and Mukesh et al. [9]. Higher plant dry weight may also be related to Zinc role in starch synthesis and glucose metabolism, which aids in improved dry matter production. It might possibly be the result of enhanced carbonic anhydrase activity, which promoted higher photosynthesis and carbon uptake [10].

3.2 Effect of Phosphorous and Zinc on Yield Attributes of Lentil

According to the yield characteristics data that was collected and analyzed at harvest, maximum number of pods per plant (123.67), maximum number of seeds per pod (1.80) and higher test weight (24.77 g) was recorded in treatment with the application of Phosphorous 50 Kg/ha + Zinc 0.75%.

According to Maqsood et al. [11], fertilizing with phosphorus may encourage a plant's flowering and fruiting, which would result in the production of more pods. The explanation for the higher number of pods per plant may be related to the moderate availability of plant nutrients, which causes the plant to produce more pods per plant when compared to other treatments. Phosphorus also significantly speeds up blooming and fruiting in plants. These findings, as well as those of Abid et al. [7], are very similar.

3.3 Effect of Phosphorous and Zinc on Yield of Lentil

After evaluated the data recorded post harvesting of crop show that significantly higher seed yield (1.72 t/ha), higher straw yield (3.36 t/ha) and harvest index (33.89%) was recorded in treatment with the application of Phosphorous 50 Kg/ha + Zinc 0.75%.

The reason for the highest pod output is that balanced plant nutrient availability and phosphorus enhance flowering and fruiting as well as enable plants to produce more pods per plant than other treatments, increasing the seed yield. These findings closely match those of Maqsood et al. [11] and Himani et al. [5]. Alloway [6] claims that Zn fertilization assisted in boosting the activity of numerous enzymes involved in photosynthesis, CO2 assimilation, starch synthesis, and protein synthesis. Higher seed yield may possibly be a result of zinc's greater contribution to the synthesis of auxins and indole acetic acid (IAA), which aid in the control of plant growth and, as a result, result in more pods per plant and higher yield. These findings and those of Abid Ali et al. [7] are very similar.

Table 1. Effect of phosphorous and zinc on growth parameters of lentil

Treatments	Plant Height (cm)	Plant Dry Weight (g)	CGR ($g/m^2/day$)	RGR (g/g/day)
Phosphorous 20 Kg/ha + Zinc 0.25%	39.54	9.15	10.34	0.057
Phosphorous 20 Kg/ha + Zinc 0.50%	40.48	9.74	10.96	0.056
Phosphorous 20 Kg/ha + Zinc 0.75%	40.72	10.14	11.36	0.056
Phosphorous 30 Kg/ha + Zinc 0.25%	41.37	10.45	11.57	0.055
Phosphorous 30 Kg/ha + Zinc 0.50%	41.71	10.93	12.33	0.057
Phosphorous 30 Kg/ha + Zinc 0.75%	43.62	11.24	12.48	0.055
Phosphorous 50 Kg/ha + Zinc 0.25%	42.57	11.15	12.67	0.058
Phosphorous 50 Kg/ha + Zinc 0.50%	44.48	11.83	13.15	0.055
Phosphorous 50 Kg/ha + Zinc 0.75%	45.28	12.15	13.06	0.052
20-40-20 kg NPK/ha (Control)	37.58	8.94	10.34	0.059
SEm(±)	1.25	0.33	0.36	0.004
CD (p=0.05)	3.49	0.97	----	----

Table 2. Effect of phosphorous and zinc on yield attributes of lentil

Treatments	Yield attributes		
	No.of pods/plant	**No.of seeds/pod**	**Test weight (g)**
Phosphorous 20 Kg/ha + Zinc 0.25%	91.87	1.33	21.62
Phosphorous 20 Kg/ha + Zinc 0.50%	94.33	1.40	21.87
Phosphorous 20 Kg/ha + Zinc 0.75%	97.53	1.47	22.29
Phosphorous 30 Kg/ha + Zinc 0.25%	101.47	1.47	22.59
Phosphorous 30 Kg/ha + Zinc 0.50%	104.67	1.53	22.81
Phosphorous 30 Kg/ha + Zinc 0.75%	114.60	1.67	23.61
Phosphorous 50 Kg/ha + Zinc 0.25%	112.40	1.60	23.08
Phosphorous 50 Kg/ha + Zinc 0.50%	120.47	1.73	24.17
Phosphorous 50 Kg/ha + Zinc 0.75%	123.67	1.80	24.77
20-40-20 kg NPK/ha (Control)	83.33	1.33	20.06
SEm(±)	3.06	0.06	0.89
CD (p=0.05)	9.10	0.17	----

Table 3. Effect of phosphorous and zinc on yield of lentil

Treatments	Seed Yield (t/ha)	Stover Yield (t/ha)	Harvest index (%)
Phosphorous 20 Kg/ha + Zinc 0.25%	1.11	2.27	32.81
Phosphorous 20 Kg/ha + Zinc 0.50%	1.23	2.47	33.13
Phosphorous 20 Kg/ha + Zinc 0.75%	1.26	2.56	32.88
Phosphorous 30 Kg/ha + Zinc 0.25%	1.46	2.86	33.88
Phosphorous 30 Kg/ha + Zinc 0.50%	1.48	2.94	33.49
Phosphorous 30 Kg/ha + Zinc 0.75%	1.54	3.34	31.56
Phosphorous 50 Kg/ha + Zinc 0.25%	1.52	3.29	31.69
Phosphorous 50 Kg/ha + Zinc 0.50%	1.70	3.34	33.77
Phosphorous 50 Kg/ha + Zinc 0.75%	1.72	3.36	33.89
20-40-20 kg NPK/ha (Control)	0.87	2.03	30.01
SEm(±)	0.06	0.09	0.92
CD (p=0.05)	0.17	0.26	----

Table 4. Effect of phosphorous and zinc on economics of lentil

Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C
Phosphorous 20 Kg/ha + Zinc 0.25%	26,668.74	61,105.00	34,436.26	1.29
Phosphorous 20 Kg/ha + Zinc 0.50%	26,981.24	67,448.33	40,467.09	1.50
Phosphorous 20 Kg/ha + Zinc 0.75%	27,293.74	69,080.00	41,786.26	1.53
Phosphorous 30 Kg/ha + Zinc 0.25%	27,199.99	80,501.67	53,301.68	1.96
Phosphorous 30 Kg/ha + Zinc 0.50%	27,512.49	81,510.00	53,997.51	1.96
Phosphorous 30 Kg/ha + Zinc 0.75%	27,824.99	84,700.00	56,875.01	2.04
Phosphorous 50 Kg/ha + Zinc 0.25%	28,262.49	83,655.00	55,392.51	1.96
Phosphorous 50 Kg/ha + Zinc 0.50%	28,574.99	93,500.00	64,925.01	2.27
Phosphorous 50 Kg/ha + Zinc 0.75%	28,887.49	94,765.00	65,877.51	2.28
20-40-20 kg NPK/ha (Control)	25,293.74	47,795.00	22,501.26	0.89

3.4 Effect of Phosphorous and Zinc on Economics of Lentil

The economic return of lentil was analyzed after harvesting the crop based on market pricing, the result indicated a growing trend in with the increasing yield trend across treatment [12,13].

The maximum Gross returns (INR 94,765.00/ha), Net returns (INR 65,877.51/ha) and Benefit cost ratio (2.28) was evaluated in treatment with the application of Phosphorous 50 Kg/ha + Zinc 0.75%.

4. CONCLUSION

Based on the above experimental findings, it is concluded that application of nutrients in combination of Phosphorous 50 Kg/ha and Zinc 0.75% accomplished better growth parameters, yield attributes, higher seed yield, higher gross returns and net returns in Lentil under eastern Uttar Pradesh conditions.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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