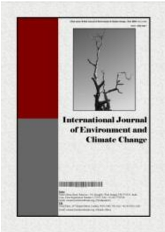

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Influence of Phosphorous and Foliar Spray of Zinc on Growth and Yield of Lentil (*Lens culinaris* M.)

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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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ABSTRACT

A field experiment was conducted during *Rabi season* of 2021-22, at crop research farm of Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj in North Eastern plains of Eastern Uttar Pradesh with the objective to study the Influence of Phosphorus and Foliar Spray of Zinc on Growth and yield of lentil (*Lens culinaris* M.) Var. KSL-0903 was conducted on Randomized block design comprising of 9 treatments designated as (T_1-T_9) with different combination of Phosphorus and Foliar Spray of Zinc on which are replicated thrice. The experimental results revealed that [Phosphorus 50kg/ha+ Zinc 0.75%] gave the tallest plants (54.53cm), Number of nodules/plant (8.66), Plant dry weight (12.73g), number of pods/plant (163.3), number of seeds/pod (2.00), test weight (25.13g), Seed yield (1.908t/ha), Stover yield (3.534 t/ha). The treatment 9 [Phosphorus 50kg/ha+ Zinc 0.75%] recorded highest net return (66348.30 INR /ha), highest gross return (97308.30 INR/ha) and benefit: cost ratio (2.14).

Keywords: Lentil; phosphorus; zinc; growth parameters; yield attributes and economics.

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1. INTRODUCTION

"India is largest pulse-growing country which accounts for nearly one-third of the total world area under pulses and one-fourth of the total world production. Lentil (*Lens culinaris* Medikus) is an important *Rabi* season legume crop in India, lentils are drought tolerant crop. It belongs to the sub-family Papilionaceae under the family Fabaceae (Leguminosae). Lentil (*Lens culinaris* M.)**.** It is locally known as Masoor. Lentil requires cold climate it is very hardy and can tolerate frost and severe winter to a great extent. It requires cold temperature at the time of maturity. The optimum temperature for growth is 18-30^{o}C. It grows on a wide range of soils ranging from light loam sand to heavy clay in northern parts, and in moderately deep, light black soil in Madhya Pradesh and Maharashtra. It is one of the important pulse crops of India which could adapt well to a wide range of climate and soil condition. It can tolerate frost & severe winter. India ranked first in area and second in the production with 39.79% and 22.79% of world area and production respectively. Canada rank first in production (41.16%) due to very high level of productivity (1633 kg/ha) as compared to India (611 kg/ha)" [1].

"Phosphorous is one of the most important elements significantly affecting the plant growth and metabolism. In legumes, the high requirement for P is consistent with the involvement of P in high rates of energy transfer that take place in the nodule. Phosphorous has also an enhancing impact on growth and biological yield through its importance as energy storage and transfer necessary for metabolic processes" [2]. Phosphorous addition increases the efficiency of plants photosynthesis, enhances the activity of rhizobia. Phosphorus contributes substantially to increased yield of legumes by enhancing the physiological functions of the crop plants, root development, and nodulation. Phosphorus application not only increases the dry matter and seed yield of lentil but also enhances the N and P content of the seed by increasing nodulation and root development.

"Zinc is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. It contributes to a number of important plant functions such as growth hormone production, plant resistance against disease, photosynthesis. Zinc is very important in reproductive phase like fertilization and pollen grain formation as pollen grains contains a high amount of zinc, most of the zinc is translocated to seeds during fertilization" [3]. "Plants enzymes activated by Zn are involved in carbohydrate metabolism, and regulation of auxin synthesis and pollen formation. Zn seems to affect the capacity for water uptake and transport in plants and also reduce the adverse effects of short periods of heat and salt stress. As Zn is required for the synthesis of tryptophan which is a precursor of IAA, it also has an active role in the production of an essential growth hormone auxin" [4].

2. MATERIALS AND METHODS

The experiment was carried out during winter season of 2021-2022 at the Crop Research Farm SHUATS, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The crop Research Farm is situated at 25^{o}24' 42" N latitude, 81^{o} 50' 56" E longitude and at an altitude of 98m above mean sea level (MSL). To assess the influence of phosphorus and Foliar Spray of zinc on growth and yield of Lentil (*Lens culinaris* M.)*.* The experiment was laid out in Randomized Block Design comprising of 9 treatments which are replicated thrice. Each treatment net plot size is 9m^{2} (3 × 3m). The treatment are categorized as with recommended doses of nitrogen through Urea and potash through Muriate of Potash, in addition with Phosphorus through Single super phosphate and Foliar Spray of zinc when applied in combinations as follows;T1- Phosphorus 30 kg/ha+ Zinc 0.25%;T2- Phosphorus 30 kg/ha + Zinc 0.5%;T3- Phosphorus 30 kg/ha + Zinc 0.75%;T4- Phosphorus 40 kg/ha + Zinc 0.25%;T5- Phosphorus 40 kg/ha + Zinc 0.5%;T6- Phosphorus 40 kg/ha + Zinc 0.75%;T7- Phosphorus 50 kg/ha + Zinc 0.25%;T8- Phosphorus 50 kg/ha + Zinc 0.5%;T9- Phosphorus 50 kg/ha + Zinc 0.75%. The Lentil crop was harvested at harvesting maturity stage. Growth parameters viz. plant height (cm), dry matter accumulation(g /plant) were recorded manually on five randomly selected representative plants from each plot of each replication separately and after harvesting, seeds were separated from each net plot and were dried under sun for three days. Later winnowed, cleaned and grain yield per ha was computed and expressed in tonnes per hectare. After complete drying under sun for 10 days stover yield from each net plot was recorded and expressed in kg/hectare. The data was computed and analyzed by following statistical method of Gomez and Gomez [5].

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

It is evident from Table 1.that plant height measured increased with advancement in crop growth. At harvest the treatment 9 (Phosphorus 50kg/ha+ Zinc 0.75%) recorded maximum height of 54.43cm. At harvest, significantly higher plant height (54.43 cm) was recorded in treatment-(T9). However, treatment-8 (Phosphorus 50 kg/ha + Zinc 0.5%) was statistically at par with treatment-(T9). The increase in plant height may be owing to phosphorus application in the soil might be due to increase availability and uptake of soil nutrients by the crop contributed by phosphorus fertilization. The higher availability of nutrients might have increased the photosynthetic ability and translocation of the metabolites to different parts which ultimately increased the root and shoot development of the crop. These findings corroborate the results of Zafar et al., [6], Singh et al., [7] in lentil.

3.1.2 Number of nodules

At harvest, significantly higher number of nodules per plant (8.66) was recorded in treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%). However, treatment- 8(Phosphorus 50 kg/ha + Zinc 0.5%) was found to be statistically at par with treatment-(T9). Application of phosphorus help in efficient utilization of nutrients, which resulted in attaining better crop canopy and further increased absorption and utilization of radiant energy resulting in higher effective and total number of nodules per plant**.** These results are confirmed with the findings of other researcher Patel et al., [8] and Ashish Masih et al., [9] who reported that application of phosphorus increased the number of nodules per plant.

3.1.3 Plant dry weight

At Harvest highest plant dry weight was found in treatment-9 Phosphorus 50 kg/ha+ Zinc 0.75% (12.73g). However, treatment- 8 (Phosphorus 50 kg/ha + Zinc 0.5%) was found to be statistically at par with treatment-(T9). Increase in dry weight due to increase in photosynthetic ability and translocation of metabolites to different parts which ultimately increased the shoot development of the crop. Similar results were found in Yumnam et al., [10].

3.2 Yield Attributes

3.2.1 Number of pods

The statistically higher number of pods/plant (163.3) was observed in treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%). which was significantly higher over rest of the treatments and treatment-8 (Phosphorus 50 kg/ha+ Zinc 0.5%), was statistically at par with treatment-(T9). It might be the reason of moderate plant nutrients availability due to which the plant produces more pods plant^{-1} as compare to other treatments and also phosphorus strongly increases the reproduction of the plants i.e., flowering and fruiting. These results were similar with that of Ali et al., [3] and Choubey et al., [11].

3.2.2 Number of seeds

Significant effect was observed by the statistical analysis of Number of seeds/pod. Treatment-9 Phosphorus 50 kg/ha+ Zinc 0.75% recorded significant and highest number of seeds/pod (2.00). However, statistically at par with treatment-8 (Phosphorus 50 kg/ha+ Zinc 0.5%).

3.2.3 Test weight (G)

The highest test weight (25.13 g) was observed in treatment-9 with (Phosphorus 50 kg/ha+ Zinc 0.75%), which was found to be significantly higher over rest of the treatments statistically at par with treatment-8 (Phosphorus 50 kg/ha+ Zinc 0.5%). Phosphorus fertilization was effective in the generative period of the plant and that such fertilization led to a much better granulation, enhancement and improvement occurred in test weight with the increasing doses of phosphorus. Similar findings were reported by Oguz et al. [12].

3.2.4 Seed yield (T/HA)

The highest seed yield (1.908 t/ha) was observed in treatment-9 with (Phosphorus 50 kg/ha+ Zinc 0.75%), which was found to be significantly higher over rest of the treatments statistically at par with treatment-8 (Phosphorus 50 kg/ha+ Zinc 0.5%). "Application of phosphatic fertilizer therefore provided balance nutrition to the crop which resulted in higher seed yield

Table 1. Influence of phosphorous and foliar spray of zinc on growth parameters of lentil

Treatments	No of Pods/ plant	No of Seeds/pod	Test weight (g)
T1:Phosphorus 30 kg/ha + Zinc 0.25%	139.8	1.00	21.82
T2:Phosphorus 30 kg/ha + Zinc 0.5%	142.1	1.30	22.10
T3:Phosphorus 30 kg/ha + Zinc 0.75%	143.1	1.60	22.90
T4:Phosphorus 40 kg/ha + Zinc 0.25%	149.2	1.40	22.63
T5:Phosphorus 40 kg/ha+ Zinc 0.5%	150.8	1.70	22.93
T6:Phosphorus 40 kg/ha + Zinc 0.75%	155.1	1.70	23.73
T7:Phosphorus 50 kg/ha + Zinc 0.25%	158.4	1.60	22.77
T8:Phosphorus 50 kg/ha + Zinc 0.5%	161.0	1.80	23.87
T9:Phosphorus 50 kg/ha+ Zinc 0.75%	163.3	2.00	25.13
F-Test	S	S	S
SEm±	3.63	0.07	0.60
CD (P=0.05)	2.59	0.20	1.80

Table 2. Influence of phosphorous and foliar spray of zinc on yield attributes of lentil

Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
T1:Phosphorus 30 kg/ha + Zinc 0.25%	1.346	2.070	39.38
T2:Phosphorus 30 kg/ha + Zinc 0.5%	1.395	2.274	38.02
T3:Phosphorus 30 kg/ha + Zinc 0.75%	1.523	2.486	38.03
T4:Phosphorus 40 kg/ha + Zinc 0.25%	1.446	2.324	38.36
T5:Phosphorus 40 kg/ha+ Zinc 0.5%	1.564	2.806	35.77
T6:Phosphorus 40 kg/ha + Zinc 0.75%	1.698	2.961	36.68
T7:Phosphorus 50 kg/ha + Zinc 0.25%	1.468	2.471	37.22
T8:Phosphorus 50 kg/ha + Zinc 0.5%	1.814	3.369	37.82
T9:Phosphorus 50 kg/ha+ Zinc 0.75%	1.908	3.534	35.04
F-Test	S	S	NS
SEm±	45.03	116.70	1.78
CD (P=0.05)	135.00	349.87	------

Table 3. Influence of phosphorus and foliar spray of zinc levels on economics of lentil

Treatments	Total cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
T1:Phosphorus 30 kg/ha + Zinc 0.25%	29425.00	68680.17	39255.17	1.33
T2:Phosphorus 30 kg/ha + Zinc 0.5%	29675.00	71145.00	41470.00	1.40
T3:Phosphorus 30 kg/ha + Zinc 0.75%	29925.00	77673.00	47748.00	1.60
T4:Phosphorus 40 kg/ha + Zinc 0.25%	29942.00	73762.83	43820.83	1.46
T5:Phosphorus 40 kg/ha+ Zinc 0.5%	30192.00	79764.00	49572.00	1.64
T6:Phosphorus 40 kg/ha + Zinc 0.75%	30442.00	86598.00	56156.00	1.84
T7:Phosphorus 50 kg/ha + Zinc 0.25%	30460.00	74868.00	44408.00	1.46
T8:Phosphorus 50 kg/ha + Zinc 0.5%	30710.00	92683.83	61973.83	2.02
T9:Phosphorus 50 kg/ha+ Zinc 0.75%	30960.00	97308.00	66348.00	2.14

of lentil. Phosphorus also increased the photosynthesis and translocation of assimilates to different plant parts for enhanced growth and yield attributing characters of the crop as observed in number of pods per plant and number of seeds per pod. In the later stage, the excess assimilates stored in the leaves was translocated towards sink development which ultimately contributed to higher seed yield". These findings were supported by Yumnam et al., [10] in lentil.

3.2.5 Stover yield (t/ha)

The highest stover yield (3.534 t/ha) was observed in treatment-9 with (Phosphorus 50 kg/ha+ Zinc 0.75%), which was significantly higher over rest of the treatments statistically at par with treatment-8 (Phosphorus 50 kg/ha+ Zinc 0.5%). Each increment in P stimulates the lentil to increase the straw yield. Similar findings were reported by Choubey et al. [11].

3.3 Economics

3.3.1 Gross returns (INR/ha)

Gross returns (97308.30 INR/ha) were found to be highest in treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%) and the lowest gross returns (68680.00 INR/ha) was found to be in treatment-1 (Phosphorus 30 kg/ha + Zinc 0.25%) as compared to other treatments.

3.3.2 Net returns (INR/ha)

Net (66348.30 INR/ha) were found to be highest in treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%) and the lowest net returns (39255.00 INR/ha) was found to be in treatment-1 (Phosphorus 30 kg/ha + Zinc 0.25%) as compared to other treatments.

The statistically higher Net returns was with the application of treatment -9 (Phosphorous 50kg/ha+ Zinc 0.75%). With increasing levels of phosphorus, the grain and straw yield increased this attributed to a higher net return. These results are in conformity with those observed by Mitra et al. [13].

3.3.3 Benefit cost ratio (B:C)

Benefit Cost ratio (2.14) was found to be highest in treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%) and the lowest benefit cost ratio (1.33) was found to be in in treatment-1 (Phosphorus 30 kg/ha + Zinc 0.25%) as compared to other treatments.

The statistically higher Benefit cost ratio was with the application of treatment-9 (Phosphorus 50 kg/ha+ Zinc 0.75%),due to the phosphorus and zinc provides conclusive condition to the soil with the synergistic influence of Phosphorus and Foliar spray of zinc resulting better benefit cost ratio.These results are supported by the findings of Mitra et al. [13] in lentil.

4. CONCLUSION

It may be concluded that the application of Phosphorus and Foliar spray of Zinc performs positively and improves the growth parameters and yield attributes of lentil. Maximum grain yield, gross return, net return, and benefit cost ratio were recorded with the application of Phosphorus 50kg/ha with Zinc 0.75%. These findings are based on one season therefore, further trails may be required for further confirmation [14-23].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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