

## Original Research Article

# Response of Biofertilizers and Foliar application of Zinc on Yield and Economics of Lentil (*Lens culinaris* L.)

## ABSTRACT

During the Rabi season of 2022, a field trial was carried out at the Crop Experimental Farm, Division of Agronomy, SHUATS, Prayagraj, UP. The trial included two variables with three levels of zinc (0.25%, 0.50%, 0.75%) and biofertilizer (*Rhizobium spp*, *Pseudomonas fluorescens*, *Rhizobium spp* + *Pseudomonas fluorescens*). The texture of the soil is sandy loam with 7.2 pH, 0.72% organic carbon, 178.48 kg/ha of available N, 27.80 kg/ha of available P, and 233.24 kg/ha of available K. The trial conducted in randomized block design with ten treatments and replicated three times. Zinc application and the use of biofertilizers had a big impact on the economics, yield attributes and yield. The outcome showed that treatment eight, *Rhizobium spp*, *Pseudomonas fluorescens* and foliar spray of zinc at 0.05% recorded maximum number of pods/plant (111.33), number of seeds per pod (2.27), seed yield (1025.37 kg/ha) and stover yield (2076.67 kg/ha). Maximum gross returns (91,856.58 INR/ha), net returns (61,406.58 INR/ha) and benefit cost ratio (2.02) were also observed in the same treatment eight in lentil crop.

**Key words:** Biofertilizer, *Rhizobium spp*, *Pseudomonas fluorescens*, Yield, Yield attributes, Economics, Rabi, Lentil.

## Introduction

Lentil is among the oldest domesticated crop cultivated in the world. Lentil also known as red dhal, masur or split peas is a staple food. It is an excellent source of vitamin A and provides fiber, potassium, vitamin B and iron (Malik *et al.*, 2022). It has the second highest ratio of protein per calorie of any legume, after soybean and contains high levels of protein (20-30%), minerals (2-5%), rich in micronutrients and had the potential to provide adequate dietary amounts, especially

iron, zinc, selenium (**Ganesh et al., 2020**). 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. India stands second in production of lentil after Canada. The major lentil growing countries of the world include India, Canada, Turkey, Bangladesh, Iran, China, Nepal and Syria. Pulses are the wonder crops as these are rich source of protein and also have an ability of biological nitrogen fixation process. These crops are used for crop diversification in different cropping systems (**Singh et al., 2017**). Lentil also has an important role in crop rotation and enhancing soil fertility and promote sustainable cereal-based production systems with a potential of fixing free nitrogen up to 107 kg/ha (**Malik et al., 2022**).

Biofertilizer is one of the most important factors that will increase the yield significantly. Seed inoculation with *Rhizobium* play a vital role in the formation of nodules to fix atmospheric nitrogen by symbiotic process in the root system of legume crop making the nutrient available to the plant (**Siddiqui et al., 2013**). Living microorganisms of bacterial, fungal, and algal origin are called biofertilizers. Atmospheric nitrogen fixed in the root nodules with the help of biofertilizers and make it available to the plant. They convert phosphates from their insoluble forms into ones that can be used. They create hormones and antimetabolites that encourage the growth of roots. When applied to seeds or soil, biofertilizers make nutrients more readily available and enhance the productivity by 10% to 25% without damaging the soil or the environment (**Kumar and Chandra, 2008**). An aerobic, gram-negative bacterium *Pseudomonas fluorescens* that present in agricultural soils, is well suited to flourish in the rhizosphere. Besides promoting plant development, it functions as a biocontrol agent. It colonizes and thrives quickly in the rhizosphere, using seed and root exudates. It produces a diverse range of bioactive metabolites, such as antibiotics, siderophores, volatiles, and growth-promoting compounds in the plant rhizosphere engage in aggressive competition with other microbes, and responds to environmental challenges (**Rakesh and Mehera, 2022**). Biofertilizers such as *Rhizobium* and PGPR are eco-friendly, low in cost and also, they have an ability to recycle the indigenous or immobile nutrients in sustainable agriculture. Improvement in plant productivity by use of PGPR occurs, when rhizobacteria supply nutrients and produce auxins, cytokinin's and gibberellins. Application of nutrient at proper dose helps to achieve profitable and also economically and environmentally best. Along with enhancing grain yield, microbial inoculations may also help in lowering the cost of production through less input of chemical fertilizers (**Singh et al., 2017**).

The role of micronutrients is also very important in growth and development of all the crops. Zinc is very important in reproductive phase like fertilization and pollen grain formation as pollen grain contains a high amount of zinc. Most of the zinc is translocated to seeds during fertilization (Ali et al., 2017). Micronutrients are important for maintaining soil health and also increasing productivity of crops (Swargiary et al., 2021). Zinc role is as multifaceted as the interface that reduces its availability. Physiologically its role in a plant is either as a metal constituent in enzymes or as a functional co-factor of number of enzyme reactions. Zinc is necessary for the synthesis of tryptophan, which is a precursor for tryptophan production. High levels of zinc enhance cell differentiation in post flowering stage (Singh et al., 2013).

The current study was conducted to determine "**Response of Biofertilizers and Foliar Application of Zinc on Growth and Yield of Lentil (*Lens culinaris* L.)**" while keeping the previously mentioned factors in consideration

## Materials and methods

The experiment was conducted during *Rabi* season of 2022, at Crop research farm of department of Agronomy at Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj. The soil had a sandy loam texture, with a pH of 7.2, organic carbon (0.72%), available N (178.48 kg/ha), available P (27.80 kg/ha) and available K (233.24 kg/ha). The experiment was laid out in randomized block design (RBD) with ten treatments each replicated thrice. The experiment comprised of three biofertilizer treatments and three levels of zinc when applied in combinations as follows, T<sub>1</sub>: *Rhizobium spp* + Zinc (0.25%), T<sub>2</sub>: *Rhizobium spp* + Zinc (0.50%), T<sub>3</sub>: *Rhizobium spp* + Zinc (0.75%), T<sub>4</sub>: *Pseudomonas fluorescens* + Zinc (0.25%), T<sub>5</sub>: *Pseudomonas fluorescens* + Zinc (0.50%), T<sub>6</sub>: *Pseudomonas fluorescens* + Zinc (0.75%), T<sub>7</sub>: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.25%), T<sub>8</sub>: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.50%), T<sub>9</sub>: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.75%), T<sub>10</sub>: Control (NPK 20-40-20 kg/ha). Five plants were tagged randomly at third week of germination for recording observations. At maturity of the pods, the lentil crop was harvested treatment wise. Followed by bundles were sun dried and weighed by balance for calculating biological yield. The seed yield was recorded after threshing of plants from each treatment and then converted into kg/ha. The Observations like number of pods per plant, number of seeds per pod, seed yield and stover yield were recorded from each plot (Ahmad *et al.*, 2017). Net returns, Gross returns and benefit cost ratio were computed based on cost of cultivation with their prevailing market price. Data was statistically analyzed by using (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

### Yield attributes

According to yield attributes data that was collected and analyzed at harvest, significantly higher number of pods/plant (111.33), seeds/pod (2.27) were recorded in treatment-8 with the combined application of *Rhizobium spp*, *Pseudomonas fluorescens* along with zinc (0.50%). Zinc enhanced the transfer of photosynthates towards the reproductive system, increasing the crop's productivity. Due to less crop competitiveness among the plants resulted increase in photosynthetic activity and also photosynthates may have been transported from source to sink more effectively (Swargiary *et al.*, 2021). Zinc produces auxin and IAA which regulates plant growth that in turn resulted in more number of pods per plant (Ali *et al.*, 2017). This could occur as an outcome of the stimulatory effect on cell division, cell elongation, and background structure of cells. In addition, higher levels might be responsible for increased leaf area and chlorophyll content which resulted in higher photosynthesis and assimilation, metabolic activities responsible for overall reproductive phase, and ultimately improved seed yield (Kasuhik and Singh, 2022). Due to zinc's role in seed setting, treatment with zinc resulted in more seeds per pod (Praveena *et al.*, 2018).

### Yield (kg/ha)

After evaluated the data recorded post harvesting of crop show that significantly maximum seed yield (1530.94 kg/ha) and stover yield (3020.00 kg/ha) were recorded with the combined application of *Rhizobium spp*, *Pseudomonas fluorescens* along with zinc (0.50%). Rhizobium and zinc interact to significantly boost yield. Growth hormones produced by Rhizobium encourage the development of roots. By increasing the quantity of these microorganisms, the microbial process swiftly speeds up, increasing the amount of nutrients available in forms that the plant can readily absorb (Mounika *et al.*, 2022). *Pseudomonas spp* produces siderophores in addition to phosphorus solubilizing capacity, thus builds symbiotic efficiency, growth, and the productivity of lentil (Khanna *et al.*, 2011). The effect of zinc treatment on straw yield may be attributed to its direct impact on auxin production, which in turn accelerate plant growth elongation processes (Praveena *et al.*, 2018). Zinc foliar spray results in adequate nutrient

availability for lush crop growth as well as efficient assimilation partitioning from source to sink (Lakshmi *et al.*, 2017).

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## Economics

Maximum gross returns (91,856.58 INR/ha), net returns (61406.58 INR/ha) and benefit cost ratio (2.02) were obtained in treatment T<sub>9</sub> with application of Rhizobium, *Pseudomonas fluorescens* and zinc at 0.50%. Integrated use of biofertilizers (Rhizobium, *Pseudomonas fluorescens*, Rhizobium + *Pseudomonas fluorescens*) improved gross returns. Application of unit fertilizer is economical, if the value of the increase in the crop yield due to the quantity of fertilizer added is greater than the cost of fertilizer used. If the unit of fertilizer does not increase the yield enough to pay for its cost, its application will not be economical and will not return profit even after a constant increase in the yield. The application of essential element in optimum quantity and right proportion is the key to increase the profit (Singh *et al.*, 2017). Because of the enhanced seed yield, highest net returns, and best benefit-cost ratio, the foliar spray of zinc twice at 40 and 60 DAS appeared to be the most cost-effective (Gourav *et al.*, 2018). The B:C ratio has increased compared to the uninoculated control, and this is due to the low cost of biofertilizers (Singh *et al.*, 2017). In comparison to single inoculation and uninoculated control, net returns and gross returns and benefit cost ratio were higher with dual inoculation of *Rhizobium* and PGPR (Biswas *et al.*, 2012).

## CONCLUSION

It is concluded that the maximum yield, gross returns, net returns, and benefit cost ratio were obtained in treatment T<sub>8</sub> with combined application of *Rhizobium spp.*, *Pseudomonas fluorescens* at a rate of 20 g/kg seed and foliar zinc application of zinc 0.05%.

**Ethical paper:** This article does not contain any studies with human participants or animals performed by any of the authors.

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**Table 1. Response of Biofertilizers and Foliar application of Zinc on Yield attributes and Yield of Lentil.**

S. No	Treatments	Number of pods/plant	Number of seeds/pod	Seedyield (kg/ha)	Stoveryield (kg/ha)
1.	<i>Rhizobium spp</i> + Zinc - 0.25%	103.00	1.73	1025.37	2076.67
2.	<i>Rhizobium spp</i> + Zinc - 0.50%	103.67	1.73	1038.44	2216.67
3.	<i>Rhizobium spp</i> + Zinc - 0.75%	104.00	1.80	1082.46	2346.67
4.	<i>Pseudomonas fluorescens</i> + Zinc - 0.25%	105.33	1.93	1192.33	2463.33
5.	<i>Pseudomonas fluorescens</i> + Zinc - 0.50%	105.67	2.00	1257.02	2570.00
6.	<i>Pseudomonas fluorescens</i> + Zinc - 0.75%	107.00	2.07	1309.93	2676.67
7.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.25%	107.33	2.13	1378.94	2843.33
8.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.50%	111.33	2.27	1530.94	3020.00
9.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.75%	109.33	2.20	1451.81	2920.00
10.	Control (20-40-20 NPK kg/ha)	101.00	1.73	997.02	2036.67
	F-test	S	S	S	S
	SEm(±)	0.912	0.06	39.13	45.98
	CD (p=0.05)	2.710	0.17	116.27	136.61

**Table 2. Response of biofertilizers and foliar application of zinc on economics of lentil.**

S.No	Treatments	Cost of cultivation (INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1.	<i>Rhizobium spp</i> + Zinc - 0.25%	30440.00	61522.42	31082.42	1.02
2.	<i>Rhizobium spp</i> + Zinc - 0.50%	30470.00	62306.16	31836.16	1.04
3.	<i>Rhizobium spp</i> + Zinc - 0.75%	30510.00	64947.39	34437.39	1.13
4.	<i>Pseudomonas fluorescens</i> + Zinc - 0.25%	30400.00	71539.72	41139.72	1.35
5.	<i>Pseudomonas fluorescens</i> + Zinc - 0.50%	30430.00	75421.04	44991.04	1.48
6.	<i>Pseudomonas fluorescens</i> + Zinc - 0.75%	30470.00	78595.99	48125.99	1.58
7.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.25%	30420.00	82736.65	52316.65	1.72
8.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.50%	30450.00	91856.58	61406.58	2.02
9.	<i>Rhizobium spp</i> + <i>Pseudomonas fluorescens</i> + Zinc - 0.75%	30490.00	87108.67	56618.67	1.86
10.	Control (20-40-20 NPK kg/ha)	29750.00	59820.92	30070.92	1.01