

Original Research Article

Response of Bio fertilizers and foliar application of Zinc on Growth and Yield of Lentil (*Lens culinaris* L.)

ABSTRACT

A field experiment was conducted during *Rabi* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom Institute of Agricultural Sciences, Prayagraj, UP, during the *Rabi* season of 2022. The experiment consisted of two variables with three levels i.e, biofertilizer (*Rhizobium spp*, *Pseudomonas fluorescens*, *Rhizobium spp* + *Pseudomonas fluorescens*) and foliar application of zinc (0.25%, 0.50%, 0.75%) at pre flowering and pod development stage. 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 (27.80kg/ha) and available K (233.24 kg/ha). The experiment conducted in randomized block design with ten treatments replicated thrice. Application of biofertilizers and zinc significantly influenced the growth parameters, yield attributing characters and yield. The results revealed that treatment eight (*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc 0.50%) recorded significantly highest plant height (43.29 cm), dry weight (35.63 g), number of pods/plant (111.33), number of seeds/pod (2.27), seed yield (1530.94 kg/ha) and stover yield (3020.00 kg/ha) in Lentil.

Keywords: Biofertilizer, *Rhizobium spp*, *Pseudomonas fluorescens*, Growth, Yield, *Rabi*, Lentil.

Introduction

Lentil (*Lens culinaris*) is an important annual leguminous crop which is locally called Masoor belongs to the family Fabaceae. It is one of the most nutritious and also known as poor man's meat because of its rich protein content and high concentration of essential amino acid as isoleucine and lysine (Nasar and Shah, 2017). Lentils contain important components of human nutrition, such as 25% protein, 1.1% fat, 59% carbohydrate, and is also rich in soluble and insoluble dietary fiber. It is also rich in calcium, iron, phosphorus, potassium, zinc, magnesium and vitamins like niacin, riboflavin, thymine and ascorbic acid (Fatima *et al.*, 2018). Lentils are naturally gluten-free. Their exceptionally low glycemic index values and resistant starch content make them suitable for a diabetic diet. Uttar Pradesh is the second largest growing state of lentil after Madhya Pradesh in the country. Lentil production of U.P was 0.47 million tonnes from an area of 0.47 million hectares and productivity of 988 kg/ha in 2020-2021 (Anonymous, 2021). It is one of the principal pulse crops cultivated in semi-arid region of the world, particularly in India sub-continent and the dry areas of Middle East (Malik, 2005).

Bio-fertilizers are living microorganisms derived from bacteria, fungi, and algae. Bio-fertilizers fix atmospheric nitrogen in legume crop soil and root nodules and make it available to the plant. They convert insoluble phosphates into soluble phosphates. They secrete hormones and antimetabolites that stimulate root growth. When applied to seed or soil, bio-fertilizers boost nutrient availability and yield by 10 to 25% without negatively impacting the soil or ecosystem (Kumar and Chandra, 2008). Optimal nutrient utilization boosts lentil production. 34reewwes Rhizobium inoculation affects lentil growth and productivity. Rhizobium efficiency was increased by co-inoculation with plant growth promoting rhizobacteria (PGPR). It plays a significant part in the industry of sustainable agriculture. The usage of PGPR has been shown to be an environmentally friendly method of enhancing agricultural yields by encouraging plant development via a direct or indirect process. PGPR regulates hormonal and nutritional balance, induces resistance against plant diseases, and solubilizes nutrients for easy uptake by plants. It has both synergistic and antagonistic interactions with microorganisms in the rhizosphere, which increases plant growth rate indirectly. Many bacteria species function as PGPR (Singh *et al.*, 2016). Increased rates of plant growth, development, and yield are frequently connected with the

use of plant growth promoting rhizobacteria. Co-inoculation with Rhizobium and PGPR improves nodulation and development of legumes even more (**Biswas *et al.*, 2012**).

When opposed to soil treatment, foliar spray of micronutrients aids in quick translocation, which is important in stress reduction in plants. Zinc functions in plants as a metal ingredient in enzymes or as a functional co-factor in a variety of enzymatic processes. Zinc is needed for the synthesis of tryptophan, which is a precursor for the production of IAA. High amounts of zinc in the plant after flowering will promote cell differentiation (**Anil *et al.*, 2013**). It is essential for the manufacture of plant hormones such as IAA, protein, and nucleic acid, all of which aid in the use of nitrogen and phosphorus in plants (**Saha *et al.*, 2018**). Zinc is more important during the reproductive period of flowering, particularly during fertilization. The majority of the zinc is directed solely to seed (**Singh *et al.*, 2013**).

Keeping the above points in view, the present investigation was carried to find out **“Response of Biofertilizers and Foliar application of Zinc on Growth and Yield of Lentil (*Lens culinaris* L.**

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 which is located 98 m altitude above the mean sea level. The soil in the experimental area was sandy loam texture with pH (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) were determined by Jackson's method, Subbaiah, and Asija's method, Olsen's method, Flame photometer method, respectively. 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, T₁: *Rhizobium spp*+ Zinc (0.25%), T₂: *Rhizobium spp*+ Zinc (0.50%), T₃: *Rhizobium spp* + Zinc (0.75%), T₄: *Pseudomonas fluorescens* + Zinc (0.25%), T₅: *Pseudomonas fluorescens* + Zinc (0.50%), T₆: *Pseudomonas fluorescens*+ Zinc (0.75%), T₇: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.25%), T₈: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.50%), T₉: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.75%), T₁₀: Control (NPK 20-40-20 kg/ha). The variety of Lentil is "PL 406". The crop was sown with pre-sowing irrigation. The line-to-line spacing was kept at 30 cm spacing with a seed rate of 40 kg/ha. A distance of 10 cm was maintained between plant to plant. Hand weeding was done twice at 30 and 50 days after sowing. Nutrients particularly, nitrogen, phosphorus, and potassium were applied as basal dose. Foliar application of zinc was done at pre flowering stage and pod development stage. The observations on five randomly selected plants from each treatment recorded on different growth parameters at 20,40,60,80 and 100 days after sowing viz. plant height (cm), dry weight (g/plant), number of pods/plant, number of seeds/pod, seed yield and stover yield. The data collected was computed and statistical analysis by analysis of variance method (Gomez and Gomez, 1984).

Result and Discussion

Growth attributes

At 100 DAS, significantly highest plant height (43.29 cm), dry weight (35.63 g) was recorded in treatment-8 with the combined application of *Rhizobium spp*, *Pseudomonas fluorescens* along with zinc (0.50%). Dual seed inoculation with *rhizobium* and PGPR gave higher plant height as it has the ability to fix atmospheric nitrogen in rhizosphere of leguminous plants through the process of N fixation. The results are in conformity with those reported by (Singh *et al.*, 2016). Zinc is required for the synthesis of tryptophan, which serves as the precursor for the synthesis of IAA (Indole acetic acid), a growth hormone implicated in stem elongation (Swargiaryet *al.*, 2021). The increased plant height could be due to faster photosynthesis, assimilation, cell division, and vegetative development caused by greater nutrition (Tiwari *et al.*, 2018). The beneficial effects of plant growth regulators and zinc may alter metabolism, photosynthetic pigments, and enzyme activity, resulting in an increase in vegetative growth. Zinc administration results in increased growth and higher dry matter accumulation, which produces growth hormones and auxin precursors (Mounikaet *al.*, 2022).

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%). The combination of *Rhizobium* and Zinc plays an important role in increasing the crop production. It increases microorganisms that accelerate microbial process which in turn augment the extent availability of nutrient in the form which is easily assimilated by the plant. Zinc helps in production of auxin which resulted in more number of pods/plant (Mounikaet *al.*, 2022). Micronutrients aid in the utilization of phosphorus and nitrogen in flower retention, pollen tube growth, seed production, and seed laying by facilitating the translocation of metabolites from source to sink (Shindeet *al.*, 2017). Zinc increased the transfer of photosynthetic to the reproductive system, increasing crop output. Better photosynthetic activity may also have resulted in better transfer of photosynthetic from source to sink due to decreased crop competition among the plants, which may have resulted in higher yield attributes (Swargiaryet

al., 2021). Because zinc aids in seed establishment, the number of seeds per pod rose following zinc administration (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%). The beneficial effect of PGPR and *Rhizobium* had probably induced the synthesis of growth promoting substances which could stimulate growth and elongation, nitrogen fixation and crop yield. The increase in seed yield has been attributed to interactions with soil-borne diseases, the creation and release of secondary metabolites for plant growth, or higher nutrient intake (Biswas *et al.*, 2012). *Pseudomonas fluorescens* apart from possessing phosphorus solubilizing ability improving symbiotic efficiency, growth and yield of lentil (Khanna *et al.*, 2011). Zinc foliar spraying results in optimal nutrient availability for lush crop growth and efficient assimilate partitioning from source to sink (Lakshmi *et al.*, 2017). Zinc administration increases stover yield due to its direct influence on auxin production, which in turn improves plant development elongation processes (Rajana *et al.*, 2017).

CONCLUSION

It can be concluded that combined application of *rhizobium spp* and *Pseudomonas fluorescens* at 20 g/kg seed along with foliar application of zinc at 0.05% (treatment T₈) recorded higher growth parameters, improved yield attributes, maximum seed yield, and stover yield in lentil crop.

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

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Table1.ResponseofBiofertilizersandFoliarapplicationofZinonGrowth attributesofLentil.

S.No	Treatment combinations	100 DAS	100 DAS	40-60 DAS
		Plant height (cm)	Dry weight (g/plant)	CGR (g/m ² /day)
1.	<i>Rhizobium</i> spp+Zinc -0.25%	32.08	30.27	10.30
2.	<i>Rhizobium</i> spp+Zinc -0.50%	33.14	29.87	9.68
3.	<i>Rhizobium</i> spp+Zinc -0.75%	34.37	30.43	10.45
4.	<i>Pseudomonasfluorescens</i> +Zinc -0.25%	35.27	30.57	11.69
5.	<i>Pseudomonasfluorescens</i> +Zinc-0.50%	36.62	32.75	12.65
6.	<i>Pseudomonasfluorescens</i> +Zinc-0.75%	37.05	31.00	12.47
7.	<i>Rhizobium</i> spp + <i>Pseudomonasfluorescens</i> +Zinc-0.25%	39.32	33.24	15.18
8.	<i>Rhizobium</i> spp + <i>Pseudomonasfluorescens</i> +Zinc -0.50%	43.29	35.63	17.53
9.	<i>Rhizobium</i> spp + <i>Pseudomonasfluorescens</i> +Zinc -0.75%	42.69	34.95	15.51
10.	Control(20-40-20NPKkg/ha)	30.94	28.20	9.38
	F-test	S	S	S
	SEm(±)	0.22	1.08	1.03
	CD(p=0.05)	0.66	3.21	3.08

Table 2. Response of Biofertilizers and Foliar application of Zinc on Growth attributes of Lentil

S.No	Treatment combinations	Number of pods/ plant	Number of seeds/pod	Seed yield (kg/ha)	Stover yield (kg/ha)
1.	<i>Rhizobium</i> spp + Zinc -0.25%	103.00	1.73	1025.37	2076.67
2.	<i>Rhizobium</i> spp + Zinc -0.50%	103.67	1.73	1038.44	2216.67
3.	<i>Rhizobium</i> spp + 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</i> spp + <i>Pseudomonas fluorescens</i> + Zinc -0.25%	107.33	2.13	1378.94	2843.33
8.	<i>Rhizobium</i> spp + <i>Pseudomonas fluorescens</i> + Zinc -0.50%	111.33	2.27	1530.94	3020.00
9.	<i>Rhizobium</i> spp + <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

UNDER PEER REVIEW