Original Research Article

Response of Biofertilizers 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 (27.80 kg/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.

Key words: *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 of bacterial, fungal and algal origin. Biofertilizers fix atmospheric nitrogen in the soil and root nodules of legume crops and make it available to the plant. They solubilize the insoluble forms of phosphates into available forms. They produce hormones and antimetabolites which promote root growth. When applied to seed or soil, biofertilizers increase the availability of nutrients and improve the yield by 10 to 25% without adversely affecting the soil and environment **(Kumar and Chandra, 2008)**. Production of lentil enhanced by optimum use of nutrients. 34reewwesInoculation with *Rhizobium* influence growth and productivity of lentil. The efficiency of *Rhizobium* improved by co-inoculation with plant growth promoting rhizobacteria (PGPR). It shows an important role in the sustainable agriculture industry. The use of PGPR has been proven to be an environmentally sound way of increasing crop yields by facilitating plant growth through either a direct or indirect mechanism. The mechanisms of PGPR include regulating hormonal and nutritional balance inducing resistance against plant pathogens, and solubilizing nutrients for easy uptake by plants. It shows synergistic and antagonistic interactions with microorganisms with in the rhizosphere, which indirectly boosts plant growth rate. There are many bacteria species that act as PGPR **(Singh *et al*., 2016)**. Use of plant growth promoting rhizobacteria is often associated with increased rates of plant growth, development and yield. Co-inoculation with *Rhizobium* and PGPR is even more effective for improving nodulation and growth of legumes **(Biswas *et al.*, 2012)**.

Foliar application of micronutrients helps in the rapid translocation when compared to soil application which is very pertinent in mitigating stress in plants. Zinc role in a plant is either as a metal constituent in enzymes or as a functional co-factor of number of enzymatic reactions. Zinc is required for synthesis of tryptophan, which in turn is precursor for synthesis of IAA. After flowering high levels of zinc in plant will enhance cell differentiation **(Anil *et al*., 2013)**. It plays vital role in the biosynthesis of plant hormone like IAA, protein and nucleic acid which helps in utilization of nitrogen and phosphorus in plants **(Saha *et al*., 2018)**. At flowering, Zinc plays a greater role during reproductive phase especially during fertilization. Most of the zinc is diverted to seed only **(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, T_1: *Rhizobium spp* + Zinc (0.25%), T_2: *Rhizobium spp* + Zinc (0.50%), T_3: *Rhizobium spp* + Zinc (0.75%), T_4: *Pseudomonas fluorescens* + Zinc (0.25%), T_5: *Pseudomonas fluorescens* + Zinc (0.50%), T_6: *Pseudomonas fluorescens* + Zinc (0.75%), T_7: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.25%), T_8: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.50%), T_9: *Rhizobium spp* + *Pseudomonas fluorescens* + Zinc (0.75%), T_{10}: 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 an important element for the synthesis of tryptophan, which is the pioneer for the synthesis of IAA (Indole acetic acid), a growth hormone, involved in stem elongation **(Swargiary *et al*., 2021)**. Increase in plant height might be attributed to the fact that the better nourishment causes accelerated rate of photosynthesis, assimilation, cell division and vegetative growth **(Tiwari *et al*., 2018)**. The favorable effect of plant growth regulator and zinc might influence the metabolism, photosynthetic pigments and activity of enzymes which in turn helps to increase in the vegetative growth. An enhanced growth and higher dry matter accumulation due to application of zinc, produce growth hormones and precursor of auxins **(Mounika *et 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 **(Mounika *et al*., 2022)**. Micro nutrients help in utilization of phosphorus and nitrogen in flower retention, pollen tube development, seed formation and seed setting through the translocation of metabolites from source to sink **(Shinde *et al*., 2017)**. Zinc improved translocation of photosynthates towards reproductive system and thereby enhancing the yield of the crop. Better photosynthetic activity also may have resulted in better translocation of photosynthates from source to sink due to less crop competition between the plants which might have led to higher yield attributes **(Swargiary *et al*., 2021)**. Seeds per pod were also increased with zinc application due to the role of zinc in seed setting **(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 have been attributed to interaction with various soil borne pathogens, production and release of secondary metabolites for plant growth, or increased uptake of nutrients **(Biswas *et al*., 2012)**. *Pseudomonas fluorescens* apart from possessing phosphorus solubilizing ability improving symbiotic efficiency, growth and yield of lentil **(Khanna *et al*., 2011)**. Foliar spray of zinc leads to optimum availability of nutrients for luxurious crop growth and efficient partitioning of assimilates from source to sink **(Lakshmi et al., 2017)**. Zinc application improve stover yield due to its direct influence on auxin production which in turn enhanced the elongation processes of plant development **(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 T_8) 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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Table 1. Response of Biofertilizers and Foliar application of Zinc on Growth attributes of Lentil.

S. No	Treatment combinations	100 DAS	100 DAS	40-60 DAS
		Plant height (cm)	Dry weight (g/plant)	CGR ($g/m^2/day$)
1.	*Rhizobium spp* + Zinc - 0.25%	32.08	30.27	10.30
2.	*Rhizobium spp* + Zinc - 0.50%	33.14	29.87	9.68
3.	*Rhizobium spp* + Zinc - 0.75%	34.37	30.43	10.45
4.	*Pseudomonas fluorescens* + Zinc - 0.25%	35.27	30.57	11.69
5.	*Pseudomonas fluorescens* + Zinc - 0.50%	36.62	32.75	12.65
6.	*Pseudomonas fluorescens* + Zinc - 0.75%	37.05	31.00	12.47
7.	*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc - 0.25%	39.32	33.24	15.18
8.	*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc - 0.50%	43.29	35.63	17.53
9.	*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc - 0.75%	42.69	34.95	15.51
10.	Control (20-40-20 NPK kg/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	Seedyield (kg/ha)	Stoveryield (kg/ha)
1.	*Rhizobium spp* + Zinc - 0.25%	103.00	1.73	1025.37	2076.67
2.	*Rhizobium spp* + Zinc - 0.50%	103.67	1.73	1038.44	2216.67
3.	*Rhizobium spp* + Zinc - 0.75%	104.00	1.80	1082.46	2346.67
4.	*Pseudomonas fluorescens* + Zinc - 0.25%	105.33	1.93	1192.33	2463.33
5.	*Pseudomonas fluorescens* + Zinc - 0.50%	105.67	2.00	1257.02	2570.00
6.	*Pseudomonas fluorescens* + Zinc - 0.75%	107.00	2.07	1309.93	2676.67
7.	*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc - 0.25%	107.33	2.13	1378.94	2843.33
8.	*Rhizobium spp* + *Pseudomonas fluorescens* + Zinc - 0.50%	111.33	2.27	1530.94	3020.00
9.	*Rhizobium spp* + *Pseudomonas fluorescens* + 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