



Effect of Bio-fertilizers and Zinc Levels on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The field experiment was carried out during *rabi* season 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The treatment combinations are T₁:Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS) T₂:Azotobacter 25g + Zinc 0.3% (30 DAS and 50 DAS) T₃: Azotobacter 25g + Zinc 0.5% (30 DAS and 50 DAS) T₄:Azospirillum 25g + Zinc 0.1% (30 DAS and 50 DAS) T₅:Azospirillum 25g + Zinc 0.3% (30 DAS and 50 DAS) T₆:Azospirillum 25g + Zinc 0.5% (30 DAS and 50 DAS) T₇:Azotobacter + Azospirillum 25g +Zinc 0.1% (30 DAS and 50DAS). T₈:Azotobacter + Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS) T₉:Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS), T₁₀: Control (RDF-80-40-40 NPK kg/ha) are used. Results obtained that the higher plant height (205.06 cm), higher plant dry weight (78.17 g/plant), higher crop growth rate (37.6 g/m² /day), higher ear head length (24.74 cm), higher grains/ear head

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(2212.69), higher test weight (10.29 gm), higher grain yield (34.16 q/ha) and higher stover yield (69.00 q/ha) were significantly influenced with application of Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS). Higher gross returns (INR 96553.67/ha), higher net returns (INR 67523.67/ha) and higher B:C ratio (2.03) were also recorded in treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)).

Keywords: Bio-fertilizers; economic, growth parameters; pearl millet; yield attribute; zinc.

1. INTRODUCTION

“Pearl millet (*Pennisetum glaucum* L.) is one of India’s most important cereal crops. It has the greatest production potential among all the millets. Pearl millet is endowed with a greater ability to withstand harsh climatic conditions. It is tolerant to adverse conditions such as drought, low soil fertility and high temperature” [1]. “The higher production potential of pearl millet in rainfed areas might be owing to a deeper root system, better extraction of soil moisture and its efficient utilization, efficient photosynthetic mechanism and rapid translocation of photosynthates from leaves to grain. Pearl millet covers an estimated 31 m ha worldwide and is grown in higher than 30 countries in arid & semi-arid tropical and subtropical areas of Africa and Asia” [1].

“Because of its drought resistance feature, Pearl millet occupies a unique position in rainy season [kharif] crops. It is a staple food for millions of people. It also provides good quality fodder to cattle in arid and semi-arid tropical regions and recognized as a valuable forage crop because of its robust and quick growth habit. Its stalk is used as fuel and for packing fruits” [2]. “It is a good source of carbohydrate, energy, RS, 92.5% dry matter, fat (5–7%), ash (2.1%), dietary fiber (1.2/100 g), 13.6% crude protein, quality protein (8–19%), 63.2% starch, α -amylase activity, minerals (2.3 mg/100 g), vitamins A and B, and antioxidants such as coumaric acids and ferulic acid” [3].

“Pearl millet is grown mostly on marginal and sub-marginal lands, poor in organic matter and low in available nitrogen and phosphorus. At the present level of productivity, it removes about 72 kg NPK Kg/ha but only about 10-12 kg of these nutrients are being supplied through fertilizers. However, the general recommendation for these nutrients is 40, 30, and 30 kg of N, P_2O_5 and K_2O kg/ha under medium rainfall conditions” [4]. “Chemical fertilizers are quite expensive, and the small and marginal farmers cannot use these fertilizers in required quantities in moisture deficit

areas. It is reported that pearl millet has a variety of nitrogen fixing bacteria in its rhizosphere which may release growth- promoting substances like indole acetic acid, gibberellins and cytokinins. These substances help increase root biomass” [5].

2. MATERIALS AND METHODS

The experiment was conducted during Rabi 2022. The experiment was conducted in Randomized Block Design (RBD) consisting of ten treatments replicated thrice and laid out with the different treatments allocated randomly in each replication. The soil of the experimental field was sandy loam in texture, slightly alkaline reaction (pH 7.1) with the low level of organic carbon (0.48%), available N (225 Kg/ha), P (13.6 kg/ha) and a higher level of K (215.4 kg/ha). The treatment combinations are Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS), Azotobacter 25g + Zinc 0.3% (30 DAS and 50 DAS), Azotobacter 25g + Zinc 0.5% (30 DAS and 50 DAS), Azospirillum 25g + Zinc 0.1% (30 DAS and 50 DAS), Azospirillum 25g + Zinc 0.3% (30 DAS and 50 DAS), Azospirillum 25g + Zinc 0.5% (30 DAS and 50 DAS), Azotobacter + Azospirillum 25g +Zinc 0.1% (30 DAS and 50DAS)., Azotobacter + Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS), Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS) and control. The observations were recorded on different growth parameters at harvest viz. plant height(cm), plant dry weight (g/plant), ear head length(cm), no. of grains/ear head, test weight(g), grain yield(t/ha) and stover yield(t/ha).

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height

Higher plant height (205.06 cm) was observed in treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)),at 80 DAS, which was significantly superior over the rest of

the treatments. However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)) was found to be statistically at par with treatment- 9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)).The significant increase in the height may be due to inoculation of bacterial preparation accelerating plant growth, providing biologically fixed nitrogen to the inoculated plant and also stimulating plant growth by excreting plant growth promoting substances like auxins, kinetins, vitamins and gibberellins as similarly observed by Patidar and Mali (2004). Further increase in plant height might be due to the application of zinc, due to the role of zinc as a "catalyst" in most physiological, metabolic, and tryptophane synthesis processes.

3.1.2 Dry weight

At 80 DAS, a significantly higher plant dry weight (78.17 gm/plant) was observed in treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)). However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)) was found to be statistically at par with treatment- 9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)).The significantly higher plant dry weight was observed with bio-fertilizers and seed inoculation. Inoculation of biofertilizers stimulates activation of hormones which helps in shoot and root elongation and high dry matter production. Similar results were observed by Rathore et al. (2006). Several enzymes, auxin and protein synthesis directly or indirectly require zinc. The nutrients applied in one crop are not fully utilized which leads to their residual effect on succeeding crops.

3.2 Yield Parameters

3.2.1 Ear head length

The significant and higher ear head length (24.74 cm) was observed in treatment-9 with (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)), was found to be statistically at par with treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)).

The significantly higher ear head length was observed with the application of zinc. This might

be due to Zinc involved in cell division, enzyme activation and with their increased supply, their availability, acquisition, mobilization and influx into the plant tissue increased and thus improved growth attributes and yield components. Similar results in accordance with Vinaysingh and mamtapandey (2018).

3.2.2 Number of grains/ear head

The significant and higher grains/earhead (2212.69) were observed in treatment-9 with (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)), was found to be statistically at par with treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)). Significant increase in number of grains /ear head is due to increase in the availability of Nitrogen through bio fertilizer inoculation by which more ear heads are produced due to increased rates of spikelets primordial production, similar results were found Marngar and Dawson (2017).

3.2.3 Grain yield

The significant and higher grain yield (34.16 q/ha) were observed in treatment-9 with (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)), was found to be statistically at par with treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)).The significant and higher grain yield (34.16 q/ha) was observed with the application of bio-fertilizers. This might be due to use of biofertilizer combinations grain and stover yield was increased by 79 percent 23 percent respectively over the control in pearl millet. The increased production of pearl millet could be ascribed to bio-fertilizers viz., Azospirillum and Azotobacter, which fixed atmosphere nitrogen into the soil and made it available to the plants Singh et al. [6]. "Further, with the application of Zinc (15 kg/ha), might be due to the greater photosynthesis efficiency or more nutrients availability due to increasing decomposition rate of organic matter or improved individual plant performance might the possible reasons for higher grain yield in zinc applied plots compared to other plots" Arshad et al. (2016).

Table 1. Effect of bio- fertilizer and zinc levels on growth parameters of pearl millet

Treatment No	Treatments	Plant height (cm) At 80 DAS	Plant dry weight (g/plant)At 80 DAS
1	Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS)	184.04	64.23
2	Azotobacter 25g + Zinc 0.3% (30DAS and 50 DAS)	188.87	65.55
3	Azotobacter 25g + Zinc 0.5% (30DAS and 50 DAS)	193.96	68.53
4	Azospirillum 25g + Zinc 0.1% (30DAS and 50 DAS)	190.71	65.31
5	Azospirillum 25g + Zinc 0.3% (30DAS and 50 DAS)	194.27	68.89
6	Azospirillum 25g + Zinc 0.5% (30DAS and 50 DAS)	197.63	70.61
7	Azotobacter + Azospirillum 25g +Zinc 0.1% (30DAS and 50 DAS)	192.27	72.20
8	Azotobacter + Azospirillum 25g+ Zinc 0.3% (30 DAS and 50 DAS)	201.05	75.93
9	Azotobacter+ Azospirillum 25g +Zinc 0.5%(30 DAS and 50 DAS)	205.06	78.17
10	Control (RDF 80:40:40 NPK kg/ha)	183.23	66.69
	SEm(±)	1.60	0.78
	CD (P=0.05)	4.75	2.31

Table 2. Effect of bio-fertilizers and zinc on yield and yield attributes of pearl millet

S. No.	Treatments	Ear head length (cm)	Grains/ear head	Test weight (g)	Grain yield(q/ha)	Stover yield(q/ha)	Harvest Index (%)
1.	Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS)	18.93	1897.13	7.80	22.19	51.55	30.09
2.	Azotobacter 25g + Zinc 0.3% (30 DAS and 50 DAS)	19.87	1952.70	7.37	24.50	53.87	31.25
3.	Azotobacter 25g + Zinc 0.5% (30 DAS and 50 DAS)	20.24	2040.69	7.94	26.54	55.48	32.34
4.	Azospirillum 25g + Zinc 0.1% (30 DAS and 50 DAS)	21.28	2008.61	8.89	26.77	55.25	32.63
5.	Azospirillum 25g + Zinc 0.3% (30 DAS and 50 DAS)	22.09	2026.42	9.34	27.58	57.03	32.58
6.	Azospirillum 25g + Zinc 0.5% (30 DAS and 50 DAS)	22.35	2066.02	9.63	30.65	61.02	33.42
7.	Azotobacter + Azospirillum 25g +Zinc 0.1% (30 DAS and 50DAS).	23.05	2031.13	9.10	27.72	63.67	30.32
8.	Azotobacter + Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)	23.81	2146.27	10.04	32.33	67.32	32.44
9.	Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)	24.74	2212.69	10.29	34.16	69.00	33.11
10.	Control (RDF 80:40:40 NPK kg/ha)	19.30	1849.06	8.76	24.17	56.49	29.73
	F- test	S	S	NS	S	S	NS
	Sem(±)	0.33	27.87	0.70	1.30	0.66	1.52
	CD (P=0.05)	0.98	82.81	--	3.87	1.97	--

Table 3. Effect of Bio-fertilizers and Zinc on economic analysis of Pearl millet

S. No.	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C ratio
1.	Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS)	25,280.00	52,146.50	26,866.50	1.06
2.	Azotobacter 25g + Zinc 0.3% (30 DAS and 50 DAS)	25,780.00	57,575.00	31,795.00	1.23
3.	Azotobacter 25g + Zinc 0.5% (30 DAS and 50 DAS)	26,280.00	62,369.00	36,089.00	1.37
4.	Azospirillum 25g + Zinc 0.1% (30 DAS and 50 DAS)	25,780.00	62,909.50	37,129.50	1.44
5.	Azospirillum 25g + Zinc 0.3% (30 DAS and 50 DAS)	26,280.00	64,813.00	38,533.00	1.47
6.	Azospirillum 25g + Zinc 0.5% (30 DAS and 50 DAS)	26,780.00	72,027.50	45,247.50	1.69
7.	Azotobacter + Azospirillum 25g +Zinc 0.1% (30 DAS and 50DAS).	25,530.00	65,142.00	39,612.00	1.55
8.	Azotobacter + Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS)	26,030.00	75,975.50	49,945.50	1.92
9.	Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS)	26,530.00	80,276.00	53,746.00	2.03
10.	Control (RDF 80:40:40 NPK kg/ha)	23,780.00	56,799.50	33,019.50	1.39

3.2.4 Stover yield

The significant and higher stover yield (69.00 q/ha) were observed in treatment-9 with (Azotobacter+ Azospirillum 25g +Zinc 0.5% at 30 DAS and 50 DAS), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter+ Azospirillum 25g +Zinc 0.3% at 30 DAS and 50 DAS), was found to be statistically at par with treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS). This increase in Stover yield might be attributed to increased height, leaf area and dry matter production. In the inorganic + biofertilizer treatments, the positive benefits of seed bacterization could be attributed mainly to nitrogen fixation and other factors like release of hormones, increase of plant growth promoting substances (PGPS) and nutrients uptake. The results of almost similar nature were also reported by Guggari and Kalaghatagi (2003). Further, increase of stover yield may be due to application of zinc. Zinc is critical to the growth and development of tryptophane, a necessary amino acid for plant growth and development. Similar results were conformity with Reddy et al. (2022).

3.3 Economic Analysis

Observations regarding economics of different treatments of pearl millet are given in Table 3.

3.3.1 Gross return (INR/ha)

Highest gross return (80,276.00 INR/ha) was obtained in treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS) as compared to other treatments.

3.3.2 Net returns (INR/ha)

Net return (53,746.00 INR /ha) was found to be highest in treatment-9 (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS) as compared to other treatments [6,7].

3.3.3 Benefit cost ratio (B:C)

Benefit Cost ratio (2.03) was found to be highest in treatment-9 with (Azotobacter+ Azospirillum 25g +Zinc 0.5% (30 DAS and 50 DAS) as compared to other treatments.

4. CONCLUSION

It is concluded that in pearl millet with the application of Azotobacter+ Azospirillum 25g/kg seeds along with the zinc 0.5% in Treatment-9 recorded highest yield and B:C ratio.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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