Original Research Article

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

Abstract

The field experiment was conducted during *rabi* season of 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 laidout in Randomized Block Design with ten treatments which are replicated thrice. The treatments combinations are T_1:Azotobacter 25g + Zinc 0.1% (30 DAS and 50 DAS) T_2:Azotobacter 25g + Zinc 0.3% (30 DAS and 50 DAS) T_3: Azotobacter 25g + Zinc 0.5% (30 DAS and 50 DAS) T_4:Azospirillum 25g + Zinc 0.1% (30 DAS and 50 DAS) T_5:Azospirillum 25g + Zinc 0.3% (30 DAS and 50 DAS) T_6:Azospirillum 25g + Zinc 0.5% (30 DAS and 50 DAS) T_7:Azotobacter + Azospirillum 25g +Zinc 0.1% (30 DAS and 50DAS). T_8:Azotobacter + Azospirillum 25g +Zinc 0.3% (30 DAS and 50 DAS) T_9: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/m^2 /day), higher ear head length (24.74 cm), higher grains/ear head (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).

Key words: *Bio-fertilizers, economic, growth parameters, Pearl millet, yield attribute and zinc*

INTRODUCTION

Pearl millet (*Pennisetum glaucum* L.) is one of the most important cereal crops of India. It has the greatest production potential among all the millets. Pearl millet is endowed with greater ability to withstand harsh climatic conditions. It is tolerant to adverse conditions such as drought, low soil fertility and high temperature. The higher production potential of pearl millet in rainfed areas might be owing to 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, Asia. (ICRISAT; http://exploreit.icrisat.org,2021)

Pearl millet occupies a unique position in rainy season (*kharif*) crops because of its drought resistance feature. It is a staple food for millions of people. It also provides good quality fodder to cattle in the arid and semi-arid tropical regions, and recognized as valuable forage crop because of its robust and quick growth habit. Its stalk is used as fuel and for packing of fruits **(Khairwal and Rai, 2007).** 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 **(Goswami *et al.*, 2020).**

Pearl millet is grown mostly on marginal and sub-marginal lands, poor in organic matter, low in available nitrogen and phosphorus. At 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, general recommendation for these nutrients is 40, 30, and 30 kg of N, P_2O_5 and K_2O kg/ha, respectively under medium rainfall conditions **(Meena and Gautam, 2005)**. The chemical fertilizers are quite expensive, and the small and marginal farmers are unable to 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 cytokinin's. These substances help in increasing root biomass **(Kumar and Gautam, 2004)**.

MATERIAL AND METHODS:

The experiment was conducted during *Rabi* 2022. The experiment was conducted in Randomized Block Design (RBD) consisting of ten treatments which are replicated thrice and was 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 low level of organic carbon (0.48%), available N (225 Kg/ha), P (13.6 kg/ha) and 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).

RESULTS AND DISCUSSION

1. Growth Parameters:

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 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 accelerate plant growth provide biologically fixed nitrogen to the inoculated plant and also stimulate 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 application of zinc, due to the role of zinc as a "catalyst" in most physiological, metabolic, and tryptophane synthesis processes

1.2. Dry weight

At 80 DAS, the 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 the application of 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).** Zinc is directly or indirectly required by several enzymes, auxin and protein synthesis. The nutrients applied in one crop are not fully utilized which leads to their residual effect on succeeding crop.

2. Yield Parameters:

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).**

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)**

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.* (2013).** 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. These results are in conformity with the findings of **Arshad *et. al.* (2016).**

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 + biofertlizer 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. Economic Analysis

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

3.2. 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.

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.

CONCLUSION

It is concluded that in pearlmillet 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.

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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/earhead	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