



# **Response of Bio Fertilizers and Phosphorus on Yield and Economics 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**

A field experiment was conducted during *kharif* season of 2022, at crop research farm, Department of Agronomy at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.).India. The objective is to study the Response of Bio fertilizers and Phosphorus on yield and economics pearl millet. The treatments consisted of three levels of Bio fertilizers (20 g/kg *Azotobacter*, 20 g/kg *Azospirillum*, 20 g/kg *Azotobacter* + *Azospirillum*) and three levels of phosphorus (35, 40 and 45 kg/ha). The experiment was laid out in randomized block design with the ten treatments combinations replicated thrice. The soil in experimental field was sandy loam in texture, having alkaline reaction (pH 7.7) with very low organic carbon (0.44%), available higher N (171.48 kg/ha), P (27.0 kg/ha) and higher level of K (291.2 kg/ha).The results show significantly higher in yield attributes *viz.* ear head length (25.25 cm), number of grains/ear head (2010.9),and yield *viz.* grain yield (3.25 t/ha) and Stover yield (6.27 t/ha). Maximum gross return (113750.00 INR/ha), net return (81010.00 INR/ha) and Benefit - cost ratio (2.47) was found in treatment (T<sub>9</sub>) with the application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous.

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## 1. INTRODUCTION

"In India, pearl millet is pre-dominantly cultivated as a rain-fed crop in diverse soils, climatic condition and indispensable arid zone. It is generally cultivated in area with rainfall ranging from 150 to 600 mm. It is growing on large-scale area due to its drought escaping mechanisms and lower water requirement as compared to other *Kharif* cereals like sorghum and maize" [1].

"Millets are the crops that can be grown successfully in varied climatic conditions because of its adaptable nature to the prevailing environment. Pearl millet (*Pennisetum glaucum* L.) is commonly known as Bulrush millet, cat tail millet or Bajra in some parts of the country. India is the largest producer of pearl millet, both in terms of area (9.3 m ha) and production (9.3 m t), with an average productivity of 1044 kg/ha during the last five years. The protein content of pearl millet is higher than maize and it has a relatively high vitamin A content and minerals" [2].

"It covers an area of about 31 m ha globally and it is widely grown in more than 30 countries in arid, semi-arid tropical and subtropical areas of Asia, Africa and Latin America" (ICRISAT, 2021). "It is widely cultivated in areas with rainfall ranging from 150 to 600 mm. Higher production of pearl millet under rainfed conditions might be due to deep root system, better moisture extraction pattern and effective utilization of water" [3].

Pearl millet is generally grown as staple food crop for most of the small and marginal farmers in Asia as well as Africa. It is a C<sub>4</sub> plant with higher photosynthetic efficiency, more dry matter production with less inputs and more economic returns [4].

"High yielding potential along with nutritional features make pearl millet an important cereal crop that can effectively address the emerging challenges of food and nutritional security, global warming, water shortages and land degradation" [5]. In order to obtain better crop growth and yield at moisture stress conditions, balanced nutrient application and its better utilization by the crop is important. For exploiting genetic potential of crop, balanced supply of nutrients is the essential one [6].

Grain of pearl millet contains higher amount of nutrient content which will provide balanced

Supplement of nutrient to human diet. Pearl millet is the cheapest source of energy, protein, iron and zinc nutrients [7]. Grains contain approximately 11 to 19% protein content, 60 to 78% carbohydrates and 3 to 4.6% fat and higher amount of carotene, riboflavin (Vitamin B<sub>2</sub>) and niacin (Vitamin B<sub>4</sub>) [8].

"Soil fertility level influenced by Bio fertilizers, which play an important role in fixing atmospheric nitrogen, solubilizing insoluble form of phosphorous and potash and mobilizes the immobile nutrients in soil. These processes enhance the nutrient status of soil" [9].

"Bio fertilizers", are carrier based preparations containing beneficial microorganisms in a viable state intended for seed or soil application designed to improve soil fertility and to help plant growth by increasing the number and biological activity of desired microorganisms in the root environment. "The most commonly used bio fertilizers in crop cultivation are *Rhizobium*, *Azotobacter* and *Azospirillum*, phosphate solubilizing bacteria and fungi" [10].

"*Azotobacter* and *Azospirillum* are the most predominant and important ones. Both are known to provide a nitrogen economy of 20-30 kg nitrogen/ha, coupled with production of growth promoting substance, besides improving growth yield quality attributes of fruit and thus, leading to the improvement of crop growth" [11-13].

## 2. MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2022. The experiment was conducted in randomized block design and it consist of ten treatment combinations with three replications and was laid out with different treatments assigned randomly in each replication. The soil in experimental field was sandy loam texture, having alkaline reaction (pH 7.7) with very low organic carbon (0.44%), available higher N (171.48 kg/ha), P (27.0 kg/ha) and higher level of K (291.2 kg/ha). Treatment combination were T<sub>1</sub> - 20 g/kg *Azotobacter* + 35 kg/ha Phosphorus; T<sub>2</sub> - 20 g/kg *Azotobacter* + 40 kg/ha Phosphorus ; T<sub>3</sub> - 20 g/kg *Azotobacter* + 45 kg/ha Phosphorus; T<sub>4</sub> - 20 g/kg *Azospirillum* + 35 kg/ha Phosphorus ; T<sub>5</sub> - 20 g/kg *Azospirillum* + 40 kg/ha Phosphorus; T<sub>6</sub> - 20 g/kg *Azospirillum* + 45 kg/ha Phosphorus ; T<sub>7</sub> - 20 g/kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorus ; T<sub>8</sub> - 20 g/kg *Azotobacter* +

*Azospirillum* + 40 kg/ha Phosphorus ; T<sub>9</sub> - 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus ; T<sub>10</sub> - Control (RDF – 80 – 40 - 40 N-P-K kg/ha) . The observations were recorded on yield and yield parameters i.e. Ear head length (cm), Number of Grains/ear head, Test weight (g), Grain yield (t/ha), Stover yield (t/ha), Harvest index (%), Gross Return (INR/ha), Net Return (INR/ha), Benefit: Cost Ratio (B: C) [14-18].

### 3. RESULTS AND DISCUSSION

#### 3.1 Yield Parameters

##### 3.1.1 Ear head length (cm)

Treatment with application of 20 g/kg *Azotobacter* + *Azospirillum*+ 45 kg/ha Phosphorous was significantly recorded highest Ear head length (25.25 cm). However, the treatments 20 g/kg *Azotobacter* + *Azospirillum*+ 40 kg/ha Phosphorous (23.87 cm) and 20 g/kg *Azotobacter* + *Azospirillum*+ 35 kg/ha Phosphorous (22.55 cm) which was found to be statistically at par with 20 g/kg *Azotobacter* + *Azospirillum*+ 45 kg/ha Phosphorous. The yield attributes were remarkably improved and gained significantly highest ear head length in response of bio fertilizer and phosphorus application. The application of Phosphorus can be related to an overall improvement in plant growth as indicated by greater dry matter accumulation, which may result from a higher supply of phosphorus. The results were similar to Reddy *et al.*, [8].

##### 3.1.2 Number of grains/ear head

Treatment of application of 20 g/kg *Azotobacter* + *Azospirillum*+ 45 kg/ha Phosphorous was significantly higher grains/ear head (2010.9). However, the treatment 20 g/kg *Azotobacter* + *Azospirillum*+ 40 kg/ha Phosphorous (1981.0) which were found to be statistically at par with 20 g/kg *Azotobacter* + *Azospirillum*+ 45 kg/ha Phosphorous.

##### 3.1.3 Test weight (g)

There was no significant difference among the treatments. However, highest test weight (6.63 g) was recorded with the treatments 20 g/ kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorous whereas, minimum Test weight (5.47 g) was recorded with 20 g/ kg *Azotobacter* + 35 kg/ ha Phosphorus.

##### 3.1.4 Grain yield (t/ha)

Treatment with application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous Significantly recorded highest Grain yield (3.25 t/ha). However, the treatments with (3.15 t/ha) in 20 g/ kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorous which were found to be statistically at par with 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous. The yield attributes were remarkably improved and gained significantly high grain yield response of Bio fertilizer and phosphorus application. Increase in grain yield per hectare in response to increasing levels of P is due to increased number of grains per ear head (Mahmud *et al.*, 2003).

##### 3.1.5 Stover yield (t/ha)

Treatment with application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous Significantly recorded highest Stover yield (6.27 t/ha). However, the treatments with (5.64 t/ha) in 20 g/ kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorous (5.43 t/ha) which were found to be statistically at par with 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous. Phosphorus plays an important role in the production of Pearl millet. The significant increase in pearl millet grain and Stover yield was mainly a result of higher growth and the subsequent rise in the various yield attributes mentioned above [19-22]. This major benefit could be due to P, which is well known for its function as "Energy currency" and plays a crucial part in the development and energy transformation in many crucial metabolic processes in the plant. Similar outcomes were reported by Singh *et al.*, [5].

##### 3.1.6 Harvest index (%)

There was no significant difference among the treatments. However, highest Harvest index (36.94 %) was recorded with the treatments 20 g/ kg *Azotobacter* + 35 kg/ha Phosphorous whereas, minimum Harvest index (32.55 %) was recorded with Control (RDF 80-40-40 N-P-K kg/ha).

#### 3.2 Economics

##### 3.2.1 Cost of cultivation

Higher cost of cultivation have been recorded with the application of 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus (Rs. 32740.00 INR/ha) followed by 20 g/kg

**Table 1. Response of Bio fertilizers and Phosphorus on yield attributes and yield of pearl millet**

Sr. No	Treatments	Ear head Length (cm)	No.of Grains/Ear head	Test Weight (g)	Grain yield (t/ha)	Stover Yield (t/ha)	Harvest index (%)
1	20 g/ kg <i>Azotobacter</i> + 35 kg/ ha Phosphorus	17.29	1597.2	5.47	2.38	4.15	36.94
2	20 g/ kg <i>Azotobacter</i> + 40 kg /ha Phosphorus	19.44	1682.9	6.03	2.31	4.30	35.49
3	20 g/ kg <i>Azotobacter</i> + 45 kg/ ha Phosphorus	20.81	1796.17	6.13	2.22	4.47	33.66
4	20 g /kg <i>Azospirillum</i> + 35 kg /ha Phosphorus	18.05	1613.4	6.00	2.70	4.98	36.22
5	20 g/ kg <i>Azospirillum</i> + 40 kg/ ha Phosphorus	19.85	1747.5	6.43	2.75	5.15	35.23
6	20 g/ kg <i>Azospirillum</i> + 45 kg/ ha Phosphorus	21.52	1891.8	6.40	2.61	5.20	33.80
7	20 g/ kg <i>Azotobacter</i> + <i>Azospirillum</i> + 35 kg/ha Phosphorous	22.55	1902.0	6.63	2.98	5.32	36.79
8	20 g/ kg <i>Azotobacter</i> + <i>Azospirillum</i> + 40 kg/ha Phosphorous	23.87	1981.0	6.53	3.15	5.64	36.05
9	20 g/ kg <i>Azotobacter</i> + <i>Azospirillum</i> + 45 kg/ha Phosphorous	25.25	2010.9	6.27	3.25	6.27	34.26
10	Control (RDF 80-40-40 N-P-K kg/ha )	15.84	1404.8	5.47	1.96	4.13	32.55
	F-test	S	S	NS	S	S	NS
	SEm(±)	0.27	32.00	0.61	0.04	0.27	1.17
	CD (p=0.05 )	2.33	95.06	-	0.13	0.80	-

**Table 2. Response of Bio-fertilizers and Phosphorus on economics of pearl millet**

<b>Sr. No</b>	<b>Treatments</b>	<b>Cost of cultivation (INR/ha)</b>	<b>Gross return (INR/ha)</b>	<b>Net return (INR/ha)</b>	<b>B:C Ratio</b>
1.	20 g/kg <i>Azotobacter</i> + 35 kg/ha Phosphorus	31848.00	83300.00	51452.00	1.61
2.	20 g/kg <i>Azotobacter</i> + 40 kg/ha Phosphorus	32173.00	80850.00	48677.00	1.51
3.	20 g/kg <i>Azotobacter</i> + 45 kg/ha Phosphorus	32500.00	77700.00	45200.00	1.39
4.	20 g/kg <i>Azospirillum</i> + 35 kg/ha Phosphorus	31828.00	94500.00	66672.00	1.96
5.	20 g/kg <i>Azospirillum</i> + 40 kg/ha Phosphorus	32153.00	97125.00	64972.00	2.02
6.	20 g/kg <i>Azospirillum</i> + 45 kg/ha Phosphorus	32480.00	91350.00	58870.00	1.81
7.	20 g/kg <i>Azotobacter</i> + <i>Azospirillum</i> + 35 kg/ha Phosphorus	32088.00	104300.00	72212.00	2.25
8.	20 g/kg <i>Azotobacter</i> + <i>Azospirillum</i> + 40 kg/ha Phosphorus	32413.00	110250.00	77837.00	2.44
9.	20 g/kg <i>Azotobacter</i> + <i>Azospirillum</i> + 45 kg/ha Phosphorus	32740.00	113750.00	81010.00	2.47
10.	Control (RDF – 80-40-40 N-P-K kg/ha)	29306.00	68600.00	39294.00	1.34

*Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus (Rs.32413.00 INR/ha) whereas minimum gross return was recorded with Control (RDF 80 – 40 - 40 N-P-K kg/ha) (Rs. 29306.00 INR/ha).

### 3.2.2 Gross returns

Higher Gross returns have been recorded with the 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus (Rs. 113750.00 INR/ha) followed by 20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus (Rs.110250.00 INR/ha) whereas minimum gross return was recorded with Control (RDF 80-40-40 N-P-K kg/ha) (Rs. 68600.00 INR/ha).

### 3.2.3 Net returns

Higher Net returns have been recorded with the treatment 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus (Rs. 81010.00 INR/ha) followed by 20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus (Rs.77837.00 INR/ha) whereas minimum Net returns was recorded with Control (RDF 80-40-40 N-P-K kg/ha) (Rs. 39294.00 INR/ha).

### 3.2.4 Benefit cost ratio

Highest Benefit cost ratio have been recorded with the treatment 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus (2.47) over rest of the treatments followed by 20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus (2.44) whereas lower Benefit cost ratio was recorded with Control (RDF 80-40-40 N-P-K kg/ha) (1.34).

## 4. CONCLUSION

Based on the findings of this experiment, it is concluded that with the application of 20 g/kg *Azotobacter* + *Azospirillum* and 45 kg/ha Phosphorus (Treatment 9) was found more productive (3.25 t/ha) in Pearl millet crop. It can be recommended to farmers following further experiments.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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