Response of Bio fertilizers and Phosphorus on Yield and Economics of Pearl millet (*Pennisetum glaucum* L.)

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 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 *Azotobacte*r, 20g/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 complete 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 and yield attributes viz. ear head length (25.25 cm), number of grains/ear head (2010.9), 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_9) with the application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous.

Key words: *Azospirillum, Azotobacter*, phosphorus, Yield attributes and Economics.

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" (Gurrala *et al.*, 2018).

"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" (Singh et al., 2019).

"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" (Sebastian *et al*., 2021).

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_4 plant with higher photosynthetic efficiency, more dry matter production with less inputs and more economic returns (Reddy *et al*., 2022).

"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" (Singh et al.,2018). 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 (Khan et al., 2005).

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 (Rao *et al*., 2006). 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_2) and niacin (Vitamin B_4) (Reddy *et al*.,2016).

"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" (Rekha *et al*., 2018).

"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" (Smitha, 2005).

"*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" (Dubey et al.,2019).

MATERIALS AND METHODS

A field experiment was carried out during *kharif* season of 2022. The experiment was conducted in randomized complete 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_1 - 20 g/kg *Azotobacter* + 35 kg/ha Phosphorus; T_2 - 20 g/kg *Azotobacter* + 40 kg/ha Phosphorus : T_3 - 20 g/kg *Azotobacter* + 45 kg/ha Phosphorus; T_4 - 20 g/kg *Azospirillum* + 35 kg/ha Phosphorus ; T_5 - 20 g/kg *Azospirillum* + 40 kg/ha Phosphorus; T_6 - 20 g/kg *Azospirillum* + 45 kg/ha Phosphorus ; T_7 - 20 g/kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorus ; T_8 - 20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus ; T_9 - 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus ; T_{10} - 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).

3. RESULTS AND DISSCUSIONS

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.,* (2022).

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 foundto 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 remarkable 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. 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.*, (2019).

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 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).

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.

REFERENCES:

Anonymous, (2016). What's the function of Phosphorus (P) in Plants https://www.greenwaybiotech.com.

Alias, Ahmad, Muhammad Usman, Ehsan Ullah, and Ejaz Ahmed Warraich. (2003). "Effects of Different Phosphorus Levels on the Growth and Yield of Two Cultivars of Maize (*Zea mays* L.)." *International Journal of Agriculture and Biology* **5** (4):632-634.

Chauhan, T. M., Lakhan, R., & Singh, V. (2017). Effect of potassium and sulphur on yield of and nutrient uptake by pearl millet (*Pennisetum glaucum*) in alluvial soil. *Annals of Plant and Soil Research*, *19*(4), 434-437.

Dubey, M., Verma, V. K., Barpete, R. D., & Verma, N. (2019). Effect of biofertilizers on growth of different crops: A review. *Plant Archives*, *19*, 1083-1086.

Forlain, G., Pastorelli, R., Branzoni, M. and Favilli, F. 1998. Root colonization efficiency, plantgrowth promoting activity and potentially related properties in plant associated bacteria. *Journal of Genetics and Breeding*, **49**: 343-351.

Goud, B. S. S., Singh, R., & Kan, W. (2021). Effect of seed inoculants and organic manures on growth and yield of organic pearl millet (*Pennisetum glaucum* L.) *Asian J Microbiol Biotechnol Environ Sci*, *23*(2), 253-7.

Gurrala, S., Guru, G. and Lokanadan, Subbalakshmi, (2018). Effect of nutrient levels and plant growth regulators on growth parameters of pearlmillet. *International Journal Pure and Applied Bioscience*. **6**(1): 1520-1525.

Himanshi, H. P. and Shroff, J. C.2020. Growth, Yield and Economics of Finger millet [*Eleusinecoracana* (L.) Gaertn] as Influenced by Integrated Nutrient Management. InternationalJournal of Current Microbiology and Applied Sciences, **11**; 724-729.

Katiyar, A. K., Shailendra Pratap Singh, Brajesh Prajapati, and P. K. Mishra. 2017. "Performance of Rainfed Pearl millet (*Pennisetum glaucum*) as Influenced by Intercropping, Fertility and Moisture Conservation Practices." International Journal of Current Microbiology and Applied Sciences **6** (6):2946-2951.

Khafi, H. R., Ramani, B. B., Mehta, A. C., & Pethani, K. V. (2000). Effects of different levels of nitrogen, phosphorus and spacing on yield and economics of hybrid bajra. *Crop Research (Hisar)*, ***20***(3), 411-414.

Khan, Muhammad Aslam, Muhammad Abid, Nazim Hussain, and Muhammad Usman Masood. 2005. "Effect of Phosphorous Levels on Growth and Yield of Maize (*Zea mays* L.) Cultivars under Saline Conditions." International Journal of Agriculture and Biology 7 (3):511-514.

Krishna, K. Vamshi, C. H. Deepthi, M. Devender Reddy, P. S. Raju, and Arunabha Pal. 2019. "Effect of Nitrogen and Phosphorus Levels on Growth and Yield of Finger Millet [*Eleusine coracana* (L.)] during Summer." Indian Journal of Agricultural Research:1-5.

Marwein BS, Singh R, Chhetri P.2019 Effect of Integrated Nitrogen Management on Yield and Economics of Foxtail Millet Genotypes. *International Journal of Current Microbiology and Applied Science*. 8(8):2543-2546.

Rao, P. Parthasarathy , P. S. Birthal, Belum V. S. Reddy, K. N. Rai, and S. Ramesh. 2006. "Diagnostics of Sorghum and Pearl Millet Grains-based Nutrition in India." SAT eJournal 2 (1).

Rathod, M., Bavalgave, V.G., Bhumika Tandel and Gudadhe, N.N. 2018. Effect of spacing andINM practices on growth, yield and economics of *rabi* sweet corn (Z*ea mays* L. var. *saccharata* Sturt) under south Gujarat condition. *International Journal of Chemical Studies* **6**(5): 247-250.

Reddy, S. Bhanu Prasad, K. V. Naga Madhuri, Keerthi Venkaiah, and T. Prathima. 2016. "Effect of Nitrogen and Potassium on Yield and Quality of Pearl Millet (Pennisetum glaucum L .)." International Journal of Agriculture Innovations and Research 4 (4):678-681.

Reddy, V. S. N., Singh, R., & Deepika, C. L. (2022). Effect of phosphorus and zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.). *The Pharma Innovation Journal* 11(4), 542-545.

Rekha, D. L. M., Lakshmipathy, R., & Gopal, G. A. (2018). Effect of integrated use of biofertilizers, chemical fertilizers and farmyard manure on soil health parameters of pearl millet (Pennisetum glaucum L.). *J Soil Sci. Plant Health*, *2*(2), 1-4.

Sebastian, B. N., Dawson, J., & Pandey, R. (2021). Influence of nitrogen and biofertilizers on growth and yield of Pearlmillet (Pennisetum glaucum L.) Var. JBV-3. *The Pharma Innovation Journal*10(11), 1101-1104.

Singh, Satybhan, Virendra Singh, Rabish Datt Shukla, and Brajesh Yadav. (2018). "Effect of Planting Geometry and Phosphorus Levels on Pearl Millet (Pennisetum glaucum)." Progressive Research – An International Journal 14 (1):18-22

Singh, S., Singh, V., Shukla, R. D., & Yadav, B. (2019). Effect of planting geometry and phosphorus levels on pearl millet (Pennisetum glaucum). *An International Journal*, *14*(1), 18-22.

Smitha, E.P. (2005). In-vitro evaluation of Pseudomonas fluorescens against rot pathogens of ginger. M.Sc. Thesis., Bharathidasan University, Tiruchirappalli.

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 *Azotobacter* + 35 kg/ ha Phosphorus	17.29	1597.2	5.47	2.38	4.15	36.94
2	20 g/ kg *Azotobacter* + 40 kg /ha Phosphorus	19.44	1682.9	6.03	2.31	4.30	35.49
3	20 g/ kg *Azotobacter* + 45 kg/ ha Phosphorus	20.81	1796.17	6.13	2.22	4.47	33.66
4	20 g /kg *Azospirillum* + 35 kg /ha Phosphorus	18.05	1613.4	6.00	2.70	4.98	36.22
5	20 g/ kg *Azospirillum* + 40 kg/ ha Phosphorus	19.85	1747.5	6.43	2.75	5.15	35.23
6	20 g/ kg *Azospirillum* + 45 kg/ ha Phosphorus	21.52	1891.8	6.40	2.61	5.20	33.80
7	20 g/ kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorous	22.55	1902.0	6.63	2.98	5.32	36.79
8	20 g/ kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorous	23.87	1981.0	6.53	3.15	5.64	36.05

9	20 g/ kg *Azotobacter* + *Azospirillum* + 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.

Sr.no	Treatments	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1.	20 g/kg *Azotobacter* + 35 kg/ha Phosphorus	31848.00	83300.00	51452.00	1.61
2.	20 g/kg *Azotobacter* + 40 kg/ha Phosphorus	32173.00	80850.00	48677.00	1.51
3.	20 g/kg *Azotobacter* + 45 kg/ha Phosphorus	32500.00	77700.00	45200.00	1.39
4.	20 g/kg *Azospirillum* + 35 kg/ha Phosphorus	31828.00	94500.00	66672.00	1.96
5.	20 g/kg *Azospirillum* + 40 kg/ha Phosphorus	32153.00	97125.00	64972.00	2.02
6.	20 g/kg *Azospirillum* + 45 kg/ha Phosphorus	32480.00	91350.00	58870.00	1.81
7.	20 g/kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorus	32088.00	104300.00	72212.00	2.25
8.	20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus	32413.00	110250.00	77837.00	2.44
9.	20 g/kg *Azotobacter* + *Azospirillum* + 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