International Journal of Plant & Soil Science

Volume 35, Issue 9, Page 146-152, 2023; Article no.IJPSS.98702
ISSN: 2320-7035

Effect of Bio Fertilizers and Phosphorus on Growth and Yield of Pearl Millet (*Pennisetum glaucum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i92915

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/98702

Original Research Article

Received: 10/02/2023
Accepted: 12/04/2023
Published: 17/04/2023

ABSTRACT

A research trail was conducted at Crop Research Farm in the Department of Agronomy during *kharif* season of 2022 on pearl millet. SHUATS, Prayagraj (U.P). To study the effect of bio fertilizers and Phosphorus on growth and yield of Pearl millet. The treatments consisted of 3 levels of Biofetilizers (20 g/kg *Azotobacter*, 20 g/kg *Azospirillum,* 20 g/kg *Azotobacter+ Azospirillum)* and phosphorus (35, 40, 45 kg/ha) and a control. The experiment was laid out Randomized Block Design with ten treatments each replicated thrice. 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). The results showed that application of 20 g/kg *Azotobacter+ Azospirillum+* 45 kg/ha Phosphorus was recorded significantly higher plant height (200.13 cm), Plant dry weight (40.33 g/plant), Ear head length (25.25 cm), grains/ear head (2010.9), Grain yield (3.25 t/ha), Stover yield (6.27 t/ha) as compared to other treatments.

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Keywords: Azospirillum; Azotobacter; phosphorus; growth attributes; yield attributes.

1. INTRODUCTION

"Pearl millet (*Pennisetum glaucum* L.) is the staple cereal of arid and semi-arid drier regions of the country. India is the largest Pearl millet growing country contributing 42 per cent of production in the world. In India, pearl millet is pre-dominantly cultivated as a rainfed crop in diverse soils, climatic condition and indispensable arid zone. In India pearl millet was cultivated in 7.12 million hectares with 8.06 million tonnes production and productivity of 1132 kg/ha during 2015-16. The major pearl millet producing states in India are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana. Therefore, there is need to improve fertility management along with optimum plant density of current hybrids for sustainable production and productivity" [1].

"Bio fertilizers are commonly called microbial inoculants which are capable of mobilizing important nutritional elements in the soil from non-usable to usable form by the crop plants through their biological processes" [1].

"Azotobacter and *Azospirillum* are the two examples of these microorganisms. Mycorrhizal symbiosis increases absorption of some elements such as phosphorus, nitrogen and micronutrients, improves water uptake, produces hormones, reduces damages caused by environmental stress. Improves quality of soil aggregate" [1].

"Azospirillum enhance the growth of the plant by influencing the mineral uptake, enhances the dry matter production. Further it also helps in improving the uptake of water and increase the yield of crops. *Azotobacter* is a N fixing bacteria which improves the crop growth through absorption of N which is fixed near the soil root zone" [2]. "*Azospirillum* is a rhizosphere bacterium colonizing the root of the crop plants making use of root exudates and fixes substantial amount of nitrogen and is benefit to plants by mechanisms related to enhancement of plant growth, increase the mineral uptake, increase the dry matter, improve the water absorption and improve the yield. *Azotobacter* is a free-living nitrogen bacterium which has been reported to fix about 20 kg N/ha in non-legumes" [2]. Phosphorus is widely called as "Bottleneck of world hunger" and an essential element with plays vital role in plant's growth and development. "Adequate phosphorus nutrition enhances many aspects of plant growth development including flowering, fruiting, roots growth and yield components of different crops. P uptake in plants is often constrained by the very low solubility of P in the soil. In agricultural systems, Phosphorus in the harvested crops is removed from the system, resulting in P deprived soils if no P is supplemented as fertilizer" [3].

"Phosphorus is essential for all living organisms. Plants must have phosphorus for normal growth and maturity. Phosphorus plays a role in photosynthesis, respiration, energy, storage and transfer, cell division enlargement and several other processes in plants. A Plant must have phosphorus to complete its normal production cycle. Phosphorus is a vital component of DNA, the genetic memory unit of all living things. It is also component of RNA, the compound that reads the DNA genetic transfer" [4].

2. MATERIALS AND METHODS

The experiment was conducted 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 variously 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 *Azotobacte*r + 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 NPK kg/ha) . The observations were recorded on growth parameters at harvest i.e. plant height(cm), dry weight (g/plant), Ear head length (cm), Number of Grains/ear head, Test weight (g), Grain yield (t/ha), Stover yield (t/ha).

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

3.1.1 Plant height (cm)

At 80 DAS, significantly highest plant height (200.13 cm) was observed in the treatment with 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus. However, the treatments with application of 20 g/kg *Azotobacter*+ *Azospirillum*+40 kg/ha Phosphorus (196.40 cm) which were found to be at par with treatment 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorus.

The probable reason for increase in plant height due to application of bio fertilizer and phosphorus were bio fertilizer play crucial role in a free-living nitrogen-fixing bacterium termed *Azotobacter* has been reported to fix about 20 kg/ha of nitrogen in non-legumes. The results were found in accordance with Ramdev et al., [5]. “The significant increase in the height may be due to inoculation of bacterial population 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” [6]. Phosphorus plays a vital role in extensive root systems efficient utilization of nutrients under conditions of sufficient P application similar results was observed by Lakhan et al., [7].

3.1.2 Dry weight (g/plant)

At 80 DAS, treatment with 20 g/kg *Azotobacter* + *Azospirillum* +45 kg/ha Phosphorus was recorded with significantly highest dry weight (40.33 g/plant) . However, the treatments with 20 g/kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorus (37.67 g/plant) which were found to be statistically at par with 20 g/kg *Azotobacter* + *Azospirillum* +45 kg/ha Phosphorus.

The significant increase in a plant dry weight at different stages of growth due to application of bio fertilizers and phosphorus was might be due to crucial role of *Azotobacter* can transforms elemental nitrogen into Ammonical form (NH4 +), which plant life uses. In addition, Azotobacter has a distinct benefit due to its capacity to synthesize auxins, vitamins, growth factors, and antifungal antibiotics. The roots absorbed the nitrogen that was being fixed by *Azotobacter* in the soil near the root zone (rhizosphere), which may have increased the crop's growth parameters. These findings closely match those of Kumar et al., [8] Inoculation of bio fertilizers stimulates activation of hormones which helps in shoot and root elongation and high dry matter production, similar results were observed by Rathore et al., [9].

3.2 Yield Attributes

3.2.1 Ear head length (cm)

The application of 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous significantly increased highest ear head length (25.25 cm). However, the treatments of 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) were statistically at par with 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous.

The yield characteristics were significantly enhanced, and the bio fertilizer and phosphorus application significantly increased the ear head length response. *Azotobacter* that helped roots grow better. Accordingly, better root advancement and energetic plant development, which thus came about to more dry matter lastly better blossoming and ear head improvement, may have been helped by the expanded accessibility of nitrogen. Similar findings were obtained [10].

3.2.2 Grains /ear head

The application of 20 g/kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous produced the highest 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. A significant increase in the number of grains per ear head is the result of an increase in the availability of nitrogen through bio fertilizer inoculation, which also results in an increase in the number of ear heads produced as a result of increased rates of spikelet primordial production; Marngar and Dawson [11] found results that were comparable.

3.2.3 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.

3.2.4 Grain yield (t/ha)

Significantly highest Grain yield (3.25 t/ha) was recorded with the treatment application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous. 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.

"Phosphorus recorded significantly higher grain yield, this could mainly be ascribed to the increased availability of the nitrogen to the plants through biological nitrogen fixation in rhizosphere by *Azotobacter* that caused better root development. Thus, the greater availability of nitrogen might have helped in better root proliferation and vigorous plant growth, resulting in more dry matter and ultimately better flowering and grain development. The increase in yield might be due to the cumulative effect of increased growth and yield attributes noted under this treatment" [12].

3.2.5 Stover yield (t/ha)

Significantly highest Stover yield (6.27 t/ha) was recorded with the treatment application of 20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous over all the treatments. 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.

Stover yield is dependent on vegetative growth as use of balanced and optimum use of fertilizer increased plant height, green leaves per hill, and dry matter production, which finally resulted in higher stover yield, similar results were obtained by Zothanmawii et al., [13].

Table 1. Effect of bio fertilizers and phosphorus on growth attributes of pearl millet

Sl. no	Treatments	Plant height (cm) 80 DAS	Dry weight (g/plant) 80 DAS
1	20 g/ kg *Azotobacter* + 35 kg/ ha Phosphorus	171.23	30.70
2	20 g/ kg *Azotobacter* + 40 kg /ha Phosphorus	179.80	31.19
3	20 g/ kg *Azotobacter* + 45 kg/ ha Phosphorus	185.43	33.59
4	20 g /kg *Azospirillum* + 35 kg /ha Phosphorus	175.03	34.22
5	20 g/ kg *Azospirillum* + 40 kg/ ha Phosphorus	183.17	34.30
6	20 g/ kg *Azospirillum* + 45 kg/ ha Phosphorus	188.70	33.88
7	20 g/ kg *Azotobacter* + *Azospirillum* + 35 kg/ha Phosphorous	192.10	34.87
8	20 g/ kg *Azotobacter* + *Azospirillum* + 40 kg/ha Phosphorous	196.40	37.67
9	20 g/ kg *Azotobacter* + *Azospirillum* + 45 kg/ha Phosphorous	200.13	40.33
10	Control (RDF 80-40-40 N-P-K kg/ha)	168.13	31.87
	F-test	S	S
	SEm(±)	1.40	0.93
	CD (p=0.05)	4.15	2.75

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

Sl. 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	-

3.2.6 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).

4. CONCLUSION

From the results, application of Bio fertilizers and P can significantly improve the growth and yield of pearl millet. The results of this study support the use of Bio fertilizers and P as a sustainable agricultural practice for improving soil fertility and crop productivity in tropical regions. 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 and it can be recommended to farmers after further trails.

ACKNOWLEDGEMENT

I express my gratitude to my advisor Dr. Rajesh Singh for constant support, guidance and for his valuable suggestions for improving the quality of this research work and to all the faculty members of Department of Agronomy, SHUATS, Prayagraj, and Uttar Pradesh (U.P). For providing all necessary facilities, for their cooperation, encouragement and support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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