Original Research Article

Influence of Bio-fertilizers and Potassium levels on growth and yield of Pearl millet (*Pennisetum glaucum L.*)

Abstract

A field experiment was conducted during *Kharif* 2021 At [CRF] Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot became sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48kg/ha), available P (15.2kg/ha) and available K (232.5 kg/ha). The experiment became specified in Randomized Block Design with ten treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 30kg/ha, T_2: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 40 kg/ha, T_3: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 50kg/ha, T_4: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 30kg/ha, T_5: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 40kg/ha, T_6: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 50kg/ha, T_7: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 30kg/ha, T_8: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40kg/ha, T_9: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 50kg/ha and T_{10}: Control are used. The results showed that application of ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50kg/ha was recorded significantly higher plant height (150.25 cm), No. of Leaves/Plant(12.65), Plant dry_weight(17.19 g/plant), No. of ears/hill(2.60), No. of grains/ear (2420.73), Test weight(9.45 g), Grain yield(3.16 t/ha) , Straw yield(7.57 t/ha), Harvest index (29.40), gross returns(Rs.79,000/ha), net returns(Rs.48,878.20/ha) and benefit cost ratio (1.62) as compared to other treatments.

Key words: ~~*Azospirillum*~~*Azospirillum*, ~~*Azotobacter*~~*Azotobacter*, Potassium, yield.

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Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. better Stuntz] is one of the important cereal crops of hot and dry areas of arid and semi-arid environmental condition conditions. it's been estimated that pearl millet embodies an incredible productivity potential significantly in areas encountering extreme environmental stress conditions on account of drought. It grows on poor sandy soils also its drought escaping character has created it a well-liked crop of drought prone areas. pearl millet provides staple food for the poor in a short amount in comparatively dry tracts of the country. it's nutritionally better than several cereals as it is an honest supply of protein having higher digestibility(12.1%), fats(5.0%), carbohydrates (69.4%) and minerals(2.3%). Grains represent a very important cattle or poultry feed. Green fodder is employed either intrinsically or is preserved as fodder or feed that has verified very helpful in dry regions **(Kacha *et al.*, 2011).**

Pearl millet occupies 6.93 million ha with the production of 8.61 million tones and also the productivity of 1243kg/ha. Rajasthan occupied 42.49 lakh ha area with the overall production of 50.59lakh tones and average productivity of 1190kg/ha. ~~it's~~ It's the sole cereal crop that's ready to produce reliable yield below the marginal environments and at the same time responds to excessive management conditions. Its nutritive grain forms the vital element of human diet and stover forms the principal maintenance ration for ruminant livestock throughout the dry season. In addition, pearl millet grain is progressively being used as feed for livestock and poultry **(Latake *et al.*, 2009).**

Potassium (K) is considerably a vital nutrient for plant growth, and has the potential to maximize plant growth and it influences soil-plant interactions as well. As, for acting as a necessary nutrient for crop production and its development; it acts as a co-factor for more than 40 enzymes that are concerned in metabolic pathways directly. Its application effects on turgor potential, opening and closing of stomata, relative water contents, photosynthetic rate, leaf water potential, grain weight, transpiration rate, grain yield, biological yield of crops and disturbed consumption mechanism of fixed **(Yadav *et al.*, 2011).**

Biofertilizers play a very important role in increasing the supply of native and applied nutrients and productivity in sustainable manner. *Azotobactor* is a nonsymbiotic N fixing bacterium. ~~it's~~ It's been reportable to fix regarding 20 kg N ha^{-1} per year in a field of non-legume crop and additionally secretes some growth promoting substances **(Subba Rao 1982).**

Phosphate solubilizing microorganism, significantly the soil bacteria belonging to the genera ~~pseudomonas~~ *Pseudomonas* and bacillus and fungi belonging to the genera genus *Penicillium* and *Aspergillus* possess the capability to transform insoluble phosphates into soluble forms. ~~an~~ An application of ~~*Azotobacter*~~*Azotobacter* biofertilizers has been found to increase the yield of wheat, maize, cotton and mustard by 0-30% over controls have

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additionally succeeded to reduce the recommended doses of chemical fertilizers required for corn and millet by 50 per cent using biofertilizers while not loss within the yield. Objectives of this study are the response of various bio-fertilizers and their combinations on growth and yield of pearl millet below 50% of the recommended dose of N and P application.

~~*Azospirillum*~~*Azospirillum* is ~~profit~~ hepls to plants by mechanisms regarding improvement of plant growth, will increase the mineral uptake, increases the dry matter, improve the water absorption and improve the yield. The carrier primarily based ~~*Azospirillum*~~*Azospirillum* substance for non-leguminous crops have become progressively popular in India in recent years. ~~Azospirillum~~*Azospirillum* could be a rhizosphere microorganism colonizing the roots of crop plants creating use of root exudates and fixes substantial quantity of atmospheric nitrogen. They exert beneficial effects on growth and yield of the many economically necessary crops

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~~Azotobacter~~*Azotobacter* improves seed germination and has a positive effect on crop growth rate (CGR). Helps increase nutrient availability and restore soil fertility for better crop response. Due to its important role in soil sustainability, it is an important part of the integrated nutrient system. Seed inoculation with ~~Azotobacter~~*Azotobacter* significantly increased plant height, dry matter accumulation, total number of tillers, chlorophyll content, effective tillers, ears length, grains/ear, test weight, grain, stover~~,~~ and biological yield, protein content, total uptake of N, P ~~,~~and K and their concentration in grain and stover.

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Materials and Methods

Comment [AD2]: Please mention the N and K fertilization schedule and crop management in brief. Include the initial soil status.

The present examination was carried out during *Kharif* 2021 at [CRF] Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28° ~~o~~N latitude, 81.54° ~~o~~E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of ten treatments with T_1: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 30kg/ha, T_2: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 40kg/ha, T_3: ~~*Azospirillum*~~*Azospirillum* 25g/kg + Potassium 50kg/ha, T_4: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 30kg/ha, T_5: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 40kg/ha, T_6: ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 50kg/ha, T_7: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 30kg/ha, T_8: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40kg/ha, T_9: ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25g/kg + Potassium 50kg/ha and T_{10}:

Control [NPK(kg/ha) – 60-30-30]. Ten treatments were replicated thrice in Randomized Block Design.

Chemical analysis of soil

Composite soil samples are collected before layout of the experiment to determine the initial soil properties. The soil samples are collected from 0-15 cm depth and were dried below shade, powdery with wood pestle and mortar, capable 2 mm sieve and were analyzed for organic carbon by rapid volumetric analysis methodology by ~~**nelson**~~ **Nelson** **(1975).** Available nitrogen was estimated by alkaline permanganate method by **Subbiah and Asija (1956)**, available phosphorous by Olsen's method as outlined by **Jackson (1967)**, available potassium determined by using the flame photometer normal ammonia acetate solution and estimating by using flame photometer (ELICO Model) as outlined by **Jackson (1973)** and available $ZnSO_4$ was estimated by Atomic Absorption photometer technique as outlined by **Lindsay and Norvell (1978).**

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Statistical analysis

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The data recorded were totally different characteristics were subjected to statistical analysis by adopting Fishers the strategy of analysis of variance (ANOVA) as represented by Gomez and Gomez (~~2010~~1984). ~~critical~~Critical difference (CD) values were calculated the 'F' test was found significant at 5% level.

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Results and Discussion

Growth attributes

Plant height

Data in table 1 tabulated that significantly highest plant height (150.25 cm) was determined within the treatment with ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + metal 50 kg/ha over all the other treatments. However, the treatments with application of ~~Azotobacter~~*Azotobacter* 25 g/kg + potassium 50 kg/ha (148.89 cm) and ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + potassium 40 kg/ha (149.62 cm) that were found to be at par with treatment ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + potassium 50 kg/ha as compared to all the treatments. Application of potassium plays an important role in meristematic growth through its impact on the synthesis of phyto hormones. Among varied plant hormones, cytokinin plays a very important role in growth of the plant. Useful impact of K on growth reported by **Kacha *et al.* (2011).**

Leaves/plant

Treatment with ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha was recorded with significantly maximum dry weight (12.65) over all the treatments. However, the treatments with ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha (11.83) and ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha (12.19) which were found to be statistically at par with ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha. Potassium application plays a crucial role in photosynthetic ~~process and~~process and formation of chlorophyll in the leaf. Similar, results observed by **Sundaresh *et al.* (2017).**

Plant dry weight (g/plant)

Treatment with ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 50kg/ha was recorded with considerably maximum dry weight (17.19 g/plant) over all the treatments. However, the treatments with ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 50kg/ha (16.70 g/plant) and ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 40kg/ha (17.01 g/plant) that were found to be statistically at par ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 50kg/ha. Inoculation of biofertilizers by microorganisms helped the production of organic acids, chelating oxoacids from sugars, and exchange reactions in growth environment, the results were found to similar with **Marngar and Dawson (2017).** The probable reason for increase in dry weight within the application of 50kg/ha K may because of the potassium during this application plays a vital role in meristematic growth through its impact on the synthesis of phyto hormones. The results were found to be similar with **Reddy *et al.* (2016).**

Table 1 Influence of Bio-fertilizers and Potassium levels on Growth parameters of Pearl millet.

Treatments	Plant height(cm)	No. of Leaves/plant	Dry weight(g)
1. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 30 kg/ha	143.69	9.78	14.65
2. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 40 kg/ha	145.41	10.58	15.44
3. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 50 kg/ha	146.22	10.93	15.86
4. ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 30 kg/ha	144.15	10.29	14.85
5. ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha	147.87	11.53	16.40
6. ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha	148.89	11.83	16.70
7. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 30 kg/ha	146.79	11.17	16.05
8. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha	149.62	12.19	17.01
9. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha	150.25	12.65	17.19
10. Control (RDF)	141.84	9.15	13.79
S. Em (±)	0.33	0.23	0.22
CD(P = 0.05)	1.00	0.69	0.66

Yield attributes and Yield

Significant maximum ears/hills (2.60) was recorded in the application treatment of ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha in all treatments. However, the treatments with ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha (2.49) were statistically equivalent to ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha. The significant increase in ears/hill is due to the increase in nitrogen availability from inoculation with biofertilizers in which more ears are produced due to enhanced rates of spikes primordial production, similar results were found **Thavaprakaash *et al.* (2018).** Potassium application enhances the development of strong cell walls and improves germination of pollen within the florets that leads to high spikelet fertility. The results were in accordance to **Jain *et al.* (2003)**.

Significantly, the highest no. of grains/ear (2420.73) was recorded with the application treatment of ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha over all treatments. However, treatments ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha (2316.13) and ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha (2358.47) were statistically equivalent to ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/ha kg + Potassium 50 kg/ha. Significant increase in the number of grains/ear is due to increase in the availability of N through bio fertilizer inoculation by that more ears are produced because of increased rates of ear primordial production, similar results were found Panchal et al. (2018). The presence of K could be attributed to higher filling of grains and thus, an increase in different yield attributing characters. The results were found to be similar with **Bangar *et al.* (2004).**

Test weight (9.45 g) was recorded significantly highest in the treatment with the application of ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha over all the treatments. However, the treatment with (9.24 g) in ~~*Azotobacter*~~*Azotobacter* 25 g/kg +Potassium 50 kg/ha and ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha (9.33 g) which were found to be statistically at par with ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha. The application of higher levels of potassium stimulated the better grain filling and bold sized seed **More *et al*. (2004)**.

The Grain yield (3.16 t/ha) was recorded significantly highest within the treatment with application of ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 50kg/ha over all the treatments. However, the treatments with (3.05 t/ha) in ~~Azotobacter~~*Azotobacter* 25g/kg +Potassium 50 kg/ha and ~~Azospirillum~~*Azospirillum* +

~~Azotobacter~~*Azotobacter* 25g/kg + potassium 40kg/ha (3.08 t/ha) that were found to be statistically at par with ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + potassium 50kg/ha. Increase in yield attributes and yield through bio-fertilizer could be attributed to provide of more plant hormones (auxin, cytokinin, gibberellin etc.) by the microorganisms inoculated or by the root resulting from reaction to microbial population similar results were obtained by **Marngar and dawson (2017).** The presence of potassium stimulates the accumulative impact of improvement in yield attributes viz., number of effective tillers per plant, ear head length and thickness and test weight and augmented availability, absorption, and translocation of K nutrient. Findings were found to be similar with **Kacha *et al.* (2011).**

The significantly higher straw yield (7.57/ha) was recorded with the application treatment of ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + Potassium 50kg/ha across all treatments. However, treatments with (7.35 t/ha) were statistically equal in ~~Azotobacter~~*Azotobacter* 25g/ha kg + Potassium 50kg/ha and ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + Potassium 40kg/ha (7.46 t/ha). with ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25g/kg + Potassium 50kg/ha. Potassium application enhances the improvement of strong cell walls and therefore stiffer straw which is probably resulted into profuse tillering and extended availability, absorption, and translocation of K nutrient. These results are agreement with those reports through Tamboli et al. (2012). The harvest index is observed to be non-significant. Whereas, maximum Harvest index (29.40 %) was recorded with the treatment application of ~~Azospirillum~~*Azospirillum* +~~Azotobacter~~*Azotobacter* 25g/kg + Potassium 50kg/ha over all of the treatments and minimum (28.20%) was recorded withinside the treatment ~~Azospirillum~~*Azospirillum* 25g/kg + Potassium 30kg/ha.

Table 2. Influence of Bio-fertilizers and Potassium levels on Yield attributes and Yield of Pearl millet.

Treatments	No. of ears/hill	No. of grains/ear	Test Weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
1. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 30 kg/ha	1.91	1767.98	8.51	2.60	6.61	28.20
2. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 40 kg/ha	2.13	1996.42	8.75	2.75	6.78	28.85
3. ~~*Azospirillum*~~*Azospirillum* 25 g/kg + Potassium 50 kg/ha	2.20	2070.69	8.84	2.82	6.96	28.84
4. ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 30 kg/ha	2.03	1884.15	8.63	2.67	6.74	28.35
5. ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha	2.35	2219.40	9.09	2.95	7.27	28.82
6. ~~*Azotobacter*~~*Azotobacter* 25 g/kg +Potassium 50 kg/ha	2.40	2316.13	9.24	3.05	7.35	29.25
7. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 30 kg/ha	2.29	2192.07	8.97	2.87	7.12	28.68
8. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 40 kg/ha	2.49	2358.47	9.33	3.08	7.46	29.16
9. ~~*Azospirillum*~~*Azospirillum* + ~~*Azotobacter*~~*Azotobacter* 25 g/kg + Potassium 50 kg/ha	2.60	2420.73	9.45	3.16	7.57	29.40
10. Control (RDF)	1.68	1680.69	8.29	2.52	6.42	28.40
F test	**S**	**S**	**S**	**S**	**S**	**NS**
S. Em (±)	0.03	35.74	0.06	0.04	0.04	0.30
CD(P = 0.05)	0.11	106.18	0.18	0.11	0.11	-

CONCLUSION

It is concluded that application of treatment ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + potassium 50 kg/ha performed exceptionally in obtaining maximum seed yield of Pearl millet. Hence, ~~Azospirillum~~*Azospirillum* + ~~Azotobacter~~*Azotobacter* 25 g/kg + potassium 50 kg/ha is useful under eastern uttar pradesh Conditions.

Comment [AD6]: Please rewrite the conclusion as per the result.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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