Original Research Article

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

Abstract

A research study was carried out at Crop Experimental Farm, Department of Agronomy, SHUATS, Prayagraj, for the duration of Kharif 2021 (U.P). The topsoil of the experimental area was sandy clay loam, nearly fair and balanced in soil properties (pH 7.1), low in organic material (0.36 %), obtainable N (171.48 kg/ha), obtainable P (15.2 kg/ha), and obtainable K (232.5 kg/ha). The experiment has been conducted in Randomized Block Design, as well as the 10 treatment options replicated three times over a period of a year. The treatments which are T_1: *Azospirillum* 25g/kg + Potassium 30kg/ha, T_2: *Azospirillum* 25g/kg + Potassium 40 kg/ha, T_3: *Azospirillum* 25g/kg + Potassium 50kg/ha, T_4: *Azotobacter* 25g/kg + Potassium 30kg/ha, T_5: *Azotobacte*r 25g/kg + Potassium 40kg/ha, T_6: *Azotobacter* 25g/kg + Potassium 50kg/ha, T_7: *Azospirillum* + *Azotobacter* 25g/kg + Potassium 30kg/ha, T_8: *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 40kg/ha, T_9: *Azospirillum* + *Azotobacter* 25g/kg + Potassium 50kg/ha and T_{10}: Control are used. The application of Azospirillum + Azotobacter 25 g/kg + Potassium 50 kg/ha resulted in significantly higher plant height (150.25 cm), number of leaves/plant (12.65), plant dry weight (17.19 g/plant), number of ears/hill (2.60), number 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, Azotobacter, Potassium, yield.

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 covered 6.93 million ha, yielding 8.61 million tonnes and a productivity of 1243kg/ha. Rajasthan utilized 42.49 lakh ha of land, with a total production of 50.59 lakh tonnes and an average yield of 1190kg/ha. It is the only cereal crop capable of producing consistent yields in poor areas while also responding to excessive management conditions. Its nutritious grain is an essential component of the human diet, and its stover is the primary sustaining feed for ruminant livestock during the dry season. Furthermore, pearl millet grain is increasingly to be used as cattle and poultry feed **(Latake *et al.* 2009).**

Potassium (K) is an essential nutrient for plant growth that has the capability to improve plant growth and alter soil-plant interactions. As a required nutrient for crop production and development, it works as a co-factor for more than 40 enzymes that are directly involved in biochemical activities. Its impacts on turgor potential, stomatal opening and closure, relative water contents, photosynthetic rate, leaf water potential, grain weight, transpiration rate, grain yield, biological yield of crops, and disrupted consumption strategy of fixed crops **(Yadav *et al.* 2011).**

Biofertilizers play a vital role in enhancing native and applied nutrient supply and yield in a sustainable manner. Azotobacterial is a microorganism that fixes nitrogen in the absence of a symbiotic relationship. It has been reported to fix approximately 20 kg N ha-1 each year on a field of non-legume crop and to release some growth promoting compounds **(Rao 1982).**

Phosphate-solubilizing microorganisms, particularly soil bacteria from the genera pseudomonas and bacillus, and fungi from the genera Penicillium and Aspergillus, have the ability to convert insoluble phosphates into soluble forms. An treatment of Azotobacter biofertilizers has been found to boost the yield of wheat, maize, cotton, and mustard by 0-30% above controls. Biofertilizers have also been used to minimize the higher dose of chemical fertilisers required for corn and millet by 50% while generating no yield loss. The goals of this research are to determine the impacts of multiple bio-fertilizers and their mixtures on the development and production of pearl millet when applied at less than 50% of the recommended dose of N and P.

Azospirillum benefits plants by improving plant growth mechanisms, increasing mineral intake, increasing dry matter, improving water absorption, and increasing yield. Azospirillum-based carrier substances for non-leguminous crops have grown in popularity in India in recent years. Azospirillum is a rhizosphere microbe that colonises agricultural plant roots through root exudates and fixes a significant amount of atmospheric nitrogen. They have a positive impact on the growth and yield of many commercially important crops.

Azotobacter promotes seed germination and promotes crop growth rate (CGR). Produces higher response by improving nutrient availability and restoring soil fertility. It is an essential part of the integrated nutrient system because of its importance in soil sustainability. Azotobacter seed inoculation improved 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 Kand concentration in grain and stover.

Materials and Methods

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* 25g/kg + Potassium 30kg/ha, T_2: *Azospirillum* 25g/kg + Potassium 40kg/ha, T_3: *Azospirillum* 25g/kg + Potassium 50kg/ha, T_4: *Azotobacter* 25g/kg + Potassium 30kg/ha, T_5: *Azotobacte*r 25g/kg + Potassium 40kg/ha, T_6: *Azotobacter* 25g/kg + Potassium 50kg/ha, T_7: *Azospirillum* + *Azotobacter* 25g/kg + Potassium 30kg/ha, T_8: *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 40kg/ha, T_9: *Azospirillum* + *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

To determine the initial soil parameters, composite soil samples are obtained prior to the experiment arrangement. Soil samples were collected from 0-15 cm depth, dried in the shade, powdered with a wood pestle and mortar, sieved through a capable 2 mm sieve, and evaluated for organic carbon using quick volumetric analytical method **(nelson 1975). Subbiah and (Asija 1956)** approximated available nitrogen that use the alkaline permanganate method, available phosphorous that use Olsen's method as outlined by (Jackson 1967), available potassium using the flame photometer normal ammonia acetate solution and estimating using the flame photometer (ELICO Model) as outlined by **(Jackson 1973),** and available ZnSO4 using Atomic Absorption photometer methodology as outlined by (Jackson 1973). **(Lindsay and Norvell 1978).**

Statistical analysis

The data were analyzed statistically using Fishers' approach of analysis of variance (ANOVA), as reported by Gomez and Gomez (2010). When the significant difference (CD) values were determined, the 'F' test was found to be statistically significant at the 5% level.

Results and Discussion

Growth attributes

Table 1 shows that the treatment with Azospirillum + Azotobacter 25 g/kg + metal 50 kg/ha resulted in the maximum plant height (150.25 cm) compared to the other treatments. However, the treatments with application of Azotobacter 25 g/kg + potassium 50 kg/ha (148.89 cm) and Azospirillum + Azotobacter 25 g/kg + potassium 40 kg/ha (149.62 cm) that were found to be at par with treatment Azospirillum + Azotobacter 25 g/kg + potassium 50 kg/ha as compared to all the treatments. The application of potassium has a significant impact on meristematic growth due to its impact on the synthesis of phytohormones. Cytokinin is a plant hormone that plays a key function in plant growth. Kacha *et al.* (2011) reported a beneficial effect of K on growth.

Leaves/plant

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

Plant dry weight (g/plant)

Treatment with Azospirillum + 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 25g/kg + potassium 50kg/ha (16.70 g/plant) and Azospirillum + Azotobacter 25g/kg + potassium 40kg/ha (17.01 g/plant) that were found to be statistically at par Azospirillum + Azotobacter 25g/kg + potassium 50kg/ha. Inoculation of biofertilizers by microorganisms aided in the synthesis of organic acids, chelating oxoacids from sugars, and exchange processes in the growth environment; the results were found to be comparable to those of **Marngar and Dawson (2017)**. The potassium during this application may play a significant role in meristematic growth through its impact on the synthesis of phytohormones, which is the most likely reason for the rise in dry weight within the application of 50kg/ha K. The findings were found to be similar to those of **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* 25 g/kg + Potassium 30 kg/ha	143.69	9.78	14.65
2. *Azospirillum* 25 g/kg + Potassium 40 kg/ha	145.41	10.58	15.44
3. *Azospirillum* 25 g/kg + Potassium 50 kg/ha	146.22	10.93	15.86
4. *Azotobacter* 25 g/kg + Potassium 30 kg/ha	144.15	10.29	14.85
5. *Azotobacte*r 25 g/kg + Potassium 40 kg/ha	147.87	11.53	16.40
6. *Azotobacter* 25 g/kg + Potassium 50 kg/ha	148.89	11.83	16.70
7. *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 30 kg/ha	146.79	11.17	16.05
8. *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 40 kg/ha	149.62	12.19	17.01
9. *Azospirillum* + *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 + Azotobacter 25 g/kg + Potassium 50 kg/ha in all treatments. However, the treatments with Azospirillum + Azotobacter 25 g/kg + Potassium 40 kg/ha (2.49) were statistically equivalent to Azospirillum + 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 + Azotobacter 25 g/kg + Potassium 50 kg/ha over all treatments. However, treatments Azotobacter 25 g/kg + Potassium 50 kg/ha (2316.13) and Azospirillum + Azotobacter 25 g/kg + Potassium 40 kg/ha (2358.47) were statistically equivalent to Azospirillum + 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* + *Azotobacter* 25 g/kg + Potassium 50 kg/ha over all the treatments. However, the treatment with (9.24 g) in *Azotobacter* 25 g/kg +Potassium 50 kg/ha and *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 40 kg/ha (9.33 g) which were found to be statistically at par with *Azospirillum* + *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 + Azotobacter 25g/kg + potassium 50kg/ha over all the treatments. However, the treatments with (3.05 t/ha) in Azotobacter 25g/kg +Potassium 50 kg/ha and Azospirillum + Azotobacter 25g/kg + potassium 40kg/ha (3.08 t/ha) that were found to be statistically at par with Azospirillum + 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 + Azotobacter 25g/kg + Potassium 50kg/ha across all treatments. However, treatments with (7.35 t/ha) were statistically equal in Azotobacter 25g/ha kg + Potassium 50kg/ha and Azospirillum + Azotobacter 25g/kg + Potassium 40kg/ha (7.46 t/ha). with Azospirillum + 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 +Azotobacter 25g/kg + Potassium 50kg/ha over all of the treatments and minimum (28.20%) was recorded withinside the treatment 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* 25 g/kg + Potassium 30 kg/ha	1.91	1767.98	8.51	2.60	6.61	28.20
2. *Azospirillum* 25 g/kg + Potassium 40 kg/ha	2.13	1996.42	8.75	2.75	6.78	28.85
3. *Azospirillum* 25 g/kg + Potassium 50 kg/ha	2.20	2070.69	8.84	2.82	6.96	28.84
4. *Azotobacter* 25 g/kg + Potassium 30 kg/ha	2.03	1884.15	8.63	2.67	6.74	28.35
5. *Azotobacte*r 25 g/kg + Potassium 40 kg/ha	2.35	2219.40	9.09	2.95	7.27	28.82
6. *Azotobacter* 25 g/kg +Potassium 50 kg/ha	2.40	2316.13	9.24	3.05	7.35	29.25
7. *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 30 kg/ha	2.29	2192.07	8.97	2.87	7.12	28.68
8. *Azospirillum* + *Azotobacter* 25 g/kg + Potassium 40 kg/ha	2.49	2358.47	9.33	3.08	7.46	29.16
9. *Azospirillum* + *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 + Azotobacter 25 g/kg + potassium 50 kg/ha performed exceptionally in obtaining maximum seed yield of Pearl millet. Hence, Azospirillum + Azotobacter 25 g/kg + potassium 50 kg/ha is useful under eastern uttar pradesh Conditions.

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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