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Effect of Bio-fertilizers and plant growth regulators on growth and yield of Pearl millet (*Pennisetum glaucum* L.)

Adey Mourya and Shikha Singh

Abstract
A field experiment was conducted during *Kharif* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36%), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out on Randomized Block Design with nine treatments each replicated thrice on the basis of one year experimentation. The treatments which are T_1: *Azotobacter* 25 g/kg + NAA 40ppm, T_2: *Azotobacter* 25 g/kg + Salicylic acid 100 ppm, T_3: *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm, T_4: *Azospirillum* 25 g/kg + NAA 40ppm, T_5: *Azospirillum* 25 g/kg + Salicylic acid 100 ppm, T_6: *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm, T_7:*Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm, T_8: *Azotobacter* + *Azospirillum* 25 g/kg + Salicylic acid 100 ppm, T_9: *Azospirillum* + *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm are used. The results showed that application of *Azospirillum* + *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm was recorded significantly higher plant height (155.81 cm), Plant dry weight (18.56 g/plant), whereas significantly highest Crop growth rate (4.61 g/m^2/day) was recorded with the treatment *Azospirillum* 25 g/kg + NAA 40ppm. However, Ear head length (26.07 cm), grains/ear head (2394.14), Test weight (8.14 g), Grain yield (3.53 t/ha), Straw yield (7.58 t/ha) as compared to other treatments.

Keywords: *Azospirillum*, *Azotobacter*, NAA, Salicylic acid, yield

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. Land, which is not only thirsty but also hungry. The estimated nutrient removal by all dryland crops is to the tune of 7.4 million tonnes (excluding secondary and micro nutrients) Approximately drylands receive 10 per cent of total nutrients use in the country, which constitutes about 1.4 million tonnes. There remains a net negative balance of about 6.0 million tonnes. The productivity of pearl millet is very low in India mainly due to poor plant stand and less use of fertilizers. Pearl millet removes 72 kg N, P2O5 and K2O/ ha /annum, whereas only 10-20 kg of these nutrient are being supplied through fertilizers. Therefore, there is need to improve fertility management along with optimum plant density of current hybrids for sustainable production and productivity (Venkata *et al.*, 2001) [14].

Biofertilizers 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. Azotobacter is a beneficial free living (nonsymbiosis) nitrogen fixing bacteria which is reported to fix 20-60 kg/ha nitrogen in soil annually. Azotobacter was the first and is the most common biofertilizer for some plants such as maize, wheat, sorghum and rice which produces some plant growth promoting metabolites, enzymes and hormones (Auxin, cytokinin and gibberellin) in addition to fixing air nitrogen (Forlain *et al.*, 1998) [3]. The plant growth regulators (PGRs) have potential for increasing crop productivity under environmental stress. Growth regulators are chemical substances which can alter the growth and developmental processes (Espindula *et al.*, 2009) [2] leading to increased yield, improved grain quality or facilitated harvesting.

Application of naphthalene acetic acid has been reported to induce physiological efficiencies, including photosynthetic ability of plants which resulted in better growth and yield of several crop without substantial increase in cost of production (Sumeriya *et al.,* 2000) [12] reported that the PGRs have potential for increasing crop productivity under environmental stress.

Materials and Methods

The present examination was carried out during *Kharif* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28°N latitude, 81.54°E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consisting of nine treatments with T_1: *Azotobacter* 25 g/kg + NAA 40ppm, T_2: *Azotobacter* 25 g/kg + Salicylic acid 100 ppm, T_3: *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm, T_4: *Azospirillum* 25 g/kg + NAA 40ppm, T_5: *Azospirillum* 25 g/kg + Salicylic acid 100 ppm, T_6: *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm, T_7:*Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm, T_8: *Azotobacter* + *Azospirillum* 25 g/kg + Salicylic acid 100 ppm, T_9: *Azospirillum* + *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm are used.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}). In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height and plant dry weight are recorded. The yield parameters like Ear head length (cm), grains per ear head, test weight, seed yield (t/ha) and stover yield (t/ha) were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results and Discussion

Growth attributes

Plant height

Significantly highest plant height (155.81 cm) was observed in the treatment with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm over all the other treatments. However, the treatments with application of *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm (154.63 cm) and *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm (155.13 cm) which were found to be at par with treatment *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm as compared to all the treatments.

NAA have a regulatory function are produce the shoot apex primary in the leaf primodial and root system stimulates stem growth dramatically and also stimulates cell division, cell elongation and enzyme secretion, which eventually increased the plant height. The improvement in plant height was due to interaction of Salicylic acid and NAA application to Pearl millet crop. The results were in accordance to Prabha and Negi (2014) [8].

The significant increase in the height may be due to inoculation of bacterial preparation 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 as similarly observed by Patidar and Mali (2004) [6].

Plant dry weight (g/plant)

Treatment with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm was recorded with significantly maximum dry weight (17.19 g/plant) over all the treatments. However, the treatments with *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm (18.23 g/plant) and *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm (18.38 g/plant) which were found to be statistically at par *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm.

NAA along with Salicylic acid promotes cell proliferation in plant developmental stages due to their own metabolism regulation and promotes the development of cells by increasing turgor pressure and it also activates different enzymes and has a positive effect on plant growth and dry matter accumulation and accumulation and whereas SA helps plant to increase the resistant against various external factors. The results were found in accordance with Ali *et al*. (2013) [1]. Inoculation of biofertilizers stimulates activation of hormones which helps in shoot and root elongation and high dry matter production, similar results were observed by Rathore *et al*. (2006) [9]

Yield attributes and Yield

Ear head length (cm)

Significantly Maximum Ear head length (26.07 cm) was recorded with the treatment of application of *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm over all the treatments. However, the treatments *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm (25.74 cm) and *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm (25.90 cm) which was found to be statistically at par with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm.

The application of NAA along with Salicylic acid helped in increase the length of ear head. Similar findings have been reported earlier by Sivakumar *et al*. (2018) [11].

Grains/ear head

Significantly Highest grains/ear head (2394.14) was recorded with the treatment of application of *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm over all the treatments. However, the treatment *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm (2329.23) and *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm (2348.01) which were found to be statistically at par with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm.

Significant increase in number of grains /ear head is due to increase in the availability of Nitrogen through bio fertilizer inoculation by which more ear heads are produced due to increased rates of spikelets primordial production, similar results were found Marngar and Dawson (2017) [5].

Table 1: Effect of biofertilizers and plant growth regulators on growth parameters of pearl millet.

S. No.	Treatment No.	Plant height (cm)	Plant dry weight (g/plant)	Crop growth rate(g/m^2/plant)	Relative Growth rate (g/g/day)
1	T_1	152.86	17.96	4.22	0.0140
2	T_2	150.89	17.53	4.59	0.0146
3	T_3	154.63	18.23	4.39	0.0133
4	T_4	150.56	17.37	4.61	0.0146
5	T_5	149.86	17.21	4.57	0.0150
6	T_6	151.85	17.74	4.54	0.0140
7	T_7	155.13	18.38	4.43	0.0130
8	T_8	153.74	18.13	4.32	0.0140
9	T_9	155.81	18.56	4.45	0.0126
	CD(P=0.05)	1.10	0.36	0.21	-
	S.Em±	0.37	0.12	0.07	0.00

Table 2: Effect of biofertilizers and plant growth regulators on yield parameters of pearl millet

S. No.	Treatment No.	Ear head length(cm)	No. of grains/earhead	Grain yield (Kg/ha)	Stover yield (Kg/ha)
1	T_1	25.43	2137.01	3.17	7.16
2	T_2	25.05	1914.43	2.97	6.95
3	T_3	25.74	2329.23	3.34	7.42
4	T_4	24.92	1825.46	2.87	6.87
5	T_5	24.84	1747.18	2.75	6.76
6	T_6	25.23	2023.93	3.06	7.09
7	T_7	25.90	2348.01	3.44	7.49
8	T_8	25.65	2218.01	3.27	7.26
9	T_9	26.07	2394.14	3.53	7.58
	CD(P=0.05)	0.43	66.30	0.23	0.22
	S.Em±	0.14	22.11	0.08	0.07

Test weight (g)

Significantly highest Test weight (8.14 g) was recorded with the treatment application of *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm over all the treatments. However, the treatment with (7.97 g) in *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm which were found to be statistically at par with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm.

Test weight an important yield determining component, is a genetic character and least influenced by environment. This was might be due to higher conservation of light energy into chemical energy and its subsequent translocation from source to sink. Similar findings were observed by Panchal *et al.* (2018) [7].

Grain yield (t/ha)

Significantly highest Grain yield (3.53 t/ha) was recorded with the treatment application of *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm over all the treatments. However, the treatments with (3.34 t/ha) in *Azotobacter* 25 g/kg + NAA+ Salicylic acid 140 ppm and *Azotobacter*+ *Azospirillum* 25 g/kg + NAA 40ppm (3.44 t/ha) which were found to be statistically at par with *Azotobacter* + *Azospirillum* 25 g/kg + NAA+ Salicylic acid 140 ppm.

Salicylic acid and NAA play a vital role in increasing seed yield because they takes place in many physiological process of plant such as plant growth, chlorophyll formation, stomatal regulation, starch utilization and resistance to various biotic and abiotic stress which enhances seed yield. The results were similar to Salem (2020) [10], Hanaa and Safa (2019) [10].

Thavaprakaash *et al.* (2018) [13] observed similar results that increase in yield attributes and yield through bio-fertilizer might be attributed to supply of more plant hormones (auxin, cytokinin, gibberellin etc.) by the microorganisms inoculated or by the root resulting from reaction to microbial population.

Straw yield (t/ha)

Significantly highest Straw yield (7.58/ha) was recorded with the treatment application of Azotobacter + Azospirillum 25 g/kg + NAA+ Salicylic acid 140 ppm over all the treatments. However, the treatments with (7.42 t/ha) in Azotobacter 25 g/kg + NAA+ Salicylic acid 140 ppm and Azotobacter+ Azospirillum 25 g/kg + NAA 40ppm (7.49 t/ha) which were found to be statistically at par with Azotobacter + Azospirillum 25 g/kg + NAA+ Salicylic acid 140 ppm.

Straw 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 straw yield, similar results were obtained by Zothanmawii *et al.* (2018) [15].

Conclusion

It is concluded that application of treatment Azotobacter + Azospirillum 25g/kg + NAA+ Salicylic acid 140 ppm was recorded significantly higher Grain yield (3.53 t/ha), higher gross returns (Rs.84720/ha), net returns (Rs.53549.2/ha) and benefit cost ratio (1.71) as compared to other treatments. Since, the findings based on the research done in one season.

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