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Effect of Different Levels of Nitrogen and Seed Treatment on Growth and Yield of Finger Millet (*Eleusine coracana* 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.

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ABSTRACT

A field experiment was conducted during *Zaid* 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) to determine the "Effect of Different levels of Nitrogen and Seed treatment on growth and yield of finger millet (*Eleusine coracana* L.)". The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.62%), available nitrogen (225 kg/ha), available phosphorus (38.2 kg/ha) and available potassium (240.7 kg/ha). The treatments consisted of three levels of [Nitrogen 40 kg/ha, 50 kg/ha, 60kg/ha] and three types of Bio-fertilizers [Azospirillum 2 g/kg, Pseudomonas fluorescens 6 g/kg, Azotobacter 3 g/kg] as seed treatment, whose effect is observed in finger millet. The results revealed that the treatment with application of Nitrogen 60 kg/ha + Azospirillum 2 g/kg recorded higher plant height (86.27 cm), number of tillers/plant (8.67/plant), plant dry weight (23.41 g/plant),

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higher test weight (2.92 g), number of fingers/plant (5.67), number of ear heads/plant (3.32), number of grains/fingers (114.14), grain yield (2,635.65 kg/ha), straw yield (4,883.10 kg/ha) and Harvest index (35.05%).
The economics *viz.*, maximum gross returns (1,05,426.00 INR/ha), net returns (67,577.00 INR/ha) and B:C (1.78) was also recorded in treatment 7 [Nitrogen 60 kg/ha + Azospirillum 2 g/kg] as compared to other treatments.

Keywords: Nitrogen; bio-fertilizers; growth; yield; economics; finger millet.

1. INTRODUCTION

In India, finger millet is also referred to as Ragi and African millet. Finger millet is a member of the Poaceae family. In India, finger millet is produced on 1.27 million hectares and produces 1.89 million tonnes per year, making up 60% of the country's total small millet production.

“With an average productivity of 1489 kg ha/ha, India finger millet is produced over an area of around 1.27 million ha, yielding 1.89 million t. With the right management, the improved varieties can produce up to 4 t of grain per hectare. China (79,000 t/ha), Afghanistan (38,000 t/ha), Nepal (1,22,000 t/ha), and India produce the most finger millet in Asia (2,613,000 t/ha). In Odisha, it is produced on 1.61 lakh/t of land spread throughout 1.66 lakh/ha, according to the 2017 Agriculture Statistics. The majority of finger millet is grown and consumed in Karnataka, India” [1].

“It is grown on an area of 9,10,780 hectares in India, with a yield of 1.35 t/ha and an annual production of 12,34,474 tonnes. With an annual production of 6,76,567 t/ha and a productivity of 1.22 t/ha, it is grown on 5,55,350 hectares in Karnataka, which is more than half of the nation's production area” (Agricultural Statistics at a Glance, 2019).

“Ragi contains, 9.2% proteins, 1.29% lipids, 76.32% carbs, 2.2% minerals, 3.90% ash, and 0.33% calcium. While vitamin A, B, and phosphorus are also present, in smaller amounts, finger millet is said to have the greatest iodine concentration of any cereal grain. Finger millet is grown on 1.27 million ha in India, with a productivity of 1489 kg/ha and a production of 2.61 million tonnes” [2].

If taken as food, it provides a steady diet, especially for people who are exercising vigorously. Straw is a great source of feed for both livestock and demand animals. People with diabetes are said to benefit from eating finger millet. A grain could also be malted, and the flour made from malted grain is used to make cakes, cereal, and other wholesome foods for people of all ages [3].

Finger millet is a demanding crop, particularly for nitrogen. Protoplasm, enzymes, and chlorophyll all depend on nitrogen as an essential ingredient. It also regulates the utilization of potassium and phosphorus. It is a critical element for improving cerealoutput and essential for both improved yield and vegetative growth. Since nitrogen is one of the elements that most severely restricts crop production, it is applied as fertilizer to the majority of annualcrops [4].

Under dry/rain fed conditions, finger millet has been shown to grow, produce more dry matter, and yield more [2]. According to studies on N fertilization, grain yields were higher when N applications between 0 and 90 kg/ha were made [5,6].

Bio-fertilizers are applied through seed or soil; bio-fertilizers are solutions containing living cells or dormant cells of productive strains of microorganisms that assist agricultural plants in absorbing nutrients through their interaction in the rhizosphere. Bio-fertilizers come in a variety of forms, including Rhizobium, Azotobacter, Azospirillum, Blue-green Algae, and Azolla. Natural processes such as nitrogen fixation, phosphorus solubilization, and plant growth-stimulating hormone synthesis are used by bio-fertilizers to add nutrients. The use of chemical pesticides and fertilizers should be decreased as a result of bio-fertilizers. The microorganisms in bio-fertilizer rebuild the soil's organic matter and nutrition cycle. Along with improving the sustainability and soil health, bio-fertilizers can be used to develop healthy plants.

“Azospirillum 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. The carrier based Azospirillum inoculation for non-leguminous crops are becoming increasing popular in India in recent years. Azospirillum is a rhizosphere bacterium colonizing the root of the crop plants making use of root exudates and fixes substantial amount of nitrogen. They exert beneficial effects on growth and yield of many economically important crop" [7]. "Azotobacter is a free living nitrogen fixation bacteria which has been reported to fix about 20 kg N/hain non-legumes" [8].

"Fluorescent pseudomonads, a group of PGPR are the most studied ones. They help in soil health maintenance and are metabolically and functionally most diverse. Fluorescent pseudomonads provide effective protection against bacterial and fungal pathogens, parasites and certain nematode infections" Kukreti et al., [9].

2. MATERIALS AND METHODS

The experiment was conducted during *Zaid* season of 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), low level of organic carbon (0.51%), available N (108.69 Kg/ha), P (80.5 kg/ha), K (83.3 kg/ha). The treatment consists of 40 kg N/ha + Azospirillum 2 g/kg, 40 kg N/ha + Pseudomonas Fluorescens 6 g/kg, 40 kg N/ha + Azotobacter 3 g/kg, 50 kg N/ha + Azospirillum 2g/kg, 50 kg N/ha + Pseudomonas Fluorescens 6 g/kg, 50 kg N/ha + Azotobacter 3 g/kg, 60 kg N/ha + Azospirillum 2 g/kg, 60 kg N/ha + Pseudomonas Fluorescens 6 g/kg, 60 kg N/ha + Azotobacter 3 g/kg and control.

The experiment was laid out in Randomized Block Design, with 10 treatments replicated thrice. The observations were recorded for plant height, Numberoftillers/plant, plant dryweight, test weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index (%). The collected data was subjected to statistical analysis by analysis of variance method. Finger millet, variety (VL-376) were selected for sowing and treated with Azospirillum, Pseudomonas fluorescens, Azotobacter. Seeds are sowed of spacing (25x10 cm).

3. RESULTS AND DISSCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data revealed that significantly higher plant height (86.20 cm) was observed in treatment 60 kg N/kg + Azospirillum 2 g/kg. However, 60 kg N/ha + Pseudomonas fluorescens 6 g/kg (83.06 cm) and 60 kg N/ha + Azotobacter 3 g/kg (85.41 cm) were statistically at par with 60 kg N/kg + Azospirillum 2 g/kg.

"Plant height increased significantly with increase in nitrogen levels from 0 to 40 and 60 kg N/ha" Gupta et al., [10]. "The plant height was significantly increased with the successive increase in nitrogen levels up to 60 kg N/ha" Dubey and Srivas [11]. "Application of bio-fertilizer like Azotobacter and Azospirillum provides the nitrogen to the crop. The ability to fix atmospheric nitrogen is some vital physiological characteristics of Azotobacter" Praveen et al*.,* [12].

3.1.2 Number of Tillers/plant

The significantly and higher number of tillers (8.67/plant) was recorded with the application of 60 kg N/ha and Azospirillum 2 g/kg. However, in treatment 60 kg N/ha + Pseudomonas fluorescens 6 g/kg (8.42/plant) were statistically at par with 60kg N/ha+ Azospirillum 2 g/kg.

Number of tillers per meter length increased significantly with the increased levels of nitrogen at all plant growths. This was mainly due to increased vegetative growth which helps the plant to produce more number of tillers Shashidhara et al., [13].

3.1.3 Plant dry weight (g/plant)

Significantly higher plant dry weight (23.41 g/plant) was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg. which was significantly higher over rest of all the treatments and statistically at par to the 60 kg N/ha + Pseudomonas fluorescens 6 g/kg (23.28 g/plant), 60 kg N/ha + Azotobacter 3 g/kg (23.24 g/plant) and 50 kg N/ha + Azospirillum 2 g/kg (23.04 g/plant).

The increase in dry matter was found due to increase in plant height, number of

leaves/planttreated with Azotobacter and Azospirillum Sharma et al., [14].

"The increase in dry matter was found due to increase in plant height, number of leaves/plant. This might be due to application of poultry manure and bio fertilizers there by increase in soil microorganism and due to better moisture and nutrient availability were reported" by Singh et al., [15].

3.2 Yield Parameter

3.2.1 Number of Fingers/ plant

Significantly higher number of fingers/plant was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg (5.67), which was significantly higher over rest of all the treatments and statistically at par to the 60 kg N/ha + Pseudomonas fluorescence 6 g/kg.

"Increasing in yield attributes could be the higher availability of nutrients under poultry manure, Azotobacter+ Azospirillum application" [16].

3.2.2 Number of Ear head/plant

Significantlyhigher number of ear head was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg (3.32) at 100 DAS. However, 60 kg N/ha + Pseudomonas fluorescens 6 g/kg (3.22) were found statistically at par with the 60 kg N/ha + Azospirillum 2 g/kg.

3.2.3 Number of Grains/finger

Results revealed that, there is no significant difference among the treatments. Higher number of seeds was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg (114.14) and lower wasControl: (60:30:30 NPK kg/ ha) (112.10).

The significant improvement in dry matter, yield attributes like number of ear heads, ear head length, number of grains per ear head, grain weight per ear head and 1000 grain weight with application of 60 kg N/ ha over that of 0, 20 and 40 kg N/ ha ultimately helped in increase of yield in the former level of N application [17]. 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 spikelet's primordial production, similar results were found Marngar and Dawson (2017).

3.2.4 Test weight (g)

The Significant and higher test weight was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg (2.92 g), which was significantly superior over rest of all the treatments and statistically at par to the 60 kg N/ha + Pseudomonas fluorescens 6 g/kg.

"Increasing levels of nitrogen up to 60 kg N/ha induced in test weight but markedly increase only up to 40 kg N/ha. The grain yield and straw yields as influenced by different levels of nitrogen 40 kg N/ha and 50kg N/ha on finger millet" Dubey and Srivas [11]. "Significant increase in weight of 1000 seeds was recorded by dual inoculation with A2+PSB followed by A1+PSB over other treatments" [18].

3.2.5 Grain yield (kg/ha)

In treatment, 60 kg N/ha + Azospirillum 2 g/kg (2,365.35 kg/ha) was recorded higher significant of grain yield. However, which was significantly superior over rest of the treatment and statistically at par to the 60 kg N/ha + Pseudomonas fluorescens 6 g/kg.

"Better filling and more grain weight at increased levels of N application leading to increased yield attributes and grain yield" Chakraborty et al., [19].

"The significant and higher grain yield (34.16 q/ha) was observed with the application of bio-fertilizers. This might be due to use of bio-fertilizer combinations grain and Stover yield was increased by 79 percent 23 percent respectively over the control in pearl millet. The increased production of pearl millet could be ascribed to bio-fertilizers *viz*., Azospirillum and Azotobacter, which fixed atmosphere nitrogen into the soil and made it available to the plants" [20].

3.2.6 Straw Yield (kg/ha)

The significant and higher straw yield (4,883.10 kg/ha) were observed in with application of 60kg N/ha + Azospirillum 2 g/kg, which was significantly higher over rest of the treatment and statistically at par to the 60 kg N/ha + Pseudomonas fluorescens 6 g/kg.

"The increase in grain and straw yields with enhanced N application could be ascribed to increases the activity of cytokines in plant which leads to the increased cell-division and

elongation which leads to better plant growth, dry-matter production and higher photosynthesis" [21].

This increase in Stover yield might be attributed to increased height, leaf area and dry matter production. In the inorganic + bio-fertilizer treatments, the positive benefits of seed bacterization could be attributed mainly to nitrogen fixation and other factors like release of hormones, increase of Plant Growth Promoting Substances (PGPS) and nutrients uptake. The results of almost similar nature were also reported by [22].

3.2.7 Harvest index (%)

Significantly higher harvest index was recorded with application of 60 kg N/ha + Azospirillum 2 g/kg (35.05%), which was significantly higher and statistically par with 60 kg N/ha + Pseudomonas fluorescens 6 g/kg and 60kg N/ha + Azotobacter 3 g/kg.

"The dry matter partitioning has been effective with increased level of nitrogen, thus, resulting in higher harvest index" S. Bhanu Prakash Reddy et al., [21].

"Pseudomonas fluorescens, Azotobacter chroococcum, Azospirillum lipoferum and Acetobacter diazotrophicus along withTrichoderma viride significantly increased the plant height, dry weight, ear length, grain and straw yield millet crop" Latake et al., [23].

3.3 Economics

3.3.1 Cost of cultivation (INR/ha)

The higher cost of cultivation was found with the application of 60 kg N/ha + Azospirillum 2 g/kg (37,849.00 INR/ha) and lower was observed in control (60:30:30 NPK/ha), (37,329.00 INR/ha).

3.3.2 Gross returns (INR/ha)

Gross returns were found higher with the application of 60 kg N/ha + Azospirillum 2 g/kg (1,05,426.00INR/ha) and lower was observed in control (60:30:30 NPK/ha), (48,210.00 INR/ha).

3.3.3 Net returns (INR/ha)

The higher net returns were found with the application of 60 kg N/ha + Azospirillum 2 g/kg (67,577.00 INR/ha) and lower was observed in control (60:30:30 NPK/ha), (10,881.00 INR/ha).

3.3.4 Benefit cost ratio

The higher B:C Ratio were found with the application of 60 kg N/ha + Azospirillum 2 g/kg (1.78) and lower was observed in control (60:30:30 NPK/ha), (0.29).

Table 1. Effect of Different levels of Nitrogen and Seed treatment on growth attributes of finger millet

		100 DAS		
Sl No.	**Treatments**	**Plant height (cm)**	**Number of tillers/plant**	**Dry weight (g/plant)**
1	40 kg N/ha + Azospirillum 2 g/kg	79.72	6.61	20.37
2	40 kg N/ha + Pseudomonas fluorescens 6 g/kg	77.57	6.33	20.05
3	40 kg N/ha + Azotobacter 3 g/kg	75.36	6.30	19.24
4	50 kg N/ha + Azospirillum 2 g/kg	82.06	7.10	23.04
5	50 kg N/ha + Pseudomonas fluorescens 6 g/kg	81.75	7.41	22.51
6	50 kg N/ha + Azotobacter 3 g/kg	80.38	6.84	22.37
7	60 kg N/ha + Azospirillum 2 g/kg	86.27	8.67	23.41
8	60 kg N/ha + Pseudomonas fluorescens 6 g/kg	85.67	8.42	23.28
9	60 kg N/ha + Azotobacter 3 g/kg	85.41	7.47	23.24
10	Control : (60:30:30 NPK kg/ ha)	74.76	6.06	18.07
	F test	S	S	S
	SEm(±)	1.25	0.16	0.35
	CD (P=0.05)	3.71	0.49	1.04

Table 2. Effect of Different levels of Nitrogen and Seed treatment on yield attributes of Finger millet

Sl.no	Treatments	Number of fingers/ plant	Number ofear heads /plant	Number of grains/fingers	Test weight(g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index (%)
1	40 kg N/ha + Azospirillum 2 g/kg	4.60	2.69	112.60	2.49	1,588.79	3,836.24	29.29
2	40 kg N/ha + Pseudomonas fluorescens 6 g/kg	4.40	2.74	112.54	2.43	1,518.84	3,766.29	28.74
3	40 kg N/ha + Azotobacter 3 g/kg	4.07	2.80	112.34	2.35	1,403.93	3,651.38	27.79
4	50 kg N/ha + Azospirillum 2 g/kg	5.40	2.93	113.54	2.69	2,036.90	4,384.35	31.74
5	50 kg N/ha + Pseudomonas fluorescens 6 g/kg	5.07	2.50	113.27	2.59	1,950.53	4,297.98	31.23
6	50 kg N/ha + Azotobacter 3 g/kg	4.80	3.11	112.87	2.55	1,935.92	4,283.37	31.13
7	60 kg N/ha + Azospirillum 2 g/kg	5.67	3.32	114.14	2.92	2,635.65	4,883.10	35.05
8	60 kg N/ha + Pseudomonas fluorescens 6 g/kg	5.60	3.22	113.67	2.80	2,322.90	4,420.39	34.45
9	60 kg N/ha + Azotobacter 3 g/kg	5.00	2.99	113.60	2.72	2,232.54	4,214.82	34.62
10	Control : (60:30:30 NPK kg/ ha)	4.00	2.60	112.10	2.11	1,205.25	3,452.70	25.87
	F test	S	S	NS	S	S	S	S
	SEm(±)	0.07	0.04	1.18	0.03	33.7	67.7	0.53
	CD (P=0.05)	0.21	0.13	-	0.09	100.17	201.15	1.58

Table 3. Effect of Different levels of Nitrogen and Seed treatment on economics of Finger millet

Sl .no	Treatments	Cost of cultivation(INR/ha)	Gross returns (INR/ha)	Net returns (INR/ha)	B:C ratio
1	40 kg N/ha + Azospirillum 2 g/kg	37,649.00	63,551.69	25,902.69	0.68
2	40 kg N/ha + Pseudomonas fluorescens 6 g/kg	37,629.00	60,735.60	23,106.60	0.61
3	40 kg N/ha + Azotobacter 3 g/kg	37,639.00	56,157.20	18,518.20	0.49
4	50 kg N/ha + Azospirillum 2 g/kg	37,749.00	81,476.00	43,727.00	1.15
5	50 kg N/ha + Pseudomonas fluorescens 6g/kg	37,729.00	78,021.20	40,292.20	1.06
6	50 kg N/ha + Azotobacter 3 g/kg	37,739.00	77,436.80	39,697.80	1.05
7	60 kg N/ha + Azospirillum 2 g/kg	37,849.00	1,05,426.00	67,577.00	1.78
8	60 kg N/ha + Pseudomonas fluorescens 6 g/kg	37,829.00	92,916.00	55,087.00	1.45
9	60 kg N/ha + Azotobacter 3 g/kg	37,839.00	89,301.60	51,462.60	1.36
10	Control: (60:30:30 NPK kg/ha)	37,329.00	48,210.00	10,881.00	0.29

4. CONCLUSION

It can be concluded that application of Nitrogen 60kg/ha and Azospirillum 2g/kg (seed treatment) has performed better in growth parameters and yield attributes of finger millet (VL- 376) and also proven profitable. Since the findings are based on one season, further trails are needed to confirm the results.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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