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Influence of nitrogen and zinc on growth and yield of pearl millet (*Pennisetum glaucum* L.)

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Abstract
A field experiment was conducted during *kharif* season of 2023 at Crop Research Farm Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Sciences and Technology. To determine “Influence of Nitrogen and Zinc on growth and Yield of Pearl Millet” The result revealed that treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)] recorded significantly higher plant height (180.10 cm), number of Leaves (23.59) higher plant dry weight (38.30 g), higher ear head length (24.66 cm), maximum number of ear head/plant (1.75), higher Grain yield (3.81 t/ha) and higher stover yield (5.94t/ha).

Keywords: Pearl millet, nitrogen, zinc, growth and yield

1. Introduction
Pearl millet (*Pennisetum glaucum* L.) is one of the important millet crops of arid and semiarid climatic condition. It belongs to the family of Poaceae. It is widely grown rainfed cereal crop in the arid and semi- arid regions of Africa and southern Asia, and can be grown in areas where rainfall is not sufficient (200 to 600 mm/yr) for the cultivation of maize and sorghum It is grown in poor sandy soil due to drought escaping character and also provides staple food in short period relatively in dry tracts of the country. After rice, wheat, maize, and sorghum, pearl millet is India's fifth most important grain and a staple diet for millions of people living in drier areas. It is nutritionally better than many cereals as good source of protein having higher digestibility (12.1%), fat (5%), carbohydrate (69.4%) and minerals (2.3%). Green fodder is either used as preserved hay or silage, which are extremely useful in dry regions. This crop is not only cultivated for grain, but is also valued for its straw and fodder purpose because of its tillering potential, drought and heat tolerance and high dry matter production. It is a dual-purpose crop of arid and semiarid areas as it provides cheap food, comparatively rich in various nutrients, protein, fat, carbohydrates and minerals for poor masses and feed for poultry birds as well as green fodder for cattle.

In India pearl millet is grown over an area of about 6.70 million hectares with a production of 9.62 million tones and productivity of 1.44 t/hectare. Total area coverage under pearl millet in Uttar Pradesh is 0.90 million hectares with a production of 1.95 million tones and the productivity 2.16 t/hectare (GOI, 2022).

Most of the Indian soils particularly the light textured ones are deficient in nitrogen which is one of the basic plant nutrients. It is involved in the formation of proteins, nucleic acids, growth hormones and vitamins and is an integral part of chlorophyll. Poor soil fertility and erratic rains are the most important constraints to crop production in arid and semi-arid region. Nitrogen deficiency is one of the major constraints to crop production. The unique feature of N is its soils having very low soil organic matter major role in increasing production and productivity of pearl millet. Nitrogen is considered as one of the most important plant nutrients for growth and development of crop plant. It also plays an important role in synthesis of chlorophyll and amino acids that contribute to the building unit of protein and thus, growth of plants. Nitrogen helps in early establishment of leaf area capable of photosynthesis. Pearl millet is an exhausting crop and heavy consumer of plant nutrients.

Nitrogen promotes leaf and stem growth rapidly which consequently increase the yield and its quality**.** (Chouhan *et al.*, 2015) [4]. Urea is the most widely used commercial nitrogen fertilizer for increasing crop productivity (Arya *et al.*, 2022) [2]. It increases growth and development of all living tissues and improves the protein content of food grains and quality of fodder. Generally, Pearl millet has been known for growing under lowNitrogen management. But several studies showed that Nitrogen application can increases millet production efficiency (Singh *et al.*, 2012) [13]. The improvement of yield attributes with progressive increase of nitrogen levels was also reported. Content, soils with particular constraints on indigenous N supply, high potential of ammonia (NH3). Due to a deficiency of N, older leaves turn an orange-yellow colour and die from the tip down; young leaves are thin, short, and rigid. Similarly, a deficiency of N causes a decrease in plant height and the number of tillers.

Zinc plays a very important role in plant growth, in metabolic functions and it increases protein content in plant. Continuous intensive cropping of high yielding crop varieties has aggravated the depletion of soil Zinc leading to low Zinc concentration in edible grains. These are one of the most important micronutrients for humans that are limiting in the diet of developing country are Zinc. Globally billions of people are facing Zinc deficiency and their ratio is very frightening in children. Use of high analysis fertilizer and intensive cropping. In many parts of India, Zinc as a plant nutrient now stands third important plant nutrient next to nitrogen and phosphorus.

2. Material and Method

The experiment was conducted during *kharif* season 2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of the experimental field was sandy loam in texture, with soil (pH 7.8), low level of organic carbon (0.62%), available N (225 Kg/ha), P (38.2 kg/ha), K (240.7 kg/ha) and zinc (2.32 mg/kg). The experiment was laid out in RBD with 10 treatments each replicated thrice. The treatment combinations are T_1 Nitrogen (60 Kg/ha)+ Zinc (10 Kg/ha), T_2 Nitrogen (60 Kg/ha) + Zinc (15 Kg/ha), T3 Nitrogen (60 Kg/ha) + Zinc (20 Kg/ha), T4 Nitrogen (70 Kg/ha) + Zinc (10 Kg/ha), T_5 Nitrogen (70 Kg/ha) + Zinc (15 Kg/ha) T_6, Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha) T_7, Nitrogen (80 Kg/ha) + Zinc (10 Kg/ha) T_8, Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha) T_9, Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha) T_{10}, Control (RDF) 70:35:35Kg/ha (NPK) Data recorded on different aspects of crop, *viz*., growth, yield attributes & yield were subjected to statistically analysed by analysis of variance method as described by (Gomez and Gomez, 1976) [8].

3. Results and Discussion

3.1 Growth Attributes

3.1.1 Plant height (cm)

The data revealed that significantly higher plant height (193.44 cm) was recorded in treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However treatment 6 [Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)] was found statically at par with treatment 9[Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and higher plant height was observed with application of Nitrogen (80kg/ha) may be due the fact that nitrogen promotes number of internode and increase length of the internodes which results increased in plant height. These results are similar to reported by (Rakesh *et al*. 2021) [12]. Further significant and higher increased in plant height was observed with application of Zinc (20 kg/ha) may be due to biosynthesis of indole 3- acetic acid a growth hormone involved in stem elongation hence the increased in the plant height. These results are similar to that reported by (Rakesh *et al.* 2021) [12].

3.1.2 Number of Leaves/plant

Results revealed that significant higher number of Leaves/plant (18.00) was recorded in treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However treatment 6 [Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)] was found statically at par with treatment 9[Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and maximum number of leaves/plant was observed with application of

nitrogen (80kg/ha) may be due to accelerated the meristematic activity, vegetative growth and photosynthetic activity, consequently increased the number of leaves/plant These results are similer to that reported by Bhoya *et al.* (2014) [3]. Further, significant and maximum increased in number of leaves/plant was observed with application of Zinc (20kg/ha) which might be due to increased starch, protein nitrogen, soluble protein and specific activity of carbonic anhydrase, specific activities of acid phosphatase and ribonuclease in leaves and pods by residues of zinc. These results are similer to that reported by Kumawat *et al*, (2018) [10].

3.1.3 Plant dry weight (g)

Results revealed that significant higher plant dry weight (47.62) was recorded in treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However treatment 6 [Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)] was found statically at par with treatment 9[Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and higher plant dry weight(g) was observed with application of nitrogen (80kg/ha), might be due to a precursor for auxin synthesis, involved in nitrogen metabolism and several oxidation reduction reactions, stability of RNA and starch formation. Thus, its suitable supply effects in higher dry matter production, ultimately growth and development of plants. Similar result was reported by Rakesh *et at.*, (2021) [12], Further significant and maximum increased in plant dry weight(g) was observed with application of Zinc (20kg/ha) which might be due to Zinc involves in biosynthesis of indole acetic acid (IAA) which helps in better development of growth attributes Similar result was reported by Prasad *et at.*, *(*2014) [11].

3.1.4 Crop Growth Rate (g/m^2/day)

The data recorded during 60-80 DAS interval, significantly higher crop growth rate (7.76) was recorded in treatment 2 [Nitrogen (60 Kg/ha) + Zinc (15 Kg/ha)], though there was no significant difference was found among all the treatment.

3.1.3 Relative Growth Rate (g/g/day)

The data revealed that during 60-80 DAS interval, higher relative growth rate) (0.0144) was recorded in treatment 5 [Nitrogen (70 Kg/ha) + Zinc (15 Kg/ha)], though there was no significant difference was found among all the treatment.

3.2 Yield and Yield Parameters

3.2.1 Ear head length

The data recorded that Significant and higher ear head length (24.66) was recorded in treatment 9

[Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However, the treatment 6 [Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)] and treatment 3 [Nitrogen (60 Kg/ha) + Zinc (20 Kg/ha)] were found statistically at par with treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and higher ear head length was with the application of nitrogen may be due to nitrogen application influenced better growth characters which ultimately resulted in higher production and translocation of photosynthates towards panicle. Similar findings were reported by Devi and Debbarma (2023) [5] in rice. Further, significantly higher ear head length with application of Zinc might be due to improvement of strong cell walls and consequently. Similar findings were reported by Rakesh *et al.* (2021) [12].

3.2.2 Number of ear head/plant

The data recorded that Significant and maximum number of ear head was recorded in treatment (1.75) was recorded in treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However, the treatment 6 [Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)] and treatment 3 [Nitrogen (60 Kg/ha) + Zinc (20 Kg/ha)] and treatment 8 [Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha)] were found statistically at par with treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and maximum number of ear head/plant was with the application of nitrogen may be due to higher manufacture of food and its subsequent partitioning towards sink. Similar findings were reported by Yadav *et al.* (2019) [15]. Further, significantly maximum number of ear head/plant with application of Zinc might be due to Zinc involves in the moisture stress and biosynthesis of indole acetic acid (IAA) which helps in better development particularly number of ear head/plant. Similar findings were reported by Kumar *et al.* (2014) [9].

3.2.3 Test weight (g)

Treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha),], recorded higher test weight (9.55 g), though there was no significant difference was found among all the treatments.

3.2.4 Seed yield (t/ha): The data recorded Significant and higher seed yield (3.81 t/ha) was recorded in treatment 9 Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha). However, treatment 8 Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha) was found statistacally at par treatment 9 Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha). Significant and higher Grain yield was the application of nitrogen may be due to the availability more water enhanced nutrient availability which improved nitrogen and other macro and micro elements absorption enhancing the production. Similar findings were reported by Devi and Debbarma (2023) [5] in rice. Further, significantly higher grain yield was application of Zinc might be due to zinc involve in many metallic enzyme system, regulatory functions and auxin production. Similar findings were reported by Prasad *el al*. (2014) [11].

Table 1: Influence of Nitrogen and Zinc on growth attributes of pearl millet

			At 60 DAS		40-60 DAS	
Treatment No.	**Treatment Details**	**Plant height (cm)**	**Number of leaves/plant**	**Plant dry weight (g)**	**Crop growth Rate (g/m^2/day)**	**Relative growth rate (g/g/day)**
1.	Nitrogen (60 kg /ha)+ Zinc (10 kg /ha)	163.55	18.40	30.81	15.44	0.0459
2.	Nitrogen (60 kg /ha) + Zinc (15 kg/ ha)	164.80	18.66	30.43	14.34	0.0417
3.	Nitrogen (60 kg/ ha) + Zinc (20 kg/ ha)	172.98	22.83	37.53	18.55	0.0450
4.	Nitrogen (70 kg/ ha) + Zinc (10 kg /ha)	168.43	20.03	32.11	15.63	0.0438
5.	Nitrogen (70 kg /ha) + Zinc (15 kg/ ha)	169.23	20.23	32.55	15.44	0.0605
6.	Nitrogen (70 kg /ha) + Zinc (20 kg/ ha)	176.43	23.14	38.14	18.85	0.0452
7.	Nitrogen (80 kg /ha) + Zinc (10 kg/ ha)	164.43	22.08	35.99	18.14	0.0464
8.	Nitrogen (80 kg /ha) + Zinc (15 kg/ ha)	167.20	22.25	36.31	17.84	0.0445
9.	Nitrogen (80 kg/ ha) + Zinc (20 kg /ha)	180.10	23.59	38.30	18.91	0.0447
10.	Control (RDF) 70:35:35 kg/ha (NPK)	162.21	15.29	28.81	16.86	0.0421
	F. Test	S	S	S	NS	NS
	CD (p=0.5)	3.570	0.755	1.473	1.430	0.003
	SEd (±)	1.699	0.359	0.701	-	-

Table 2: Influence of Nitrogen and Zinc on yield and yield attributes of pearl millet

		Yield and yield attributes					
Treatment No.	**Treatment Details**	**Ear length (cm)**	**Number of ear/plant**	**Test weight (g)**	**Grain Yield (t/ha)**	**Stover Yield (t/ha)**	**Harvest Index (%)**
1.	Nitrogen (60 Kg/ha)+ Zinc (10 Kg/ha)	21.40	1.27	8.44	3.06	5.06	37.67
2.	Nitrogen (60 Kg/ha) + Zinc (15 Kg/ha)	21.83	1.26	8.52	2.91	5.09	36.40
3.	Nitrogen (60 Kg/ha) + Zinc (20 Kg/ha)	24.20	1.57	9.42	3.37	5.52	37.93
4.	Nitrogen (70 Kg/ha) + Zinc (10 Kg/ha)	22.16	1.33	8.72	3.18	5.19	37.99
5.	Nitrogen (70 Kg/ha) + Zinc (15 Kg/ha)	22.33	1.37	8.98	3.39	5.22	39.08
6.	Nitrogen (70 Kg/ha) + Zinc (20 Kg/ha)	24.39	1.60	9.47	3.77	5.85	39.20
7.	Nitrogen (80 Kg/ha) + Zinc (10 Kg/ha)	22.50	1.42	9.23	3.38	5.35	38.68
8.	Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha)	22.69	1.50	9.33	3.34	5.49	37.86
9.	Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)	24.66	1.75	9.55	3.81	5.94	39.36
10.	Control (RDF) 70:35:35Kg/ha (NPK)	20.94	1.19	8.06	2.14	4.84	30.63
	F. Test	S	S	NS	S	S	NS
	CD (p=0.5)	0.413	0.063	0.127	0.121	0.088	0.0895
	SEd (+)	0.197	0.030	-	0.058	0.042	-

3.2.5 Stover yield (t/ha): Significant and higher stover yield (5.94 t/ha) was recorded in treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. However, treatment 8 [Nitrogen (80 Kg/ha) + Zinc (15 Kg/ha)] was found statistacally at par treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha)]. Significant and higher stover yield was the application of nitrogen may be due to Nitrogen is the main component of the protoplasm involves in various metabolic processes *viz*. photosynthesis, stimulation of cell division and elongation. Similar findings were reported by Kumar *et al.* (2014) [9]. Further, significantly higher stover yield was application of Zinc might be due to zinc in biosynthesis indole acetic acid especially due to its role initiation of primordial reproductive parts promoting photosynthesis to ward them. Similar findings were reported by Rakesh *et al*. (2021) [12].

3.2.6 Harvest index (%)
Treatment 9 [Nitrogen (80 Kg/ha) + Zinc (20 Kg/ha),], recorded higher Harvest index (39.36), though there was no significant difference was found among all the treatments.

4. Conclusion
The study on the influence of varying levels of nitrogen and zinc on the growth and yield of pearl millet (*Pennisetum glaucum* L.) has highlighted several key findings:

1. **Optimal Nutrient Combinations:** The combination of 80 kg/ha nitrogen and 20 kg/ha zinc (Treatment 9) yielded the highest plant height, number of leaves per plant, plant dry weight, ear head length, number of ear heads per plant, test weight, seed yield, and stover yield. This suggests that higher nitrogen and zinc levels significantly enhance the growth and yield of pearl millet, likely due to improved nutrient uptake and increased biosynthesis of growth-promoting substances.
2. **Growth Attributes:** Significant increases in plant height, leaf number, and plant dry weight were observed with higher nitrogen and zinc applications, particularly at 80 kg/ha nitrogen combined with 20 kg/ha zinc. This indicates that nitrogen promotes overall plant growth by enhancing internode length and leaf area, while zinc aids in growth hormone production and stress tolerance.
3. **Yield Improvement:** Treatment 9 also resulted in the highest seed yield and stover yield. Enhanced nitrogen availability contributes to better nutrient uptake and photosynthesis, while zinc plays a crucial role in enzyme activation and stress resistance, leading to improved yield attributes.
4. **Quality and Efficiency:** The harvest index, which reflects the efficiency of biomass conversion into grain, was highest in Treatment 9. This demonstrates the effectiveness of combined nitrogen and zinc application in optimizing both growth and yield.
5. **Statistical Significance:** Although the data showed significant improvements in most growth and yield parameters with higher nutrient levels, some parameters such as crop growth rate and relative growth rate did not show significant differences across treatments. This suggests that while certain growth and yield attributes are responsive to nutrient levels, others may have varying sensitivity or require different nutrient management strategies.

For optimizing pearl millet production in arid and semi-arid regions, a combination of 80 kg/ha nitrogen and 20 kg/ha zinc appears to be highly effective. This nutrient strategy not only boosts growth and yield but also enhances the quality of the grain and overall crop productivity. Future research could explore the long-term effects of these nutrient levels and their economic feasibility in different soil and climatic conditions.

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