Integrated Impact of Inorganic Fertilizers (Nitrogen+Zinc) Growth and Yield of Millet (Pennisetumglacum L.)

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Abstract

The study aimed to determine the impact of varying zinc and nitrogen levels on the components and production of millet. The trial treated the variety YBS-98 with five different concentrations of zinc and nitrogen. The control T1 doesn't apply any fertilisers. T3 = N 100 + Z 10%, T4 = N 140 + Z 15%, T5 = N 180 + Z 20%, and T2 = N 60 + Z 5%. The study achieved the best results with a maximum plant height of 222.98 cm, stem diameter of 0.91 cm, a leaf area per tiller (cm–2) of 1780.81 cm, green fodder yields (t ha-1) of 77.91 cm, a plant density (m-2) of 154.19 cm, several leaves per tiller of 12.60 cm, a dry matter percentage of 14.75 cm, a crude fibre percentage of 10.37 cm, a crude protein percentage of 46.15%, and an ash percentage of 7.29 per cent. Giving millet nitrogen 180 and zinc 20% positively impacted its growth and yield. On the other hand, the control (T1 = no fertilizer) had the lowest results. The minimum plant height was 155.0 cm, the stem diameter was 0.60 cm, the leaf area per tiller (cm-2) was 802.91, the green fodder yields (t ha-1) were 50.70 cm, the plant density (m-2) was 153.11 cm, the number of leaves per tiller was 10.11, the dry matter percentage was 8.01%, the crude fibre percentage was 7.00, the crude protein percentage was 44.15, and the ash percentage was 5.1.

Keywords: Integrated, Nitrogen, Zinc, Growth, Millet

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Introduction

One of the hardest cereal crops for the global warm season is pearl millet (Pennisetum glaucum L.). Reddy et al., 2013. When we talk about "millets," we usually mean a diverse range of highly variable small-seeded grasses (like Paspalum scrobiculatum, Setaria italica, Pennisetum glaucum, and Cenchrus americanus) with varying origins, taxonomies, and cultivation distributions. Proso millet, which dates back more than 10,000 years, is one of the world's oldest cultivated cereal crops and is crucial for smallholder farmers' survival in the semiarid regions of numerous tropical countries. The Flajsman Group, 2019. Livestock and poultry farms use pearl millet grain as feed because of its high nutritional content. It also contains high levels of vitamins, riboflavin, and thiamine, and it gives the body a lot of easily digested energy. (Yadav and Associates, 2021). In addition to producing shrivelled grains and being generally stunted, nitrogen-deficient plants also mature later and produce fewer blooms. Use fertilizer sparingly and appropriately to improve forage quality, particularly protein content, in addition to yield (Ayub et al., 2009). Proteins, nucleic acids, and chlorophyll are known to contain nitrogen, which is necessary for plant growth. For the plant to reach its maximum photosynthetic potential and for the tillers and leaves to fully develop, there must be an adequate supply of N in the diet. Pearl millet primarily requires N, and its application has varying effects on yield and growth. (2018) Arshewar et al. Pearl millet is generally recognized for growing with little N control (Arshewar et al., 2018). However, several studies revealed that applying N could boost millet production efficiency (Ayub et al., 2009). Zinc is essential for several physiological activities in plants, including photosynthesis, the synthesis of proteins and carbohydrates, fertilization and seed development, growth regulation, and the immune system against illness (Khinchi et al., 2017). Zinc (Zn) is currently considered the fifth biggest nutrient shortfall in humans worldwide due to its inadequate availability in the soil. Zinc plays specialized and vital physiological roles in plant metabolism, affecting both quality and yield (Suri et al., 2011). Zinc plays a crucial role in plants due to its involvement in enzymes and proteins involved in gene expression, protein synthesis, auxin (growth regulator) metabolism, pollen formation, biological membrane maintenance, defence against heat stress and photooxidative damage, and resistance to infection by specific pathogens (Alloway, 2008). During the Tando jam, the soil's macro- and micronutrient deficiencies reduced the yield. To achieve better outcomes, add zinc and nitrogen to boost output. In light of the aforementioned information, the current study was carried out to determine how nitrogen and zinc levels affect pearl millet.

Materials and Methods

Field experiment

We conducted a field experiment at the Latif Farm, Sindh Agriculture University, Tando Jam, Sindh, Pakistan, in 2024 to investigate the effects of different zinc and nitrogen levels on millet production and growth. Using urea, nitrogen and zinc were applied at rates of N 60+ Z 5%, N 100+ Z 10%, N 140+ Z 15%, and N 180+ Z 20% kg/ha during several growth phases. With a net plot size of 5 m x 3 m = 15 m2, each treatment was duplicated three times in a randomised full-block design. The field was laser levelled after two dry ploughings to prepare the land. Water for irrigation was then used to create the right amount of moisture. To generate a fine seedbed, the soil was then levelled with a plank and ploughed twice with a crosswise cultivator.

Growth and yield parameters

Plant height cm, stem diameter cm, leaf area per tiller (cm-2), green fodder yields (tha-1), Plant density (m2), Number of leaves per tiller, Dry matter%, crude fiber%, crude protein%, and ash% were recorded manually. Every five days during the first ten days after crop planting, Five plants were selected from each plot to evaluate the different traits of the plants.

Statistical Analysis

Using Statistics v. 8.1 (Analytical Software, USA), the analysis of variance (ANOVA) approach was used for the statistical analysis of the gathered data. Using the least significant design (LSD) test with α = 0.05, the difference between treatment means was computed (Steel et al., 1997).

Results

Plant height (cm)

The application of zinc and nitrogen to millet significantly and favourably influenced numerous physiological yields and yield constituent parameters (Table 1). There are differences in the amounts of zinc and nitrogen that impact millet plant height (measured in cm). The crops receiving T4 = Nitrogen 140 + Zinc 15% ha-1, T3 = Nitrogen 100 + Zinc 10% ha-1, and T2 = Nitrogen 60 + Zinc 5% ha-1 produced mean plant heights of 209.17 cm, 200.1 cm, and 168.9 cm, respectively. The treatments T5 = Nitrogen 180 + Zinc 20% ha-1 produced a maximum plant height of 222.98 cm. Furthermore, T1 = Control no fertilizer, 00 kg ha-1, was shown to have the lowest mean plant height (155.0 cm).

Stem diameter (cm)

Zinc and nitrogen content are impacted by millet stem diameter (cm). The crops treated with T4 = Nitrogen 140+ Zinc 15% ha-1, T3 = Nitrogen 100+ Zinc 10% ha-1, and T2 = Nitrogen 60+ Zinc 5% ha-1 yielded mean stem diameters of 0.85 cm, 0.81 cm, and 0.72 cm, respectively. The treatments T5 = Nitrogen 180+ Zinc 20% ha-1 produced a maximum stem diameter of 0.91 cm. Moreover, T1 = Control, no fertilizer, 00 kg ha-1, had the lowest mean stem diameter cm (0.60 cm).

Leaf area per tiller (cm^{-2})

Different levels of nitrogen and zinc affect the leaf area per tiller (cm2) of millet. The treatments T_5 = Nitrogen 180+ Zinc 20% ha^{-1} produced a maximum leaf area per tiller (cm2) of 1780.81 cm2, while the crops receiving T4 = Nitrogen 140+ Zinc 15% ha^{-1}, T_3 = Nitrogen 100+ Zinc 10% ha^{-1}, and T2 = Nitrogen 60+ Zinc 5% ha^{-1} resulted in mean leaf area per tiller (cm2) of 1601.56 cm2,1585.00 cm2,and 1390.12 cm2, respectively. Further, the lowest mean leaf area per tiller (cm2) of 802.91 cm2 was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Table.1 Integrated Impact of Inorganic Fertilizers Nitrogen and Zinc Growth Yield of Millet

Treatments	Plant Height cm	Stem diameter cm	Leaf area per tiller (cm^{-2})	Green Fodder yields (the^{-1})
T1=No fertilizers	155.0	0.60	802.91	50.70
T2=N 60+ Z 05 %	168.9	0.72	1390.12	61.63
T3=N 100+ Z 10 %	200.1	0.81	1585.00	65.00
T4=N 140+ Z 15 %	209.17	0.85	1601.56	71.17
T5=N 180+ Z 20 %	222.98	0.91	1780.81	77.91
LSD	0.781	0.010	0.699	0.220

Green Fodder Yields (t ha^{-1})

Different levels of nitrogen and zinc affect the green fodder yields (t ha-1) of millet. The treatments T_5 = Nitrogen 180+ Zinc 20% ha^{-1} produced a maximum green fodder yield (t ha^{-1}) of 77.91 t ha^{-1}, while the crops receiving T4 = Nitrogen 140+ Zinc 15% ha^{-1}, T_3 = Nitrogen 100+ Zinc 10% ha^{-1}, and T2 = Nitrogen 60+ Zinc 5% ha^{-1} resulted in mean green fodder yields (t ha^{-1}) of 71.17 t

ha^{-1}, 65.00 t ha-1,and 61.63 t ha^{-1}, respectively. Further, the lowest mean green fodder yield (t ha-1) of 802.91 cm2 was noted with T_1 = control, no fertilizer, 00 kg ha^{-1}.

Plant density (m^{-2})

Applying zinc and nitrogen to millet significantly and favourably impacted numerous physiological yields and yield constituent parameters (Table 2). There are differences in the amounts of zinc and nitrogen that impact millet plant density (m2). The crops receiving T4 = Nitrogen 140+ Zinc 15% ha-1, T3 = Nitrogen 100+ Zinc 10% ha-1, and T2 = Nitrogen 60+ Zinc 5% ha-1 produced mean plant densities (m-2) of 153.1 cm2, 152.99 cm2, and 151.00 cm2, respectively. The treatments T5 = Nitrogen 180+ Zinc 20% ha-1 produced a maximum plant density (m-2) of 154.19 cm2. Furthermore, T1 = control, no fertilizer, and 00 kg ha1 were found to have the lowest mean plant density (m2) of 153.11 cm2.

No. of leaves per tiller

Different levels of nitrogen and zinc affect the number of leaves per tiller of millet. The crops that were treated with T5 (nitrogen 180+zinc 20% ha-1) had the most leaves per tiller (12.60), while the crops that were treated with T4 (nitrogen 140+zinc 15% ha-1) had the average number of leaves per tiller (12.14), T3 (nitrogen 100+zinc 10% ha-1), and T2 (nitrogen 60+zinc 5% ha-1) had the average number of leaves per tiller (10.26). Furthermore, T1 = control, no fertilizer, 00 kg ha-1, yielded the lowest mean number of leaves per tiller, 10.11.

Dry matter%

Zinc and nitrogen content are impacted by millet's dry matter percentage. Different amounts of T4 (140+ Zinc 15% ha-1) nitrogen, T3 (100+ Zinc 10% ha-1) nitrogen, and T2 (60+ Zinc 5% ha-1) nitrogen were used to treat crops. The average dry matter percentages for these treatments were 13.66, 12.99, and 11.25, respectively. The highest dry matter percentage was 14.75 for T5 (180+ Zinc 20% ha-1). Moreover, T1 = control, no fertilizer, 00 kg ha-1, had the lowest mean dry matter percentage of 8.01.

Crude fiber%

Various zinc and nitrogen contents have an impact on millet's crude fibre content. The crops treated with T4 = Nitrogen 140+ Zinc 15% ha-1, T3 = Nitrogen 100+ Zinc 10% ha-1, and T2 = Nitrogen 60+ Zinc 5% ha-1 yielded mean crude fibre percentages of 9.99, 9.12, and 8.80, respectively. The treatment T5 = Nitrogen 180+ Zinc 20% ha-1 yielded a maximum crude fiber percentage of 10.37. Furthermore, T1 = control; no fertilizer, 00 kg ha-1, had the lowest mean crude fiber percentage (7.00).

Table.2 Integrated Impact of Inorganic Fertilizers Nitrogen and Zinc Growth Yield of Millet

Treatments	Plant density (m^{-2})	No leaves per tillers	Dry matter %	Crude fibre %
T1=No fertilizers	153.11	10.11	8.01	7.00
T2=N 60+ Z 05 %	151.00	10.26	11.25	8.80
T3=N 100+ Z 10 %	152.99	11.00	12.99	9.12
T4=N 140+ Z 15 %	153.1	12.14	13.66	9.99
T5=N 180+ Z 20 %	154.19	12.60	14.75	10.37
LSD	0.121	0.370	0.321	0.02

Crude protein%

The application of nitrogen and zinc to millet significantly and favourably impacted various physiological yields and yield constituent characteristics (Table 3). Different levels of nitrogen and zinc affect the crude protein content of millet. The treatments T_5 = Nitrogen 180+ Zinc 20% ha^{-1} produced a maximum crude protein percentage of 46.15, while the crops receiving T4 = Nitrogen 140+ Zinc 15% ha^{-1}, T_3 = Nitrogen 100+ Zinc 10% ha^{-1}, and T2 = Nitrogen 60+ Zinc 5% ha^{-1} resulted in mean crude protein percentages of 45.95, 45.44, and 44.98, respectively. Furthermore, T1 = control, no fertilizer, 00 kg ha-1, yielded the lowest mean crude protein percentage (44.1).

Ash %

Different levels of nitrogen and zinc affect the ash content of millet. It had the highest ash percentage (7.29%) when treated with T5 (nitrogen 180+zinc 20% ha-1), while the mean ash percentages for crops treated with T4 (nitrogen 140+zinc 15% ha-1), T3 (nitrogen 100+zinc 10% ha-1), and T2 (nitrogen 60+zinc 5% ha-1) were 7.12, 7.00, and 6.40, respectively. Furthermore, T1 = control, with no fertilizer and 00 kg ha-1, yielded the lowest mean ash percentage of 5.1.

Table.3 Integrated Impact of Inorganic Fertilizers Nitrogen and Zinc Growth Yield of Millet

Treatments	Crude protein %	Ash %
T1=No fertilizers	44.1	5.1
T2=N 60+ Z 05 %	44.98	6.40
T3=N 100+ Z 10 %	45.44	7.00
T4=N 140+ Z 15 %	45.95	7.12
T5=N 180+ Z 20 %	46.15	7.29
LSD	1.01	2.34

Discussion

Pearl millet, or *Pennisetum glaucum*, is the sixth most important grain crop in the world and ranks fourth among key tropical cereals (Ismail et al., 2012). Pearl millet is a grain that can be used for both feed and fodder. Therefore, in hot and arid regions of the world such as Pakistan, people regard this crop as an excellent means to protect the meals of the agricultural poor (Vadez et al., 2012). As noted by Sanon et al. (2014) and Ayub et al. (2007), the primary causes of Pakistan's low yields are a lack of the most effective production options (poor crops, poor planting times), poor management practices, inadequate use of micronutrients (primarily zinc and nitrogen), competition from other grains, and an inability to meet crop demand. Because finger millet can contribute both nitrogen and zinc to the soil solution during the crop's growth period, increasing the amounts of both fertilizers has a favourable impact on the growth and yield components of the crop. Leila and Ali's (2014) research on the impact of varying nitrogen fertilizer levels on forage corn grain output also found that nitrogen had a significant ($p < 0.05$) effect on forage grain yield. In a related study, Kumara et al. (2007) and Tsado et al. (2016) also found that adding nitrogen had a favourable impact on finger millet development and yield components, which translated into longer, wider, and larger leaves. These may have enhanced the utilization of solar energy for more efficient photosynthetic processes (Bekele et al., 2016). Furthermore, the production of wider and longer leaves may be the cause of the plants' increased height. In addition to the availability of nitrogen in the presence of sufficient moisture in the soil, optimal photosynthetic activities may also be responsible for the noteworthy correlation shown between rising nitrogen levels and yield and growth components. This verified that finger millet responds positively to nitrogen treatment, as reported by Gupta et al. (2012). Similar results were reported by Jakhar et al., (2006) and Prasad et al., (2014). Also, Mesquita and Pinto (2000) and Yakardi and Reddy (2009) have reported an increase in the number of tillers as a result of nitrogen application. Although nitrogen and zinc appear to work synergistically to increase many physiological and molecular activities that improve yield-attributing characteristics, zinc nourishment aids in improving the nitrogen content of plants through biological nitrogen fixation (BNF) (Cakmak et al., 2010). Applying zinc to dry land areas improves the roots' ability to absorb minerals (Singh et al., 2017). Zinc is essential for increasing straw output because it is involved in numerous physiological processes in plants, including chlorophyll production, stomatal opening regulation, starch utilization, and biomass accumulation, all of which increase harvest yield. In crops, zinc also helps to increase yield by converting ammonia to nitrate. Pradhan et al. (2016) reported comparable results. Nitrogen, a key nutrient applicable in all physiochemical interactions, may contribute to an increase in grain yield. These results of the present investigation support the findings of Alkaff and Saeed (2007), Ayub et al., (2009), and Yakadri and Reddy (2009).

Conclusion

Therefore, applying varying amounts of zinc and nitrogen to millet crops can greatly increase grain output. Therefore, considering the agro-climatic conditions in Tando Jam, Sindh, Pakistan, we recommend using T5=Nitrogen 180+ Zinc 20% as the most cost-effective approach to achieve the highest quality green and dry matter in millet yield.

Further Research Recommendation

Further advancement should be made by the subsequent research in optimizing the application rates of both nitrogen (180%) and zinc (20%) for greater nutrient use efficiency, soil health improvement, and lower environmental pollution. Also, the utilization of organic amendments should be adopted to provide efficient and location-specific fertilization solutions.

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