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Impacts Of Varying Nitrogen And Phosphorus Fertilizer Types On Millet Growth, Yield, And Nutrient Management Strategies

Article Details

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ABSTRACT

The study aimed to determine the effects of varying nitrogen and phosphorus levels on millet growth, yield components, and overall productivity. During the experiment, the YBS-98 millet variety was treated with five varying concentrations of nitrogen and potassium. T1 received no fertilizers, T2 received N 40+ P 20%, T3 received N 40+ P 25%, T4 received N 40+ P 30%, T5 received N 60+ P 20%, T6 received N 60+ P 25%, and T7 received N 60+ P 30%. The study achieved the best results with the following traits: Their maximum height is 222.1 cm, their stem diameter is 0.90 cm, their leaf area per tiller (cm–2) is 1785.11 cm, the green fodder yields (t ha-1) are 77.11 cm, their plant density (m–2) is 155.11 cm, they have 12.50 cm of leaves per tiller, the dry matter percentage is 14.71 cm, the crude fibre percentage is 10.40 cm, the crude protein percentage is 46.20%, and their ash percentage is 7.30 percent. The development and output of millet were positively improved by providing it with 60 nitrogen and 30 phosphorus. However, the results were lowest for the control (T1 = no fertilizer). The plant observed 155.0 cm at the minimum height, 0.60 cm at the stem, 802.91 cm at the leaf area per tiller (cm-2), 50.70 cm at the green fodder yields (t ha-1), 149.11 cm at the plant density (m-2), 10.11 leaves per tiller, 8.01% dry matter, 7.00% crude fiber, 44.11% crude protein, and 5.2 percent ash.

INTRODUCTION

Pearl millet (Pennisetum glaucum L.) ranks among the most heat-tolerant cereal crops globally, particularly in warm-season growing conditions (Reddy et al., 2013). When you hear the word "millets," it usually refers to a large group of very different small-seeded grasses that come from different places, are classified in different ways, and are grown in different places. Examples include Paspalum scrobiculatum, Setaria italica, Pennisetum glaucum, and Cenchrus americanus. In the semiarid regions of several tropical countries, small-scale farmers depend on proso millet, one of the world's oldest cereal crops, which has been cultivated for more than 10,000 years (Flajsman et al., 2019). Because of its high nutritional content, pearl millet grain is used as feed for farms producing animals and poultry. It also provides the body with a lot of easily digested energy and has high quantities of vitamins, riboflavin, and thiamine (Yadav et al., 2021). Nitrogen-deficient plants mature slower and produce smaller flowers in addition to having reduced grains and generally decreased development. Nitrogen has been found to be present in proteins, nucleic acids, and chlorophyll and is essential for plant growth. There must be a sufficient amount of nitrogen in the diet for the plant to develop its full ability for photosynthetic activity as well as for the tillers and leaves to mature. N is the main nutrient that pearl millet needs, and its use affects growth and yield in many different ways. Arshewar et al., 2018. The potential of pearl millet to grow strongly with minimum N control is widely accepted. N application, however, has been shown in several experiments to increase millet production efficiency (Ayub et al., 2009). Fertilizers containing nitrogen and phosphorus are indispensable for achieving food security. Nitrogen made from urea-formaldehyde, urea-super granule, or urea-triple superphosphate could be used as a nitrogen source that releases nitrogen over time with DAP, GSSP, or TSP, which is good for plants. (Penuelas et al., 2023).

Each nitrogen fertilizer influences nitrogen dynamics in soil-plant systems, as well as the performance of crops. Despite being an essential nutrient for crops, phosphorus availability to plants in phosphorus-fixed soil is often very low due to immobilization by various chemicals, particularly iron and aluminium oxides and clay minerals. (Gupta et al., 2020) Phosphorus is also crucial for facilitating carbon, nitrogen, and sulphur cycles, and phosphorus fertilization can affect soil organic carbon and nitrogen mineralization (Pan et al., 2021). The various effects of the same or different nitrogen or phosphorus fertilisers on crop performance are not widely known. As both nitrogen and phosphorus fertilizers are essential for crop growth, studies on the individual and the combination of nitrogen and phosphorus fertilizers are important for advancement (Li et al. 2020). Millet is an important forage crop, playing a significant role in purifying environmental pollutants, providing services, energy, and food production. (Babu et al., 2022) and (Sheoran et al., 2024). However, the effects of a series of nitrogen and/or phosphorus fertilizers on the millet-millet companion cropping systems are not clear. Unlike single-crop systems, the effect of different fertilizer combinations on inter-plant competition is a necessary factor for the performance of the eco-agro system (Khan et al., 2023).

MATERIALS AND METHODS

FIELD EXPERIMENT

A study conducted at Latif Farm, Sindh Agriculture University (Tando Jam, Pakistan) in 2023 examined the influence of different nitrogen and phosphorus application rates on millet growth and yield parameters. The researchers added nitrogen and phosphorus using urea at varying rates. Throughout the period of different growth stages, T1 = no fertilizers; T2 = N 40 + P 20%; T3 = N 40 + P 25%; T4 = N 40 + P 30%; T5 = N 60 + P 20%; T6 = N 60 + P 25%; and T7 = N 60 + P 30%. A randomized complete block design was used to repeat each treatment three times, with a net plot size of 5 m x 3 m = 15 m^2. The soil was prepared for agriculture by laser-levelling the field after two dry ploughs. To get the proper level of moisture, irrigation water was then applied. After levelling the soil with a planker, we ploughed it again with a crosswise cultivator to create a fine seedbed.

PARAMETERS OF YIELD AND GROWTH

The measurements include plant height (cm), plant density (m-2), leaf area per tiller (cm-2), green fodder yields (tha-1), and stem diameter (cm). The total number of leaves on each tiller was recorded. The following percentages were manually recorded: dry matter, crude fiber, crude protein, and ash %.

STATISTICAL ANALYSIS

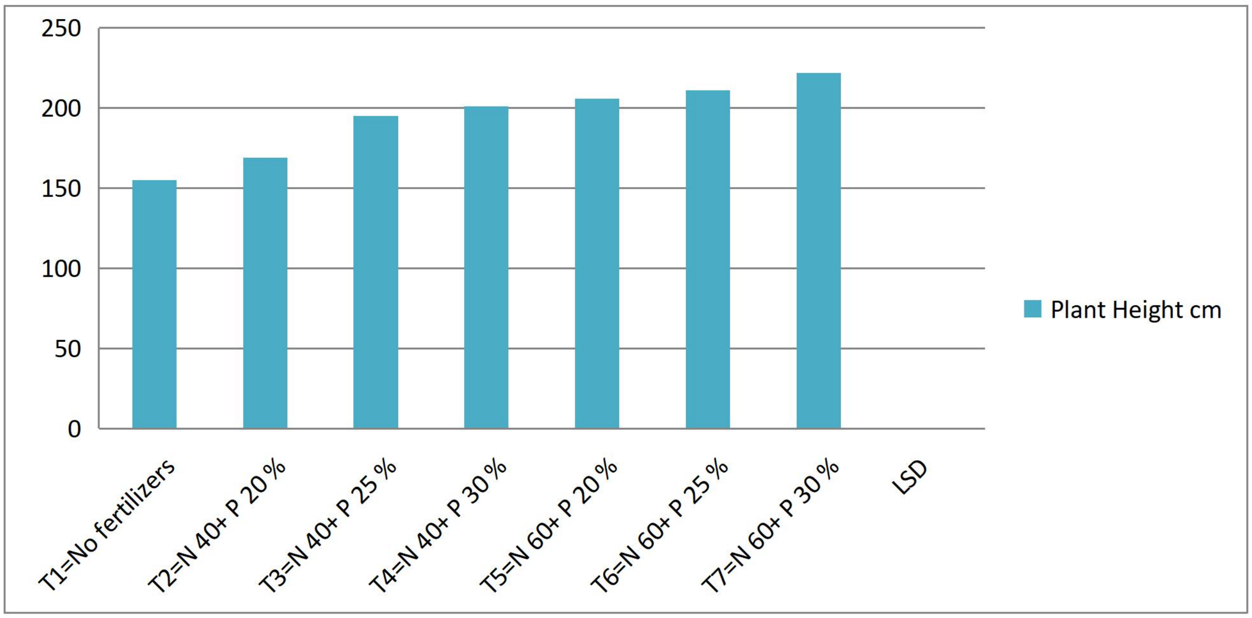
The data was analyzed using the analysis of variance (ANOVA) method with Statistix v. 8.1 (Analytical Software, USA). The difference between treatment means was evaluated using the least significant design (LSD) test with $\alpha = 0.05$ (Steel et al., 1997).

RESULTS

PLANT HEIGHT (CM)

Results depicted in Figure 1 indicate that nitrogen and phosphate treatments exerted significant positive effects on key physiological yield parameters and yield-contributing traits in millet. Variations in the amounts of nitrogen and phosphate influence the height (cm) of millet plants. The highest plant height recorded with treatments T7=N 60+ P 30% ha-1 was 222.1 cm. Additionally, the lowest mean plant height of 155.0 cm was observed in T1 = Control, which was not fertilized at a rate of 00 kg ha-1. The mean plant heights of the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1 were 211.0 cm, 205.98 cm, 201.17 cm, 195.1 cm, and 168.9 cm, all of them.

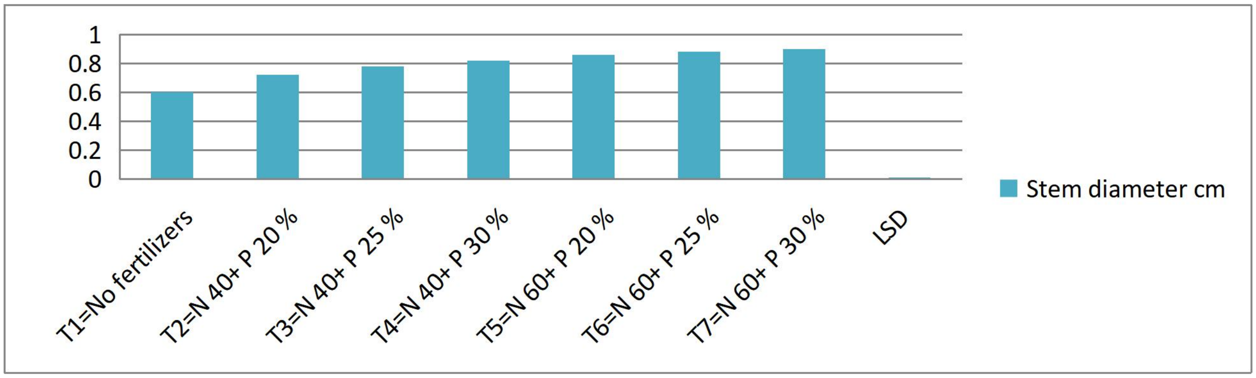
FIGURE.1 IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



STEM DIAMETER (CM)

The data presented in Figure 2 indicate that the combined use of nitrogen and phosphorus fertilizers resulted in statistically significant improvements in various physiological yield components and yield-related traits of millet. The total amount of phosphorus and nitrogen that affects millet stem diameter (cm) varies. The treatments T7 = N 60 + P 30% ha-1 achieved the highest stem diameter (cm) of 0.90 cm. additionally, it was found that the control group T1 (no fertilizer, 00 kg ha-1) had the lowest mean stem diameter (cm), measuring 0.60 cm. The mean stem diameter (cm) of the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1 was 0.88 cm, 86 cm, 0.82 cm, 0.78 cm, and 0.72 cm, respectively.

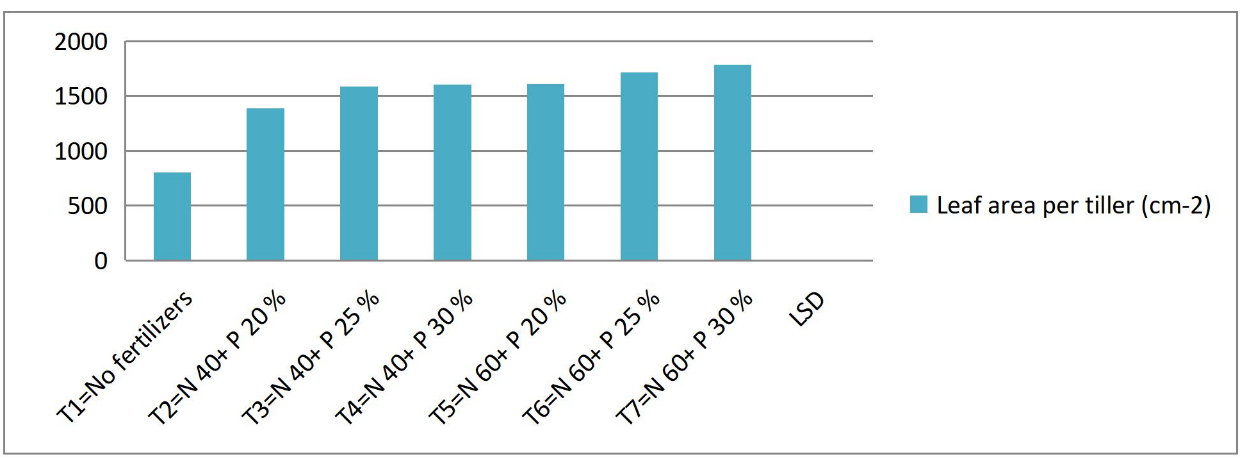
FIGURE.2 IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



LEAF AREA PER TILLER (CM^{-2})

The data presented in Figure 3 demonstrate that nitrogen and phosphorus level variations affected leaf area development per tiller (cm^2) in millet. Variations in the levels of phosphate and nitrogen affect the millet leaf area per tiller (cm-2). Treatments T7=N 60+ P 30% ha-1 generated the highest leaf area per tiller (cm-2) at 1785.11 cm-2. Additionally, it was found that the control T1 (no fertilizer, 00 kg ha-1) had the lowest mean leaf area per tiller (cm-2) (802.91 cm-2). Mean leaf area per tiller (cm-2) was 1715.01 cm2, 1611.00 cm2, 1601.56 cm2, 1585.00 cm2, and 13.90.12 cm-2 for the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1, respectively.

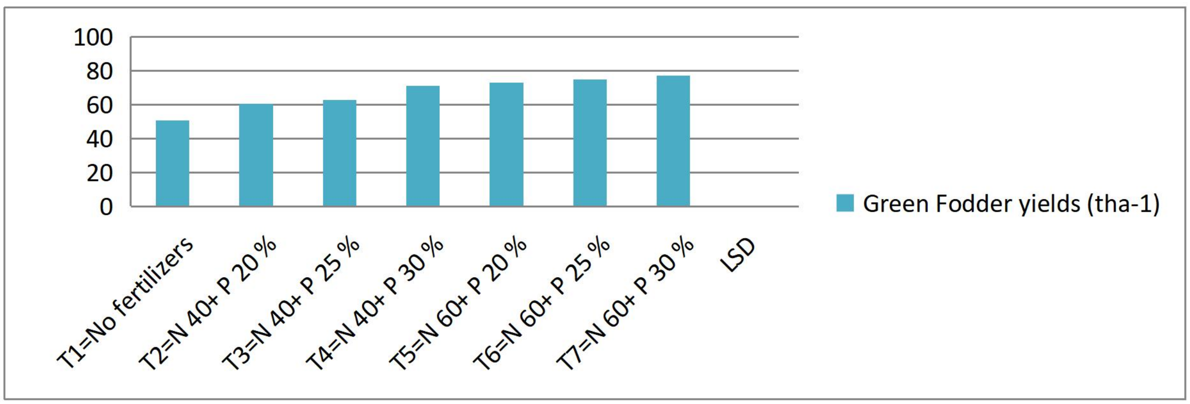
FIGURE.3 IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



GREEN FODDER YIELDS T HA^{-1}

Figure 4 demonstrates the significant effects of varying nitrogen and phosphorus application rates on millet green fodder yield (tha^{-1}). The highest yield (77.11 tha^{-1}) was achieved with treatment T7 (N 60 + P 30% ha^{-1}), while the control (T1, no fertilizer application) produced the lowest yield (50.70 tha^{-1}). Intermediate yields were observed for other treatments: T6 (N 60 + P 25%) yielded 75.09 tha^{-1}, T5 (N 60 + P 20%) 72.91 tha^{-1}, T4 (N 40 + P 30%) 71.17 tha^{-1}, T3 (N 40 + P 25%) 63.00 tha^{-1}, and T2 (N 40 + P 20%) 60.63 tha^{-1}

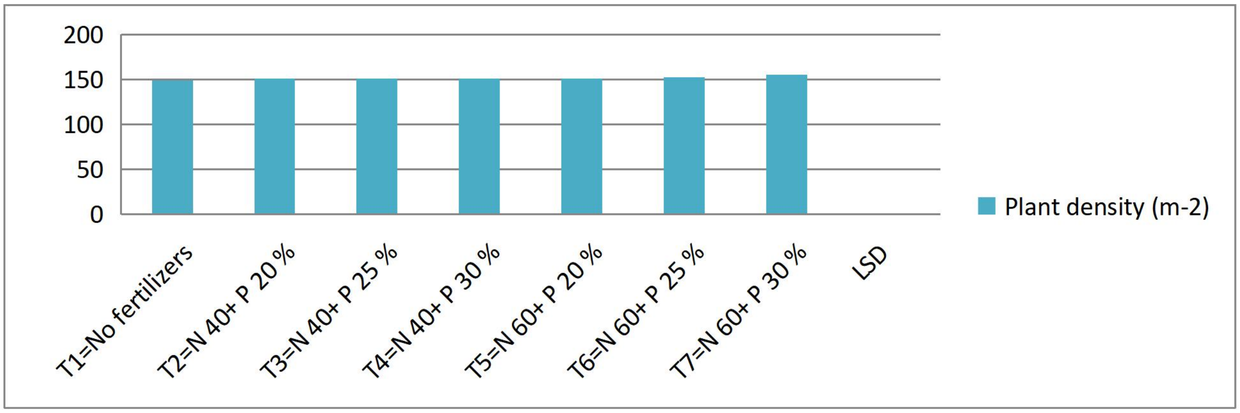
FIGURE.4IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



PLANT DENSITY (M^{-2})

Figure 5: Nitrogen and phosphate levels influence the number of plants. Treatments T7 = N 60 + P 30% ha-1 yielded a maximum plant density (m-2) of 155.11 (m-2). Additionally, T1 = Control, which did not receive any fertilizer (0 kg ha-1), had the lowest mean plant density (149.11 m-2). The mean plant density (m-2) of the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1 were 152.66, 150.99, 150.90, and 151.00 cm-2, respectively.

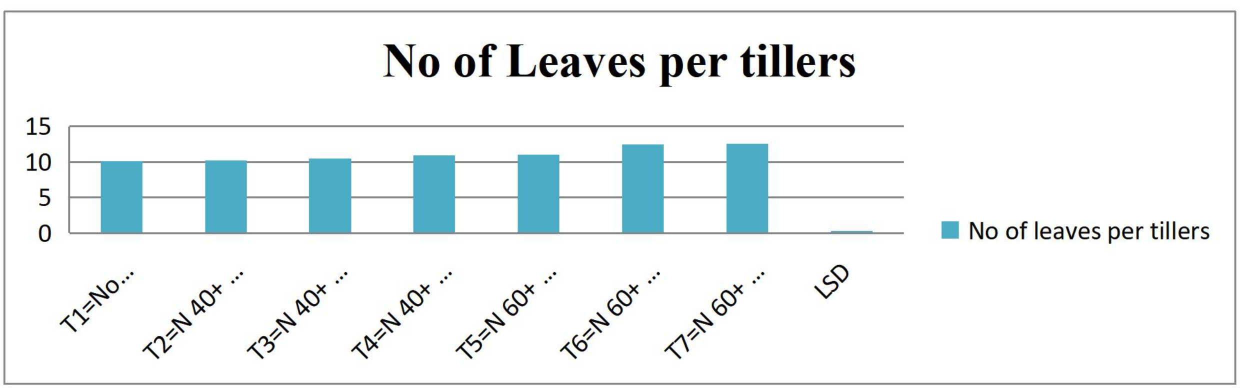
FIGURE.5IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



NO. OF LEAVES PER TILLER

Figure 6: Different amounts of nitrogen and phosphate influence the number of leaves per millet tiller. The maximum number of leaves produced by the crops treated with T7 = N 60 + P 30% ha-1 was 12.50 per tiller. Moreover, T1 = Control, which did not receive any fertilizer (0 kg ha-1), produced the lowest mean number of leaves per tiller (10.11). T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1 yielded the highest average number of leaves per tiller, which were 12.45, 11.00, 10.94, 10.45, and 10.22, respectively.

FIGURE.6IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION

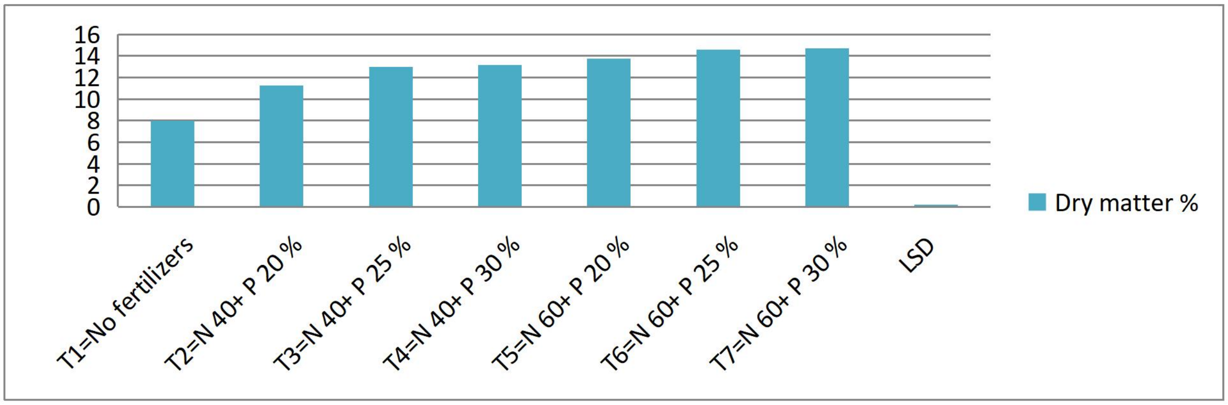


DRY MATTER%

Figure 7: The dry matter percentage of millet affects the amount of nitrogen and phosphorus; various amounts of T7=N 60+ P 30% ha-1 resulted in a maximum dry matter percentage of 14.71. Mean dry matter percentages were 14.60, 13.75, 13.16, 12.99, and 11.25 for the crops

that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1, respectively. The lowest mean dry matter percentage, 8.01, was also found in T1 = control, which received no fertilizer and (00 kg ha^{-1}).

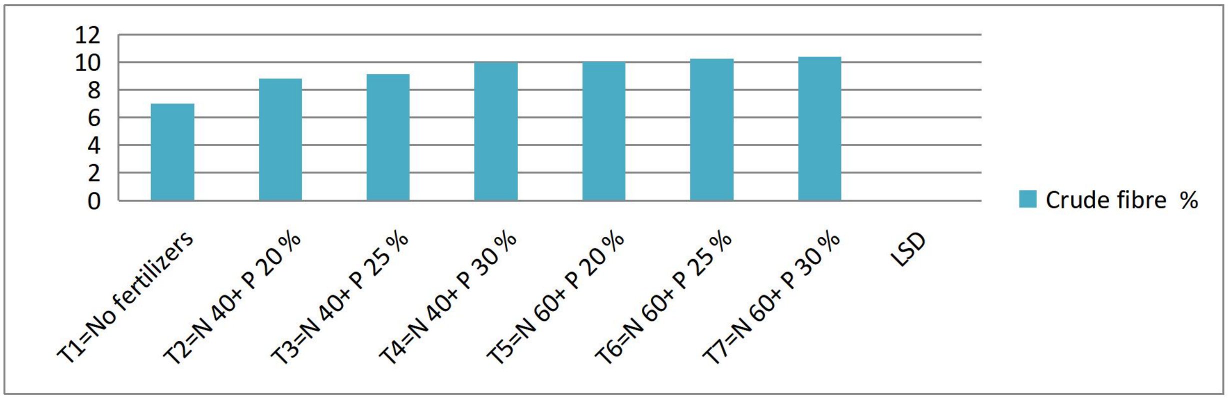
FIGURE.7IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



CRUDE FIBER%

Figure 8: Variations in its nitrogen and phosphorus concentrations affect the percentage of crude fiber in millet. The crops treated with T7=N 60+ P 30% ha-1 produced the highest percentage of crude fiber, 10.40. Mean crude fiber percentages were 10.25, 10.01, 9.95, 0.12, and 8.80 for the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3 = N 40+ P 25% ha-1, and T2=N 40+ P 20% ha-1, respectively. Additionally, T1 = control, which did not receive fertilization at a rate of 00 kg ha-1, had the lowest mean crude fiber percentage (7.00).

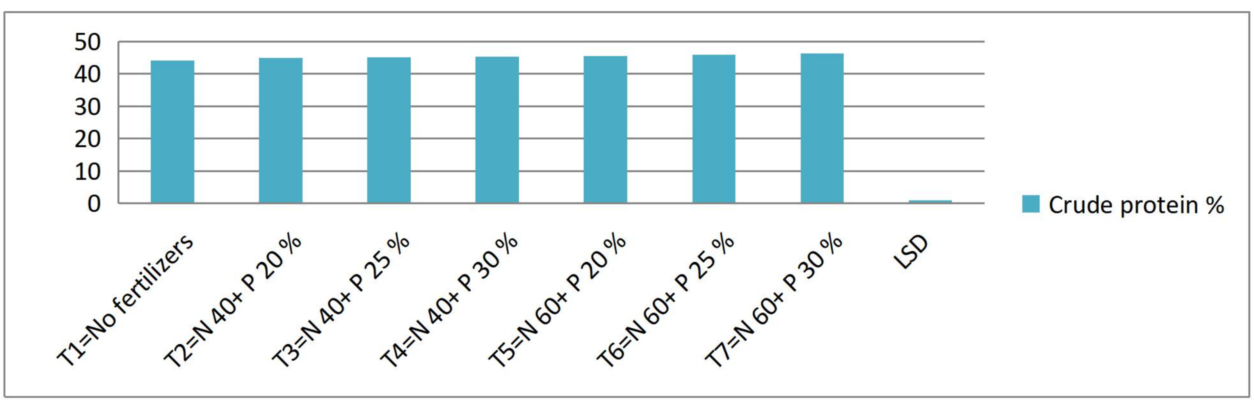
FIGURE.8IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



CRUDE PROTEIN%

Figure 9: The addition of nitrogen and phosphorus to millet resulted in a significant and positive impact on various physiological yields and constituent properties. Different amounts of nitrogen and phosphorus influence the crude protein content of millet. The crops treated with T7=N 60+ P 30% ha^{-1} yielded the highest crude protein percentage of 46.20. T6 = N 60+ P 25%, T5 = N 60+ P 20%, T4 = N 40+ P 30%, T3 = N 40+ P 25% ha^{-1}, and T2 = N 40+ P 20% ha^{-1} yielded mean crude protein percentages of 45.90, 45.50, 45.30, 45.15, and 44.90, respectively. Furthermore, T1 = control, which did not receive fertilization at a rate of 00 kg ha-1, had the lowest mean crude protein percentage, 44.11.

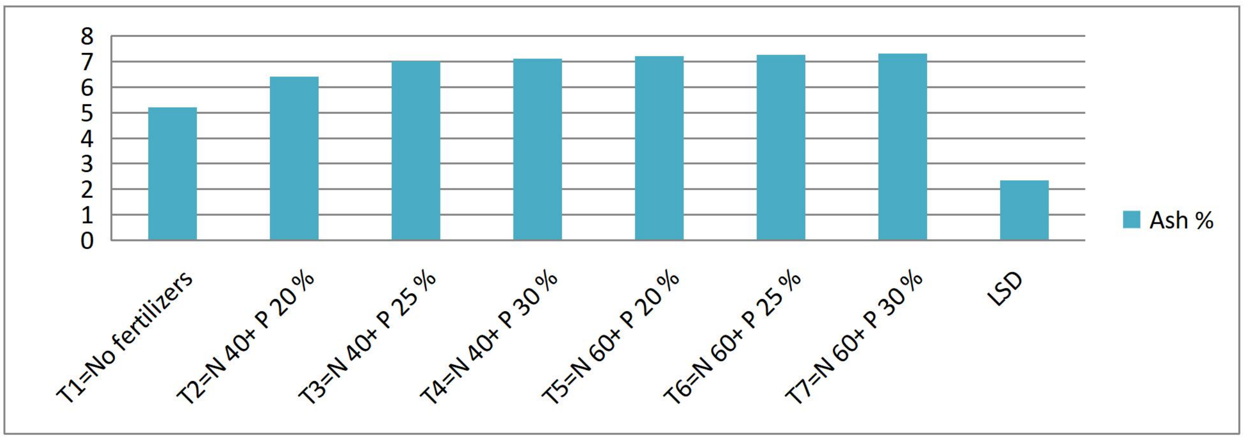
FIGURE.9 IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



ASH %

Figure 10: Various quantities of nitrogen and phosphorus influence the ash content of millet. The crops treated with T7=N 60+ P 30% ha^{-1} produced the highest percentage of ash, 7.30. Mean ash percentages were 7.25, 7.20, 7.11, 7.01, and 6.40 for the crops that received T6=N 60+ P 25%, T5=N 60+ P 20%, T4=N 40+ P 30%, T3=NN 40+ P 25% ha^{-1}, and T2=N 40+ P 20% ha^{-1}, respectively. Additionally, the lowest mean ash percentage (5.2) was found in T1 = control, which received no fertilizer (0 kg ha^{-1}).

FIGURE.10IMPACT OF N AND P, TWO INORGANIC FERTILIZERS, TOGETHER ON MILLET PRODUCTION



DISCUSSION

As a staple crop in tropical agriculture, pearl millet (Pennisetum glaucum L.) ranks sixth globally among grains and fourth in tropical cereal production (Ismail et al., 2012). Its resilience makes it indispensable for food security in drought-prone regions such as Pakistan (Vadez et al., 2012). The crop's productivity is intrinsically linked to soil-fertility dynamics, with fertilizer management playing a pivotal role in sustaining yields by optimizing soil-plant interactions (Zhang et al., 2023; Chen et al., 2019). Our study results indicate that control T1 does not apply any fertilizers. T1=No fertilizers, T2 = N 40 + P 20%, T3 = N 40 + P 25%, T4 = N 40 + P 30%, T5 = N 60 + P 20%, T6 = N 60 + P 25%, T7 = N 60 + P 30%. The study produced the best results with a maximum plant height of 222.98 cm, a stem diameter of 0.91 cm, a leaf area per tiller (cm-2) of 1780.81, green fodder yields (t ha-1) of 77.91 cm, a plant density (m-2) of 154.19 cm, a number of 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 percent. When given 180 nitrogen and 25% phosphorus, millet increased and produced more. Leila and Ali (2014) examined how different amounts of nitrogen fertilizer affected the amount of fodder maize grains produced. They reported that nitrogen significantly ($p < 0.05$) affected the amount of forage grains produced. Similar research by Kumara et al. (2007) and Tsado et al. (2016) revealed that the addition of nitrogen greatly enhanced finger millet growth and yield components, leading to the production of longer, broader, and bigger leaves. Bekele et al. (2016) suggest that this may have enhanced the utilization of sunlight for more effective photosynthetic activities. Moreover, the plants may have grown taller due to the formation of larger and longer leaves. A soil with sufficient water content may also have optimal photosynthetic activity and nitrogen availability, which would explain the significant correlation between elevated nitrogen levels and growth parameters. This confirmed the assertion by Gupta et al. (2012) that finger millet responds positively to nitrogen treatment. Sufficient energy provision, early nutrient release, and optimal P availability led to an increase in nutrient usage efficiency. Development of characteristics of growth that increased the potential grain yield. Latake et al. (2009) confirmed these results by demonstrating the efficient use of phosphate-solubilizing and nitrogen-fixing microorganisms in the seed to enhance the growth and yield of finger millet crops. These microorganisms may also be able to reduce the crop's need for chemical fertilizers (Muraliduman et al., 2010).

Consequently, we examined in this study how fertilizers affected agronomic characteristics, production, component parts of yield, and quality indicators. Various N and P combinations significantly impact the growth and health benefits of millet, according to research. The findings of Wang et al., 2023, and Guan et al., 2022, support this claim. The soluble sugar content of the leaves significantly increased at high levels of phosphorus and nitrogen, whereas the starch content significantly decreased. It's also likely that the soluble sugar of the leaves was more susceptible to treatments with high nitrogen and phosphorus levels, which reduced the starch content (Peng et al., 2021). The results of this study showed that the impacts of N and P fertilizers, as well as how they connected, on foxtail millet yield and quality varied significantly. Previous research has shown that nitrogen fertilization has a big effect on foxtail millet grain yield and aboveground growth (Wang et al., 2023), and a lack of nitrogen makes folate levels lower (Guan et al., 2022). Our results demonstrate that nitrogen (N) application exhibited a significant positive correlation with both grain yield and protein content. However, excessive N fertilization was observed to suppress phosphorus (P) uptake efficiency, even at equivalent P application rates.

CONCLUSION

The study confirms that graded application of N and P fertilizers can substantially improve millet yields. Under Tando Jam's agro-ecological conditions, the T5 treatment (60 kg N ha^{-1} + 30 kg P ha^{-1}) emerged as the most cost-effective strategy for maximizing both green fodder and dry matter production.

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