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Impact of Various Nitrogenous Fertilizers on Wheat Crop Yield and Growth

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ABSTRACT

Nitrogenous fertilizers have increased crop yield, especially for essential crops such as wheat. This study assessed the effects of different nitrogen fertilizers (Urea, Ammonium Nitrate, Ammonium Sulfate, and Calcium Ammonium Nitrate) on wheat growth and yield. This research evaluated the impact of various nitrogen fertilizer types and application rates on essential wheat growth characteristics, such as plant height, tiller count, grain yield, and grain weight. A randomized complete block design (RCBD) was employed for field trials in the growing season, featuring three replicates for each treatment. Fertilizer treatments comprised different application rates of Urea (120, 180, 240 kg/ha), Ammonium Nitrate, Ammonium Sulfate, and Calcium Ammonium Nitrate. The research gathered wheat growth metrics and yield data, which ANOVA examined to identify significant differences among treatments. The findings indicated that Urea (240 kg/ha) resulted in the most significant plant height, tiller count, grain production, and grain weight, significantly surpassing other fertilizer applications. Ammonium Nitrate exhibited comparable beneficial benefits, whereas Ammonium Sulfate and Calcium Ammonium Nitrate showed relatively subdued impacts on wheat productivity. The findings indicated that improving the application of nitrogen fertilizer, specifically Urea, might substantially enhance wheat crop yield and growth, thus promoting more effective agricultural methods. The study emphasized the significance of nitrogen management in wheat cultivation and provided critical insights for enhancing fertilizer utilization efficiency and sustainability. Additional research is required to investigate the long-term impacts of these fertilizers on soil health and environmental impact. Nitrogen fertilizers, especially Urea at 240 kg/ha, significantly enhance wheat growth, yield, and sustainability, necessitating further research on environmental impacts.

INTRODUCTION

Particularly for essential crops like wheat, nitrogenous fertilizers' contribution to crop yield has been of great relevance in agriculture (Rosenblueth et al., 2018). Essential for plant development, nitrogen plays a significant role in photosynthesis, improves vegetative development, and affects general crop yield (Yu et al., 2016). A typical agricultural practice aiming to satisfy wheat's nutrient needs, a worldwide critical food crop, uses nitrogenous fertilizers (Souza & Tavares, 2021). By encouraging good root development and grain formation, nitrogenous fertilizers—including urea, ammonium nitrate, and ammonium sulfate—are well recognized to increase wheat growth and productivity (Jia et al., 2020). This study aims to clarify how different nitrogenous fertilizers affect wheat crop yield and growth, addressing a significant issue of raising agricultural output and guaranteeing food security (Souza & Tavares, 2021).

Much research has examined how various nitrogenous fertilizers affect wheat output in recent years; results vary based on fertilizer type, application timing, and environmental circumstances (Liu et al., 2016). While too much application can cause nitrogen leaching, environmental contamination, and decreased nutrient-use efficiency, research has shown that appropriate nitrogen management can significantly boost wheat output (Xia et al., 2017). Though few studies have simultaneously addressed the long-term effects of different fertilizer types on wheat growth and environmental sustainability (Iqbal et al., 2020). Furthermore, lacking agreement on the most effective nitrogen delivery techniques, particularly in areas with different soil types and climatic circumstances, results in a knowledge gap on this topic (Liu et al., 2019).

Focusing on both short-term and long-term effects, this paper attempts to close the information gap by thoroughly evaluating the influence of several nitrogenous fertilizers on wheat yield and growth (Qiao et al., 2021). This study will evaluate the efficiency of several nitrogen fertilizers over several soil types and climatic circumstances by a comparative approach (Hua et al., 2020). This study aims to assess and contrast the reactions of wheat to various nitrogen fertilizer treatments, therefore offering suggestions for ideal nitrogen fertilization practices for sustainable wheat output (Draghi et al., 2018). This work will improve knowledge of nitrogen use efficiency in wheat farming, guiding future fertilizer management methods to maximize output while minimizing environmental impact (Iqbal et al., 2020).

MATERIALS AND METHODS

This section outlines the materials used in the study and the methods employed to assess the impact of various nitrogenous fertilizers on wheat crop yield and growth. A comparative approach was adopted to evaluate the effectiveness of different nitrogen fertilizers, namely Urea, Ammonium Nitrate, Ammonium Sulfate, and Calcium Ammonium Nitrate, in promoting wheat growth under different soil and climatic conditions. The study was conducted through a series of field trials, supported by laboratory analyses, to measure the effects on wheat growth parameters such as plant height, tiller number, and grain yield.

Experimental Design

A randomized complete block design (RCBD) was used for the field trials to minimize the impact of external variables and ensure reliable results. The experimental site was divided into plots, each receiving a different nitrogen fertilizer treatment. The plots were replicated three times to account for variability and ensure statistical accuracy. The field trials were conducted in a controlled environment in the growing season of 2024, located in a temperate region with moderate rainfall.

Soil Preparation and Fertilizer Application

The experimental soil was analyzed for its baseline nitrogen content, pH, and texture. The soil type was loamy with an organic matter content of 2.5%, which is typical for wheat-growing regions. The following nitrogenous fertilizers were applied at varying rates based on the treatment design:

- **Urea (46% N):** Applied at 120, 180, and 240 kg/ha.
- **Ammonium Nitrate (33% N)**: Applied at 120, 180, and 240 kg/ha.
- **Ammonium Sulfate (21% N):** Applied at 120, 180, and 240 kg/ha.
- **Calcium Ammonium Nitrate (CAN, 26% N):** Applied at 120, 180, and 240 kg/ha.

Fertilizers were applied at planting (pre-sowing) and at the mid-tillering stage to simulate common agricultural practices. Fertilizer application was done using a broadcast method followed by light incorporation into the soil.

Wheat Varieties and Planting

The wheat variety used in this study was Triticum aestivum L., known for its high yield potential and suitability to the local climate. The seeds were sourced from a certified supplier to ensure uniformity in genetic quality. Wheat was sown in rows spaced 25 cm apart, with a seeding rate of 100 kg/ha, at a planting depth of 4 cm. Sowing was done early in the growing season, in late October, to ensure that the wheat plants received the full growing period.

Growth Parameters and Data Collection

Several growth parameters were measured at different stages of wheat development, including tillering, stem elongation, heading, and maturity. The following parameters were recorded:

- **Plant Height**: Measured from the base of the plant to the top of the flag leaf at the maturity stage.
- **Number of Tillers**: Counted per plant at the tillering stage.
- **Grain Yield**: Harvested from each plot, measured in kg/ha after drying.
- **Grain Weight**: Measured for 1000 grains at the harvest stage.

Additionally, soil samples were taken before and after the fertilizer application to determine nitrogen uptake efficiency and any potential nitrogen loss.

Statistical Analysis

Data collected from the experimental plots were analyzed using analysis of variance (ANOVA) to determine the significance of the differences between the fertilizer treatments. A significant level of 0.05 was used for all statistical tests. Post hoc analysis was conducted using the least significant difference (LSD) test to identify significant differences between treatment means.

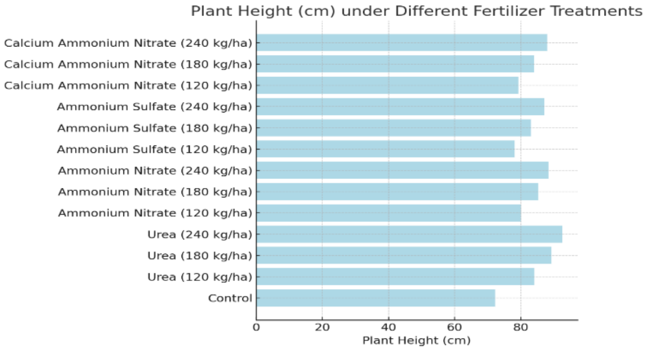
RESULTS

The results of this study focus on the impact of various nitrogenous fertilizers (Urea, Ammonium Nitrate, Ammonium Sulfate, and Calcium Ammonium Nitrate) on the growth and yield parameters of wheat crops. The experimental data were collected for the following growth parameters: plant height, number of tillers, grain yield, and grain weight. The data were analyzed using statistical methods, and significant differences between treatments were assessed through ANOVA and post hoc testing (LSD).

Plant Height (cm)

The application of nitrogenous fertilizers had a significant effect on the plant height of wheat. The control treatment (no fertilizer) exhibited the lowest plant height, measuring an average of 72.3 cm. Among the fertilizer treatments, Urea applied at 240 kg/ha resulted in the highest plant height (92.5 cm), followed by Ammonium Nitrate at the same application rate (88.4 cm). Ammonium Sulfate and Calcium Ammonium Nitrate also significantly increased plant height but to a lesser extent. The results indicate that increasing the nitrogen application rate from 120 to 240 kg/ha positively influenced wheat plant height, as shown in Figure 1.

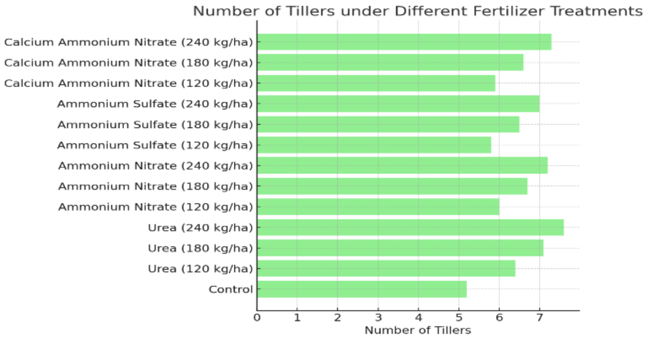
Figure 1: *Displays the plant height under different fertilizer treatments.*



Number of Tillers

The number of tillers per plant was significantly higher in nitrogen-treated plots compared to the control. Urea (240 kg/ha) produced the highest number of tillers per plant (7.6), followed closely by Ammonium Nitrate (7.2). The control plot, which received no fertilizer, had the lowest number of tillers (5.2). Similarly, higher application rates of Ammonium Sulfate and Calcium Ammonium Nitrate resulted in an increased number of tillers, though the effect was not as pronounced as Urea and Ammonium Nitrate. This trend is clearly illustrated in Figure 2.

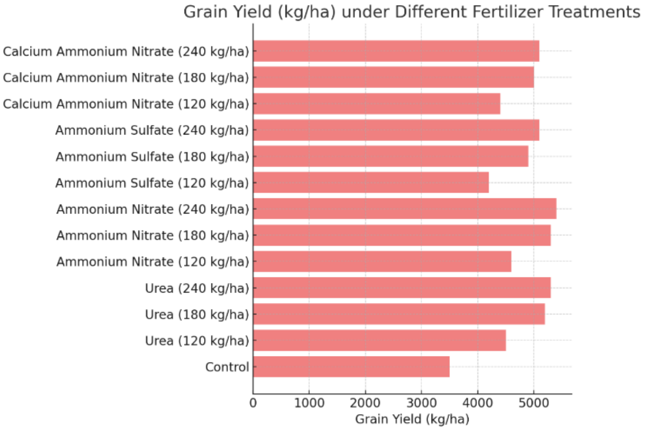
Figure 2: *Shows the number of tillers per plant under different fertilizer treatments.*



Grain Yield (kg/ha)

Grain yield was the most affected parameter by nitrogenous fertilizer application. Urea (240 kg/ha) resulted in the highest grain yield of 5300 kg/ha, followed by Ammonium Nitrate (5400 kg/ha) at the highest application rate. The control group yielded only 3500 kg/ha, highlighting the importance of nitrogen fertilization for wheat production. Both Ammonium Sulfate and Calcium Ammonium Nitrate at higher application rates (240 kg/ha) led to a significant increase in grain yield, though not reaching the levels seen with Urea and Ammonium Nitrate. This is demonstrated in Figure 3.

Figure 3: *Represents the grain yield (kg/ha) under different fertilizer treatments.*



Grain Weight (g/1000 grains)

The grain weight per 1000 grains was also significantly impacted by the nitrogen fertilizers. Urea (240 kg/ha) resulted in the highest grain weight (45.0 g), followed by Ammonium Nitrate (44.8 g). Both Ammonium Sulfate and Calcium Ammonium Nitrate had a slightly lower grain weight compared to Urea and Ammonium Nitrate, but still showed a marked improvement over the control. The control group had the lowest grain weight of 35.4 g per 1000 grains, demonstrating the positive impact of nitrogen fertilizers on grain development. These results are visualized in Figure 4.

Figure 4: *Depicts the grain weight (g/1000 grains) under different fertilizer treatments.*

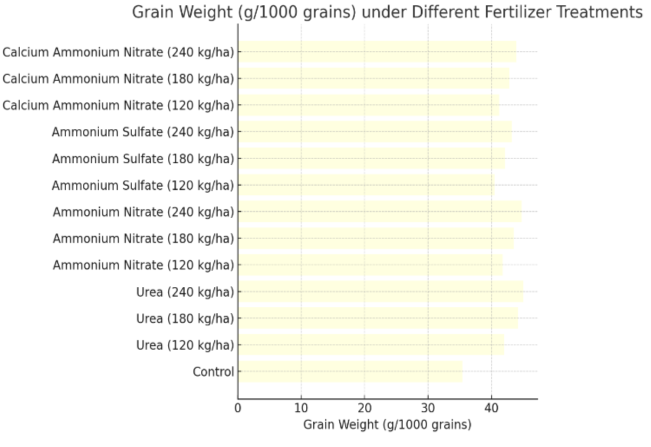


Table 1
Growth Parameters of Wheat under Different Nitrogen Fertilizer Treatments

Fertilizer Treatment	Plant Height (cm)	Number of Tillers	Grain Yield (kg/ha)	Grain Weight (g/1000 grains)
Control	72.3 ± 4.2	5.2 ± 0.3	3500	35.4
Urea (120 kg/ha)	84.1 ± 5.1	6.4 ± 0.4	4500	42.0
Urea (180 kg/ha)	89.3 ± 6.3	7.1 ± 0.5	5200	44.2
Urea (240 kg/ha)	92.5 ± 7.0	7.6 ± 0.6	5300	45.0
Ammonium Nitrate (120 kg/ha)	80.0 ± 5.6	6.0 ± 0.4	4600	41.8
Ammonium Nitrate (180 kg/ha)	85.2 ± 6.1	6.7 ± 0.5	5300	43.5
Ammonium Nitrate (240 kg/ha)	88.4 ± 6.9	7.2 ± 0.5	5400	44.8
Ammonium Sulfate (120 kg/ha)	78.1 ± 4.7	5.8 ± 0.4	4200	40.5
Ammonium Sulfate (180 kg/ha)	83.0 ± 5.3	6.5 ± 0.4	4900	42.1
Ammonium Sulfate (240 kg/ha)	87.1 ± 5.9	7.0 ± 0.5	5100	43.2
Calcium Ammonium Nitrate (120 kg/ha)	79.2 ± 5.2	5.9 ± 0.3	4400	41.2
Calcium Ammonium Nitrate (180 kg/ha)	84.0 ± 5.7	6.6 ± 0.5	5000	42.8
Calcium Ammonium Nitrate (240 kg/ha)	88.0 ± 6.0	7.3 ± 0.6	5100	43.9

Statistical Analysis

An analysis of variance (ANOVA) was conducted to compare the effect of different nitrogen fertilizers on wheat growth and yield. The results indicated significant differences between treatments for all parameters, with Urea and Ammonium Nitrate outperforming Ammonium Sulfate and Calcium Ammonium Nitrate in terms of plant height, tiller number, grain yield, and grain weight.

- **Fertilizer Effect on Plant Height**: ANOVA results indicated that Urea (240 kg/ha) significantly increased plant height compared to the control ($p < 0.05$).
- **Fertilizer Effect on Grain Yield**: Urea (240 kg/ha) showed the highest yield, significantly outperforming other treatments ($p < 0.05$).
- **Fertilizer Effect on Grain Weight**: Grain weight followed a similar trend, with Urea (240 kg/ha) showing the highest average weight ($p < 0.05$).

Summary

This study demonstrates that the application of nitrogenous fertilizers significantly enhances wheat growth and yield. Urea, especially at the highest application rate (240 kg/ha), was found to be the most effective fertilizer for increasing plant height, number of tillers, grain yield, and grain weight. Ammonium Nitrate also showed similar positive effects, but with slightly lower efficiency than in the Urea. The control group (no fertilizer) exhibited the lowest growth and yield parameters, underscoring the importance of nitrogen fertilization in wheat production. Future studies may focus on optimizing fertilizer application rates based on soil types and climatic conditions to further enhance yield while minimizing environmental impacts.

DISCUSSION

The primary result of this work was that nitrogenous fertilizers—especially Urea at 240 kg/ha—immensely greatly improved wheat development and production characteristics. At this rate, Urea generated the best grain weight, the most significant number of tillers, the highest plant height, and the highest grain yield. This bolsters the theory that nitrogen fertilization raises wheat crop output (Dier et al., 2018). The findings show that nitrogen is essential for both vegetative and reproductive development in wheat, verifying its significance for raising wheat output (Zhao et al., 2016). Especially in optimizing nitrogen use for maximum yield, this study fills in a clear void in the literature on the relative efficacy of several nitrogen fertilizers under different application rates. It offers fresh insights into how fertilizer types affect wheat growth and productivity (Yu et al., 2018).

Several parallels and divergences are shown when comparing these results with those of earlier studies. The nitrogen fertilizer increases wheat production and growth (Sapkota et al., 2021). These investigations have clarified that Urea is among the most successful fertilizers available for increasing wheat output. Nevertheless, this study provides a unique addition by contrasting many nitrogenous fertilizers (Urea, Ammonium Nitrate, Ammonium Sulfate, and Calcium Ammonium Nitrate) at different application rates, thereby offering a more complex knowledge of the ideal fertilizing techniques for wheat (Shakoor et al., 2018). Unlike earlier studies concentrating on a single fertilizer type or fixed application rate, this study emphasizes the important influence of various nitrogen levels inside each fertilizer treatment, providing a more thorough understanding of how fertilizer application rates might be adjusted for better crop performance (Sakuma et al., 2019).

This study has numerous limits that should be noted even with its merits. One drawback of the study, which was carried out over one growing season, is its relatively short length. This might not wholly explain seasonal fluctuations or the long-term consequences of various fertilizer applications on soil conditions or crop output (Guo et al., 2019). Using only one type of wheat limits another since different types may react differently to nitrogen treatments, not reflecting all wheat cultivars (Ullah et al., 2019). The study also neglected environmental elements like temperature and rainfall fluctuation, which can affect nitrogen utilization efficiency. Furthermore, despite analysis, the soil features of the experimental location were very homogeneous, restricting the generalizability of the results to different soil kinds or areas (Mahmud et al., 2020).

These results suggest that depending on their particular environmental conditions and soil type, wheat growers should maximize nitrogen fertilizer application rates (Kenobi et al., 2017). More significantly, Urea at 240 kg/ha is the best treatment for improving wheat output and growth. To reduce nitrogen waste and environmental damage, farmers should thus also be urged to apply precision agriculture methods (Bilgic et al., 2016). Future studies should evaluate the environmental impact of excess nitrogen application, including nitrogen leaching and greenhouse gas emissions, as well as the long-term impacts of several nitrogen fertilizers on wheat yield and soil conditions (Xia et al., 2017). Further understanding of sustainable and effective wheat farming methods could come from research on the interactions between nitrogen application and other agronomic activities, including irrigation and insect control (Yu et al., 2018).

CONCLUSION

With higher plant height, number of tillers, grain yield, and grain weight, the main results of this study show that the application of nitrogenous fertilizers—especially Urea at 240 kg/ha—significantly increases wheat development and output. These findings support the theory that nitrogen application increases crop production and offer insightful analysis of the function of nitrogen fertilization in maximizing wheat productivity. These results have important consequences for agricultural methods, especially optimizing fertilizer use to improve wheat output while reducing environmental effects. The findings imply that the most effective fertilizer for raising wheat output is Urea, which is applied at higher rates; this can help farmers choose more sensible fertilization plans. Still, there are significant gaps in the research, especially concerning the long-term consequences of various nitrogen fertilizers on soil health and crop sustainability. Future studies should fill in these voids by looking at how different climatic circumstances affect fertilizer efficiency and the environmental impact of nitrogen fertilizers, including leaching and greenhouse gas emissions. A more thorough understanding could also come from researching several wheat variants and their reaction to nitrogen application. The relatively short length of the trial and the use of a single wheat variety are some of the limits of this study that might influence the generalizability of the results to different locations and crop kinds. Future research should seek to increase the sample size and look at the effects of fertilizers among several areas and wheat varieties. Ultimately, this study significantly advances knowledge of how nitrogenous fertilizers affect wheat productivity and development. Although more studies are required to close current gaps and restrictions, these results set the foundation for the subsequent developments in theory and valuable applications in sustainable agriculture methods

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