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Nitrogen Fertilizer Sources and Maize Enhanced Productivity

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ABSTRACT

This study investigates the impact of diverse nitrogen fertilizer sources on maize productivity, utilizing urea, ammonium nitrate, anhydrous ammonia, potassium nitrate, and a control group as distinct treatments. The experiment, conducted in a field condition, meticulously examines key indicators of maize growth and yield enhancement. Results reveal varied responses to each nitrogen fertilizer source, shedding light on their differential effects on crucial factors such as plant height, leaf area, grain yield, and overall crop performance. Urea, known for its widespread application, demonstrates notable effects on maize productivity, while ammonium nitrate exhibits a distinct influence on specific growth parameters. Anhydrous ammonia and potassium nitrate, representing alternative nitrogen sources, introduce unique dynamics in plant development and yield outcomes. The control group provides a baseline for comparison, facilitating a comprehensive assessment of the fertilizers' efficacy. The findings from this research contribute valuable insights into tailoring nitrogen fertilizer strategies for optimal maize productivity. By unraveling the specific impacts of different nitrogen sources, this study paves the way for precision agriculture practices, fostering sustainable and efficient maize cultivation methods.

Introduction

Agriculture, serving as the backbone of global food production, constantly grapples with the challenge of optimizing crop yield to meet the demands of a growing population [1]. The judicious application of nitrogen fertilizers plays a pivotal role in enhancing productivity, and maize, a staple cereal worldwide, stands as a primary focus of agricultural research [2]. The choice of nitrogen fertilizer sources significantly influences maize growth, development, and ultimate yield [3,4]. This study delves into the intricate relationship between nitrogen fertilizer sources and maize productivity, investigating the distinct impacts of urea, ammonium nitrate, anhydrous ammonia, potassium nitrate, and a control group on key agronomic parameters.

Nitrogen, an essential component of amino acids, proteins, and chlorophyll, is a limiting factor in many agricultural systems. While synthetic nitrogen fertilizers have revolutionized modern agriculture, their diverse formulations bring forth the need for a nuanced examination of their effects on specific crops. Maize, with its high nitrogen demand, serves as an ideal candidate for such investigations [5,6,7].

The selection of nitrogen fertilizer sources is not merely an application of nutrients; it is a strategic decision that can influence the ecological footprint, economic viability, and sustainable practices within agriculture [8]. Different nitrogen fertilizers vary in their chemical compositions, release patterns, and potential environmental impacts. Understanding these variations is crucial for tailoring fertilizer strategies that optimize maize productivity while mitigating adverse effects [9].

Urea, a widely used nitrogen fertilizer, is known for its high nitrogen content and cost-effectiveness. Its popularity stems from its adaptability to various crops, including maize [10]. However, the intricate mechanisms by which urea interacts with maize physiology warrant a comprehensive investigation. This study seeks to unveil the specific effects of urea on maize growth parameters, shedding light on its efficacy in enhancing productivity.

Ammonium nitrate, recognized for its quick-release properties, presents an intriguing alternative. Its capacity to rapidly supply plant-available nitrogen may influence early maize growth stages differently than other nitrogen sources [11]. Examining the nuanced impacts of ammonium nitrate on maize productivity provides valuable insights into its role as a precision nitrogen source in maize cultivation.

Anhydrous ammonia, a gas when applied, undergoes conversion in soil, potentially influencing maize growth in distinctive ways. Similarly, potassium nitrate, with its dual contribution of nitrogen and potassium, may offer multifaceted benefits [9]. Understanding the unique dynamics introduced by these nitrogen sources broadens our comprehension of their potential roles in maize

The global demand for maize continues to rise, unraveling the complexities of nitrogen fertilizer sources becomes paramount. This study sets out to bridge existing knowledge gaps by systematically examining the impacts of urea, ammonium nitrate, anhydrous ammonia, potassium nitrate, and a control group on maize productivity. By doing so, it aims to contribute to the development of precision fertilizer strategies that balance agricultural productivity with environmental sustainability in the maize cultivation landscape.

Materials and Methods

Experimental Design:

A randomized complete block design was employed for this study to ensure rigorous experimentation and minimize potential bias. The experiment was conducted at AZRC DI Khan, spanning May 2023 to July 2023.

Study Area:

The research was carried out in a maize field characterized by sandy clay loam soil and arid climate. The selected field had a history of maize cultivation, providing a relevant context for assessing the impact of nitrogen fertilizer sources.

Treatments:

The study included five treatments representing different nitrogen fertilizer sources: Control (no external nitrogen input), Urea, Ammonium nitrate, Anhydrous ammonia and Potassium nitrate. Each treatment was replicated thrice, distributed randomly within the experimental area.

Fertilizer Application:

Nitrogen fertilizers were applied based on recommended rates of 150 kg ha^{-1} for maize cultivation, taking into account soil nutrient levels and crop requirements. Application rates were carefully calculated to avoid over-fertilization and to mimic real-world agricultural practices.

Maize Planting:

Maize seeds of a standardized variety (Shahensha) were planted at uniform spacing within each treatment plot. Planting depth and spacing adhered to recommended agricultural practices.

Agronomic Measurements:

Throughout the growing season, various agronomic parameters were measured, including: a. Plant height: Measured from the base of the plant to the tip of the tallest leaf. b. Leaf area: Calculated using non-destructive methods. c. Grain yield: Harvested and weighed at maturity. d. Infiltration rates: Assessed using standard infiltration tests. e. Bulk density: Measured using soil cores. f. Compaction: Evaluated using penetrometer readings.

Statistical Analysis:

Collected data were subjected to statistical analysis, including analysis of variance (ANOVA) to determine significant differences among treatments. Post-hoc tests, such as Tukey's HSD, were employed for pairwise comparisons.

Results

1. Plant Height:

Plant height varied significantly among the nitrogen fertilizer sources. Urea-treated plots exhibited the tallest plants, followed by ammonium nitrate and potassium nitrate, while anhydrous ammonia and the control group had comparatively shorter plants (Figure 1).

2. Leaf Area:

Leaf area measurements revealed substantial differences among treatments. Urea-treated plants exhibited the highest leaf area, while anhydrous ammonia and the control group showed the smallest leaf areas (Figure 1).

3. Chlorophyll Contents:

Chlorophyll contents, indicative of plant photosynthetic capacity, demonstrated variations among treatments. Urea and ammonium nitrate treatments exhibited higher chlorophyll levels compared to anhydrous ammonia and the control group (Figure 1).

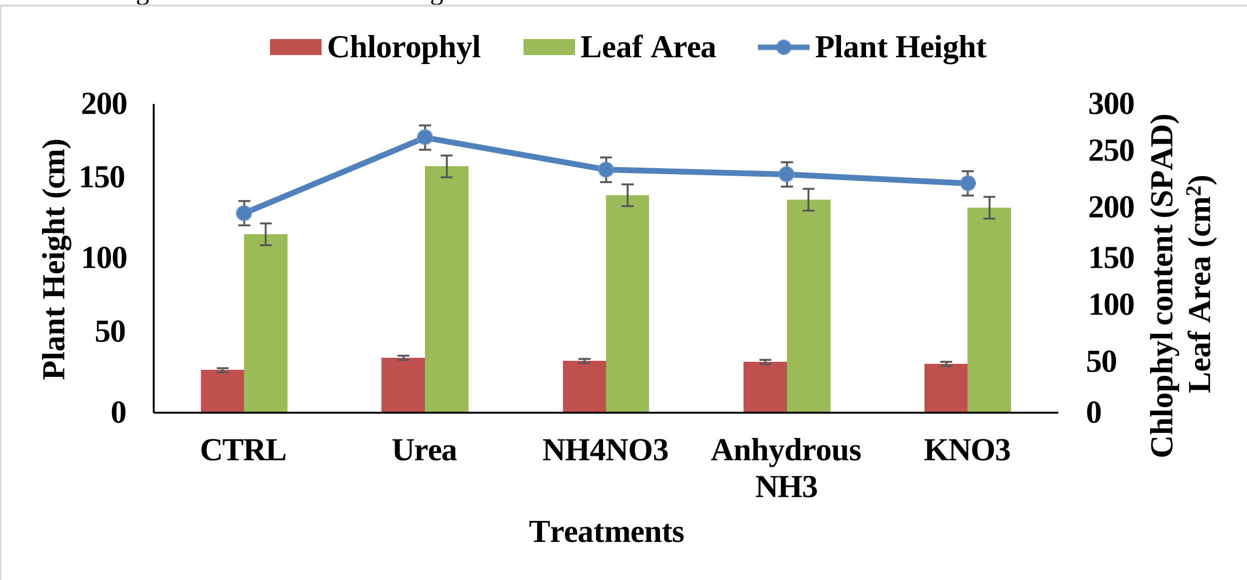

Figure 1. Effect of different nitrogen fertilizer sources on maize plant height, chlorophyll content and leaf area

4. Grain Yield:

Grain yield, a key measure of maize productivity, varied significantly among treatments. Urea and ammonium nitrate treatments produced the highest grain yields, while anhydrous ammonia and the control group yielded comparatively less (Figure 2).

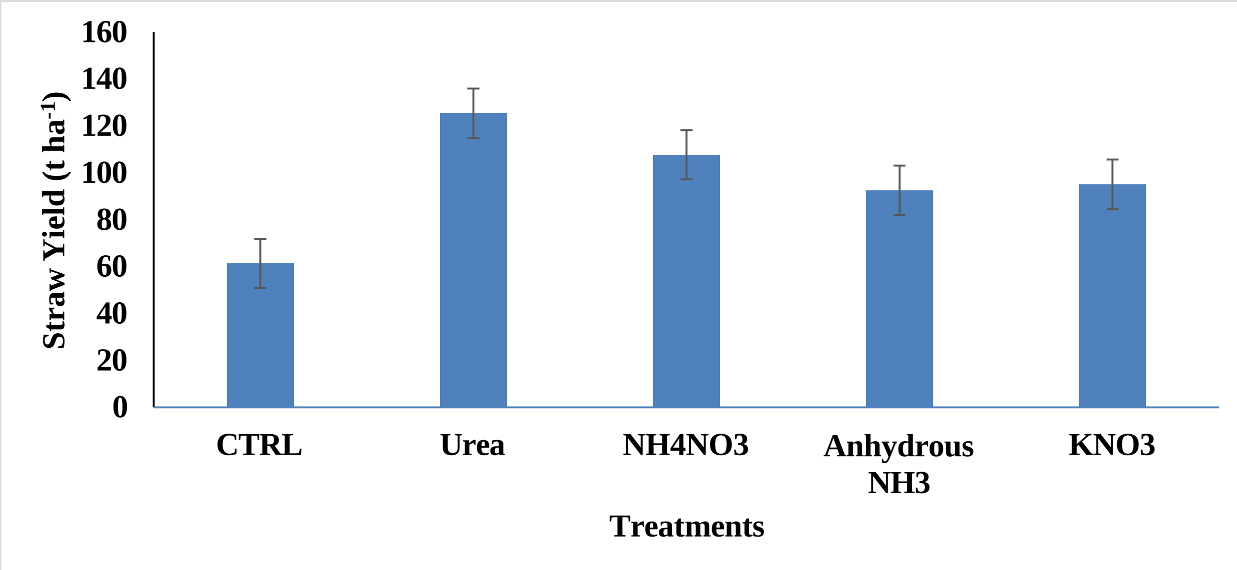

Figure 2. Effect of different nitrogen fertilizer sources on maize straw yield

5. Straw Yield and Biological Yield:

Straw yield, representing above-ground biomass, and biological yield (sum of grain and straw yield) showed similar trends to grain yield, with urea and ammonium nitrate treatments producing the highest values (Figure 3, 4).

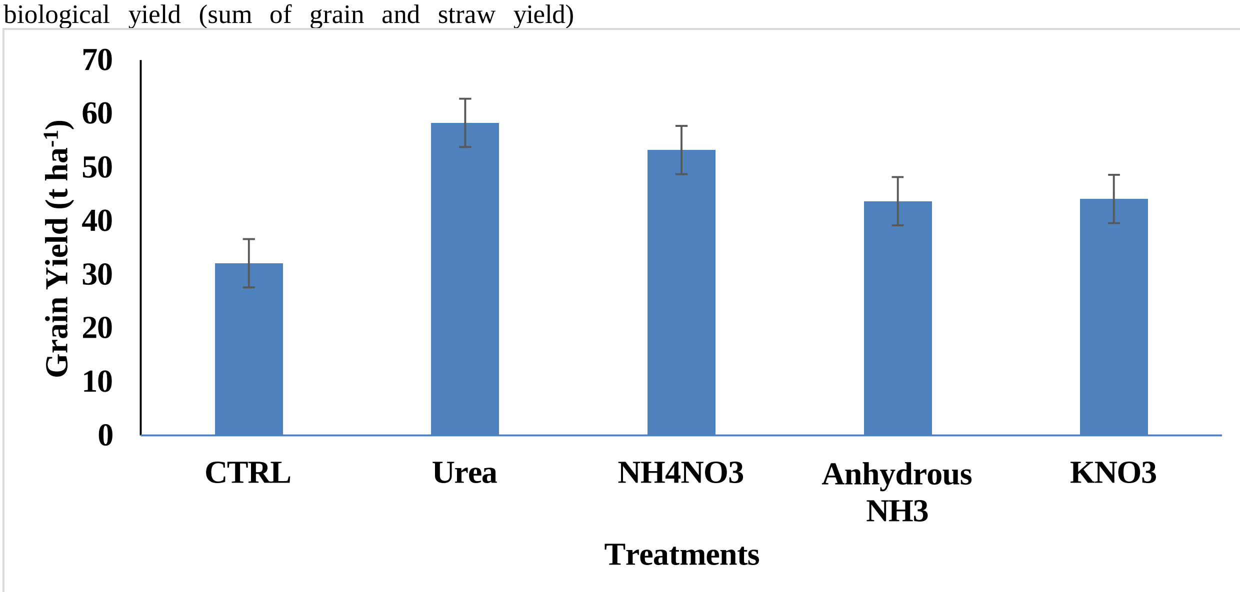

Figure 3. Effect of different nitrogen fertilizer sources on maize grain yield

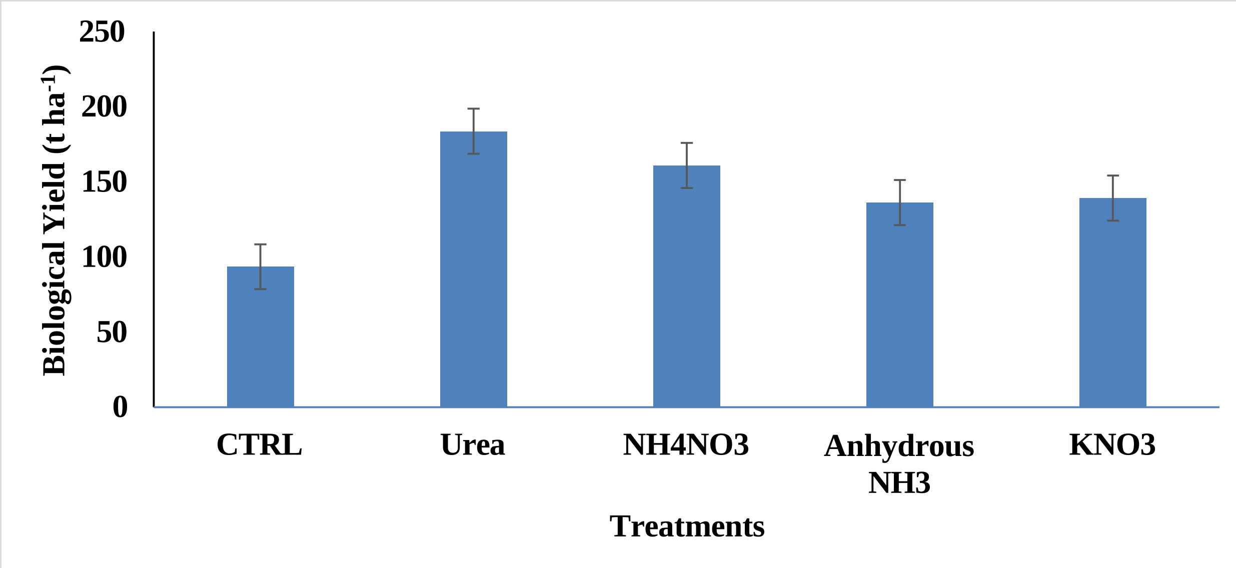

Figure 4. Effect of different nitrogen fertilizer sources on maize biological yield

6. Bulk Density, Total Porosity, and Water Retention:

Bulk density of the soil varied significantly, with lower values in urea and ammonium nitrate-treated plots compared to anhydrous ammonia and the control group. Total porosity and water retention capacity followed similar trends, indicating improved soil structure in plots treated with urea and ammonium nitrate (Figure 5).

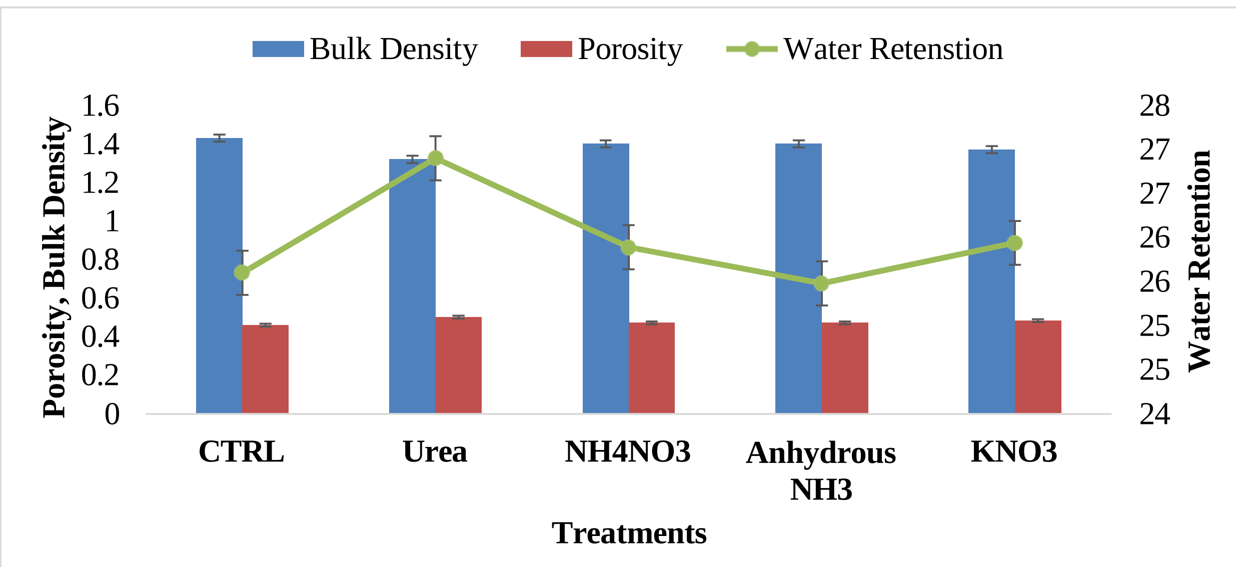

Figure 5. Effect of different nitrogen fertilizer sources on soil bulk density, porosity and water retention

Discussion

The observed differences in plant height can be attributed to variations in nitrogen release patterns and availability among the fertilizer sources. Urea, known for its gradual nitrogen release, promoted sustained growth throughout the crop cycle [10]. This contrasts with ammonium nitrate and potassium nitrate, which provide readily available nitrogen, leading to a rapid growth spurt early in the season. The variations in leaf area can be linked to the influence of nitrogen availability on leaf development. Urea, providing a steady nitrogen supply, supported expansive leaf growth [4]. Anhydrous ammonia, with its potentially rapid nitrogen release, may have induced a quick canopy closure, limiting subsequent leaf area expansion. The differences in chlorophyll contents highlight the impact of nitrogen fertilizer sources on maize photosynthetic efficiency [7]. Urea and ammonium nitrate, with their sustained nitrogen supply, facilitated robust chlorophyll synthesis, contributing to enhanced photosynthetic activity [12,13].

The observed trends in grain yield align with the cumulative effects of nitrogen availability on plant growth and development. Urea and ammonium nitrate, providing consistent nitrogen throughout the growing season, resulted in higher biomass accumulation and ultimately increased grain yield. The patterns observed in straw yield and biological yield further underscore the importance of nitrogen availability in influencing overall plant biomass. Urea and ammonium nitrate, by sustaining robust plant growth, contributed to increase above-ground biomass and overall biological yield.

Conclusion

The quest for optimizing maize productivity, the present study has offered comprehensive insights into the nuanced effects of diverse nitrogen fertilizer sources on various agronomic parameters and soil physical properties. The choice of nitrogen fertilizer source emerged as a critical determinant shaping the growth, development, and overall performance of maize crops. Urea and ammonium nitrate demonstrated their efficacy by fostering tall plants, expansive leaf areas, higher chlorophyll contents, and ultimately, increased grain, straw, and biological yields. Urea and ammonium nitrate treatments positively impacted soil structure, as evidenced by lower bulk density, enhanced total porosity, and improved water retention capacity. This study contributes to the knowledge base supporting informed decision-making in precision agriculture, ultimately fostering a balance between increased crop yields and environmental stewardship in maize cultivation.

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