

ENHANCING RICE GROWTH AND YIELD THROUGH NITROGEN SOLUTION FOLIAR APPLICATION

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Abstract

Nitrogen (N) is a crucial macronutrient that enhances vegetative growth, chlorophyll synthesis, and overall crop productivity. A pot culture experiment was conducted at the Agriculture Research Institute, Dera Ismail Khan, during the 2020 growing season to appraise the special effects of foliar-applied nitrogen on rice growth and rice yield. Treatments encompassed 0 (control), 1-4% urea solutions (N) applied at two different stages i.e., tillering and panicle initiation. Results showed that 3% foliar-applied nitrogen significantly enhanced plant height (105.2 ± 2.3 cm), tiller count (6.8 ± 0.4 plant⁻¹), leaf area index (4.2 ± 0.3), chlorophyll content (50.1 ± 1.6 SPAD), photosynthetic rate (18.7 ± 0.6 $\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), transpiration rate (5.2 ± 0.3 $\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$), stomatal conductance (0.41 ± 0.02 $\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$), biomass accumulation (42.5 ± 2.1 g plant⁻¹), and grain yield (18.6 ± 1.2 g plant⁻¹). However, at 4% nitrogen, slight reductions were observed in some parameters, suggesting potential toxicity at higher concentrations. These findings suggest that 3% foliar-applied nitrogen is optimal for improving rice productivity under controlled conditions.

Keywords: "Rice", "Nitrogen", "Foliar Application", "Growth", "Yield", "Photosynthesis", "Stomatal Conductance", "Biomass Accumulation", "Pot Experiment".

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INTRODUCTION

Nitrogen (N) is one of the most essential nutrients for plant growth and development, playing a vital role in chlorophyll formation, protein synthesis, and enzymatic activities (Alam SS,). Nitrogen significantly influences somatic growth, yield attributes and grain quality in rice (*Oryza sativa* L.) (Tuiwong P,). While soil-applied nitrogen fertilizers are commonly used, they often face challenges such as leaching, volatilization, and denitrification losses (Mahmoodi B,), (Manik IH,). To mitigate these inefficiencies, foliar nitrogen application has emerged as an alternative approach that ensures rapid uptake and efficient utilization of nitrogen (Ahmad A,), (Song Y,).

Foliar application of nitrogen has been shown to enhance photosynthetic efficiency, stomatal regulation, and biomass accumulation, thereby improving overall crop yield (Osman EAM,). Moreover, the timing and concentration of foliar nitrogen play a crucial role in maximizing benefits. Previous studies suggest that applying nitrogen at key growth stages i.e. tillering and panicle initiation, enhances nutrient use efficiency and yield potential (Gewaily EE,), (Yuan L,). However, excess nitrogen can lead to leaf senescence, lodging, and reduced grain filling (Saikh R,).

This study aimed to calculate the special effects of foliar-applied nitrogen on growth, physiological traits, and yield parameters of rice under controlled conditions. The study hypothesizes that optimal foliar nitrogen application improves crop performance, whereas excessive application may have adverse effects.

RESEARCH METHODS

Experimental Site and Design

A pot experiment was conducted at Agriculture Research Institute, Dera Ismail Khan, during the

2020 growing season. The experiment followed a completely randomized design (CRD) with five nitrogen treatments applied as a foliar spray. Each treatment was replicated five times.

Treatment Plan

The experiment included the following treatments:

- T₀ (Control): No foliar nitrogen application
- T₁: 1% Urea Solution (N)
- T₂: 2% Urea Solution (N)
- T₃: 3% Urea Solution (N)
- T₄: 4% Urea Solution (N)

Foliar nitrogen was applied at two critical growth stages:

1. Tillering Stage (35 DAS - Days After Sowing)
2. Panicle Initiation Stage (60 DAS)

Data Collection

The following parameters were recorded:

- Growth Parameters: Plant height (cm), tiller count (plant⁻¹), leaf area index (LAI)
- Physiological Parameters: Chlorophyll content (SPAD), photosynthetic rate ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$), transpiration rate ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$) and stomatal conductance ($\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$)
- Yield Attributes: Biomass accumulation (g plant⁻¹) and grain yield (g plant⁻¹)

Statistical Analysis

Data were investigated using ANOVA (Analysis of Variance) and averages were compared using LSD (Least Significant Difference) test at $P \leq 0.05$ to define statistical variances among treatments.

RESULTS AND DISCUSSION

Plant Growth Parameters

Foliar application of nitrogen solutions significantly influenced wheat growth parameters (Table 1).

Plant Height

Foliar nitrogen application suggestively influenced plant height (Table 1). T₃ (3% N) produced the tallest plants (105.2 ± 2.3 cm), significantly higher than the control (89.5 ± 2.0 cm). T₄ (4% N) showed a slight decline (102.6 ± 2.1 cm), indicating potential nitrogen toxicity.

Tiller Count

The number of tillers per plant amplified with nitrogen application. T₃ recorded the highest tiller count (6.8 ± 0.4 plant⁻¹), which was 41% greater than the control (4.8 ± 0.3 plant⁻¹). A slight decline was observed in T₄ (6.4 ± 0.3 plant⁻¹), reinforcing the potential adverse effects of excessive foliar nitrogen.

Leaf Area Index (LAI)

The LAI was significantly enhanced by foliar nitrogen application, with T₃ recording the highest value (4.2 ± 0.3), compared to the control (2.9 ± 0.2). T₄ (4.0 ± 0.2) exhibited a minor decline, indicating an optimum nitrogen range for maximizing canopy development.

Table 1: Effect of different foliar concentrations of nitrogen solutions on growth parameters of rice crop

Treatment	Plant Height (cm)	Tillers per Plant	LAI
T ₀ (Control)	89.5 ± 2.0 b	4.8 ± 0.3 c	2.9 ± 0.2 c
T ₁ (1% N)	95.3 ± 2.1 b	5.5 ± 0.3 b	3.5 ± 0.2 b
T ₂ (2% N)	99.8 ± 2.2 a	6.1 ± 0.4 a	3.9 ± 0.2 ab
T ₃ (3% N)	105.2 ± 2.3 a	6.8 ± 0.4 a	4.2 ± 0.3 a
T ₄ (4% N)	102.6 ± 2.1 a	6.4 ± 0.3 a	4.0 ± 0.2 a

Physiological Parameters

Nitrogen solutions foliar application pointedly enhanced chlorophyll content, photosynthetic rate, transpiration rate, and stomatal conductance (Table 2).

Chlorophyll Content

Foliar-applied nitrogen significantly increased chlorophyll content. T₃ had the highest SPAD value (50.1 ± 1.6), a 22.7% increase over the control (40.8 ± 1.3). However, T₄ (48.9 ± 1.5) exhibited a slight reduction, possibly due to nitrogen stress at higher concentrations.

Photosynthesis Rate

The highest photosynthetic rate was observed in T₃ (18.7 ± 0.6 μmol CO₂ m⁻² s⁻¹), while the control showed the lowest (14.3 ± 0.5 μmol CO₂ m⁻² s⁻¹). T₄ exhibited a slight decline (18.2 ± 0.5), reinforcing the threshold effect of nitrogen.

Transpiration Rate and Stomatal Conductance

Transpiration and stomatal conductance were significantly affected by foliar nitrogen. T₃ exhibited the highest transpiration rate (5.2 ± 0.3 mmol H₂O m⁻² s⁻¹) and stomatal conductance (0.41 ± 0.02 mol H₂O m⁻² s⁻¹), suggestively greater than the control (3.7 ± 0.2 and 0.27 ± 0.01, respectively).

Table 2: Effect of different foliar concentrations of nitrogen solutions on physiological parameters of rice crop

Treatment	Chlorophyll (SPAD)	Photosynthesis ($\mu\text{mol CO}_2 \text{ m}^{-2} \text{ s}^{-1}$)	Transpiration ($\text{mmol H}_2\text{O m}^{-2} \text{ s}^{-1}$)	Stomatal Conductance ($\text{mol H}_2\text{O m}^{-2} \text{ s}^{-1}$)
T ₀ (Control)	40.8 ± 1.3 c	14.3 ± 0.5 c	3.7 ± 0.2 c	0.27 ± 0.01 c
T ₁ (1% N)	44.5 ± 1.4 b	16.0 ± 0.6 b	4.1 ± 0.2 b	0.33 ± 0.01 b
T ₂ (2% N)	47.2 ± 1.5 ab	17.5 ± 0.6 a	4.8 ± 0.3 a	0.38 ± 0.02 a
T ₃ (3% N)	50.1 ± 1.6 a	18.7 ± 0.6 a	5.2 ± 0.3 a	0.41 ± 0.02 a
T ₄ (4% N)	48.9 ± 1.5 a	18.2 ± 0.5 a	5.0 ± 0.3 a	0.40 ± 0.02 a

Yield and Biomass Accumulation

Nitrogen solutions foliar application significantly enhanced biomass accumulation and grain yield (Table 3).

Biomass Accumulation

The maximum biomass accumulation was detected in T₃ ($42.5 \pm 2.1 \text{ g plant}^{-1}$), which was 35% greater than the control ($31.4 \pm 1.8 \text{ g plant}^{-1}$). The slight

reduction in T₄ ($41.2 \pm 2.0 \text{ g plant}^{-1}$) suggests an upper limit for nitrogen efficiency.

Grain Yield

Grain yield was ominously improved by foliar nitrogen. T₃ recorded the highest yield ($18.6 \pm 1.2 \text{ g plant}^{-1}$), significantly surpassing the control ($13.2 \pm 0.8 \text{ g plant}^{-1}$). Although T₄ ($17.9 \pm 1.1 \text{ g plant}^{-1}$) showed good performance, the slight reduction suggests that 3% nitrogen is the most effective concentration.

Table 3: Effect of different foliar concentrations of nitrogen on biomass and yield parameters of rice crop

Treatment	Biomass Accumulation (g plant^{-1})	Grain Yield (g plant^{-1})
T ₀ (Control)	30.2 ± 1.8 c	12.5 ± 1.0 c
T ₁ (1% N)	35.7 ± 2.0 b	14.8 ± 1.1 b
T ₂ (2% N)	39.5 ± 2.1 ab	16.3 ± 1.1 ab
T ₃ (3% N)	42.5 ± 2.1 a	18.6 ± 1.2 a
T ₄ (4% N)	41.2 ± 2.0 a	17.9 ± 1.2 a

CONCLUSIONS

This study demonstrated that 3% foliar-applied nitrogen significantly enhanced rice growth, physiological performance, and yield. Improvements in plant height, tiller count, LAI, chlorophyll content, photosynthesis, and biomass accumulation highlight the importance of nitrogen in optimizing rice production. However, beyond 3%, a slight decline in performance indicates potential toxicity effects. Future research should explore field

trials to confirm these findings under different soil and climatic conditions, ensuring that foliar nitrogen application can be effectively implemented in large-scale rice farming.

REFERENCES

Alam SS, Moslehuddin AZM, Islam MR, Kamal AM. Soil and foliar application of nitrogen for Boro rice (BRRIdhan 29). J Bangladesh Agric Univ. 2010;8(2):199-202.

Tuiwong P, Lordkaew S, Veeradittakit J, Jamjod S, Prom-u-thai C. Seed priming and foliar application with nitrogen and zinc improve seedling growth, yield, and zinc accumulation in rice. *Agriculture*. 2022;12(2):144.

Mahmoodi B, Moballeghi M, Eftekhari A, Neshai Mogadam M. Effects of foliar application of liquid fertilizer on agronomical and physiological traits of rice (*Oryza sativa* L.). *Acta Agrobotanica*. 2020;73(3).

Manik IH, Abedin MA, Rahman MR, Chakrobarty T, Jaman SB, Al Noor M, Sultana R. Reducing urea demand for rice crop through foliar application of urea in Boro season. *Res Agric Livest Fish*. 2016;3(1):79-85.

Ahmad A, Afzal M, Ahmad AUH, Tahir M. Effect of foliar application of silicon on yield and quality of rice (*Oryza sativa* L.).

Song Y, Dong M, Chen F, Hu Y, Zhu Y, Gu J, Chen P, Xie Y, Yuan C, Qiao Z, Yu Y. Effects of nitrogen

fertilizer reduction combined with foliar fertilizer application on the physiological characteristics and yield of high-quality japonica rice. *Int J Plant Prod*. 2024;18(2):239-254.

Osman EAM, El-Masry AA, Khatab KA. Effect of nitrogen fertilizer sources and foliar spray of humic and/or fulvic acids on yield and quality of rice plants. *Adv Appl Sci Res*. 2013;4(4):174-183.

Gewaily EE, Ghoneim AM, Khattab EA. Nano-silicon and nitrogen foliar spray affects the growth, yield, and nutrient content of rice. *World J Agric Sci*. 2019;15(6):367-375.

Yuan L, Wu L, Yang C, Lv Q. Effects of iron and zinc foliar applications on rice plants and their grain accumulation and grain nutritional quality. *J Sci Food Agric*. 2013;93(2):254-261.

Saikh R, Murmu K, Sarkar A, Mondal R, Jana K. Effect of foliar zinc application on growth and yield of rice (*Oryza sativa*) in the Indo-Gangetic Plains of India. *Nusantara Biosci*. 2022;14(2).



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