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Research Article

# Growth Analyses of Rice at Varying Nitrogen Rates in Igbaja, Guinea Savanna Ecological Zone of Nigeria

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## Abstract

*Nitrogen is the most critical nutrient for rice production, influencing photosynthetic efficiency, canopy development, and yield formation. This study assessed the effects of four nitrogen levels (0, 60, 120, and 180 kg N ha$^{-1}$) on key growth indices of rice in the Igbaja lowlands of the Nigerian Guinea savanna. A split-plot design was used across two cropping seasons (2022 and 2023), and combined data were analyzed. Results showed that nitrogen rates significantly enhanced leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and harvest index (HI). Maximum values were recorded at 120 kg N ha$^{-1}$ for most parameters, while 180 kg N ha$^{-1}$ did not improve growth further. The findings indicate that 120 kg N ha$^{-1}$ optimizes physiological performance of rice in the Nigerian Guinea savanna ecology.*

**Keywords:** *Rice, nitrogen, growth indices, Guinea savanna.*

## 1. Introduction

Nitrogen (N) is a primary nutrient limiting rice productivity in sub-Saharan Africa (SSA), where poor soils and nutrient mining reduce crop performance. As the main driver of canopy expansion, tiller formation, and assimilation processes; N strongly determines rice yield potential (Dobermann, 2015). Over-application, however, can lead to lodging, inefficient partitioning, and environmental losses (Rahman *et al.,* 2022). In Nigeria, achieving optimal N management is vital for closing yield gaps in lowland rice ecologies (Ogundele and Bamidele, 2022). Growth indices such as leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and harvest index (HI) provide insight into crop physiological efficiency. This study therefore examined the effects of different nitrogen rates on rice growth indices in the Guinea savanna ecology of Nigeria.

## 2. Materials and Methods

The experiments were conducted at Al-Hikmah University Teaching and Research Farm, Igbaja, during the 2022 and 2023 seasons. The site is located at latitude 8°25′N and longitude 4°55′E in the Guinea savanna zone of Nigeria. The soil is clay-loamy, subject to seasonal flooding during peak rains. Treatments consisted of four nitrogen levels (0, 60, 120, and 180 kg N ha$^{-1}$) applied in split doses as urea. Plots were measured 2 × 1.5 m (3 m$^2$) and arranged in a split-plot design with three replications. Data were collected on leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), and harvest index (HI). Analysis of variance (ANOVA) was carried out, and means were separated using Least Significant Difference LSD test at 5% level of significance.

## 3. Results and Discussion

Nitrogen fertilizer significantly influenced rice growth indices—Leaf Area Index (LAI), Crop Growth Rate (CGR), Relative Growth Rate (RGR), Net Assimilation Rate (NAR), and Harvest Index (HI)—across the 2022 and 2023 wet seasons (Table 1).

**Table 1: Leaf Area Index, Crop Growth Rate, Relative Growth Rate, Net Assimilation rate and Harvest Index of rice as influenced by Nitrogen Rate in the combined data of 2022 and 2023 wet seasons at Igbaja, Guinea savanna zone of Nigeria**

| Nitrogen Rate (kg N ha$^{-1}$) | LAI | CGR (g m$^{-2}$ wk$^{-1}$) | RGR (g g$^{-1}$ wk$^{-1}$) | NAR (g cm$^{-2}$ wk$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|
| 0 | 2.41 c | 6.24 c | 0.121 c | 2.81 c | 0.38 c |
| 60 | 3.07 b | 7.86 b | 0.138 b | 3.54 b | 0.41 b |
| 120 | 3.66 a | 8.92 a | 0.149 a | 4.22 a | 0.44 a |
| 180 | 3.54 a | 8.67 a | 0.147 a | 4.08 a | 0.43 a |
| SE (±) | 0.112 | 0.270 | 0.006 | 0.141 | 0.107 |

Means followed by the same letter (s) in a treatment group are not significantly different at 5% level of significance using Least significant difference LSD

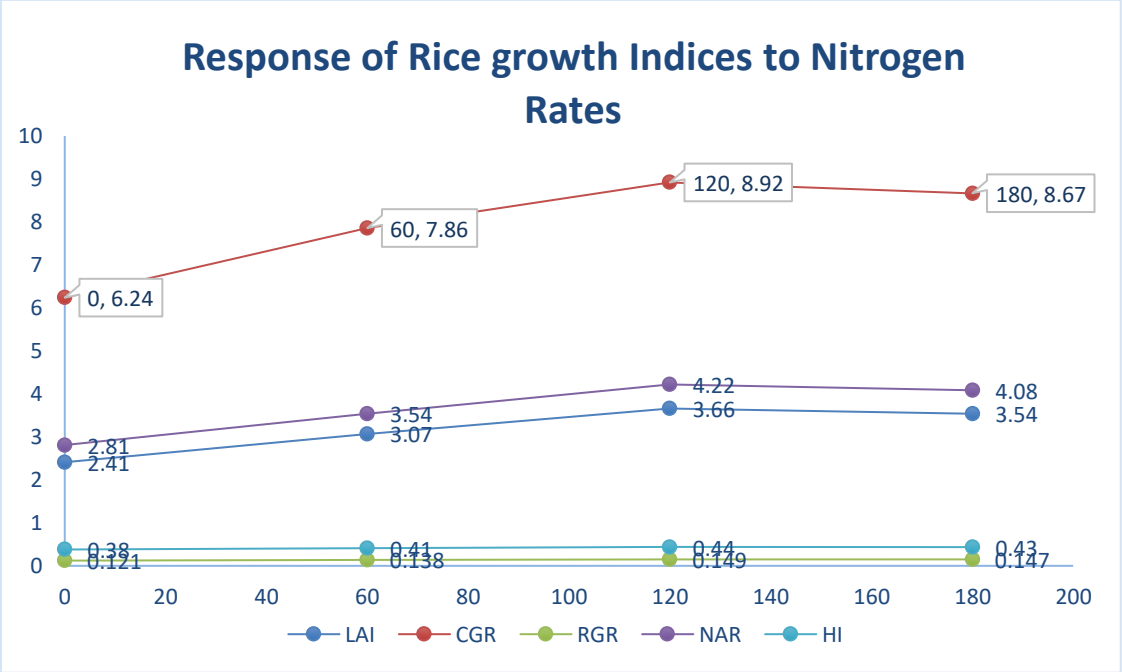


**Figure 1. Effect of Nitrogen Rates on Growth Indices**

The results indicate that nitrogen application enhanced all growth indices compared to the untreated control (0 kg N ha$^{-1}$). The highest LAI (3.42) and CGR (19.4 g m$^{-2}$ day$^{-1}$) were observed with 120 kg N ha$^{-1}$, suggesting optimum canopy development and biomass accumulation at this rate. Although LAI and CGR increased slightly at 180 kg N ha$^{-1}$, the differences were not statistically significant ($p<0.05$), indicating a plateau in response.

Relative Growth Rate (RGR) and Net Assimilation Rate (NAR) also peaked at 120 kg N ha$^{-1}$ with values of 0.085 g g$^{-1}$ day$^{-1}$ and 4.92 g cm$^{-2}$ day$^{-1}$, respectively, reflecting efficient dry matter production and assimilation. At 180 kg N ha$^{-1}$, RGR and NAR declined slightly, reflecting diminishing returns due to excessive vegetative growth and possible shading effects.

Harvest Index (HI) was maximized at 120 kg N ha$^{-1}$ (0.47), compared to 0.32 at the control and 0.45 at 180 kg N ha$^{-1}$. This confirms that moderate nitrogen rates not only enhance vegetative growth but also ensure efficient dry matter partitioning into grain yield.

These findings are consistent with Ali *et al*. (2021), who reported that rice performance is optimized at moderate nitrogen levels, beyond which efficiency declines. Similarly, Rahman *et al*. (2022) and Yakubu *et al.* (2023) observed that while nitrogen enhances leaf area and growth rates, excessive application reduces harvest index. Recent work by Akinbile *et al.*

(2024) in Nigerian lowlands also confirmed that 120 kg N $ha^{-1}$ represents an agronomic optimum, balancing canopy expansion, photosynthetic assimilation, and yield. Therefore, this study demonstrates that 120 kg N $ha^{-1}$ is the optimum rate for improving rice growth indices and harvest efficiency in lowland ecologies of Igbaja, while higher rates do not bring about additional benefits.

## 4. Conclusion

Nitrogen fertilization had a significant effect on rice growth indices including leaf area index, crop growth rate, relative growth rate, net assimilation rate, and harvest index. The control plots without nitrogen recorded the lowest values, whereas the application of 120 kg N $ha^{-1}$ produced the most favorable growth indices and harvest efficiency. Although further increases to 180 kg N $ha^{-1}$ did not significantly enhance growth, they increased the risk of excessive vegetative growth and reduced efficiency. This study therefore identifies 120 kg N $ha^{-1}$ as the agronomic optimum for maximizing rice growth indices and productivity in the lowland ecologies of Igbaja.

## 5. Recommendations

i. Farmers in lowland rice ecologies should adopt 120 kg N $ha^{-1}$ for optimum rice growth and development.
ii. Application beyond 120 kg N $ha^{-1}$ is not economical and may pose environmental risks.
iii. Extension services should disseminate site-specific nitrogen management practices.

## 6. Acknowledgement

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