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Yield of Rice As Influenced By Plant Population Density in Igbaja, Guinea Savanna Ecological Zone of Nigeria

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ABSTRACT **Original research paper**

Optimizing plant population density is critical for improving rice productivity in sub-Saharan Africa, where yield gaps persist due to suboptimal crop management. Two experiments were conducted during the wet seasons of 2022 and 2023, to evaluate the effect of three plant population densities (444,444, 250,000 and 160,000 plants ha-1, achieved at 15cm × 15 cm, 20 × 20 cm, and 25 × 25 cm spacing levels, respectively) on key yield components and grain yield of lowland rice (Oryza sativa L.) in Igbaja, Guinea savanna ecological zone of Nigeria. A split-plot design was used, and data were analyzed for combined years. Results showed that higher plant population density of 444,444 plants ha-1 significantly increased tiller count and panicles per stand, but intermediate density of 250,000 plants ha-1 produced the highest grain yield (5.23 t ha^{-1}). Low plant density of 160,000 plants ha-1produced more spike per panicle and heavier grains (1000-grain weight), but resulted to lower yield per hectare. These findings suggest that an intermediate density of 250,000 plants ha-1 optimizes rice yield under the Guinea savanna ecology.

Keywords: Rice yield, Planting density, Igbaja, Guinea savanna.

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1. Introduction

Rice is a staple crop in sub-Saharan Africa, contributing to food security and livelihoods. In Nigeria, demand for rice continues to rise, yet yield per hectare remains below the global average (FAO, 2023). Optimizing agronomic practices, particularly plant population density, has been shown to enhance yield through better resource use efficiency (Singh *et al.*, 2019; Ali *et al.*, 2021). Plant density directly influences tiller formation, panicle production, grain filling, and ultimately yield (Adigbo*et al.*, 2021). High densities increase competition for light and nutrients, while low densities reduce tiller and panicle production per unit area (Rahman *et al.*, 2022). Thus, identifying an optimal density is critical for the Guinea savanna zone, where lowland rice is constrained by both weed pressure and nutrient limitations. This study investigates the influence of three planting densities on yield attributes such as tiller number, panicles per stand, and spikes per panicle, 1000-grain weight, and

grain yield in order to recommend an optimum spacing for farmers in Igbaja lowlands.

2. Materials and Methods

The experiment was conducted at Al-Hikmah University Teaching and Research Farm, Igbaja, Nigeria, during the 2022 and 2023 wet seasons. The site is located in the Guinea savanna ecology (latitude 8°25′N, longitude 4°55′E). Soils are clay-loamy with seasonal flooding during peak rains. A split-plot design was used with three plant population densities: 444,444 plants ha^{-1}(high density), 250,000 plants ha^{-1}(intermediate density), and 160,000 plants ha^{-1}(low density). Each treatment was replicated three times. Sub-plot size was 2m × 1.5m ($3m^2$). Standard agronomic practices were followed, including basal fertilizer (NPK 60:30:30 kg ha^{-1}) and supplementary nitrogen. Data collected include tiller count (m^{-2}), panicles per stand, spikes per panicle, 1000-grain weight (g) adjusted to 14% moisture, and grain yield (t ha^{-1}). Analysis of variance (ANOVA) was performed using combined year data, and means were separated with DNMRT at 5% level of significance.

3. Results and Discussion

Table 1 show that plant population density significantly influenced rice tiller formation, panicle production, spike formation, grain weight, and final yield across the combined seasons of 2022 and 2023. The plant density of 444,444 plants ha^{-1} recorded the highest tiller count (336 m^{-2}) and panicles per stand (14.6), indicating vigorous vegetative growth at higher density. However, this did not translate into superior yield, likely due to intense intra-specific competition.

The density of250,000 plants ha^{-1} produced the highest grain yield (5.23 t ha^{-1}), despite moderate tiller numbers (278 m^{-2}) and panicle counts (12.8). This suggests that intermediate spacing allowed rice plants to balance vegetative growth with assimilate partitioning into reproductive structures. The spike number per panicle (65) and grain weight (27.4 g per 1000 grains) also supported higher yield at this density.

The plant density of 160,000 plants ha^{-1}gave fewer tillers (189 m^{-2}) and panicles (9.4), but the spikes per panicle (75) and 1000-grain weight (28.8 g) were highest, reflecting better resource availability per plant but poor yield potential (2.81 t ha^{-1}) due to lower stand density (Figures 1 and 2).

These findings align with Oladosu *et al.* (2018) who emphasized that optimum plant density improves canopy light interception and assimilate use efficiency in rice. Ndungu et al. (2021) and Okafor*et al*. (2022) also observed that moderate density maximizes yield by balancing interplant competition and reproductive efficiency. More recent studies in Nigeria (Yakubu *et al*., 2023; Akinbile*et al*., 2024) confirmed that closer spacing enhances tillering, but intermediate spacing ensures sustainable yield levels. Thus, this study highlights that while high plant density favors vegetative growth, yield optimization in lowland rice depends more on balanced intermediate density of 250,000 plants ha^{-1} that enhances both panicle formation and grain filling.

4. Conclusion

The results demonstrated that rice yield and yield components were strongly influenced by planting density. Closer spacing promoted higher tiller numbers, panicle production, and ultimately increased grain yield, while wider spacing reduced competition but also reduced yield potential. The findings confirm that moderate plant densities provide the best balance between resource use efficiency and yield. Therefore, rice farmers in lowland ecologies such as Igbaja are encouraged to adopt optimum plant density to maximize productivity and ensure sustainable returns.

5. Recommendations

i. Farmers in lowland rice ecologies of Nigeria should adopt 250,000 plants ha^{-1} for balanced growth and optimum yield.
ii. Further studies should integrate spacing with nitrogen fertilizer and herbicide regimes to refine site-specific recommendations.
iii. Extension agencies should disseminate guidelines on proper plant population management to reduce yield gaps.

6. Acknowledgement

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Table 1: Tiller count, panicles per stand, spikes per panicle, 1000-grain weight and grain yield of rice as influenced by plant population density in the combined data of 2022 and 2023 wet seasons at Igbaja, Guinea savanna zone of Nigeria

Plant Density plants ha^{-1}	Tiller Count (m^{-2})	Panicles Stand^{-1}	Spikes Panicle^{-1}	1000-Grain Weight (g)	Grain Yield (t ha^{-1})
444,444	336 a	14.6 a	54 c	26.7 c	4.41 b
250,000	278 b	12.8 b	65 b	27.4 b	5.23 a
160,000	189 c	9.4 c	75 a	28.8 a	2.81 c
SE (±)	**12.41**	**0.572**	**2.311**	**0.460**	**0.182**

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

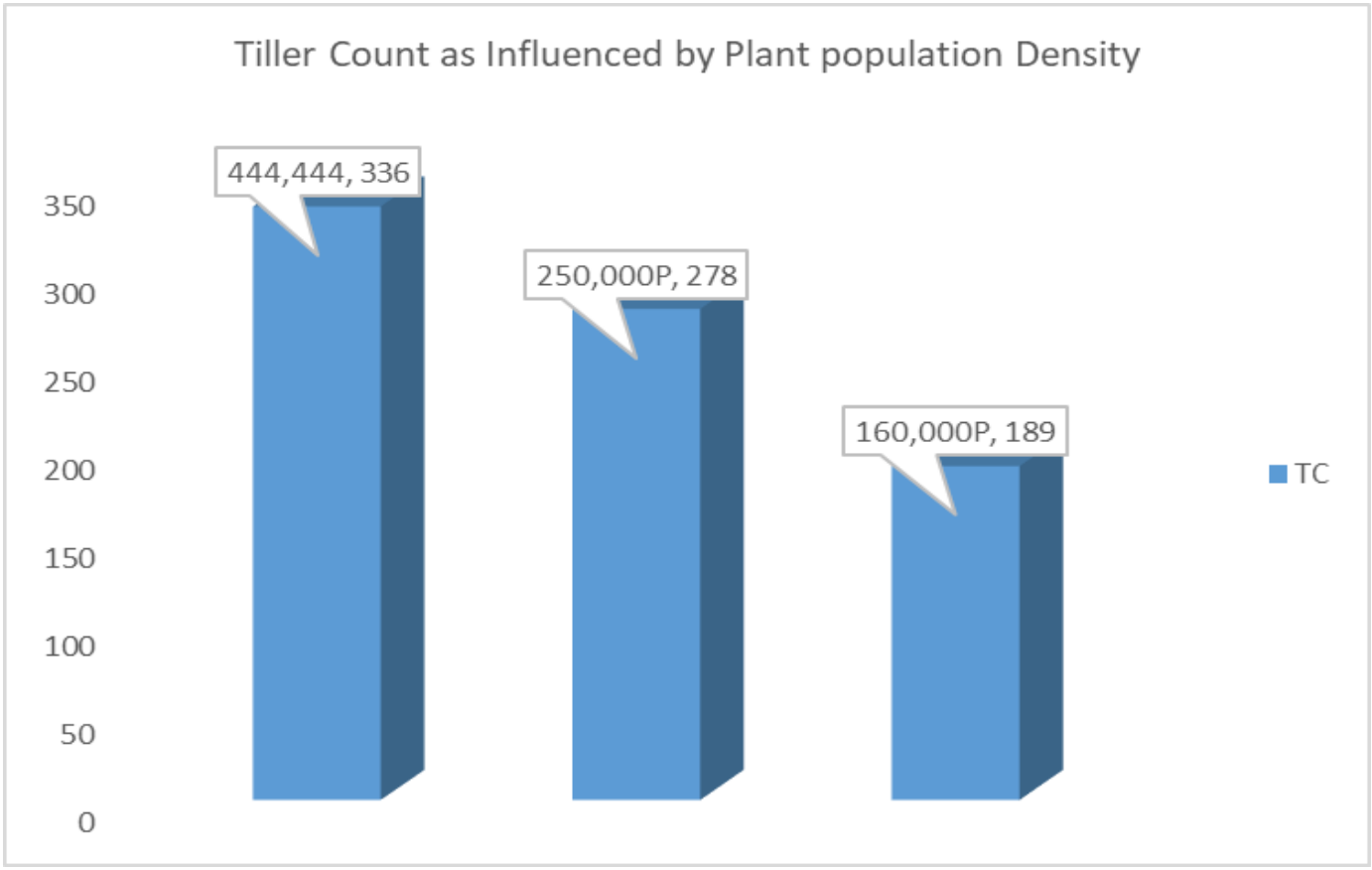

Figure 1: Tiller count per plot m^{-2} as influenced by Plant population density

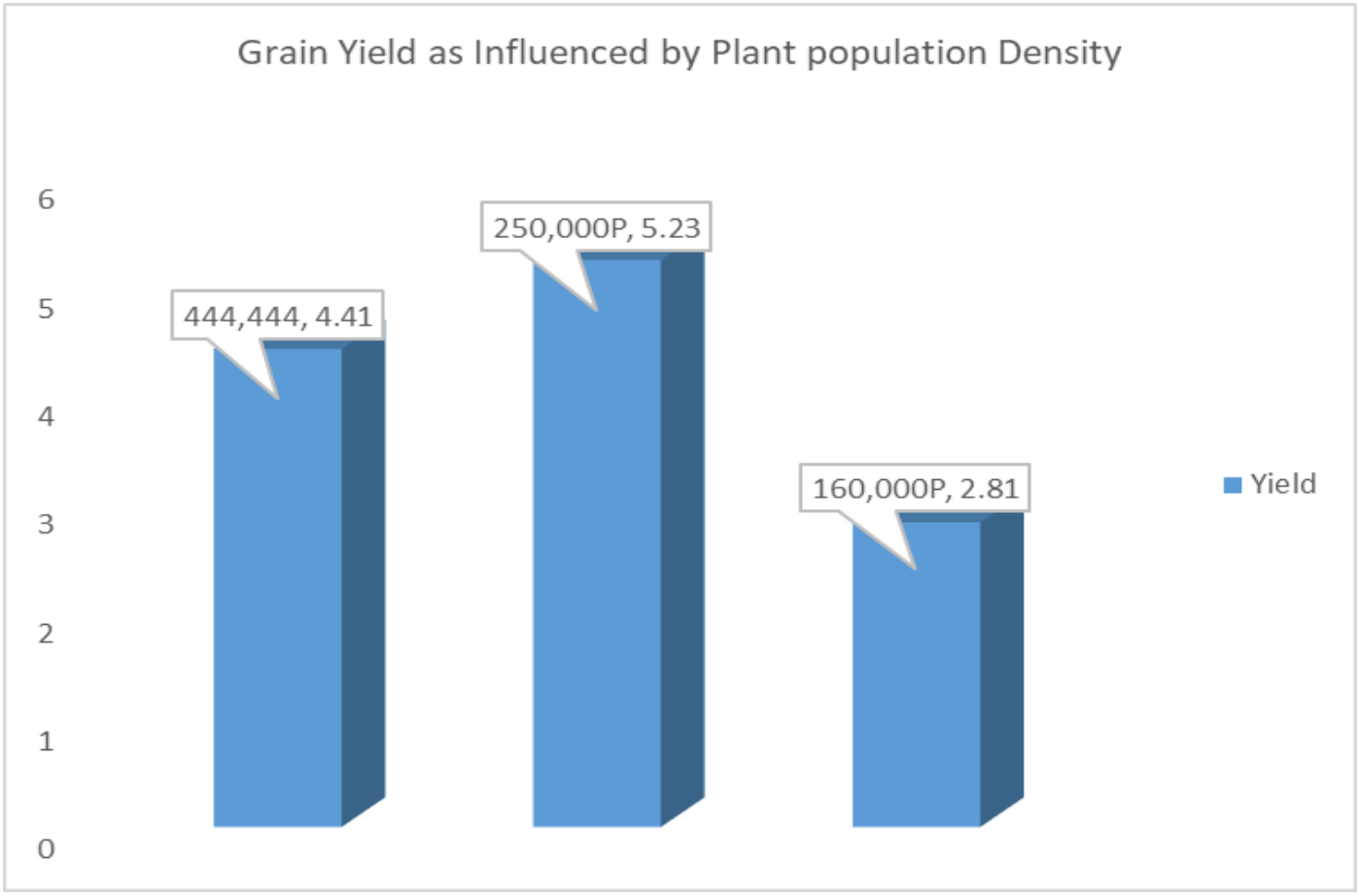

Figure 2: Grain yield (t ha^{-1}) as influenced by Plant population density