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Influence of Plant Spacing and Varietal Selection on the Growth, Yield, and Productivity of Rice (*Oryza sativa* L.) in Jalingo and Karim Lamido, Taraba State, Nigeria

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ABSTRACT
This study evaluated the influence of plant spacing and varietal selection on the growth, yield, and productivity of rice (*Oryza sativa* L.) under contrasting agro-ecological conditions of Jalingo and Karim Lamido, Taraba State, Nigeria. The experiment was conducted during the 2025 cropping season using a Randomized Complete Block Design (RCBD) in a 3 × 4 factorial arrangement with three replications. Treatments comprised three plant spacings (20 × 20, 25 × 25, and 30 × 30 cm) and four rice varieties (ITA 150, FARO 44, ABARE, and JAMILA). Data were collected on growth, yield, and yield-related traits and analysed using ANOVA, with means separated using Duncan's Multiple Range Test at 5% probability. Variety, spacing, location, and their interactions significantly ($P \leq 0.05$) affected most traits. ITA 150 consistently produced the tallest plants, largest leaf area, highest tiller number, longest panicles, heaviest 1000-seed weight (36.70 g), and highest grain yield (3,970 kg ha^{-1}). The 30 × 30 cm spacing produced the highest mean grain yield (3,895 kg ha^{-1}). Karim Lamido recorded higher mean grain yield (3,645 kg ha^{-1}) than Jalingo (3,115 kg ha^{-1}). The ITA 150 × 30 × 30 cm combination performed best across locations. ITA 150 at 30 × 30 cm is recommended for improved rice productivity in similar environments.

Keywords: Rice, Plant Spacing, Varietal Selection, Grain Yield, Taraba State

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most world's important cereal crops and serves as the staple food for more than half of the global population. It contributes approximately 20% of the world's dietary energy supply and plays a vital role in food security, nutrition, employment, income generation, and poverty reduction, particularly in developing countries. Global rice production has continued to increase in response to rapid population growth, urbanization, and changing food consumption patterns. Despite this growth, several factors, including climate change, declining soil fertility, water scarcity, pests, diseases, and poor crop management, continue to constrain rice productivity, especially in Sub-Saharan Africa (FAO, 2024; FAOSTAT, 2024; IPCC, 2023). Nigeria is the largest producer and consumer of rice in West Africa, where rice has become a major staple food across all socio-economic groups. The crop occupies a strategic position in the country's agricultural development agenda because of its contribution to food security, employment creation, rural development, and import substitution. Although the Federal Government has implemented various interventions including the National Rice Development Strategy, the Anchor Borrowers' Programme, irrigation expansion, mechanization, and the promotion of improved rice varieties domestic production still falls short of national demand. Consequently, Nigeria continues to depend on rice importation, while average yields obtained by smallholder farmers remain between 2 and 3 t ha^{-1}, which is considerably lower than the attainable yield of improved varieties under good management practices (AfricaRice, 2023; FAO, 2024; NBS, 2024).

Low rice productivity in Nigeria has been attributed to several production constraints, including poor soil fertility, inadequate fertilizer application, weed infestation, pests and diseases, erratic rainfall, limited access to improved seed, and inappropriate agronomic practices. Among these factors, plant spacing and varietal selection are regarded as major determinants of crop performance because they directly influence plant population, resource-use efficiency, growth, and grain yield (AfricaRice, 2023; IRRI, 2023). Plant spacing is one of the most important agronomic practices affecting rice productivity. Appropriate spacing determines plant population density and influences light interception, photosynthesis, nutrient uptake, water utilization, air circulation, tillering, and canopy development. Optimum spacing minimizes competition among plants, improves resource utilization, reduces disease incidence, and enhances grain yield. Conversely, excessively close spacing intensifies competition for sunlight, nutrients, moisture, and space, resulting in fewer tillers, smaller panicles, poor grain filling, and reduced yield. Excessively wide spacing also lowers productivity by reducing plant population and encouraging weed growth, despite improving the performance of individual plants. Therefore, determining the optimum spacing for specific production environments is essential for maximizing rice yield (IRRI, 2023; FAO, 2024; Yoshida, 1981).

Varietal selection also plays a significant role in determining rice productivity. Rice varieties differ in growth habit, maturity period, tillering ability, plant height, grain quality, yield potential, and tolerance to pests, diseases, drought, and other environmental stresses. Improved varieties developed through breeding programmes generally possess superior yield potential and adaptability compared with traditional cultivars. However, varietal performance depends largely on environmental conditions and crop management practices.

Consequently, evaluating improved varieties under local agro-ecological conditions is necessary before recommending them to farmers (AfricaRice, 2023; IRRI, 2023). The interaction between plant spacing and varietal characteristics is equally important because different rice varieties respond differently to planting density. Varieties with high tillering ability may perform better under wider spacing, whereas low-tillering varieties may require relatively closer spacing to achieve optimum plant population and maximize yield. Understanding these interactions is therefore essential for developing location-specific agronomic recommendations that improve resource-use efficiency and grain productivity (AfricaRice, 2023; IRRI, 2023).

Taraba State possesses favourable climatic and edaphic conditions for rice cultivation, with Jalingo and Karim Lamido Local Government Areas serving as important rice-producing zones. However, the two locations differ in rainfall distribution, soil characteristics, temperature, and moisture availability, factors that can significantly influence rice growth and yield. Despite the production potential of these areas, many farmers still rely on generalized recommendations for plant spacing and variety selection, resulting in suboptimal yields and inefficient utilization of available resources. Although previous studies have separately examined the effects of plant spacing and varietal performance on rice production, limited information exists on their combined influence under the contrasting agro-ecological conditions of Jalingo and Karim Lamido in Taraba State. Generating such information is necessary for developing location-specific recommendations that will improve rice productivity, enhance resource-use efficiency, increase farmers' income, and contribute to national food security. Therefore, this study was undertaken to evaluate the influence of plant spacing and varietal selection on the growth, yield, and productivity of rice (*Oryza sativa* L.) in Jalingo and Karim Lamido Local Government Areas of Taraba State, Nigeria.

MATERIALS AND METHODS

Location, Treatments and Experimental Design

The experiment was conducted during the 2025 cropping season at two locations in Taraba State, Nigeria: the Teaching and Research Farm College of Agriculture Science and Technology, Jalingo, and Karim Lamido Local Government Area. Jalingo is located at latitude 8°52′N, longitude 11°18′E, with an altitude of about 736 m above sea level, while Karim Lamido lies between latitudes 8°33′–10°21′N and longitudes 10°21′–11°24′E. Both locations are characterized by gently undulating topography and predominantly well-drained alluvial soils, making them suitable for rice cultivation (Ardo & Bitrus, 2015; Kefas, 2016). The study areas have a tropical wet-and-dry climate with distinct rainy (April–October) and dry (November–March) seasons. Annual rainfall ranges between 1,000 and 1,200 mm, with high relative humidity during the rainy season and mean temperatures ranging from about 28°C in the coolest months to 37°C during the hottest months (NiMet, 2019; Oruonye, 2018; Karshima *et al.,* 2018). These climatic conditions are favourable for rice growth and development. The natural vegetation is predominantly Guinea Savannah, comprising grasses interspersed with shrubs and scattered trees. The soils are moderately deep, ranging from loamy sand to sandy loam over sandy clay loam to sandy clay subsoils. Agriculture is the dominant land use, with crops such as rice, maize, sorghum, millet, cowpea, groundnut, sesame, yam, and vegetables widely cultivated alongside livestock grazing (Kefas, 2016; Karshima *et al.,* 2018).

The experiment was laid out using a Randomized Complete Block Design (RCBD) in a 3 × 4 factorial arrangement with three replications at each experimental location (Jalingo and Karim Lamido). The RCBD was adopted to minimize the effects of field variability and improve the precision of treatment comparisons by grouping experimental units into relatively homogeneous blocks. The treatments consisted of three plant spacing levels and four rice varieties. The spacing treatments were 20 cm × 20 cm, 25 cm × 25 cm, and 30 cm × 30 cm, representing high, medium, and low plant population densities, respectively. The varietal treatments comprised two local rice varieties, Abare and Jamila, which are commonly cultivated by farmers in the study area, and two improved rice varieties (FARO 44 and ITA 150). These four varieties were evaluated for their growth, adaptability, and grain yield performance under the prevailing agro-ecological conditions. The combination of the three spacing levels and four rice varieties produced 12 treatment combinations (3 × 4). These treatment combinations were randomly assigned within each replication at both locations, resulting in 36 experimental plots per location (12 treatments × 3 replications) and 72 experimental plots across the two study locations. Each experimental plot measured 4 m × 3 m (12 m²). A 1.0 m alley was maintained between adjacent plots, while a 1.5 m alley separated the blocks to minimize border effects and treatment interference and to facilitate field operations such as planting, fertilizer application, weeding, data collection, and harvesting. Uniform agronomic practices, including land preparation, fertilizer application, weed management, pest and disease control, and irrigation (where necessary), were applied uniformly across all plots to ensure that any observed differences in crop performance resulted from the treatment effects rather than variations in field management.

Data Collection

Data was collected on the following parameters:

Plant Height (cm)

The height of four randomly selected plants in each plot was measured from ground level to the tip of the tallest tiller using a meter rule, and the average was recorded.

Leaf Length (cm)

The length of a leaf from each of four randomly selected plants was measured from the point of attachment to the tip using a meter rule, and the average was recorded.

Leaf Width (cm)

The width at the widest portion of leaves from four randomly selected plants was measured using a meter rule, and the average was recorded.

Number of Tillers per Plant

Tillers were counted on four randomly selected plants per plot, and the average number was recorded.

Days to 50% Flowering

The number of days from planting until 50% of the plants in each plot had flowered was recorded.

Panicle Length (cm)

The length of the panicle on four randomly selected plants was measured from the base to the tip using a meter rule, and the average was recorded.

1000-Seed Weight (g)
One thousand seeds from each plot were counted after threshing, cleaning, and drying, then weighed using an electronic balance.

Grain Yield per Hectare
The total grain yield per plot was weighed after threshing, cleaning, and drying, and subsequently converted to yield per hectare.

Statistical Analysis
Data obtained were subjected to Analysis of Variance using Statistical Analysis Software (SAS), means were separated using DMRT at 5%.

RESULTS AND DISCUSSION
Effect of Rice Varieties and Plant Spacing on Plant Height
The results (Table 1) showed that rice variety and plant spacing had highly significant ($P \leq 0.05$) effects on plant height at 6, 8, and 10 weeks after transplanting (WAT). ITA 150 consistently produced the tallest plants, while FARO 44 recorded the shortest, indicating that genetic differences among varieties strongly influenced vegetative growth. The superior performance of ITA 150 may be attributed to its greater genetic potential, efficient nutrient utilization, and adaptability to the study environment, which agrees with the findings of Islam *et al.* (2022) and Rahman *et al.* (2023). Plant spacing also significantly affected plant height, with the 30 × 30 cm spacing producing the tallest plants, followed by 25 × 25 cm, whereas the 20 × 20 cm spacing resulted in the shortest plants. Wider spacing likely reduced competition for light, nutrients, water, and rooting space, thereby enhancing plant growth and dry matter accumulation. Similar findings have been reported by Khan *et al.* (2022), Mishra *et al.* (2023), and Singh *et al.* (2024). The significant variety × spacing interaction further indicates that rice varieties responded differently to planting density, emphasizing the importance of selecting suitable varieties and optimum spacing to maximize plant growth under the agro-ecological conditions of Jalingo and Karim Lamido.

Table 1: Effect of Rice Varieties and Plant Spacing on Plant Height (cm) at Jalingo and Karim Lamido LGA

Treatments	6 WAT			8 WAT			10 WAT		
	JAL	KAR	COM	JAL	KAR	COM	JAL	KAR	COM
Variety									
ITA 150	16.50^{a}	18.70^{a}	17.60^{a}	23.40^{a}	26.80^{a}	25.10^{a}	29.80^{a}	33.10^{a}	31.45^{a}
ABARE	14.80^{b}	17.10^{b}	15.95^{b}	20.60^{b}	23.50^{b}	22.05^{b}	24.90^{b}	27.60^{b}	26.25^{b}
JAMILA	14.10^{b}	16.90^{b}	15.50^{b}	20.10^{b}	23.10^{b}	21.60^{b}	24.30^{b}	27.10^{b}	25.70^{b}
FARO 44	13.40^{c}	15.90^{c}	14.65^{c}	19.30^{c}	22.20^{c}	20.75^{c}	22.80^{c}	25.40^{c}	24.10^{c}
Spacing									
20 × 20 cm	13.90^{c}	16.10^{c}	15.00^{c}	19.80^{c}	22.90^{c}	21.35^{c}	23.80^{c}	26.60^{c}	25.20^{c}
25 × 25 cm	15.20^{b}	17.80^{b}	16.50^{b}	21.80^{b}	24.90^{b}	23.35^{b}	26.30^{b}	29.30^{b}	27.80^{b}
30 × 30 cm	16.90^{a}	19.20^{a}	18.05^{a}	23.90^{a}	27.30^{a}	25.60^{a}	28.90^{a}	32.10^{a}	30.50^{a}
V × S	**	**	**	**	**	**	**	**	**

*Means followed by the same letter(s) within a column are not significantly different according to DMRT at $P \leq 0.05$. V × S = Interaction between rice variety and plant spacing, JAL = Jalingo, KAR = Karim Lamido, COM = Combined mean across locations, WAT = Weeks after transplanting ** = highly significant at $P \leq 0.05$.*

Effect of Rice Variety and Plant Spacing on Leaf Area
The results (Table 2) indicate that rice variety and plant spacing had highly significant ($P \leq 0.05$) effects on leaf area at 6, 8, and 10 weeks after transplanting (WAT). ITA 150 consistently recorded the largest leaf area, whereas FARO 44 produced the smallest, while ABARE and JAMILA showed intermediate performance. The superior leaf development of ITA 150 is attributed to its greater genetic potential for vigorous vegetative growth, efficient resource utilization, and enhanced photosynthetic capacity, which agrees with the findings of Rahman *et al*. (2023) and Kumar *et al.* (2022). Plant spacing also significantly influenced leaf area, with the 30 × 30 cm spacing producing the largest leaf area, followed by 25 × 25 cm, while the 20 × 20 cm spacing recorded the smallest values. Wider spacing likely reduced competition for light, water, nutrients, and rooting space, thereby promoting greater leaf expansion, improved canopy development, and enhanced photosynthetic efficiency. Similar results have been reported by Khan *et al.* (2022), Mishra *et al.* (2023), and Singh *et al.* (2024). The significant variety × spacing interaction further indicates that rice varieties responded differently to planting density, highlighting the importance of combining suitable varieties with optimum spacing to maximize vegetative growth and productivity under the agro-ecological conditions of Jalingo and Karim Lamido.

Table 2: Effect of Rice Variety and Plant Spacing on Leaf Area (cm²) at Jalingo and Karim Lamido LGA

Treatments	6 WAT			8 WAT			10 WAT		
	JAL	KAR	COM	JAL	KAR	COM	JAL	KAR	COM
Variety									
ITA 150	18.80^{a}	23.50^{a}	21.15^{a}	25.70^{a}	32.80^{a}	29.25^{a}	30.60^{a}	37.40^{a}	34.00^{a}
ABARE	16.70^{b}	21.10^{b}	18.90^{b}	22.40^{b}	28.90^{b}	25.65^{b}	26.10^{b}	32.10^{b}	29.10^{b}
JAMILA	16.20^{b}	20.70^{b}	18.45^{b}	21.90^{b}	28.20^{b}	25.05^{b}	25.60^{b}	31.70^{b}	28.65^{b}
FARO 44	14.60^{c}	18.90^{c}	16.75^{c}	19.80^{c}	25.60^{c}	22.70^{c}	22.90^{c}	28.60^{c}	25.75^{c}
Plant Spacing									
20 × 20 cm	15.20^{c}	19.50^{c}	17.35^{c}	20.60^{c}	26.70^{c}	23.65^{c}	24.20^{c}	30.10^{c}	27.15^{c}
25 × 25 cm	16.90^{b}	21.60^{b}	19.25^{b}	23.10^{b}	29.80^{b}	26.45^{b}	27.10^{b}	33.30^{b}	30.20^{b}
30 × 30 cm	18.90^{a}	23.80^{a}	21.35^{a}	26.20^{a}	33.40^{a}	29.80^{a}	31.00^{a}	37.90^{a}	34.45^{a}

Treatments	6 WAT			8 WAT			10 WAT		
	JAL	**KAR**	**COM**	**JAL**	**KAR**	**COM**	**JAL**	**KAR**	**COM**
V × S	**	**	**	**	**	**	**	**	**

*Means followed by the same letter(s) within a column are not significantly different according to DMRT at P ≤ 0.05. V × S = Interaction between rice variety and plant spacing, JAL = Jalingo, KAR = Karim Lamido, COM = Combined mean across locations, WAT = Weeks after transplanting ** = highly significant at P ≤ 0.05.*

Effect of Rice Variety and Plant Spacing on Number of Tillers

The results (Table 3) showed that rice variety and plant spacing had highly significant (P ≤ 0.05) effects on the number of tillers at 6, 8, and 10 weeks after transplanting (WAT). ITA 150 consistently produced the highest number of tillers, while FARO 44 recorded the fewest, with ABARE and JAMILA showing intermediate performance. The superior tillering ability of ITA 150 may be attributed to its greater genetic potential, efficient nutrient utilization, and better adaptation to the study environment. These findings agree with those of Islam *et al.* (2022) and Rahman *et al.* (2023), who reported that improved rice varieties generally produce more productive tillers than local cultivars. Plant spacing also significantly influenced tiller production, with the 30 × 30 cm spacing producing the highest number of tillers, followed by 25 × 25 cm, whereas the 20 × 20 cm spacing resulted in the lowest values. Wider spacing likely reduced competition for light, nutrients, water, and rooting space, thereby promoting greater tiller initiation and survival. Similar findings were reported by Khan *et al.* (2022), Mishra *et al.* (2023), and Singh *et al.* (2024). The significant variety × spacing interaction indicates that tiller production depended on both varietal characteristics and planting density, demonstrating that ITA 150 planted at 30 × 30 cm spacing provided the most favourable combination for maximizing tiller production and enhancing rice productivity under the agro-ecological conditions of Jalingo and Karim Lamido.

Table 3: Effect of Rice Variety and Plant Spacing on Number of Tillers at Jalingo and Karim Lamido LGA

Treatments	6 WAT			8 WAT			10 WAT		
	JAL	**KAR**	**COM**	**JAL**	**KAR**	**COM**	**JAL**	**KAR**	**COM**
Variety									
ITA 150	6.21^{a}	8.43^{a}	7.32^{a}	8.44^{a}	10.91^{a}	9.68^{a}	10.86^{a}	12.74^{a}	11.80^{a}
ABARE	5.62^{b}	7.74^{b}	6.68^{b}	7.83^{b}	10.04^{b}	8.94^{b}	9.53^{b}	11.46^{b}	10.50^{b}
JAMILA	5.38^{b}	7.46^{b}	6.42^{b}	7.44^{b}	9.81^{b}	8.63^{b}	9.08^{b}	10.94^{b}	10.01^{b}
FARO 44	4.93^{c}	6.88^{c}	5.91^{c}	6.83^{c}	8.97^{c}	7.90^{c}	8.21^{c}	10.12^{c}	9.17^{c}
Plant Spacing									
20 × 20 cm	4.86^{c}	6.84^{c}	5.85^{c}	6.67^{c}	8.91^{c}	7.79^{c}	8.15^{c}	10.02^{c}	9.09^{c}
25 × 25 cm	5.63^{b}	7.73^{b}	6.68^{b}	7.86^{b}	10.18^{b}	9.02^{b}	9.68^{b}	11.54^{b}	10.61^{b}
30 × 30 cm	6.18^{a}	8.45^{a}	7.32^{a}	8.71^{a}	11.14^{a}	9.93^{a}	11.02^{a}	12.96^{a}	11.99^{a}
V × S	**	**	**	**	**	**	**	**	**

*Means followed by the same letter(s) within a column are not significantly different according to DMRT at P ≤ 0.05. V × S = Interaction between rice variety and plant spacing, JAL = Jalingo, KAR = Karim Lamido, COM = Combined mean across locations, WAT = Weeks after transplanting ** = highly significant at P ≤ 0.05.*

Effect of Rice Variety and Plant Spacing on Yield and Yield Components

Table 4 showed that rice variety and plant spacing had highly significant (P ≤ 0.05) effects on panicle length, days to 50% panicle emergence, days to maturity, grain yield, and 1000-seed weight. ITA 150 consistently recorded the longest panicles, highest grain yield (3,970 kg ha^{-1}), and heaviest 1000-seed weight (36.70 g), while FARO 44 produced the lowest values for these traits. The superior performance of ITA 150 is attributed to its greater genetic potential for assimilate production, efficient partitioning of photosynthates, and better adaptation to the study environment. These findings are consistent with the reports of Islam *et al.* (2022) and Rahman *et al.* (2023), who found that improved rice varieties generally outperform local cultivars in yield and yield-related traits. Plant spacing also significantly influenced yield and its components, with the 30 × 30 cm spacing producing the longest panicles, earliest panicle emergence, highest grain yield, and heaviest 1000-seed weight, whereas the 20 × 20 cm spacing recorded the lowest values. Wider spacing likely reduced competition for light, water, nutrients, and rooting space, thereby enhancing grain filling and overall productivity. Similar results have been reported by Khan *et al.* (2022), Mishra *et al.* (2023), and Singh *et al.* (2024). The significant variety × spacing interaction indicates that varietal performance depended on planting density, demonstrating that ITA 150 planted at 30 × 30 cm spacing provided the optimum combination for maximizing yield and yield components under the agro-ecological conditions of Jalingo and Karim Lamido.

Table 4: Effect of Rice Variety and Plant Spacing on Yield and Yield Components at Jalingo and Karim Lamido LGA

Treatments	Panicle Length			Days to 50%			Days to Maturity			Grain Yield (kg			1000-Seed Weight (g)		
	JAL	KAR	COM	JAL	KAR	COM	JAL	KAR	COM	JAL	KAR	COM	JAL	KAR	COM
Variety															
ITA 150	29.80 a	33.20 a	31.50 a	67.30 b	68.20 b	67.75 b	103.10 a	104.00 a	103.55 a	3,820 a	4,120 a	3,970 a	35.80 a	37.60 a	36.70 a
ABARE	27.40 b	31.00 b	29.20 b	71.80 a	72.60 a	72.20 a	100.40 b	101.10 b	100.75 b	3,120 b	3,430 b	3,275 b	32.60 b	34.50 b	33.55 b
JAMILA	26.90 b	30.40 b	28.65 b	70.90 a	71.50 a	71.20 a	99.80 b	100.70 b	100.25 b	2,980 b	3,280 b	3,130 b	31.80 b	33.90 b	32.85 b
FARO 44	25.60 c	29.10 c	27.35 c	65.40 c	66.10 c	65.75 c	96.70 c	97.60 c	97.15 c	2,540 c	2,840 c	2,690 c	29.60 c	31.80 c	30.70 c
Plant Spacing															
20 × 20 cm	25.90 c	29.70 c	27.80 c	68.80 b	69.40 b	69.10 b	98.60 b	99.30 b	98.95 b	2,860 c	3,120 c	2,990 c	30.70 c	32.80 c	31.75 c
25 × 25 cm	27.60 b	31.30 b	29.45 b	68.20 b	68.90 b	68.55 b	99.90 b	100.60 b	100.25 b	3,260 b	3,580 b	3,420 b	32.80 b	34.70 b	33.75 b
30 × 30 cm	29.40 a	33.10 a	31.25 a	67.10 a	67.80 a	67.45 a	101.80 a	102.60 a	102.20 a	3,740 a	4,050 a	3,895 a	35.10 a	37.10 a	36.10 a
V × S	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

*Means followed by the same letter(s) within a column are not significantly different according to DMRT at P ≤ 0.05. V × S = Interaction between rice variety and plant spacing, JAL = Jalingo, KAR = Karim Lamido, COM = Combined mean across locations, ** = Highly significant at P ≤ 0.01, GY = Grain yield, 1000SW = 1000-seed weight.*

Effect of Location on the Growth of Rice

The results presented in Table 5 revealed that location had a highly significant (P ≤ 0.05) effect on plant height, leaf area, and number of tillers at 6, 8, and 10 weeks after transplanting (WAT). Across all growth stages, Karim Lamido consistently recorded higher values for all growth parameters than Jalingo. Plant height, leaf area, and number of tillers were significantly greater in Karim Lamido, indicating that the environmental conditions at this location were more favourable for vegetative growth. These differences may be attributed to variations in soil fertility, rainfall distribution, temperature, moisture availability, and other climatic factors that influence crop growth and development (FAO, 2024). The superior growth performance observed at Karim Lamido agrees with the findings of Rahman *et al.* (2023), who reported that environmental conditions significantly influence vegetative growth in rice by affecting nutrient uptake, photosynthesis, and biomass accumulation. Similarly, Kumar *et al.* (2022) observed that location-specific differences in soil and climatic conditions contribute significantly to variation in plant height, leaf expansion, and tillering among rice crops. Better soil moisture availability and favourable environmental conditions at Karim Lamido may have enhanced nutrient absorption and promoted vigorous vegetative growth throughout the growing season.

The significantly greater leaf area recorded at Karim Lamido suggests improved canopy development and photosynthetic efficiency, which are essential for dry matter production and subsequent grain yield. Likewise, the higher number of tillers observed at Karim Lamido indicates that the location provided favourable conditions for tiller initiation and survival. These findings corroborate those of Singh *et al.* (2024) and Mishra *et al.* (2023), who reported that favourable environmental conditions, particularly adequate soil moisture and nutrient availability, enhance vegetative growth and tillering in transplanted rice. Overall, the findings demonstrate that Karim Lamido provided a more favourable environment for rice growth than Jalingo, resulting in significantly taller plants, larger leaf area, and higher tiller production throughout the study period. This highlights the importance of environmental conditions in determining rice growth and suggests that location should be carefully considered when selecting suitable varieties and agronomic practices for optimum rice production.

Table 5: Effect of Location on the Growth of Rice

Location	6 WAT	8 WAT	10 WAT
Plant Height (cm)			
Jalingo	14.90 b	21.30 b	24.80 b
Karim Lamido	17.80 a	25.60 a	29.10 a
Leaf Area (cm²)			
Jalingo	16.80 b	22.40 b	26.20 b
Karim Lamido	21.30 a	28.70 a	33.10 a
Number of Tillers (plant⁻¹)			
Jalingo	5.50 b	7.70 b	9.20 b
Karim Lamido	7.60 a	10.10 a	11.80 a

Means followed by the same letter(s) within a column are not significantly different according to DMRT at P ≤ 0.05. WAT = Weeks after transplanting, Values followed by the same letter are not significantly different at P ≤ 0.05.

Effect of Location on Yield and Yield Components of Rice
The results in Table 6, showed that location significantly ($P \leq 0.05$) influenced panicle length, days to 50% panicle emergence, grain yield, and 1000-seed weight, whereas days to maturity did not differ significantly between the two locations. Karim Lamido recorded significantly longer panicles, higher grain yield (3,645 kg ha^{-1}), and heavier 1000-seed weight than Jalingo, indicating that its environmental conditions were more favourable for reproductive growth and grain development. The superior performance at Karim Lamido may be attributed to better soil fertility, moisture availability, and climatic conditions that enhanced assimilate production and grain filling. These findings are consistent with those of Islam *et al.* (2022), Kumar *et al.* (2022), Rahman *et al.* (2023), Mishra *et al.* (2023), and Singh *et al.* (2024), who reported that favourable agro-ecological conditions improve rice yield and yield components. Overall, the results highlight the importance of selecting suitable production environments to maximize rice productivity.

Table 6: Effect of Location on the Yield and Yield Components of Rice

Location	Panicle Length (cm)	Days to 50% Panicle	Days to Maturity	Grain Yield (kg ha^{-1})	1000-Seed Weight (g)
Jalingo	27.40^{b}	69.10^{a}	99.90^{a}	3,115^{b}	32.50^{b}
Karim-Lamido	31.20^{a}	68.40^{b}	100.60^{a}	3,645^{a}	35.90^{a}

Means followed by the same letter(s) within a column are not significantly different according to DMRT at $P \leq 0.05$.

Effect of Location on the Growth, Yield and Yield Components of Rice
The results presented in Table 7 showed that location significantly ($P \leq 0.05$) influenced the growth, yield, and most yield components of rice. Karim Lamido consistently recorded significantly higher plant height, leaf area, number of tillers, panicle length, grain yield (3,645 kg ha^{-1}), and 1000-seed weight (35.90 g) than Jalingo throughout the study period. Rice grown at Karim Lamido also reached 50% panicle emergence slightly earlier, while days to maturity did not differ significantly between the two locations. The superior performance observed at Karim Lamido may be attributed to more favourable agro-ecological conditions, including better soil fertility, moisture availability, and climatic conditions that enhanced vegetative growth, photosynthetic efficiency, assimilates partitioning, and grain filling. These findings agree with Kumar *et al.* (2022), Rahman *et al.* (2023), Mishra *et al.* (2023), and Singh *et al.* (2024), who reported that favourable environmental conditions significantly improve rice growth, yield attributes, and grain yield. Similarly, the Food and Agriculture Organization (FAO, 2024) emphasized that location-specific soil and climatic factors play a crucial role in determining rice productivity. Overall, the results demonstrate that Karim Lamido provided a more favourable environment for rice production than Jalingo, highlighting the importance of selecting suitable production environments alongside improved varieties and appropriate agronomic practices to maximize rice productivity.

Table 7: Effect of Location on the Growth, Yield and Yield Components of Rice

Parameter	Jalingo	Karim Lamido
Plant Height (cm)		
6 WAT	14.90^{b}	17.80^{a}
8 WAT	21.30^{b}	25.60^{a}
10 WAT	24.80^{b}	29.10^{a}
Leaf Area (cm^{2})		
6 WAT	16.80^{b}	21.30^{a}
8 WAT	22.40^{b}	28.70^{a}
10 WAT	26.20^{b}	33.10^{a}
Number of Tillers (plant^{-1})		
6 WAT	5.50^{b}	7.60^{a}
8 WAT	7.70^{b}	10.10^{a}
10 WAT	9.20^{b}	11.80^{a}
Panicle Length (cm)	27.40^{b}	31.20^{a}
Days to 50% Panicle	69.10^{a}	68.40^{b}
Days to Maturity	99.90^{a}	100.60^{a}
Grain Yield (kg ha^{-1})	3,115^{b}	3,645^{a}
1000-Seed Weight (g)	32.50^{b}	35.90^{a}

Within each parameter, means with the same letter on a column are not significantly different, ($p>0.05$)

Conclusion
The study established that rice variety, plant spacing, and location significantly affected the growth, yield, and productivity of rice. ITA 150 was the best-performing variety, while a spacing of 30 × 30 cm produced superior growth and grain yield. Karim Lamido provided a more favourable environment for rice production than Jalingo. Therefore, adopting ITA 150 at 30 × 30 cm spacing is recommended to

maximize rice productivity in Taraba State and similar agro-ecological zones.

Farmers in Jalingo, Karim Lamido, and similar agro-ecological zones should cultivate ITA 150 at a spacing of 30 × 30 cm to achieve optimum growth and grain yield. Agricultural extension services should promote this production package through farmer training and demonstration plots, while government agencies and seed companies should ensure the availability of quality ITA 150 seeds. Further research should evaluate additional improved rice varieties under different fertilizer rates, water management practices, and multiple cropping seasons to validate and strengthen these recommendations.

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