



Effect Of Nitrogen Doses on Productivity of Selected Local and Improved Rice Varieties Under Irrigation and Rainfed Conditions in Sokoto

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Abstract

Rice is considered to be the major source of calories and staple food worldwide. The aim of the study was to determine effect of nitrogen doses on productivity of selected local and improved rice varieties under irrigation and rainfed conditions in Sokoto. The two varieties of rice used for this study are (FARO 44 and TOFA). Physical and chemical Parameters of the soil were analyzed. Rice cultivars were sown in nursery beds. Data collected from the experiments both in the laboratory and field were subjected to Analysis of Variance (ANOVA). The results under irrigation indicated no significant ($P < 0.05$) effect of nitrogen on plant height at 2, 4, 10 and 12 WAP, however nitrogen had significant effect on plant height at 6 and 8 WAP and under rainfed plant height are at 2, 4, 6, 8, 10 and 12 WAP. The interaction of N application between treatment and varieties indicated that there is significant ($P < 0.05$) difference in plant height at 6, 8 and 10 (irrigation) and 2, 4 and 12 WAP (rainfed). The results under irrigation on grain yield indicated significant ($P < 0.05$) effect of nitrogen on grain yield such that 150 kg/ha has the highest grain yield while the least grain yield was from 50 kg/ha and under rainfed 100 kg/ha has the highest grain yield while the least grain yield was from control. The interaction of treatment and varieties indicated that there is significant ($P < 0.05$) difference on number of panicle, panicle length, panicle weight and number of grain per panicle, seed length, seed width and grain yield for both the seasons. Vegetative parameters (plant height, panicle length and number of tillers) were better established in TOFA than in FARO44 both under irrigation and rainfed at 200 kg N/ha and considering the good performance of TOFA local variety under irrigation

Key; Nitrogen, Tillers, Panicle, Irrigation and Rainfed

I. INTRODUCTION

Rice (*Oryza sativa* L.) also known as Global Grain is one of the most important staple food crops for more than half of the world's population, and as it is extensively cultivated across the world, (Prasad *et al.*, 2019; Harisha *et al.*, 2022). Rice is an important staple food crop for more than 60 percent of humans in the world. Being one of the oldest cultivated cereal crops throughout the world, rice is staple food crop in Nigeria that is adapted to both flooded and non-flooded soil conditions in all the agro-ecological zones. Over 90% of the world's rice production was done under irrigation (Hussain *et al.*, 2013). Species in *Oryza* have already attracted enormous attention from scientists worldwide because of their agronomic importance. Many studies on taxonomy, phylogeny, and genetic relationships of the *Oryza* species have been conducted. Crop development and flowering dates are altered by N fertilizer levels, even though was not limiting to plants, which is important for farmer that do use fertilizers, because a long peak tillering for N fertilizer. Nitrogen (N) management in addition to water management differs considerably across rice cropping systems (Saito *et al.*, 2000). In Africa, low N application rates are predominant in upland rice because of uneven rainfall distribution during the growing season (Saito *et al.*, 2000, Kondo *et al.*, 2005).

Rice is a staple food crop in Nigeria, playing a critical role in food security and income generation for millions of households. In Sokoto State, rice production has been expanding both in rainfed lowland and irrigated ecologies (Oikeh *et al.*, 2008). However, the productivity of rice remains low compared to global averages due to several agronomic and environmental challenges. Among these challenges, the application and management of nitrogen (N) fertilizer stand out as a major constraint



affecting rice yields. Farmers in Sokoto often apply suboptimal or inconsistent nitrogen doses, either due to poor access, high cost, or lack of knowledge about appropriate application rates for different rice varieties and ecological conditions. Additionally, the performance of local rice varieties, which are often more adapted to the region but less responsive to fertilizers, differs significantly from that of improved varieties under the same management practices. This has led to variable yield outcomes, inefficient use of inputs, and low economic returns (Oikeh *et al.*, 2008).

The problem is compounded by the fact that different rice varieties respond differently to nitrogen under specific environmental conditions. Local varieties are often better suited to local soil and climatic conditions but tend to have lower yield potential and nitrogen responsiveness. Improved varieties, on the other hand, require higher inputs for optimal performance but are more vulnerable to abiotic stresses like drought or nutrient loss in rainfed systems (Singh *et al.*, 2002). Moreover, the contrasting nature of rainfed and irrigated systems in Sokoto introduces further complexity. In irrigated systems, water availability supports better nutrient uptake and assimilation. In rainfed systems, however, irregular rainfall patterns reduce nitrogen use efficiency (NUE), as water stress impairs uptake and nitrogen losses through leaching and denitrification become prevalent (Dobermann and Fairhurst, 2000).

Rice (*Oryza sativa* L.) is the world's most important staple food for more than two billion people in Asia (Asian population 4,706,488,992 equivalent to 59.22% of world population) and hundreds of millions in Africa and Latin America. Within Southeast Asia, rice provides about 60% of the human food consumption. About 55% of the Asian rice is produced in irrigated areas, which accounts for about 75% of Asia's total rice production with an estimated 2.2 billion Asian rice farmers and consumers depending upon the sustainable productivity of the irrigated lowland rice ecosystem for their food supply (Takebe and Yoneyama, 2019).

Rice cultivation is a vital component of agricultural development in Sokoto State, contributing significantly to food security and rural livelihoods. However, persistent low productivity continues to hinder the full potential of rice farming, especially under traditional management practices. Nitrogen fertilizer remains the most yield-limiting nutrient in rice production, and its appropriate application is key to achieving optimal yields (Zhang *et al.*, 2015). The justification for this study

lies in the pressing need to determine the most effective nitrogen doses for both local and improved rice varieties under different production systems—irrigated and rainfed. While improved rice varieties generally have higher yield potential, their response to nitrogen in specific agro-ecologies like Sokoto remains poorly understood. Likewise, local varieties, although less responsive, are often preferred for their adaptability and resilience to environmental stresses (Buresh *et al.*, 2010). The aim of the study was to determine the effect of nitrogen doses on productivity of selected local and improved rice varieties under irrigation and rainfed conditions in Sokoto and the specific objectives of this research are to; determine the seed germination percentage and seedling growth of the rice cultivars, determine the effect of nitrogen levels on the growth performance and yield component of the two rice cultivars and determine grain dimensions of the selected rice cultivars.

II. MATERIALS AND METHODS

Study Area

The research was conducted in the research farm lowland of Kwalkwalawa and Plant Physiology Laboratory of Usmanu Danfodiyo University, Sokoto. Sokoto is located within the latitude 11°30' N, to 14°00' longitudes 4°00' E to 6°40' and altitude 351.0 m above the sea level (SERC, 2015). Sokoto State accounts for 2.3% of Nigeria's total population. Situated in the North Western corner of Nigeria, the State territory occupies 25,973 square kilometres. Sokoto shares its borders with Niger Republic to the North, Zamfara State to the East, Kebbi state to the South-West (NPC, 2023). The State has an estimated population of about 6, 391,000 people as of 2023 with 95.9 persons per square kilometer, and 3% growth rate annually (NPC, 2023). Occupation of the city inhabitants includes farming, trading, commerce, with a reasonable proportion of the population working in private and public sectors (NPC, 2023).

Experimental Design

The treatments consisted of factorial combination of five N rates (50, 100, 150 and 200 kgN/ha) a control (0 N) and two varieties of Rice (Faro 44 and Tofa) laid out in Randomized Complete Block Design (RCBD) and replicated 3 times.

Land Preparation

Prior to the land preparation sample of soil in the experimental area was collected and subjected to physical and chemical analysis in the laboratory.



Here the land was prepared tilled, harrowed and demarcated. First, 36 m² of land area was ploughed, harrowed for the purpose of the experiment. The area will be divided into plots and blocks. Two meter squared (2m²) of land was used for each individual treatment and between the 1 m² area lead way between plots of 0.5 m was allowed. Each plot consists of 12 m² and there are 3 blocks had been earmarked for the experiment representing the 3 replicates. The total experimental area comprising of the 3 blocks each having 10 plots give the net area for the experiment as 168.75m (Sahrawat, 2014). The experimental design to be used is randomized complete block design (RCBD).

Nursery Beds Preparation and Practices

Method of Wang, (2016) had been adopted. Rice cultivars were sown at different nursery beds. 2m by 4m field was secured using thorn fence and the seeds were sown by broadcasting method. The seeds were allowed to germinate to seedlings and grow for 3 weeks to ensure they are ready for transplanting. The soil had been watered based on moisture requirement after mixing. The seedlings were transplanted according to treatments and spacing (Sahrawat, 2014). Each seedling was transplanted in dug hole on soil 3 cm depth and about 5cm spacing between seedling transplants will be allowed.

Transplanting of Rice Seedlings

Method of Peng *et al.* (2016) was adopted. After germination the rice seeding was transported according to the treatments and spacing method. Each seedling was planted at 20 cm both inter and intra row spacing. This was done for each of the treatments and blocks for the 3 replicates. Transplanting was done 3 weeks after germination.

Data Collection

The following growth and yield parameters were evaluated adopting the Standard Evaluation System for rice (SES, 2012) of International Rice Research Institute (IRRI).

Plant heights: Height of the five randomly selected and tagged plants were measured from the ground to tip and recorded in cm.

No of tillers/plant: The tiller numbers of the selected and tagged five plants (during plant height) were counted and their mean were computed.

No. leaves/ plant (LAI): The numbers of leaves were counted for each of the selected tagged plants and their mean were calculated.

No. of panicles/plant: The numbers of panicles were counted for each of the selected tagged plants and their mean was calculated.

Length of the panicle: Length of five previously selected panicles (during grains/panicle

development) for each of the selected plant were taken in cm and their mean was calculated.

Thousand grain weight: A thousand grains for each variety was counted from grain yield of the plot and weighed with the help of the portable electronic balance.

No. of grains/ panicles: Number of filled grains of five randomly selected panicles from each of the selected plant was taken and their mean was calculated.

Seed yield/plant: Seed yield/plant was taken of the five selected plants for each replication and their mean was computed.

Statistical Data Analysis

Data collected from the experiments were subjected to one way Analysis of Variance (ANOVA) and where the treatment are significant, Duncan's New Multiple Range Test (DMRT) was used to separate the mean at $P < 0.05$. Correlation analysis was employed to establish the relationship between vegetative parameters, yield and nitrogen levels.

III. RESULTS

Effect of N Application and variety on Plant Height of Rice under Irrigation and Rainfed at kwakwalawa

The results under irrigation indicated no significant ($P < 0.05$) effect of nitrogen on plant height at 2, 4, 10 and 12 WAP, however nitrogen had significant effect on plant height at 6 and 8 WAP. At 6 WAP application of nitrogen at 200 kg/ha differed significantly ($P < 0.05$) with tallest plant, which is statistically similar with application of N 150, 100 and control and the shortest plant was from 50 kg/ha. At 8 WAP application of N at 100 kg/ha differed significantly with tallest plant which is statistically similar to 200 kg/ha, the lowest was from 50 and 150 kg/ha which are statistically same. At 2 WAP application of N at 50 kg/ha did not differ significantly with tallest plant ($P > 0.05$) while the shortest plant was from control, at 4 WAP application of N at 200 kg/ha has the tallest plant while the shortest plant was from control, at 10 WAP application of N at 150 kg/ha had the tallest plant while the shortest plant was from control and at 12 WAP the application of N at 150 kg/ha had the tallest plant while the shortest plant was from control. The tallest plants were observed with application of N as shown in Table 1.

The results under rainfed indicated significant ($P < 0.05$) effect of nitrogen on plant height at 2, 4, 6, 8, 10 and 12 WAP. At 12 WAP application of nitrogen at 100 and 150 kg/ha differed significantly ($P < 0.05$) with tallest plant,



which is statistically similar with application of N 200 and the shortest plant was from control. At 8 WAP application of N at 100 kg/ha differed significantly with tallest plant, followed by 150 kg/ha which is statistically similar with 200 kg/ha and the shortest plant was from control. At 4 WAP application of N at 200 kg/ha was differed significantly with tallest plant followed by 150 kg/ha while the shortest plant was from control. The tallest plant were observed with application of N because N in plants is important in plant growing as shown in Table 2. The results on effect of variety under irrigation indicated that there is no significant ($P>0.05$) differences on plant height at 4, 6 and 12 WAP, however there is significant ($P<0.05$)

differences on plant height at 2, 8 and 10 WAP as shown in Table 1. The results on effect of variety under rainfed indicated that there is no significant ($P>0.05$) differences on plant height at 8, 10 and 12 WAP, however there is significant ($P<0.05$) difference on plant height at 2, 4 and 6 WAP as shown in Table 2. The results on the interaction of N application between treatment and varieties indicated that there is significant ($P<0.05$) difference in plant height at 6, 8 and 10 (irrigation) and 2, 4 and 12 WAP (rainfed), however there is no significant ($P>0.05$) difference in plant height at 2, 4 and 12 (irrigation) and 2, 4, 6, 8, 10 and 12 WAP (rainfed) as shown in Table 2.

Table 1: Effect of N Application and variety on Plant Height of Rice under Irrigation at kwalkwalawa

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
0 kg N/ha	17.00	27.04	46.73 ^b	65.23 ^b	71.39	81.98
50 kg N/ha	19.84	28.23	48.47 ^b	68.22 ^b	74.47	83.77
100 kg N/ha	18.32	28.27	50.39 ^{ab}	73.64 ^a	75.35	83.75
150 kg N/ha	18.74	29.46	49.92 ^{ab}	68.34 ^b	76.03	85.22
200 kg N/ha	19.41	29.50	51.25 ^a	71.70 ^a	75.60	83.70
SE±	0.27	0.32	0.52	1.12	0.32	0.51
Significant	*	*	**	**	*	*
Varities						
FARO 44	18.03 ^a	28.81	49.99	70.81 ^a	78.56 ^a	84.26
TOFA	19.29 ^b	28.59	49.51	69.25 ^b	71.78 ^b	83.10
SE±	0.63	0.11	0.24	0.78	3.39	0.58
Significant	**	*	*	**	**	*
Interaction						
T×V	*	*	**	**	**	*

Values are Mean ± SD of biological triplicate, Means with the same letters within column are not significantly different ($P<0.05$). T=treatment, V=varities, **=significant, *=not significant

Table 2: Effect of N Application and variety on Plant Height of Rice under Rainfed at kwalkwalawa

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP	12WAP
0 kg N/ha	16.84 ^c	26.51 ^b	46.61 ^c	67.00 ^b	73.57 ^b	81.67 ^b
50 kg N/ha	19.30 ^b	28.14 ^a	48.58 ^b	69.83 ^a	78.70 ^a	83.43 ^{ab}
100 kg N/ha	19.99 ^{ab}	28.14 ^a	50.19 ^{ab}	71.84 ^a	77.94 ^a	84.97 ^a
150 kg N/ha	21.23 ^a	29.10 ^a	50.97 ^a	71.50 ^a	78.24 ^a	84.97 ^a
200 kg N/ha	21.00 ^a	29.21 ^a	51.52 ^a	70.82 ^a	79.29 ^a	84.25 ^a
SE±	0.36	0.31	0.50	0.55	0.50	0.43
Significant	**	**	**	**	**	**
Varities						
FARO 44	19.17 ^b	27.33 ^b	48.04 ^a	69.84	77.61	83.74
TOFA	20.17 ^a	29.11 ^a	51.03 ^b	70.57	77.49	83.98
SE±	0.63	0.20	0.32	0.35	0.31	0.27
Significant	**	**	**	*	*	*
Interaction						
T×V	**	**	**	**	**	**

Values are Mean ± SD of biological triplicate, Means with the same letters within column are not significantly different ($P<0.05$). T=treatment, V=varities, **=significant, *=not significant



Effect of N Application and variety on Number of Tillers of Rice under Irrigation and Rainfed at kwalkwalawa

The results under irrigation indicated no significant ($P < 0.05$) effect of nitrogen on number of tillers at 8, 10 and 12 WAP. At 8 WAP application of N at 200 kg/ha had the highest number of tillers while the least number of tillers was from control, at 10 WAP application of N at 100 kg/ha has the highest number of tillers while the least number of tillers was from control and at 12 WAP the application of N at 150 kg/ha has the highest number of tillers while the least number of tillers was from control. The highest number of tillers were observed with application of N because N in plants is important in having more number of tillers per plant as shown in Table 3. The results under rainfed indicated no significant ($P > 0.05$) effect of nitrogen on number of tillers at 12 WAP, however nitrogen had significant ($P < 0.05$) effect on number of tillers at 8 and 10 WAP. At 2 WAP application of nitrogen at 150 and 200 kg/ha differed significantly ($P < 0.05$) with highest number of tillers, which is statistically similar with application and the shortest plant was

from control. At 8 WAP application of N at 100 kg/ha differed significantly ($P > 0.05$) with highest number of tillers while the least number of tillers was from control, at 10 WAP application of N at 100 kg/ha had the highest number of tillers while the least number of tillers was from control. The highest numbers of tillers were observed with application of N because N in plants is important in having more number of tillers per plant as shown in Table 4. The result under irrigation on effect of variety on number of tillers indicated that there is no significant ($P > 0.05$) difference on number of tillers at 8 and 10 WAP, however there is significant ($P < 0.05$) difference on number of tillers at 12 WAP as shown in Table 4. The results under rainfed on effect of variety on number of tillers indicated that there is no significant ($P > 0.05$) difference on number of tillers at 8, 10 and 12 WAP as shown in Table 4. The result on the interaction of treatment and varieties indicated that there is no significant ($P > 0.05$) difference on number of tillers at 8, 10 and 12 WAP for both the two seasons (irrigation and rainfed) as shown in Table 3 and 4.

Table 3: Effect of N Application and variety on Number of Tillers of Rice under Irrigation at kwalkwalawa

Treatment	8WAP	10WAP	12WAP
0 kg N/ha	20.00	26.67	30.33
50 kg N/ha	23.00	28.17	32.50
100 kg N/ha	23.33	28.50	31.83
150 kg N/ha	21.83	27.50	33.17
200 kg N/ha	24.50	28.33	31.50
SE±	0.29	0.17	0.21
Significant	*	*	**
Varities			
FARO 44	22.53	27.73	32.60 ^a
TOFA	22.53	27.93	31.13 ^b
SE±	0.00	0.10	0.74
Significant	*	*	**
Interaction			
T×V	*	*	*

Values are Mean ± SD of biological triplicate, Means with the same letters within column are not significantly different ($P < 0.05$). T=treatment, V=varities, **=significant, *=not significant

Table 4: Effect of N Application and variety on Number of Tillers of Rice under Rainfed at kwalkwalawa

Treatment	8WAP	10WAP	12WAP
0 kg N/ha	22.00 ^b	26.00 ^b	30.33
50 kg N/ha	23.83 ^{ab}	28.50 ^a	33.33
100 kg N/ha	24.50 ^a	27.83 ^{ab}	33.00
150 kg N/ha	23.67 ^{ab}	27.67 ^{ab}	33.17
200 kg N/ha	23.83 ^{ab}	28.00 ^a	32.67
SE±	0.55	0.45	0.76
Significant	**	**	*
Varities			
FARO 44	23.07 ^a	27.80 ^a	33.13 ^a



TOFA	24.07 ^a	27.40 ^a	31.8 ^a
SE±	0.36	0.28	0.48
Significant	*	*	*
Interaction			
T×V	*	*	*

Effect of N Application and Variety on Number of Panicle (NP) Panicle Length (PL) Panicle Weight (PW), Number of Grain per Panicle (NGPP) and Grain Yield (GY)

The results under irrigation on number of panicle indicated no significant ($P < 0.05$) effect of nitrogen on panicle weight such that 50 kg/ha had the highest number of panicle while the least number of panicle was from control. The results under rainfed on number of panicle indicated significant ($P < 0.05$) effect of nitrogen on panicle weight such that 50 kg/ha has the highest number of panicle while the least number of panicle was from control. The results under irrigation on panicle length indicated no significant ($P > 0.05$) effect of nitrogen on panicle length such that 150 kg/ha had the highest panicle length while the lowest panicle length was from 50 kg/ha. The results under rainfed on panicle length indicated significant ($P > 0.05$) effect of nitrogen on panicle length such that 150 kg/ha has the highest panicle length while the lowest panicle length was from control.

The results under irrigation on panicle weight indicated no significant ($P > 0.05$) effect of nitrogen on panicle weight such that 200 kg/ha has the highest panicle weight while the least panicle weight was from control. The results under rainfed on panicle weight indicated no significant ($P > 0.05$) effect of nitrogen on panicle weight such that 50

kg/ha had the highest panicle weight while the least panicle weight was from control. The results under irrigation on grain number per panicle indicated significant ($P < 0.05$) effect of nitrogen on number of grain per panicle such that 150 kg/ha has the highest number of grain per panicle while the least number of grain per panicle was from control. The results under rainfed on grain number per panicle indicated significant ($P < 0.05$) effect of nitrogen on number of grain per panicle such that 50 kg/ha had the highest number of grain per panicle while the least number of grain per panicle was from control. The results under irrigation on grain yield indicated significant ($P < 0.05$) effect of nitrogen on grain yield such that 150 kg/ha has the highest grain yield while the least grain yield was from 50 kg/ha. The results under rainfed on grain yield indicated significant ($P < 0.05$) effect of nitrogen on grain yield such that 100 kg/ha has the highest grain yield while the least grain yield was from control. The results on effect of variety indicated that there is significant ($P < 0.05$) difference on number of panicle, panicle weight, number of grain per panicle and grain yield for both the seasons. The results on the interaction of treatment and varieties indicated that there is significant ($P < 0.05$) difference on number of panicle, panicle length, panicle weight and number of grain per panicle, seed length, seed width and grain yield for both the seasons as shown in Table 5 and 6.

Table 5: Effect of N Application and Variety on Number of Panicle (NP) Panicle Length (PL) Panicle Weight (PW), Number of Grain per Panicle (NGPP) and Grain Yield (GY tone/ha) under Irrigation at kwakwalawa

Treatment	NP	PL	PW	GNPP	GY
0 kg N/ha	20.17	21.37	2.18 ^b	148.5 ^b	70.59 ^c
50 kg N/ha	21.50	21.05	2.57 ^a	156.7 ^{ab}	69.17 ^c
100 kg N/ha	21.17	22.90	2.47 ^a	158.2 ^{ab}	71.66 ^{bc}
150 kg N/ha	20.33	23.65	2.63 ^a	160.5 ^a	78.02 ^a
200 kg N/ha	20.50	22.00	2.67 ^a	150.2 ^{ab}	76.64 ^{ab}
SE±	0.26	0.48	0.09	2.33	1.24
Significant	*	*	**	**	**
Varities					
FARO 44	19.87 ^b	22.27	2.24 ^b	150.5 ^b	69.65 ^b
TOFA	21.60 ^a	22.11	2.77 ^a	159.1 ^a	76.78 ^a
SE±	0.55	0.08	0.27	4.30	0.79
Significant	**	*	**	**	**
Interaction					
T×V	**	**	**	**	**



Values are Mean \pm SD of biological triplicate, Means with the same letters within column are not significantly different ($P < 0.05$). T=treatment, V=variety, **=significant, *=not significant

Table 6: Effect of N Application and Variety on Number of Panicle (NP) Panicle Length (PL) Panicle Weight (PW), Number of Grain per Panicle (GNPP) and Grain Yield (GY tone/ha) under Rainfed at kwalkwalawa

Treatment	NP	PL	PW	GNPP	GY
0 kg N/ha	19.83 ^b	20.52 ^b	2.43	143.8 ^b	68.88 ^c
50 kg N/ha	22.50 ^a	22.52 ^{ab}	2.71	164.5 ^a	72.01 ^{bc}
100 kg N/ha	22.33 ^a	23.32 ^a	2.64	157.7 ^a	76.95 ^{ab}
150 kg N/ha	21.67 ^{ab}	23.71 ^a	2.67	162.0 ^a	76.49 ^a
200 kg N/ha	21.67 ^{ab}	23.07 ^a	2.67	158.7 ^a	74.49 ^a
SE \pm	0.46	0.53	0.07	2.57	0.98
Significant	**	**	*	**	**
Varieties					
FARO 44	21.67	23.02	2.41 ^b	154.3 ^b	70.49 ^b
TOFA	21.53	22.24	2.83 ^a	160.3 ^a	77.07 ^a
SE \pm	0.29	0.34	0.05	1.62	0.62
Significant	**	**	*	*	**
Interaction					
T \times V	**	**	**	**	**

Values are Mean \pm SD of biological triplicate, Means with the same letters within column are not significantly different ($P < 0.05$). T=treatment, V=variety, **=significant, *=not significant

IV. DISCUSSION

The Analysis of variance for plant height was found to be significantly different ($P < 0.05$) among the cultivars studied. An increase in plant height in response to the recommended dose of nitrogen was due to the improved vegetative growth and the supplementary contribution of nitrogen as opined by Awan *et al.* (2011). Increase in the addition of N on the two cultivars resulted in higher values of growth parameters in this study relative to the control and this was also in agreement with the findings of Mohanty *et al.* (2013). The variation in plant height by the nutrient sources could be attributed to the variation in the level of N application. Nitrogen as one of the major plant nutrients is very essential for growth and yield of rice (Ahmed *et al.*, 2005).

It has been observed in this experiment that plant height increased as the rate of nitrogen application increased from 73.92 cm at the control plot to 93.02cm at 150 kg N. Similar findings were reported by Lee (1998) that application of nitrogen fertilizer produced more vigorous and taller plants than those that did not receive any nitrogen. The increase in plant height with increased nitrogen application might be primarily due to enhanced vegetative growth with more nitrogen supply to plant. Similar to plant height, nitrogen has great influence on days to flowering and maturity in rice. High quantity of N fertilizers applied led to an

increase in plant height which improved the rate of translocation of nitrogen from culms to leaves which led to production of photosynthates that enhanced further translocation of nutrients for development of panicles. Regarding the number of tillers, the results showed variability between the cultivars tested. The large number of tillers produced by the varieties tested in the study is a good indicator of good productivity. The irrigated or lowland varieties had better tillering than the rainfed varieties under irrigation conditions. This could be justified by the fact that irrigated cultivars have a longer cycle than rainfed cultivars. In general, a long-cycle variety will have a higher tillering ability than a short-cycle variety (Sie, 1997). Indeed, the very high number of tillers observed during the experiment could also be explained by the fact that the water level above the soil was almost zero but the wet part of the soil remained permanently moist and the soil was not saturated and therefore remained well aerated. This created exceptionally favorable wetting conditions (no deficit) and good water nutrition for the plants. The cultivars tested showed a good rate of tillers fertility. Rainfed varieties were more fertile than irrigated or lowland varieties. The low fertility rates observed in these irrigated or lowland varieties could be due to the very high number of tillers per bunch, which caused competition for space and nutrients preventing the tillers from having good vigour and high productivity. However, they are higher than those obtained with improved rice



varieties, indicating a rate varying between 69 and 75% (Bedi *et al.*, 2017). The tillering stage normally starts with the appearance of the first tiller from the axillary bud in one of the lower most nodes. Paul, (2018) reported that high and early tillering capacity was considered an essential trait for optimum grain yield, thus tillering ability is one of the most important traits of rice because it impacts directly on production of panicles. Low tillering and low tiller productivity are caused by high temperatures during the tillering phase Yan *et al.* (2010). Moreover, the number of grains obtained in rainfed varieties was lower than in irrigated varieties, suggesting competition between grains for assimilates. This could also be explained by the fact that continuous irrigation strongly stimulated the number of grains produced per unit area of irrigated or lowland varieties, which induced a correlative reduction in the weight of a grain. These results are similar to those reported by Bahlouli *et al.* (2005) who mentioned that increasing the number of grains per square meter induces a reduction in the weight of 1000 grains. The best grain yields were obtained with the irrigated varieties on TOFA. This shows that the irrigated varieties were better adapted to drip irrigation conditions than the rainfed varieties. Our results are comparable to those obtained by Nikiema *et al.* (2021), who showed that irrigated rice varieties performed better under drip irrigation than when the same varieties were grown under flood irrigation. This shows that irrigated rice varieties are well adapted to drip irrigation. The high yield of these varieties could be due to good production conditions such as good crop management, water, applied nutrients and good soil biological activity that led to good plant development. The variety is said to be late if the sowing-flowering cycle is longer than 100 days. On the other hand, it is early if the sowing-flowering cycle is less than 100 days (Nguetta *et al.*, 2005). The lengthening of the cycle of varieties has had consequences on rainfed varieties which have gone from early to late varieties in the same way as irrigated varieties. The difference in the number of days between the 50% flowering of these varieties (rainfed or irrigated) is linked to climatic conditions, cultivation and cultivation techniques (Sie, 1997). The flowering and maturity time of rainfed varieties was relatively shorter than that of irrigated or lowland varieties. This varietal difference in flowering (maturity) times can be attributed to the natural difference in cycle length of the varieties studied (Africarice, 2008).

V. CONCLUSION

In this study, it can be concluded that vegetative parameters (plant height, panicle length and number of tillers) were better established in TOFA than in FARO44 both under irrigation and rainfed at 200 kg N/ha. Similarly, higher 1000 grain weight was obtained in TOFA based on its performance on low level of N application. The relative performance of each of the two rice varieties was glaring, giving each of them the opportunity to perform best at the optimum nitrogen rate throughout the study period. However, this level of Nitrogen application would provide similar or grain and vegetative yield under conventional rice production in the Sokoto Sudan Savannah. Giving the performance of TOFA in most parameters in this study, it can be established that the TOFA variety should be studied intensively and accepted for better rice production in the Sudan Savanna Agro-ecological zone.

VI. RECOMMENDATIONS

1. Considering the good performance of TOFA local variety under irrigation, its cultivation by local farmers should be given a boost through provision of agricultural facilities and better funding by the government.
2. Agronomical evaluation trials at farmer's field should be encouraged to seek more information and farmer's opinions on suitability of the FARO44 and TOFA
3. Farmers should be encouraged to grasp the importance of maintaining soil fertility status for sustainable soil productivity and encouraging farmer to split nitrogen fertilizer into two, at tillering and panicle initiation stage.
4. The use of leaf colour chart (LCC) is a novel and promising technology; hence more research needs to be conducted in details especially at varietal level so as to monitor the real time need of N application
5. More research should be performed to evaluate response of upland rice varieties and make very specific recommendations depending on soil characteristics and response of the varieties

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