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PERFORMANCE OF TEN VARIETIES OF RICE (*Oriza sativa* L.) GROWN UNDER IRRIGATION DURING THE DRY SEASON IN BAUCHI, NIGERIA

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ABSTRACT

Investigation into the performance of ten rice varieties of rice grown under irrigation during the dry seasons of 2004/2005 and 2005/2006 in Bauchi, was carried out. Ten rice varieties; FARO 46, WITA 4, AIC 233, WAB 233, WAB 189 (FARO 54), FARO 44, Ex-China, NERICA 1 (FARO 55), WAB 450 and NERICA 7 were considered during the study. The experiment was laid out in a randomized complete block design with four replications. A significant (P<0.05) difference was observed among the varieties on plant height, number of leaves and tillers per plant. Variety FARO 44 produced significantly (P<0.05) higher number of tillers per plant than all the other varieties. Similarly, in yield and yield related characters, FARO 44 and WITA 4 had significantly higher number of spikes per hill, weight per spike, grain weight per hill and yield per hectare than all the other varieties considered.

KEYWORDS: Rice varieties, Irrigation, Dry season.

INTRODUCTION

In Nigeria, rice has been known to contribute about 14% of the total food requirement and its consumption has been rising in West Africa at a rate of 45% annually (Yoshida, 1978). However, the domestic production has not been enough to meet the demand of the crop.

With the first ban on importation of rice in the country in 1985; rice production has been increasing steadily from year to year. Currently Nigeria produce paddy rice of about 3.5 million tones, ranking first in the West African sub-region (Okocha, 2003). But even with this encouraging production in rice, the country's average yield is still very low of about 2 tons/ha and Nigeria still faces great deficit as current supply cannot meet the demand at homes. For the country to be successful in its bid to meeting the rice production and consumption demand of its citizens in the new millennium, the short term solution for bridging the gap between demand and supply of rice must be made by expanding the rice area through the use of improved varieties and better agronomic practices.

Above all, emphasis should be laid on availability of rice in Nigeria all year round, which will depend on how farmers can embark on irrigated rice production during the dry season. The potential yield of irrigated rice can be as high as 8 t/ha (Okocha 2002), which is far higher than all the other rice ecologies under rainfed condition. Therefore, irrigated rice production will supplement or increase with the quantity produced during the wet season which is below the quantity demanded presently in the country. Even though, dry season rice production is highly profitable it is not left without its own share of constraints which include lack of irrigation facilities limited appropriate technology etc. Until adequate and long lasting solutions to most of the problems of wet and dry season rice production are found, problem of self sufficiency in rice production generally will remain (Okocha, 2002).

To achieve these, high yielding varieties that can produce higher yields, resistant to diseases and photoperiod insensitive (Gomme, 1992) should be identified and improved upon. However, addressing some of these problems could be a first step for attaining self sufficiency in rice production in Nigeria. Based on the above, the research work was intended to investigate the possibilities of producing rice in dry season through the use of some promising varieties in Bauchi.

MATERIAL AND METHODS

Field experiments were conducted during the dry seasons of 2004/2005 and 2005/2006 at the Fadama Research Farm of Abubakar Tafawa Balewa University, Bauchi Nigeria. Bauchi is located in the Northern Guinea Savanna zone of Nigeria; 10°17"N and 9°49"E and it lies at 609.3m above sea level (Kowal and Knabe, 1972).

The materials used in this study were 10 varieties of rice which comprised of 4 adapted (FARO 46, Ex-China, WITA 4 and FARO 44) and 6 newly released varieties from West African Rice Development Authority (WARDA). These varieties are; NERICA 7, AIC 233, WAB 340, WAB 189 (FARO 54), WAB 450 and NERICA 1 (FARO 55). The ten varieties were laid out in a randomized completed block design with four replications. Plot size of $4.0m^2$ with 30cm path between plots and 1m path between replicates was used. The ten varieties were sown on the same day on the 23rd of December of 2004 and 2005.

The land was first ploughed and harrowed to obtain a fine tilth before sowing. Plots and blocks were made with water channels in between plots for easy irrigation. A spacing 20x20cm inter and intra row was use of all the varieties with 3-5 seeds planted per hill, following the recommendation of National Cereal Research Institute (2003) Badeggi Niger State. Before the beginning of the research, soil was first sampled and analyzed. The physicochemical properties of the soil at the experimental site are presented in Table 1. This formed the basis for the fertilizer application in the area. A compound fertilizer, NPK 20:10:10 was applied using broadcast method at the rate of 60kg N, 30kg P_2O_5 and 30kg K_2O per hectare at two weeks after emergence. At six and ten weeks after emergence, Urea fertilizer was split applied as top dress at the 10kg N per hectare at each application. The plots were kept free of weeds using manual means after Gramaxone was first applied as pre-emergent herbicide at the rate of 4 litres per hectare. Problem of rats and birds were observed during the research and method of scaring was employed to curtail the problem. Some of the varieties were also observed to be infected with blast, a disease cursed by *Pyricularia oryzae* and *Bentex T.* fungicide powder was used for the control at the of 900g per hectare. Eight hills were randomly tagged from four middle rows (net plot) of $1.2m^2$ for data collection. Parameters were taken at weekly intervals starting from 2 weeks after emergence until harvest.

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During the investigation, parameters such as plant height, number of leaves and tillers per plant, spikes per hill spikelets per spike, eyes per spike, eye and spike weight were all taken. Plant height was measured with the aid of a measuring tape from the base of the plant to the tip of the growing plumule. Numbers of tillers were counted excluding the main stem. Number of spikes per hill, spikelets per spike, eyes per spike, eye weight were all taken at harvest. Spike weight was measured with the aid of weighing balance (Mettler 2000) in the laboratory. During the period of study, water was supplied through furrow irrigation with the aid of a pumping machine from a nearby stream. During growth and development of the crop, water was supplied every 2 days in the mornings until it reaches field capacity (20 litres per plot) for the area. However, the frequency of irrigation was reduced towards the maturation period of the crop to ones a week.

The two year data collected were subjected to combined analysis of variance to study the effect of the treatments. The treatment means were then compared using the student Newman Keuls, (SNK) to test for the level of significance (MSTAT, 1996).

Table 1: Physico-chemical properties of the soils at the experimental site at the Fadama Farm of Abubakar Balewa University Bauchi, Nigeria

Section 1.01 *Soil characteristics*	Experiment Site (Soil depth at 0-30cm)
Section 1.02 Physical analysis	
Particle size distribution (gkg-1)	
Sand	120.02
Silt	230.40
Clay	640.58
Texture	Clay loam
Chemical analysis	
P^H water (1:1)	5.82
P^H $cacl_2$ (1:2)	5.31
Organic carbon (gkg^{-1})	1.80
Total nitrogen (gkg^{-1})	0.28
C:N	6.43
Available P ($mgkg^{-1}$)	6.78
CEC C mol (+) kg^{-1}	4.52
Exchangeable bases Cmol (+) kg^{-1}	
Ca	2.18
Mg	0.85
K	0.37
Na	0.03
BS (%)	75.86

RESULTS AND DISCUSSION

Significant ($P\leq0.05$) difference was observed among the ten varieties throughout the study period (Table 2). FARO 46 was observed to be significantly ($P\leq0.05$) taller (79.6cm) than all the other varieties. However, Ex-China and NERICA 1 were the shortest (40.6cm and 42.6cm respectively) among all the varieties studied. Based on general observations and literatures, plant height observed during this study was far shorter than the plant height of most of the varieties grown under the same ecology and during the dry season. According to the findings of Ayotade (1991), rice grown under irrigation can attain a height of between 110-140cm depending on the variety and the environmental conditions at the time. Even though varietal differences could be the major reason for the variation between the two researches, fundamentally, the environmental factors prevailing at the time of the study might have affected the growth and development of the crop rather negatively.

Number of tillers per plant (Table 3) shows that there was a significant ($P\leq0.05$) difference among the ten varieties. Throughout the study period, WITA 4 and FARO 44 produced significantly ($P\leq0.05$) higher number of tillers per plant (24 each) than all the other varieties. NERICA 1 however was the least in tiller number per plant (4). The variation in tillering potential among the varieties could be genetically controlled. Even though tiller production is controlled genetically by hereditary traits, environmental factors during the dry season might have influenced the tillering ability of some of the varieties like NERICA 1 which is known to tiller up to 11 per plant during the rainy season in Bauchi (WARDA, 2003).

Results obtained in this investigation indicated that rice yield and yield related characters (Table 4) differed significantly ($P\leq0.05$) among the varieties. The effect of rice variety on number of spikes per hill, number of eyes per spike, weight per eye, weight per hill and grain yield per hectare, showed that all were significantly affected except number of spikelets per spike.

Number of spikes per hill varied significantly ($P\leq0.05$) among the varieties studied. WITA 4 and FARO 44 produced significantly ($P\leq0.05$) higher number of spikes per hill than all the other varieties. The differences observed among the varieties could be due to hereditary traits inherent within the different varieties investigated. Even though tillers are known to potentially produce spikes, it was observed in the present investigation that not all the tillers were able to produce spikes. This could be attributed to environmental factors which affected the crop prior to jointing stage; a critical stage of production in rice. Another reason to be advanced could be that, an environmental factor like temperature (Baker, 1988) or more may not have been at its optimum during the dry season, thereby affecting spike production in these varieties. The present study lends support to the report of Yoshida, (1978) that initiation of spikes in rice requires optimum temperature (critical temperature) of $15^{O}C$. This may not have been the same in the area at the time of the investigation. This might have affected some of the spikes not to be initiated. However, season and location of the two studies could be another reason for the variation in the two reports. As it was observed during the present investigation, there were other factors, such as insect pests and rodents which were responsible for the reduction on number of spikes produced.

Table:2 Effect of variety on plant height of rice from 2 WAS to 15 WAS grown under irrigation during the dry seasons of 2004/2005 and 2005/2006 at Bauchi, Nigeria.

	Plant height (cm)				
VARIETY	2 WAS	5 WAS	8 WAS	12 WAS	15 WAS
FARO 46	10.6d	20.9ab	37.3a	51.3ab	79.6a
WITA 4	9.3e	16.9bc	26.3bc	32.9cd	57.9c
AIC 233	11.9c	19.8ab	30.2ab	51.5ab	66.2b
WAB 340	11.9c	19.5ab	29.4ab	45.7c	57.8c
WAB 189 (FARO 54)	12.6b	21.1cb	34.6a	51.5ab	54.7c
FARO 44	8.1F	13.1cb	19.1cd	25.9de	40.6d
Ex-China	7.7F	11.5e	19.4cd	28.3cd	42.6d
NERICA 1 (FARO 55)	14.1a	27.7a	42.3a	58.2a	70.2b
WAB 450	9.9e	17.9ab	27.8bc	45.2c	56.2c
NERICA 7	11.6c	22.1ab	34.3a	55.5a	56.2c
S.E (±)	0.39	1.08	1.94	1.61	1.71
SNK (P≤ 0.05)	1.92	5.31	9.54	7.92	8.41

Means followed by common letters are not significantly different at 5% probability level (SNK).
WAS = Weeks After Sowing.

Table: 3 Effect of variety on number of tillers per plant of rice from 6 WAS to 18 WAS grown under irrigation during the dry seasons of 2004/2005 and 2005/2006 at Bauchi, Nigeria.

VARIETY	6 WAS	9 WAS	12 WAS	15 WAS	18 WAS
FARO 46	2bc	4b	8ab	13ab	13ab
WITA 4	5a	11a	19a	24a	24a
AIC 233	2bc	4b	6ab	8cb	9bc
WAB 340	2bc	4b	5ab	6d	7cb
WAB 189 (FARO 54)	2bc	5b	6ab	7b	7cd
FARO 44	4a	15a	21a	22a	24a
Ex-China	3ab	5b	11ab	14ab	14ab
NERICA 1 (FARO 55)	2bc	3b	4c	4d	4e
WAB 450	1cd	3b	4c	5d	6cd
NERICA 7	2bc	3b	4c	5d	6cd
S.E (±)	0.30	1.03	1.26	1.16	0.99
SNK (P≤ 0.05)	1.48	5.06	6.21	571	4.87

Means followed by common letters are not significantly different at 5% probability level (SNK).
WAS = Weeks After Sowing.

Table: 4 Effect of variety on yield and yield related characters of rice grown under irrigation during the dry seasons of 2004/2005 and 2005/2006 at Bauchi, Nigeria.

VARIETY	Number of Spikes/hill	Number of spikelets/spike	Number of eyes/spike	Weight/ eye (g)	Weight/ spike (g)	Weight/ hill (g)	GrainYield (Kg/ha)
FARO 46	13b	6a	44cd	0.0254b	1.11ab	14.86ab	37192ab
WITA 4	18a	9a	10a	0.0126F	1.37ah	23.93a	5982.2a
AIC 233	7bc	7a	79a	0.0184e	1.44ab	10.18ab	25145.5ab
WAB 340	6bc	8a	72a	0.0269a	1.70a	11.24ab	2809.6ab
WAB 189 (FARO 54)	5bc	7a	60ab	0.0223c	1.39ab	7.76a	1941.2bc
FARO 44	15a	8a	90a	0.0226c	2.27a	30.17a	7565.8a
Ex-China	14b	5a	60ab	0.0136F	0.88bc	12.25ab	3062.0ab
NERICA 1 (FARO 55)	4bc	6a	57bc	0.0202cd	1.16ab	4.42d	3605.8a
WAB 450	5bc	11a	92a	0.0195cd	1.77a	11.67ab	2296.5bc
NERICA 7	6bc	10a	97a	0.0112g	1.15ab	6.97ab	1743.1bc
SE (±)	0.76	6.68	6.68	0.0003	0.14	1.54	722.5
SNK (P≤ 0.05)	3.74	32.87	32.87	0.0013	0.69	7.58	3554.5

Means followed by common letters are not significantly different at 5% probability level (SNK).

Significant varietal effect on number of eyes per spike observed in this study showed WITA 4 producing significantly (P≤0.05) higher number of eyes per spike (104) than all the other varieties. FARO 46 however, had fewer number of eyes per spike (44) than the rest of the varieties. Differences in number of eyes per spike among the varieties could be due to environmental factors which could be detrimental to fertilization in some of the varieties. Adaptation and sensitivity to the environment could be another factor that might have militated against effective conversion of flower to eye set in these varieties. Environmental factors like temperature might have been at work during the entire time of flowering and eye set leading to flower abortion in these varieties (Coffer *et al.* 1996). During the investigation and particularly during flowering and eye setting periods, the temperature was generally high, which may be higher than the optimum temperature required by rice plants during eye formation. As was reported by Yoshida, (1978), rice requires optimum temperature of 30-33 ^{0}C at the time of anthesis. However, its genetic factors inherent within the varieties coupled with level of adaptation of the varieties to the ecology of Bauchi, might have been another factor for consideration.

Significant (P≤0.05) difference was also observed among the varieties studied on weight per spike (Table 4). The result indicated that for all the varieties studied, FARO 44 was the heaviest in weight per spike (2.29g), while Ex-china was the least. This could basically be as a result of poor eye weight which was due to infertility that was observed with some varieties during the investigation. This implies that the weight of spike is determined by eye weight. Invariably, the spike weight could be due to two fundamental characters; number and weight of eyes per spike.

Spike weight per hill (Table4) differed among the ten varieties, with WITA 4 producing heavier spike weight per hill (4.43g). Variation among the ten varieties may best be explained by the varietal characteristics as regard their adaptability to dry season and fluctuations in weather conditions. Even though some varieties had reasonable weight per hill which could be due to the fact that they were adaptable to the season and the ecology, production of higher spike weight per hill by WITA 4 could possibly be explained by the variety's high number of leaves and high number of tillers which enabled it to partition more photosynthates and nutrients used in the production of more spike weight per hill than the other varieties. This result corroborates the findings of Coffer and Hammer, (1996), who reported similar trend in rice production for more yield.

Grain yield varied significantly (P≤0.05) among the ten varieties (Table 4). FARO 44 and WITA 4 were the highest yielding varieties (7565.8 kg/ha and 5982.5 kg/ha respectively) when compared to the other varieties investigated (Table 4.). Variety's NERICA 7, WAB 189 and WAB 450 however, were significantly (P≤0.05) lower in grain yield with 1743.1, 1941.3 and 2296.5 kg/ha respectively. The performance of FARO 44 and WITA 4 in grain production per hectare may be due to their ability to produce more photosynthates which were utilized in the production of grains than the other varieties during anthesis and grain filling stages. This present report lends support to the work of Coffer and Hammer, (1996) who reported similar trend during anthesis and grain filling in rice. It could also be due to the genes that are inherent in the varieties vis-a-vis production of larger sized grains. The yield obtained from the present investigation agrees with that of Okocha,(2002) who reported that rice grown under irrigation can yield as high as 8 tones/ha. While the yield of NERICA 7, WAB I89 and WAB 450 that were significantly (P≤0.05) lower compared to other varieties, still agrees with the result of Singh *et al.* (1997), that rice grown under irrigation can have yield ranges from 2 to 4 tons/ha, depending on their sensitivity to different environments. The production of low yield in WAB 189 especially, that is known to produce higher yield of up to 5 t/ha during the rainy season (Edmond, 2006) could be due to the change in the season. WAB 189 has never been tried in the dry season in Bauchi. Therefore its ability to perform during this period remains a question. The variation in the two reports which supported both higher and lower yielding varieties in the present study may be as a result of varietal characteristics. Some of the varieties like AIC 233, WAB 340, WAB 189 (FARO 54) and NERICA 1 (FARO 55) are upland types while some of them like FARO 44 and WITA 4 are lowland types. Upland rice is less productive than lowland rice (WARDA, 2003) partly because it depends on nutrients that are dissolved in the soil moisture. When soil moisture is low, few nutrients are available, compared to the store house of the nutrients typically found in paddy waters for lowland rice (Singh *et al.* 1997). The yield of 2-4 tons/ha as obtained by Singh *et al.* (1997) could also be a result of geographical location of the research and also on the level of adaptation of these varieties.

Apart from what was observed in the present study, it was believed generally that so long as water which is the most important factor responsible for high yield in rice is kept at its best, higher yields could always be expected. However, environmental factors like temperature and sunshine hours (Fushison, 2006) might have also affected some of these varieties into not attaining to their full potentials in production.

Generally, all the varieties investigated on produced optimally. The reason could be that, apart from some limitations possibly from the environment like temperature, water through irrigation was sufficiently provided through out the growth and developmental stages of the crop. Similarly, adequate fertilization was provided for the crop. This may have also contributed to the appreciable yield observed during the study. The contribution of water and fertilizer application to rice has been supported by the report of Gomme, (1992), that the dry matter production after flowering directly correlated with yield under optimum conditions during dry season rice production. However during wet season, due to climatic constraints like low light and high night temperatures, the contribution of the reserved carbohydrates become substantial for grain filling and yield. An intriguing observation made during the study was the fact that the ten varieties used were all harvested at between 5-6 months after planting (December 23rd to June 6th) except Ex-China, NERICA 7 and FARO 44 that were harvested on the 14th, 14th and 17th of June respectively. This intriguing observation on the long duration to maturity noticed with all the varieties lend support to an earlier report by Gomme, (1992) that depending on the variety and climate, rice grains can be harvested in three to six months. The present finding also agrees with that of Yoshida, (1978) that temperature regimes greatly influence not only the growth pattern of the rice plant but also the growth duration as well. Based on this observation the higher grain yield produced by most varieties during the period might have also been due to the long time the varieties spent (about 6month) partitioning dry matter to grain production. On the other hand, it has well being established that respiration becomes low at low temperatures. The low respiration due to low night temperatures (Yoshida, 1978) during the grain development phases of rice may favor grain development and filling during the entire period.

CONCLUSION

Among all the varieties investigated, FARO 44 and WITA 4 were observed to perform better in grain yield than all the other varieties. From the yield obtained in the ten varieties, FARO 44 and WITA 4 seemed promising and can therefore be recommended for dry season rice production in Bauchi. Growing these varieties will go a long way in bridging the gap between the demand and consumption of rice in the country.

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