COMPARATIVE STUDY OF SELECTED AGRONOMIC CHARACTERISTIC OF LOCAL AND IMPROVED RICE VARIETIES IN GOMBE STATE, NIGERIA

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ABSTRACT

Rice is popularly known for its nutritional value, calories and its ability to eliminate hunger. Rice production faces many difficulties in Nigeria due to some environmental factors and failure to choose the right varieties by farmers.. These losses are due to many factors, among which include drought, diseases, erosion, low amount of rainfall and other factors. A total of 15 selected indigenous and newly introduced hybrid rice varieties in Gombe State, Nigeria, had their agronomic characteristics assessed. The rice varieties were grown under same environmental conditions and screened for morpho-agronomic traits. Significant differences ($P<0.05$) were picked among the 15 rice varieties for all the traits evaluated. The results showed that plant height ranged between 51.2 cm in Jamila and 36.2 cm in Nerica. The leaf area showed the highest value of 63.8 $cm^2 \pm 0.01$ in Sippi. Flowering time ranged from 68 ± 6.0 days in Mai Lemo to 48.5 ± 4.0 days in China, while Nerica and Sippi took the shortest period of 14 days after flowering to mature. Nerica had the highest value 143.2 g ± 12.25 for panicle weight. Mai Zabo had high number of seeds per panicle (139 ± 0.19). Nerica had the highest value of 14850.0 ± 1965.8 for 100 seeds per panicle. In order to conserve the wholeness of the richness of indigenous rice varieties, farmers are advised to begin the cultivation of improved varieties capable of withstanding drought and harsh weather conditions and produce high yield. Further research should be conducted on Jamila, Mass and Madara local varieties in waterlogged areas as these varieties produced no flower as a result of drought and harsh weather conditions, as suggested by some practical farmers.

Keywords: Morpho-agronomic traits; Rice varieties; Growth physiology; indigenous varieties

INTRODUCTION

The Nigerian economy has gone through many years of vicissitude, especially in the agricultural sector. The rice sub-sector is still growing but is faced with many challenges, including biotic, abiotic, and socio-economic constraints, with greater Pressure from the socio-economic constraints (Abdul-Gafar *et al.,* 2016). Most rice-producing countries in Africa attained yields below the world average (4.3MT) from 2008 to 2014. The pivotal factors for the low yield are inadequate extension services, poor management practices, and structural obstacles. According to FAOSTAT (2012) estimate, although rice yield has been increasing recently, it is still below the yield experienced during the 1970s and 1980s. According to some researchers (Akande *et al.,* 2009), this stagnation is attributed to depreciating land fertility as a result of production constraints, poor crop management practices, and policy inconsistency. Over time, the trend of rice yield in Nigeria exhibits little or no contribution to total output. Increasing the cultivated area has been the most effective means to increase rice output in the country (Kebbeh *et al*., 2003; Ogundele and Okoruwa 2006).

In Nigeria, rice is important for several reasons, including being a major contributor to internal and sub-regional trade. Two types of rice have been mainly cultivated in Nigeria: African rice *(Oryza glaberrima)* and the Asian rice (*Oryza sativa).* In recent times, however, new rice varieties have also been introduced including, the West African Rice Development Association's (WARDA) hybrid rice varieties referred to as NERICA i.e. New Rice for Africa, which are interspecific hybrids between the African and Asian rice. According to Jones, the African rice *O. glaberrima* originated from the wild rice (*O. barthii*) some 3500 years ago and its offspring domesticated probably in the inland delta area of Nigeria from where it spread through the upper Niger valley to the rest of West Africa. African rice is cultivated as field crop and a paddy crop. For the Niger Benue trough, Sokoto – Rima and Chad Basin, rice has been cultivated long enough for a rice culture to evolve as far back as 1500 BC.

Rice is rich in genetic diversity, with thousands of varieties grown throughout the world and its economic importance related to agro-ecological adaptation, household food security, ceremonies, nutritional diversification, income generation and employment. Remarkable deepwater varieties of *O. glaberrima* exist which are specific to the un-usual flood conditions that occur in the inland Niger Delta, the Sokoto-Rima valley and other flood plains of the extreme north of Nigeria (Oko *et al*., 2012). *O. glaberrima* is known by different local names as "hakorin montol" in Plateau / Nasarawa area and jatau (red) throughout Hausa land and the Chad Basin (Oko *et al*., 2012). The ecological adaptation of the two species may be more important from the point of view of human selection. The *O. glaberrima* varieties have certain negative features with respect to *O. sativa*: e.g. the seed shatters easily, the grain is brittle and difficult to mill and, most importantly, the yields are lower. But the *O. glaberrima* types also offer distinct advantages: tolerates fluctuations in water depth, iron toxicity, infertile soils, and adaptation to the ecological conditions of Africa. However, Asian rice has long been introduced into Nigeria and is gradually displacing African rice due to its superior attributes (Oko *et al*., 2012).

Consequently, local rice farmers in Nigeria have long adopted the Asian rice and some local names given to such rice varieties based on their quality attribute and/or the person that introduced such varieties. As such, two or more local rice varieties in various localities may be the same (single) cultivar. An estimated 25 percent of Nigeria's rice is under rainfed low land cultivation. Total crop failure, in this case, means low production, which seriously affects the chemical composition and agronomic character of rice. Total crop failure also leads to a reduction in the grain quality and the organoleptic properties of the lowland rice. The production of rice represents 38.89 % of total cereal production in Nigeria**.** Global rice production stands at 596.5 million tons from 155 million hectares (ha) in 1999. Rice produced in Gombe is marketed to states around the region, and the rice production and commercialization chain are well developed. Therefore, the objective of this work was to assess the variation in the agronomic traits of the selected indigenous and newly introduced rice varieties to provide a comparative measure of their growth and yield potential.

Rice Environments in Nigeria

The three rice production environments and their coverage in Nigeria are rainfed lowland (69.0%), irrigated lowland (2.7%), and rainfed upland (28.3%). More than 90% of Nigeria's rice is produced by resource-poor small-scale farmers, while corporate/commercial farmers produce the remaining 10%. About 95% of the processors are small-scale with low-capacity and obsolete mills. Nigeria possesses a huge but largely untapped potential for developing irrigated rice. There is an estimated 3.14 million ha of irrigable land, out of which less than 50,000 ha are growing irrigated rice. Nigeria has large irrigation schemes in Anambra, Kwara, Kogi, Adamawa, Niger, Sokoto, Kebbi, Borno, Bauchi, and Benue states (FAOSTAT, 2012).

Nigeria is before among the top countries producing rice in the world. About 30 to 50 percent of expected yields are frequently reduced because some of the varieties we mostly cultivated are not adapted to our environment. There is a need to cultivate more rice varieties that will withstand some of the environmental factors affecting rice production.

Rice is popularly known for its nutritional value, calories, and its ability to eliminate hunger. Rice production is facing lots difficulties in Nigeria due to some environmental factors and failure to choose the right varieties by farmers.

These losses are due to many factors, including drought, diseases, erosion, low amount of rain fall and others are considered as a principal cause. (Gao *et al.,* 2013).

The main aim of this study is to identify some environmental factors associated with the reduction of rice production in Gombe State, Nigeria, having the following objectives:-

i. To assess and identify varieties that are suitable for cultivation in Gombe State.

ii. To make a comparative study between yield parameters of the rice cultivars grown.

The research was conducted in Gombe State of Nigeria. The result will be useful in providing knowledge to Gombe rice farmers on better rice varieties selection and provide means on how to eradicate factors that causes the reduction of rice yield expectations in Gombe State.

MATERIALS AND METHODS

Description of the Study Area

The new site of the Botanical garden was founded in 2017 and is situated adjacent Faculty of Science Complex within Gombe State University, Gombe, Nigeria.It has a total size of 270 square meters or 2.7 hectares. The garden lies between latitude 10°E 18' and longitude 11° 10' 36.43"E and has an altitude/ elevation of 438-478m above sea level (figure 1).

Collection of Plant Materials

After their harvest, fifteen rice cultivars were collected from Gombe rice farmers. The rice cultivars were collected from different parts of the State in places like Dogon Ruwa Kaltingo Local Government Area Gombe South senatorial zone, Kwadon Yemaltu Deba Local government Area Gombe North senatorial district, Tudun Hatsi Gombe Local Government Area Gombe Central senatorial district and Tarsani Balanga Local Government Area, Gombe South senatorial district. In addition, some three (3) hybrid rice varieties (improved varieties) were collected from Leventis Foundation Agric training Collage Tumu Akko Local Government Area of Gombe State (Table 1 & 2). The different rice cultivars (which were all *O. sativa* types), the actual identities of the locally named cultivars, their sources and dates of collection are as shown in Table 1. The rice cultivars were all planted on the field under similar cultural practices.

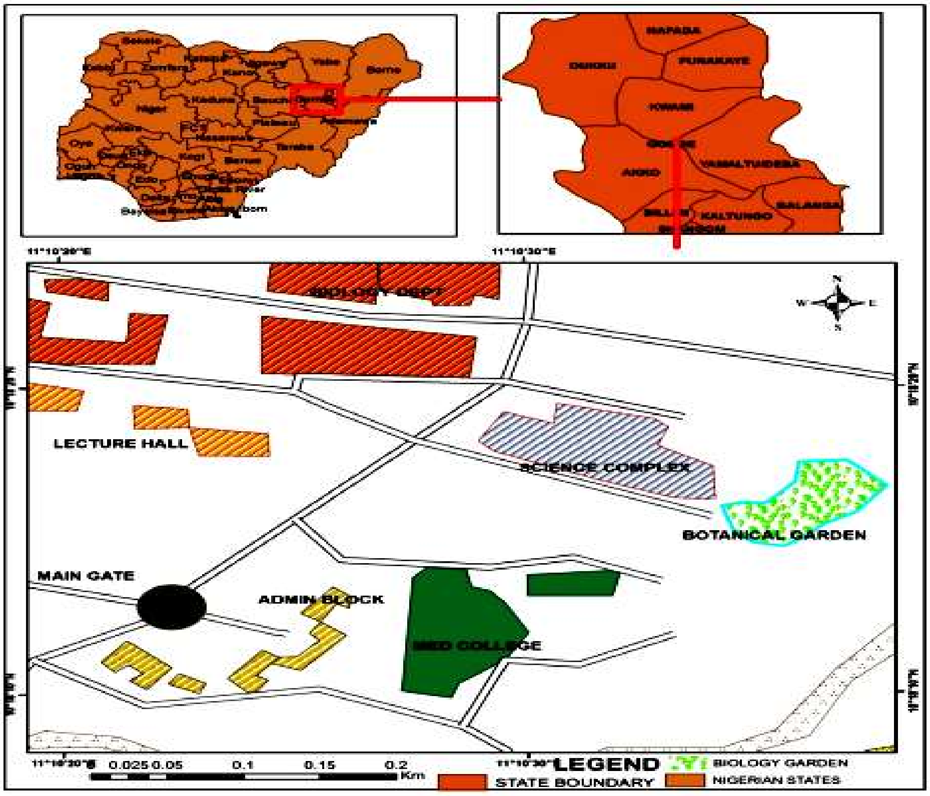

Figure 1: Map of Gombe State University showing the location of the Botanical Garden.

Field Experimental Layout and Establishment

The plant materials were cultivated at the department of Biological Sciences botanical garden located adjacent to the Faculty of Science complex Gombe State University.

The land was cleared using hoe, Cutlass and Rake. The cleared grasses are burnt to kill any rice contaminants present in the piece of land under the rice cultivation. After burning, the land was ploughed and harrowed manually using hand Rigger and divided into fifteen equal-sized plots. The experimental layout was a Complete Block Design (CBD) and the cultivars were randomly allocated to each experimental plot measuring 50 x 50 m. Three seeds were initially sown per hole at a plant spacing of 10 x 10 cm with an inter-plot spacing of 20 cm created to aid easy movement between the plots (Plate 1A). At 15 days after seedling emergence, the seedlings were thinned to 2 seedlings per hole for free ventilation (Plate 1B). Each plot containing a cultivar was replicated three times. The experimental rice plot was irrigated using a watering-can. The irrigation was done immediately after sowing the seeds as the rice seeds needed sufficient water to germinate and this was continued all through the period of cultivation. Weeding was carried out manually at 21 days after sowing and a second weeding during panicle initiation (42 days after sowing). A basal dose of N-P-K fertilizer (15:15:15) at the rate of 300 g/plot was applied at 15 days after sowing (as soon as the weeds have been removed). Subsequently, urea was top-dressed at the rate of 200 g/plot at 30 days after sowing.

Table.1 Local rice varieties used in the study

S/N	Local names	Species	Location collected	Collection Date
	Jamila	*O. glaberrima*	Gombe Central	27/11/2017
2	Mai Lemo	*O. glaberrima*	Gombe Central	27/11/2017
3	Yar China	*O. glaberrima*	Gombe Central	27/11/2017
4	Mai Zabo	*O. glaberrima*	Gombe Central	27/11/2017
5	Mahanga	*O. glaberrima*	Gombe North	18/12/2017
6	Madara	*O. glaberrima*	Gombe North	18/12/2017
7	Mai Kwalli	*O. glaberrima*	Gombe North	18/12/2017
8	Mass	*O. glaberrima*	Gombe South	03/01/2018
9	Yar Tudu	*O. glaberrima*	Gombe South	03/01/2018
10	B.G Doguwa	*O. glaberrima*	Gombe South	03/01/2018

Table.2 Improved rice varieties used in the study

S/N	**Varieties**	**Species**	**Collection Area**	**Collection Date**
1	Nerica	O. sativa	Leventis	5/12/2017
2	Sippi	O. sativa	Leventis	5/12/2017
3	Faro 16	O. sativa	Ibadan	23/3/2018
4	Faro 44	O. sativa	Ibadan	23/3/2018
5	Faro 57	O. sativa	Ibadan	23/3/2018

Plate 1A & 1B. Prepared plots with rice cultivars sown and rice at five weeks after germination

Data Collection for Agronomic Characters

Plant height was measured by running a thread from the base of the plant to the apex and measuring the length of the thread with a meter rule to the nearest centimeter. (Plate 2A). Leaf area (LA) was measured by tracing the out-line of the leaves onto a standard mass/area paper. The leaf trace on the paper was carefully cut out with scissors and its weight measured with a digital weighing balance. The weight of the paper was used to calculate the corresponding area of the leaf with high precision. For the determinate cultivars, the third fully developed leaves counting from the apex of the plants were sampled for leaf area measurement, whereas the middle leaves were used for the indeterminate plants. LA was measured in replicates of three. Flowering time was measured as the number of days from sowing to 50 % flowering and was recorded separately for each plot. The number of seeds per panicle and panicle was directly counted, while panicle weight was estimated using electronic weighing balance (Plate 2B). At maturity, the rice within each plot was harvested, threshed carefully, winnowed, and recorded pertinent data on yield components. All measurements were taken in triplicates. The rice grains were sun-dried to about 14 % moisture content and preserved for the analysis (Plate 2C).

Plate 2A, B & C. Rice at ten weeks of age, Grains yield of different varieties gained from the study and Nerica at maturity stage

Data Analysis

All data were analyzed by the Analysis of Variance (ANOVA) procedure using SPSS 16.0 full version software. Differences were declared statistically significant when $P < 0.05$. Where significant differences were detected, the means were separated by the least significant difference (LSD) at a 5 % probability level. Interrelationships among traits values were estimated using the Pearson correlation coefficient.

RESULTS

The mean values of the traits evaluated in this study, viz: plant height (cm), leaf area (cm^2), number of panicles per plant, panicle weight (g), number of seeds/panicle and days to 50 % flowering, are shown in Table 3 below.

Table 3. Summary of the Mean Values of some of the Measured Agronomic Traits of the rice varieties

S/N	Rice cultivars	Plants height (cm)	leaf area (cm^2)	No of panicle s/plant	Panicle weight(g)	No. of seeds/ panicle	No. of seeds/ plant	Days to 50% flowering
1	China	50.0cm	470.1	108	122.96g	156	16,891	97 Days
2	Mahanga	42.7cm	605.5	50	57.37g	166	8,330	123 Days
3	Mai Lemo	49.7cm	667.5	52	38.59g	168	8,746	136 Days
4	B.G Doguwa	44.2cm	565.1	64	92.89g	159	7,314	113 Days
5	Mai zabo	49.3cm	554.1	74	180.76g	217	16,058	121 Days
6	Yar Tudu	47.2cm	563.5	108	213.40g	172	18,608	125 Days
7	Mai Kwalli	48.2cm	491.1	70	160.20g	217	13,020	130 Days
8	Faro 16	43.4cm	551.5	23	21.57g	216	4,991	135 Days
9	Nerica	36.2cm	362.1	135	286.53g	220	29,700	104Days
10	Faro 44	46.3cm	555.1	97	93.87g	160	15,520	124 Days
11	Sippi	49.0cm	679.1	98	239.07g	210	20,580	110 Days
12	Faro 57	47.3cm	640.1	93	201.08g	228	17,228	129 Days
13	Jamila	51.2cm	698.1	-	-	-	-	-
14	Mass	41.2cm	671.1	-	-	-	-	-
15	**Madara**	**43.5cm**	**664.5**	**-**	**-**	**-**	**-**	**-**

The cultivars showed significant differences for these traits ($P < 0.0001$), which suggests a wide variation in the cultivars used in this study. The $LSD_{0.5}$ values indicate the occurrence of real differences among the accessions tested. The mean plant height among the cultivars was 101 ± 22.4 cm, which ranged from 36.20-51.20 cm. Nerica had the least plant height (36.20 cm), followed by Mahanga (41.20 cm), while Jamila was the tallest cultivar (51.20 cm), as shown in figure 2 below. Leaf area significantly varied from 698-362 cm^2 with a mean value of 35.28 ± 12.94 cm^2. The newly introduced rice cultivars such as Faro 16, Faro 44 and Nerica have relatively small leaf areas compared with other cultivars with relatively higher values for leaf area e.g. Jamila, China, Sippi as shown in **table 3** above.

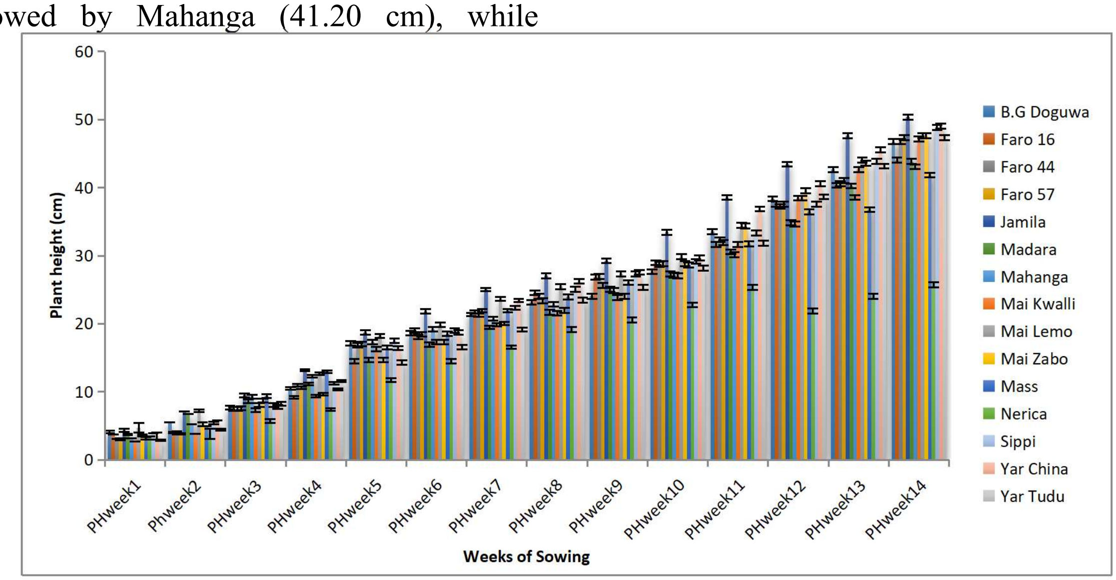

Figure 2. Plant height (cm) of rice varieties per week. Bars (Standard error bars of means).

The mean panicle number per plant was highest (135) in Nerica, while Faro 16 had the least number of panicles/plant of 23. The mean value among the 15 accessions is 42.35 ± 20.94 panicles per plant, as shown in **Table 4**.

Table 4. Number of panicles per plant

S/N	Varieties	Mean±Std
1	B.G Doguwa	32.00±2.82a
2	China	54.00±5.56a
3	Faro 16	11.50±0.70a
4	Faro 44	48.50±2.12a
5	Faro 57	46.50±9.19a
6	Mahanga	25.00±2.28a
7	Mai Kwalli	35.00±7.07a
8	Mai Lemo	26.00±4.24a
9	Mai Zabo	377.5±10.6a
10	Nerica	67.00±1.41a
11	Sippi	49.00±8.48a
12	Yar Tudu	83.91±35.35a
	Total	42.35±20.94a
	P.value	**0.00**

Panicle weight among the 15 accessions ranged from 21.57 to 286.53 g with a mean weight of 69.06 ± 40.38 g. Two of the newly improved rice varieties, Faro 16, had the least panicles weight of 21.57 g, while Nerica had the highest value for panicles weight (286.53 g), as shown in Table 5 below.

Table 5. Panicles weight (g) variation between the cultivars

S/N	Varieties	Mean±Std
1	B.G Doguwa	46.44±7.41a
2	China	61.48±4.27a
3	Faro 16	42.251±2.89a
4	Faro 44	46.93±6.130a
5	Faro 57	91.70±10.04a
6	Mahanga	18.97±1.230a
7	Mai Kwalli	41.77±8.520a
8	Mai Lemo	19.29±1.470a
9	Mai Zabo	90.38±20.05a
10	Nerica	143.26±12.25a
11	Sippi	119.53±6.88a
12	Yar Tudu	106.70±27.01a
	Total	69.06±40.38a
	P.value	**0.00**

Significant variation was obtained in the number of seeds per panicle among the studied rice accessions with a mean value of 7540.83 ± 3561.7 numbers of seeds/panicle, which ranged from 156 seeds/panicle in China to the highest value of 228 seeds/panicle in faro 57 (**Table 6**).

Table 6. Numbers of seeds per panicle in each cultivar

S/N	Varieties	Mean±Std
1	B.G Doguwa	79.50±13.43a
2	China	78.00±11.31a
3	Faro 16	108.00±11.31a
4	Faro 44	80.00±7.070a
5	Faro 57	114.00±8.481a
6	Mahanga	83.00±9.890a
7	Mai Kwalli	93.00±18.38a
8	Mai Lemo	84.00±22.62a
9	Mai Zabo	108.50±16.26a
10	Nerica	110.00±15.55a
11	Sippi	105.00±7.07a
12	Yar Tudu	86.00±19.79a
	Total	94.08±17.09a
	P.value	**0.00**

The number of days to 50 % flowering significantly varied among the 15 accessions studied and ranged from 97 – 135 days, with a mean value of 60.29±8.79 days among the 15 cultivars. China had the shortest flowering time of 97 days, followed by Nerica and B.G Doguwa, which attained 50 % flowering between 104-113 days, while much delay in flowering was observed in Mai Lemo (i.e. 136 days), as shown in **table 7** below.

Table 7. Days to 50 % flowering among the rice cultivars

S/N	Varieties	Mean±Std
1	B.G Doguwa	56.5±2.121a
2	China	48.5±3.536a
3	Faro 16	67.5±0.007a
4	Faro 44	62±1.4140b
5	Faro 57	64.5±5350c
6	Mahanga	61.5±0.707d
7	Mai Kwalli	65±5.6560e
8	Mai Lemo	68±5.6560a
9	Mai Zabo	60.5±10.6f
10	Nerica	52.0±2.828a
11	Sippi	55.0±11.31a
12	Yar Tudu	62.5±24.70a
	Total	60.29±8.79
	P.value	**0.00**

DISCUSSION

Significant variation was observed in agronomic traits evaluated among the 15 rice cultivars, including plant height (cm), leaf area (cm^2), number of panicles per plant, panicle weight (g), number of seeds per panicle and days to 50 % flowering. Jamila China and Mai Lemo were the tallest among the 15 rice varieties studied. However, these three relatively tall varieties were not as tall as the African and Philippine upland varieties reported by Chang *et al*. (2008) which were generally more than 150 cm under upland planting conditions. Chang *et al.* (2008) had pointed out that the lowland rice varieties generally grew much shorter, while the semi-dwarf types seldom exceeded 80 cm. Nerica, mass and some other varieties could be neatly classified as a dwarf, having maintained a dwarf phenotype. The majority of rice farmers prefer tall plants to lessen the burden of bending down to cut the panicles with a knife during harvesting.

Moreover, tall plants have long rice straws needed to mix with clay in building tents among the indigenous people. However, extremely tall cultivars tend to lodge, which could be a very serious problem, especially under swampy, lowland conditions. This serious lodging effect, especially among the tall African rice species (*O. glaberrima*), makes the high yielding, relatively short *O. sativa* cultivars or their interspecific hybrids (i.e. *O. glaberrima* x *O. sativa*) preferable. The panicle traits are important yield attributes of rice and include the number of panicles per plant, panicle weight, and the number of seeds per panicle. These traits affect the overall rice yield as they are often used as a guide to assess the performance of a particular rice cultivar. Based on the data collected by Pramod *et al.* (2009) for lowland rice, the range of mean values for different panicle traits were 7.6 -13.2 for the number of panicles per plant and panicle weight: 0.9 – 5.7 g. These values can vary depending on the variety and environmental factors. The panicle weight of Nerica and a most others were higher than this range of values reported by Pramod *et al.* (2009) while others fell within the range just as in "Chinyerugo" which symbolizes a rice variety with bumper harvest as observed by the local farmers reported by Oko *et al.* (2012).

The variety ("Chinyereugo") accordingly had the highest panicle weight and number of seeds per panicle which indicated the potentially high yielding ability as observed by the farmers. Jamila and Sippi had the highest values for leaf area. This presupposes that photosynthetic activities will be higher in such varieties, suggesting a better yield. Flowering time indicates the onset of seeding. Mai Lemo, Faro 16 Faro 57 and Mahanga took longer times to flower, suggesting that they are late flowering. In contrast, China, Nerica, Faro 44 and B.G Doguwa flowered within a relatively shorter time, suggesting earliness. Mai Zabo, Mai Kwalli, Faro 57, Faro 44 Sippi and Nerica all had a high number of seeds per panicle which is a desirable trait to farmers. The increase in some of these agronomic characters could be attributed to some factors stated by Gentry *et* *al.* (2013) that plant height and leaf area affects panicle traits. And that plants with good leaf area and increased plant height could utilize sunlight energy for photosynthesis more efficiently. Such rice varieties, therefore, have the potential for high yield due to effective utilization of sunlight, which would increase the rate of photosynthesis.

The other varieties with somewhat reduced leaf area showed reduced panicle traits, invariably reducing the potential yield. Despite the observed variations in all these traits, all the varieties had the normal range of values for all the traits studied as reported by Pramod *et al.* (2009) except for traits like the number of seeds per panicle and days to 50 % flowering, which are in conformity with the values given by Vange and Obi (2006) who studied the effect of planting date on some agronomic traits.

CONCLUSION

Based on this study, most of the newly introduced rice varieties such as Nerica, Sippi, Faro 44 and Faro 57 shows the highest agronomic traits needed by rice farmers in terms of yield production such as panicles weight, numbers of seeds per panicle, numbers of seeds per plant and days to 50% flowering. No flowers were observed on some of the varieties used in this study like Jamila, Madara and Mass, which happen as a result of such varieties required an area with high moisture content as suggested by some practical farmers. In contrast, China, Nerica, B.G Doguwa and Sippi flowered within a relatively shorter time, suggesting earliness. Yar Tudu, Nerica, Sippi and Madara are drought resistance varieties observed in the study. In contrast, local varieties like China show early maturity traits and Mai Zabo has a high number of seeds per panicle.

Recommendation

It is recommended that Gombe rice farmers begin to cultivate improved varieties capable of withstanding drought and harsh weather conditions and produced high yield. Further research can be carry out on Jamila, Mass and Madara in water logged area as these varieties produced no flower as a result of drought and harsh weather conditions as suggested by some practical farmers.

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