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Research Paper

Agronomy and genetic evaluation of some rice cultivars (Oryza sativa) in MAGA: A case study in the Sudano-Sahelian zone of Cameroon

Martin Diri Bouba[1*], Abega Juste Philantrope[1], Djongmo Victor Awé[2]
[1]*Institute of Agricultural Research for Developpment-Waka Agricultural Research Center*
[2]*Department of Biological Sciences, University of Ngaoundere, Cameroon*
***Corresponding author:** Martin Diri Bouba, Institute of Agricultural Research for Developpment-Waka Agricultural Research Center*

Abstract
Rice (Oryza sp.) is the staple diet of more than half of the world's population. However, most African countries import rice from Asian countries and the United States. To deal with this problem, studies have been conducted to select high-performance varieties of upland rice that adapts to the Sudano-Sahelian region of Cameroon, specifically to Maga. The seven varieties used come from the G0 collection of SEMRY, and are among the most used varieties. Each variety was sown using a completely randomized block design with three replicates. The total number of tillers at maturity, the size of the plants, the number of panicles per tuft, the rate of sterility as well as the yield were measured. Among the cultivars studied, the varieties IR46, Gambiaka, Sabongari, and N36 respectively produced more grains (159.66,15.00,140.33,107.66) among which some produced the most tillers (IR46, N36). All the cultivars tested are adapted to varying degrees. However, four varieties can be identified among the others during this study. These are: Sabongari, N36, Gambiaka, and IR46 which presented a very good yield.

Keywords
Rice (Oryza sp.), Cultivars, Upland rice, Yield, SEMRY, Maga, Cameroon.

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I. Introduction

Rice (oryza sp) is the staple food of more than half of the world's population (Folefack et al., 2014). It ranks as the second most cultivated cereal in the world after wheat (Osanyinlusi et al., 2016). The importance of this crop is no longer to be demonstrated, as evidenced by the declaration of the year 2004 as the "International Year of Rice" by the General

Assembly of the United Nations. In 2009, the world production of rice was evaluated after 680 million tons with a forecast record of 710 million tons of rice in 2010. There is an increase in consumption of nearly 8 million tons (FAO, 2010)

In Africa, rice is produced and consumed in 39 countries (sanni et al.,2020). Rice cultivation is a very valuable activity for the populations of certain areas of West and Central Africa, ensuring food security for nearly 20 million producers, and directly supporting nearly 100 million people, if an average of five people per peasant family is assumed (WARDA, 2002). For the period 2000 – 2005, Africa produced approximately 17.4 million tonnes of paddy rice; while for the period from 2006 to 2009 this production increased to around 22 million tons of paddy rice (FAO, 2011). The demand for rice in West and Central Africa is increasing at a rate of 6% per year; faster than anywhere in the world; while at the same time production only increases by 4% per year (WARDA, 2004; Sanni et al., 2009) . Faced with this state of affairs, the populations of its regions are forced to resort to imports to meet their needs. moreover, this need is mainly linked to population growth and the increase in the share of rice in the diet, it is estimated that production will have to increase by 40% by 2030 to meet demand (khush., 2005) however 60% of Africa's rice needs are covered by imports because local production remains largely insufficient. (Nguetta et al.; 2006).

In Cameroon, rice is a staple food and is the most consumed cereal after corn. Annual national requirements are estimated at 300 million tonnes. In 2013, more than 819,800 tons of rice were imported with national financial reserves estimated at more than 212 billion CFA francs according to statistics from the national balance of payment technical committee. Despite the growing needs for rice, its 300,000 tons are almost essentially covered by imports according to the national strategy document for the development of rice cultivation in Cameroon (SNDR 2009) and this dependence is made more intense by the observed decrease in productivity. To correct this situation of food deficit, reduce the importation of rice and remedy the growing food insecurity and the decline in yield, the production in large quantities is a national priority. Thus, a solution involves the choice of varieties with characteristics (agronomic and technological) superior to those that are already being popularized. This is where the researcher (geneticist) comes in to select the right varieties. This is why the Cameroonian government, accompanied by these international partners, has set up a strategy for the development of rice growing in Cameroon (SNDR) then it emerges from the SNDR (2009) that despite the scale of the investments to absorb the demand domestic rice, Cameroonian production was only able to satisfy domestic demand up to 20 %. Based on SNDR (2009) and malaa et al.; (2011). From the foregoing, the questions raised in this study are whether the selection of new varieties with evaluated agronomic and genetic performance could enhance rice production? What are the selection criteria? what would be their impact on the agricultural landscape of Cameroon?

This study has the overall objective of evaluating the varietal diversity and the agronomic and genetic performance of seven varieties of rice selected by SEMRY in the locality of Maga through agro-morphological evaluation in order to make available to researchers and developers, a database on the characteristics of the collection of maga's rice.

II. Materials and Methods

Study area

The investigations were carried out in Maga in the irrigated rice perimeter of the Yagoua Rice Modernization and Expansion Company (SEMRY). Mage is located in the department of Mayo – Danay, region of the extreme – north of Cameroon, and between 10°9’ and 10°50’ north latitude and 14°57’ and 15°12’ east longitude. Maga is also one of the 11 arrondissements in the department of mayo - Danay. The experimental plot is located about 500 m from the tapadai village in the middle of a peasant field a few meters from the road. It is located in zone 34, district 01, locker 3A in the Semry rice field.

Plant material

The plant material consists of seven elite varieties of rice including: WASSA, GAMBIAKA (suruni kogoni), from Mali IR46 from the Philippines, M53, SABONGARI harvested in the fields, N36, N60 from Africa rice all from the SEMRY collection. These are high-performance varieties, most of which come from the interspecific cross between the Asian rice Oryza sativa L and the African rice Oryza glaberrima.

Variety code	Name	Variety
V1	SABONGARI	Composite
V1	WASSA	Composite
V3	N36	Hybride
V4	N60	Hybride
V5	M53	Composite
V6	GAMBIAKA	Composite
V7	IR46	Composite

Experimental device

The experimental device used in our experiment is a completely randomized block device with three repetitions. According to the principle of randomization used by the national institute for the study and agronomic research (INERA, 2011). The sowing of the seven varieties was carried out manually over a total area of 5000 m2. The device in completely randomized blocks with three repetitions was used for the establishment of all the plots. The dimensions of a block are 8m wide by 200m long, i.e. an area of 1600m2. In each block, the elementary plots are 24.5m long and 8m wide, giving an area of 196m2. The sowing is in line with an interline spacing of 20cm and intraline of 20cm between pockets. Like that proposed by (Nguetta et al., 2006) all the standard cultural practices recommended for good production are respected.

Cultivation management

A transplant of 2 seedlings/hole was carried out for each variety using a 28-day nursery. Mineral fertilization consisted of a basic fertilizer of ammonium sulphate 21% N 24% S and urea 46% of 50 Kg each just 10 days after transplanting followed by a basic urea 46% N fertilizer of 50 Kg 40 days after sowing. Including six 50 kg bags for one hectare.

Collection of agro-morphological data
The agro-morphological data collected concerned the following parameters:
- Tillering: evaluated on 5 pockets chosen at random at the level of the useful plot at 70 days after sowing;
- Height (cm) at maturity: measured on 5 pockets chosen at random in the useful plot 70 days after sowing;
- Yield: Harvest of the useful plot, the grain weight assessed is reported in tonnes per hectare (t/h);

The performance components were made up of parameters such as:
- the number of panicles: evaluated on 5 pockets chosen at random at the level of the useful plot, during the reproductive phase;
- the number of grains per panicle and its ramification: evaluated on 5 randomly chosen panicles for each variety at the level of each repetition;
- sterility (number of empty grains per panicle): evaluated on 5 panicles chosen at random for each variety at the level of each repetition;
- the weight of the 1000 grains: 1000 grains of each variety were weighed for each repetition. The average for each variety was considered.

Genetic and statistical analyzes

The method of analysis of variance (ANOVA) was used to understand the distribution of the elementary values in the test, the causes of the dispersion, the comparison between the different values, the significance of the differences and the hierarchy. Duncan's test was performed to classify the means when the analysis of variance was significant. To do this, we used Excel software and stat Graphics plus version 5. Thus the heritability which measures the degree of transmission of a quantitative trait is estimated from the formula of Mahmud and Kramer (1951): $h2 = \sigma g2 / \sigma p2 = (\sigma p2 - \sigma E2) / \sigma p2 = (\sigma I2 - \sigma i2) / \sigma I2$

With σI = intervarietal variance σi = intravarietal variance.

Similarly, the selection gain was evaluated from the value of the heritability and the phenotypic variance using the formula proposed by Allard (1960): $G = K \times (\sigma p2)^{1/2} \times h2$ With: G = expected gain of selection, K = standardized selection differential (k= 1.75 for a selection intensity of 10%).

III. Result and Discussion

Agro-morphological parameters

- Tillering density

The tillering density observed varies, on average, between 18.2 and 25.33 tillers/m2. The comparison of the averages made it possible to note that there is a significant difference between the varieties with regard to the tillering density determined at 35 days after sowing. The M53 and N36 varieties have a higher tillering density than the other varieties tested. The measured values are much lower than those obtained by Nguetta et al. (2006) in the subequatorial region of Congo Brazzaville. Our results do not corroborate those of Ngakou et al. (2013), on the Jarra and NERICA NL28 varieties in Dang; which could be explained by the environmental conditions which would have a significant influence on the parameters tested.

The total number of tillers produced by a variety is related to the stage of plant development and is strictly related to the variety. Nguetta et al., (2006). Furthermore, heritability for this trait is moderately heritable (h2=0.54) (Table 1), which confirms the preponderance of genetic variance over environmental variance. Consequently, the genetic improvement of tillering density is possible in its tested varieties. These results corroborate the results recorded by Abid et al. (2002). The expected gains from selection after a selection cycle are estimated at 45.2% compared to the average of the initial population (Table 1). According to Demarly (1977) these gains can only be effectively obtained when all the genes have additive effects.

In addition, the total number of tillers produced at maturity evaluated at 70 days after sowing varies, on average, between 15.26 and 25.33 tillers/m2. This shows significant variability between cultivars. The IR46, M53 varieties have a higher total number of tillers. Furthermore, WASSA has a low tiller rate with 15.26. The analysis of variance shows a significant difference between the varieties at a threshold of 5%. These values are much higher compared to those obtained by Djihinto et al. (2012) in the rice fields of the interfluve zone of Chad, which obtained average values of 5.25 and 7.3. Our results do not corroborate those of Moukoumbi et al. (2001) and Sié et al. (2006).

The heritability for this trait is average (h2 =0.49) (table), which confirms the importance of genetic variability and environmental variance. Therefore, genetic improvement of the total number of tillers produced at maturity is possible. These results corroborate the results recorded by Nguetta et al., (2006). The expected selection gains after a selection cycle are estimated at 23.11% compared to the average of the initial population.

Table 1: genetic variability and heritability value for tillering density

Variety	Density at tillering at 35 days	Total number of tillers produced at maturity
SABONGARI	18.20 ± 2.18[d]	20.13 ±2.14[e]
WASSA	20.73± 1.25[bc]	15.27 ±3.80[f]
N36	23.33± 3.97[a]	23.80 ± 2.31[bc]
N60	20.87 ±3.06[c]	23.20 ± 1.44[c]
M53	25.33 ±2.60[a]	24.80 ±4.20[ab]
GAMBIAKA	21.40 ± 2.69[b]	21.87 ±6.80[d]
IR46	21.07 ± 2.81[bc]	25.33 ± 0.95[a]
Genotypic mean	21.56 ± 3.37	22.06 ± 3.09
Genetic Variance	10.48	9.46
Variety variation	18.53	18.70
Mean broad-sense heritability	0.54	0.49
PPDS	1.33	1.06
Selection gain estimated at 10% (K= 1.75)	45.2	23.11

Means followed by the same letter are not significantly different at the 5% level.

- Height (cm) at maturity

The results obtained made it possible to indicate that there is a variability between the varieties tested with regard to the size of the plants at maturity. The M53, WASSA, N36, N60, and IR46 varieties have the largest sizes (81.73 and 84.66 cm). GAMBIAKA and SABONGARI are less than 80 cm tall. the analysis of variance shows a significant difference between the varieties at a threshold of 5%. Our results are similar to those obtained by Tendro et al. (2010) in the Vakinankaratra region (Madagascar). They also corroborate the results obtained by Nguetta et al., (2006) On 22 varieties tested in the district of Oyo in the subequatorial region of Congo-Brazzaville. The heritability for this trait is quite high (h2=0.58) (Table 2), which confirms the dominance of genetic variance over environmental variance. This suggests that genetic improvement in terms of plant size is possible in these tested varieties. the results are comparable to those obtained by kocou et al. (2012) in the lowlands of Bamé in Benin the expected gains from selection after a selection cycle are estimated at 34.11% compared to the population average initial which would be due to the additivities of the genes.

Table 2: genetic variability and heritability value for plant height at 70 days.

Variety	Plant pruning at 70 days
SABONGARI	74.87 ± 0.61[d]
WASSA	82.93± 2.21[b]
N36	84.67± 3.52[ab]
N60	87.53 ±7.37[a]
M53	81.73 ±2.00[b]
GAMBIAKA	78.13 ± 6.12[c]
IR46	84.00 ± 3.80[b]
Genotypic mean	81.98 ± 3.78
Genetic Variance	11.45
Variety variation	19.50
Mean broad-sense heritability	0.58
PPDS	3.66
Selection gain estimated at 10% (K= 1.75)	34.11

Means followed by the same letter are not significantly different at the 5% level.

- Yield and yield components.

The yield components concerned the number of fertile tillers and full grains per panicle, sterility and 1000 grain weight.

- The number of panicles

The results obtained would indicate that there is variability between the varieties tested in terms of the number of panicles per tuft. These results vary, on average between 16.40 and 28.40 per square meter. M53, N60 and IR46 have the highest number of panicles per tuft (28.40, 27.93, 27.73. GAMBIAKA and N36 have an average number of panicles while SABONGARI and WASSA have a much lower number. The analysis of variance shows a significant difference between the varieties tested.These results are much higher than those obtained by Dossou et al., (2011) which range from 0.88 to 12.85 panicles per tuft.

Heritability is low for this trait (h2=0.37), which shows the importance of environmental variability. The expected gains of selection after a selection cycle are estimated at 11.66% compared to the average of the initial population.

The length of the panicle observed at maturity varies on average between 22.93 and 25 cm. The differences between the varieties are not significant (p> 0.05). these values are much higher than those of Tendro et al. (2010) of the trial conducted in the vakinankaratra region (Madagascar) which obtained an average value of 19.4 and 23. Our results are comparable to those of Dossou and al., (2011).

Table 3: Genetic variability and heritability value for number of panicles per clump, panicle length.

Variety	the number of panicles per clump	panicle length.
SABONGARI	17.20 ± 2.30[c]	23.27 ±0.58[a]
WASSA	16.40± 0.72[c]	23.13 ±1.33[a]
N36	21.80± 1.63[b]	24.80 ± 0.40[a]
N60	27.93 ±1.06[a]	25.00 ± 0.35[a]
M53	28.40 ±0.00[a]	24.20 ±0.00[a]
GAMBIAKA	23.93 ± 2.81[b]	24.20 ±0.72[a]
IR46	27.73± 1.61[a]	22.93 ± 1.03[a]
Genotypic mean	23.34 ± 1.73	23.93 ± 0.63
Genetic Variance	1.15	
Variety variation	3.06	
Mean broad-sense heritability	0.37	
PPDS	2.11	
Selection gain estimated at 10% (K= 1.75)	11.66	

Means followed by the same letter are not significantly different at the 5% level.

- Number of grains per panicle and its ramification

The results show that the varieties tested have an almost similar panicle branching number, the average of which varies between 10.26 and 11.8. The analysis of variance shows a non-significant difference between the varieties (p>0.05). our results do not agree with those obtained by Sié et al. (2010). Our results are also part of the range of ramifications noted by Dossou et al. (2011) analyzing 159 rice varieties in Benin.

The total number of grains per panicle at maturity varies, on average between 74 and 159.66 (Table 4). Varieties IR46, GAMBIAKA, and SABONGARI (159.66, 150,140.33) have the highest total number of grains. The analysis of variance shows a significant difference between the varieties at a threshold of 5%. These values are comparable to those of Sié et al. (2010). Thus there is a positive correlation between grain yield and the number of panicles Sié et al., (2010). Moreover, the heritability for this trait is quite high (h2=0.58) table 4, which confirms the preponderance of variability over environmental variance. Consequently, the genetic improvement of grain yield is possible in these tested varieties. The expected gains of selection after a cycle of selection are estimated at 27.13% compared to the average of the initial population (table 4).

Table 4: Genetic variability and heritability value for Panicle branching, Number of grains per panicle.

Variety	Panicle branching	Number of grains per panicle
SABONGARI	11.33 ± 0.23[a]	140.33 ±26.91[b]
WASSA	10.47± 0.50[a]	87.66±15.37[d]
N36	10.27± 0.42[a]	107.66 ± 20.59[c]
N60	11.13 ±0.42[a]	91.00 ± 26.85[d]
M53	11.80 ±0.60[a]	74.00±25.04[e]
GAMBIAKA	11.13 ± 0.42[a]	150.00±24.75[ab]
IR46	11.40± 0.53[a]	159.66 ± 25.78[a]
Genotypic mean	11.0.44 ± 0.44	115.76 ± 30.76

Genetic Variance		204.12
Variety variation		566.48
Mean broad-sense heritability		0.58
PPDS		9.66
Selection gain estimated at 10% (K= 1.75)		27.17

Means followed by the same letter are not significantly different at the 5% level.

- Genetic variability of the sterility rate (number of empty grains per panicle)

The rate of sterility varies on average between 1.5 and 13.2% the rate of sterility is determined at maturity by the ratio of the number of empty grains and the number of normal grains per panicle. GAMBIAKA, N60 and SABONGARI have a markedly low rate of sterility compared to the others. The analysis of variance shows a significant difference between the varieties at a threshold of 5%. Whole grain yield is one of the essential criteria in the rice improvement and extension program. These results are much lower than those of Tendro et al. (2010) and comparable to those of Kouakou et al. (2014).

Table 5: Genetic variability of Sterility rate (%)

Variety	Sterility rate (%)
SABONGARI	1.50 ± 0.01^{a}
WASSA	5.00 ± 0.02^{c}
N36	3.00 ± 0.01^{b}
N60	6.00 ± 0.06^{b}
M53	13.00 ± 0.12^{a}
GAMBIAKA	3.00 ± 0.01^{c}
IR46	4.00 ± 0.05^{bc}
Genotypic mean	5.00 ± 0.04
PPDS	0.00

Means followed by the same letter are not significantly different at the 5% level.

-Genetic variability and heritability of thousand kernel weight

Table 6 presents the weight of a thousand seeds of seven varieties of rice produced in the study area. The analysis of the weight of a thousand seeds of these lines shows that the genotypic effects are significant ($p<0.05$) it oscillates between 50 and 100mg with an average of (67± 13). Previous work notes no significant effect of the genetic variability of this trait in NERICA in the Sudano-Sahelian zone of Senegal Kouakou et al. (2004). Our results are much lower than those obtained by Tendro et al., (2006). We note that the varieties, N60 and N36 have the most important weights, while WASSA, SABONGARI and M53 have a distinct weight (table 6). Growers prefer large, weighty grains for good marketing. This is a major constraint in this study area. The level of variability of a trait is one of the main factors of selection efficiency.

Table 6. presents the weight of a thousand seeds of seven varieties of rice produced in the study area

Variety	1000 grain weight in (mg)
SABONGARI	60.0 ± 4.8^{c}
WASSA	50.0 ± 4.3^{d}
N36	100.5 ± 3.7^{a}
N60	100.2 ± 3.9^{a}
M53	50.5 ± 4.0^{d}
GAMBIAKA	90.4 ± 8.7^{b}
IR46	90.0 ± 10.0^{b}
Genotypic mean	67.5 ± 13.0
Genetic Variance	122.66
Variety variation	139.0
Mean broad-sense heritability	0.85
PPDS	8.88
Selection gain estimated at 10% (K= 1.75)	33.80

Means followed by the same letter are not significantly different at the 5% level.

- Genetic variability and heritability in yield per hectare

The analysis of variance of genotypes for yield per hectare shows significant variability at the 5% threshold (Table 7). The inter-varietal averages range from 5.16 and 13.83 tons per hectare, these values are much higher compared to those of Buri et al., (2011) in Ghana which obtained an average value of 1 and 6. Our results do not corroborate those of Wakatsuki et al., (2011), Sanogo et al., (2010) on NERICA 60; which could be explained by the environmental conditions which would have a significant influence on the parameters tested. Moreover, according to Nwite et al., (2008) the supply of fertilizers makes it possible to meet the nutritional needs of the plants, the assimilation of water and nutrients by the rice plants, strongly conditions the yield. Yield in fields depend not only because of good soil preparation, but also and above all because of the availability and efficient management of water, Wakatsuki et al., (2008). Yield per hectare (10,000 m2) was estimated by extrapolation for each variety and the same treatment from the surface area of each experimental unit and the mass of the grains per treatment (Ngakou et al., 2013).

Moreover, heritability for this trait is highly heritable (h2=0.76), which confirms the preponderance of genetic variability over environmental variability. Consequently, the genetic improvement of grain yield per hectare is possible in the varieties tested. The expected gains from selection after a selection cycle are estimated at 29.66% compared to the average of the initial population (Table 7). According to Demarly (1977) these gains cannot be effectively obtained when all the genes have an additive effect.

Table 7: Genetic variability and heritability value for Yield per hectare (t)

Variety	Yield per hectare (t)
SABONGARI	13.83 ± 3.05^{a}
WASSA	5.16 ± 2.09^{e}
N36	11.36 ± 1.83^{b}
N60	6.91 ± 1.30^{a}
M53	6.69 ± 1.35^{d}
GAMBIAKA	9.75 ± 1.15^{c}
IR46	7.46 ± 3.05^{d}
Genotypic mean	8.74± 1.97
Genetic Variance	1.28
Variety variation	6.43
Mean broad-sense heritability	0.76
PPDS	29.66

Means followed by the same letter are not significantly different at the 5% level.

IV. Conclusion

In the light of the results of this study, the general objective of which was to evaluate the varietal diversity and the agronomic and genetic performance of seven varieties of rice selected by SEMRY in the locality of Maga through agro-morphological evaluation in order to make available to researchers and developers a database on the characteristics of Maga's rice collection. The results observed from the agronomic evaluation showed that there is variability between the different varieties tested. This variability was observed for traits such as total number of tillers at maturity, plant size, number of panicles, sterility rate and yield. Based on the agronomic traits evaluated, four varieties could be selected as promising among the lot. These are the SABONGARI, N36, GAMBIAKA and IR46 cultivars which also have a respective yield of 13.83, 11.36, 9.75 and 7.47 t/h. Also, these varieties were characterized by a relatively short vegetative growth cycle compared to most lowland rice varieties grown in the area. However, it is important to emphasize that the large amount of water observed in the study area throughout the development phase of the plants did not allow the different varieties to express their full potential.

The results obtained should not be considered definitive. The selected varieties as well as the others should in subsequent studies be monitored over large areas in the same region in order to confirm the results obtained.

Conflict of Interest

The authors declare that they have no conflict of interest.

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