AGRO-MORPHOLOGICAL CHARACTERIZATION OF AFRICAN RICE ACCESSIONS (Oryza glaberrima) IN RAINFED AND IRRIGATED CULTURAL CONDITIONS

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ABSTRACT

African rice is used for its resistance to diseases and stresses, to improve Asian species. Unfortunately, its culture is greatly neglected in favor of Asian varieties and because of this only many African rice varieties are literally on the way of extinction. Due to its potential, it is important to preserve this agricultural resource. This work aims primarily at doing agro-morphological characterization of African rice accessions in the perspective to identify the useful varieties of Oryza glaberrima for future exploitation. This study was carried out at the Africa Rice Center sites in Republic of Benin and Senegal, for this 235 African rice accessions including two controls (CG14, NERICA4) have been observed during rainfed (Benin) and irrigated (Senegal) culture using “Augmented design in randomized complete block” method. Result of study revealed that all accessions completed their life cycle; among the tested accessions, 22 were reported as O. sativa and interspecific accessions while reset 213 accessions were phenotypically identified as O. glaberrima. The discriminate variables of PCA (based on the 9 main parameters) of 213 O. glaberrima accessions, leaded to a dendrogram with two clusters: cluster I (114 accessions) is characterized by the precocity of their cycle: it can be used as an important...
1 Introduction

The rice (*Oryza* spp) is a basic food that provides 27% of the energy intake in population of third world countries (FAO, 2004). It is an important agricultural product for food in West Africa, where 40% of needs are insured by the international market (Mendez del Viflar & Bauer, 2013). Two species *Oryza sativa* (Asian rice) and *Oryza glaberrima* Steud (African rice) are mainly cultivated in Africa (Anonymous, 1991; Anonymous, 2002). The African species is composed of several varieties used for a long time in varietal improvement systems because of their potential for resistance to diseases and drought (Africa Rice, 2010). The introduction and rapid adoption of Asian rice varieties has, on one hand, led to an increase in rice production resulting in a positive impact on producer’s income (Obilana & Okumu, 2005), and on the other hand, abandonment of African rice. However, the success of Asian and improved varieties does not fully satisfy breeder’s ambitions and the expectations of producers and consumers. There is still an unfavorable difference between improvement varieties and their parent *O. glaberrima* either in the form of resistance, tolerance to cultural constraints (biotic and abiotic), or organoleptic and nutritional quality (Futakuchi & Sié, 2009; Africa Rice, 2010). These observations challenges breeders to improve the abilities of native varieties (interspecific) being created and tested under various growing conditions (rainfed, lowland, irrigated, etc.) so that they can better adapted, more productive and accepted by consumers. The use of parents such as the *O. glaberrima* was therefore indispensable, since they constitute the very basis of the creation of interspecific varieties.

Domestication, gene flow and natural introgression are interspecies phenomena that can affect over time the diversity of rice species. In West Africa, due to its abandonment, very few studies have focused on characterization of the African rice in varied growing conditions. This study would make it possible to better evaluate, with a wide range of agro-morphological indicators, the agronomic potentials of the African rice. This work, in context of a research project about the valorization of African rice, aims mainly to identify the successful accessions of African rice useful for varietal improvement systems, through a hierarchical classification based on agronomic descriptors. The results will not only complete the list of characterized African rice varieties, but also ensure the use of its diversity for the development of new rice varieties.

2 Material and Methods

2.1 Test sites

Two sites namely “the Africa Rice station of Cotonou (Benin)” for rainfed test (between October and January) and “the Africa Rice station of Sahel (Ndiaye, Saint Louis, Senegal)”, for irrigated test (between September and December) were exploited for testing.

2.2 Materials

It consists of 235 accessions of African rice collected in the villages of Danyi in Togo (in August and December 2008) and two controls (CG 14, NERICA4) having all been subjected to the germination test.

2.3 Experimental Setup

The setup used for the implementation of the two tests is built according to the method "Augmented Design in Randomized Complete Block" described by Nokoe (2001). This test has been used because of the high number of accessions while the quantity of seed is very limited (about 5g). The method consists in designing a device in which only the controls are repeated in each block (Sharma, 1988), to be used for the estimation of the experimental error and the block effect. 24 blocks of 10 entries and two witnesses, totaling 12 entries per block were designed. Each elementary plot has a density of 42 plants 20cm apart between the lines and on the lines. The elementary plots (1.68 m2 of area) are separated by a path of 30cm.

2.4 Agronomic Practices

2.4.1 For rainfed crops (Benin)

Sowing was carried out in a line by a direct method at the rate of 2 seeds per plant, with a separation (after two weeks) at one plant. Only basic fertilizer NPK (10-18-18) is applied at the rate of 100 kg / ha at seeding. Irrigation was carried out with a watering system and weeding was carried out manually.

2.4.2 For irrigated crops (Senegal)

The seeds were pre-germinated at artificial incubator at 30°C for 48 hours. Seedlings were transfer in to pots in greenhouse conditions. Nine (09) days after sowing, the pots were removed from the greenhouse and exposed to natural conditions for
acclimatization; this transplanting was carried out in a line. Selective Herbicide, LONDAX 60% (Bensulfuron-Methyl 100 g/kg) was applied for weed control with a recommended application rate of 100g/ha (Africa Rice 2010). This application is accompanied by manual weeding. Three successive applications of fertilizer NP2O5K2O (150-60-60) were carried out for the treatment of the tests. For irrigation, draining system has been developed to allow the management and renewal of water whose level is controlled according to the evolutionary stage of the plants.

2.5 Agro-morphological parameters observed

Observations are related to agro-morphological characteristics of varieties and some characteristics of post-harvest grain. Overall 36 quantitative and qualitative parameters were measured according to the SES (Standard Evaluation System) and the International Rice Research Institute (IRRI) descriptors. However, nine mains parameters viz tillering at 30 days after Sowing (Till30), tillering at 60 days after Sowing (Till60), height 60 days after Sowing (Hgt60), maturity height (Mat.Hgt), flowering date (Flw.Date), maturity date (Mat.Date), number of fertile panicles (NFP), weight of 1000 grains (Wgt.1000g) and yield have been studied in detail.

2.6 Statistical treatment

Since only the witnesses were repeated the effect of the blocks was first evaluated and the adjustment of the averages of the accessions was then realized. For the different parameters, the level of variability and degree of heritability within the collection were studied to ensure homogeneity and absence of the effect of the environmental factor. A simple descriptive analysis was realized with the R software, followed by significance and correlation test of a Genotype-Environment (GXE) Principal Component Analysis (PCA), Hierarchical Ascending Classification (HAC) and study of variance of the different groups were realized using the adjusted averages of the common parameters evaluated at the two sites.

3 Results

The results of germination test of the accessions showed on average of 80%. Within the tested collection, it was observed in the two sites, twenty-two (22) accessions within agromorphological characteristics widely distinct from others, with a mixture of specific traits (of O. sativa or interspecific).

3.1 Presentation of Agronomic Characteristics

The heritability coefficient varies between 0.86 and 0.99 for rainfed conditions and between 0.84 and 0.99 for the irrigated conditions. The coefficient of variability varies between 0.021 and 1.9. The correlation Genotype X Environment of parameters showed a p-value above 0.05 for the yield. The adjusted average of the data of the two sites made it possible to extract the descriptive values from the agronomic parameters (Table 1) and to make a Principal Component Analysis (PCA).

3.2 Identified Phenotypic Groups

The individuals factor map (Figure 1) obtained from PCA showed the distribution of accessions based on their similarity. The two axes of distribution map represent more than 50% of the information in the collection. The selection of the characteristics parameters was made from their value contribution, which informs on the quality of their representation and their contribution to the distribution.

These results made it possible to make the hierarchical classification represented by the dendrogram (Figure 2), this appeared two groups (clusters) phenotypes. Table 2 shows the different values-tests for the variables of each cluster. The fundamental difference between the accessions is related to the variables as: Till30 (4.10), Till60 (16.62), Hgt60 (83.15cm), Mat.Hgt (81.07cm), Flw.Date (≈ 48 days), Mat.Date (≈ 80 days), NFP (19.76), and yield (497.30g/m²). This grouping made it possible

| variables   | Moy  | Low  | Max  | Standard deviation |
|-------------|------|------|------|--------------------|
| Till30      | 4.10 | 1.94 | 9.10 | 0.16               |
| Till60      | 16.62| 9.51 | 26.07| 1.97               |
| Hgt60 (cm)  | 83.15| 69.21| 100.64| 3.25              |
| Mat.Hgt (cm) | 81.07| 66.16| 99.83| 1.42              |
| Flw.Date (days) | 47.20| 41.30| 59.10| 2.65              |
| Mat.Date (days) | 79.80| 74.35| 90.05| 5.47              |
| NFP         | 19.76| 12.10| 29.45| 5.09               |
| Wgt.1000g (g) | 26.61| 20.41| 36.15| 1.98               |
| Yield (g/cm²) | 497.30| 297.57| 702.25| 60.97              |

Table 1 Descriptive values of the agronomic characteristics of the accessions studied.

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Figure 1: Accessions distribution map

Figure 2: Hierarchical classification of accessions according to their agronomic characteristics
Absence of Genotype X Environment effects on yield revealed that site variation does not seem to affect the productivity. These results are in agreement with the findings of Gueye et al. (2010) and Plura et al. (2014) genotypic variation is an important factor for the improvement of variability and selection of new varieties. Absence of Genotype X Environment effects on yield revealed that site variation does not seem to affect the productivity. These results are in agreement with the findings of Gueye et al. (2010) and Plura et al. (2014) genotypic variation is an important factor for the improvement of variability and selection of new varieties. Absence of Genotype X Environment effects on yield revealed that site variation does not seem to affect the productivity. These results are in agreement with the findings of Gueye et al. (2010) and Plura et al. (2014) genotypic variation is an important factor for the improvement of variability and selection of new varieties. 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with the assertions of Linares (2002) who estimates the productivity of African rice varieties (O. glaberrima) and reported lower yield. These observations explain a relative control of chattering, lodging incidence and pests; these factors being controlled by fillets, bird hunters and border plants during agronomic test. In fact, lodging incidence and chattering are the factors of the low yield potential of African rice (Futakuchi & Sié, 2009). Similar results were observed by Africa Rice (2010) and Aboa et al. (2004), those who suggested that water lodging and chattering are the major limiting factors for O. glaberrima varieties. The exsorption panicle also contributes to the reduction of damage. Indeed, a good exsorption of the panicle is a characteristic of weak attack of blast on the neck of the panicle and a good maturation of the spikelets (Jacquot, 1974). This character obviously favored the absence of damage due to blast and maturation of grain that improved yields. This study revealed that there are still accessions of African rice that can have strong yield potential.

### 4.2 Phenotypic groups identified

The classification of the accessions showed two groups (cluster1 and cluster2). The fundamental difference was reported between the studied accessions. Studied nine characteristics are well discriminating the selected African rice collection. Previous studies conducted on agronomic characteristics revealed that height of plant and tillering ability are essential characteristics which can discriminate rice populations (Ogunbayo et al., 2007; Ojo et al., 2009; Moukoumbi et al., 2011). Current study identified two clusters, among these, cluster I have 114 accessions while cluster II have 99 accession of African rice, this cluster also have two controls CG14 and NERICA4. The values-test (y-test) obtained made it possible to distinguish the variables that strongly characterize the accessions of each cluster. Indeed, cluster 1 groups more than half of the accessions, and the two clusters are strongly characterized by tillering ability 60 days after sowing (Till60), height of plant (at 60 days after sowing and at maturity) and yield. For these variables, the accessions of cluster 1 have their averages relatively lower than the average of the entire collection; on the other hand, the accessions of cluster 2 are characterized by their average values above the average of the entire collection. Concerning the variable « precocious of the cycle », which is an interesting and exploitable trait for the varietal selection, the accessions of the cluster 1 are revealed very early, with sowing-flowering and sowing-maturity cycles very short compared to the average of the collection. Results of current study are contradictory to the findings of Montcho et al. (2017) those who reported that O. sativa has a shorter life cycle than O. glaberrima. According to Takeshi (2007), the vegetative cycle is an important factor that can be used as a control parameter for climatic factors and pests. The cycle time of a rice variety is strongly related to its photoperiod sensitivity and depends mainly on the duration of its basic vegetative phase (Dingkuhn & Asch, 1999).

### Conclusion

The results of this study reveal that the collection is composed of O. glaberrima accessions grouping according to agronomic performance in two clusters. The characteristics of the hierarchical groups show that these varieties present an appreciable agronomic performance with the capacity to develop under several constraints associated with several ecosystems such as the rainfed and the irrigated cultural condition. Globally, the accessions of cluster 1 seem to be the most interesting, owing to their good performance in different conditions (sites and seasons) and their precocious cycle. It is favorable materials for further study because these genotypes have good environmental adaptation, higher productivity, high and stable yields. This collection constitutes a reservoir of interesting genes, which explains its use in variety improvement programs. These results give an opening on the study of the nutritional values in order to reveal over assets for the valorization of the African rice O. glaberrima.

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### Conflict of interest

There is no conflict of interest for the publication of this article.

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