



"Participatory Pedigree Selection of 40 Tongil Rice (*Oryza sativa* L.) Lines Based on Qualitative Parameters under the Agroecological Conditions of Bumba, Democratic Republic of the Congo"

Mopanzo Malonga Anicet^{1*}, Malomalo Akwa Mthilde¹, Andia Wikipakpo Prosper¹, Lisasi Mopepene Constant¹, Mwanza Tshikana Richard¹, Mambokolo Molongo Charles², Liboga Oenabaiso Bienvenu² and Mumba Djamba Antoine³

^{1*}Higher Pedagogical Institute of Bumba, B.P 124 Bumba, Democratic Republic of Congo

²Faculty Institute of Agronomic Sciences of Yangambi B.P. 1232 Kisangani, Democratic Republic of Congo

³National Pedagogical University, Faculty of Agricultural Sciences, B.P. 8815 Kinshasa-Ngaliema, Democratic Republic of Congo.

Abstract

This study carried out participatory pedigree selection of several Tongil rice (*Oryza sativa* L.) lines based on qualitative parameters under the agroecological conditions of Bumba, Democratic Republic of the Congo.

The treatments were conducted under the same experimental conditions in order to allow the best varieties to express their potential in accordance with the genetic aptitude of each one.

The recorded data were processed and analyzed through analysis of variance (ANOVA), principal component analysis (PCA), and hierarchical cluster analysis using the Cluster software.

The obtained results are summarized as follows:

- ✓ The shape, color, and translucency of the grain indicate that only two varieties are closely related.
- ✓ The comparison of qualitative parameters among the 40 rice varieties studied resulted in five distinct classes when the axis was cut at 5 cm, as illustrated in Figure 2.
- ✓ The lines KF230002, Lienge, KF230049, KF230058, and KF230114 exhibited earliness compared with the others in terms of growth cycle.
- ✓ The varieties T21, NERICA4, and T30 stand out as priorities for rapid dissemination and adoption by farmers.
- ✓ Varieties with average yield but low variability (e.g., T26, T35, T16) may represent stable options for specific plots.
- ✓ Varieties with low yield and high variability (e.g., T2, T29, T33, T34) should either be excluded from selection or subjected to further testing

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I. Introduction

Rice (*Oryza sativa* L.) is one of the most widely consumed cereals in the world (CTA, 2013). More than 479.2 million tons of rice are produced annually, with an average human consumption of 468 million tons (FAO, 2013). Unfortunately, over 90% of global production (approximately 675 million tons) is concentrated in Asia, while Africa contributes only about 4% (29 million tons). The annual per capita consumption is estimated at 100–120 kg in Asia and about 40 kg in Africa (CIRAD, 2010).

More than 200 million hectares of arable land in Africa are potentially suitable for rice cultivation (AfricaRice, 2013). However, only about 9.7 million hectares are currently utilized for this purpose. In short, Africa remains the continent with the greatest untapped potential for rice development (Futakuchi *et al.*, 2011).

In the Democratic Republic of Congo, rice cultivation remains largely the domain of smallholder farmers, who cultivate on average about 0.50 ha under upland conditions and 0.20 ha under lowland (flooded) conditions, with respective yields of approximately 1 ton and 3 tons of paddy per hectare (Futakuchi *et al.*, 2011).

Despite concerted efforts to develop and disseminate improved rice varieties through various development programs and projects, and the existence of a national rice research program that possesses high-yielding varieties and breeding lines, a large proportion of farmers in the Bumba Territory of the former Equateur Province and its surroundings still rely on a few traditional local varieties (Moukoubi, 2001).

Information gathered from the Congolese Ministry of Agriculture (Minagri-RDC, 2013) and from local farmers indicates that only a few varieties represent the existing varietal diversity of rice in the Bumba Territory, namely NERICA4, NERICA7, and IRAT112, which appear to have undergone genetic degeneration. The white rice produced from these varieties is predominantly sold in Kinshasa under the name "Bumba rice" referring to its area of origin. Although widely cultivated, these varieties exhibit several weaknesses, particularly in terms of yield, grain quality, and susceptibility to diseases and pests.

In this context, the present study, conducted within a plant breeding and improvement program, aims to evaluate and promote several improved rice genotypes through a Participatory Varietal Selection (PVS) and Participatory Pedigree Selection (PPS) approach (Minagri-RDC, 2013).

This PVS/PPS process is intended to provide farmers in the Bumba Territory with a range of rice varieties and lines, enabling them to select those that best meet their production needs and preferences (Minagri-RDC, 2013)

II. Study Area, Materials, and Methods

2.1. Study Area

The locality of Bumba, initially established as a state post in 1888, was elevated to the status of a town in 1988 (Ordinance-Law 87-233 of June 25, 1988). In 2013, it was granted city status; however, this status was not retained following the administrative reform implemented in 2015, after which Bumba was designated a rural commune.

The main agricultural products in Bumba include rice, peanuts, and cassava. In 2005, a survey conducted by the DSCRCP classified the city of Bumba as being in a state of alarming poverty (Le Potentiel, 2005). The population growth rate is estimated at 2.3% per year (IRRI, 1996). According to the Bumba Urban Health Zone, the population in 2020 was approximately 256,000 inhabitants (SNDR II, 2016)

Bumba is located on the right bank of the Congo River, near the confluence with the Itimbiri River, and is accessible via National Road RN6, at a distance of 156 km from Lisala. Its geographic coordinates are 2°11'16" N latitude and 22°28'06" E longitude, at an altitude of 362 m (Omasombo, 2015).

According to Weatherpark (<https://fr.weatherspark.com>), the annual temperature generally ranges from 21 °C to 32 °C and rarely falls below 19 °C or exceeds 38 °C. The very hot season lasts approximately 1.8 months, from January 22 to March 16, with an average daily maximum temperature above 31 °C. The hottest month of the year in Bumba is February, with an average maximum temperature of 32 °C and an average minimum of 23 °C (SNDR II RDC, 2023).

The Mongala Province falls within the Am climatic zone, characterized by a dry season lasting approximately one month, except in the Bumba Territory, where two dry seasons are observed, lasting approximately one and a half months and four months, respectively (Omasombo, 2015). This corresponds to a tropical savanna climate with a dry winter (AW) according to the Köppen-Geiger classification (ISSR Journals, 2021).

2.2. Materials

The biological material used in this study consisted of rainfed rice varieties and lines (*Oryza sativa* L.) adapted to the local ecological conditions. These varieties were developed by INERA and/or obtained through collaboration with AfricaRice (SIE M., 1991).

The implementation of this study was made possible through the use of various equipment, including a measuring tape, drying sheets, nylon, a magnifying lens, a calculator, a computer, a camera, mechanical and electronic balances, a knife, packaging materials, a caliper, and a trimotor.

2.3. Experimental Method

The experimental design used was a completely randomized block design with four replications and 40 treatments consisting of rice lines/varieties to be evaluated, established in experimental plots measuring 1 × 2 m. The experimental plots were separated by 0.5 m, while the blocks (replications) were separated by 1 m. Direct sowing was carried out at a spacing of 25 × 20 cm. The elementary plot measured 2 m², and the portion constituting the population sample (useful plot) was 0.7 m². The assignment of lines to blocks was performed by random drawing without replacement.

For sampling (useful plot), 14 plants were selected, representing 35% of the total population of the plot (0.7 m²). The useful plot was entirely harvested to assess yield. For other observational and varietal/line description parameters, four plants were sampled in a zigzag pattern within the useful plot, representing approximately 30% of the sample, from which specific traits were measured.

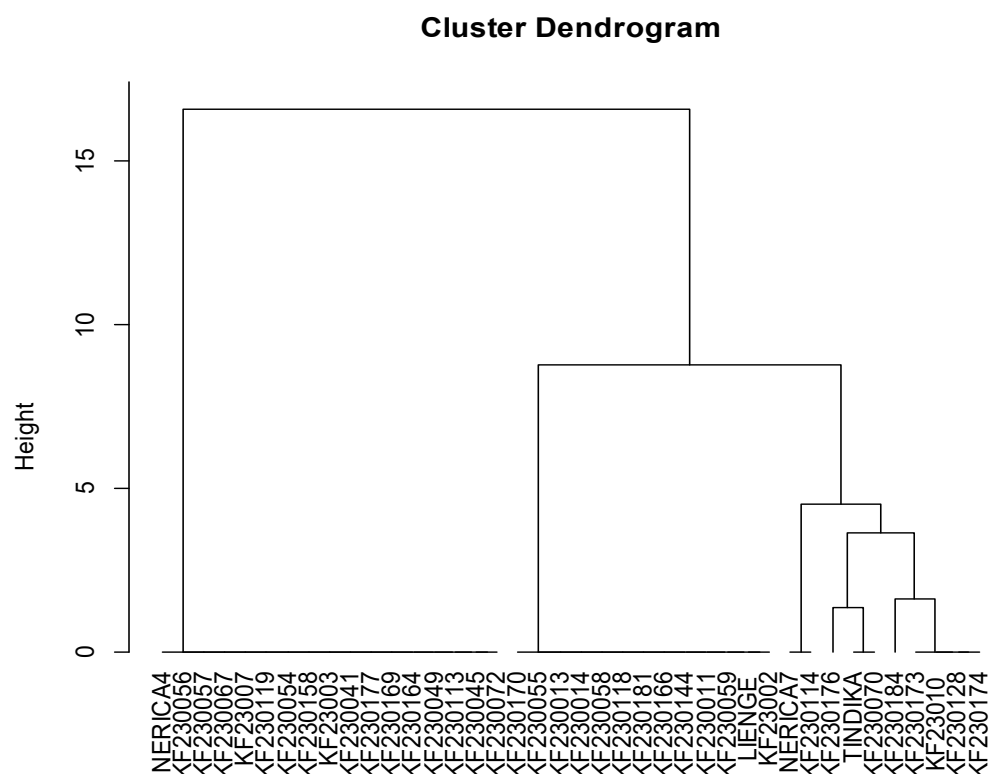


Figure 2. Similarity of Rice Varieties

3.1.2. Sowing-to-Heading and Sowing-to-Maturity Cycles

The values corresponding to the sowing-to-heading and sowing-to-maturity cycles are illustrated in Figure 3

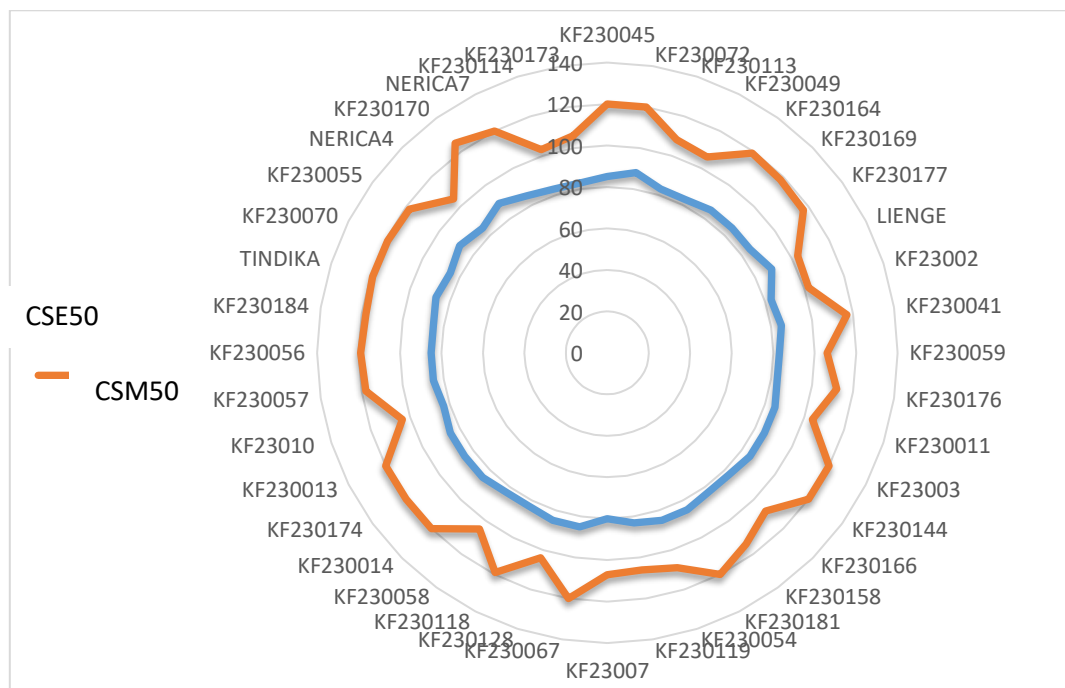


Figure 3. Sowing-to-Heading (CSE50) and Sowing-to-Maturity (CSM50) Cycles

From the results shown in this figure, it appears that the lines KF230002, Lienge, KF230049, KF230058, and KF230114 were early compared to the others. The first three weeks of the trial were very challenging due to drought, which likely contributed to delayed heading. Only a few lines were somewhat early, with the overall cycle generally lasting 3.5 to 4 months.

According to farmers' observations, late-maturing varieties are often sold at the right time, provided they are productive. This preference explains the choice of the KF230045 variety.

3.1.3. Results of Participatory Farmer Selection

The numerical values from the **participatory farmer selection** are presented in **Table 1**.

Table 1. Participatory Farmer Selection

	KF230045	NERICA7	NERICA4	TINDIKA	KF230007	KF230057	KF230144	KF230056	KF230144	LIENGE
HOMME	5	5	4	2	5	4	3	3	3	3
FEMME	5	5	4	3	5	4	2	2	2	2

In this table, the selection was based on parameters such as tillering (number and panicle-bearing), panicle length and weight, plant height (not too tall to avoid lodging), grain density and size, plant vigor, and disease resistance. By combining the choices of both men and women, we recorded the farmers' preferences and motivations:

- **KF230045**: good plant height, good tillering, although late-maturing;
- **NERICA 7**: already cultivated in Bumba, but highly notable;
- **KF230007**: very good performance;
- **NERICA4**: already cultivated in Bumba, but highly notable;
- **KF230057**: a promising line if the soil conditions are optimal and rainfall is adequate.

The interpretation of this participatory selection is presented in Table 2.

Table 2. Interpretation of Participatory Selection

Ranck	Treatment	Mean (g)	Écart-type	Interprétation	Selection Priority
1	T21 (KF23007)	382,00	94,15	Very high yield, moderate variability	Very high
2	T36 (NERICA4)	353,75	28,45	High yield, low variability (stable)	Very high
3	T30 (KF230057)	312,00	64,91	High yield, moderate variability	Very high
4	T20 (KF230119)	271,75	53,85	Good yield, adequate stability	High
5	T29 (KF23010)	253,00	128,05	Good yield, high variability	mean
6	T25 (KF230058)	214,50	40,58	Moderate yield, adequate stability	High
7	T40 (KF230173)	210,75	45,83	Moderate yield, adequate stability	High
8	T38 (NERICA7)	210,75	53,65	Moderate yield, moderate variability	High
9	T19 (KF230054)	199,25	62,25	Moderate yield, moderate variability	mean
10	T8 (LIENGE)	196,50	20,76	Moderate yield, low variability	High
11	T9 (KF23002)	189,25	121,96	Moderate yield, low variability	mean
12	T13 (KF230011)	187,75	77,91	Moderate yield, moderate variability	mean
13	T15 (KF230144)	173,75	70,65	Moderate yield, moderate variability	mean
14	T28 (KF230013)	174,25	88,67	Moderate yield, high variability	mean
15	T11 (KF230059)	172,00	87,47	Moderate yield, moderate variability	mean
16	T6 (KF230169)	171,50	71,84	Moderate yield, moderate variability	mean
17	T35 (KF230055)	175,00	29,20	Moderate yield, low variability	mean-high
18	T4 (KF230049)	215,25	114,28	Moderate yield, high variability	mean
19	T1 (KF230045)	220,25	92,01	Moderate yield, high variability	mean
20	T16 (KF230166)	192,75	32,90	Moderate yield, low variability	mean-high
21	T24 (KF230118)	178,75	52,67	Moderate yield, moderate variability	mean
22	T3 (KF230113)	166,75	35,78	Low-moderate yield, low variability	mean
23	T5 (KF230164)	161,25	43,84	Low-moderate yield, moderate variability	mean
24	T17 (KF230158)	144,75	49,78	Low yield, moderate variability	Low
25	T33 (TINDIKA)	147,75	104,22	Low yield, high variability	Low
26	T27 (KF230174)	148,00	23,15	Low yield, low variability	Low-mean
27	T22 (KF230067)	149,75	50,29	Low yield, moderate variability	mean
28	T14 (KF23003)	133,75	52,51	Low yield, moderate variability	Low
29	T32 (KF230184)	133,25	67,16	Low yield, high variability	Low
30	T26 (KF230014)	125,25	15,97	Low yield, but stable	Low-mean

31	T34 (KF230070)	114,25	103,12	Very low yield, high variability	Low
32	T37 (KF230170)	100,75	42,66	Very low yield, moderate variability	Low
33	T18 (KF230181)	92,00	22,11	Very low yield, stable	Low
34	T7 (KF230177)	81,00	52,97	Very low yield, moderate variability	Low

From the analysis of the results presented in this table, the following observations can be made:

- ✓ Varieties T21, NERICA4, and T30 stand out as priorities for rapid dissemination and adoption by farmers.
- ✓ Varieties with moderate yield but low variability (e.g., T26, T35, T16) may serve as stable options for certain plots.
- ✓ Varieties with low yield and high variability (e.g., T2, T29, T33, T34) either require withdrawal from selection or further testing.
- ✓ The table serves as a guide for participatory pedigree selection, combining agronomic performance with local preferences.

These results demonstrate that participatory selection successfully identified rice varieties adapted to local conditions, with significant yields depending on the environment and farmers' preferences.

GENERAL CONCLUSION

This study focused on the "Participatory Pedigree Selection of Selected Tongil Rice (*Oryza sativa* L.) Lines Based on Qualitative Parameters under the Agroecological Conditions of Bumba, Democratic Republic of Congo."

All treatments were subjected to the same conditions, allowing each variety to express its potential. It is assumed that they could perform equally well under more favorable conditions.

The evaluation of these 40 varieties included assessment of grain shape, translucency, color, as well as the sowing-to-heading and sowing-to-maturity cycles. This assessment was complemented by a participatory selection process involving farmers

From the results obtained, it was established that:

- ✓ Grain shape, color, and translucency indicated that two varieties (those whose two straight edges form an acute angle) are closely related, while the other varieties displayed specific characteristics.
- ✓ Hierarchical cluster analysis grouped the varieties into five classes.
- ✓ Regarding the crop cycle, results showed that the lines KF230002, Lienge, KF230049, KF230058, and KF230114 were early-maturing compared to the others.
- ✓ Farmers' preference for late-maturing varieties is explained by the fact that these varieties are often sold at the right time, provided they are productive, which justified their choice of variety KF230045.
- ✓ The combined selection by men and women, based on their preferences and motivations across the 40 rice varieties, led to the following conclusions
 - KF230045: good grain size, good tillering, although late-maturing;
 - NERICA 7: already cultivated in Bumba, but very remarkable;
 - KF230007 : very good performance;
 - NERICA 4: already cultivated in Bumba, but very remarkable;
 - KF230057: a promising line if soil fertility is adequate and rainfall conditions are favorable.
- ✓ Varieties T21, NERICA4, and T30 stand out as priorities for rapid dissemination and adoption by farmers.
- ✓ Varieties with moderate yield but low variability (e.g., T26, T35, T16) may serve as stable options for certain plots.
- ✓ Varieties with low yield and high variability (e.g., T2, T29, T33, T34) either require withdrawal from selection or further testing.
- ✓ The table serves as a guide for participatory pedigree selection, combining agronomic performance with local preferences

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