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Research Paper

Participatory pedigree selection of 40 tongil lines of rice (Oryza sativa L.) in the agro-ecological conditions of Bumba, in the Democratic Republic of Congo

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Abstract
This study conducted a participatory pedigreed selection of several Tongil rice (Oryza sativa L.) lines under the agroecological conditions of Bumba, Democratic Republic of Congo.
The treatments were subjected to the same experimental conditions to allow the best varieties to express their potential in accordance with their genetic aptitude.
The collected data were analyzed using analysis of variance, Bonferroni, and Tukey. The evaluation of the 40 Tongil rice (Oryza sativa L.) lines under the agroecological conditions of Bumba allowed for the measurement of production performance (g) and the variability associated with each variety.
The results obtained showed a wide range of yields, from 382 g for the variety (KF23007) to 81 g for (KF230177), with standard deviations ranging from 15.97 to 128.05, indicating differences in stability between treatments.
The varieties with high production potential are: KF23007 (382 g), NERICA4 (353.75 g), KF230057 (312 kg), and KF230119 (271.75 g).
These varieties are classified as very high or high breeding priority because they combine performance and stability.
Varieties with average production potential are:
➢ *Varieties such as T25/KF230058, T40/KF230173, T38/NERICA7, T8/LIENGE, T16/KF2300166, T35/KF2300055, and T24/KF230118, with a production of between 171 and 215 g.*
The others are varieties with very low production potential.

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I. Introduction

Rice (Oryza sativa L.) is one of the most consumed cereals in the world (CTA, 2013). More than 479.2 million tonnes of rice are produced annually, for an average human consumption of 468 million tonnes (FAO, 2013). Unfortunately, more than 90% of this global production is accounted for by Asia (675 million tonnes). Africa produces only 4% (29 million tonnes). Annual per capita consumption is 100 to 120 kg in Asia and 40 kg in Africa (CIRAD, 2010). More than 200 million hectares of arable land can be used for rice cultivation (AfricaRice, 2013). It only uses 9.7 million hectares for rice. In short, Africa is the continent with the most resources for rice development (Futakuchi et al., 2011).

In the Democratic Republic of Congo, rice cultivation remains the preserve of small producers, cultivating an average of 0.50 ha under dryland cultivation and 0.20 ha under flooded cultivation, with respective yields of around 1 ton and 3 tons of paddy per hectare.

Despite these combined efforts to develop improved varieties and their dissemination through various development programs and projects, as well as the presence of a rice research program in the country that provides high-yielding rice varieties and lines, a large proportion of farmers in the Bumba Territory in the former Grande

Province de l'Equateur and its surrounding areas remain attached to a few old local varieties (Moukoumbi Y.D., 2001).

Information gathered from the Congolese Ministry of Agriculture (Minagri-RDC, 2013) and farmers indicates that the few varieties representing the varietal diversity of rice in the Bumba territory are apparently degenerate (NERICA4, NERICA7, IRAT112). White rice of these varieties is mainly sold in Kinshasa under the name "Bumba rice," referring to its place of production. Although widely cultivated, these varieties have certain weaknesses, notably yield, grain quality, sensitivity to diseases and pests, etc.

In this perspective, the present research, which is part of a plant improvement and selection program, aims to evaluate and popularize some improved rice genotypes through Participatory Varietal Selection/Pedigree. This PVS/PPS will thus make several rice varieties/lines available to farmers in the Bumba Territory, so that they can choose those that correspond to their needs.

II. Setting, Materials, Method

2.1. Study Setting

The town of Bumba, chosen as a state post in 1888, was established as a city in 1988 (Ordinance-Law 87-233 of June 25, 1988). In 2013, it obtained city status. This status was not maintained during the administrative reform implemented in 2015; it was subsequently granted the status of Rural Commune.

Bumba's agricultural products are rice, corn, peanuts, and cassava. In 2005, a DSCRP survey judged the town of Bumba to be in a situation of alarming poverty (Le Potentiel, 2005). Population growth is estimated at 2.3% (OCHA FISS, 2018). According to the Bumba Urban Health Zone, its population in 2020 was 256,000 inhabitants (ZSUR Bumba, 2020).

The city of Bumba is located on the right bank of the Congo River and near the confluence of the Itimbiri River. It is served by the RN6 national road, 156 km from Lisala. Its geographical coordinates are 2°11'16"N latitude and 22°28'06"E longitude; it is at an altitude of 362 m (Omasombo, 2015).

According to Weatherpark (https://fr.weatherspark.com), the temperature generally ranges from 21°C to 32°C throughout the year and rarely falls below 19°C or rises above 38°C. The very hot season lasts 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 a minimum of 23°C (SNDR II DRC, 2023).

The Mongala province belongs to the Am climatic zone, characterized by a dry season lasting one month, with the exception of the Bumba territory where two dry seasons lasting one and a half months and four months respectively are observed (Omasombo, 2015). This brings it to the dry winter savannah climate type (AW), according to the Koppen-Geiger classification (Contressens.net, 2025).

2.2. Materials

The biological material used in this research consists of ecologically adapted rainfed rice (Oryza sativa L.) varieties and lines. These varieties were developed by INERA and/or acquired through cooperation with AfricaRice (SIE M., 1991).

This work was made possible through the use of a tape measure, drying tarpaulins, nylon, a magnifying glass, a calculator, a computer, a camera, mechanical and electrical scales, a knife, packaging, a caliper, and a trimotor.

2.3. Method

The experimental design used was a randomized complete block design, with four replicates and 40 treatments consisting of the lines/varieties to be evaluated, in 1x2 m experimental plots. The experimental plots were separated by 0.5 m, while the blocks or replicates were separated by 1 m, and direct sowing was carried out at 25 x 20 cm spacings. The elementary plot was 2 m², and the sample portion of the population (useful plot) was 0.7 m². Lines were assigned to the blocks by random selection without replacement.

Sample (Useful Plot): 14, representing 35% of the total population of the plot (0.7 m²). The useful plot was fully harvested for yield expression. But, for other observation parameters and those of description of the lines/varieties, we drew from the sample, in a zigzag pattern, 4 plants, representing approximately 30% of the sample, on which certain parameters are taken.

2.3.1. Observed Parameters and Their Characteristics

Data were collected using the IRRI Standard Rice Evaluation System (SERS) (2002).

Observations included germination rate, average number of tillers per clump, number of grains per panicle, 1000-grain weight, and seed yield in tons per hectare.

2.3.2. Results Analysis

This participatory breeding approach uses empirical methods such as analysis of variance.

Farmers' preferences for rice were rated using Likert scales: 1 = very insignificant; 2 = unimportant; 3 = undecided; 4 = important; and 5 = very important (Mattson, 1986). Data analysis combined farmers' preferences, yield performance, and breeders' stability. Rice yield data by line were analyzed by analysis of variance (ANOVA), using R, SPSS and STATISTIX software.

III. Results and Discussion

3.1. Germination Rate

The overall average rate was 61.6%. Since the seeds came from Yangambi, some may have significantly lost their germination capacity. The lowest rate was observed in lines KF 230174 (18%) and Tindika (20%).

3.2. Number of Tillers

Tillers were counted visually for all varieties studied; the corresponding averages are shown in Figure 9.

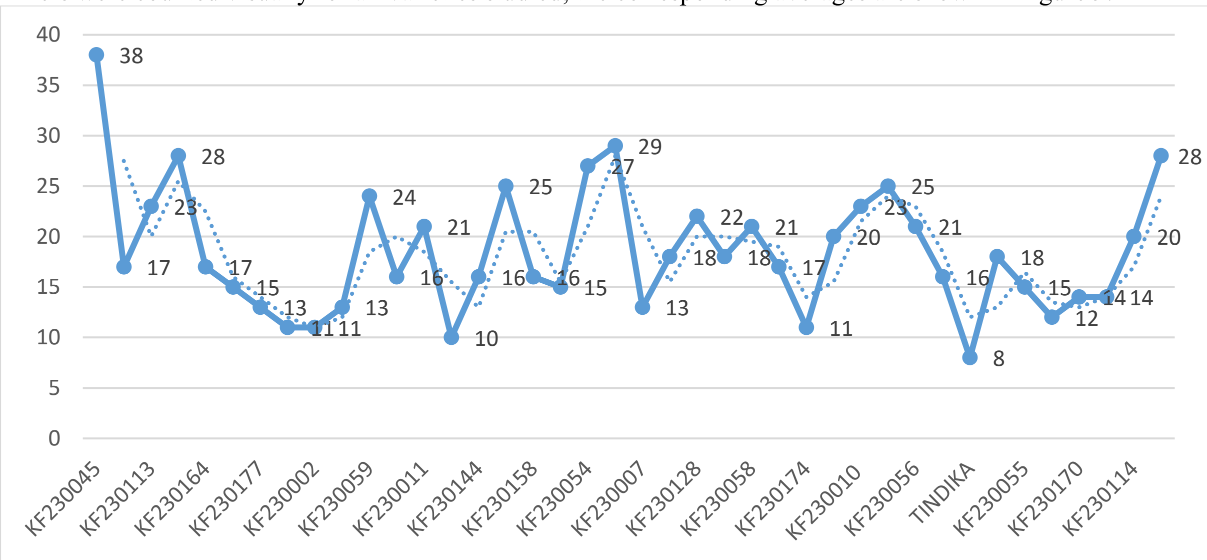


Figure 1. Average number of tillers per variety

The results in Figure 1 show that the number of tillers varied from one rice line to another. These results showed that line KF230045 exhibited a high tillering ability (38 tillers on average). It, followed by lines KF230119 (29 tillers), KF230049, and KF230173 exhibited a similar tillering ability (28 tillers).
The high tillering observed in variety KF230045 is linked to its genetic makeup and its ability to adapt to Bumba conditions.

3.3. Thousand-seed mass, length, width, L/L ratio, and seed shape

The results relating to thousand-seed mass, length, width, L/L ratio, and seed shape are presented in the figures below.

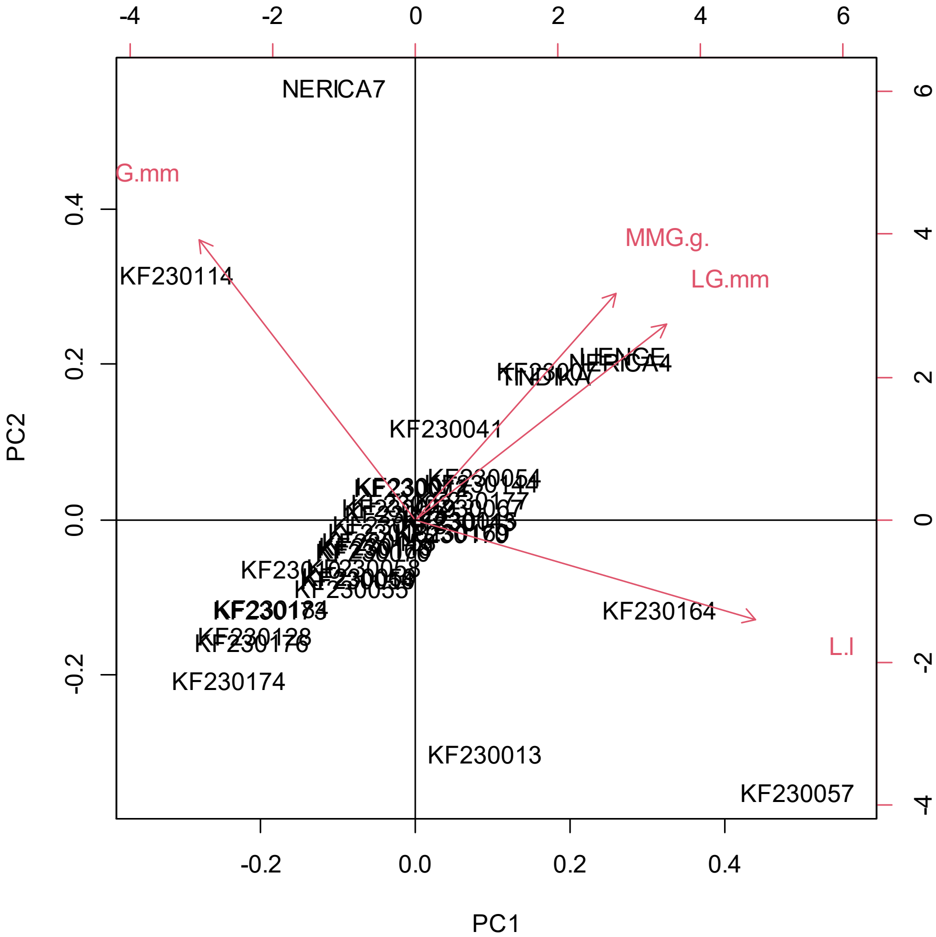
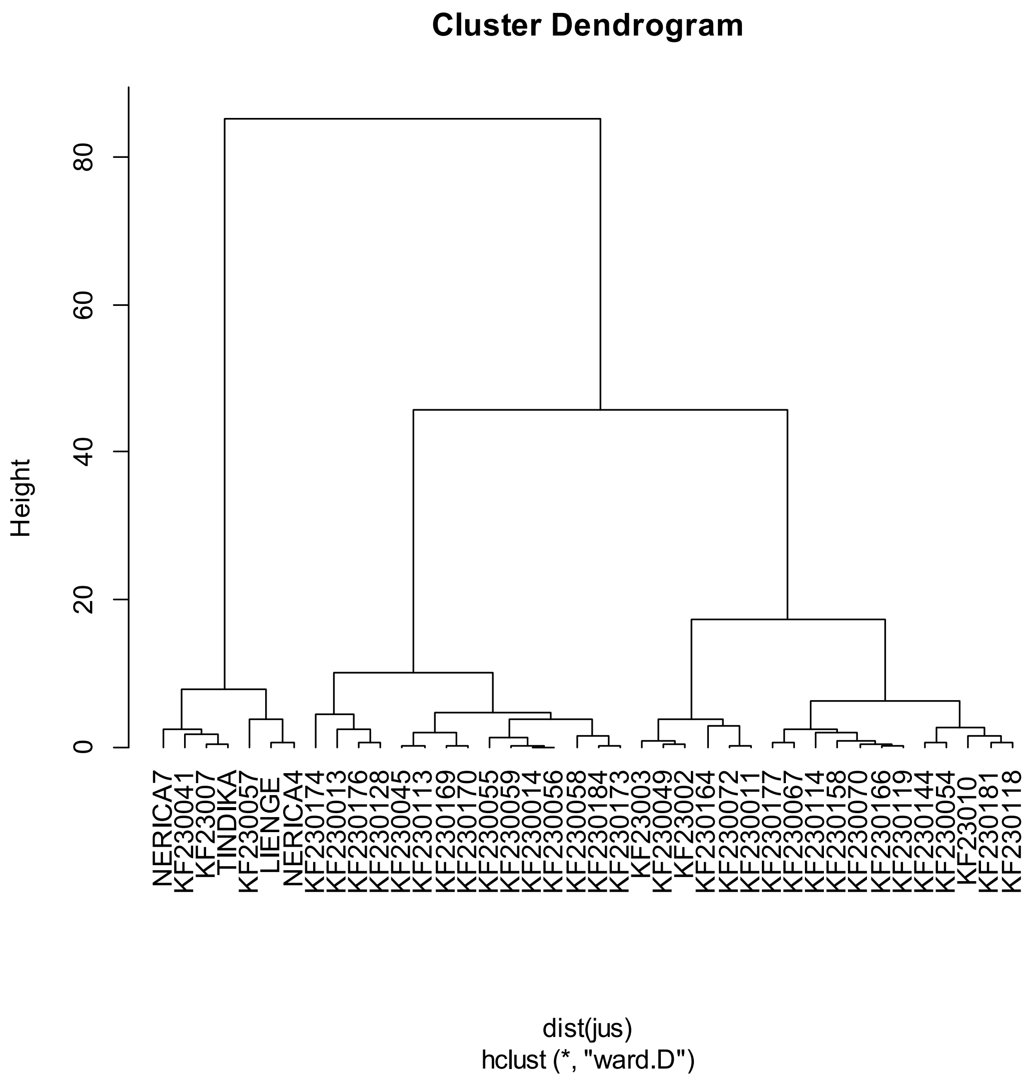


Figure 2. Thousand-seed mass, length, width, L/W ratio, and seed shape

Analysis of the results in the figure above reveals that varieties KF230114 and KF230164 differ in terms of seed width and seed L/W ratio. Varieties with right-angled arrows are close to each other in terms of thousand-seed mass and seed length.
These results group the studied varieties into three classes at a Euclidean distance of 20. Furthermore, the number increases with decreasing Euclidean distance, as shown in the figure below.



3.4. Seed Yield of Lines/Varieties

Table 5.6 gives the weight in grams of the sample plots, or 0.7 m², equivalent to 14 plants taken as a sample of the population. The following statistical analysis, as well as the impressions of both male and female farmers, will guide us in selecting the best ones.

Table 1. Plot Production (grams/0.7 m²) and Theoretical Yield (kg/ha)

Traitement	**Série/variété**	(g)/0,7 m^2	kg/ha
T21	KF23007	382	5 457
T36	NERICA4	353,75	5 054
T30	KF230057	312	4 457
T20	KF230119	271,75	3 882
T29	KF23010	253	3 614
T2	KF230072	229,5	3 279
T31	KF230056	222	3 171
T1	KF230045	220,25	3 146
T4	KF230049	215,25	3 075
T25	KF230058	214,5	3 064

T38	NERICA7	210,75	3 011
T40	KF230173	210,75	3 011
T19	KF230054	199,25	2 846
T8	LIENGE	196,5	2 807
T16	KF230166	192,75	2 754
T13	KF230011	187,75	2 682
T9	KF23002	186,75	2 668
T24	KF230118	178,75	2 554
T35	KF230055	175	2 500
T28	KF230013	174,25	2 489
T15	KF230144	173,75	2 482
T11	KF230059	172	2 457
T6	KF230169	171,5	2 450
T3	KF230113	166,75	2 382
T39	KF230114	163	2 329
T5	KF230164	161,25	2 304
T10	KF230041	150,75	2 154
T22	KF230067	149,75	2 139
T27	KF230174	148	2 114
T33	TINDIKA	145,25	2 075
T17	KF230158	144,75	2 068
T23	KF230128	135,75	1 939
T14	KF23003	133,75	1 911
T32	KF230184	133,25	1 904
T26	KF230014	125,25	1 789
T34	KF230070	114,25	1 632
T12	KF230176	101	1 443
T37	KF230170	100,75	1 439
T18	KF230181	92	1 314
T7	KF230177	78,5	1 121

From the results in Table 6, it appears that seed weight varied generally from one variety to another. These results show that the KF23007 variety performed better (382 g). This was followed by the varieties NERICA4 (353.75 g) and KF230057 (312 g).

Furthermore, the descriptive analysis shows that the four experimental blocks have relatively similar production averages, as follows :

Block 1: 167.85 g ± 95.25

Block 2: 185.93 g ± 96.86

Block 3: 195.40 g ± 84.90

Block 4: 185.60 g ± 90.87

The overall average of 160 observations is 185.60 g, with a standard deviation of 91.71, and a 95% confidence interval ranging from 169.75 to 198.39 g. The minimum and maximum values (10 to 57 g and 368 to 506 g) across blocks reflect the significant heterogeneity and dispersion of yields within the blocks.

The p-value > 0.05 indicates that there is no statistically significant difference in rice production between the four blocks.

Concretely, the variations observed between blocks are likely due to chance or natural variability in treatments and not to the effect of the block.

However, comparing the production averages of the 40 treatments confirms that there is significant variability, ranging from 81 g (T7 – KF230177) to 382 g (T21 – KF23007). The standard deviations obtained also vary significantly (T2 = 204.76, T26 = 15.97), which confirms differences in production performance between the rice varieties studied. These results classify rice varieties into 3 categories : high-yielding varieties (T21 (KF23007) : 382 g; NERICA4 (T36): 353.75 g; T30 (KF230057): 312 g; T20 (KF230119): 271.75 g), low-yielding varieties (T7 (KF230177): 81 g; T18 (KF230181): 92 g; T34 (KF230070): 114.25 g) and intermediate-yielding varieties (T20 (KF230119), T29 (KF23010), T25 (KF230058), T40 (KF230173), T38 (NERICA7).
With p value = 0.000 < 0.05, the analysis shows that there are significant differences between 40 varieties in terms of seed weight.
Tukey's post hoc test was used to compare the 40 rice varieties two by two. The results in Table 13 show that varieties with common letters are similar to each other, and those with different letters are different.

Table 2. Comparison of seed yield using Tukey's analysis

N°	Variété	Poids(g)	Significativité (p=0,05)
1	T21	382.00	a
2	T36	353.75	ab
3	T30	312.00	abc
4	T20	271.75	abcd
5	T29	253.00	abcd
6	T2	229.50	abcd
7	T31	222.00	abcd
8	T1	220.25	abcd
9	T4	215.25	abcd
10	T25	214.50	abcd
11	T38	210.75	abcd
12	T40	210.75	abcd
13	T19	199.25	abcd
14	T8	196.50	abcd
15	T16	192.75	abcd
16	T13	187.75	abcd
17	T9	186.75	abcd
18	T24	178.75	abcd
19	T35	175.00	abcd
20	T28	174.25	abcd
21	T15	173.75	abcd
22	T11	172.00	abcd
23	T6	171.50	abcd
24	T3	166.75	abcd
25	T39	163.00	bcd
26	T5	161.25	bcd
27	T10	150.75	bcd
28	T22	149.75	bcd
29	T27	148.00	bcd
30	T33	145.25	bcd
31	T17	144.75	bcd
32	T23	135.75	cd
33	T14	133.75	cd
34	T32	133.25	cd
35	T26	125.25	cd
36	T34	114.25	cd
37	T12	101.00	cd
38	T37	100.75	cd
39	T18	92.00	d
40	T7	78.50	d

IV. Discussion

The results obtained in this study were compared with those of other researchers.
In Madagascar, a study conducted on 20 reference farms revealed yields ranging from 1.04 to 4.5 tonnes per hectare. These yields were as follows :
- FOFIFA 182 variety : 2.9 t/ha ;
- SCRID 195 variety : 1.65 t/ha. These yields remained lower than those obtained by our elite varieties (KF23007 : 5.4 t/ha, NERICA 4 : 5.0 t/ha, KF230057 : 4.4 t/ha, KF230119: 3.8 t/ha, KF23010: 3.6 t/ha), or those of some of our varieties considered low-yielding. These differences are related to the conditions of the study environments, the growing seasons, and the varieties.

In a trial conducted at INERA M'vuazi during the 2014-2016 growing seasons, the following varieties were selected with the participation of rice farmers for their adaptation to local conditions, their yield, and their disease resistance (SNDR, 2023) :
Variety NERICA 12 : 2.7 t/ha
 Variety NERICA 8 : 2.5 t/ha;
 Variety NERICA 14 : 2.5 t/ha;
 Variety NERICA 18 : 3.18 t/ha;
 Variety NERICA 13 : 2.5 t/ha;
 Variety NERICA 17 : 2.5 t/ha;
 Variety NERICA 16 : 2.32 t/ha.
As in the previous case, our results are superior to those obtained at INERA-M'vuazi. This demonstrates that the agro-ecological conditions in Bumba are conducive to rice cultivation.
Trials conducted on short-cycle (100 days) and medium-cycle (120 days) rice varieties as part of research on optimal sowing periods and agro-ecological adaptation at INERA-Yangambi yielded the following results :
 Varieties IRAT 112, NERICA 4, and NERICA 12: 3.5 t/ha;
 WITA 9, NERICA 8, and IR 64: 4.2 t/ha.
The rice yield obtained through selection at Yangambi is lower but close to the results recorded at Bumba.

Conclusion

This study, focused on "Participatory Pedigreed Selection of Some Tongil Rice Lines (Oryza sativa L.) in the Agroecological Conditions of Bumba, Democratic Republic of Congo," conducted between February and September 2025, with the objective of rice varietal selection, was conducted with full respect for the art of agronomic research. However, it was not spared from climatic hazards; in this case, a dry period lasting three weeks after sowing.

Since all treatments were subjected to the same conditions, we recognize that each was able to demonstrate its potential, and could do so as much if all were placed in much more comfortable conditions.

Bonferroni analysis was used to compare production means between different rice (Oryza sativa L.) varieties/lines in our treatments. This method adjusts the significance threshold to reduce the risk of Type I errors during multiple comparisons. The results show the difference in means, standard error, significance (p), and 95% confidence intervals for each comparison.

The evaluation of the 40 Tongil rice (Oryza sativa L.) lines under the agroecological conditions of Bumba allowed us to measure production performance (g) and the variability associated with each variety. The results show a wide range of yields, from 382 g for variety T21 (KF23007) to 81 g for T7 (KF230177), with standard deviations ranging from 15.97 to 128.05, indicating differences in stability between varieties.
The varieties with high production potential are: KF23007 (382 kg), NERICA4 (353.75 kg), KF230057 (312 kg), and KF230119 (271.75 kg).
The varieties with medium production potential: T25/KF230058, T40/KF230173, T38/NERICA7, T8/LIENGE, T16/KF2300166, T35/KF2300055, and T24/KF230118 have yields ranging from 171 to 215 kg.
Varieties with very low production potential: T17/KF230158, T33/TINDIKA, T22/KF230067, T14/KF230003, T32/KF230184, T26/KF230014, T34/KF230070, T37/K230170, T18/KF230181, T7/KF230177 show low to very low yields (from 144.75 to 81 kg).
These varieties are considered low or low-medium priority and can serve as genetic material for future improvements.
4. Reconciling the varietal/pedigree selection by farmers with the results detailed above, there is a convergence of high-potential choices for the following lines/varieties: KF230007, KF230057, and NERICA 4.
Looking ahead, we hope that future steps will take into account the various aspects raised in this study:
1. Variability and stability: Standard deviations allow us to assess yield stability. Varieties with low variability (T36, T16, T8) are particularly interesting for predictable production.
2. Overall yield: A majority of varieties have medium to high yields, demonstrating that the agroecological conditions of Bumba are favorable for growing Tongil rice. 3. Participatory selection: Varieties with high yield and moderate or low stability are prioritized for later offering to farmers, while varieties with low yield or high variability can be used as references or for genetic improvement programs.

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