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RESEARCH ARTICLE

AGRO-MORPHOLOGICAL CHARACTERIZATION OF TWO RICE VARIETIES FROM JAPAN; *ORYSA SATIVA* L. AND FOUR NERICAS VARIETIES IN AN AGRO-ECOLOGICAL ZONE OF THE TOWN OF YAOUNDE (CAMEROON); COMPARATIVE STUDY OF THEIR PERFORMANCES

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ABSTRACT

The performances of four lines of the NERICA variety and two varieties of the *Oryzasativa* species were evaluated by considering parameters such as the number of panicle per rice plant, the number of primary branches of the panicles, panicle length, the plant height, the number of grains and empty balls per panicle. It appears that *O. sativa* from Japan has a number of empty balls less than NERICA's varieties from Africa. We also noted that *O. sativa* has the highest number of panicles per rice plant (a mean of 14.05 ± 6.14). However, the number of grains per panicle NERICA's varieties was very high (a mean of 164 ± 38.82) and therefore they shows more attractive characters than *Orysa sativa* lines. The differences were statistically significant above all the parameters considered in both African and Japan rice studied. A significant correlation that was negative has been observed between the number of panicles per rice plant and the number of primary branches per panicle within the NERICA 9 variety ($P < 0.05$). The correlation was highly significant and positive ($P < 0.001$) between the number of primary branches per panicle and the number of grain per panicle. These results suggest another demonstration of the hybrid vigor of NERICA varieties.

INTRODUCTION

Rice is no longer a luxurious food but as a cereal, it has become a major source of energy, for urban people as well as rural ones (Ojo *et al*., 2009). Second world culture and main food of nearly the half world's population, rice contributes for more than 20% of world calorie consumed (WARDA, 2006). This cereal belongs to the poaceae family, Oryzeae tribe and the *Oryza* genus. (Megan and McCouch, 2007; Tang *et al.*, 2010). In 2000, global production of milled rice was around 415 million tons (CIRAD, 2008). From the year 2000 to 2003, this production has gradually declined to 385 million tons; but it increased in 2004 from 390 million tons of milled rice to 445 million tons in 2008 (CIRAD, 2008). In 2009, the trend has fallen and global production fell 1% from the 2008 record of 680 million tons of rice paddy. This reduction is due to irregular monsoon rains and the recovery of El Niño conditions (FAO, 2010). In Africa, rice is produced and consumed in about 39 countries (Sanni *et al*., 2009 a). Rice cultivation is a very important activity for people in certain areas of West and Central Africa ensuring food security of nearly 20 million producers, and making live nearly 100 million people directly, if we admit an average of five people per farmer family (WARDA, 2002). For the period from 2000 to 2005, Africa produced about 17.4 million tons of rice paddy; while for the period from 2006 to 2009 this production has increased to about 22 million tons of rice paddy (FAO, 2011). However,

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production is still below the needs and a large quantity of rice is imported to satisfy domestic demand (Adegbola and Singbo, 2005). Cameroon shows a strong external dependency regarding this food crop. Domestic demand was estimated in 2009 at 300 000 tons, largely covered by imports (NRDS, 2009). The total value of imports rice is around 118 582 278 133 F CFA. Although rice is one of the three most important cereals in the human diet in Cameroon, the domestic production of rice was estimated at 240,000 tons of paddy and 120,000 tons of white rice in 2009 (Malaa, 2011). This is below the white rice demand estimated at 600 000 tons. Since, all efforts for an interspecific cross between the Asian species and the African species were in vain because of the existence of a genetic barrier between these two species (WARDA, 2002), F1 hybrids obtained for this purpose were always sterile. Until the advent of biotechnology with the WARDA researchers; for instance, Monty Jones (WARDA, 2002) this infertility problem was resolved with the creation of NERICAs varieties (New Rice for Africa) by crossing the Japanese species, *O. sativa* and the African species *Oryzaglaberrima*. Agro-morphological characterization is a process of evaluation of all observable characteristics that could identify varieties or accessions in a collection. It can be realized in various forms depending on the objectives. In the Philippines, Caldo *et al.* (1996) conducted a study to assess the morphological diversity of ancestral lines of 84 ecotypes of rice. The research concluded that five of the parameters allow discrimination among the population.

In Cameroon, rice research is still underdeveloped. The aim of our study is to determine the characteristics of some NERICA varieties from Africa and Japanese varieties in paddy, compare their performance to find high-yielding varieties better adapted to our type of soil and climate.

MATERIALS AND METHODS

The work was carried out at Nkolbisson, a small neighborhood of Yaounde, Central Region of Cameroon; located between 03 ° 51' North latitude and 011 ° 27' East longitude (Fig. 1). Here, the climate is equatorial (Yaoundéen), characterized by the alternation of two dry seasons and two rainy seasons (Suchel, 1987). An average temperature of 23.5 ^{o}C contrast between 16 and 31 ^{o}C depending on the season and 1650 mm water per year recorded. The average humidity of 80% day and varies between 35 and 98% (Suchel, 1987). The frequent winds are wet and blow toward the southwest; winds are oriented northwest. The vegetation is predominantly intertropical the southern rainforest (Wéthé, 2001).

Seeding technique and maintenance of the culture

African varieties (NERICA 3; NERICA 8; NERICA 9; NERICA 13) and Japan (Akitakomachi and Fukuhibiki) were grown in lowland, soil tilled manually. Each variety occupied an area of 30.6 m² (6m x 5.1m). For each, the separation was 30 cm on the lines and 15cm between the lines. The distance between two varieties was 50 cm. Planting took place on April 4th 2014. Two weeding were carried out. The first took place 15 days after sowing and the second, a month after the first. Thinning occurred after the first weeding where per hill, two vigorous plants were left for a total of 738 planting holes per varieties.

Fertilization

Two weeks after planting, 300 kg / Ha NPK (20-10-10) were applied; 65 kg / Ha of urea 46% panicle initiation is done that means 60-70 days after sowing according to the variety and 35 kg / ha of urea to at the flowering stage.

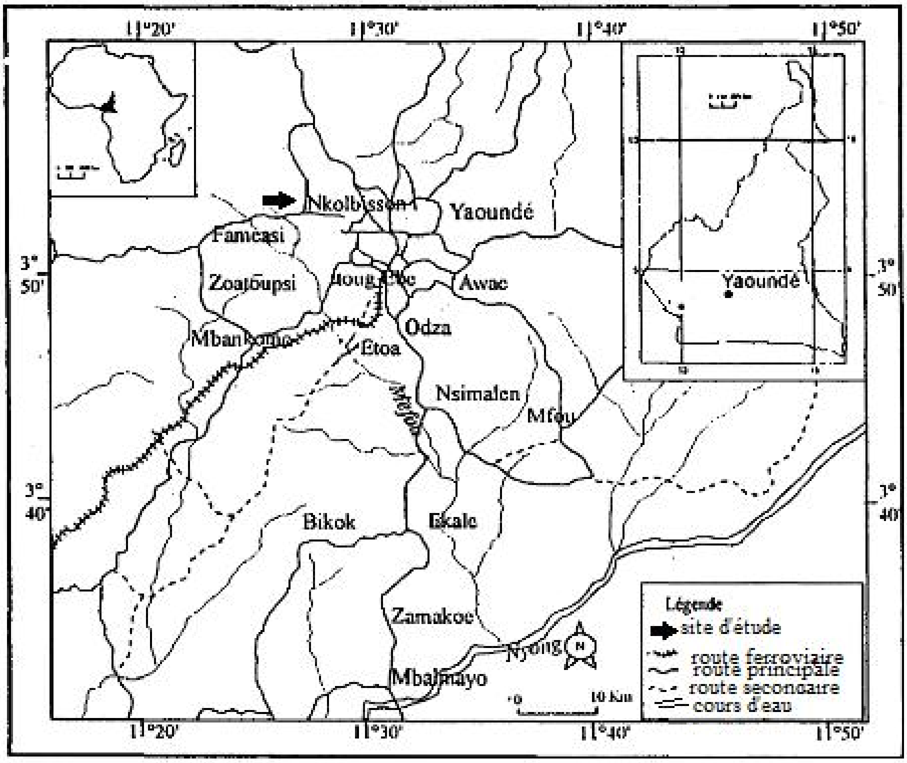

Figure 1. Location map of the study site (Ngon Ngon, 2007, modified)

The parameters considered were: the number of grains per panicle, number of panicle per rice plant, the number of empty balls per panicle, number of primary branches of the panicle, panicle length, height of the plant, measured on the blade master (or the longest tiller) from ground level to the top (Fig. 2). The counts were done manually; the measurements were taken using a graduated ruler measuring 30 cm in length.

Statistical Analyses

The data do not follow a normal distribution; the Shapiro non parametric test was used. To study the probable links between the different variables, the Spearman r correlation test was made. P values were determined, if $P \leq 0.05$; the difference is significant.

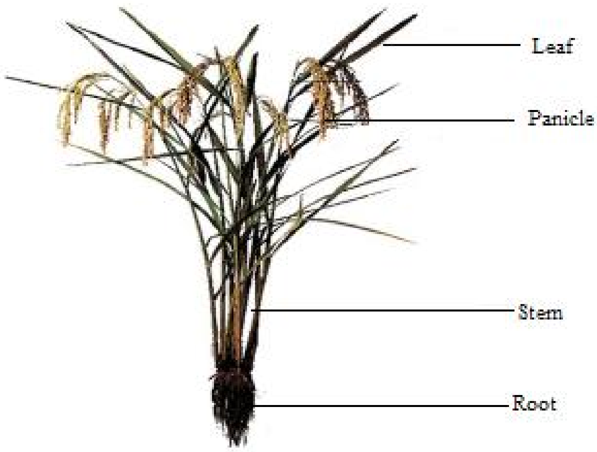

Fig. 2. Rice plant with various parts (Lacharme, 2001, modified)

Calculating the yield (Yd)

Performance was evaluated by the method of Lacharme (2001). It contents various components. The yield is per hectare. Yd = NP × 10000 m² ×NG × NPA × PG

Where Yd = yield, NP = number of plants per hectare, NPA = number of panicle per tiller, NG = number of grains per panicle, PG = weight of a grain Each of these components has been noted in a given period of the plant life cycle.

RESULTS

For each parameter, thirty samples were examined. This means 120 samples for the four African varieties and 60 for the two Japanese varieties. The length of the plants for the Akitakomachi and Fukuhibiki varieties are smaller than the one of other varieties (Fig. 3).

This length varies between 41 cm for Fukuhibiki and 139 cm for NERICA 13. These parameter values of the number of panicles per rice plant and the number of primary branches per panicle vary very little within the same line The number of grains per panicle varies widely between different varieties (Fig. 3). It is 23 for Akitakomachi variety and 294 for NERICA 3 This is a factor that influences performance. The number of grains per panicle is proportional to the panicle length. The higher this number, the greater the values of the panicle length.

Descriptive statistics for each variety

The NERICA 13 variety shows the highest height of the plant while the smallest height is the one of Fukuhibiki (Table 1).

This parameter is proportional to the length of the variety cycle. Fukuhibiki and Akitakomachi cycles are significantly shorter than those of the NERICA's varieties. The number of grains per panicle varies between 23 for the Akitakomachi variety and 294 for the NERICA 3 variety. The NERICA 8 presented the largest number of empty balls which was 80 (Table 3).

Descriptive statistics based on the geographical origin

The differences between the parameters considered for the rice varieties from the two geographic origins are highly significant ($P < 0.0001$). Plant height for example varies around 112.97 ± 11.14 cm for rice varieties from Africa and around 70.03 ± 9.38 cm for Japanese varieties (Table 4).

The yield (Yd)

Considering the spacing (15×30) cm, the average number of plants per m² is 28.

The yield of the Japanese varieties

Yd = 28×10000×14.05×55×0.029= 6382915 g/Ha =6.38 tons / Ha

The yield of the African varieties

Yd = 28×10000×5.67×164 ×0.033= 8592091.2 g/Ha =8.59 tons / Ha

Spearman correlation coefficient

For the Fukuhibiki and NERICA 13 varieties, correlations were significantly positive ($P < 0.05$) between the number of primary branch per panicle and the number of empty balls per panicle, the number of primary branch per panicle and the number of grains per panicle, the number of empty balls per panicle and the number of grains per panicle. For the Akitakomachi variety, the correlations were significantly positive between the number of primary branch per panicle and the number of empty balls per panicle, the number of primary branch per panicle and the number of grains per panicle. These correlations were highly significant ($P < 0.001$) and positive for the NERICA 3 variety while for the NERICA 8 variety only the correlation between the number of primary branch per panicle and the number of grains per panicle was significant and positive ($P < 0.05$). The correlation between the number of panicle per rice plant and the number of primary branch per panicle was significantly negative for the NERICA 9 variety ($P = 0.05$), whereas the correlation between the number of primary branch per panicle and the number of grains per panicle was highly significant ($P < 0.001$) and positive.

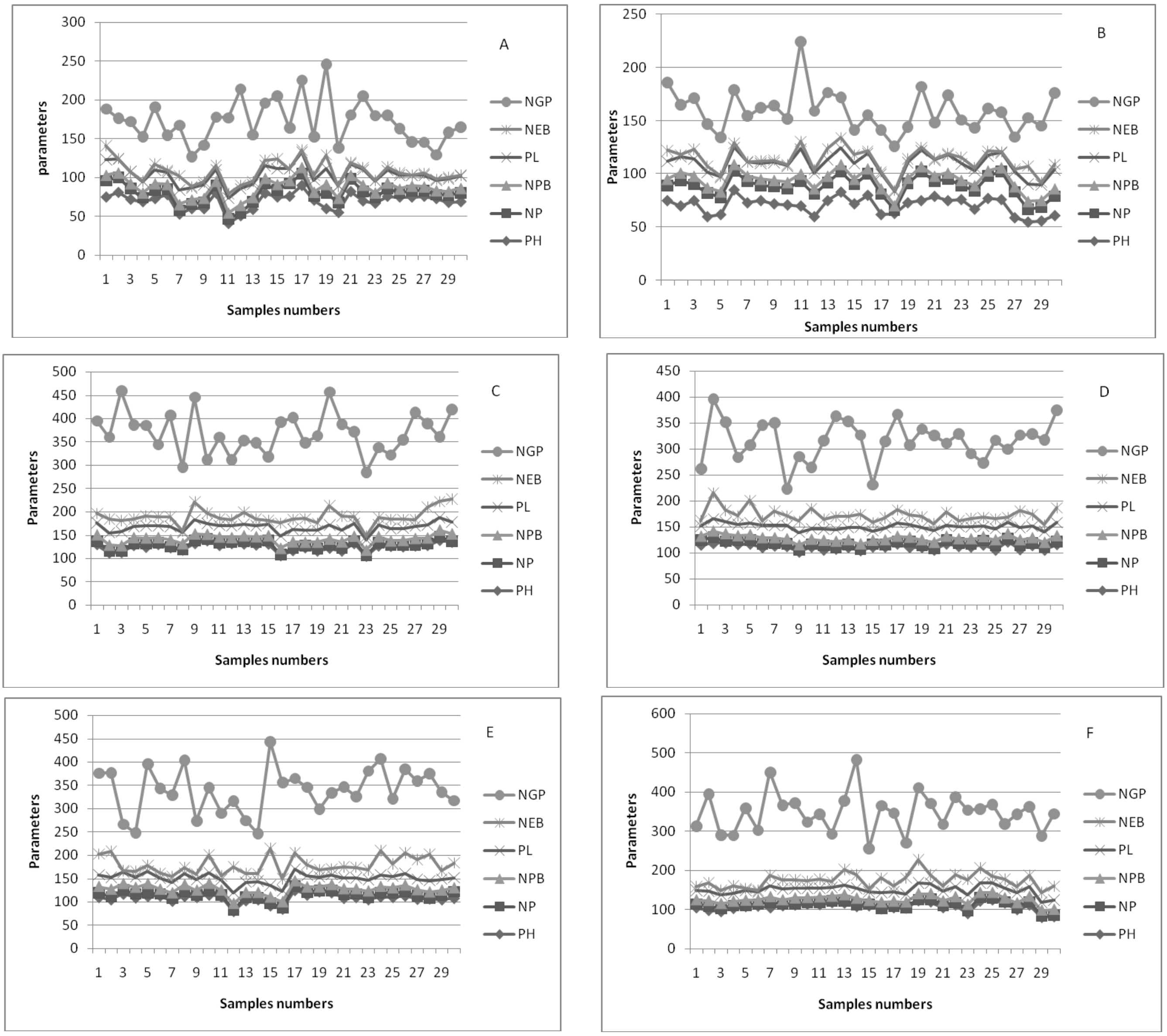

Figure 3. Variation des différents paramètres en fonction des variétés. A: Fukufibiki; B: Akitakomachi C: NERICA 13; D: NERICA 9; E: NERICA 8; F: NERICA 3. NGP =Number of grains per panicles; NEB= Number of empty balls per panicles; PL= panicle length; NPB= Number of primary branches per panicle; NP= Number of panicles per plant; PH= Plant height

Table 1. Plant height and panicle length (Cm) of the varieties

	plant height			panicle length		
	Min	Max	M ± Sd	Min	Ma	M ± Sd
FUKUHIBIKI	41	90	69 ± 10.68	13.0	21.0	16.79 ± 2.12
AKITAKOMACHI	55	85	70± 8.04	13.2	23.5	15.44 ± 1.89
NERICA 13	105	139	124 ± 8.61	22.3	31.0	26.16 ± 2.02
NERICA 9	101	121	111 ± 5.08	18.0	32.0	23.00 ± 2.42
NERICA 8	80	125	108 ± 9.45	21.0	26.7	23.43 ± 1.30
NERICA 3	80	125	107 ± 10.91	20.2	28.0	23.69 ± 1.91

Notes/ M : mean, Max : maximim, Min : minimum, Sd : standard deviation

Table 2. Number of panicles per rice plant and number of primary branches per rice panicle

	number of panicles			number of primary branches		
	Min	Max	M ± Sd	Min	Max	M ± Sd
FUKUHIBIKI	4	21	10.2 ± 4.78	4	11	6.23 ± 1,50
AKITAKOMACHI	3	27	17.9 ± 4.83	4	8	5.63 ± 0,96
NERICA 13	1	8	4.43 ± 1.94	8	16	12.53 ± 1,75
NERICA 9	3	12	6,03 ± 2.38	8	15	10.33 ± 1,53
NERICA 8	2	14	6.73 ± 2.87	8	19	12.20 ± 2,38
NERICA 3	2	13	5.50 ± 2.64	9	16	13.13 ± 1,94

Notes/ M : mean, Max : maximim, Min : minimum, Sd : standard deviation

Table 3. Total number of grains and empty balls per panicle

	number of grains			number of empty balls		
	Min	Max	M ± Sd	Min	Max	M ± Sd
FUKUHIBIKI	31	124	64.63 ± 22.30	0	19	4.90 ± 5.45
AKITACHOMACHI	23	94	45.60 ± 13.72	0	17	4.26 ± 3.87
NERICA 13	114	277	179.43 ± 38.21	2	49	21.63 ± 10.58
NERICA 9	51	193	143.3 ± 36.77	8	50	21.83 ± 9.72
NERICA 8	82	230	159.80 ± 38.78	4	80	28.43 ± 18.50
NERICA 3	90	294	173.53 ± 41.55	4	60	24.16 ± 12.64

Notes/ M : mean, Max : maximim, Min : minimum, Sd : standard deviation

Table 4. Descriptive statistics based on the geographical origin

	Plant height (cm)			Panicle length (cm)		
	Min	Max	M ± Sd	Min	Max	M ± Sd
African varieties	80	139	112.97 ± 11.14	18	32.0	24.07 ± 2.29
Japanese varieties	41	90	70.03 ± 9.38	13	23.5	16.11 ± 2.10
		F = 657.2; Df = 1, P<0.0001			F = 507, Df = 1, P<0.0001	
		Number of panicle			Number of primary branches	
	Min	Max	M ± Sd	Min	Max	M ± Sd
African varieties	1	14	5.67 ± 2.59	8	19	12.05 ± 2.17
Japanese varieties	3	27	14.05 ± 6.14	4	11	5.93 ± 1.28
		F = 164.8; Df = 1, P<0.0001			F = 402.7; Df = 1, P<0.0001	
		Number of empty balls			Number of grains	
	Min	Max	M ± Sd	Min	Max	M ± Sd
African varieties	2	80	24 ± 13.43	51	294	164 ± 38.82
Japanese varieties	0	19	5 ± 4.7	23	124	55 ± 18.01
		F = 118.1; Df = 1, P<0.0001			F = 377.2; Df = 1, P<0.0001	

Df : Degree of freedom, F: F-value, M : mean, Max : maximim, Min : minimum, Sd : standard deviation

DISCUSSION

NERICA lines are hybrids because they are derived from a cross between the Japanese species and the African species. *O. glaberrima* has important characteristics that make it resistant to biotic and abiotic stresses. Indeed, African rice shows resistance to salinity, drought and iron toxicity (Bezançon and Diallo, 2006). It is a species that can survive in conditions of low intakes of inputs and competitiveness with weeds (Sarla *et al.,* 2005) as well as in harsh ecosystems such as high rainfall areas, coastal areas, mangrove areas and even hilly areas (Sarla *et al.,* 2005; Bezançon and Diallo, 2006). Its ability to face competition with weeds is due to its vigor, a low extinction coefficient and effective use of light (Bezançon and Diallo, 2006). It has drooping leaves that prevent sunlight from reaching the ground. In addition to its large accumulation of aboveground biomass, it has many thin roots with a good exploration of the rhizosphere; which helps to effectively and efficiently fight against weeds (Bezançon and Diallo, 2006). This species has an abundant tillering with a rapid ground cover allowing it to stifle and suppress weeds (WARDA, 2002). In addition to its ability to fight against weeds, the *O. glaberrima* species has other desirable characteristics that WARDA has listed in 2002. African rice grows well above 30° C, but above 35° C, spikelet fertility drops significantly. Values below 25° C reduce growth and yield. *O. glaberrima* is usually a short life cycle plant, but its sensitivity to the light varies among ecotypes from very sensitive to non-sensitive plants (Bezançon and Diallo, 2006). African rice is grown over a wide range. Water availability is an adequate condition but the African rice species has natural predisposition to withstand drought. NERICAs varieties (New Rice for Africa) are ideotype that combined the best features of their parents; better, it even exceeds its parents for some characters. This is the heterosis effect (hybrid vigor).

As for the Asian species *O. sativa*, it grows on dry or flooded soil and the average temperature during the growth phase varies from 20 to 38°C. Night temperatures below 15°C may cause sterility spikelet. Temperatures above 21°C during flowering are needed for anthesis and pollination. Under rainfed conditions, 750 mm precipitations over a period of 3 to 4 months are required in contrast to the African species; *O. sativa* is vulnerable to drought. This could explain the yield obtained which is smaller than the African rice yield. Considering the positive correlation between grain yield and the number of panicles per m² (Sié *et al.,* 2010), the results of this study are contrary to the assertions of Linares (2002), which estimates that the productivity of African species (*O. glaberrima*) ecotypes is low.

Conclusion

NERICA lines are more efficient in yield than those of the *Orysa sativa* species from Japan. The average of the number of grains per panicle it is 124 for Japanese varieties and 294 for the African varieties. In addition, the number of primary branches average is 11 for the Japanese varieties and 19 for the African varieties. The yield is therefore greater with the NERICA. However, the number of empty balls which is a factor that reduces the yield is smaller for Japanese rice lines (19 in mean) while this average is more important with the African rice lines (80 in mean). Also, the only significant and negative correlation is between the number of panicles per plant and the number of primary branches and it concerns NERICA 9. The correlation between the number of primary branches and the number of grains per panicle was significant and positive for all rice lines examined in this study.

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