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Full Length Research Paper

Evaluation of intra and interspecific rice varieties adapted to valley bottom conditions in Burkina Faso

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Rice is one of the major staple foods in Burkina Faso and in-country production covers about 60% of the demand and 40% is met from imports. The immense potential of the lowlands in Burkina Faso for durable intensification of rice cropping have not been realised due to biotic and abiotic constraints. Hence, there is an urgent need to increase and improve the production of rice in order to meet up with the high demand. To meet the demand, the rice research program in Burkina Faso evaluated intra and interspecific lowland progenies in 2002 and 2003. The aim of the study is to introduce new lowland NERICAs through a participatory approach and to identify ideotypes that are adapted to lowland conditions. Variations did exist among the 16 rice varieties with respect to the 9 variables that were evaluated. A principal components plot and clustering analysis technique were used to group the accessions. The interspecific varieties formed the most interesting group and have a better capacity for adaptation to the diversity of lowlands. They have acceptable yields, sometimes higher than those of intraspecific varieties and check. Thus, the results obtained were quite encouraging and showed that, the varieties possess good agronomic traits that are well adapted to intensify lowland rice farming. The recent naming of some of these interspecific varieties as NERICA-L (New Rice for Africa Lowland) by AfricaRice Center has confirmed that they compare well with the traditional varieties. Thus from this study, we now have a new set of interspecific lines that are adapted to lowland conditions that can be tested to meet farmers' needs.

Key words: *Oryza glaberrima, Oryza sativa,* hybridisation, inter-specific, NERICA, sterility, yields.

INTRODUCTION

Rice is developing as a major staple food item of Burkina Faso and demand has grown at an annual rate of 3% between 1973 and 1992 compared with an annual population growth rate of 2.9%, which can be explained by changing consumer preferences (WARDA, 1996; Randolph, 1997). Currently, in-country production covers about 60% of the demand and 40% is met from imports (Segda et al., 2005). Hence, there is an urgent need to increase and improve the production of rice in Burkina Faso and in Africa as a whole, in order to meet the high demand (Ogunbayo et al., 2005; 2007). Burkina Faso has three major rice ecologies – upland (10% of land area with 5% of the country's rice production), irrigated (23% of area and 53% of production) and rain fed lowland (67% of area and 42% of production) Sié (1999). Irrigated systems were introduced in the 1960s. Its development was accentuated from the 1970s onward. Average yields of irrigated rice in Burkina Faso were estimated at 4.0 to 4.5 t ha^{-1} and in general two crops per year are grown (Illy, 1997; Wopereis et al., 1999).

Thus, rain fed lowland is the major rice ecology in the country, combining the characteristics of upland and irrigated systems. The declining and unpredictable rainfall pattern has led to decreasing in the genetic diversity of traditional *Oryza sativa* cultivars. Farmers continue cultivating *Oryza glaberrima* varieties, which has good agronomic traits that are plant vigor, resistance to major

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biotic and abiotic stresses and acceptable grain quality (Pham, 1992; Adeyemi and Vodouhe, 1996; Sié, 1999). In Africa, there are two major cultivated rice species; *O. glaberrima* (Steud) and *O. sativa* (L), both species have distinct and complementary advantages and disadvantages for use in African farming systems (Rodenburg et al., 2006).

The Asian rice (*O. sativa*) has good agronomic traits but susceptible to most African stresses (Pernes et al., 1984 and Mande et al., 2005). African indigenous species (*O. glaberrima*) is an interesting genetic resource due to its resistance to many of rice constraints (Sie, 1991; Jones et al., 1997b; Johnson et al., 1998; Jones and Singh, 1999; Sie, 1999; Futakuchi et al., 2001).

In 1992, the Africa Rice Center (AfricaRice) and its partners started the interspecific hybridization project (IHP) in an attempt to combine the useful traits of both cultivated rice species (*O. sativa* and *O. glaberrima*) in varieties adapted to upland ecology. Crossing the two species is complicated by their incompatibility, which leads to hybrid mortality. This problem was overcome through backcrossing with the *O. sativa* parent coupled with another culture. This work resulted in the first interspecific rice progenies from cultivated varieties (Jones et al., 1997a, b; Jones, Simony and Aluko, 1997) which lead to the development of NERICA (New Rice for Africa).

In addition to the upland NERICA varieties, AfricaRice and national programs of West African countries developed NERICA varieties suitable for irrigated and rain fed lowlands, one of the most complex rice ecologies in the world. Key to this success was the unique R and D partnership model forged between AfricaRice and the national programs in West and Central African countries through the Rice Research and Development Network for West and Central Africa (ROCARIZ), which facilitated the shuttle-breeding approach to accelerate the selection process and achieve wide adaptability of the lowland NERICAs (WARDA, 2006).

To meet the demand of rice farmers and consumers, the rice research program in Burkina Faso started evaluating intra and interspecific lowland progenies obtained from AfricaRice, Senegal, in 2000. This study aimed to identify, through a participatory approach, high yielding varieties with resistance to biotic and abiotic stresses.

MATERIALS AND METHODS

The plant materials comprised of 16 genotypes which include nine interspecific lines (*O. glaberrima x O. sativa indica*), six intraspecific (*O.sativa x O.sativa*) lines and one check. The check variety (TOX 3055-10-1-1-1) had been released and disseminated in Burkina Faso. The experiment was carried out in valley bottom at the Banfora research station in the southwest of Burkina Faso during 2002 - 03 wet seasons. Seeds were sown directly, three seeds per hill and latter thin to one seedling, at a spacing of 0.25 m within and between rows. The randomized complete block design with three replications was used with 16 rows of 5 m and plot area was 20 m^2. A pre-drilling base application of 200 kg.ha^{-1} of NPK (15-15-15) was made, followed by a total of 100 kg.ha^{-1} of urea in two applications of 35 kg/ha at 14 days after seeding, and 65 kg/ha at the panicle initiation.

Two manual weeding were carried out and no chemical treatment was applied. Plants in the middle rows in each plot were harvested, leaving one border row on each side. The IRRI Standard evaluation system (IRRI, 1996) for rice was used to score quantitative traits, disease and insect pest damage. Agronomic traits evaluated were plant height at maturity, tillering, days to flowering, number of panicles p/m^2, sterility and yield. Reaction to diseases and insects observed were: Stem borer, gall midge, leaf blast. The data collected were subjected to statistical analysis using SAS (SAS, 1999) and GGE biplot version 5.2 (Yan, 2003). A GGE biplot was constructed using the first two principal components (PC1 and PC2) derived from subjecting the environment-centered data to singular-value decomposition and it has many visual: (i) The polygon view of a GGE biplot allows visualization of the which-won-where pattern (that is, which variety had the highest yield in which environment), (ii) the average environment coordination view allows simultaneous visualization of the mean performance and stability of the treatments, the discriminating ability vs. representativeness of the environments and (iii) the environment vector view allows visualization of the interrelationship among environments (Yan, 2001, 2002; Yan and Kang, 2003). In addition, attempting to characterize the environments and to relate the mean yield of the environments to the ecology, a biplot based on an environment x factor two-way table was constructed, which was similar to that based on a genotype x trait two-way table described by Yan and Rajcan (2002). All biplots presented in this paper were generated using the software GGEbiplot package that runs in a windows environment. Principal components grouping of the traits was employed to examine the percentage contribution of each trait to total genetic variation and to spot characters that reflected the greatest proportion of variations among the 9 variables. This is because the PCA has been reported to be able to choose independent (orthogonal) axes that are minimally correlated and then represent linear combinations of the original characters (Akoroda, 1983).

The relative discriminating power of the axes and their associated characters were measured by the Eigen values and factor scores, respectively. The similarity coefficient was used to construct a dendrogram by the unweighted pair group method with arithmetic average (UPGMA) according to Sneath et al. (1973); Swofford et al. (1990); Rohlf (1993).

RESULTS

2002 wet season

Table 1 presents the means of nine characters measured in sixteen rice varieties. Highly significant differences were observed in plant height, cycle, sterility and leaf blast while variance of analysis could not detect any significant difference in tiller number, panicles, AfRGM and yield.

However, eight varieties including four intra-specifics and four interspecifics had a higher number of tillers than the average (118 tillers). Seven lines including one intra-specific and 6 interspecifics recorded low panicle number which is below the average number (52). Regarding plant height eight varieties had values below the average (106 cm) and based on IRRI standard evaluation system (1996) all varieties tested with the exception of two intra-

Table 1. Means of nine characters measured in sixteen rice varieties (2002).

S/No.	Variety	Tiller	Pan/ m^2	Height (cm)	Flw DAS	Sterility	Leaf Blast	Stem borer	AfR GM	Yld (Kg/ha)
1	WAT 1176-B-FKR-B-B	90	55	135	88	1	0	1	6	1177
2	WAT 1184-B-FKR-B-B	115	59	114	86	1	0	1	5	1182
3	WAT 1191-B-FKR-B-B	135	47	102	87	1	1	1	5	1173
4	WAS 105-B-IDSA-B-WAS-2-1-FKR-B-B	125	55	100	90	1	0	1	6	1162
5	WAS 114-B-IDSA-B-WAS-5-1-FKR-B-B	122	54	111	86	1	0	1	5	1283
6	WAS 129-B-IDSA-B-WAS-1-1-FKR-B-B	133	60	107	85	1	0	1	6	1293
7	WAS 122-IDSA-1-WAS-6-1-FKF-B-B	132	49	113	85	1	0	1	6	1153
8	WAS 122-IDSA-1-WAS-2-FKR-B-B	99	43	106	85	1	0	1	6	950
9	WAS 122-IDSA-1-WAS-1-1-B-FKF-B-B	97	43	106	85	1	0	1	6	1068
10	WAS 161-B-6-4-FKR-B-B	118	48	103	84	1	1	1	6	1053
11	WAS 161-B-9-3-FKR-B-B	126	50	91	83	1	1	1	6	1052
12	WAS 161-B-6-3-FKR-B-B	123	65	97	80	1	0	1	6	992
13	WAS 163-B-5-3-FKR-B-B	115	38	94	89	1	2	1	6	793
14	WAS 191-8-3-FKR-B-B	130	55	100	82	1	1	1	5	1207
15	WAS 191-9-3-FKR-B-B	104	61	107	82	1	1	1	5	1077
16	TOX 3055-10-1-1-1 (check)	123	62	102	107	1	1	1	5	1028
Mean		118	52	106	86	1	1	1	6	1103
Significance		ns	ns	**	**	**	**	ns	ns	ns

*, **, Significant at 5 and 1% probability levels, respectively.

Table 2. Correlation coefficients of nine traits used in characterizing sixteen rice varieties (2002).

Character	Tiller at 60 DAS	Pan (m^2)	Plant height (cm)	Flw date	Sterility	Leaf blast	Stem borer	AfRGM	Yield (t ha^{-1})
Tiller at 60 DAS	1.000								
Pan m^2	0.206	1.000							
Plant height (cm)	-0.502*	0.163	1.000						
Flw date	0.040	0.108	0.034	1.000					
Sterility	0.030	-0.139	-0.289	0.740**	1.000				
Leaf Blast	0.173	-0.314	-0.531*	0.191	0.617*	1.000			
Stemborer	0.027	0.391	0.058	0.032	0.143	0.000	1.000		
AfRGM	-0.207	-0.371	-0.039	-0.242	-0.098	-0.211	0.098	1.000	
Yield (t ha^{-1})	0.318	0.441*	0.455*	-0.128	-0.585*	-0.531*	0.125	-0.347	1.000

*, **; Significant at 5 and 1% probability levels, respectively.

specifics and one interspecific were semi dwarf and these have medium height. Out of the varieties tested three of intra-specific and eight of interspecific varieties had flowering days of 86 days while all materials had the same value to sterility and stem borer. The average yield recorded was 1103 kg/ha. All the interspecific varieties tested had higher yields than the average while only two were recorded among the intra-specifics. V13 recorded the lowest value with 793 kg/ha and V6 the highest value with 1293 kg/ha.

The correlation matrix showed that panicle/m^2 was positively and significantly associated with yield. However, plant height had negative but significant association with leaf blast and positive significant association with yield. Sterility was positively and significantly correlated to leaf blast and negative significant association with yield. While flowering date were also positively and highly significant correlated to sterility. Tiller was also negatively and significantly correlated to plant height while leaf blast was negatively and significantly correlated to yield (Table 2).

Table 3 presents the principal components analysis showing the contribution (factor scores) of each character among the 16 varieties. The three principal components accounted for about 76% of total variance with the first and second principal component taking 32.8 and 25.9%

Table 3. Principal components analysis showing the contribution (factor scores) of each character among the sixteen rice varieties (2002).

Character	Prin 1	Prin 2	Prin 3
Yield	0.564	-0.179	-0.209
Plant height	0.464	0.354	0.341
Leaf blast	-0.499	-0.303	0.198
Panicle per m2	0.421	-0.319	0.045
Tiller	-0.011	-0.576	-0.454
AfRGM	-0.194	0.505	-0.342
Flower days	-0.046	-0.25	0.69
Eigen value	2.297	1.812	1.211
Variance (%)	0.328	0.259	0.173
Cumulative (%) variance	0.328	0.587	0.76

Table 4. Characteristics of morphological groups defined by typology in (2002).

Character	Group 1		Group 2		Group 3	
	Min	Max	Min	Max	Min	Max
Tiller No. at 60 days	90	135	97	126	115	115
Panicle number [Pan m-2]	47	60	43	65	38	38
Plant height [Ht]	100	135	91	107	94	94
Flowering date [FLW]	82	90	80	107	89	89
Sterility	1	1	1	1	1	1
Leaf Blast [LB]	0	1	0	1	2	2
Stemborer	1	1	1	1	1	1
AfRGM	5	6	5	6	6	6
Yield [Kg/ha]	1153	1293	950	1077	793	793

respectively. The relative discriminating power of the principal axes as indicated by the Eigen values was highest (2.29) for axis 1 and lowest (1.21) for axis 3. The first principal component that accounted for the highest proportion (32.8%) of total variation was mostly correlated with plant height, yield, Pan/m^2 and leaf blast. They have good yield, plant height and they are moderately resistance to sterility and leaf blast. Characters that were mostly correlated with the second principal component were tillering number, panicle number and AfRGM.

Table 4 shows characteristics of morphological groups defined by topology. In group 1 tiller number at 60 days ranged from 90 to 135 m^2, panicle number ranged from 47 to 60, plant height ranged from 100 to 135 cm indicating that varieties are semi-dwarf to medium height type, flowering occurred between 82 to 90 while grain yield ranged from 1153 to 1293 kg ha-1, leaf blast ranged from 0 to 1 and AfRGM ranged from 5 to 6 while group 2 and 3 has its own distinct characteristics.

Figure 1 presents the morphological dendrogram showing the minimum distance between cluster groups and genotypes were divided into three. Figure 3 defined the genotypes that performed best in 2002 (which genotype won in which trait). The polygon is formed through connecting the best genotypes in each trait to other. Starting from the biplot origin, perpendicular lines are drawn to each side of the polygon, which divide the biplot into 5 sectors. The which-won-where pattern is examined as follows. The varietals number at the vertex of polygon in any sector is the genotype that produces the highest value in trait(s) that fall in that sector. Thus, genotypes (2, 4, 5, 6 and 15) had good yield and pan/m^2 while genotype (5) produced the highest yields. The genotypes that won in flowering date and number of tiller were (3, 14 and 16). While genotypes (1, 7, 12 and 9) were moderately resistant to stem borer, sterility and genotype 1 was the tallest. The genotype (8) had the highest value for AfRGM. Three genotypes (10, 11 and 13) were affected with most of the stresses evaluated in the study especially leaf blast and genotype 13 had highest value for the leaf blast and due to this it had

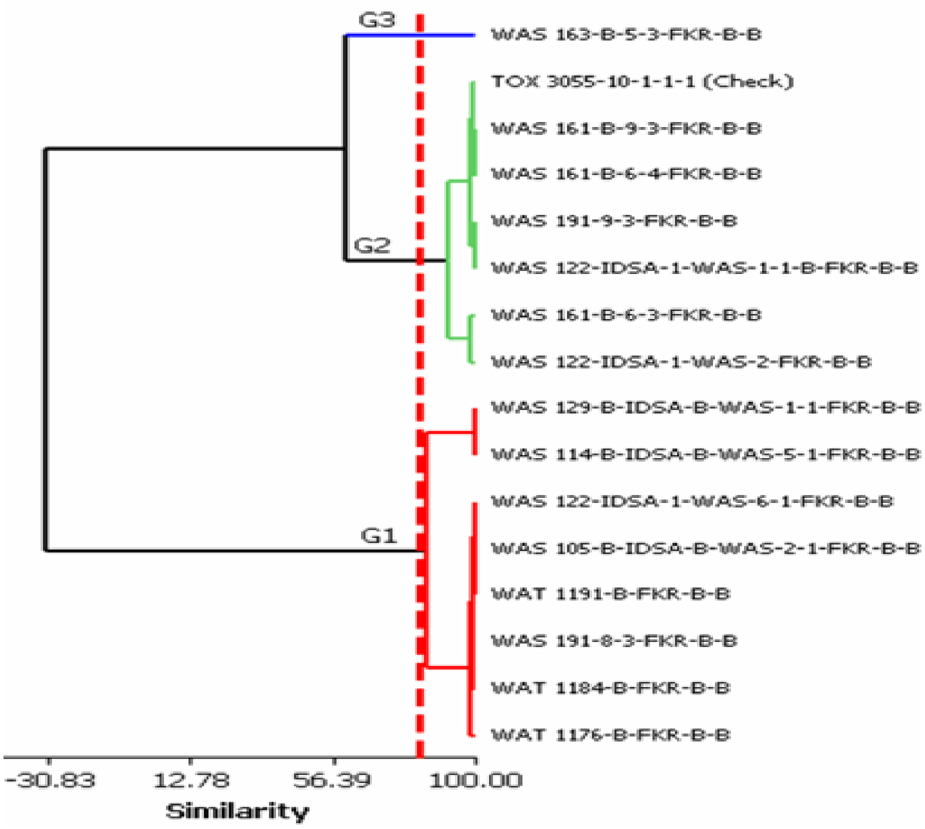

Figure 1. Morphological dendogram showing the minimum distance between cluster groups (2002).

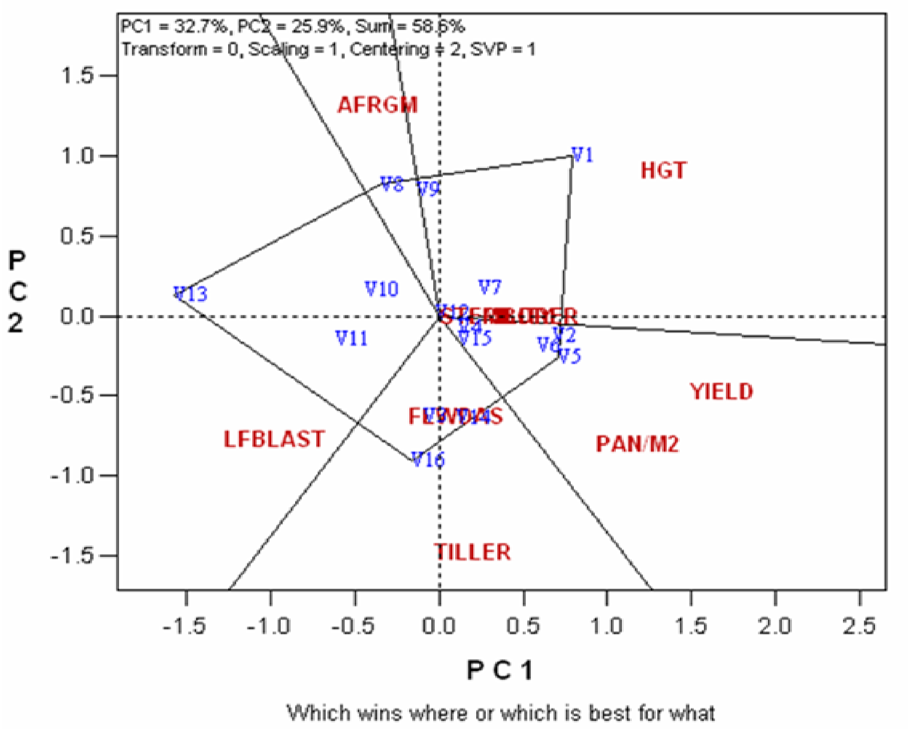

Figure 3. A polygon view of the GGE biplot of genotype x trait, showing which genotype won where or best for which trait (2002).

Table 5. Means of nine characters measured in sixteen rice varieties (2003).

S/N	Variety	Tiller	Pan/ m^2	Height (cm)	Flw DAS	Sterility	Leaf blast	Stem borer	AfRGM	Yld (Kg/ha)
1	WAT 1176-B-FKR-B-B	292	233	136	85	1	0	1	7	3153
2	WAT 1184-B-FKR-B-B	238	228	128	88	1	0	1	6	3405
3	WAT 1191-B-FKR-B-B	417	265	97	88	1	0	0	7	3423
4	WAS 105-B-IDSA-B-WAS-2-1-FKR-B-B	271	249	100	89	1	0	1	6	3438
5	WAS 114-B-IDSA-B-WAS-5-1-FKR-B-B	298	248	106	86	1	1	1	5	3373
6	WAS 129-B-IDSA-B-WAS-1-1-FKR-B-B	294	257	116	85	1	0	1	6	3261
7	WAS 122-IDSA-1-WAS-6-1-FKF-B-B	414	273	105	88	1	0	1	6	3164
8	WAS 122-IDSA-1-WAS-2-FKR-B-B	490	304	104	85	1	0	0	7	2745
9	WAS 122-IDSA-1-WAS-1-1-B-FKF-B-B	391	275	110	87	1	0	1	7	2937
10	WAS 161-B-6-4-FKR-B-B	424	269	84	91	1	0	1	6	3078
11	WAS 161-B-9-3-FKR-B-B	317	240	113	86	1	1	1	6	4053
12	WAS 161-B-6-3-FKR-B-B	321	245	91	82	1	0	1	6	3247
13	WAS 163-B-5-3-FKR-B-B	346	283	91	88	2	0	1	8	2778
14	WAS 191-8-3-FKR-B-B	348	287	93	88	1	0	1	6	3348
15	WAS 191-9-3-FKR-B-B	324	255	97	86	1	0	0	6	3149
16	Tox 3055-10-1-1-1 (check)	503	332	114	108	2	0	1	8	3036
	Mean	353	265	104	87	1	1	1	7	3255
	Significance	**	*ns*	**	**	*	*ns*	*ns*	*ns*	*ns*

*, **; Significant at 5 and 1% probability levels, respectively.

lowest yield.

2003 wet season

Table 5 presents the means of nine characters measured in sixteen rice varieties. Analysis of variance showed highly significant differences in tillering number, plant height and flowering days while significant difference was also observed in sterility. There was no significant difference in panicle number, leaf blast, AfRGM, Stem borer and yield. However, five varieties including one intra-specifics and four inter-specifics had a higher number of tillers than the average (353 tillers). Out of the materials tested, eight varieties had height below an average value (106 cm). Thus, twelve varieties were semi-dwarf while varieties (V1, V2 and V11) had medium height. Ten varieties had flowering days below the average and this indicates that they are medium maturing varieties. Seven varieties have higher panicle number than an average (265). The average yield recorded was 3255 kg/ha and all varieties were moderately resistance to sterility except V13.

The correlation matrix showed that tiller was positively and significantly associated with flowering date, AfRGM and highly significant with panicle/m^2. However, tiller had negative but significant association with yield. Panicle/m^2 was positively and significantly associated with sterility, AfRGM and highly significant to flowering date. However, panicle/m^2 had negative but significant association with yield. While flowering date were also positively and significant to AfRGM and highly significant correlated to sterility. Leaf blast was positively and significantly correlated to yield while AfRGM was negatively and significantly correlated to yield (Table 6).

Table 7 presents the principal components analysis showing the contribution (factor scores) of each character among the 16 varieties. The three principal components accounted for about 75.84% of total variance with the first and second principal component taking 44.92 and 18.14% respectively. The relative discriminating power of the principal axes as indicated by the Eigen values was highest (4.04) for axis 1 and lowest (1.15) for axis 3. The first principal component that accounted for the highest proportion (44.92%) of total variation was mostly correlated with tiller, panicle number and AfRGM. They have good tiller, panicle number and they are moderately resistance to AfRGM. Characters that were mostly correlated with the second principal component were plant height, flowering date and stem borer. Table 8 shows characteristics of morphological groups defined by topology. In group 1 tiller number at 60 days ranged from 292 to 503 m^2, panicle number ranged from 233 to 332, plant height ranged from 84 to 136 cm indicating that varieties are semi-dwarf to medium height type, flowering occurred between 82 to 108 while grain yield ranged from 2745 to 3261 kg ha-1, sterility ranged from 1 to 2, Stem borer ranged from 0 to 1 and AfRGM ranged from 6 to 8 while

Table 6. Correlation coefficients of nine traits used in characterizing sixteen rice varieties (2003).

Character	Tiller at 60 DAS	Pan (m^{-2})	Plant height (cm)	Flw Date	Sterility	Leaf blast	Stemborer	AfRGM	Yield (t ha^{-1})
Tiller at 60 DAS	1.000								
Pan m^{-2}	0.860**	1.000							
Plant height (cm)	-0.304	-0.298	1.000						
Flowering date	0.528*	0.668**	0.055	1.000					
Sterility	0.350	0.607*	-0.079	0.677**	1.000				
Leaf Blast	-0.243	-0.304	0.117	-0.146	-0.143	1.000			
Stemborer	-0.353	-0.173	0.213	0.156	0.182	0.182	1.000		
AfRGM	0.534*	0.610*	0.081	0.491*	0.749**	-0.450	-0.140	1.000	
Yield (t ha^{-1})	-0.495*	-0.569*	0.185	-0.156	-0.402	0.619*	0.191	-0.546*	1.000

*, **; Significant at 5 and 1% probability levels, respectively.

Table 7. Principal components analysis showing the contribution (factor scores) of each character among the sixteen rice varieties (2003).

Character	Prin 1	Prin 2	Prin 3
Tiller at 60 DAS	-0.402	-0.169	-0.327
Panicle number (Pan m^{-2})	-0.453	-0.01	-0.257
Plant height (cm)	0.115	0.409	0.48
Flowering date (FLW)	-0.341	0.411	-0.215
Sterility	-0.369	0.384	-0.008
Leaf Blast	0.254	0.281	-0.576
Stemborer	0.097	0.573	0.095
AfRGM	-0.41	0.131	0.276
Yld (t ha^{-1})	0.355	0.25	-0.366
Eigen value	4.043	1.633	1.15
Variance (%)	44.92	18.14	12.78
Cumulative (%) variance	44.92	63.06	75.84

Table 8. Characteristics of morphological groups defined by topology in (2003).

Character	Group 1		Group 2		Group 3	
	Min	Max	Min	Max	Min	Max
Tiller No. at 60 days	292	503	238	417	317	317
Panicle number [Pan m-2]	233	332	228	287	240	240
Plant height [Ht]	84	136	93	128	113	113
Flowering date [FLW]	82	108	86	89	86	86
Sterility	1	2	1	1	1	1
Leaf Blast [LB]	0	0	0	1	1	1
Stemborer	0	1	0	1	1	1
AfRGM	6	8	5	7	6	6
Yield [Kg/ha]	2745	3261	3348	3438	4053	4053

group 2 and 3 has its own distinct characteristics. Figure 2 presents the morphological dendrogram showing the minimum distance between cluster groups and genotypes were divided into three major groups. Figure 4 defined the genotypes that performed best in 2003 (which genotype won in which trait). The polygon is formed through connecting the best genotypes in each trait to other. Starting from the biplot origin, perpendicular lines are drawn to each side of the polygon, which divide the biplot into 5 sectors. The which-won-where pattern is examined as follows. The varietals number at the vertex of polygon in any sector is the genotype that produces the highest value in trait(s) that fall in that sector. Thus, genotypes (1, 2, 4, 5, 6 and 11) had good yield while genotype (11) produced the highest yields. The genotypes (9, 13 and 16) had good tillering number, pan/m^2, out of these, V16 had the highest number in tiller, pan/m2, flowering date and also highest value in sterility and AfRGM and these lead to reduction in yield.

Figure 5 represents the average tester coordination view, showing the performance of the genotypes across the years and their stability under valley bottom condition. Visualization of the mean and stability of genotypes is achieved by drawing an average environment coordinate (AEC) on the genotype-focused biplot. First, an average environment, represented by the small circle, is defined by the mean PC1 and PC2 scores of the environments. The small circle near Banfora 2003 location suggests Banfora site as the average location in relation to other location in term of yield performance. The line connecting the biplot origin and the circle (Banfora) is referred to as the average-tester axis. Based on their mean performance, the genotypes are ranked along the average-tester axis with the arrow pointing towards genotype with greater value. Thus, the genotypes are ranked along the AEC abscissa, with the arrow pointing to higher mean

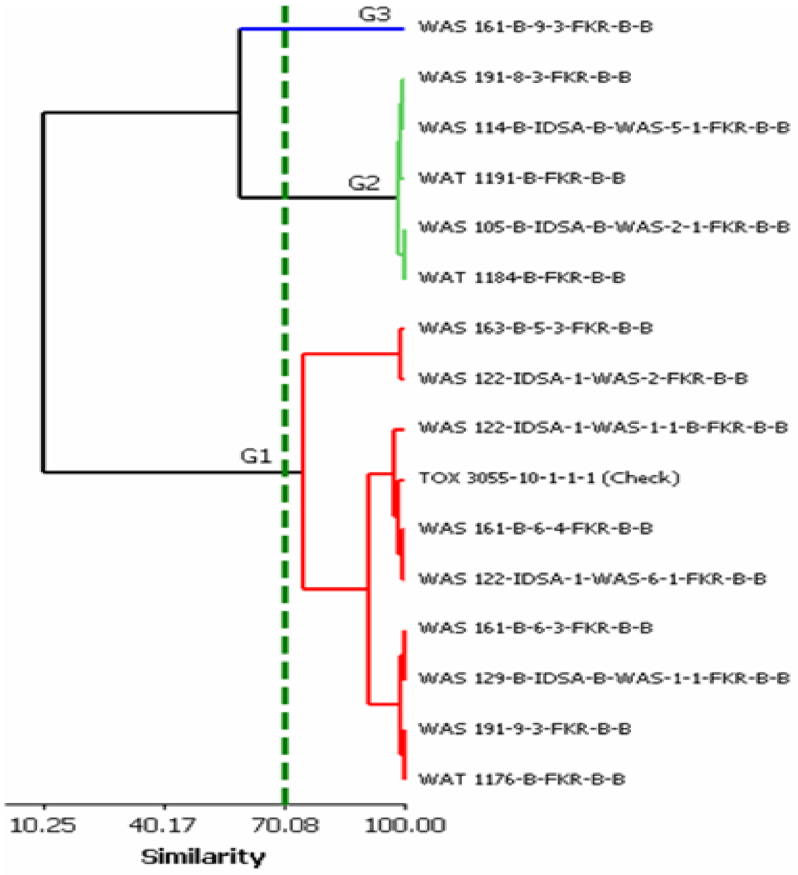

Figure 2. Morphological dendogram showing the minimum distance between cluster groups (2003).

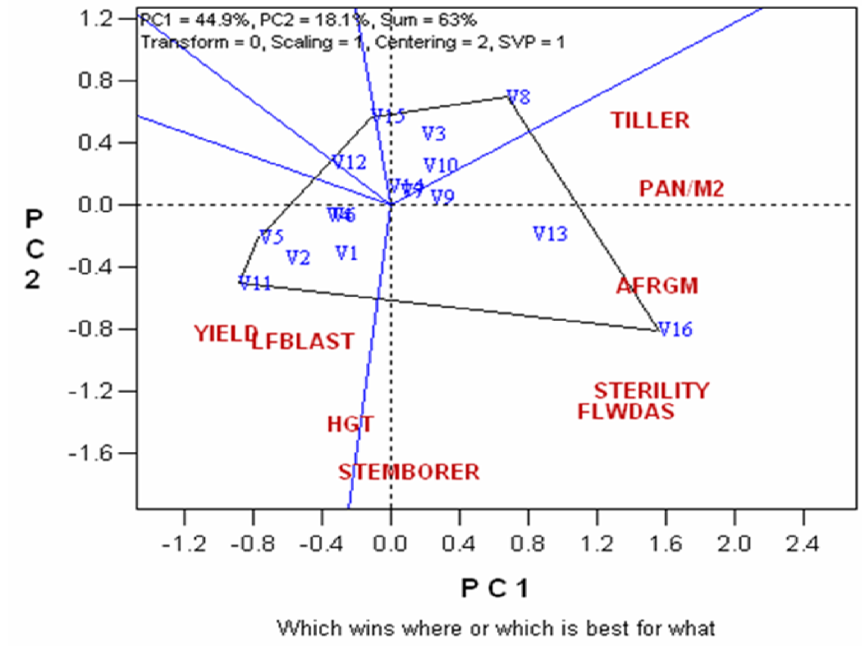

Figure 4. A polygon view of the GGE biplot of genotype x trait, showing which genotype won where or best for which trait (2003).

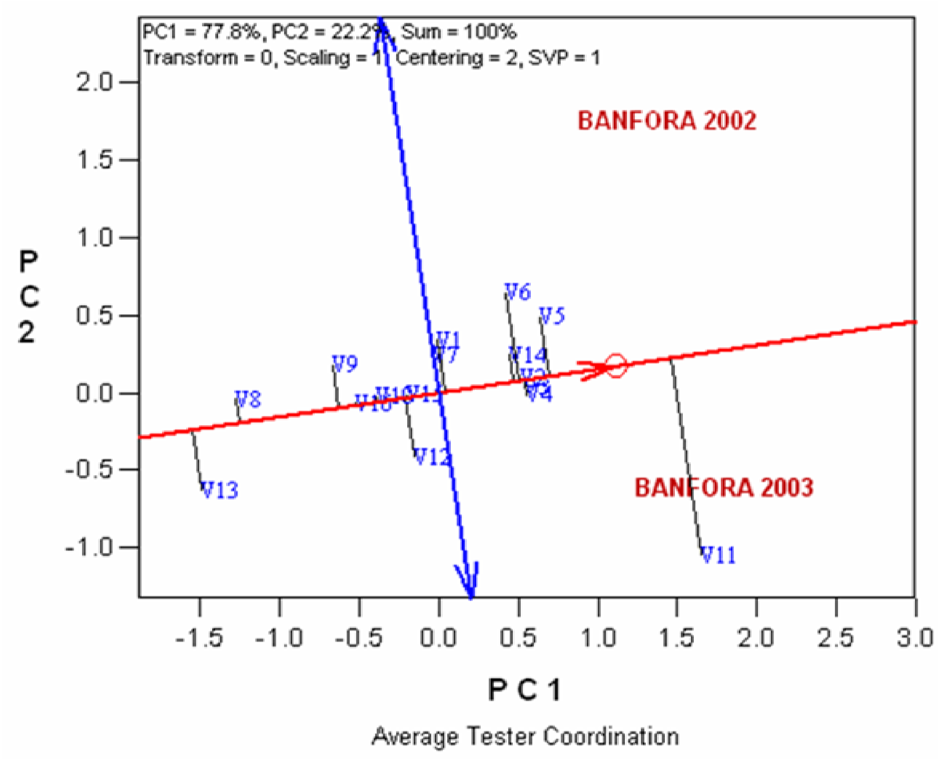

Figure 5. The mean performance vs. stability of the 16 rice varieties across the two seasons under valley bottom lowland condition.

performance. Based on this, Genotype (11) was clearly the highest-yielding, on average, in these environments, followed by (5, 2, 4, 6, 14, 1 and 7) and the least in terms of performance was the genotype (13). The double arrow indicates that a greater projection onto the AEC ordinate, regardless of the direction, means greater instability. The biplot confirmed the conclusions drawn from Figures 3 and 4.

Trends in insects and diseases attacks according to varieties and seasons

Insects (stem borer and African rice gall midge) attacks were averagely the same in both year and no significant deference was observed between varieties. AfricaRice gall midge attacks were however more significant (6) in 2002 and (8) in 2003 compared to 1 for stem borer rates). In 2002, five interspecific lines had no scores for blast compared to intra-specific lines.

DISCUSSION

Variations did exist among the genotypes tested with respect to the traits that were evaluated. Total number of tillers, panicle number and flowering days were observed to greatly influence the yield among the genotypes that were evaluated. The yields recorded in 2003 were all higher than those recorded in 2002 and this was due to the differences observed between the genotypes in panicle numbers and insect attacks. The number of tillers produced which ascertains panicle number is the most important factor in high grain yield. However, this characteristic does not seem to be the causal factor in this study because V11, which had tiller number below average, recorded a higher yield of 4053 kg/ha. Thus, the rate of fertile tillers was a factor that could justify this, because high tillering associated with high grain sterility rate reduces panicle number, meanwhile high tillering associated with low grain sterility rate increases panicle number. Moreover, inter-specific varieties showed cycles that was generally shorter than intra-specific varieties and check. Height was also an important factor in the lowland, because what was sought was a variety that was not too tall to avoid lodging, but not also too short to bear strong water levels. For this characteristic, V3, V4, V10, V12, V13 and V14 were below average during the both years and no variety was susceptible to lodging during the both years.

Principal components analysis and hierarchical clustering generated from similarity or genetic distance matrices has provided an overall pattern of variation as well as the degree of relatedness among the genotypes. In addition, the principal component analysis, confirmed the contributions of the three traits to grain yield among the genotypes. The implication is that if selection is to be made between cluster groups for a future breeding exercise, panicle number, total number of tillers, days to heading, should be given high priorities. The GGE biplot generated several graphic biplots, strong genotype by environment interaction was confirmed. It also revealed the relationship among genotypes in terms of their responses and stability to the environments and traits. The results confirmed that the interspecific genotypes (WAS 122; WAS 161; 163; and 191 series) performed well across the locations and they were very stable. The interspecific varieties formed the most interesting group and have a better capacity for adaptation to the diversity of lowlands. They have acceptable yields, sometimes higher than those of intra-specific varieties and checks.

Conclusion

In Burkina Faso the major concern of the national rice breeding and improvement program is to develop short or average height materials (lodging resistance) with short cycle, high yield potential and resistant or tolerant to various biotic and abiotic stresses. The results confirmed that the interspecific genotypes performed well across the seasons. Interestingly, interspecific varieties produced the greatest number of tillers and these observations confirm those made by Jones et al. (1996), who noted that interspecific *O. glaberrima x O. sativa* had a very high tillering capacity, which predisposed them to be more competitive with weeds.

In conclusion, the results obtained were quite encouraging and showed that, the varieties possess good agronomic traits that are well adapted to intensify lowland rice farming. The recent naming of some of these interspecific varieties as NERICA-L (New Rice for Africa Lowland) by AfricaRice has confirmed that they compare well with the traditional varieties. Based on the typology of the varieties, it is concluded that the interspecific crossings *O. glaberrima x O. sativa indica* can increase lowland rice biodiversity. Thus from this study, we now have a new set of interspecific lines that are adapted to lowland conditions and which the national research programs in Burkina Faso can use in various tests for satisfying farmers' needs.

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