Research Application Summary

Screening of rice varieties for their weed competitiveness

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Abstract

Weed competition is a major constraint in rice production systems in Africa. This study was conducted at the Africa Rice Experimental Station in Benin in the dry and rainy seasons to screen rice varieties for weed competitiveness. The experiment was factorial under a a split plot design with 14 contrasting cultivars planted under three weeding regimes: 0, 1 and 4 weedings. Agro-morphological characters, growth indeces and weeds were used to evaluate the cultivars. Highly significant differences (P<0.0001) between cultivars were observed. The impact of weeds on agro-morphological traits was expressed through an increasing senescence of plants in relation to the weeding regime. Weed-competitive cultivars typically showed a leaf area index less than 3, a high specific leaf area and a Soil-Plant Analyses development (SPAD) unit less than 30. High affinities between traits were observed and three types of descriptors were identified based on their broad sense heritability. CG20, an *O. glaberrima* variety was the most competitive against weeds.

Key words: Competitive variety, descriptor, heritability, rice, weed

Résumé

Les mauvaises herbes constituent l'une des principales contraintes en riziculture en Afrique Sub Saharienne. Les essais ont été réalisés à la station expérimentale d'AfricaRice. Le dispositif expérimental utilisé est le split plot et le criblage a été réalisé à partir de 14 variétés suivant 3 régimes d'enherbement : 0, 1 et 4 sarclages. Les caractères agro-morphologiques, les indices de croissance et les adventices ont été mesurés. Des effets hautement significatifs (0,0001) ont été obtenus entre variétés. L'impact des adventices sur les caractères agro-morphologiques s'est traduit par une dégénérescence croissante des plantes en fonction du régime d'enherbement. Un indice foliaire inférieur à 3, une surface foliaire spécifique grande et une unité SPAD inférieure à 30 caractérisent les plantes compétitives. Les affinités fortes entre variables ont été mises en évidence, trois groupes de variables ont été identifiés par rapport à leur héritabilité et la variété CG 20 (*Oryza glaberrima*) s'est révélée la plus compétitive.

Mots clés : Riz, descripteur, adventice, variété compétitive héritabilité

Background

In Africa, inland valley ecosystems account for about 44% of land cropped with rice (WARDA, 2004). Weeds are undoubtedly one of the major factors limiting rice cultivation in Africa (Halidou *et al*., 2006). Weeds compete directly with rice for growth sources such as water, nutrients, light and space (Johnson *et al*., 1997). Weeds, like diseases, insects and other pests are a serious and severe constraint in uplands rice systems , in irrigated rice as well as in lowland conditions (Haefele *et al*., 2004). In West Africa, estimated yield losses due to weeds range between 12 and 22% (Haefele *et al*., 2000; Becker and Johnson, 2001).

Literature Summary

Rice and wheat are major crops in the World as they represent staple foods for 3/4 of the world population. Rice alone represents the base food for a large part of the population of developing countries. In 2009 and 2010, world rice production was estimated at 680 and 710 million tons, respectively (FAO, 2010). An increase in rice consumption of about 8 million tons was also reported. Weed infestation is a major constraint in all rice production systems in Africa. In rainfed rice, yield losses due to weeds can go up to 84%, depending on the weed species, rice varieties and the soil moisture regime (Akintayo *et al*., 2008). Yield losses of 40% have been reported under hydromorphic conditions (Dogbé and Aboa, 2004) compared to 8 to 30% for transplanted rice under rainfed lowland and irrigated conditions (WARDA, 2000). In addition to the costs of weed control, weeds account for yield losses estimated to be at least 2.2 million tons per year in sub-Saharan Africa with a value of $1.45 billion (Rodenburg and Johnson, 2009). This yield loss due to weeds is equivalent to approximately half the current total imports of rice in the region.

Study Description

Experiments were conducted on land that had been fallow for six months in the experimental farm of the Africa Rice Center in Benin in the dry season and rainy season 2009. Fourteen rice entries were evaluated for weed competitiveness. The experimental design was a split plot with three blocks corresponding to weeding regimes as subplot treatments and 14 variety sub-blocks corresponding to main plot treatments. There were six replications. The weeding treatments were: 0 weeding; 1 weeding 14 days after sowing (DAS) and 4 weedings (weeded every 15 days from 14 DAS). Each plot had 5 rows with seeds planted at the rate of 4 to 5 per hill at 0.25 m intervals between rows and 0.2 m within rows. Fertiliser was applied at the rate of 200 kg ha^{-1} of NPK15-15-15 (basal), 50 kg urea ha^{-1} at first weeding (15 DAS) and also at heading. Plants were thinned to one plant per hill at 15 DAS. Three agro-morphological descriptors were measured – tillering, plant height and grain yield. The effect of weeds on rice growth and development was estimated based on the agro-morphological descriptors. Leaf area index (LAI), specific leaf area (SLA) and *in situ* chlorophyll content of the test plants (SPAD) were measured. Weed dry biomass (WDB) and the soil covered density of each variety (CDR) were evaluated. The predominant weed species were inventoried and identified in each plot.

Repeated mixed model ANOVA and simple ANOVA were performed. Analysis was done using SAS, version 9.1 (2003). In addition, the Pearson linear correlation coefficients among 8 quantitative variables in relation to weeding regime were determined with the XLSTAT 2009 software. Broad sense heritability was estimated with SAS (version 9.1, 2003) using data for both seasons and determined using 8 quantitative characters depending on the different variance components.

Research Application

Results obtained during the two seasons are shown in Tables 1 and 2. Under the 0-weeding regime in the dry season, grain yield ranged from 0 (IG10, SHAWHON, FKR19, FKR54, JAYA, IR64, IR31875-58-1-2-3-3, WITA2, WITA7) to 547 gm^{-2} (CG20) (Table 5) and from 191 (WITA7) to 2023 gm-2(TOG5681) in the rainy season. The six African varieties yielded 345 (CG17) to 2023 gm-2(TOG5681) compared to 191 (WITA7) to 994 gm^{-2} (WITA2) for the Asian varieties. CG20 gave the highest grain yield (547gm^{-2}) in the dry season and 1130 gm^{-2} in the rainy season under 0-weeding. However, the average yield for CG20 was low, 96.25 gm^{-2} with 1-weeding and 5.53 gm^{-2} with the 4-weedings regime.

Secondly, for the determination of variance component and assessment of broad sense heritability, «Genotype × weed regime » and «genotype» variance component (Table 2) were low to nil based on the variables T60, yield, SPAD and CDR

Table 1. Grain yield (g/m²) of the varieties in relation to weeding regime

Traits	Dry season				Rainy season			F value
	0 weeding	1 weeding	4 weeding	F value	0 weeding	1 weeding	4 weeding	
CG14	118	1326	1480	9.64**	1309	1243	1901	9.45**
CG17	254	1419	1773	16.4***	345	1336	1570	0.09ns
CG20	547	1990	2824	5.28*	1130	1754	2560	0.04*
IG10	0	1575	2211	7.81**	1505	2430	1888	16.77***
SHAWHON	0	1285	1942	5.29*	906	1367	1824	2.44ns
TOG5681	415	1137	1658	2.25ns	2023	1267	1613	13.3***
IR64	0	1355	1817	5.38ns	766	1347	2165	4.95ns
IR31875	0	1487	2216	2.1ns	843	2286	2592	20.96***
WAB 56-50	164	1629	2512	5.62**	436	1232	2481	0.12ns
WITA 2	0	1285	2120	6.97**	994	1252	2430	7.5**
WITA 7	0	1571	2318	3.26*	191	2172	2638	5.74*
FKR 19	0	1576	2753	2.95ns	416	1784	2903	3.08ns
FKR 54	0	1264	2378	6.12**	381	1752	2708	6.66**
JAYA	0	1525	1657	2.17ns	797	1491	2139	7.97***
Means	150	1458.86	2118.5		860.14	1622.4	2243.7	

ns: Not significant at 0.05; * : significant at 0.05; ** : significant at 0.01-0.001; ***: significant at 0.0001.

Table 2. Variances combining the two cropping seasons, the three weeding regimes and corresponding broad heritability.

Traits	0 weeding				1 weeding				4 weedings			
				$h^2_{bs\ 1\text{-}2}$				$h^2_{bs\ 1\text{-}2}$				$h^2_{bs\ 1\text{-}2}$
Tillering	0,1	0,3	1,4	**0,2**	4,2	3,3	9,3	**0,6**	11,8	2,7	11,2	**0,8**
Height plant at maturity	0,0	395	546,8	**0,0**	45,7	99,7	239,5	**0,4**	51	95,2	112,2	**0,5**
Grain yield	0,0	0,1	0,45	**0,0**	0,0	0,1	0,9	**0,1**	0,1	0,1	0,7	**0,6**
LAI	0,0	0,0	2,62	**0,0**	0,0	0,0	2,7	**0,0**	0,0	0,3	1,5	**0,0**
SLA	0,0	201,4	13143,7	**0,0**	0,0	544,4	6615,7	**0,0**	0,0	644,3	6682,6	**0,0**
SPAD	3,6	3,1	40,5	**0,4**	6,0	12,0	34,7	**0,4**	7,1	6,7	74,5	**0,4**
Weed biomass	0,0	581,8	3624,9	**0,0**	121,4	0,0	3063	**0,3**	0,0	0,4	11,5	**0,0**
Rice coverage	11,8	4,9	78,6	**0,6**	1,1	0,0	48,3	**0,2**	0,0	0,0	191,6	**0,0**

δ^2_G : Genotype variance; δ^2_{GxT}; Genotype x saison interaction; δ^2_E Variance error under the three weeding regimes. However, high «genotype × treatment» variances were detected based on the variables Hmat and SLA for the three weeding regimes except for the variable WDB under 0-weeding regime. With this latter regime, estimated broad sense heritability was nil for most of the characters except the variables CDR (0.57), SPAD (0.42) and T60 (0.17). Under 1-weeding, two characters (SLA and LAI) showed nil broad sense heritability while this heritability varied between 0.13 and 0.63 for the other characters. The highest broad sense heritability was recorded, under the 4-weeding regime, with the variable T60 (0.84) while broad sense heritability estimates varied between 0 (LAI,SLA, WDB and CDR) and 0.58 (Yld).

References

Akintayo, I., Cissé, B. and Zadji,L.D. 2008. Guide pratique de la culture des NERICA de plateau. WARDA. pp. 28.

Becker M. and Johnson D.E. 2001. Improved water control and crop management effects on lowland rice productivity in West Africa. *Nutr. Cycl. Agroecosyst.,* 59: 119–127.

Dogbe, S.Y. et Aboa, A. 2004. Evaluation des hybrides inter et intraspécifiques pour leur compétitivité avec les adventices en riziculture de bas-fonds. Actes de la seconde revue régionale de la recherche rizicole. pp: 41–45.

FAO. (2010). Trends of rice paddy production: monitoring the market. http://www.fao.org\esc\fr\15\70\highlight_71html.

Haefele. S.M., Johnson. D.E., Diallo. S., Wopereis M.C.S. and Janin I. 2000. Improved soil fertility and weed management is profitable for irrigated rice farmers in the Sahel. *Field Crops Res.,* 66: 101–113.

Haefele S.M., Johnson D. E., Bodj D.M., Wopereis M.C.S and Miezan K. M. 2004. Field screening of diverse rice genotypes for weed competitiveness in irrigated lowland ecosystems. Field Crops. Res., 88: 39–56.

Halidou A., Sido A.Y. et Toudou A. 2006. Evaluation de lignées de riz pour leur compétitivité vis-à-vis des adventices. Conference Proceedings. « Beyond the first generation NERICA in Africa : paradigms and partnerships for the next decade”. Dar es Salaam, Tanzania. pp. 157 – 161.

Johnson D.E., Jones M.P., Dingkhun M. and Mahamane M.C. 1997. The response of *O. glaberrima. O. sativa* and interspecific hybrid rice cultivars to weed competition. The British Crop Protection Council. Farnham. Surrey - United Kingdom. pp. 197-202.

Rodenburg, J. and Johnson, D.E. 2009. Weed management in rice-based cropping systems in Africa. Advances in Agronomy, 103: 150–201.

WARDA. 2000. Développement de modèles informatiques pour la compétition riz - adventices au sahel. Rapport annuel. pp. 39-43.

WARDA. 2004. Going beyond Upland NERICA: Another New Rice for Africa is born. Towards New horizons. pp. 14-19.