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An assessment of diversity pattern and genetic relationships of the response of rice varieties to stresses

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ABSTRACT: Multiple stress management is a major solution to high yield reduction experienced in farmers' fields. Studies were conducted to assess the variability of response of four major pests of rice to a total of one hundred and nine rice varieties. These constraints include blast. African rice gall midge, iron toxicity and drought. African rice gall midge and iron toxicity studies were conducted at Edozhigi (Central Nigeria) in a natural field condition. Blast studies were conducted at International Institute of Tropical Agriculture under artificial inoculation while drought was screened at Badeggi (Central Nigeria) in dry days. The result showed that the diversity of the test materials to the stresses varies with respect to the dates scoring as well as from year to year. Mean values for all the stresses showed that none of the test materials possess resistant genes to the four stresses. Blast scores showed more diverse gene distribution from moderately susceptible to highly susceptible levels than the other stresses. The computer drawn dendogram produced thirteen groups at 100% level of similarity.

Key words: Variability, Diversity, Stresses, Rice and varieties.

Introduction

Rice, like the other cultivated crops is threatened by multiple stresses. Pest organisms including insects, weeds and diseases place a substantial constraint on crop production world wide (Mathew and Waage, 1996). Current estimate put global losses to pests at about 30% of potential world food, fiber and field crop production (NRI, 1992). In farmers' fields multiple pest organism is a common occurrence (Gana et al., 2000).

The population of wild plants and crop landraces are in general genetically polymorphic. This is an important issue in deciding the strategy and system of germplasm conservation (Oka, 1988). In wild rice, perennial populations are more divergent from one another (Morishma and Oka, 1970). This reflects their distant breeding system as shown by their heterozygote frequencies. Upland rice population is generally more polymorphic than lowland rice population (Oka, 1988). According to Harlan, (1975) these landraces have low yielding capacity but high yielding stability. Such crops carry an array of resistant genes so that no single race or biotype of parasites can increase to an epidemic level (Harlan, 1975). In a study conducted at Yunnan, China where 5200 rice accessions were characterized for 31 traits including drought tolerance, cold tolerance and resistance to blast and bacterial leaf blight, large differences between diversity indices of indica; and japonica rice varieties were observed.

Resistant varieties have been identified as major components of pest and disease control. However evolving races or biotypes of these organisms usually give a short life span to the genotypes that are released to farmers. A population with brood-based genetic background offers more promise that will contain pest resurgence in a sustained manner. In many cases, multiple genes are required for sustained resistance to pest menance. For example in most of the Inland Valley and flood plain in Guinea Savanna and rain forest ecological zones of Nigeria, iron toxicity and AfRGM are serious production constraints (Singh et al., 1997; Gana et al., 2002). However, in the fields, farmers do not operate in a monoculture system since two or more crop varieties are often encountered in one farmer's field.

This system usually enhances biodiversity as well as reducing the effects of multiple stresses. The focus of this study is to evaluate to the potentials of these materials with respect to their extant genetic resources in combating these natural stresses and thus achieve a sustainable breeding program either by selection for crop mixtures or by hybridization programs.

Materials and Methods

Four major rice stresses were considered for this work. These include blast, AfRGM, iron toxicity and drought. The blast trial was screened at the International Institute of Tropical Agriculture (IITA) in an augmented design, using cheeks of known reaction to blast. Spreader rows were inoculated two weeks before the test entries. Blast scores were taken at 20, 40 and 60 days after seeding. The AfRGM and iron toxicity trials were conducted at Edozhigi in a randomized complete block design replicated three times in a natural field condition. The AfRGM scores were taken at 42 and 63 days after transplanting (DAT) for three years while iron scores were taken at 40 and 60 DAT for three years. Drought studies were conducted at Badeggi in an irrigated system. The scores were taken at 18 and 28 days after application of water.

fertilizer was applied at the rate of 80:40 kg/ha of N2 P202, 420 (active ingredient) except for blast and drought trials.

Results and Discussion

Table 1 shows the mean values of entry scores of blast for the three dates. Sixty days at sowing (DAS) has a higher mean of 6.46 but a lower standard deviation of 1.875. The implication of this is that at higher rate of scoring, the response of the varieties to the stress tends to cluster around the average. The differences in response tend to reduce at 60 DAS. Though 40 DAS has an average of 5.20, it gave a higher SD, suggesting that there was more variability in response of the test material at 40 DAS than the other dates. Selection at 40 DAS would probably increase the diversity of genes available in the population because of the potential variability that exists among the test materials. Variability has been identified as a tool in breeding programs (Allard, 1960).

Table 2 shows the descriptive statistics for AfRGM occurrence for three years. The highest mean was obtained at 42 (DAT) days after transplanting for year 1 (20.66%). This shows that the response of test materials to the insect was more diverse in year 1 than in the other years. However based on scoring dates year 3 at 63 DAT was more diverse (3.25% to 35.15%). The standard deviation was lowest at 63 DAT in year 2 (1.405) which was followed by 63 DAT at year 1 (2.073). The other dates had almost the same SD. This indicates that variability in response of the varieties to the insect was lowest at 63 DAT in year 2 followed by 63 DAT in year 1. The highest variance was obtained in year 3 at 63 DAT. From this table it could be observed that variation that exists in insect infestation levels range between 13.15% (63 DAT in year 1) to 20.66% (42 DAT in year 1). It appears that little progress can be made in genetic improvement for AfRGM resistance among the test materials as a result of low variability in response to the insect (Guei et al., 2004).

Table 1: Mean and descriptive statistics for blast score.

Blast score	Mean	SD	SE	VAR	RANGE
20 DAS	3.243	1.956	0.189	3.827	7
40 DAS	5.202	2.216	0.214	4.914	8
60 DAS	6.458	1.875	0.181	3.515	6

Table 2: Mean and descriptive statistics for AfRGM for three years

Year	Scoring (DAT)	Menu	SD	SE	VAR	RANGE
1	42	20.66	4.10	0.41	16.87	22.6
1	63	13.15	2.07	0.21	4.30	12.05
2	42	18.50	4.07	0.39	16.55	18.54
2	63	14.90	1.41	0.14	1.97	6.4
3	42	13.72	4.14	0.38	17.14	22.98
3	63	19.40	4.84	0.46	23.41	31.9

Means and other descriptive statistics for iron toxicity are shown in Table 4. Higher means occurred in the first year at both 40 and 60 DAT compared to years 2 and 3. The deviation from the mean was higher at 60 DAT in year 3 suggesting that there is greater diversity from the mean than in the other years. Also there is more variation among the test entries in year 3 than in the other years.

The result in Table 5 showed the contribution of either susceptible or resistant genes that could be derived from this population. At a moderately resistant level (score 3) entries score 11.3% for AfRGM, 28.44% for iron and 1.78% for drought. Reaction to iron toxicity was higher at moderately susceptible level (71.55%) than blast, AfRGM and drought (14.67) (28.3%) BLAST, (0%) AfRGM, and 14.67% for drought. 38.3% of the varieties reacted to blast at susceptible level, 100% for AfRGM and 70.64% for drought.

Cluster analysis for the stresses

Table 6 shows the cluster analysis based on the scores for the stresses. At 100% level of similarity 13 groups can be recognized. Cultivars are not delineated into groups based on varietal types, since each group contains a mixture of local and improved varieties.

Cultivars in the same group will not generate much variability. Genetic heterogeneity has been known to provide greater disease suppression when used over a large area (Wolfe, 1985; Mundt, 1994).

From the study, varieties in group one could be used for hybridization programmes, while members of groups 5 and 6 could be used for blast management in highly infested locations. The overall reactions of the four stresses to the test materials indicate that none of the varieties was totally resistant (score 1 and 0) to the four stresses. Percentage number of lines that reacted to blast at score of 3 (moderately resistant) was 11.3%, 0% for AfRGM, and 28.44% for iron but none for drought. This suggests the amount of the donor genes that could be available in this population for parental selection. However, more resistant genes are available in this population for iron followed by blast.

Heinrichs, (1986) confirmed that pest resistant genes are rare and predominantly found in unimproved wild accessions. For example, resistance to insects is found only in 0.01.2% of rice genotypes and much of these occur in landraces. In potato, high level of resistance to the green peach aphid (*Myzus oersicae*) has been identified in about 6% of examined accessions of wild Solanum species (Flanders et al., 1992). Varieties with scores of 5 (moderately susceptible) are good for cultivation where the infestation levels are low. They could provide increased yield compared to susceptible varieties. Similarly varieties that are susceptible to highly susceptible levels are not suitable for cultivation (AAS, 1999). Yield reduction could be significant in highly infected fields. Results from this study areas showed that 61% of the varieties are either susceptible or highly susceptible to blast, 100% to AfRGM and 60.4% to drought. These percentages indicate that these materials are not suitable for cultivation where these stresses occur so as to avoid yield loss. According to Ahn. (1994), reaction scores of 0-3 indicate qualitative resistance of a given test site. Scores of 4 – 9 indicate the presence of compatible races as well as possible different levels of quantitative resistance.

Table 3: Mean and descriptive statistics for iron toxicity for three years

Year	**Scoring (DAT)**	**Means**	**SE**	**VAR**	**RANGE**
1	40	4.19	1.18	0.118	5
1	60	5.67	5.67	0.132	5
2	40	2.93	2.93	0.11	5
2	60	3.52	1.07	0.102	5
3	40	3.64	1.45	0.143	6
3	60	3.62	1.49	0.135	6

Table 4: Mean and descriptive statistics for drought score

Drought score	**Mean**	**SD**	**SE**	**VAR**	**RANGE**
1st	1.56	0.63	0.06	0.397	2
2nd	6.404	0.954	0.091	0.910	5

Table 5: Level of infestation for the stresses

Stress	**R**	**MR**	**MS**	**S**	**HS**
Blast	0(0)	12(11.3)	30(28.3)	41(38.3)	24(22.6)
AfRGM	0(0)	0(0)	0(0)	100(100)	0(0)
Iron	0(0)	31(28.44)	78(71.55)	0(0)	0(0)
Drought	0(0)	1(1.78)	(14.67)	46(70.64)	1(13.79)

*Fig. in parentheses are percentages
R – Resistant; MR – Moderately resistant; MS – Moderately susceptible; S – Susceptible; HS – Highly susceptible.

Table 6: Cluster groups for varietal response to the stresses

GP1	GP2	GP3	GP4	GP5	GP6	GP7
Danboto	Bubanfari	Domsxhihi	FaroSipi	Faro 27	Tos 8189	Faro 44
	Dubba 1	Eyewawagi	Gyanako(ch)	Tos 14499	Tos 8089	Faro 50
	Manbekochi	Shagari	Ndawodzufan	Faro 23		Faro 10
	Faro 20	Kpuruga	Bokuchi	Faro 18		Faro 51
	Finiko	Ndabissangi	Janiri	Tos 8081		Faro 11
	Dokochi	Jarankuara	Ebangichi	Tos 14519		Faro 47
		Tos 7730	Akpuruka(Nd)	Faro 31		Ndachele
		Faro 37	Ndachelegbo			Phillipines
		Nasara 2	Farnkuara			Sagannwungi
		Faro 4	Mass			
		Faro 7	Gargaza			
		Faro 15	Phillipines			
		Faro 33	Faro 43			
		Tos 8163	HTA 60			
		Jufangi	Faro 45			
			NCRI 1			
			Faro 44			
			Faro 30			
			Faro 35			
			Tos 12465			
			Tos 9285			
			Toma			

GP8	GP9	GP10	GP11	GP12	GP13
Faro 36	Faro 46	Faro 5	Manbechi(Ed)	Akpuruga	Faro 16
	Nnakashikpanti	Faro 48	Dubbu 2	Kparazhiko	Faro 40
	Ebangichi(KK)	Manbechi	Ghagudo		Faro 2
	Gyanako (Ch)		Bisanyakolo		Faro 17
	Manbechi (Kb)		Ebangichi (Gz)		Faro 32
	Egwazanwunkpa(Ba)		Faro 22		Nasara 1
	Faro 13		Faro 46		Egwazanwunkpa(DO)
	Faro 19		Faro 8		Ebangichi (KU)
	Danmale		Gabachi		Landanchi
	Ebangichi (Gb)				Tomako
	Gyanako				Ebangichi (Ba)
	Faro 28				
	Faro 12				
	Faro 29				
	Faro 39				
	Nasara				

References

AAS (Academy of Agricultural Sciences) (1999). Manual for the international training of the rice breeding experts for the effective use of rice genetic resources in developing countries. Pyangyang D.P.R. of Koriea, pp. 3 – 6.

Agn, S.W. (1994). International collaboration on breeding for resistance to rice blast. In rice blast disease edited by R.S. Zeigler, S.A. Leong, P.S. Teng IRRI. Philippines, pp. 137 – 154.

Allard, R.W. (1960). Principles of plant breeding. Willey International Edition, New York, London, 485pp.

Flanders, K.L.; Hawkers, J.G.; Radeliff and Lauer, F.I. (1992). Insect resistance in potatoes: sources, evolutional relationship, morphological and chemical defenses and ecogeographical associations. Euphyitica 61: 83 – 111.

Gana, A.S.; A.T. Maji; M.N. Nkwungwu; E.D. Imolehin and L. Ogunremi (2000). Rice varietal development for rain fed lowland ecology of Nigeria. Challenges and opportunities. Paper presented at the first ROCARIZ meeting held in Mbe Buoake Coted'Ivoire, pp. 1 – 8.

Gana, A.S.; A.T. Maji; M.N. Ukwngwu (2002). Evaluation of advance rice breeding lines; for resistance to the African rice gall midge and iron toxicity. Proceeding of the second ROCARIZ Meeting, WARDA, Buoake Coted'Ivoire, pp. 99 – 104.

Guei, R.G.; Abamu, F.J.; Karim, T. and Naman, S. (2004). Genetic variability in morphological and physiological traits within and among rice species and their interspecific progenies. Agronomie Africaine 16(1): pp. 15 – 32, Coted'Ivoire.

Harlan, J.R. (1975). Crop and Man. American Society of Agronomy. Madison, Wisconsin 295p.

Heinrich, E.A. (1986). Perspectives and directives for the continued development of insect resistant rice varieties. Agriculture, Ecosystems and Environment 18: 9-3.

Mathew, T. and J. Wage (1996). Integration of biological control and host plant resistance breeding. A scientific and Literature review; Wageningen. The Netherlands.

Morishma, H. and Oka, H.I. (1970). A survey of genetic variation in the population of Wild Oryza species and their cultivated relatives JPN J. Genet. 45a, 371 – 385.

NRI (1992). Synopsis of integrated pest management in developing countries in the tropics. Natural Resource Institutes, Chatam, UK, 20pp.

Oka, H. (1988). Origin of cultivated rice, Elsevier, Japan Science Society Press, Amsterdam/Tokyo, 254pp.