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Screening for Blast and Genotype by Environment Interaction of Rice

Gbadeyan, S. T.[1], Salami, A. O.[2], Maji, E. A.[1], Umar, A.[1], Isong A.[3*], Ehirim, B. O.[1] and Uyokei U.[1]

[1]National Cereals Research Institute, P.M.B 8 Bida, Nigeria

[2]Obafemi Awolowo University, Ile-Ife, Nigeria

[3]Tamil Nadu Agricultural University, Coimbatore, India

*Corresponding Author E-mail: tohkunbor@gmail.com

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ABSTRACT

The study was to identify rice genotypes that are resistant to leaf blast disease and assess the effect of different environments on the resistance and growth parameters of the rice genotypes. Thirty rice genotypes were planted at NCRI research fields at Badeggi and Edozhigi. The experiment was laid out in a 5 by 6 lattice design with three replicates. Observations were made on plant height, number of tillers and leaf blast scores. The data were subjected to Analysis of Variance (ANOVA) and means were separated using LSD at 5% level of probability. Genotype by genotype by environment (GGE) biplot was applied to determine the interaction. The results revealed that the genotypes responded differently to leaf blast. Significant interaction was also observed between the environment and genotypes regarding leaf blast disease. Genotype contributed highest sum of squares to number of tillers and plant height. The mean separation also revealed that the number of tillers and the plant height at maturity did not differ significantly from one environment to another. The genotypes TETEP, K1, IRBL5-M, NIPPON BARE and MOROBEREKAN were found to be resistant to leaf blast disease across environments. It was also concluded that environment played major role in disease development in each genotype whereas the growth parameters were mainly controlled by their genetic composition.

Key words: *Rice, Interaction, Resistance, Environments, Genotype.*

INTRODUCTION

Rice *(Oryza* spp) is a staple food in most countries of the world[4]. It is the second most cultivated cereal and usually taking three to six months to grow from germination to maturity[10]. It is closely associated with the culture of billions of people around the world, especially Asia and Africa. Of all the continents, Asia is the largest producer of rice[10]. It is a crop that feeds more than half of the world's population and supplies 20% and 13% of the required daily calories and protein respectively[7]. Rice belongs to the family Poaceae and genus *Oryza*, it can grow in almost any biophysical environment. The two cultivated species are *Oryza sativa* and *Oryza glaberrima*[6].

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Rice production in Africa is challenged by inadequate input, insufficient number of extension agents, poor acceptance of new innovation on the part of the farmers, climate change, diseases and poor irrigation system[14]. Some diseases that affects rice include, rice yellow mottle virus, rice blast, bacterial blight, brown spot, leaf scald, black kernel, sheath rot, crown sheath rot, sheath blight, bacterial grain rot, bacterial leave streak, foot rot, grain rot, pecky rice and sheath brown[11]. Sonia and Gopalakrishna[15] reported that rice blast fungus is one of the main pathological threats to rice crop globally. It is a fungal disease caused by *Magnaporthe grisea*. The pathogen attacks the leaves, causing leaf blast during the vegetative stage of growth, or neck, nodes and panicle branches during the reproductive stage[2]. Blast is present nearly everywhere rice is grown which is usually marked by cooler climates[12] and is favoured by rains, high humidity, inadequate spacing and excessive use of nitrogen. Although successful chemical control measures have evolved, these are too expensive and hence, host resistance is given priority in disease control strategy. It is considered as a no-cost technology, especially for the poor farmers and also an important component of the eco-friendly technique of integrated disease management program. However, neither chemical nor breeding for resistance provides absolute control, due to the ability of pathogen to rapidly adapt, thereby crops remain vulnerable[13].

Breeders are dogged in their efforts to have rice varieties that are resistant to most diseases. They have not only collected many traditional rice varieties that are resistant to blast, but have also identified a number of rice genes that they believe are responsible for the resistance. The use of resistant varieties has been proven to be the most effective and economical way of controlling rice blast disease[17]. However, failures of resistances are observed under different field conditions, as the susceptibility of rice varieties to blast pathogen differs depending on the locality, diversity of the pathogen and the resistant gene carried by the different species of rice plant[17]. Therefore information on the rice genotypes that are resistant to leaf blast disease at different locations is of utmost importance. This present investigation therefore seeks to identify the rice genotypes that are resistant to leaf blast and to assess the effect of different environments on their resistance. It also aims to assess effects of different environment on some growth parameters of the rice genotypes.

MATERIAL AND METHOD

Thirty rice genotypes (C104LAC, C103TTP, C105TTP-1, CO39, TETEP, IRBL5-M, IRBLTA2-Pi, IRBL1-CL , NIPPON BARE, AICHI ASAHI, 75-1-127, MOROBEREKAN, MARATELLI, SUITO 11, OWARI HATA MOCHI, MODAN, SHA TIAO-TSAO , KANTO51, C101LAC, ARICA 1, ARICA 2, ARICA 3, ARICA 4, ARICA 5, IRBLK-KA, KUSABUE, K1, PiN°4, Irat 13, Zenith) were obtained from National Cereals Research Institute, Badeggi, Nigeria. The study was carried out during the raining season of 2017 at three locations known to be hot spot for rice blast disease; Badeggi rainfed, Badeggi hydromorphic and Edozhigi rainfed ecology. The experimental plot of 13.3 x 6.3m was ploughed, harrowed, leveled and carefully marked out. The experiment was laid out in a 5 by 6 lattice design and replicated three times. Three highly susceptible genotypes (infecting bands) were set perpendicularly on each side of the genotype to attract the blast spores. Each infecting band had 3 rows that were 12 m long and the rows were spaced by 10 cm. Each genotype had 3 rows of 30 cm long and a spacing of 10 cm between and within rows, which indicated that each entry had an area of 600 cm^2. The spacing between two genotypes was 20 cm while two replications were spaced by 1 m. Three-four seeds were sown per hole with infecting bands sown 14 days prior to planting of the test entries. At the emergence of the seedlings, infected leaves were collected from infecting bands, shredded and spread along test entries. Thinning was done 2 weeks later to 1 plant per hole leaving twelve plants per genotype. 300kg/ha of urea was applied at sowing and at 21 and 42 days after sowing.

Irrigation and weeding was carried out accordingly. Observations for Leaf blast was scored at one week interval for five weeks .Rating scale and calculation for disease incidence was according to standard evaluation system, IRRI[9]. Plant height and number of tillers were also observed. Data collected were subjected to analysis using statistical analysis system (SAS) version 9.13. Analysis of variance (ANOVA) was carried out and significant means were separated using LSD at 5% probability level. Genotype by genotype by environment (GGE) biplot was used to analyse genotype by environment interaction.

RESULTS

Environment, genotypes and genotype by environment interaction showed highly significant differences in the mean squares of leaf blast severity across the days except for the effect of the environment on leaf blast severity at 42 days after planting (DAP). The environment, genotypes and genotype by environment interaction showed high significant differences in the mean squares for the leaf blast incidence across the days, except at 35 DAP for the effect of the environment on the leaf blast incidence (Table 1). Highly significant differences in the mean squares were observed for genotypes for the number of tillers and plant height at maturity (Table 2).

Pattern of resistance/susceptibility

The 2 selected resistant genotypes (75-1-127 and Tetep) had different leaf blast severity pattern and are not statistically different from each other (Figure 1). This trend was also observed for the 2 selected susceptible genotypes (IRBLTA2-Pi and ARICA 4). The leaf blast severity pattern for the 2 selected resistant and 2 susceptible genotypes across the environments showed that there was significant difference between the susceptible and resistant genotypes at 35 DAP (Figure 1).

There were significant differences between the means of the leaf blast severity and leaf blast incidence across the environments. However, differences in the mean values of numbers of tillers and plant height at maturity were not significant across the environment (Table 3).

The polygon view of the GGE biplot revealed which genotype is best for which environment. The biplot decomposes the significant G x E interaction obtained in the analysis of variance to expose the pattern of the interaction that exists between the set of environments and the genotypes under study. Genotypes found at the vertex of the polygon are considered the best for the environment or set of environments which fell within the sector. The lines from the origin of the figure divide the polygon into different sectors. Genotype TETEP which is the vertex genotypes was the most resistant genotype to leaf blast disease during the harmattan season at Badeggi and during the raining season at Edozhigi. Genotypes AICHI ASAHI, ARICA 2 and K1 were also resistant to leaf blast disease during the harmattan season at Badeggi and during the raining season at Edozhigi (Figure 2). NIPPON BARE which is another vertex genotype was the most resistant to leaf blast disease during the raining season at Badeggi and genotypes IRBL5-M and MOROBEREKAN were also resistant to leaf blast disease during the raining season at Badeggi (Figure 2). Among the resistant genotypes, TETEP, AICHI ASAHI, ARICA 2, and K1 showed the highest stability in terms of resistance to leaf blast disease while genotypes, IRBL5-M, NIPPON BARE, and MOROBEREKAN were also moderately stable (Figure 3).

DISCUSSION

The response of different rice genotypes used in this study is important in the selection of resistant varieties from one location to the other. The resistant ability of these genotypes may be due to the deficiency of suitable nutrient required for the growth and development of the organism causing these diseases in the environment. This is similar to the findings of Obilo *et al.*[11] who reported that genotypes responded in different ways when grown in different environments. Significant differences were observed in the response of the genotypes to leaf blast disease which confirms varietal differences in their susceptibility or resistant ability. This is in line with the work of Spyridon *et al*.[16] who reported that varietal differences significantly contributed to the resistance or susceptibility of the rice to leaf blast. Significant interactions were also observed in this study between the environments and Genotype. These interactions indicated that the establishment of the disease is favoured in one environment over the other, this may be as result of high nitrogen content of the. Obilo *et al.*[11] reported that each rice variety responds characteristically and differently to changes in the environment.

It was observed that environments and the interaction had the greatest contribution to the total sum of squares for leaf blast severity and incidence. Hence, environment has great influence on the severity and incidence of the disease. The susceptible accessions were not significantly different from each other in terms of their responses to leaf blast from 28 to 56 days after planting across the environments. Also, the resistant genotypes were not significantly different from each other in terms of resistance to leaf blast across the environment. This implied that environment affected the expression of resistant genes in the genotypes. The ability to express resistance is greatly conditioned by environmental factors[8].

Genotype had the highest contribution to the total sum of squares for the number of tillers and the plant height. The mean separation also revealed that the number of tillers and the plant height at maturity did not differ from one environment to another. According to Idowu *et al*.[8], this is an indication that the growth parameters were largely controlled by the genetic make-up of the rice

TETEP and K1 were established to be the most resistant to leaf blast across the three environments and were not receptive to *Magnaporthe grisea*, the causative agent of rice blast. TETEP is resistant to blast disease in West-African countries[14]. IRBL5-M, NIPPON BARE and MOROBEREKAN were the most resistant to leaf blast during the raining season at Badeggi and their stability implied consistency in their ability to resist leaf blast disease. It could be inferred that IRBL5-M, NIPPON BARE and MOROBEREKAN posses the ability to prevent the infection by *Magnaporthe grisea* in this environment. Earlier works by Fomba and Taylor[5] revealed that MOROBEREKAN has durable resistance over the years in West-Africa. Ahn[1] also reported that MOROBEREKAN was resistant to blast disease in 69% of the trials with scores of between 0 and 3. Two dominant loci, Pi5 (t) and Pi7 (t) conferring qualitative resistance to blast resistance were identified in MOROBEREKAN[3].

This study concluded that TETEP, K1, IRBL5-M, NIPPON BARE and MOROBEREKAN are resistant to leaf blast, environment played a major role in disease development and the growth parameters were mainly controlled by the genetic composition of the genotypes.

Table 1: Mean squares of Leaf blast severity and incidence of the 30 rice Genotypes

		Leaf blast severity					**Leaf blast incidence**				
Source of var	**Df**	**28**	**35**	**42**	**49**	**56**	**28**	**35**	**42**	**49**	**56**
Environ	2	1.31**	13.20**	12.58**	13.76**	15.66**	4711.67**	17321.76**	91961.12**	8516.20**	11534.98**
Rep(env)	6	0.24	0.16	0.02	0.06	0.07	328.70	172.07	491.49	125.00	134.52
Block(env*rep)	45	0.13	0.14	0.06	0.09	0.07	248.49	163.79	782.56	72.09	85.06
Genotype	29	0.38	1.92**	3.66**	4.20**	3.83**	862.14**	2289.75	4551.06**	2125.68**	1618.35**
Gen*env	58	0.26**	0.72**	0.91**	0.86**	0.77**	439.57**	908.05**	3759.26**	650.98**	477.64**
Error	129	0.11	0.18	0.35	0.01	0.09	277.84	157.73	560.79	97.88	168.64
CV		15.08	11.47	6.75	2.96	1.92	16.94	12.02	6.84	5.38	2.92
R^2%		69.79	93.31	97.00	97.78	97.57	70.62	90.18	97.17	93.41	84.18

*, ** Significantly different at 0.05 and 0.01 level of probability, respectively

28, 35, 42, 49 and 56- Days after Planting

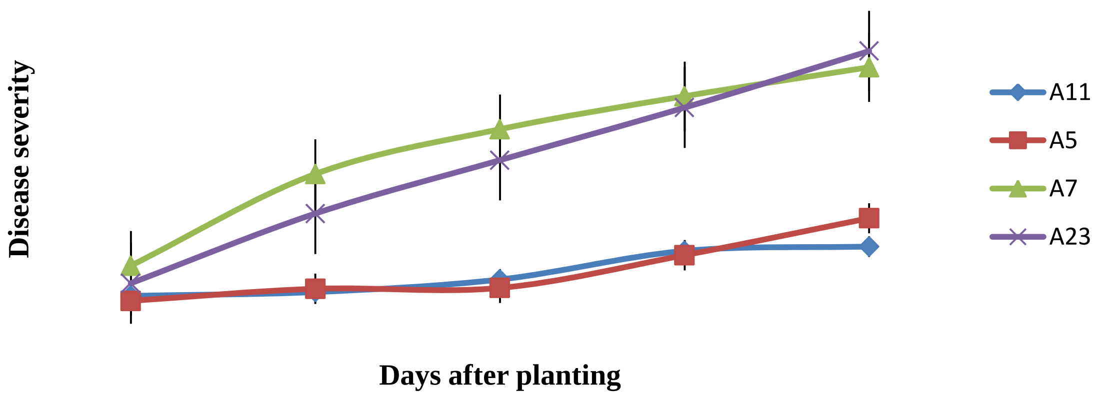
Table 2: Mean squares of number of tillers and plant height for the 30 rice genotypes

Source of var	Df	Plant height at maturity	Number of tillers at maturity
Environment	2	1768.79	125.07
Rep(environ)	6	23.29	3.56
Block(environ*rep)	45	11.56	3.34
Genotypes	29	146.04**	9.56**
Genotypes***environ**	58	30.05	4.77
Error	129	15.65	2.52
CV		5.53	6.44
R^2%		0.85	0.76

*, ** Significant at 0.05 and 0.01 level of probability respectively

Table 3: Mean values of some growth parameters and level of disease development across the three environments

Parameters	BadeggiR	BadeggiH	EdozhigiR	$LSD_{(0.05)}$
Leaf blast severity	5.87	4.81	5.11	0.19
Leaf blast incidence	74.72	58.13	64.72	3.83
Plant height	75.03	72.51	73.89	2.98
Number of tillers	15.22	14.25	15.49	1.42



*A11 = 77-1-127, A5 = TETEP, A7 = IRBLTA2_Pi, A23 = ARICA 4

Fig. 1: Pattern of leaf blast severity of two selected resistant and two selected susceptible rice genotypes across the environments from 28 to 56 days after planting

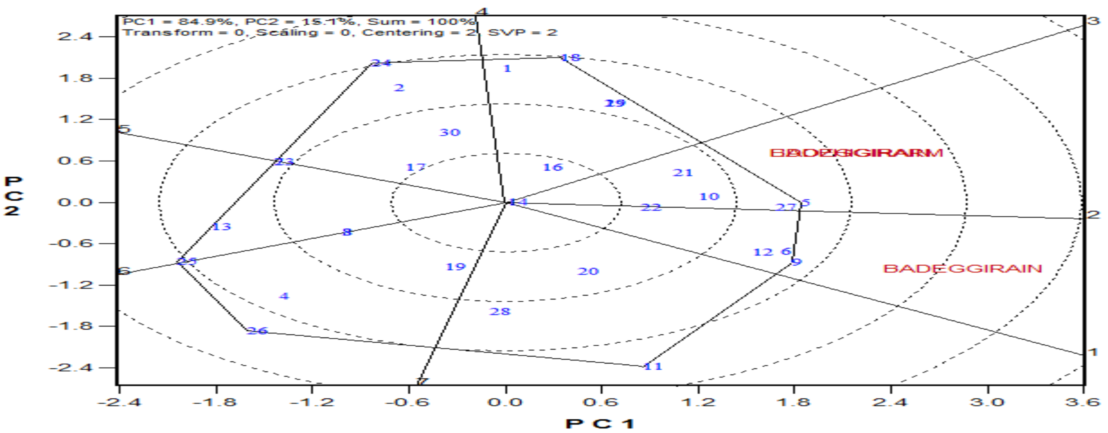


Fig. 2: Polygon view of GGE biplot based on the leaf blast severity of the 30 genotypes

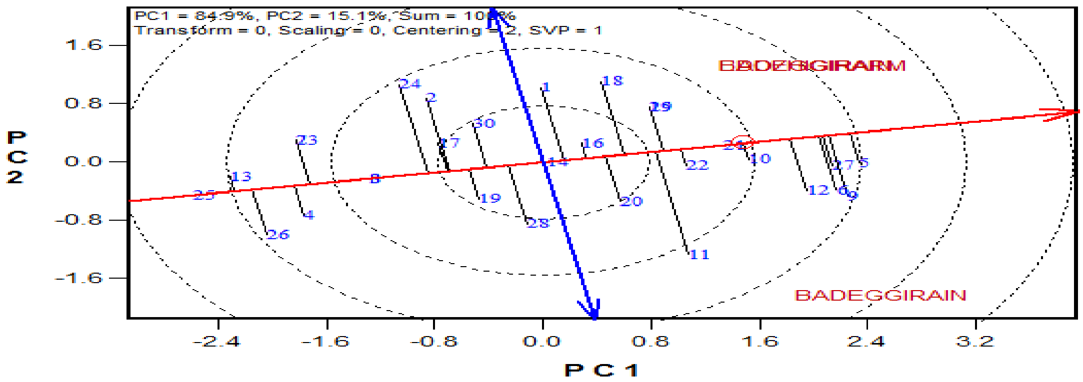


Fig. 3: Average environment view of the GGE biplot showing the mean resistance for Leaf Blast severity and the stability of the genotypes

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