PERFORMANCE OF UPLAND RICE CULTIVARS UNDER TWO NITROGEN LEVELS IN RELATION TO LEAF BLAST

ANNE S. PRABHU[1]; NAPOLEÃO S. SOUZA[2]; MARTA C. FILIPPI[1]; LUIZ G. BARROS[2] & DIÓGENES P.M. AZEVEDO[3]

[1]Centro Nacional de Pesquisa de Arroz e Feijão (EMBRAPA/CNPAF), Caixa Postal 179, 74001-970, Goiânia, GO;
[2]EMPAER/MT, Caixa Postal 225, 78070-000, Cuiabá, MT;
[3]EMBRAPA/CPAF-RO, Caixa Postal 406, 78900, Porto Velho, RO.

(Accepted for publication on 26/01/96)

PRABHU, A.S.; SOUZA, N.S.; FILIPPI, M.C.; BARROS, L.G. & AZEVEDO, D.P.M. Performance of upland rice cultivars under two nitrogen levels in relation to leaf blast. Fitopatol. bras. 21: 281-284. 1996.

ABSTRACT

The performance of improved rice cultivars, in relation to the development of leaf blast, was compared under low and high nitrogen levels in a field experiment conducted in Goiania (GO), Jaciara (MT) and Vilhena (RO), during three successive years (1986-1989). The treatments consisted of two nitrogen levels (10 and 60 kg/ha of nitrogen) and six upland rice cultivars (Centro América, Cuiabana, Guarani, IAC 47, IAC 165, Rio Paranaíba). The criteria utilized for measuring slow leaf blasting included area under disease progress curve, the rate of disease increase until it attains maximum and the maximum leaf blast severity during the course of the epidemic. Nitrogen application at the rate of 60 kg/ha resulted in overall increase of leaf blast. The improved early maturing cultivars Centro America and Guarani, and medium maturing cultivars Cuiabana and Rio Paranaiba, were superior to IAC 165 and IAC 47, respectively, in relation to the rate of leaf blast increase both at low and high nitrogen levels. The effectiveness of leaf blast resistance was greater at Goiania, where they were developed, than in Jaciara and Vilhena.

Key words: *Oryza sativa*, *Pyricularia grisea*, rice blast, slow blasting, partial resistance.

RESUMO

Comportamento de cultivares de arroz de sequeiro em relação a brusone nas folhas em dois níveis de nitrogênio

Foi comparado o comportamento de cultivares de arroz de sequeiro melhoradas em relação ao desenvolvimento da brusone nas folhas, sob dois níveis de nitrogênio, em experimentos de campo realizados em Goiânia (GO), Jaciara (MT) e Vilhena (RO) durante três anos consecutivos. Os tratamentos incluíram dois níveis de N (10 e 60 kg de nitrogênio/ha) e seis cultivares de arroz (Centro América, Cuiabana, Guarani, IAC 47, IAC 165, Rio Paranaíba). Os parâmetros de avaliação do progresso lento da brusone nas folhas foram a área sob curva de progresso, taxa de aumento até a brusone atingir o máximo de severidade e o máximo de severidade de brusone durante o curso da epidemia. A aplicação de nitrogênio à base de 60 kg/ha, em geral, resultou em aumento de brusone nas folhas. As cultivares melhoradas de ciclo precoce Centro América e Guarani, e de ciclo médio como Cuiabana e Rio Paranaíba, foram superiores a IAC 165 e IAC 47, respectivamente, em relação a taxas de aumento de brusone nas folhas tanto em baixa como alta adubação nitrogenada. A resistência das cultivares foi maior em Goiânia, onde foram desenvolvidas, do que em Jaciara e Vilhena.

INTRODUCTION

Assessment of resistance level of cultivars to rice blast caused by *Pyricularia grisea* (Cooke) Saccardo (Syn. *P. oryzae* Cav.) under different environments is important in disease management. Improved upland rice cultivars exhibit different degrees of slow blasting under field conditions. The term slow blasting has been widely used to describe the reduced rate of disease development (Villareal *et al.*, 1980; Ahn, 1981; Marchetti & Xinghua, 1986). Slow blasting in rice similar to slow mildewing in wheat (Shaner & Finney, 1977) is a relative trait which can be assessed by comparing with its development on a suceptible cultivar under the same conditions in the field. This type of resistance, characterized by susceptible infection type and few sporulating lesions, could be partial resistance (Parlevliet & Ommeren, 1975). Its evaluation in the field is complicated because of the presence of major genes in some of the rice cultivars. The degree of partial resistance in upland rice cultivars is variable and has been quantified by challenging rice seedlings with *P. grisea* isolates compatible to all test cultivars under greenhouse conditions (Filippi & Prabhu, 1987). Its expression is subjected to changes in pathogen population and soil fertility levels.

Nitrogen fertilizer is one of the major nutritional factors that greatly increase the cultivar susceptibility to rice blast (Hashioka, 1950; Atkins, 1956; Volk *et al.* 1958; Kozaka, 1965; Soave *et al.*, 1977; Faria *et al.* 1982; Santos *et al.* 1986). The inability to use higher levels of nitrogen imposes a ceiling on grain yields in susceptible cultivars such as IAC 47 and IAC 165. The availability of improved upland rice cultivars with slow blasting characteristic, here referred to as synonymous to partial resistance without any genetic connotation, may permit the use of adequate doses of nitrogen. It is, however, not known how far the existing levels of partial resistance in the improved rice cultivars is altered by high nitrogen levels.

The purpose of the present research was to study the relative performance of improved upland rice cultivars under two nitrogen levels in relation to leaf blast development under field conditions.

MATERIALS AND METHODS

A field trial was conducted under upland conditions in Goiania (GO), Jaciara (MT) and Vilhena (RO) during three successive years (1986-89). The soil was dark red latosol according to the Brazilian system of classification. The layout of the experiment was a randomized complete block design with three replications. The treatments consisting of two nitrogen levels (10 and 60 kg of N/ha) and six cultivars (Centro America, Cuiabana, Guarani, IAC 47, IAC 165, Rio Paranaiba) were arranged in a split-plot scheme. Main plots and subplots were assigned nitrogen levels and cultivars, respectively. Each subplot consisted of eleven 5.0 m long rows and spaced 0.5 m between rows. Seeds were sown at the rate of 40 kg/ha. Fertilizer was applied at the planting time at a rate of 200 kg/ha (5-30-15 + Zn) of NPK in addition to 20 kg/ha of zinc sulphate. An additional 50 kg of N/ha in the form of ammonium sulphate was added in the main plots with N 60 treatment. Three buffer rows of a cultivar highly resistant to blast (Três Marias) were established around each subplot to minimize the inter-plot interference.

Four evaluations of leaf blast were made at three to four day intervals. Leaf blast was assessed on four to five fully expanded upper leaves on 10 main tillers of randomly selected plants in the five central rows of each subplot. A 10-grade scale (0; 0.5; 1.0; 2.0; 4.0; 8.0; 16.0; 32.0; 64.0; 82.0% of leaf area affected) according to Notteghem (1981) was utilized for evaluating disease severity.

Three criteria were used to analyse the slow leaf blasting trait of cultivars.

1. Area under disease progress curves (AUDPC) were computed for each subplot treatment according to Shaner & Finney (1977).

$$AUDPC = \sum_{i=1}^{n-1} \left[\frac{(y_i + y_{i+1})}{2}\right] (d_{i+1} - d_i)$$

where **i** = assessment period from 1 to n; y_i = leaf blast severity at the ith observation; $\mathbf{d_i}$ = days at the ith observation and **n** = total number of observations Log transformation of the data was used to reduce the heterogeneity of variance because of the association between mean and standard deviation. Analysis of variance (ANOVA) was made using the transformed values. Disease severity at 30 days after planting was considered equal to zero in all cultivars.

2. The maximum disease severity (y_{max}) during the disease progress. The data were transformed to arc sin before subjecting to ANOVA.

3. The rate of disease increase until it attains maximum (r_{ymax}) in the disease progress was estimated because the regression lines starting at different dates may have the same slopes (b) or infection rates. The epidemic was considered to start at zero level, 30 days after planting in all cultivars and ended when it attained maximum. The levelling off of the disease was not considered in the regression analysis. The leaf blast severities in percentages were transformed to logits and plotted against time in days (Plank, 1963). The slope of the regression line which is an estimate of r_{ymax} was determined for each subplot

The data from the 1987 experiment conducted at Jaciara was not included in the combined analysis of variance because of the low blast incidence.

RESULTS AND DISCUSSION

The combined analysis of eight experiments during three years showed that cultivar x N level interaction was significant only for the leaf blast assessment parameter r_{ymax}. The interaction was, however, not significant for AUDPC and y_{max}. Cultivar differences in relation to leaf blast development, averaged over N levels, were compared using three disease assessment criteria (Table 1). The values of r_{ymax}, y_{max} and AUDPC for IAC 165 and IAC 47 used as susceptible controls for early and medium maturing cultivars, respectively, were significantly higher than values for other test cultivars. The evaluation using different parameters did not affect the ranking order of the cultivars. However, differences in leaf blast development between suceptible controls

TABLE 1 - Rates of increase until the blast attains maximum (r_{ymax}), maximum disease severity (y_{max}) and area under disease progress curve (AUDPC) for six upland rice cultivars.

Cultivars	Leaf blast assessment parameters		
	r_{ymax} [1]	y_{max} [2]	AUDPC[3]
IAC 165	0.269[4]a[5]	14.069a	162.16a
IAC 47	0.258a	13.768a	148.32a
Cuiabana	0.178b	8.922b	87.09b
Rio Paranaiba	0.148bc	7.775b	47.61b
Guarani	0.143bc	7.569b	55.93b
Centro-America	0.125c	6.847b	46.38b
C.V.(%)	36.1	32.3	51.8

[1] r_{ymax} is the linear regression coefficient (b) determined by plotting logit of leaf blast severity against time until the disease attains y_{max}..
[2] y_{max} is the peak leaf blast severity value in a disease progress curve.
[3] AUDPC is area under disease progress curve, values transformed to $\log_{10}$.
[4] Each value represents the mean of eight experiments including nitrogen levels.
[5] Means followed by the same letter in a column do not differ signifcantly according to Tukey's test at P = 0.05.

and test cultivars were more evident and greater in the analysis made using AUDPC than by using y_{max} or r_{ymax}.

The data on application of nitrogen averaged across cultivars are shown in Table 2. Increasing nitrogen level from 10 to 60 kg/ha significantly increased leaf blast development, analysed with all three assessment parameters. The treatment effect was, however, discriminated better by AUDPC than by r_{ymax} and y_{max}. These results confirmed the earlier reports of increased susceptibility of rice to leaf blast with increasing nitrogen levels in upland rice (Soave *et al.* 1977; Faria *et al.* 1982; Santos *et al.* 1986).

TABLE 2 - Rates of leaf blast increase until it attains maximum (r_{ymax}), maximum leaf blast severity (y_{max}), and area under disease progress curve (AUDPC) at two nitrogen levels.

Nitrogen (kg/ha)	Leaf blast assessment parameters		
	r_{ymax} [1]	y_{max} [2]	AUDPC[3]
60	0.24[4]a[5]	12.45a	124.5a
10	0.14b	7.20b	57.9b

[1] r_{ymax} is the linear regression coefficient (b) determined by plotting logit of leaf blast severity against time until the disease attains y_{max}..
[2] y_{max} is the peak leaf blast severity in a disease progress curve.
[3] AUDPC is area under disease progess curve; transformed values of $\log_{10}$.
[4] Each value represents mean of six cultivars and eight experiments.
[5] Means followed by the same letter in a column do not differ significantly according to Tukey's test at P = 0.05.

The differential response of cultivars across nitrogen levels at three different locations is presented in Table 3. The performance of cultivar Cuiabana was significantly superior over the susceptible control IAC 47 in Goiania but not in Jaciara and Vilhena. Cultivar Centro America has shown significantly lower values of r_{ymax} at all three locations relative to IAC 165. The overall performance of improved rice cultivars was superior in Goiania than in Jaciara and in Vilhena. The better performance of improved rice cultivars, with respective to leaf blast development, may be attributed to the early generation screening of seggregating populations in Goiania.

TABLE 3 - Rates of increase until the leaf blast attains maximum (r_{ymax}) at three locations, for six cultivars.

Cultivar	r_{ymax} [1]		
	Goiania	Jaciara	Vilhena
Centro America	0.09b[2]	0.20b	0.11c
Guarani	0.07bc	0.25ab	0.14c
Rio Paranaiba	0.05bc	0.27ab	0.17bc
Cuiabana	0.01c	0.33a	0.25a
IAC 47	0.23a	0.33a	0.24ab
IAC 165	0.27a	0.33a	0.23a

[1] r_{ymax} is the linear regression coefficient (b) determined by plotting logit of leaf blast severity over time until the disease attains y_{max}. Each value represents mean of three experiments and nitrogen levels.
[2] Means followed by the same letter in a column do not differ significantly according to Tukey's test at P = 0.05.

The rates of leaf blast increase (r_{ymax}) for all four improved rice cultivars were significantly lower than for susceptible control in 1986 (Table 4). In the succeding year, three of the four improved rice cultivars differed from the susceptible controls in r_{ymax} values. In the third year, none of the four cultivars showed significant difference from their respective susceptible controls. These results indicated the increase in susceptibility with time, possibly due to the increase in frequency of matching races to the resistance genes in these cultivars or differences in aggressiveness of races in different locations (Filippi & Prabhu, 1988).

Cultivar differences at two nitrogen levels in relation to leaf blast development as measured by r_{ymax} are shown in Table 5. At lower nitrogen level the cultivar Centro America significantly exhibited low rates of disease increase whereas at high nitrogen level, it did not differ from the rice cultivar Cuiabana. Also, cultivar Cuiabana showed differential performance as compared to susceptible controls at low and high nitrogen levels. Cultivar Cuiabana did not differ from its susceptible control IAC 47 at N10 with regard to the rate of disease increase. The differences in r_{ymax} values were statistically significant at N60. All improved rice cultivars were superior to their respective susceptible controls at N60 indicating thereby that the level of resistance is effective under high levels of nitrogen fertilization. However, further studies are required to determine if the existing levels of leaf blast resistance are effective in reducing panicle blast and consequent increase in grain yield.

Results of this study indicated that the susceptibility of the improved rice cultivars increased with the application of nitrogen fertilization at the rate of 60 kg/ha as compared to 10 kg/ha at planting. Similar results were obtained with all the three assessment criteria utilized. However, the cultivar x nitrogen level interaction was significant only for r_{ymax}. Differential response of cultivars at different locations and increase in susceptibility with time are noteworthy.

TABLE 4 - Rates of increase until the leaf blast attains maximun (r_{ymax}) during three years, for six upland rice cultivars.

Cultivar	r_{ymax} [1]		
	1986	1987	1988
Centro America	0.14b[2]	0.09d	0.13ab
Guarani	0.17b	0.15cd	0.11ab
Rio Paranaiba	0.18b	0.19bc	0.09b
Cuiabana	0.19b	0.28ab	0.10ab
IAC 47	0.30a	0.35a	0.16ab
IAC 165	0.30a	0.36a	0.17a

[1] r_{ymax} is the linear regression coefficient (b) determined by plotting logit of leaf blast severity over time until the disease attains y_{max}. Each value represents mean of three experiments and nitrogen levels.
[2] Means followed by the same letter in a column do not differ significantly according to Tukey's test at P = 0.05.

TABLE 5 - Rates of increase until the leaf blast attains maximum (r_{ymax}) at two nitrogen levels, for six upland rice cultivars.

Cultivar	r_{ymax} [1]	
	N10	N60
Centro America	0.08c[2]	0.17b
Guarani	0.10bc	0.20b
Rio Paranaiba	0.10bc	0.18b
Cuiabana	0.16ab	0.19b
IAC 47	0.20a	0.32a
IAC 165	0.20a	0.34a

[1] r_{ymax} is the linear regression coefficient (b) determined by plotting logit of leaf blast severity over time until the disease attains y_{max}. Each value represents mean of eight experiments. The leaf blast 30 days after planting was considered equal to zero for all rice cultivars.
[2] Means followed by the same letter in a column do not differ significantly according to Tukey's test at P = 0.05.

Furthermore, precision in the data analysis of a multilocation trial can be obtained by using more than one disease assessment criterion. Slight differences in resistance level of improved rice cultivars over suceptible controls may not be adequate to eliminate other disease management practices such as chemical and cultural control measures.

ACKNOWLEDGEMENTS

The authors thank Dr. Francisco J.P. Zimmermann for helpful suggestions in the statistical analysis.

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95109