EFFECT OF LEAF BLAST CONTROL BY PYROQUILON SEED TREATMENT ON PANICLE BLAST PROGRESS AND GRAIN YIELD

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ABSTRACT

Four early maturing upland rice genotypes (IAC 165, IAC 25, Guarani and CNA 4136) were assessed for yield response to seed treatment towards rice blast control in three field experiments. Seed treatment with the systemic fungicide pyroquilon (4.0 g a.i./kg seed) suppressed leaf blast in all the three experiments exhibiting different degrees of disease severity. When the cultivars and experiments were examined, it was found that leaf blast was controlled by 26.8%, on average. The mean leaf and panicle blast severities were positively correlated in two out of three experiments. The control of panicle blast varied in different genotypes. Linear multiple regression equations using leaf and panicle blast as the independent variables and grain yield as the dependent variable showed that both leaf and panicle blast significantly accounted for variation in grain yield. Pyroquilon seed treatment significantly increased the average yield in one of the three experiments when compared to the untreated control.

Key-words: *Pyricularia grisea, Pyricularia oryzae, Oryza sativa*, epidemiology.

RESUMO

Efeito do tratamento de sementes com fungicida pyroquilon no controle da brusone nas folhas, panículas e produtividade

Foi avaliada a produtividade de quatro genótipos de arroz de sequeiro (IAC 165, IAC 25, Guarani e CNA4136) com sementes tratadas com fungicida pyroquilon para o controle da brusone em três experimentos de campo. O tratamento de sementes com este fungicida sistêmico (4.0 g i.a./kg de sementes) reduziu significativamente a severidade da brusone nas folhas, em todos os três experimentos, com diferentes níveis de doença. O controle da brusone nas folhas foi de 26,8% considerando a severidade da doença nas cultivares e experimentos. As correlações entre médias de severidade da brusone nas folhas e nas panículas foram positivas e significativas em dois dos três experimentos. O controle da brusone nas panículas foi variável com os genótipos. A análise da regressão múltipla utilizando a severidade foliar e nas panículas como variáveis independentes, e produtividade, como variável dependente, mostrou que ambas contribuiram significativamente para a variação na produtividade. O tratamento de sementes aumentou significativamente a produtividade em um dos três experimentos em comparação à da testemunha.

INTRODUCTION

Rice blast caused by *Pyricularia grisea* (Cooke) Sacc. (Syn. *P. oryzae* Cav.) is the most destructive disease in upland rice mainly in west-central Brazil. Grain yield losses in the traditional upland rice cultivars have been shown to be significant (Frattini & Soave, 1972; Prabhu *et al.*, 1989). Cultivar resistance and fungicidal sprays are the two widely recommended control measures. The degree of resistance in the majority of upland rice cultivars is inadequate, and thus, the use of chemical control measures is inevitable. Even though there are no accurate estimates of yield losses in the improved rice cultivars, losses due to both leaf and panicle blast are still considered to be significant in both favorable and unfavorable upland ecosystems. This is due to the recent changes in cultural practices, such as closer spacing, high plant density and high levels of nitrogen fertilization.

Fungicides are applied primarily as a preventive measure against panicle blast (Toledo *et al.* 1976; Brignani *et al.* 1979; Tanaka & Souza, 1981; Prabhu & Morais, 1986). A single spray with a systemic fungicide has proven to be economically feasible in reducing yield losses due to panicle blast in upland rice (Prabhu *et al.*, 1990). Leaf blast has assumed economic importance due to successive plantings in extensive areas beginning in October with the onset of rains until the end of January. Successful in leaf blast control through foliar application of fungicides during the vegetative phase has been limited (Prabhu & Morais, 1986).

Seed treatment is an important tool for blast disease management. Several fungicides have been reported to reduce the seedborne inoculum in Brazil and elsewhere (Gonçalves & Terra, 1957; Ribeiro, 1978; Ou, 1985; Lasca *et al.*, 1987; Agrawal *et al.*, 1989). A large number of seed treatment fungicides for controlling leaf blast have been registered in Brazil. They also include systemic fungicides such as carboxin and thiabendazole (Kimati *et al.*, 1986). Newly labeled systemic fungicide pyroquilon has been shown to be successful in controlling leaf blast at the susceptible stage between 30 to 45 days after sowing due to its prolonged residual activity (Bandong *et al.*, 1979; Prabhu, 1985; Williams *et al.*, 1985; Guyer & Marjuddin, 1986; Nakamura, 1986; Loehken, 1990). Seed treatment with pyroquilon alone should be adequate to reduce yield losses if weather conditions after heading are not favorable for panicle blast incidence (Prabhu & Filippi, 1993).

In view of the promising results obtained by pyroquilon seed treatment in controlling leaf blast in upland rice, the scope of the investigation in the present study has been further extended to determine the effect of leaf blast control on panicle blast progress and the corresponding yield increase.

MATERIALS AND METHODS

Field plots

Three field experiments were conducted at the National Rice and Bean Research Center (CNPAF/EMBRAPA), Goiania, GO, during the 1988-89 rice growing seasons on different dates of planting to obtain varying disease levels. A split-plot design with six replications was used. Main plot treatments were four early maturing genotypes (115 days), including two traditional susceptible cultivars (IAC 165 and IAC 25), improved rice cultivar Guarani and an advanced line CNA 4136 (IAC 25 x 68-83). The subplots were seed treated with pyroquilon (4.0 g a.i./Kg seed) and untreated seed. Main plot treatments and subplot treatments within the main plots were randomized. Four 36 m^2 (6.0 x 6.0 m^2) main plots of each one of the four genotypes were established in the form of a square (144 m^2) per block. Each subplot consisted of 6 rows, 6.0 m long, with a space of 0.50 m between the rows. Three spreader rows with a mixture of susceptible cultivars (IAC 47, IAC 165 and IRAT 112) were sown on all four sides of the block 15 days before planting the experiment.

Plots were fertilized at the time of planting with 200 Kg/ha (5-30-15) of NPK+Zn in addition to 50 Kg/ha of N in the form of ammonium sulfate and 20 Kg/ha of zinc sulfate. Seeds were sown in plots on 10 November (Experiment I), 20 November (Experiment II) and 16 December, 1988 (Experiment III) at the rate of 40 Kg/ha. Weighed quantities of seed (500 g) were treated with fungicide as a slurry (4.0 g a.i./Kg seed) with 10 ml of water per Kg of seed in a 2 l capacity, round bottomed flask.

Disease and yield assessment

Leaf blast severity (LBS) was assessed in 15 randomly selected plants on 4 to 5 fully expanded superior leaves in the four central rows of each subplot. Disease evaluations were made 57, 41 and 40 days after sowing (d.a.s.) in the experiments I, II and III, respectively. Leaf blast was measured using the Horsfall-Barratt grading system (Horsfall & Barratt, 1945). The ratings were converted to percent disease severity (Berger, 1980).

Four half meter observational row units, one in each of the four central rows, were demarcated for panicle blast evaluation. All panicles in each one of the four observational row units were assessed using a six grade scale (0, 5, 25, 50, 75, 100% infected spikelets/panicle). The mean percentage of panicle blast severity (PBS) was calculated based on approximately 200 panicles per treatment. Serial observations were made at 3 to 4 day intervals 87, 90, 94, 97 and 101 (d.a.s.) in experiment I; 87, 91, 94, 98, 101 and 105 (d.a.s.) in experiment II and 90, 94, 97 and 101 (d.a.s.) in experiment III. The central 6.0 m^2 plot was harvested for grain yield (Kg/ha) and adjusted to 13% moisture.

Data analysis

Data from all experiments was analyzed using a standard analysis of variance (ANOVA) technique. Combined analysis of variance of the three experiments were performed for leaf and panicle blast, as well as grain yield data. The percentages of disease severity were transformed to arcsine to reduce the heterogeneity of variance before undergoing to analysis. Treatment mean comparisons were made using Tukey's test at the 0.05 probability level. The differences between plots of treated and untreated seeds for panicle blast as a result of leaf blast control were further verified based on disease progress curves. The percentages of disease severities were converted to logit of 'x' and plotted on time lines to estimate the infection rate according to Van Der Plank (1963). Slopes of the disease progress curves were compared for their significance between treatments using the t-test at the 0.05 probability level (Snedecor & Cochran, 1978).

RESULTS

Leaf blast

Genotype and seed treatment differences were significant for leaf blast, but the genotype x seed treatment interaction was not significant. Accordingly, the results are presented in the form of overall treatment effects (Tables 1 and 2). Averaged across genotypes and experiment, seed treatment significantly suppressed leaf blast by 26.8% (Table 1). The percentage control was relatively lower at higher disease severities in the experiments II and III, than in the experiment I under low disease severity. The genotype differences combining the data of plots of treated and untreated seed showed that the leaf blast severities in the cultivar Guarani and the line CNA 4136 were significantly lower than in traditional cultivars IAC 25 and IAC 165 (Table 2).

Panicle blast

The seed treatment differences were significant in two of the three experiments for panicle blast. However, the genotype x seed treatment was not significant at 101 d.a.s. in all experiments. Averaged across genotypes, pyroquilon seed treatment reduced panicle blast 101 d.a.s. by 25.5% and 23.9% in experiments I and III, respectively. Because of the

TABLE 1 - Effect of pyroquilon seed treatment on leaf blast severity.

Treatment	Leaf blast severity (%)[1]			
	Experiment I 57 d.a.s.[2]	Experiment II 41 d.a.s.	Experiment III 40 d.a.s.	Mean
Untreated	3.83 a[3]	6.73 a	21.32 a	10.63 a
Treated	1.82 b	4.45 b	17.07 b	7.78 b
Control (%)	52.5	33.9	19.9	26.8

[1] Mean leaf blast severity was based on four genotypes (IAC 165, IAC 25, CNA 4136, Guarani) and six replications.
[2] d.a.s. = days after sowing.
[3] Means followed by the same letter in a column do not differ significantly according to Tukey's test at the 0.05 probability level.

TABLE 2 - Mean leaf blast severity in plots of pyroquilon-treated and untreated seeds in four rice genotypes.

Genotype	Leaf blast severity (%)[1]			
	Experiment I 57 d.a.s.[2]	Experiment II 41 d.a.s.	Experiment III 40 d.a.s.	Mean
IAC 165	3.02 ab[3]	7.55 ab	22.91 a	11.16 a
IAC 25	6.77 a	9.13 a	24.91 a	13.60 a
CNA4136	0.82 b	2.92 b	14.28 b	6.00 b
Guarani	0.70 b	2.77 b	14.68 b	6.05 b

[1] Mean leaf blast severity of each cultivar in an experiment was based on six plots of treated seed and six plots of untreated seed totalling 12 plots.
[2] d.a.s. = days after sowing.
[3] Means followed by the same letter in a column do not differ significantly according to Tukey's test at the 0.05 probability level.

significant genotype x seed treatment interaction 94 d.a.s., the treatment effect by genotype is presented in Table 3. The seed treatment significantly reduced panicle blast in cultivars IAC 165, IAC 25 and line CNA 4136 at 94 d.a.s. only under high disease pressure in experiment III. Under low disease pressure the seed treatment reduced panicle blast only in cultivar IAC 25. The difference between plots of treated and untreated seeds was neither significant for cv. Guarani under low nor high disease severities. The panicle blast progress in plots of treated and untreated seeds by cultivars is shown in Fig. 1. Onset of panicle blast was consistently lower than in the untreated plots in all cultivars and experiments. However, the differences in slopes according to Student's t-test were not significant. While genotype differences for panicle blast were significant, genotype x seed treatment interaction was not, in disease assessment made 101 d.a.s. in experiments I and III. The cultivar Guarani had exhibited significantly lower disease severities compared to cultivars IAC 25 and IAC 165 (Table 4).

Grain yield

The treatment differences were significant whereas the genotype x treatment interaction was not for grain yield when the data of all three experiments were subjected to combined analysis of variance. Also, the yield differences among experiments were highly significant only in one of the three experiments. Pyroquilon seed treatment increased mean grain yield by 233 Kg/ha corresponding to 7.97%, however, this increment was not significant in experiments II and III (Table 5). Genotype differences were significant in all three experiments. Considering the averages of plots of treated and untreated seeds the improved cultivar Guarani and the line CNA 4136 consistently showed significantly higher yields compared to IAC 25 and IAC 165 (Table 6). Also, the average yield of Guarani was significantly superior than the rest of the genotypes including the advanced line CNA 4136.

Both mean leaf and panicle blast severities were negatively correlated to grain yield in all three experiments (Fig. 2). However, the correlation between leaf and panicle blast severities was positive and significant only in experiments I and III.

Linear multiple regression equations using leaf blast (x_1) and panicle blast (x_2) severities as independent variables and grain yield (y) as a dependent variable by experiment are as follows:

Experiment I. $Y = 4168.3-109.2LBS-59.5PBS$ ($R^2 = 0.518$)
Experiment II. $Y = 4138.6-91.7LBS-105.7PBS$ ($R^2 = 0.63$)
Experiment III. $Y = 4232.6-40.62LBS-25.5PBS$ (R2 = 0.397)

As it is evident from the R^2 values, both leaf and panicle blast contributed to a greater part of the variation in grain yield in all experiments.

TABLE 3 - Effect of pyroquilon seed treatment on panicle blast severity in four upland rice genotypes.

Genotype	Panicle blast severity (%)[1]					
	Experiment I		Experiment II		Experiment III	
	Untreated	Treated[2]	Untreated	Treated	Untreated	Treated
IAC 165	3.02	2.19	9.24	6.12	6.29	2.68*
IAC 25	7.77	3.90[3]*	4.05	3.14	10.72	2.72*
CNA 4136	3.44	2.00	3.78	5.45	8.15	3.60*
Guarani	2.07	1.75	2.81	2.23	1.75	1.66
Mean	4.07	2.46	4.97	4.23	6.72	2.66

[1] Panicle blast data was based on disease assessment made 94 days after sowing.
[2] Seeds were treated with pyroquilon fungicide at the rate of 4.0 g a.i/kg seed.
[3] Means followed by the asterisk differ significantly from the untreated plots according to Tukey's test at the 0.05 probability level.

TABLE 4 - Mean panicle blast severities of plots of pyroquilon-treated and untreated seed in four rice genotypes.

Genotype	Panicle blast severities (%)[1]		
	Experiment I	Experiment II	Experiment III
IAC 165	17.71 a[2]	33.50 a	29.39 a
IAC 25	17.05 a[3]	22.35 a	24.05 a
CNA4136	10.18 b	27.20 a	23.06 ab
Guarani	6.06 b	19.92 a	14.33 b

[1] Mean panicle blast severity of each cultivar in an experiment was based on six plots of treated seed and six plots of untreated seed totalling 12 plots.
[2] Means were based on assessment made 101 days after sowing.
[3] Means followed by the same letter in a column do not differ significantly according to Tukey's test at the 0.05 probability level.

TABLE 5 - Effect of pyroquilon seed treatment on grain yield.

Treatment	Grain yield (kg/ha)[1]			
	Experiment I	Experiment II	Experiment III	Mean
Untreated	2949 a[2]	3041 a	2776 a	2922 a
Treated	3252 b	3235 a	2977 a	3155 b

[1] Grain yield averaged across genotypes (IAC 165, IAC 25, CNA 4136, Guarani) and six replications.
[2] Means followed by the same letter in a column do not differ significantly according to Tukey's test at the 0.05 probability level.

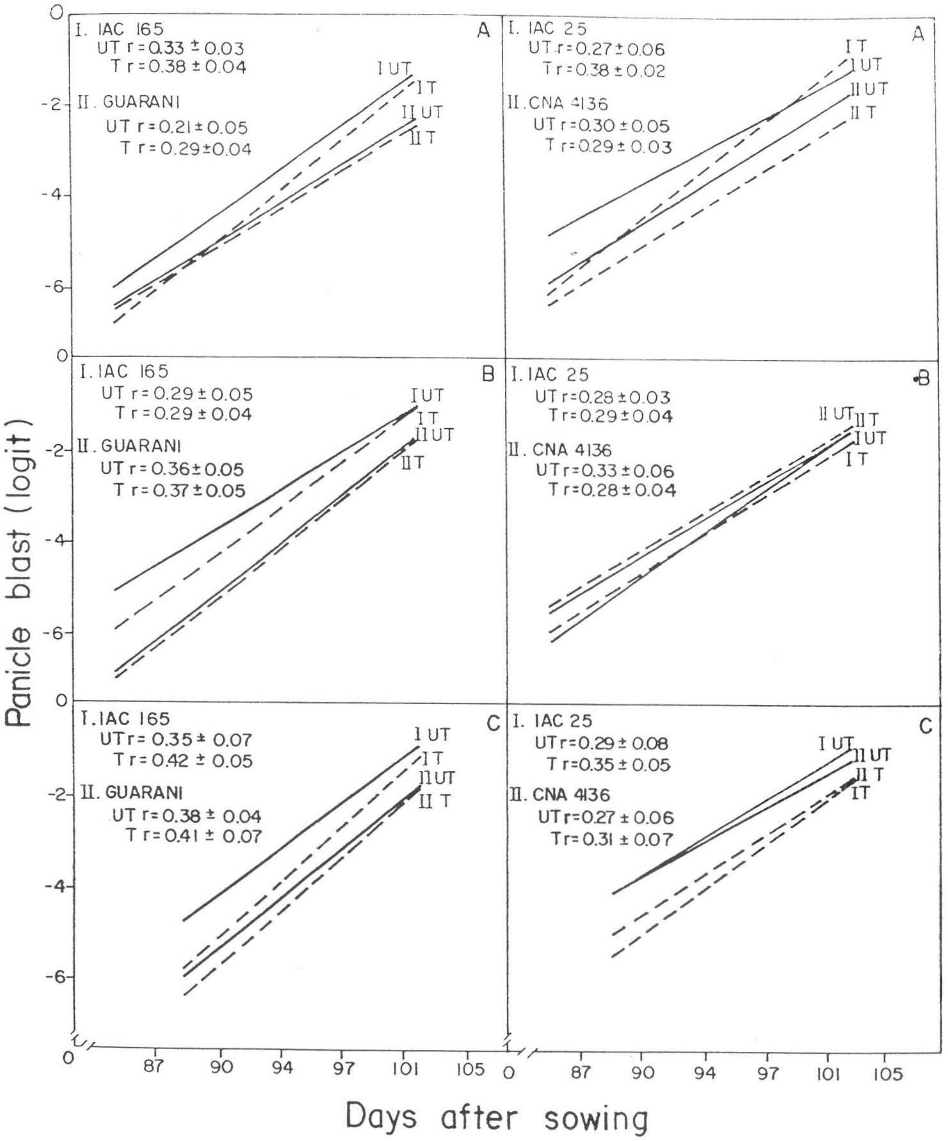

FIG. 1 - Progress of panicle blast in seed treated (T) and untreated (UT) plots in four rice cultivars. Seed were treated with fungicide pyroquilon at the rate of 4.0 g a.i./ha. Panicle blast severities were transformed to logit of x; r = the apparent infection rate standard error; A = Experiment I; B = Experiment II; C = Experiment III.

TABLE 6 - Mean grain yield of plots of pyroquilon-treated and untreated seed in four rice genotypes.

Genotype	Grain yield (kg/ha)[1]			
	Experiment I	Experiment II	Experiment III	Means
IAC 165	2417 a[2]	2397 a	2499 a	2438 a
IAC 25	2253 a	2973 ab	2739 ab	2655 a
CNA4136	3618 b	3359 bc	2971 ab	3316 b
Guarani	4115 b	3823 c	3298 c	3745 c

[1] Grain yield data was based on averages of plots of treated and untreated seed and six replications.
[2] Means followed by the same letter in a column do not differ significantly according to Tukey's test at the 0.05 probability level.

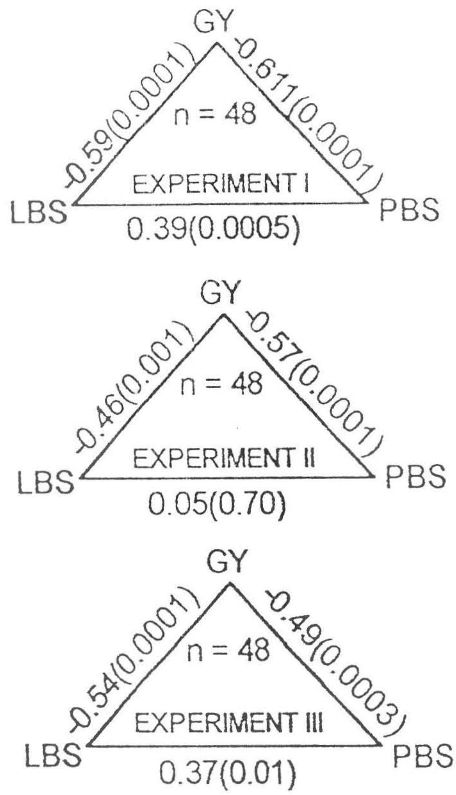

FIG 2 - Correlation between yield (GY) and mean leaf blast (LBS) and panicle blast (PBS) severities (Experimentes I, II, III). The values in parenthesis following correlation coefficients indicate the probability level.

DISCUSSION

Pyroquilon seed treatment effectively suppressed leaf blast in all experiments both under low as well as high disease severity (Table 1). These results confirm the earlier reports of its efficiency in controlling leaf blast (Bandong *et al.*, 1979; Prabhu, 1985; Prabhu & Filippi, 1993; Williams *et al.*, 1985; Guyer & Marjuddin, 1986; Nakamura, 1986; Loehken, 1990). Results in the present study have further shown that the percentage of leaf blast control is inversely proportional to the disease severity in untreated plots. The leaf blast severity in the experiment I at 57 d.a.s. was seven times less than the disease severity in experiment III at 40 d.a.s.. The difference could have been much larger if the assessment had been made at 40 d.a.s. in experiment I. The prolonged residual effect of fungicide was evident under low disease severity. The protection of plants after 60 d.a.s. is unimportant because of the age related resistance. The increased resistance of rice with age has been demonstrated by several investigators (Anderson *et al.*, 1947; Kahn & Libby, 1958; Barksdale, 1967; Prabhu & Zimmermann, 1985; Koh *et al.*, 1987; Bonman *et al.*, 1989; Roumen *et al.*, 1992).

Under high disease severity in the field, seed treatment controlled leaf blast by 20% up to 40 d.a.s. when disease severities were averaged across cultivars. In earlier studies conducted with IAC-47, IAC-25, IAC-164 and L-50, seed treatment resulted in 39% control at 42 d.a.s. under approximately similar mean leaf blast severities in the untreated field plots (Prabhu & Filippi, 1993). However, in the uniform blast nursery experiment, the pyroquilon seed treatment reduced diseased leaf area from 94% to 15% and from 100% to 30% in cvs. IAC-25 and IAC-47, respectively, at 38 d.a.s. The different levels of control obtained in the present and previous investigations showed that the fungicide efficiency in controlling leaf blast depends on the degree of host-plant resistance and the rate at which the disease develops. The lack of statistically significant cultivar x seed treatment interaction for leaf blast did not allow for the study of effective treatment by cultivar. The leaf blast was suppressed uniformly in all cultivars, indicating that the differences in the degree of resistance in the test genotypes was not adequate to be detected by the ANOVA using observations made on the same date. The analysis of disease progress curves of plots of treated and untreated seeds may be required to precisely determine the small differences in the degree of resistance of cultivars and its contribution in increasing the efficiency of seed treatment. The delay in the onset of disease in susceptible cultivars has important significance in reducing yield losses due to leaf blast (Prabhu & Filippi, 1993). The mean leaf blast severities of untreated and treated plots showed that Guarani and line CNA 4136 significantly had lower disease levels than cvs. IAC-25 and IAC-165 but the level of resistance possibly may not be adequate to avoid the seed treatment.

There is adequate evidence with reference to the extent to which the protection of plants at the vegetative phase by pyroquilon seed treatment reduce the panicle blast severity. The results showed significant decrease in the panicle blast in three genotypes of experiment III under high disease severity with varying leaf blast severities. Even though the correlations between mean leaf and panicle blast severities in plots were significant, they were low possibly due to the different degrees of cultivar susceptibility and interplot interference. The correlation is expected to be higher in large size plots without interplot interference. The panicle blast control resulting from the reduced leaf blast severity in this study appears to be subestimated. However, the results are closer to the real situation in farmers' fields where there is a continuous flow of inoculum arriving from earlier plantings in the same or neighboring farms. The insignificant difference between plots of treated and untreated seeds of Guarani both under high and low disease severities could be attributed to the degree of cultivar resistance to panicle blast. These results are applicable only to the disease levels obtained in these experiments. Detailed investigations are necessary to determine the level of leaf blast control required to obtain the significant reduction in panicle blast severities and grain yield increase.

The results in the present study further showed grain yield increase due to leaf blast control in one of the three experiments. The lack of yield response to blast in experiments II and III could be due to high terminal (101 d.a.s.) panicle blast severities and interplot interference. The present investigation in relation to the effect of seed treatment on grain yield was made possible due to absence of other diseases during the year under study. Besides, drought did not interfere with the results as is evident from the grain yields ranging from 2,400 to 3,700 Kg/ha. The use of early maturing rice genotypes has possibly facilitated the disease escape from the commonly occurring dry spells "veranicos" in the later plantings. Multiple regression analysis showed the contribution of both leaf and panicle blast in explaining the variation in grain yield. The negative and significant correlation coefficients of yield to leaf and panicle blast further confirm the disease's effect on yield. The degree of control required to obtain the maximum yield depends upon the level of cultivar resistance but the lack of significant genotype x seed treatment interaction did not permit the determination of yield increase by genotype. However, the protection of panicle by fungicide spray may offer additional control resulting in a greater yield increase besides the seed treatment.

The role of seed borne inoculum in the upland rice is not well defined. It is not an important source of primary inoculum compared to the wind borne inoculum or the inoculum from the infected debris of the previous rice crop (Prabhu & Morais, 1986). The epidemic may be initiated from the seed borne inoculum only in some situations where planting is followed by continuous rains. The fallen seeds on the ground surface germinate and produce sporulating lesions (Agrawal *et al.*, 1989). In the upland rice it is important to protect the crop at the vegetative phase against the incoming inoculum from the neighboring fields.

Leaf blast control is a major concern because the diseased plants produce less dry matter than the healthy ones (Prabhu & Filippi, 1993). The root system of the affected plants can be very small and, as a result, absorb and utilize nutrients less efficiently and also become more sensitive to drought. High disease levels accelerate senescence and might contribute to yield decrease. However, in the present study the data on senescence was not available to provide evidence for the increase in yields due to delayed senescence as a result of seed treatment and require further investigation.

Integration of seed treatment with cultural practices which reduce the initial inoculum such as crop rotation and further disease development, could provide an effective means of leaf blast control.

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