GENETIC VARIABILITY FOR DISEASE RESISTANCE IN BRAZILIAN UPLAND RICE NATIVE GERMPLASM[1]

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ABSTRACT - Thirty nine rice genotypes were evaluated under dryland field conditions for resistance to leaf and neck blast, brown spot, leaf scald, narrow brown leaf spot and grain discoloration in 13 test sites during a three-year period. These include 17 land races, six traditional cultivars, 11 improved breeding lines and three exotic cultivars. There was a great diversity in the native germplasm in relation to resistance to different pathogens. The land races Iguapé Redondo, Arroz de Guerra, Cateto and Chatão exhibited partial resistance to leaf blast comparable to IRAT 13 and IRAT 104 and superior to the traditional cultivar IAC 47. The leaf blast severities and neck blast incidences of medium maturing genotypes were positively correlated ($r = 0.86$, $P < 0.01$). A number of genotypes exhibited a high degree of resistance to grain discoloration relative to the susceptible controls, Vermelho miudo, Mimoso and Cajueiro Liso. The correlation between mean brown leaf spot and mean grain discoloration severities of different trials was positive both for early maturing ($r = 0.93$, $P < 0.01$) and medium maturing ($r = 0.77$, $P < 0.01$) genotypes. The early maturing improved line M 39 had shown a high level of multiple disease resistance. The localities Goiânia (GO) and Jaciara (MT) were identified as hot spot screening sites for rice blast and grain discoloration, respectively.

Index terms: *Pyricularia grisea, Pyricularia oryzae, Drechslera oryzae, Gerlachia oryzae, Cercospora oryzae*, genetic diversity, partial resistance.

VARIABILIDADE GENÉTICA QUANTO A RESISTÊNCIA A ENFERMIDADES EM GERMOPLASMA NATIVO DE ARROZ DE SEQUEIRO NO BRASIL

RESUMO - Foram avaliados trinta e nove genótipos de arroz em condições de sequeiro, no campo, quanto à resistência à brusone nas folhas e panículas, mancha-parda, escaldadura das folhas, mancha-estreita e mancha nos grãos, em treze diferentes locais e três anos nas condições de sequeiro. Estes incluem dezessete genótipos nativos, seis cultivares tradicionais, onze linhagens melhoradas e três cultivares introduzidas. Houve grande diversidade em germoplasma nativo em relação a resistência a diferentes patógenos. Os genótipos nativos, como: Iguape Redondo, Arroz de Guerra, Cateto, e Chatão, apresentaram resistência parcial à brusone nas folhas, em comparação com as cultivares IRAT 13 e IRAT 104, e foram superiores à cultivar tradicional IAC 47. As severidades médias de brusone nas folhas, dos genótipos de ciclo médio, foram correlacionadas positivamente com as severidades médias de brusone no pescoço das panículas ($r = 0{,}86$, $P < 0{,}01$). Um grande número de genótipos mostrou maior grau de resistência à mancha-nos-grãos, do que as testemunhas Vermelho Miudo, Mimoso e Cajueiro Liso. A correlação entre severidades médias de mancha-parda nas folhas e manchas nos grãos foi positiva e significativa, tanto nos genótipos de ciclo precoce ($r = 0{,}93$, $P < 0{,}01$) como nos de ciclo médio ($r = 0{,}77$, $P < 0{,}01$). A linhagem melhorada de ciclo precoce M 39 apresentou alto nível de resistência múltipla às doenças. Os locais Goiânia (GO) e Jaciara (MT) foram mais indicados para avaliação de material genético quanto à brusone e manchas nos grãos, respectivamente.

Termos para indexação: *Pyricularia grisea, Pyricularia oryzae, Drechslera oryzae, Gerlachia oryzae, Cercospora oryzae*, diversidade genética, resistência parcial.

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INTRODUCTION

Upland rice is annually planted in approximately 2.9 million hectares out of a total 4.5 million hectares of rice growing area in Brazil. More than 45% of it is concentrated in savannas of West-Central Brazil. The average yields are as low as 1.4 t/ha due to poor management practices, drought and diseases.

The major rice diseases that limit the grain yield and quality in upland rice are blast [*Pyricularia grisea* (Cooke) Sacc.], brown spot [*Drechslera oryzae* (Breda de Haan) Subramaniam & P.C. Jain] leaf scald [*Microdochium oryzae* (Hashioka & Yokogi) Samuels and Hallett], narrow brown leaf spot [*Cercospora janseana* (Racib.) O. Const.] and grain discoloration mainly caused by *Phoma sorghina* (Sacc.), Boerema, Dorenbosch & Van Kesteren; *Alternaria padwickii* (Ganguly) Ellis, *D. oryzae, M. oryzae, Drechslera* spp., *Curvularia* spp., *Nigrospora* spp. etc.

Breeding for disease resistance is the most economical mean of controlling diseases under upland condition. Search for sources of resistance in the existing or old local germplasm collection is the basic requirement for breeding disease resistant plants. Land races are not very susceptible to common diseases in the region because very susceptible plants are eliminated both by natural and artificial selection (Russel, 1978). The crops are becoming steadily more uniform as old land races are replaced by modern cultivars (Harlan, 1976). There has been a rapid decline in the genetic variability in the improved rice cultivars (Cuevas-Perez et al., 1992).

In Brazil, the introduction of germplasm and breeding upland rice cultivars only began in 1937 (Banzatto & Carmona, 1971). In the first decade of this century native germplasm was grown both in lowland and upland. The land races Cateto and Jaguari for upland and Dourado Agulha and Iguape Agulha for irrigated conditions were commonly cultivated in the state of São Paulo. A small seed sample with accession number 55 obtained from the Genetics Department of Minas Gerais State named as Perola replaced Jaguari (Viegas et al., 1945). Later, a selection from this, named Pratão possessing consumer preferred grain quality was released. All the earlier releases were derived from local types well adapted to the soil and climatic conditions of São Paulo State. Subsequently, crosses were made between the local cultivars and introduced ones such as Nira, Yola, Matão, Fortuna, Dourado Peludo etc, from other centers. A series of cultivars from these crosses denominated IAC 1 to IAC 9 were released by the Agronomic Research Institute (IAC) in Campinas (Germek & Banzatto, 1972). The most popular upland rice cultivar IAC 1246 derived from a cross between Perola and Pratão was tolerant to drought and blast. According to Banzatto & Carmona (1971), it occupied 60% of the upland rice in São Paulo and widely cultivated in other upland rice growing states. Later, the medium maturing cultivar IAC 47 (IAC 1246/IAC 1391), replaced IAC 1246 due to higher yield potential in 1973. Early maturing cultivars IAC 25 and IAC 165 (Dourado Precoce/IAC 1246) were released for cultivation in 1974 and 1976, respectively. They were grown for over a decade in all upland rice growing regions in Brazil. The cultivars Cuiabana (IAC 47/SR 2041-50-1) and Araguaia (IAC 47/TOS 2578/7-4-2-3-B2) with moderate and high degree of blast resistance, respectively, developed by the National Rice and Bean Research Center (CNPAF/EMBRAPA) in collaboration with other State Research Organizations, in 1984 replaced IAC 47. They were followed by the release of Rio Paranaíba (IAC 47/63-83) and Guarani (IAC 25/63-83) with moderate levels of partial resistance to blast.

An unimportant disease in the past such as glume blight has assumed economic importance with the release of improved rice cultivars (Prabhu & Bedendo, 1988). So far, a limited success has been obtained in breeding for multiple disease resistance.

A preliminary characterization of native germplasm collection in Brazil had exhibited wide diversity to disease resistance (Fonseca et al., 1981). Varietal screening for glume blight has revealed promising sources of resistance in the native germplasm (Souza & Zambolim, 1987). Screening germplasm in the greenhouse for leaf scald showed the existence of diverse sources of resistance in the old primitive cultivars (Faria & Prabhu, 1980; Prabhu & Bedendo, 1991). Several of these sources of resistance are important as parents in crosses to substitute the use of introduced indica rice cultivars because of undesirable agronomic characteristics and infertility problems. The native germplasm that was subjected to long-term natural selection process is valuable for resistance breeding (Dinoor & Eshed, 1984).

The primary concern of plant pathologists is to assemble and conserve the resistant genotypes from which the superior upland rice cultivars were developed. There is very little information on the field performance of land races in a wide range of soil and climatic conditions in relation to the disease resistance. The major objective of this study was to identify land races possessing a single or multiple disease resistance and to select hot spot screening sites for major rice diseases.

MATERIALS AND METHODS

The materials utilized were part of a field trial in which 100 genotypes were tested to study the occurrence and disease severity in seven to eight locations per year during three consecutive years (1983-86). Fifty each of the early and late maturing genotypes were planted in two blocks separated by a distance of 5 to 10 m. Ten cultivars resistant and susceptible to different diseases were included on either side and center of the block as controls. The medium maturing genotypes including 14 land races, five traditional improved cultivars, four advanced breeding lines and two exotic upland rice varieties totalling 25 and early maturing genotypes consisting of six land races, seven traditional improved lines and one exotic introduced cultivar totalling 14 were selected for the analysis in the present study. These entries were common in two or more sites during a three-year period.

Each genotype was planted in a single 5.0 m long row. The dates of planting (October-December), fertilizer dosage (200 kg/ha of NPK), spacing (40 to 50 cm) and plant density (70 to 80 seeds per m/linear) and other locally recommended practices were employed in each location.

Leaf blast was assessed 40 to 60 days after planting on four superior leaves of five randomly selected tillers totalling 20 leaves per genotype. A 10-grade visual rating scale (0; 0.5; 1.0; 2.0; 4.0; 8.0; 16.0; 32; 64; 82% of leaf area affected) according to Notteghem (1981) was utilized.

The evaluation of leaf scald was made at the boot leaf stages (80 to 90 days after sowing) on four superior fully opened leaves of five tillers utilizing a four-grade scale (0 = no symptoms; 1 = 1-5%; 2 = 6-25%, 3 = > 25% leaf area affected).

Observations on brown spot and narrow brown leaf spot were made between soft dough and semi mature stages on three superior leaves, using a four-grade scale developed on the basis of number of lesions/leaf (0 = no symptoms; 1 = 1-20; 2 = 21-40; 3 = > 40 lesions/leaf). The mean disease ratings were calculated based on fifteen leaves per genotype.

The neck blast percentage was based on 50 randomly selected panicles per genotype. The grain discoloration was expressed as percentage of discolored grains assessed using a disease rating scale of five grades (1 = < 5%, 2 = 6-25%, 3 = 26-50%; 4 = 51-75%, 5 = 76-100% of spotted grains). The mean disease was based on a sample of ten panicles per genotype. Both neck blast and grain discoloration was evaluated at the semi-mature grain filling stage.

The standard analysis of variance procedure (ANOVA) was made using location, year and cultivar as sources of variation. The combined analysis of variance maintaining the same genotypes for all experiments was performed. Each experiment corresponded to one trial executed at each location in a given year but not all combinations (location x year) were always available. The means were separated by Ryan - Einot - Gabriel - Welsch Multiple F test (REGWF).

RESULTS AND DISCUSSION

A combined analysis of variance of disease ratings, for both medium and early maturing genotypes are presented in Table 1. Differences among years, locations and cultivars were significant for all diseases. Also, the interaction location x year was significant for both early and medium maturing sets.

Rice blast - Differences among medium maturing genotypes are evident for mean leaf blast severities (Table 2). The native genotypes Chatão, Arroz de Guerra, IAC 1246, Iguape Redondo, Cateto and Nenem did not differ significantly from either IRAT 13 and IRAT 104 utilized as controls for partial resistance as well as the improved breeding lines CNA 104 and CNA 108. Cultivar IRAT 13 was known to have a high level of partial resistance to rice blast (Notteghem & Andriatompo, 1977; Villareal et al., 1980). The partial resistance nature of IRAT 13, IRAT 104 and Arroz de Guerra was determined in previous studies under controlled greenhouse conditions by challenging with a virulent race of *P. grisea* (Prabhu, 1989). The mean low leaf blast severities of the above land races, in 17 different tests under field conditions, indicate the level of partial resistance comparable to IRAT 13 and IRAT 104. The term partial resistance is used in the present study for the genotypes showing susceptible lesion type but relatively low disease severities as synonymous to field resistance without any genetic connotation. Even though the improved breed-

TABLE 1. Combined analysis of variance for disease ratings of genotypes in the field tests conducted during three years.

Source	Leaf blast		Neck blast		Brown spot		Leaf scald		Narrow brown leaf spot		Grain discoloration	
	df	MS	df	MS	df	MS	df	MS	df	MS	df	MS
Medium maturing cultivars												
Location	4	434.94***[1]	7	10599.52***	11	4.79***	4	15.72***	7	11.0***	3	27.71***
Year	2	152.60**	2	7548.06***	2	12.13***	2	6.85***	2	2.79***	2	6.94***
Genotype	24	98.52***	24	868.95***	24	0.28***	24	0.28***	24	0.46***	24	1.57***
Location x Year[2]	4	706.26***	5	2864.74***	3	11.13***	4	2.31**	-[3]	-	4	12.63***
Location x Genotype	96	21.54ns	168	223.93**	264	0.13**	96	0.12ns	-	-	72	0.31ns
Year x Genotype	49	12.85ns	48	183.18ns	48	0.16**	48	0.09ns	48	0.17*	48	0.19ns
Early maturing cultivars												
Location	5	194.27***	7	6145.06***	11	4.47***	4	4.82***	8	1.67***	3	11.42***
Year	2	4.45**	2	3527.55***	2	3.03***	2	4.71***	2	3.36***	2	1.42*
Genotype	13	113.01***	13	639.90**	13	0.76***	13	0.10ns	13	1.22**	13	4.40***
Location x Year	6	188.97***	5	4754.03***	4	4.81***	4	3.91***	-	-	4	4.80***
Location x Genotype	65	14.29ns	91	387.29*	143	0.14*	52	0.10ns	-	-	39	0.44ns
Year x Genotype	26	7.44ns	26	459.05*	26	0.13ns	26	0.08ns	26	0.08ns	26	0.39ns

[1] Level of significance according to F test (*** = P<0.001; ** P = P<0.01; x P = <0.05; ns = non-significant).
[2] Not all location x year combinations were present.
[3] The number of combinations was not sufficient to account for the estimate.

TABLE 2. Mean disease ratings of medium maturing genotypes in field tests at different locations during three years.

Cultivar/Line	Accession number (Germplasm bank--CNPAF)	Leaf blast (%) [1]n=11	Neck blast (%) n=15	Brown spot (score) n=17	Leaf scald (score) n=11	Narrow brown leaf spot (score) (n=10)	Grain discoloration (score) (n=10)
Vermelho miúdo*[2]	CNA 6609	11.6 a[3]	44.2 a	1.2 a	0.8 abcde	0.6 abcdef	3.7 a
Campineiro* (PR)	CNA 6553	10.6 ab	36.4 ab	0.9 abcdef	0.9 abc	0.7 abc	2.3 b
Maranhão Vermelho*	CNA 6586	9.7 abc	25.5 bcdefg	1.1 ab	0.9 abcd	0.3 def	2.4 b
IPEACO 562*	CNA 1436	7.0 bcd	24.5 bcdefg	0.9 abcdef	0.8 abcdef	0.7 abc	2.4 b
Fernandes*	CNA 6558	6.3 cde	21.0 cdef	0.9 abcdef	0.7 bcdefg	0.8 a	2.3 b
IAC 76-49**	CNA 6567	6.3 cde	21.1 bcdefg	0.9 abcdef	0.6 efg	0.8 ab	2.3 b
IAC 47**	CNA 2023	6.1 cdef	28.6 bcd	0.9 abcdef	0.6 cdefg	0.5 abcdef	2.2 b
Silvanot* (MG)	CNA 6603	6.1 cdef	22.7 bcdefg	1.0 abcde	0.7 bcdefg	0.7 abcd	1.9 b
IAC 5544**	CNA 6565	6.1 cdefg	26.0 bcdef	1.0 abcde	0.8 abcdefg	0.6 abcdef	2.4 b
Guatambo* (MG)	CNA 6560	5.8 cdefgh	16.3 defgh	0.9 abcdef	0.6 cdefg	0.3 def	2.8 b
Corte (SP)	CNA 6539	5.5 cdefgh	32.5 abc	0.8 bcdef	1.0 ab	0.3 cdef	2.6 b
Perola*	CNA 6595	4.9 cdefghi	21.0 cdef	1.0 abc	0.7 bcdefg	0.8 ab	2.3 b
Montanha Liso*	CNA 2459	4.6 cdefghi	28.4 bcde	0.9 abcdef	0.8 abcdef	0.6 abcdef	2.4 b
Chatão (AM)	CNA 6543	4.5 cdefghijk	26.3 bcdef	0.8 bcdef	0.5 defg	0.3 f	2.6 b
Arroz de Guerra* (CE)	CNA 6530	3.5 defghijk	17.9 cdef	0.8 bcdef	0.7 bcdefg	0.4 abcdef	2.2 b
IAC 1246**	CNA 6561	3.4 defghijk	23.5 bcdefg	1.0 abcd	0.7 bcdefg	0.9 a	2.5 b
Iguape Redondo* (GO)	CNA 6569	3.7 defghijk	14.7 efgh	0.8 bcdef	0.5 efg	0.3 f	2.1 b
Cateto* (PR)	CNA 6547	3.0 defghijk	22.8 bcdefg	0.7 cdef	0.7 bcdef	0.7 abcde	2.1 b
Nenem*	CNA 6593	2.8 efghijk	23.3 bcdefg	1.0 abcde	1.0 a	0.5 abcdef	2.7 b
IRAT 13***	CNA 1462	2.6 fghijk	20.8 cdef	0.7 def	0.6 efg	0.3 ef	2.5 b
CNA 104-B-34-2****	CNA 4749	1.9 ghijk	25.8 def	0.8 bcdef	0.8 abcdef	0.5 abcdef	2.7 b
CNA 108-B-42-10-2B****	CNA 6536	1.3 hijk	16.5 cdef	0.8 bcdef	0.5 fg	0.3 f	2.3 b
IRAT 104***	-	0.9 ijk	13.3 gh	0.8 bcdef	0.5 fg	0.3 f	2.5 b
CNA 104-B-2-43-2****	CNA 4748	0.6 jk	13.7 fgh	0.7 ef	0.7 bcdefg	0.3 bcdef	2.2 b
CNA 108-B-28-11****	CNA 4115	0.3 k	10.7 gh	0.6 f	0.5 fg	0.5 abcdef	2.1 b

[1] n = number of field tests including years and locations.

[2] Asteriscs following genotype refer to: * = land race; ** = traditional cultivar developed from land race; *** = introduced cultivar with partial resistance to blast (check); **** = advanced improved breeding lines.

[3] Means followed by the same letter in a column do not differ significantly according to Rayn - Einot - Gabriel - Welsch (REGWF) multiple F-test at the 0.05 probability.

ing lines showed low mean leaf blast severities they exhibited complete race-specific resistance in few test sites indicating that they are not comparable with the land races and IRAT 13 which exhibited susceptible lesion types in all tests. The superior performance of IAC 1246 over IAC 47 has shown the possible erosion of partial resistance of the latter to leaf blast in the breeding process.

Among the early maturing genotypes, the improved lines 79-233, CNA 095-BM-30-BM 9-10, L 43, L 80-63 and M 39 developed using native germplasm as their parents were superior to the widely used land race Dourado Precoce (Table 3). The reported high level of partial resistance of Dourado Precoce in tests conducted at three locations in Philippines using three isolates of *P. grisea* (Villareal et al., 1980) was not supported by field studies performed in Goiânia. The land race Dourado Precoce showed low level of partial resistance as indicated by high apparent infection rate and disease gradients (Prabhu & Bedendo, 1991). They showed that the determination of level of partial resistance in the cultivars, utilizing apparent infection rate as an assessment criterion, is applicable to the location and the region in which tests were performed. The relatively low level of disease resistance of Dourado Precoce obtained in 19 field tests confirms the earlier observations on horizontal resistance (Prabhu & Bedendo, 1991). The high degree of resistance exhibited by Salumpikiti cannot be considered as a control for partial resistance due to the absence of matching races of *P. grisea* in some test sites. The results in the present study, however, do not provide adequate evidence for the non-race specific nature of partial resistance.

A wide range of variation in susceptibility among the genotypes, in relation to neck blast was observed (Tables 1 and 2). The average neck blast incidence of land races Fernandes, Perola and Arroz de Guerra did not differ significantly from the partial resistance control IRAT 13. The advanced lines showed relatively higher degree of resistance comparable to IRAT 104 among the medium maturing cultivars. It is evident from Fig. 1 that the relationship between mean leaf blast severities and neck blast incidences of medium maturing genotypes was linear and posi-

TABLE 3. Mean disease ratings of early maturing genotypes in field tests at different locations during three years.

Cultivar/line	Accession number (Germplasm bank-CNPAF)	Leaf blast (%) [1]n=14	Neck blast (%) n=15	Brown spot (score) n=18	Leaf scald (score) n=11	Narrow brown leaf spot (score) n=11	Grain discoloration (score) n=10
Mimoso*[2] (PI)	CNA 6589	10.7 a[3]	35.7 ab	1.4 a	0.6 a	0.3 abc	3.7 a
Cajueiro Liso* (MG)	CNA 6555	8.5 ab	41.5 a	1.3 ab	0.6 a	0.4 abc	3.7 a
Limeira* (CE)	CNA 6580	5.5 bc	28.7 ab	0.9 cde	0.6 a	0.6 abc	2.5 bc
Dourado Precoce* (GO)	CNA 1012	5.0 cd	23.1 ab	1.0 cde	0.6 a	0.6 ab	1.9 c
Batatais*	CNA 6534	4.5 cd	32.6 ab	0.9 cde	0.7 a	0.6 abc	2.3 bc
CNA 762260**	CNA 4124	4.4 cd	27.5 ab	0.9 cde	0.6 a	0.7 a	2.1 bc
CNA 092-BM-11-BM-19-P2**	CNA 4135	4.3 cde	26.7 ab	0.9 de	0.8 a	0.4 abc	2.1 bc
Barbalho* (CE)	CNA 6533	3.9 cde	31.2 ab	0.8 de	0.6 a	0.2 c	2.5 bc
79-233**	CNA 6614	3.7 cdef	26.5 ab	0.8 de	0.6 a	0.3 bc	2.2 bc
CNA 095-BM-30-BM9-10**	CNA 1211	2.6 cdef	23.5 ab	0.9 cde	0.6 a	0.3 abc	2.0 c
L 43**	CNA 6582	2.0 cdef	28.4 ab	1.2 abc	0.7 a	0.6 ab	2.6 bc
L 80-63**	CNA 6585	1.5 cdef	27.6 ab	0.9 cde	0.7 a	0.5 abc	2.8 b
M 39****	CNA 6592	1.4 ef	13.1 b	0.7 e	0.4 a	0.3 abc	2.3 bc
Salumpikit***	CNA 6600	0.3 f	25.2 ab	1.2 bcd	0.5 a	0.3 bc	2.6 bc

[1] n = number of field tests including years and locations.

[2] Asteriscs following genotype refer to: * = land race; ** = traditional cultivar/line developed from land race; *** = introduced cultivar with partial resistance to blast (check); **** = mutant of IAC 25.

[3] Means followed by the same letter in a column do not differ significantly according to Rayn - Einot - Gabriel - Welsch (REGWF) multiple F-test at the 0.05 probability.

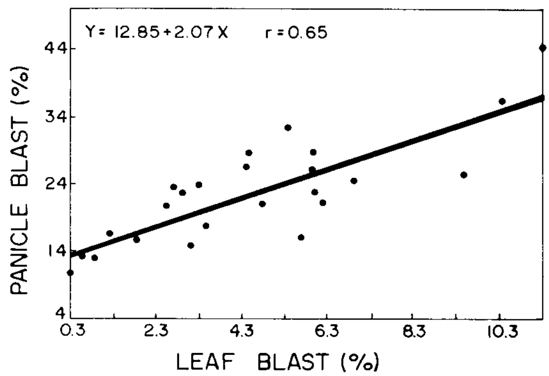

FIG. 1. Relationship between mean leaf blast severity and neck blast incidence in 25 medium maturing upland rice genotypes, under field conditions. (Mean disease of each one of the genotype was based on 15 field trials).

tive (r = 0.86, P < 0.01). In general, the lines showing susceptible lesion type on leaves, superior to 4 in a 0-9 scale, showed positive correlation between leaf and panicle blast severities (Ahn & Rubiano, 1984; Prabhu & Ferreira, 1991). In the present study, the land race Iguape Redondo, the partial resistance controls IRAT 13, and IRAT 104 showed high level of both leaf and neck blast resistance. The slow disease progress of both leaf and neck blast indicating the partial resistance nature was determined for Iguape Redondo and IRAT 13 in the absence of allo--infection in large 400 to 900 m^2 plots (Prabhu & Ferreira, 1991). The neck blast resistance of other genotypes and advanced lines can be compared relative to Iguape Redondo and IRAT 13 as control. There are, however, few exceptions to this general rule (Koh et al., 1987; Bonman et al., 1989). The land race Guatambu which showed susceptible reaction to leaf blast was relatively resistant to neck blast, whereas IAC 1246 which was classified as resistant to leaf blast exhibited neck blast susceptibility. These results are in accord with the previous studies of Bonman et al. (1989) that the relative levels of leaf and neck blast resistance differ in certain cultivars. Similar results were obtained with respect to the early maturing genotypes. The improved line M 39 showed both leaf and neck blast resistance (Table 2).

Brown spot - Significant differences in varietal diversity for brown spot was also observed but the magnitude of differences was not as wide as for leaf blast (Tables 1 and 2). The land races Vermelho Miúdo among the medium maturing genotypes, Mimoso and Cajueiro Liso among the early maturing ones showed high degree of susceptibility. Some of the land races which exhibited a high degree of partial resistance to leaf blast such as Arroz de Guerra, Iguape Redondo, Cateto and M 39 had relatively low brown spot ratings on leaves. The low brown spot disease rating of Chatão confirmed the earlier studies conducted under heavy disease pressure in Bragança (EMBRAPA, 1984). In general, the reduction in grain weight was related to the grain infection rather than brown spot severity on leaves (Prabhu et al., 1980).

Leaf scald - The differences were significant only for medium maturing genotypes in relation to leaf scald (Table 1). The relatively low disease severities were shown by IAC 47, Guatambu, Chatão, Iguape Redondo, IRAT 13 and IRAT 104. The advanced lines of CNA 108 had lower ratings than the sister lines of CNA 104.

Even though, the early maturing line M 39 did not differ statistically from the rest of the genotypes, it had shown low mean disease rating, confirming the results of artificial inoculation tests in the greenhouse (Prabhu & Bedendo, 1982). The advanced line M 39 may be used as a leaf scald source of resistance for upland rice improvement.

Narrow brown leaf spot - The disease has been sporadic in nature and the data was obtained only from 10 to 11 tests. The land races Maranhão Vermelho, Guatambu, Corte, Chatão, Iguape Redondo among the medium maturing group and Mimoso, Barbalho, among the early maturing ones had low mean disease ratings. The exotic genotypes IRAT 13 and IRAT 104 as well as improved advanced lines CNA 108-B-42-10-2B and CNA 104-B-2-63-2 showed superior performance among the medium maturing genotypes. The early maturing line 79-233 which showed relatively high degree of resistance (Table 2) had also shown intermediate stability (Prabhu et al., 1991). Even though narrow brown leaf spot is sporadic in nature, the precision of the disease data, averaged across test sites and years totalling 10, was shown by the susceptible reaction of IAC 1246. The high degree of susceptibility of IAC 1246 indicated by mean relative disease index of 0.9 in this study, is in accord with the earlier observation made by Germek & Banzatto (1972) when the genotype was released for cultivation.

Grain discoloration - Variation among medium maturing genotypes for grain discoloration was not wide. However, all genotypes significantly had lower incidence than the susceptible land race Vermelho Miúdo. Similarly, all early maturing genotypes differed significantly from the susceptible land races Mimoso and Cajueiro Liso which are commonly used as susceptible controls in grain spot field screening. The land races Silvanot and Dourado Precoce among the medium and early maturing genotypes, respectively, had lowest incidence of grain discoloration.

It is evident from Figs. 2 and 3 that the correlation between brown spot severities on leaves of different genotypes and grain discoloration was positive both for medium maturing (r = 0.47, P < 0.01) and early maturing ones (r = 0.81, P < 0.01). A high degree of correlation between *Helminthosporium oryzae* and grain spotting was observed in 4 out of 5 test sites in the Mato Grosso State (Souza et al., 1991). The results in the present study suggest the predominant role of leaf lesions of *D. oryzae* in causing grain discoloration besides other fungi.

Multiple disease resistance - Multiple resistance in decreasing order according to resistance level to all five pathogens can be seen in land races Iguape Redondo, Arroz de Guerra and Cateto and advanced breeding lines CNA 108-B-42-10-2B and CNA 108-B-28-11 (Table 1). Among the early maturing lines, M 39, CNA 095-BM-30-BM9-10 and 79-233 showed relatively high level of multiple disease resistance for more than three pathogens. The genotypes Iguape Redondo and CNA 108-B-42-10-2B as well as 79-233 and M 39 also showed lowest mean disease index indicating high level of partial resistance in seven tests conducted over a three-year period in Mato Grosso (Souza et al., 1991). Several other land races showed resistance to one or the other diseases. Evidence for the partial resistance for diseases other than blast is easy because of the absence of distinct pathogenic races. The land race Nenem which showed high degree of partial resistance to leaf blast was susceptible to brown spot and leaf scald whereas IAC 1246 was resistant to leaf blast and

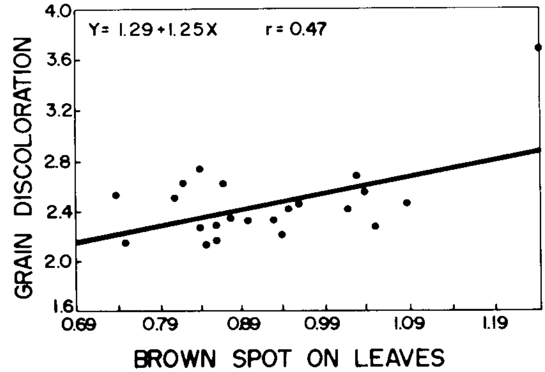

FIG. 2. Relationship between mean brown spot rating and grain discoloration in 25 medium maturing upland rice genotypes, under field conditions. (Mean disease score of each one of the genotypes was based on 10 field trials).

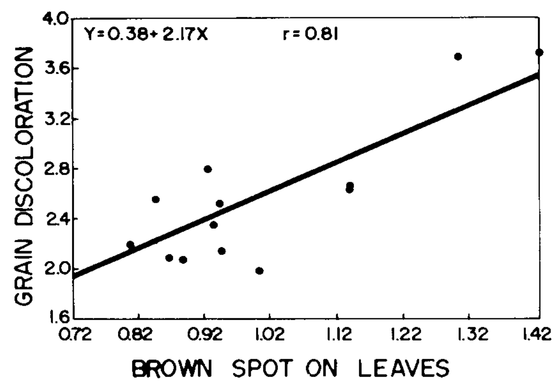

FIG. 3. Relationship between mean brown spot rating and grain discoloration in 12 early maturing upland rice genotypes, under field conditions. (Mean disease score of each one of the genotype was based on 10 field trials).

susceptible to brown spot and narrow brown leaf spot.

Test locations and years - Different degrees of disease pressures were obtained in test sites both for medium and early maturing genotypes (Tables 4 and 5). The test location Vilhena showed a high disease pressure but the means were based on only one year's data. Considering mean disease ratings of two or three years data, the disease pressure was high at Goiânia and Mococa for leaf and neck blast, and Jaciara for grain discoloration. Further work is

TABLE 4. Mean disease ratings of medium maturing genotypes according to location in field tests during three years.

Location	Leaf blast (%)	Neck blast (%)	Brown spot (score)	Leaf scald (score)	Grain discoloration (score)
Vilhena (RO)	32.0 a[1] (n=25)[2]	-	1.4 a (n=25)	1.9 a (n=25)	4.7 a (n=25)
Mococa (SP)	7.5 b (n=50)	54.2 a (n=50)	0.6 d (n=50)	0.7 d (n=50)	-
Goiânia (GO)	5.5 b (n=75)	24.1 c (n=75)	0.9 c (n=50)	-	1.8 e (n=75)
Rondonópolis (MT)	2.8 c (n=25)	5.4 e (n=25)	1.0 bc (n=25)	1.0 c (n=25)	4.2 b (n=25)
Jaciara (MT)	2.6 c (n=50)	13.5 d (n=75)	0.9 e (n=50)	0.2 e (n=75)	3.2 c (n=75)
Porto Velho (RO)	2.2 c (n=50)	31.8 b (n=25)	1.5 a (n=50)	0.6 d (n=50)	2.2 de (n=50)
Manaus (AM)	1.4 c (n=25)	27.1 bc (n=25)	0.9 c (n=25)	0.2 c (n=25)	2.6 d (n=25)
Quatro Marcos (MT)	1.3 c (n=25)	-	1.2 b (n=25)	1.0 e (n=25)	1.8 e (n=25)
Bacabal (MA)	0.6 c (n=25)	-	-	1.0 c (n=25)	1.2 f (n=25)
Planaltina (DF)	0.6 c (n=25)	12.6 d (n=50)	0.6 d (n=25)	-	1.3 f (n=25)
Cáceres (MT)	0.3 c (n=50)	14.9 d (n=50)	1.0 bc (n=50)	0.1 c (n=50)	-
Pindorama (SP)	-	-	0.1 e (n=25)	-	-
Capitão de Poço (PA)	-	-	0.6 d (n=25)	1.4 b (n=50)	-

[1] Means followed by the same letter do not differ significantly according to Ryan - Einot - Gabriel - Welsch multiple F-test (REGWF) at the 0.05 probability level.
[2] n = number of observations utilized in the calculation of means.

needed to identify hot spot screening sites for brown spot, leaf scald and narrow brown leaf spot diseases.

The average disease ratings in different years are presented in Table 6. Leaf and all other disease ratings were significantly higher in the first year. Although, no attempt was made to relate the environmental conditions to disease incidence in different years, it is reasonable to assume the role of weather in explaining the observed differences. The relationship between the total precipitation and number of rainy days to disease pressure in seven test locations of Mato Grosso State could not be established (Souza et al., 1991).

Genetic diversity was detected among land races with the same denomination. On the other hand, some cultivars with similar denomination collected at different sites did not differ with each other in agronomic traits indicating that they are genetically similar (Rangel et al., 1991). It is logical to expect a similar situation with respect to the diversity in land races of disease resistance. For this reason, the germplasm tested in this study for disease reaction was given an accession number, and deposited in the germplasm Bank of the National Rice and Bean Research Center (CNPAF/EMBRAPA) at Goiânia for future use in breeding program when required.

TABLE 5. Mean disease ratings of early maturing genotypes according to location in field tests during three years.

Location	Leaf blast (%)	Neck blast (%)	Brown spot (score)	Leaf scald (score)	Grain discoloration (score)
Vilhena (RO)	27.3 a[1] (n=14)[2]	-	1.3 b (n=14)	2.3 a (n=14)	4.6 a (n=14)
Mococa (SP)	7.1 b (n=28)	60.6 (n=28)	0.7 c (n=28)	1.1 b (n=28)	-
Goiânia (GO)	5.3 bc (n=42)	26.5 (n=42)	1.2 b (n=42)	-	1.8 fg (n=42)
Porto Velho (RO)	2.8 cd (n=28)	25.4 bc (n=14)	1.2 b (n=28)	0.7 c (n=28)	2.5 de (n=28)
Rondonópolis (MT)	2.8 cd (n=14)	21.2 bc (n=14)	1.3 b (n=14)	0.3 def (n=14)	3.7 b (n=14)
Jaciara (MT)	2.2 cd (n=42)	12.0 c (n=42)	0.6 c (n=28)	0.2 ef (n=42)	3.0 cd (n=42)
Quatro Marcos (MT)	1.4 d (n=14)	-	1.1 b (n=14)	1.3 b (n=14)	2.6 cde (n=14)
Cáceres (MT)	1.3 d (n=28)	23.3 bc (n=28)	1.8 a (n=28)	0.1 f (n=28)	2.3 ef (n=28)
Manaus (AM)	0.9 d (n=14)	36.5 (n=14)	0.8 c (n=14)	0.1 ef (n=14)	3.1 bc (n=14)
Planaltina (DF)	0.5 d (n=28)	25.9 (n=28)	0.6 c (n=14)	-	1.2 g (n=14)
Bacabal (MA)	0.3 d (n=14)	-	-	0.4 de (n=14)	1.6 g (n=14)
Capitão de Poço (PA)	-	-	0.5 c (n=14)	0.6 cd (n=28)	-
Pindorama (SP)	-	-	0.1 d (n=14)	-	-

[1] Means followed by the same letter in a column do not differ significantly according to Ryan - Einot - Gabriel - Welsch multiple F-test (REGWF) at the 0.05 probability level.
[2] n = number of observations utilized in the calculation of means.

TABLE 6. Mean disease ratings of medium and early maturing genotypes in field test according to year.

Year	Leaf blast (%)	Neck blast (%)	Brown spot (score)	Leaf scald (score)	Narrow brown leaf spot (score)	Grain discoloration (score)
Medium maturing genotypes						
1983/84	10.1 a[1] (n=125)[2]	33.2 a (n=100)	1.3 a (n=100)	1.1 a (n=125)	1.0 a (n=75)	3.1 a (n=125)
1984/85	2.7 b (n=175)	19.4 b (n=125)	0.9 b (n=125)	0.6 b (n=175)	0.4 b (n=50)	2.3 b (n=175)
1985/86	2.2 b (n=125)	18.4 b (n=150)	0.7 c (n=200)	0.4 c (n=100)	0.3 b (n=125)	1.8 c (n=100)
Early maturing genotypes						
1983/84	7.4 a (n=84)	34.3 a (n=70)	1.2 a (n=56)	0.7 a (n=70)	0.7 a (n=56)	3.1 a (n=70)
1984/85	2.7 b (n=112)	30.3 a (n=56)	1.1 a (n=84)	0.7 a (n=98)	0.5 a (n=28)	2.4 b (n=98)
1985/86	2.6 b (n=70)	21.1 b (n=84)	0.8 b (n=112)	0.2 b (n=56)	0.2 b (n=70)	2.0 c (n=56)

[1] Means followed by the same letter in a column, within each maturing group of genotypes do not differ significantly according to Ryan - Einot - Gabriel - Welsch multiple F test (REGWF) at the 0.05 probability level.
[2] n = number of observations utilized in the calculation of means.

CONCLUSIONS

1. Some land races show high susceptibility to one or more pathogens whereas others exhibit multiple disease resistance.
2. A relatively small sample of land races is adequate to obtain a large variation in resistance to rice pathogens.
3. Among the test sites, Jaciara (MT) and Goiânia (GO) are ideal for screening germplasm for rice blast and grain discoloration, respectively.

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