

Dilatory Blast Resistance in Rice Lines Exotic to the Southern United States

M. A. MARCHETTI, Research Plant Pathologist, Agricultural Research Service, USDA, Texas A&M University Agricultural Research and Extension Center, Beaumont 77706

ABSTRACT

Marchetti, M. A. 1983. Dilatory blast resistance in rice lines exotic to the southern United States. *Plant Disease* 67:1362-1364.

Twenty-five rice cultivars from Japan, Egypt, Turkey, and China were evaluated for dilatory resistance to rice blast in blast nursery "miniplots" in Beaumont, TX. As a group, the Japanese cultivars, selected for high field resistance to blast in Japan, were the most blast-resistant here. The single Chinese entry, Nanjing 11, was also highly resistant. Two Turkish cultivars, Akceltik and Sariceltik, were significantly more susceptible to blast than an American susceptible check cultivar, M-101. The Egyptian cultivars, as a group, were significantly more susceptible than the Japanese cultivars but more resistant than two of three Turkish cultivars.

Additional key words: general resistance, *Pyricularia oryzae*

Rice blast, caused by *Pyricularia oryzae* Cav., is not a major constraint on rice yields in the southern United States although individual fields have occasionally sustained yield reductions of 60% or more. Recent studies indicate that many U.S. rice cultivars and parental lines possess considerable levels of general resistance (sensu Caldwell [3]) to blast (8).

Southern rice breeders are increasing their use of exotic germ plasm in efforts to improve cold tolerance, tillering, plant type, and ratooning ability and broaden the genetic base of U.S. rice. Rice researchers are aware of the danger of diluting general resistance to endemic diseases, including blast, in the process of transferring genes for desirable traits from exotic sources into domestic lines. Consequently, a technique requiring relatively little space and seed was developed for evaluating general blast resistance in potential parental lines and early-generation breeding lines (8).

The term general resistance presupposes that the resistance is race-*non*-specific, ie, it operates more or less uniformly against all races of a pathogen (3). Because this study was conducted with only one race of the blast pathogen, it is more appropriate to refer to the host response as dilatory resistance (sensu Browning et al [2]), ie, resistance that slows the rate of disease development (a term with no connotation as to race-specificity of the resistance). In this experiment, a number

of Japanese, Egyptian, Turkish, and Chinese rice cultivars were evaluated for dilatory blast resistance in the blast nursery at Beaumont, TX. Race IG-1, the most widespread race of *P. oryzae* in the United States, was used to evaluate the cultivars and compare them with highly resistant and highly susceptible U.S. cultivars.

MATERIALS AND METHODS

The cultivars selected for this experiment possessed no major (*Pi*)-gene resistance to race IG-1 according to standard greenhouse tests (6) conducted previously. Some of the test cultivars had the blast-resistance genes *Pi-a*, *Pi-i*, and *Pi-k^s*, but race IG-1 is virulent against all these *Pi* genes. The study was conducted with only one race to preclude confounding by differential major-gene resistance among the cultivars and cross-protection sometimes observed when rice seedlings are exposed simultaneously to inocula of virulent and avirulent races (5).

Fourteen Japanese, seven Egyptian, three Turkish, one Chinese, and two American "check" cultivars (very resistant Nartai and very susceptible M-101 [8]) were planted on 12 July 1982 in duplicate, randomized within replicates, in 3-row by 60-cm-long "miniplots," 30 seeds per row, in blast nursery beds. Miniplots were separated by two densely planted buffer rows of highly blast-resistant Labelle. A single row of M-101 was planted as a spreader the length of each 15.3-m nursery bed, windward of and perpendicular to the miniplots. A single row of Labelle was planted on the leeward side parallel to the M-101 spreader. Seedlings emerged on 17 July. Dew periods were lengthened by sprinklers that operated intermittently from 1600 to 1930 and from 0900 to 1030 hours daily. Nursery beds were fertilized with ammonium sulfate (21% N) at 90 kg N/ha broadcast when seedlings were at

the two- to three-leaf stage. Primary inoculum was generated from spreader rows in adjacent blast nursery beds where routine blast resistance screening with race IG-1 was ongoing (8).

Percent diseased leaf area (DLA) was estimated visually for each miniplot 19, 24, 27, 30, 34, and 37 days after emergence. At the conclusion of the experiment, lesions were collected randomly from six miniplots for isolation and race identification in greenhouse inoculations of international differentials (7). Areas under disease progress curves (AUDPC) and percent DLA (arc sine-square root transformed) were analyzed statistically to evaluate the cultivars for dilatory resistance.

RESULTS

The AUDPCs and percent DLAs at 24, 30, and 37 days after seedling emergence are summarized in Table 1. Disease progress curves for blast on representative cultivars are plotted in Figure 1. The rankings of entries by AUDPC and percent DLA values were similar. Among the Japanese cultivars, all but Fukuyuki and Aichi Asahi are considered to have moderate to very high field resistance to leaf blast in Japan (A. Ezuka, *personal communication*; 4). In this study, the Japanese blast-resistant cultivars were among the highest in dilatory resistance. Even Fukuyuki, considered very susceptible in Japan (4), was significantly more resistant ($P=0.05$) than all the Egyptian and Turkish cultivars, according to the AUDPC and the final percent DLA estimated 37 days after emergence. The single Chinese cultivar, Nanjing 11, a high-yielding semidwarf cultivar, ranked highest in dilatory resistance.

Most striking was the rapid rate of disease increase in two Turkish cultivars, Akceltik and Sariceltik, both significantly more susceptible than M-101, among the most susceptible of U.S. cultivars (Table 1, Fig. 1). Miniplots of Sariceltik were practically killed by blast at first rating 19 days after emergence. The third Turkish cultivar, Sarikilcik, ranked with the best of the Egyptian cultivars. As a group, the Egyptian cultivars were least variable in dilatory resistance, with only Yabani Lulu significantly more resistant than any other Egyptian cultivars.

Several test cultivars carried *Pi* genes for blast resistance (Table 1) (1,4; M. A. Marchetti and T. Abdel-Hak, *unpublished*). No detectable residual resistance was afforded by these "defeated" resistance genes as has

Accepted for publication 21 June 1983.

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "advertisement" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

This article is in the public domain and not copyrightable. It may be freely reprinted with customary crediting of the source. The American Phytopathological Society, 1983.

been reported for other host-parasite interactions (9,10).

All six isolates collected at the final rating were race IG-1. Blast is rare on the experiment station except in the blast nursery, where sprinklers are used to extend dew periods. Almost 90% of the commercial acreage is planted to Labelle, from which only race IC-17 has been isolated in Texas since 1971. The Labelle buffers were free of leaf blast. Therefore, I concluded that race IG-1 was the only race present in the test plots.

DISCUSSION

Some reductions in percent DLA over time probably resulted from errors in estimating the ratio of diseased to healthy foliage, particularly among more resistant cultivars (Table 1, Fig. 1). At least some of the fluctuation in apparent disease progress was probably caused by daily fluctuations in weather, continuous production of new vegetation, and increasing resistance to infection with age of plants. The rate at which resistance with aging develops varies among cultivars and should be considered a component of dilatory resistance. This phenomenon should also be most apparent in the disease progress curves of the more resistant cultivars. Among the cultivars tested, Kogane Nishiki and most of those with lower AUDPCs tended to show a leveling off of their respective disease progress curves long before the amount of uninfected leaf area became limiting.

The blast nursery where these tests were conducted was designed for evaluating specific resistance (8). Because of the small size and proximity of test plots, interplot interference caused by alloinfection is inevitable. Consequently, evaluation of dilatory resistance tends to be biased on the "safe side" in terms of plant disease resistance breeding. The effectiveness of dilatory resistance in field-size stands of a cultivar, where alloinfection should contribute relatively little to disease progress, would be underestimated in the blast nursery.

At present, much of the southern U.S. rice belt is "environmentally marginal" for rice blast development, as indicated by the infrequency and localized nature of serious outbreaks of the disease. Previous studies indicate that present southern U.S. cultivars and parental lines possess considerable levels of dilatory resistance (8). Under breeding nursery conditions in which the most susceptible southern cultivars were free of blast, adjacent plots of exotic cultivars like Akceltik were destroyed by leaf blast and California cultivars like M-101 were severely affected. Therefore, one must consider the genetic background of southern U.S. rice cultivars as a major component of our marginal environment for blast. It is important that we preserve and improve the levels of dilatory (and

Table 1. Areas under disease progress curves (AUDPC) and percent diseased leaf areas of 25 exotic rice cultivars and U.S. resistant and susceptible check cultivars in an evaluation of dilatory resistance to race IG-1 of *Pyricularia oryzae* in blast nursery miniplots, Beaumont, TX, 1982

Cultivar	Country of origin	Pi genes ^x	AUDPC ^y	Percent diseased leaf area ^z (days after seedling emergence)		
				24	30	37
Nanjing 11	China	?	0.5 a	0.3 a	2 a	6 a
Chiyohikari	Japan	+	0.8 a	9 abc	5 a	6 a
Kuroka	Japan	Pi-a	1.7 ab	7 ab	10 ab	15 abcd
Ginga	Japan	+	1.8 ab	12 cde	10 ab	13 abc
Nortai	USA	+	1.9 ab	14 cdef	13 abc	13 abc
Rikuto Norin Mochi 4	Japan	+	2.0 ab	7 ab	18 abcd	23 abcde
Ou 247	Japan	+	2.3 ab	17 cdef	10 ab	7 ab
Yoneshiro	Japan	Pi-i	2.7 abc	9 abc	15 abcd	20 abcde
Fujiminori	Japan	Pi-a	2.9 abc	14 cdef	20 abcd	18 abcd
Yamabiko	Japan	Pi-a	3.1 abc	15 cdef	20 abcd	20 abcde
Ginmasari	Japan	Pi-a	3.2 abc	25 cdefg	18 abcd	25 abcde
Rikuto Norin 24	Japan	+	3.5 abc	19 cdefg	23 abcd	28 bcde
Rikuto Norin Mochi 26	Japan	+	4.2 bc	14 cdef	33 bcde	43 de
Kogane Nishiki	Japan	+	4.8 bc	20 cdefg	38 cde	40 cde
Fukuyuki	Japan	Pi-i	5.4 c	23 cdefg	40 def	48 e
Yabani Lulu	Egypt	+	7.6 d	28 cdefg	50 ef	75 f
Sarikilcik	Turkey	?	7.9 d	25 cdefg	50 ef	75 f
Nahda	Egypt	Pi-k ^s	9.7 de	40 fgh	65 fg	88 fg
Giza 159	Egypt	+	9.8 de	38 cefgh	65 fg	95 g
Aichi Asahi	Japan	Pi-a	10.9 e	33 defg	80 gh	98 g
Giza 171	Egypt	Pi-k ^s	11.7 ef	40 fgh	93 hi	100 g
Yabani M7	Egypt	Pi-k ^s	11.9 ef	48 gh	85 gh	100 g
Yabani 15	Egypt	+	12.0 ef	40 fgh	85 gh	100 g
Sabienny	Egypt	Pi-k ^s	12.2 ef	45 gh	88 ghi	100 g
M-101	USA	+	13.9 f	63 h	100 i	100 g
Akceltik	Turkey	+	17.1 g	100 i	100 i	100 g
Sariceltik	Turkey	?	18.0 g	100 i	100 i	100 g

^xBlast resistance (Pi) genes known to be present, as determined in other studies (1,4; A. Ezuka, personal communication; M. A. Marchetti and T. Abdel-Hak, unpublished). + = No known Pi gene present, ? = no information.

^yMaximum possible value = 18.0 (100% diseased leaf area at first rating for an 18-day rating period). Values followed by the same letter are not significantly different ($P=0.05$) according to Duncan's multiple range test.

^zStatistical analyses were performed on arc sine-square root transformed data. Values in the same column followed by the same letter are not statistically different ($P=0.05$) according to Duncan's multiple range test.

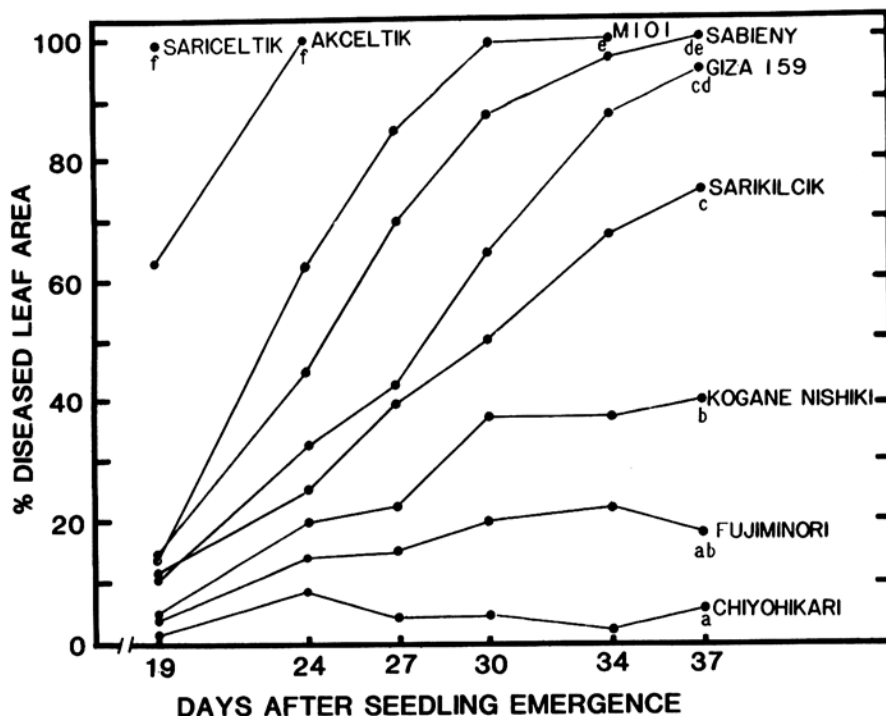


Fig. 1. Disease progress curves for selected rice cultivars representing a range of dilatory resistance to race IG-1 of *Pyricularia oryzae* in duplicate blast nursery miniplots planted on 12 July 1982 in Beaumont, TX. Areas under disease progress curves accompanied by the same letter are not significantly different according to Duncan's multiple range test.

general) resistance in our breeding material, at least by being aware of serious weaknesses in lines like Akceltik that may otherwise be desirable and preferably by avoiding such lines as parental material.

ACKNOWLEDGMENTS

I wish to thank A. Ezuka (Japan), T. Abdel-Hak (Egypt), N. Acikgoz (Turkey), and Guang-nan Wu (People's Republic of China) for providing rice seed and R. C. Kolander for technical assistance.

LITERATURE CITED

1. Acikgoz, N., and Marchetti, M. A. 1977. Susceptibility of Turkish rice cultivars to six races of *Pyricularia oryzae*. Page 12 in: Proc. Turkish Sci. Cong. 5th, Ankara, Turkey.
2. Browning, J. A., Simons, M. D., and Torres, E. 1977. Managing host genes: Epidemiologic and genetic concepts. Pages 191-212 in: Plant Disease. An Advanced Treatise. Vol. 1. J. G. Horsfall and E. B. Cowling, eds. Academic Press, New York.
3. Caldwell, R. M. 1968. Breeding for general and/or specific plant disease resistance. Pages 263-272 in: Proc. Int. Wheat Genet. Symp. 3rd.
4. Ezuka, A. 1972. Field resistance of rice varieties to blast disease. Rev. Plant Prot. Res. 5:1-21.
5. Kiyosawa, S., and Fujimaki, H. 1967. Studies on mixture inoculation by *Pyricularia oryzae* on rice. Bull. Nat. Inst. Agric. Sci. (Japan) Ser. D. 17:1-20.
6. Latterell, F. M., Marchetti, M. A., and Grove, B. R., Jr. 1965. Coordination of effort to establish an international system for race identification in *Pyricularia oryzae*. Pages 257-274 in: The Rice Blast Disease. Johns Hopkins Press, Baltimore, MD.
7. Ling, K. C., and Ou, S. H. 1969. Standardization of the international race numbers of *Pyricularia oryzae*. Phytopathology 59:339-342.
8. Marchetti, M. A. 1983. Dilatory resistance to rice blast in USA rice. Phytopathology 73:645-649.
9. Martin, T. J., and Ellingboe, A. W. 1976. Differences between compatible parasite/host genotypes involving the *Pm4* locus of wheat and the corresponding genes in *Erysiphe graminis* f. sp. *tritici*. Phytopathology 66:1435-1438.
10. Nass, H. A., Pedersen, W. L., MacKenzie, D. R., and Nelson, R. R. 1981. The residual effect of some "defeated" powdery mildew resistance genes in isolines of Chancellor winter wheat. Phytopathology 71:1315-1318.