Relation Between Qualitative and Quantitative Resistance to Rice Blast

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ABSTRACT

In an upland rice cultivar trial at our experimental farm, all entries were affected by blast (*Pyricularia oryzae*), however, they differed in the number of lesions on the leaves. Representative rice lines (IR1514A-E666, IR2031-421, and IR442-2-58) had an average of 3, 36, and 73 lesions per tiller, respectively. Twenty-six fungal races were identified from 105 randomly field-collected lesions. The lines with fewer lesions were resistant to more races and isolates. Thus, the quantitative difference in resistance (lesion umber) observed in the field was an indicator of the qualitative (race reaction) resistance of the rice lines.

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An outbreak of rice blast occurred in an upland cultivar trial at the International Rice Research Institute during the 1973 wet season. All of the cultivars and lines appeared to be susceptible to the fungus, but the numbers of lesions on each of the cultivars or lines varied greatly. They varied from a few typical lesions per tiller to so many lesions the leaves were killed. The quantitative differences in susceptibility were not due to environment or uneven distribution of the pathogen, since host lines responded the same in all replications. Since low lesion numbers could reflect correspondingly low frequencies of virulence alleles in the pathogen population, the races active in the population were determined and the virulence of each on three representative lines was assessed.

MATERIALS AND METHODS.—At the maximum tillering stage of the rice plants, three lines [IR1514A-E666 (IR1514), IR2031-421 (IR2031) and IR442-2-58 (IR442)] representing a small, intermediate, and large number of lesions, respectively, were selected and the number of typical blast lesions on 100 randomly selected tillers were counted.

Individual lesions were sampled at random from the three replicates of each of the three lines in the field plot. Each lesion and the adjacent healthy leaf tissue was washed, affixed to the inside of a petri dish cover with a wet filter paper in which a hole had been cut, and placed over a potato-dextrose agar plate. Conidia from the lesion dropped onto the plate and in 24 hours produced a single-lesion isolate of the fungus. The fungus was grown on autoclaved rice stem nodes in flasks for mass spore production. A total of 105 lesion samples were isolated and tested.

Three-week-old seedlings of the 12 Philippine differential cultivars (3) and the three lines were simultaneously inoculated with each fungal isolate. Plants were grown in wooden flats or plastic pots and placed inside dew chambers. The seedlings were inoculated in the late afternoon by spraying 80 ml of spore suspension at a concentration of about 3×10^4 spores/ml into these chambers. The control plants were sprayed with water. Inoculated plants were kept in the dew chambers 24 hours, then removed to a greenhouse equipped with evaporative cooling. Readings of reactions and lesion counts were made 7 days after inoculation as described earlier (3).

RESULTS AND DISCUSSION.—The average

TABLE 1. The relative numbers of rice blast lesions caused by *Pyricularia oryzae* on three rice lines in the field and the reactions of the lines to 105 isolates of 26 races in the greenhouse

Rice lines	Lesions per tiller in the field (no.)	Lesions/10 seedlings greenhouse (no.)	Isolates pathogenic	Races pathogenic
IR442	73	35	94	24
IR2031	36	11	68	18
IR1514	3	1	6	3

number of lesions found on IR1514, IR2031, and IR442 by natural infection in the field were 3, 36, and 73 per tiller, respectively. Many leaves of IR442 were killed by the lesions. Qualitatively, they may be referred to as resistant, intermediate, and susceptible, respectively, to this population of the pathogen.

The average numbers of lesions that developed on ten seedlings of three rice lines following artificial inoculations with the 105 fungal isolates were 1, 11, and 35, respectively. The quantitatively resistant line has a much lower average number of lesions than the intermediate, which in turn has less than the susceptible line. The differences were comparable to those found in the natural field infection.

The 105 isolates were grouped into 26 races based on the reactions of the 12 Philippine differential cultivars. The reaction of the three lines of rice to the 26 fungus races and 105 isolates is presented in Table 1. The lines susceptible to larger numbers of races have correspondingly more lesions. The control plants produced no lesions.

The pathogenicity patterns of the 105 isolates on the three lines and their frequencies are shown in Table 2. Six of the eight possible patterns based upon the three host lines are found among the 105 isolates. Pattern V (IR1514, resistant; and IR2031 and IR442, susceptible) occurred most frequently (61 isolates out of 105). Pattern II (IR1514 and IR2031 resistant, IR442 susceptible) was shown by 27 isolates. Isolates of these two patterns contribute most to the susceptibility of the three lines.

The results confirm earlier reports (1, 5) of the presence of many races of *Pyricularia oryzae* in a field. Cultivars or lines that were more resistant in the field were resistant to a larger number of fungus races. Thus, quantitative reaction in the field reflected the sum of qualitative reactions of the cultivars or lines to different races. These rice lines react differently to different races, and thus have vertical resistance sensu van der Plank (6).

Although the number of vertical resistance genes is unknown, it seems possible that the IR1514 line has more resistance genes than the IR442 and IR2031 lines since it is resistant to more races. These data appear to support the concept that many vertical resistance genes in a common genetic background can contribute to stability of resistance and may appear as horizontal resistances (4). The results also suggest that a higher level of resistance may be accomplished by pyramiding resistance genes (2).

TABLE 2. Pathogenicity patterns among the 105 isolates of *Pyricularia oryzae* on three rice lines

Rice lines	Pathogenicity patterns							
	I	II	III	IV	V	VI	VII	VIII
IR442	R[a]	S	R	R	S	R	S	S
IR2031	R	R	S	R	S	S	R	S
IR1514	R	R	R	S	R	S	S	S
Frequency	9	27	2	0	61	0	1	5

[a]R indicates resistant and S, susceptible reaction; See (3) for details.

LITERATURE CITED

1. INTERNATIONAL RICE RESEARCH INSTITUTE. 1972. Annual report for 1971. The International Rice Research Institute. Los Baños, Laguna, The Philippines. 238 p.
2. NELSON, R. R. 1973. The use of resistance genes to curb population shifts in plant pathogens. Pages 49-66 *in* R. R. Nelson, ed. Breeding plants for disease resistance—concepts and applications. The Pennsylvania State University Press, University Park. 401 p.
3. OU, S. H., and M. R. AYAD. 1968. Pathogenic races of Pyricularia oryzae originating from single lesions and monoconidial cultures. Phytopathology 58:179-182.
4. OU, S. H., F. L. NUQUE, and V. A. AWODERU. 1971. A type of stable resistance to blast disease of rice. Phytopathology 61:703-706.
5. QUAMARUZZAMAN, M. D., and S. H. OU. 1970. Monthly changes of pathogenic races of Pyricularia oryzae in a blast nursery. Phytopathology 60:1266-1269.
6. VAN DER PLANK, J. E. 1963. Plant diseases: epidemics and control. Academic Press, New York. 349 p.