

SIGNIFICANCE OF MULTI-LOCATION SCREENING FOR DURABLE RESISTANCE TO BLAST DISEASE IN RICE

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ABSTRACT

Frequent appearance of *Magnaporthe grisea* [Hebert] Barr (Telemorph) races leading to development of heterogeneous blast populations and the inability of current screening techniques to detect elite lines with broad-spectrum resistance are major problems in developing rice varieties with stable and durable resistance to blast. This study showed differential reactions of rice varieties for blast at different locations indicating the presence of blast races with varying levels of virulence at different locations. Establishment and maintenance of multi-locational blast screening nurseries to represent different agroclimatic regions will provide a practical means of selecting elite lines with broad spectrum resistance with a view to improving the durability of blast resistance in cultivated varieties.

KEY WORDS: Broad spectrum resistance, Differential reaction, Rice blast disease, Virulence.

INTRODUCTION

Rice blast disease caused by *Magnaporthe grisea* [Hebert] Barr (Telemorph) is considered the principal fungal disease of rice, for its destructiveness and worldwide distribution (Ou, 1986). Losses caused by blast vary and depend on the growth stage of the plant at which infection occurs, level of resistance of the variety and prevailing environmental conditions (Dissanayake, 1992). Endemic and epidemic development of leaf and panicle blast is more frequent in rainfed areas of the up country and eastern regions of Sri Lanka especially in the Maha season (Wet season, Oct.-Mar.) due to favourable environmental conditions for disease development. Cultivar resistance is the most practical and preferred means of blast disease management (Zeigler *et al.*, 1994); hence, breeding for blast resistance is a major objective of the national rice breeding programme in Sri Lanka.

However, the development of rice varieties with durable blast resistance has been

elusive despite the concerted effort at breeding for blast resistance in many international (Ou, 1986) and national rice breeding programmes (Dissanayake, 1994). Spontaneous and frequent appearance of new races of the fungus (Ou and Ayad 1968; Kiyosawa, 1976), interaction between segregating rice lines (having different race specific major genes for blast resistance) and heterogeneous blast populations for virulence are some basic constraints in developing varieties with durable resistance (Ling and Ou, 1969).

The success of developing rice varieties with durable and stable blast resistance largely depends on the efficiency of screening techniques to detect elite breeding lines with resistance to as many individual races as possible (high level of horizontal resistance) (Nottingham, 1993) and the ability of the screening technique to reliably assess the degree of blast resistance of a given variety or elite line (Ahn and Ou, 1982). The present method of blast screening (Uniform Upland

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Blast Screening Technique adapted by International Rice Research Institute) cannot differentiate elite breeding lines with monogenic and polygenic resistance or identify with certainty the different degrees of resistance apparent among lines included in a given screening nursery. Therefore, pyramiding of major genes into an elite line becomes remote as detecting such pyramided lines from the rest is difficult. Similarly, higher levels of resistance observed in certain varieties/lines at a given screening site may not necessarily be the same at a different screening site due to differences in race composition and environmental conditions. An alternate approach to avoid this problem is to identify the *M. grisea* race composition and their prevalence in a given screening site so that one is aware of the race diversity and their frequencies under which the test entries were screened. In the past, this was possible only through inoculation of a differential set of rice varieties with individual fungal isolates, which is extremely time consuming and laborious, when handling many thousand breeding lines in a national rice breeding programme. However, the modern molecular tools available now provide molecular markers to carry out population analysis of pathogens but these techniques need modern laboratory facilities, skilled personnel and infrastructure. Alternatively, the use of differential varieties in multilocal screening tests provides indirect information to a great extent on the occurrence of different races and their distribution, while also providing an opportunity to select elite lines with broad-spectrum resistance.

In the past, blast screening nurseries were located at Karadian Aru (Eastern province), Paranthan (Northern province), Karapincha (Sabaragamuwa province), Getambe- Peradeniya (Central province) and Batalagoda (North western province) where a

considerable and reliable blast disease pressure could be experienced (hot spots). A differential reaction to blast by certain rice varieties in these locations had been observed. However, no attempt had been made to classify the major blast race groups prevalent at these locations.

In an international co-operative study, Atkins *et al.* (1967) identified two international race groups; IA and IC from isolates obtained from Sri Lanka. However, no information is available from which locations the isolates were collected. In addition, no attempt has been made in the past to identify the predominant groups of blast races occurring especially at blast screening sites in Sri Lanka. Security issues and the restructuring of Department of Agriculture resulted in the loss of four of the important "hot spots" of blast screening viz., Karadiyan Aru, Paranthan, Karapincha and Peradeniya.

This paper presents the results of a study conducted to detect major blast race groups at two blast screening sites and also evidence for the existence of site-specific blast races in order to highlight the need for multi-local screening for durable and stable resistance to blast in rice.

MATERIALS AND METHODS

The experiment consisted of two parts. Part I was conducted to detect the existence of locational differences of blast resistance among some selected rice varieties. Sixty rice varieties/elite breeding lines were screened for seedling blast resistance at 3 locations viz., Central Rice Breeding Station (presently Rice Research and Development Institute), Batalagoda (Intermediate zone), Regional Agricultural Research Centre, (presently Regional Agricultural Research and Development Centre) Makandura (Intermediate zone) and Central Agricultural

Research Institute, (presently Horticultural Research and Development Institute) Gatembe-Peradeniya (Mid country wet zone) during Yala (dry season, March-Sep.) 1989 and in Maha (wet season, Oct.-Feb.) 1989/90. At all locations and in each season the Upland Blast Screening Technique adopted by the International Rice Research Institute (IRRI) was used and ratings were based on the Standard Evaluation System for rice of International Rice Research Institute (IRRI, 1988). No inoculations were done at any location; however, infection was induced by covering the nurseries with a colourless plastic sheet for 5 consecutive nights (from 4.00 pm. to 9.00 am. the following morning) starting at 10 days after sowing to increase the humidity and lengthen the dew period. Disease inception and development were satisfactory at all locations in both seasons to record a reliable rating of blast reactions. Tetep and Pachchaiperumal were the standard resistant and susceptible checks, respectively.

Part II of the experiment was designed to identify the predominant field races of *M. grisea* in two blast screening sites viz., Gatembe-Peradeniya and Batalagoda. International Rice Blast Differential (IRBD) varieties were screened with two replications per location during Yala 89 and Maha 89/90 against seedling blast at the above two blast screening sites. Tetep and Pachchaiperumal were the standard resistant and susceptible checks, respectively. The nursery plot design and method of seedling establishment were based on the Uniform Upland Blast Nursery Technique adapted by the International Rice Research Institute, and evaluations were made using SES for rice (IRRI, 1988). Races were identified using the method described by Ling and Ou (1969). Blast occurrence and development were very satisfactory during both seasons and at both locations to make a

reliable record of differential varietal reaction to blast in each screening test.

RESULTS AND DISCUSSION

Blast reactions of some selected rice varieties and elite breeding lines recorded at the three locations, viz., Batalagoda, Gatembe-Peradeniya and Makandura during Yala 89 and Maha 89/90 are presented in Table 1. The standard blast resistant check Tetep was free of blast at all 3 locations showing a resistant reaction while the standard susceptible check Pachchaiperumal expressed an uniform susceptible reaction across all 3 locations over both seasons. These observations confirmed the presence of suitable environmental conditions for the occurrence and development of blast disease in all screening tests, thus subjecting test entries to conducive environmental conditions for blast occurrence.

Based on the pattern of blast reactions of test entries across locations appearing in Table 1, the test entries could be divided into two groups. Group 1 consists of varieties/ lines that show uniform resistant or susceptible reaction across locations in both seasons. Varieties Bg 300, Bg 301, and line # At 85-1, Bg 850-1, Bg 1203-1, Bg 1321, Bg 1219 and Ld 179-1 expressed uniform resistant reaction while variety Bg 350, Bg 94-1, Bg 450 and line # At 84-3, and Bw 298-2 expressed uniform susceptible reaction. These observations do not provide any evidence or support for detecting blast races of different virulence across the screening sites tested. Nevertheless, this nature of multi-location screening provides for the breeders an inexpensive and practical means of selecting breeding lines/varieties with broad spectrum resistance to blast.

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Table-1. Seedling Blast reaction of some selected rice varieties/elite lines at three different locations in Yala 89 and Maha 89/90.

Category	Varieties/ Lines	Location					
		Batalagoda		Makandura		Peradeniya	
		Yala 89	Maha 89/90	Yala 89	Maha 89/90	Yala 89	Maha 89/90
Varieties	H4	R	R	R	R	S	S*
	Bg 11-11	R	R	R	R	S	S*
	Bg 12-1	R	R	MR	MR	S	S*
	Bg 379-2	R	R	R	R	S	S*
	Bg 407	R	R	R	R	S	S*
	Bg 38	R	R	R	R	MS	S*
	Bg 745	MR	MR	R	R	MS	S*
	Bg 300	R	R	R	R	R	R
	Bg 301	R	R	R	R	R	R
	Bg 350	S	S	S	S	S	S
	Bg 94-1	S	S	S	S	S	S
	Bg 450	MS	S	S	S	S	S
	IR 36	MR	MR	MR	MR	R	R
	IR 50	MR	MR	MR	MR	R	R
Elite lines	Bg 915	R	R	MS	MS	MS	MS*
	Bg 1564	S	S	R	MR	S	S*
	Bg 1575	S	S	R	MR	MS	MS*
	Bg 1165-4	MR	MR	R	R	R	R
	Bg 846	R	R	R	R	MS	MS*
	Bw 297-2	R	R	R	R	MS	MS*
	At 86-1	R	R	R	MR	S	S*
	At 84-3	S	S	S	S	S	S
	Bw 298-2	S	S	S	S	S	S
	At 85-1	R	R	R	R	R	R
	Bg 850-1	R	R	R	R	R	R
	Bg 1203-1	R	R	R	R	R	R
	Bg 1321	R	R	R	R	R	R
	Bg 1219	R	R	R	R	R	R
	Ld 179-1	R	R	R	R	R	R
Check varieties	Pachchaiperumal Tetep	SS	SS	SS	SS	SS	SS
		R	R	R	R	R	R

R =Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible; SS =Highly susceptible.

*Distinct differential reactions at two or all locations

Group 2 consists of varieties/lines that exhibited a differential blast reaction across locations. Varieties H4, Bg 11-11, Bg 12-1, Bg 379-2, Bg 407, Bg 38 and Bg 745 showed susceptible reaction at Peradeniya while they were resistant at Batalagoda and Makandura. Similarly, line # Bg 846, Bw 297-2, At 86-1 behaved the same way. On the other hand, Bg 1564 and Bg 1575 showed a susceptible reaction at Batalagoda and Peradeniya and a resistant reaction at Makandura. In the presence of conducive environmental conditions for occurrence and development of blast disease the differential reactions of a given rice variety at different locations can only be explained by the presence of different races of the fungus varying in virulence (Ou and Ayad, 1968). Therefore, differential blast reactions of above varieties/lines is an evidence for the existence of pathogen races differing in virulence at the screening sites tested.

The earlier blast reaction records indicate that the varieties H4, Bg 11-11, Bg 12-1, Bg 379-2, Bg 407, Bg 38, and Bg 745 have had a moderate (MR) or resistant (R) blast reaction at Peradeniya at the time these were recommended for cultivation (Dissanayake, 1994, In Press). Therefore, the susceptible reactions observed in the present study could be due to enhanced virulence of blast races at Peradeniya over the years. Variety H4, a popular cultivar among farmers in upcountry areas has been reported to be infected with blast in the late 80's and this could also be attributed to the enhanced virulence of blast races in the area.

The national rice breeding programme in Sri Lanka has lately recognized the difficulty of developing varieties to suit all stress conditions prevailing in different agroecological zones in the entire island. Therefore, development of region-specific varieties for areas such as problem soils in wet zone, flood tolerance in Ma wee areas, salt tolerance in coastal areas and cold tolerance in upcountry rice lands are region-specific needs. The varieties recommended for a specific area needs blast resistance only in that area and islandwide blast resistance may not be compulsory. Multilocal screening data are helpful in developing region-specific varieties with blast resistance for that area.

2.2 Differential reactions of the International Rice Blast Differential (IRBD) varieties for blast at Batalagoda and Peradeniya are presented in Table 2. When the differential varieties are arranged in order as in Table 2, the blast reaction pattern of IRBD varieties at Batalagoda shows that variety Kanto 51 is the first variety having a susceptible (S) reaction for blast. Therefore, the predominant blast race group at Batalagoda could be classified as International race group F (IF) (Ling and Ou, 1969). Similarly, at Peradeniya NP 125 is the first variety to be susceptible (S) in the IRBD varietal set, so that the predominant blast race group at Peradeniya could be classified as international race group C (IC). These results clearly indicate the presence of physiologically different blast races with varying levels of virulence at the above screening sites.

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Table 2. Seedling Blast reaction of the International Rice Blast Differential varieties at Peradeniya and Batalagoda in Yala 89 and Maha 89/90.

Category	Variety	Blast reaction			
		Batalagoda		Peradeniya	
		Yala 89	Maha 89/90	Yala 89	Maha 89/90
IRBD Varieties	Raminard str. 3	R	R	R	R
	Zenith	R	R	R	R
	NP 125	R	R	S*	S
	Usen	R	R	R	R
	Dular	R	R	S*	S
	Kanto 51	S	S	S	S
	Sha-tiao-tsao	S	S	S	S
	Caloro	S	S	S	S
Check Varieties	Tetep	R	R	R	R
	Pachchaperumal	SS	SS	SS	SS

R=Resistant; S=Susceptible; SS= Highly susceptible

* Distinct differential reactions at two locations

In the process of developing broad-spectrum resistant varieties for blast, the theoretical requirement is to test each and every breeding line against all individual blast races present in a given rice growing area, using single spore isolates. However, in practice, screening of several thousand breeding lines against several hundred blast isolates individually in a breeding station is an impossible task. Therefore, the practical approach is to first establish the presence of

different blast race groups at different locations and then screen the breeding lines at multi-locations exposing them to infection by blast races with varying levels of virulence as present in nature thereby facilitating selection of elite lines with broad-spectrum resistance to blast. The results of the present study clearly indicate the feasibility of this practical approach in detecting rice varieties/ breeding lines with broad spectrum resistance to blast.

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