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Genetics of resistance of rice cultivar ARC 10550 to Bangladesh brown planthopper biotype

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Abstract. Resistance to brown planthopper in rice cultivar ARC 10550 was found to be governed by a single recessive gene which was designated *bph* 5. It conveys resistance to brown planthopper populations in South Asia but not to the populations in East and Southeast Asia. This gene segregated independently of four other known genes for brown planthopper resistance. It should be possible to combine this gene with any of the other four genes to develop rice cultivars with a broad spectrum of resistance.

Keywords. *Nilaparvata lugens* Stal; *Oryza sativa* L.; recessive gene; independent segregation.

1. Introduction

Natural populations of brown planthopper *Nilaparvata lugens* Stal. (BPH) in South Asia differ from those in East and Southeast Asia in virulence patterns. Cultivars of rice *Oryza sativa* L. with *Bph* 1 or *bph* 2 genes (Athwal *et al* 1971) are resistant to BPH populations in East and Southeast Asia but not in South Asia. Rice cultivars with *Bph* 3 and *bph* 4 (Lakshminarayana and Khush 1977) are resistant to BPH populations in all the regions of Asia (Khush 1977). However, some rice cultivars such as ARC 10550 are resistant to BPH populations in South Asia but not in East and Southeast Asia (Seshu and Kauffman 1980). The genetic basis of resistance of these cultivars has not been investigated.

On the basis of these differential reactions, BPH populations in different countries have been categorized into four biotypes. The original populations in East and Southeast Asia belonged to biotype 1. Biotype 2 originated in the Philippines, Indonesia and Vietnam in 1976–1977 after the introduction and widescale cultivation of cultivars with *Bph* 1 (Khush 1979), and is the dominant biotype in these countries. Biotype 3 was produced in the laboratory at the International Rice Research Institute (IRRI) by rearing the insect on ASD 7, a rice cultivar with *bph* 2 for resistance (Pathak and Khush 1979). The BPH populations in South Asia have been variously referred to as the South Asian biotype (Khush 1977) or biotype 4 (Khush 1984).

This study was undertaken to determine the genetic basis of resistance to biotype 4 (Bangladesh population) of BPH.

2. Materials and methods

Rice cultivars used in the study and their reactions to different biotypes are listed in table 1. A Northeast India cultivar ARC 10550, which is susceptible to biotypes 1, 2 and

Table 1. Rice cultivars used in the study, and their reactions to different biotypes of brown planthopper.

Cultivar	Accession No.	Gene possessed by the cultivar and reaction to biotypes: Gene	Reaction to biotypes*: 1	2	3	4
TN1	105	None	*S*	*S*	*S*	*S*
IR1539-823	32618	*Bph 1*	*R*	*S*	*R*	*S*
IR1154-243	19909	*bph 2*	*R*	*R*	*S*	*S*
Rathu Heenati	11730	*Bph 3*	*R*	*R*	*R*	*R*
Babawee	8978	*bph 4*	*R*	*R*	*R*	*R*
ARC 10550	12507		*S*	*S*	*S*	*R*

*R = resistant; S = susceptible.

3 but resistant to biotype 4, was crossed with TN1, which is susceptible to all the known biotypes of BPH. The F_1, F_2, and F_3 populations were tested for reactions to biotype 1 at IRRI, Los Banos, Philippines, and to biotype 4 at the Bangladesh Rice Research Institute (BRRI), Joydebpur, Bangladesh.

For allele tests, ARC 10550 was crossed with IR1539-823, IR1154-243, Rathu Heenati, and Babawee. F_1, F_2, and F_3 populations were tested for reaction to biotype 1 at IRRI and for reaction to biotype 4 at BRRI. The same set of F_3 lines of two crosses (IR1539-823/ARC10550 and IR1154-243/ARC10550) was tested for reaction to biotypes 1 and 4 to determine the independence of the two genes involved.

All the crosses were made at IRRI and F_1 and F_2 populations were also grown at IRRI. Part of the seed of F_1 and F_2 populations and each of the F_3 lines was used for tests against biotype 4 at IRRI and part was tested at BRRI.

Greenhouse reared populations of biotypes 1 and 4 were used. The bulk seedling test (Athwal *et al* 1971) was employed for evaluating the reaction of parents, F_1 hybrids, and segregating populations. F_1 populations and F_3 lines were scored on a row basis and were classified as resistant, susceptible, or segregating. Each seedling of the F_2 populations was classified as resistant or susceptible. Scoring was done when the seedlings of the susceptible control were killed.

3. Results

The F_1 and F_2 populations of the cross TN1/ARC 10550 were susceptible to biotype 1 as expected (table 2). The F_1 progenies of this cross were susceptible to biotype 4 but the F_2 population segregated in a ratio of 1 resistant to 3 susceptible and the F_3 families segregated in a ratio of 1 resistant:2 segregating:1 susceptible (table 2). These results show that resistance to biotype 4 in ARC 10550 is governed by a single recessive gene.

The F_1 progeny of the cross IR1539-823/ARC 10550 was resistant to biotype 1 and the F_2 population segregated in a ratio of 3 resistant to 1 susceptible. The F_3 families of this cross segregated in a ratio of 1 resistant:2 segregating:1 susceptible. These results indicated the segregation of *Bph* 1 in this cross. The F_1 progeny of this

Table 2. Reaction[a] to brown planthopper biotypes 1 and 4 of F_1 and F_2 populations and F_3 lines from the crosses of ARC 10550 with various testers.

	Reaction to biotype 1								Reaction to biotype 4							
	F_1	F_2 (No seedlings)			F_3 (No lines)				F_1	F_2 (No seedlings)			F_3 (No lines)			
Cross		R[b]	S	X^2 1:3	R	Seg	S	X^2 1:2:1		R	S	X^2 1:3	R	Seg	S	X^2 1:2:1
TN1/ARC 10550	S	0	425	—	—	—	—	—	S	57	195	0·76	28	65	31	0·44
IR1539-823/ARC 10550	R	458	173	1·96	31	77	38	1·11	S	92	295	0·31	35	77	34	0·45
IR1154-243/ARC 10550	S	181	540	0·004	36	73	27	1·93	S	96	236	2·71	33	68	35	0·06
Rathu Heenati/ARC 10550	R	322	96	0·96	37	79	34	0·55	R	153	56	8·87[c]	58	67	13	2.37[d]
Babawee/ARC 10550	S	201	523	2·95	38	82	34	0·86	S	—	—	—	—	—	—	—

[a]Reaction to biotype 1 was determined at IRRI, Philippines and reaction to biotype 4 was determined at BRRI, Bangladesh.
[b]R = resistant; Seg = segregating, S = susceptible; [c]X^2 for 13:3 ratio; [d]X^2 for 7:8:1 ratio.

Table 3. Two-way classification of F_3 lines from the crosses of ARC 10550 with IR 1539-823 and IR 1154-243, for reaction to biotypes 1 and 4 of brown planthopper[a].

Reaction to biotype 1	Reaction to biotype 4											
	F_3 lines of IR1539-823/ARC 10550 (no.)						F_3 lines of IR1154-243/ARC 10550 (no.)					
	R^b	Seg	S	Total	X^{2c}	X^{2d}	R	Seg	S	Total	X^{2c}	X^{2d}
R	7	17	7	31			5	20	11	36		
Seg	21	42	14	77	$3{\cdot}97^{ns}$	$5{\cdot}44^{ns}$	18	37	18	73	$4{\cdot}60^{ns}$	$7{\cdot}45^{ns}$
S	7	18	13	38			10	11	6	27		
Total	35	77	34	146			33	68	35	136		

[a]Reaction to biotype 1 was determined at IRRI, Philippines and reaction to biotype 4 was determined at BRRI, Bangladesh;

[b]R = resistant; Seg = segregating; S = susceptible; [c]X^2 for independence of reaction to two biotypes; [d]X^2 for 1:2:1:2:4:2:1:2:1 ratio; *ns* = nonsignificant at 5% level.

cross was susceptible to biotype 4 and the F_2 population segregated in a ratio of 1 resistant:3 susceptible. The F_3 families of this cross segregated in a ratio of 1 resistant:2 segregating:1 susceptible. The results indicated the segregation of the recessive resistance gene of ARC 10550 for biotype 4 in this cross.

The two-way classification of the F_3 lines of this cross for their reaction to biotypes 1 and 4 (table 3) showed that the recessive resistance gene of ARC 10550 segregates independently of *Bph* 1.

The F_1 progeny of the cross IR1554-243/ARC 10550 was susceptible to biotypes 1 and 4 and the F_2 population segregated in a ratio of 1 resistant:3 susceptible. The F_3 families segregated in a ratio of 1 resistant:2 segregating:1 susceptible for both biotypes. Resistance to biotype 1 was governed by *bph* 2 and the resistance to biotype 4 by the resistance gene of ARC 10550. The two-way classification of the F_3 lines of this cross for their reaction to two biotypes (table 3) showed that the two recessive genes segregate independently of each other.

The F_1 progeny of the cross Rathu Heenati/ARC 10550 was resistant to biotype 1 and the F_2 population segregated in a ratio of 3 resistant:1 susceptible. The F_3 families segregated in a ratio of 1 resistant:2 segregating:1 susceptible. These results indicated segregation of *Bph* 3 for resistance to biotype 1. The F_1 progeny of this cross was resistant to biotype 4 and the F_2 population segregated in a ratio of 13 resistant:3 susceptible. The X^2 value for the 13:3 ratio was significant but its applicability was confirmed by segregation of F_3 families in a ratio of 7 resistant:8 segregating:1 susceptible. These results indicated that the recessive resistance gene of ARC 10550 segregates independently of *Bph* 3.

The F_1 hybrid Babawee/ARC 10550 was susceptible to biotypes 1 and 4. The F_2 population and F_3 families of this cross were evaluated for resistance to biotype 2 only. F_2 segregated in a ratio of 1 resistant:3 susceptible and the F_3 families in a ratio of 1:2:1.

4. Discussion

The results show that ARC 10550 has a recessive gene for resistance to biotype 4 of BPH.

This gene does not convey resistance to biotypes 1, 2 and 3. However, it confers resistance to BPH populations in Bangladesh, India, and Sri Lanka, which are presently assumed to constitute biotype 4. This recessive gene is distinct from the other four known genes for resistance to BPH. Following the standard rules for gene nomenclature (IRC – International Rice Commission – 1959) this new gene is designated *bph* 5.

The data also show that *bph* 5 segregates independently of *Bph* 1, *bph* 2 and *Bph* 3. Since *Bph* 3 and *bph* 4 are tightly linked, it is assumed that *bph* 5 is independent of *bph* 4. It should be possible to combine *bph* 5 with either of the other genes in future rice varieties to gain a wider spectrum of resistance. This new gene should be particularly useful in developing resistant varieties for Bangladesh, India, and Sri Lanka. Numerous other varieties with resistance to biotype 4 have been identified. We are analyzing more varieties genetically to identify additional genes for resistance to biotype 4.

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