Theor. Appl. Genet. 61, 19–22 (1982)

Genetic Analysis of Resistance to Whitebacked Planthopper in Twenty-one Varieties of Rice, *Oryza sativa* L.

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Summary. The inheritance of resistance to whitebacked planthopper *Sogatella furcifera* (Horvath) was studied in 21 rice varieties. Reactions of F_1, F_2 and F_3 progenies of the crosses of 21 resistant varieties with the susceptible variety 'TN 1' revealed that a single dominant gene governs resistance in 'Mushkan 41', 'Santhi', 'Siahnakidar 195', 'SM2-34', 'Tirisurkh 251', 'Zirijowaian 245', '18', '24 A', '39', '76 S', '78', '180', '213 B', '267', '293', 'CI 6037-4', 'NP 97', 'S 39 JKW' and 'Bansphul'. In varieties '65' and '274 A', resistance is governed by one dominant and one recessive gene which segregate independently of each other. Tests for allelism with the *Wbph 1* gene originally identified in 'N 22' revealed that the dominant gene present in all the test varieties is the same as *Wbph 1*. Further studies are required to determine the allelic relationships of the recessive gene found in varieties '65' and '274 A'.

Key Words: *Sogatella furcifera* (Horvath) – Dominant gene – Recessive gene

Introduction

Because the whitebacked planthopper, *Sogatella furcifera* (Horvath) is an important insect pest of rice, incorporation of resistance is an important objective of the rice improvement program of IRRI (Khush 1978). Hundreds of rice varieties have been screened for resistance, and several were found resistant (Pathak 1972).

Genetics of resistance was first investigated by Sidhu et al. (1979). They found that a single dominant gene, designated *Wbph 1*, governs resistance in 'N 22'. Angeles et al. (1981) reported that two genes, *Wbph 1* and *Wbph 2*, govern resistance in IR 2035-117-3. Identification of these genes paved the way for their systematic incorporation into improved germplasm.

This study investigated the mode of inheritance of resistance to whitebacked planthopper in 21 additional resistant rice varieties. It also determined the allelic relationships of genes for resistance in these resistant varieties.

Materials and Methods

Twenty-one tall indica rice varieties, which showed high levels of resistance to whitebacked planthopper in tests conducted at IRRI, were selected for the study (Table 1). These varieties were used as male parents in crosses with 'Taichung Native 1' (TN 1), a semidwarf cultivar with high susceptibility to whitebacked planthopper. The F_1, F_2, and F_3 progenies from these crosses were studied to determine the mode of inheritance of resistance.

These 21 varieties also were crossed with 'N 22', a cultivar homozygous for *Wbph 1*. F_1, F_2, and F_3 progenies from these

Table 1. Whitebacked planthopper resistant rice varieties studied

Variety	IRRI Acc. no.	Country of origin
'Mushkan 41'	6,828	Pakistan
'Santhi'	28,222	Pakistan
'Siahnakidar 195'	28,265	Pakistan
'SM2-34'	28,266	Pakistan
'Tirisurkh 251	28,310	Pakistan
'Zirijowaian 245'	28,325	Pakistan
'18'	28,348	Pakistan
'24 A'	28,358	Pakistan
'39'	28,377	Pakistan
'65'	28,390	Pakistan
'76 S'	82,399	Pakistan
'78'	28,401	Pakistan
'180'	28,424	Pakistan
'213 B'	28,428	Pakistan
'267'	28,434	Pakistan
'274 A'	28,440	Pakistan
'293'	28,442	Pakistan
'CI 6037-4'	3,667	India
'NP 97'	3,700	India
'S 39 JKW'	6,836	India
'Bansphul'	28,313	Nepal

0040-5752/82/0061/0019/$ 1.00

crosses were studied to determine the allelic relationships of the resistance genes of these test varieties.

The bulk seedling test (Athwal et al. 1971) was used to evaluate the hybrid materials for whitebacked planthopper resistance. The test materials were sown in rows 5 cm apart in 60×45×10 cm flats. During the one-leaf stage, the seedlings were infested with second to third instar nymphs of the whitebacked planthopper reared on 'TN 1'. An average of five nymphs were used per seedling.

Reactions were scored 7 to 8 days after infestation when the rows of the susceptible check were completely killed. The F_1 populations were scored on a row basis. Each F_2 seedling was classified as resistant or susceptible. The F_3 lines were classified as homozygous resistant, segregating or homozygous susceptible.

Results

Inheritance of Resistance

The reactions of the F_1, F_2, and F_3 progenies from the crosses of 'TN 1' with resistant cultivars are presented in Tables 2 and 3. The F_1 seedlings of all the crosses were resistant. This indicated that resistance was dominant over susceptibility in all the 21 test varieties. The F_2 populations from the crosses of 'TN 1' with 'Mushkan 41', 'Santhi', 'Siahnakidar 195', 'SM2-34', 'Tirisurkh 251', 'Zirijowaian 245', '18', '24A', '39', '76S', '78', '180', '213B', '267', '293', 'CI6037-4', 'NP97', 'S39JKW', and 'Bansphul' segregated in a ratio of three resistant to one susceptible seedlings (Table 2), which indicated that single dominant genes govern resistance in these cultivars. In the crosses of 'TN 1' with '65' and '274A', the segregation showed a good fit to a 13 resistant to 3 susceptible ratio (Table 3). This indicated resistance in these two varieties was governed by one dominant and one recessive gene.

The F_3 families from the crosses of 'TN 1' with 'Mushkan 41', 'Santhi', 'Siahnakidar 195', 'Tirisurkh 251', 'Zirijowaian 245', '18', '24A', '39', '76S', '78', '180', '213B', '267, 293', 'CI6037-4', 'NP97', 'S39JKW', and 'Bansphul' segregated in a ratio of 1 resistant:2 segregating:1 susceptible. These results confirm the finding that resistance in these varieties is controlled by one dominant gene.

Data on the segregation of F_3 lines from the crosses of 'TN 1' with '65' and '274A' are given in Table 3. In these two crosses, the segregating families were subdivided into two categories. Segregating families with more resistant than susceptible seedlings were designated R/S. Segregating families with more susceptible than resistant seedlings were designated S/R. These data show a good fit to the expected ratio of 7 resistant:6 segregating (R/S):2 segregating (S/R):1 susceptible. These results confirm the conclusions drawn from F_2 data that resistance to whitebacked planthopper in '65' and '274A' is governed by one dominant and one recessive gene which segregate independently of each other.

Allele Tests

The reactions of F_1 and F_2 populations and F_3 lines from the crosses of N22 with resistant varieties are giv-

Table 2. Reactions of the F_1 and F_2 populations and F_3 lines from crosses of 'TN 1' with resistant cultivars to whitebacked planthopper

Cross	F_1 reaction	F_2 seedlings (no.)			F_3 lines (no.)			
		Resistant	Susc.	X^2 3:1	Resistant	Segreg.	Susc.	X^2 1:2:1
'TN1'×'Mushkan 41'	Resistant	247	92	0.83	46	75	33	2.30
'TN1'×'Santhi'	Resistant	185	73	1.49	47	75	32	3.03
'TN1'×'Siahnakidar 195'	Resistant	306	91	0.91	41	81	32	1.47
'TN1'×'SM2-34'	Resistant	297	107	0.61	29	79	43	2.92
'TN1'×'Tirisurkh 251'	Resistant	417	128	0.67	30	82	35	2.31
'TN1'×'Zirijowaian 245'	Resistant	242	88	0.49	38	68	26	2.30
'TN1'×'18'	Resistant	268	76	1.55	47	71	36	2.51
'TN1'×'24A'	Resistant	249	96	1.47	36	88	30	3.61
'TN1'×'39'	Resistant	279	74	3.07	42	82	29	3.00
'TN1'×'76S'	Resistant	344	109	0.21	39	87	28	4.17
'TN1'×'78'	Resistant	228	69	0.50	31	70	29	0.83
'TN1'×'180'	Resistant	165	53	0.06	43	79	32	1.68
'TN1'×'213B'	Resistant	268	81	0.60	46	76	32	2.57
'TN1'×'267'	Resistant	234	91	1.56	36	66	25	2.10
'TN1'×'293'	Resistant	242	78	0.07	39	82	33	1.12
'TN1'×'C16037-4'	Resistant	313	99	0.21	48	76	30	4.23
'TN1'×'NP97'	Resistant	355	109	0.56	38	61	32	1.17
'TN1'×'S39W'	Resistant	213	62	0.88	43	79	32	1.68
'TN1'×'Bansphul'	Resistant	185	71	1.02	48	71	35	3.13

Table 3. Reactions of the F_1 and F_2 populations and F_3 lines from crosses of 'TN1' with resistant varieties '65' and '274A' to whitebacked planthopper

Cross	F_1 reaction	F_2 seedlings (no.)			F_3 lines (no.)				
		Resistant	Susc.	X^2 13:3	Resistant	Segregating		Susc.	X^2 7:6:2:1
						R/S	S/R		
'TN1'×'65'	Resistant	222	45	0.63	95	74	21	18	3.94
'TN1'×'274A'	Resistant	352	69	1.54	57	67	17	13	4.53

Table 4. Reactions of the F_1 and F_2 populations and F_3 lines of crosses of 'N22' with test varieties to whitebacked planthopper

Cross	F_1 reaction	F_2 seedlings (no.)		F_3 lines (no.)		
		Resistant	Susceptible	Resistant	Segregating	Susceptible
'N 22'×'Mushkan 41'	Resistant	221	0	141	0	0
'N 22'×'Santhi'	Resistant	269	5	154	0	0
'N 22'×'Siahnakidar 195'	Resistant	283	0	154	0	0
'N 22'×'SM2-34'	Resistant	476	2	154	0	0
'N 22'×'Tirisurkh 251'	Resistant	367	8	154	0	0
'N 22'×'Zirijowaian 245'	Resistant	412	5	154	0	0
'N 22'×'18'	Resistant	384	7	154	0	0
'N 22'×'24A'	Resistant	387	0	154	0	0
'N 22'×'39'	Resistant	351	6	144	0	0
'N 22'×'65'	Resistant	282	4	152	0	0
'N 22'×'76S'	Resistant	492	6	154	0	0
'N 22'×'78'	Resistant	358	3	154	0	0
'N 22'×'180'	Resistant	384	0	145	0	0
'N 22'×'213B'	Resistant	362	7	154	0	0
'N 22'×'267'	Resistant	297	0	154	0	0
'N 22'×'274A'	Resistant	284	2	154	0	0
'N 22'×'293'	Resistant	378	9	154	0	0
'N 22'×'CI6037-4'	Resistant	379	0	147	0	0
'N 22'×'NP97'	Resistant	328	4	154	0	0
'N 22'×'S39 JKW'	Resistant	302	5	154	0	0
'N 22'×'Bansphul'	Resistant	528	0	154	0	0

en in Table 4. As expected, F_1 seedlings in all crosses were resistant. Data on the reactions of F_2 progenies from crosses of 'N 22' with the test varieties showed essentially no segregation for susceptibility. A negligible number of seedlings, however, were classified as susceptible in some crosses. Even in the resistant checks, a small number of seedlings were classified as susceptible. Similarly, all F_3 lines of these crosses showed resistant reactions. These data clearly show that the dominant genes present in all the test varieties are allelic to *Wbph 1*.

Discussion

The study revealed that a single dominant gene *Wbph 1* governs resistance to whitebacked planthopper in 'Mushkan 41', 'Santhi', 'Siahnakidar 195', 'SM2-34', 'Tirisurkh 251', 'Zirijowaian 245', '18', '24A', '39', '76S', '78', '180', '213B', '267', '293', 'CI6037-4', 'NP97', 'S39JKW', and 'Bansphul'. In varieties '65' and '274A', resistance to whitebacked planthopper is governed by *Wbph 1* and another recessive gene.

Angeles et al. (1981) reported the presence of a recessive gene for resistance to whitebacked planthopper in varieties '368', 'WC 1240', 'ARC 10239' and 'Colombo'. In '368' and 'WC 1240', in addition to the recessive gene, *Wbph 1* also is present. In 'ARC 10239' and 'Colombo', the resistance is governed by a recessive gene and *Wbph 2*. Efforts should be made to study the allelic relationships of the recessive genes identified in this study and those reported by Angeles et al. (1981).

Wbph 1 gene generally has been used as the source of resistance to whitebacked planthopper in the breeding program at IRRI. Efforts are being made to incorporate *Wbph 2* gene as an additional source of resistance. The genetic diversity for resistance to whitebacked

planthopper is expected to provide protection against any unexpected change in insect biotypes. Khush (1979) has outlined the different breeding approaches when a number of genes for resistance become available. Other varieties resistant to whitebacked planthopper have been identified. These are being systematically analyzed to identify additional genes for resistance.

Acknowledgement

Kind assistance of Ms. Esperanza Bacalangco, IRRI, in rearing the insects used in the study is gratefully acknowledged.

Literature

Angeles, E.R.; Khush, G.S.; Heinrichs, E.A. (1981): New genes for resistance to whitebacked planthopper in rice. Crop Sci. **21,** 47–50

Athwal, D.S.; Pathak, M.D.; Bacalangco, E.H.; Pura, C.D. (1971): Genetics of resistance to brown planthoppers and green leafhoppers in *Oryza sativa* L. Crop Sci. **11,** 747–750

Khush, G.S. (1978): Breeding methods and procedures employed at IRRI for developing rice germplasm with multiple resistance to diseases and insects. Trop. Agric. Res. Ser. **11,** 69–75

Khush, G.S. (1979): Breeding for multiple disease and insect resistance. In: Rice Improvement in China and other Asian Countries, pp. 219–238. Los Baños, Philippines: Int. Rice Research Institute

Pathak, M.D. (1972): Rice resistance to pests in rice varieties. In: Rice Breeding, p. 325–341. Los Baños, Philippines: Int. Rice Research Institute

Sidhu, G.S.: Khush, G.S.: Medrano, F.G. (1979): A dominant gene in rice for resistance to whitebacked planthopper and its relationship to other plant characteristics. Euphytica **28** (2) 227–232

Received May 22, 1981
Communicated by H. F. Linskens

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