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INHERITANCE OF BLAST RESISTANCE IN RICE

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ABSTRACT

The inheritance of resistance to blast was studied in seven rice cultivars, (BG 367–4, IRAT 102, IR 4547-6-2-5, Milyang 46, Secanado Brazil, Tetep and VL 8) crossed with two blast susceptible cultivars, VLK 39 and Thapachini. The F_1, F_2, BC_1 and BC_2 generations were raised and inoculated with the VLH-K1 isolate of *Pyricularia oryzae* Cav. at seedling stage. The resistance in 12 out of 15 crosses was found to be governed by a single dominant gene, while in the cross IR 4547–6–2–5 x Thapachini it was one dominant and one recessive gene. The cross between two resistant parents, Tetep and VL 8, showed allelic relationship, whereas the cross between the two susceptible cultivars, VLK 39 and Thapachini, showed that each cultivar carried a single but different recessive gene for resistance.

Key words: Rice, blast, inheritance, *Oryza sativa* L., resistance, *Pyricularia oryzae* Cav.

Blast caused by *Pyricularia oryzae* Cav. is one of the most widespread diseases occurring in the major rice growing areas worldwide resulting in severe yield losses [1]. The resistance was demonstrated to be controlled by one [2–8], two [3, 8, 9], three [6, 10, 11] or more [12, 13] genes. The present investigation aims to determine the inheritance of blast resistance in rice against VLH-K1 isolate of the pathogen.

MATERIALS AND METHODS

Seven blast resistant rice cultivars, namely, BG 367-4, IRAT 102, IR 4547-6-2-5, Milyang 46, Secanado Brazil, Tetep and VL 8; and two susceptible cultivars, Thapachini and VLK 39, were used in the study. All the test cultivars except IR 4547-6-2-5 were crossed with both the susceptible parents, while IR 4547-6-2-5 was crossed only with Thapachini. One cross each between the resistant (Tetep x VL 8) and susceptible (VLK 39 x Thapachini) parents was also made to determine allelic relationship of the resistance and susceptibility genes, respectively.

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During 1988, the F_1, F_2, BC_1 and BC_2 generations involving nine parents were evaluated for resistance and susceptibility by inoculating 21-day-old seedlings using the spore spray technique at concentration 9 x 10^{4-5} spores/ml [14]. Lesion types were scored 7 days after inoculation in the polythene house on a 0–4 scale based on IRRI 1980 system. Seedlings with 0–2 reaction (0–no lesions; 1–small brown specks of pinhead size; 2–larger brown specks) were recorded as resistant and those having lesions of 3 and 4 types (3—small, roundish to slightly elongated, necrotic grey spots, 1–2 mm in diameter with a brown margin; 4–typical blast lesion, elliptical, more than 2 mm long) as susceptible [8]. Entire populations in different generations were scored on individual plant basis. The χ^2 test using Yate's correction factor [15] for the goodness of fit was applied.

RESULTS AND DISCUSSION

Disease reactions of F_1, F_2, BC_1 and BC_2 generations were studied in 15 crosses against the isolate VLH-K1 of *P. oryzae*. The observed and expected segregation ratios, χ^2 and P range values are given in Table 1. All the F_1 plants in crosses involving resistant x susceptible parents, and the only cross involving both the resistant parents were resistant. The F_1 plants

Table 1. Inheritance of blast resistance in F_1, F_2 and backcross generations of 15 rice crosses

Cross	Generation	Total plants	Segregation R	Segregation S	Expected ratio R:S	χ^2 value	P
BG 367-4 (R) x Thapachini (S)	F_1	22	22	0			
	F_2	226	173	53	3:1	0.212	0.7–0.5
	BC_1	18	18	0			
	BC_2	24	14	10	1:1	0.375	0.7–0.5
BG 367-4 (R) x VLK 39 (S)	F_1	16	16	0			
	F_2	211	165	46	3:1	0.987	0.5–0.3
	BC_1	15	15	0			
	BC_2	36	20	16	1:1	0.250	0.7–0.5
IRAT 102 (R) x Thapachini (S)	F_1	18	18	0			
	F_2	224	174	50	3:1	0.720	0.5–0.3
	BC_1	15	15	0			
	BC_2	27	15	12	1:1	0.148	0.7
IRAT 102 (R) x VLK 39 (S)	F_1	20	20	0			
	F_2	296	220	76	3:1	0.040	0.9–0.8
	BC_1	20	20	0			
	BC_2	21	11	10	1:1	0.000	1.0
IR 4547-6-2-5 (R) x Thapachini (S)	F_1	16	16	0			
	F_2	162	135	27	13:3	0.334	0.7–0.5
	BC_1	14	14	0			
	BC_2	14	9	5	3:1	0.380	0.7–0.5

(Contd.)

Table 1 (contd.)

Cross	Generation	Total plants	Segregation		Expected ratio R:S	χ^2 value	P
			R	S			
Milyang 46 (R) x Thapachini (S)	F_1	23	23	0			
	F_2	144	114	30	3:1	1.120	0.3–0.2
	BC_1	15	15	0			
	BC_2	34	16	18	1:1	0.029	0.9–0.8
Milyang 46 (R) x VLK 39 (S)	F_1	20	20	0			
	F_2	248	191	57	3:1	0.435	0.7–0.5
	BC_1	27	27	0			
	BC_2	20	11	9	1:1	0.05	0.9–0.8
Secanado Brazil (R) x Thapachini (S)	F_1	16	16	0			
	F_2	424	316	108	3:1	0.028	0.9–0.8
	BC_1	14	14	0			
	BC_2	22	12	10	1:1	0.045	0.9–0.8
Secanado Brazil (R) x VLK 39 (S)	F_1	14	14	0			
	F_2	421	305	116	3:1	1.33	0.3–0.2
	BC_1	20	20	0			
	BC_2	30	16	14	1:1	0.033	0.9–0.8
Tetep (R) x Thapachini (S)	F_1	17	17	0			
	F_2	252	188	64	3:1	0.005	0.95–0.90
	BC_1	14	14	0			
	BC_2	3	3	0	Not considered		
Tetep (R) x VLK 39 (S)	F_1	25	25	0			
	F_2	244	185	59	3:1	0.049	0.9–0.8
	BC_1	14	14	0			
	BC_2	2	2	0	Not considered		
VL 8 (R) x Thapachini (S)	F_1	20	20	0			
	F_2	350	260	90	3:1	0.060	0.9–0.8
	BC_1	15	15	0			
	BC_2	27	12	15	1:1	0.148	0.7
VL 8 (R) x VLK 39 (S)	F_1	20	20	0			
	F_2	280	196	84	3:1	3.470	0.10–0.05
	BC_1	26	26	0			
	BC_2	33	16	17	1:1	0.000	1.0
Tetep (R) x VL 8 (R)	F_1	16	16	0			
	F_2	293	293	0	1:0		
	BC_1	21	21	0			
	BC_2	15	15	0	1:0		
VLK 39 (S) x Thapachini (S)	F_1	20	0	20	0:1		
	F_2	375	29	346	1:15	1.165	0.3–0.2
	BC_1	14	0	14	0:1		
	BC_2	15	0	15	0:1		

R—resistant, S—susceptible.

of the cross VLK 39 x Thapachini were susceptible. This indicates that the resistance in BG 367-4, IRAT 102, IR 4547-6-2-5, Milyang 46, Secanado Brazil, Tetep and VL 8 was governed by dominant genes. VLK 39, though a susceptible parent, showed the presence of a recessive gene for resistance when it was crossed with another susceptible parent Thapachini. Several workers have reported that resistance to blast is governed by dominant genes [8, 16–19] but in a few cases the resistance was also reported due to recessive genes [3, 8]. The present findings are in conformity with the earlier workers.

In F_2 generation 12 out of 15 crosses involving resistant and susceptible parents, gave monogenic inheritance, while one cross [IR 4547-6-2-5 x Thapachini] showed digenic pattern of inheritance for blast resistance. The F_2 plants of the cross between the resistant cultivars Tetep and VL 8 did not show any segregation. However, the cross between the two susceptible cultivars VLK 39 x Thapachini exhibited a ratio of 1R : 15 (S). Considering the overall results it is deduced that resistance was monogenic dominant to isolate VLH-K1 in 12 crosses, viz., BG 367-4 x Thapachini, BG 367-4 x VLK 39, IRAT 102 x Thapachini, IRAT 102 x VLK 93, Milyang 46 x Thapachini, Milyang 46 x VLK 39, Secanado Brazil x Thapachini, Secanado Brazil x VLK 39, Tetep x Thapachini, Tetep x VLK 39, VL 8 x Thapachini and VL 8 x VLK 39. The monogenic pattern of inheritance in these crosses was confirmed by screening the plants of backcross generations against the isolate except in the cross Tetep x Thapachini and Tetep x VLK 39, due to nonavailability of sufficient number of BC_2 seedlings, but these two crosses showed a good fit to the segregation of 3R : 1S in F_2 generation. The findings of monogenic inheritance of dominant nature for resistance are in agreement with the results of several workers [4, 5, 7, 16, 20–23]. Tetep is a well known donor for resistance to blast and has been widely used as a source for resistance in developing blast resistant varieties [24]. Its nature of resistance to specific isolates (races) has also been studied. Though resistance in Tetep is reported to be governed by more than one gene [8, 11, 12], presence of one dominant gene governing resistance in this variety has also been confirmed [3, 8] against specific races / isolates. Moreover, the expression of the gene depends on the virulent gene(s) present in the fungus. If a race changes, the pattern of resistance may also change.

The F_2 generation of the cross IR 4547-6-2-5 x Thapachini, segregated into 13(R) : 3(S) ratio, indicating the presence of one dominant and one recessive gene governing resistance to isolate VLH-K1 which was also confirmed by backcross data, giving a good fit to the expected 3R : 1S ratio. Similar inheritance has also been reported for the cross Brazos x Galfrose [25]. Two resistance genes (one dominant and one recessive) have also been reported in case of variety Nira to the US race 2 [26].

In a cross between the resistant parents Tetep x VL 8, there was no segregation in F_2 as well as in backcrosses. All the plants displayed resistance to the disease. This indicated that genes governing resistance to isolate VLH–K1 in Tetep and VL 8 are allelic or closely linked which is in confirmity with earlier reports [3, 11, 25]. Tetep has been widely used as a donor of blast resistance. Since no segregation was observed in the cross between these two cultivars in the present study, it can be assumed that hybridization with any of the two varieties will generate genetically identical resistant lines against fungus isolates like VLH-K1.

The results of the cross between the two susceptible cultivars, VLK 39 and Thapachini, showed that each cultivar carries a single but different recessive gene for resistance. The resistant phenotype was produced only when both the recessive genes were present in homozygous state. Similar results from crosses between susceptible genotypes carrying dominant genes for susceptibility have also been reported in PI 180061 and Yakeiko [3]. The present study also indicates the possibility of evolving resistant materials by crossing at least some of the susceptible cultivars if they carry different recessive genes for resistance. However, the recessive genes should preferably be used only when dominant sources are not available as this needs screening of a larger population to recover resistant phenotypes (1 out of 16) and the chances of breaking down the resistant reaction are quite high. The most durable form of resistance can be created by combining dominant as well as recessive genes for resistance against a specific pathogen as the two sets of genes will protect the plant simultaneously through different mechanisms.

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