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Inheritance of Resistance in Rice Cultivars, Toyonishiki, Milyang 23 and IR 24 to Myanmar Isolates of Bacterial Leaf Blight Pathogen

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Abstract

In order to identify resistance genes for bacterial leaf blight in some selected rice cultivars, Toyonishiki, Milyang 23 IR 24 and Cas 209, and their hybrids were subjected to test with new isolates of the pathogen. Toyonishiki was resistant to the two Myanmar isolates, BM8417 and BM8429 and susceptible to the Japanese isolate H8584. Milyang 23 and IR 24 were resistant to all these isolates. Cas 209 was resistant to the Japanese isolate, but susceptible to the Myanmar isolates. The F_2 analysis indicates that Milyang 23 and IR 24 have two dominant genes, consisting of one for resistance to the Myanmar isolates and the other for resistance to the Japanese isolate. Toyonishiki, Milyang 23 and IR 24 share a dominant gene for resistance to the Myanmar isolates. Cas 209 has a dominant gene identical to that of Milyang 23 and IR 24. This gene, apart from another gene of *Xa-10*, controls resistance to H8584, a Japanese isolate. This resistance gene conveyed by Milyang 23, IR 24 and Cas 209 might be identical to that of Te-tep identified by Noda and Ohuchi. The gene in Toyonishiki, Milyang 23 and IR 24 for resistance to the Myanmar isolates is recognized as a new resistance gene. It was designated as *Xa-18* by the Rice Genetic Cooperative.

Discipline: Plant disease

Additional key words: near-isogenic line, *Oryza sativa*, recurrent parents, resistance gene *Xa-18*, *Xanthomonas campestris* pv. *oryzae*

Introduction

In initiating a project with an objective of establishing a set of near-isogenic lines of rice each carrying a single gene for resistance to bacterial leaf blight (BB) (*Xanthomonas campestris* pv. *oryzae*), the following three cultivars were selected as the recurrent susceptible parents: Toyonishiki, Milyang 23 and IR 24[3]. These cultivars were recognized to be susceptible to all the races of BB in Japan and the Philippines at that time. At the onset of the project implementation, a number of BB isolates were collected from various Asian countries, including Bangladesh, India, Indonesia, Malaysia, Myanmar, Nepal, Philippines and Thailand. Among the isolates collected, two were identified to be avirulent to the above recurrent parents and virulent to Te-tep and Cas 209[4]. It was reported later on that one isolate collected in Japan was avirulent to Milyang 23 and IR 24, while it was virulent to Toyonishiki[2].

It was therefore required to remove the resistance gene(s) carried by Milyang 23 and IR 24 in developing near-isogenic lines with single resistance gene each. At first, an analysis was undertaken regarding the inheritance of resistance of the three cultivars, Toyonishiki, Milyang 23 and IR 24, to the Myanmar and the Japanese isolates. This analysis was followed by the attempt to develop susceptible lines with a Toyonishiki, Milyang 23 or IR 24 genetic background without any resistance genes to the isolates. This paper presents the inheritance of resistance in these three cultivars.

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Materials and methods

Varietal crossings were made among the selected three cultivars, Toyonishiki, Milyang 23 and IR 24. Each of them was also crossed with Cas 209, which is one of the IRRI (International Rice Research Institute) BB differentials.

The concerned parents, the F_1 hybrids and the F_2 plants were transplanted in pots (1/5000 a, 2 plants per pot) in about 3 weeks after seeding. Tillers of each plant were divided into three or four bundles for the simultaneous inoculations with different isolates.

The hybrids between the recurrent parents and Cas 209 were inoculated by two Myanmar isolates, BM8417 and BM8429, a Japanese isolate H8584, and a Philippine isolate PXO86 (race 2). The hybrids from the crossings among the recurrent parents were inoculated by the Myanmar and the Japanese isolates.

Bacterial suspension of n × 10^7 cells per m*l* was clip-inoculated at the booting to flowering stage. The reaction of each plant was recorded in 3 to 4 weeks after inoculation.

All inoculation tests were conducted in the isolation greenhouse at the Tropical Agriculture Research Center in Tsukuba, Japan in 1988.

Results and discussion

1) Reaction of the parents and their F_1 hybrids to the isolates

In regard to the resistant and susceptible reaction of the cultivars and their hybrids to the isolates, the differentiations were highly distinctive. No symptoms were seen in the incompatible host-and-isolate combination, while typical lesions developed in the compatible one.

As shown in Table 1, Toyonishiki was resistant to the two Myanmar isolates, whereas susceptible to the Japanese and the Philippine isolates. Milyang 23 and IR 24 were resistant to the two Myanmar isolates and the Japanese isolate, while susceptible to the Philippine isolate. On the other hand, Cas 209 was suceptible to the two Myanmar isolates and resistant to the Japanese and the Philippine isolates.

The F_1 hybrid of Toyonishiki/Milyang 23 showed a resistant reaction to the Japanese isolate, and the F_1 hybrids of the recurrent parents/Cas 209 were resistant to all the four inoculated isolates. This result suggests that the resistance genes involved in these reactions be dominant.

Table 1. Reaction of rice cultivars and their F_1 hybrids to the Myanmar, Japanese and Philippine isolates

Parent or cross	Reaction to each isolate*			
	Myanmar		Japan	Philippine
	BM8417	BM8429	H8584	PXO86
Toyonishiki	R	R	S	S
Toyonishiki/Milyang 23	R	R	R	S
Milyang 23	R	R	R	S
Milyang 23/IR 24	R	R	R	S
IR 24	R	R	R	S
Cas 209	S	S	R	R
Toyonishiki/Cas 209	R	R	R	R
Milyang 23/Cas 209	R	R	R	R
IR 24/Cas 209	R	R	R	R

* R: Resistant, S: Susceptible.

Table 2. Segregations in the F_2 populations of the crosses between the recurrent parents and Cas 209

Cross		Reaction pattern of the F_2 plants to BM8417, BM8429, H8584 and PXO86**								χ^2	P
		RRRR	RRRS	RRSR	SSRR	RRSS	SSRS	SSSR	SSSS		
Toyonishiki/Cas 209	O*	125	40	36	43	10	18	15	7	4.502	0.7–0.8
	E	124	41	41	41	14	14	14	5	(27:9:9:9:3:3:3:1)***	
Milyang 23/Cas 209	O	160	42		57		20			2.901	0.3–0.5
	E	157	52		52		17			(9:3:3:1)	
IR 24/Cas 209	O	147	50		61		27			7.459	0.05–0.1
	E	160	53		53		18			(9:3:3:1)	

* O: Observed number, E: Expected number.

** The combined four capitals stand for the reactions to the isolates BM8417, BM8429, H8584 and PXO86 from left to right, respectively.
R: Resistant, S: Susceptible.

*** Expected ratio in parenthesis.

2) Segregation of resistance in the F_2 populations of the crosses between the recurrent parents and Cas 209

The F_2 plants from the crossing of Toyonishiki/Cas 209 showed various patterns of the reactions to the four isolates. However, all the plants resistant to the Myanmar isolate BM8417 were also resistant to BM8429, and those susceptible to BM8417 were also susceptible to BM8429 without any exceptions. Therefore, it may be concluded that the resistance to the two Myanmar isolates is controlled by the same gene. In that F_2 population, 211 palnts were resistant and 83 plants were susceptible to the Myanmar isolates. The segregation fits a ratio of 3 : 1 (χ^2 = 1.637, P: 0.2–0.3). This result indicates that Toyonishiki carries one dominant gene for resistance to the two Myanmar isolates. Regarding the reactions to the Japanese isolate H8584, to which Toyonishiki is susceptible and Cas 209 is resistant, the F_2 population showed a segregation of 226 resistant and 68 susceptible plants, fitting well a ratio of 3 : 1 (χ^2 = 0.549, P: 0.3–0.5). This result shows that Cas 209 carries one dominant gene for resistance to H8584. The reactions of the same F_2 population to the isolate PXO86 (Philippine race 2) were: 219 plants resistant and 75 susceptible. This segregation also fits well a ratio of 3 : 1 (χ^2 = 0.041, P: 0.8–0.9). This fitness confirms that Cas 209 carries one dominant gene, designated *Xa-10*, resistant to Philippine race 2[5].

Following was the segregation in the F_2 population of the cross of Toyonisiki/Cas 209: 125RRRR, 40RRRS, 36RRSR, 43SSRR, 10RRSS, 18SSRS, 15SSSR and 7SSSS, where the combined four capitals stand for the reactions to the isolates to BM8417, BM8429, H8584, and PXO86 from left to right, respectively. This segregation fits well a ratio of 27:9:9:9:3:3:3:1, implying that three dominant genes are associated independently.

From the result as described above, it is concluded that Toyonishiki carries one dominant gene for resistance to the two Myanmar isolates, BM8417 and BM8429, while Cas 209 carries one dominant gene to the Japanese isolate H8584 in addition to *Xa-10*, and that the three resistance genes inherit independently each other.

The F_2 population of the cross of Milyang 23/Cas 209 did not segregate any plants susceptible to H8584. Therefore, Milyang 23 is identified to carry the same gene as that of Cas 209, showing resistance to that isolate. On the other hand, 202 plants resistant and 77 plants susceptible to the two Myanmar isolates were segregated in the same F_2 population. This segregation fits well a ratio of 3 : 1 (χ^2 = 1.005, P: 0.3–0.5). Concerning the reaction to the Philippine isolate PXO86, 217 plants were resistant and 62 susceptible. This also fits well a ratio of 3 : 1 (χ^2 = 1.148, P: 0.2—0.3). These results indicate that in addition to a resistance gene to the Japanese

isolate H8584, Milyang 23 carries one dominant gene for resistance to the two Myanmar isolates, while Cas 209 carries, in addition to *Xa-10*, one dominant gene for resistance to H8584. The segregation of each reaction pattern fits a ratio of 9RRRR : 3RRRS : 3SSRR : 1SSRS (χ^2 = 2.901, P:0.3–0.5) in the F_2 population of Milyang 23/Cas 209. Therefore, it is concluded that the resistance gene of Milyang 23 to the Myanmar isolates is independent from *Xa-10* of Cas 209. A similar result was obtained in the cross of IR 24/Cas 209, where the F_2 population showed a segregation of 147RRRR, 50RRRS, 61SSRR, 27SSRS, which fits a ratio of 9:3:3:1. Those data suggest that IR 24 carries two dominant resistance genes, comprising one for resistance to the two Myanmar isolates, and the other to the Japanese isolate H8584 which is identical to the resistance gene of Cas 209.

In conclusion, the above results indicate that Milyang 23 and IR 24 carry one dominant gene for resistance to the Japanese isolate H8584, which is, apart from *Xa-10*, also conveyed by Cas 209. Toyonishiki, Milyang 23 and IR 24 convey one dominant gene for resistance to the Myanmar isolates, BM8417 and BM8429. A further study is required to determine whether the resistance gene or genes carried by the different recurrent parents are all identical.

3) Segregation of resistance to H8584 in the F_2 populations of the crosses among the recurrent parents

The F_2 population, 243 plants in size, of Toyonishiki/Milyang 23 showed no segregation of the plants susceptible to the two Myanmar isolats, BM8417 and BM8429, while that population segregated 186 resistant and 52 susceptible plants to the Japanese isolate H8584. This segregation of the population fits well a ratio of 3 : 1 (χ^2 = 1.261, P: 0.2–0.3). The F_2 population, 229 plants in size, of Toyonishiki/IR24 did not also segregate any susceptible plants to the Myanmar isolates, while the population segregated 171 resistant and 55 susceptible plants to H8584, fitting well a ratio of 3 : 1 (χ^2 = 0.053, P: 0.8–0.9).

From these results, it is concluded that Toyonishiki, Milyang 23 and IR 24 carry the same gene which is resistant to the Myanmar isolates, BM8417 and BM8429, and that Milyang 23 and IR 24 carry one dominant gene for resistance to the Japanese isolate H8584.

The F_2 population of Milyang 23/IR 24 did not segregate any susceptible plants when 172 and 165 plants were inoculated by the two Myanmar isolates and by the Japanese isolate, respectively. This result confirms that the resistance of Milyang 23, IR 24 and Cas 209 to H8584 is controlled by the same gene, and that the resistance of the former two cultivars and Toyonishiki to the Miyanmar isolates is governed by another common gene.

Noda and Ohuchi[2] identified in cultivar Te-tep a dominant gene for resistance to the Japanese isolate H8584. That resistance gene was designated *Xa-16* according to the rule of gene nomenclature of rice[1]. The gene for resistance to H8584 in Milyang 23, IR 24 and Cas 209 subjected to genetic analysis in the present study might be the same with that gene identified by Noda and Ohuchi.

The present study has identified for the first time a resistance gene conveyed by Toyonishiki, Milyang 23 and IR 24, which is effective for the following two Myanmar isolates, BM8417 and BM8429.

The Rice Genetics Cooperative has recently approved to designate that specified gene as *Xa-18*. It is proposed that in the rice breeding program for resistance to BB with the use of Toyonishiki, Milyang 23 or IR 24 as a parent, the resistance genes identified in the present study be fully taken into consideration.

References

1) Kinoshita, T. (1986): Report of the committee on gene symbolization, nomenclature and linkage groups. *Rice Genet. Newsl.*, **3**, 4–5.
2) Noda, T. & Ohuchi, A. (1989): A new pathogenic race of *Xanthomonas campestris* pv. *oryzae* and inheritance of resistance to it. *Ann.Phytopathol. Soc. Jpn.*, **55**, 201–207.
3) Ogawa, T. & Yamamoto, T. (1987): Selection of recurrent parent to develop near-isogenic lines resistant to bacterial leaf blight of rice. *JARQ*, **21**, 65–69.
4) Yamamoto, T. & Ogawa, T. (1988): The distribution of *Xanthomonas campestris* pv. *oryzae* races in tropical Asian countries (abst.). *In* 5th Internat. Congr. Pl. Pathol. 257.
5) Yoshimura, A. et al. (1983): Inheritance of resistance to bacterial blight in rice cultivar Cas 209. *Phytopathology*, **73**, 1409–1412.

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