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Grouping of Rice Cultivars based on Reaction Pattern to Philippine Races of Bacterial Blight Pathogen (*Xanthomonas campestris* pv. *oryzae*)

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For identifying new sources of resistance to bacterial blight of rice, we inoculated rice cultivars from the International Rice Germplasm Center (IRGC) of International Rice Research Institute (IRRI) with races 1, 2, 3, and 4 of bacterial blight pathogen from Philippines. Based on the reaction patterns to the four races, rice cultivars were classified into eight groups. Four groups are based on single genes. (1) Java 14 group having resistance to four races with brownish margins around lesions. Cultivars of this group have *Xa-3* for resistance. (2) TKM 6 group with resistance to race 1, moderate resistance to race 4 but susceptibility to races 2 and 3. Cultivars of this group have *Xa-4.* (3) DZ 192 group with resistance to races 1, 2 and 3 and moderate resistance to race 4. Cultivars of this group have *xa-5.* (4) CAS 209 group with resistance to race 2 only. Cultivars of this group have *Xa-10.* Four groups, each having two genes were recognized. These groups are: Mond Ba (*Xa-4*+*Xa-10*), DV85 (*xa-5*+*Xa-7*), Makhmal Mehi (*xa-5*+*Xa-4*), and BJ1 (*xa-5*+*xa-13*). Electrophoretic variation at isozyme loci was examined in a number of cultivars belonging to different groups. These results suggest that the differentiation of BB resistance genes probably linked with the differentiation of cultivars into distinct ecotype.

KEY WORDS: *Oryza sativa, Xanthomonas campestris* pv. *oryzae,* disease resistance, varietal differentiation, isozymes.

Introduction

Rice cultivar were initially divided into four groups (Kinmaze, Kogyoku, Rantai Emas and Wase Aikoku) based on reaction to Japanese races of bacterial blight (BB) pathogen (*Xanthomonas campestris* pv. *oryzae* (KOZAKA 1969, EZUKA and HORINO 1974). YAMAMOTO *et al.* (1977) reclassified Wase Aikoku group into two groups, e.g., Wase Aikoku and Java groups, based on the reaction of cultivars of this group to Indonesian races. In addition, YAMADA *et al.* (1979) described two new groups (Elwee and Heen Dikwee groups) based on reaction of rice cultivar to five Japanese races. Five rice cultivars (IR8, IR20, IR1545-339-2-2, CAS209, and DV85) have been employed as differentials at IRRI to identify six races of BB pathogen in Philippines (MEW 1987) (Table 1).

About 80,000 rice cultivars from different countries are being maintained in the International Rice Germplasm Center (IRGC) of IRRI. In 1983, we started screening this collection using four BB races from Philippines to identify additional genes for resistance and to study the distribution of known genes in different countries.

We have classified resistant rice cultivars into eight groups based on their reaction pat-

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tern to four BB races. These reaction patterns correspond to those of rice cultivars with known genes for resistance.

The study was carried out at IRRI, Los Banos between 1983~1988 under a collaboration research between Ministry of Agriculture, Forestry and Fisheries of Japan and IRRI.

Materials and Methods

Department of Plant Pathology, IRRI, screened about 30,000 rice cultivars using BB races from Philippines and more than 3,000 were found to be resistant. We further studied bout 1,400 of these cultivars with high level of resistance to Philippines races. The seeds for this study were obtained from IRGC.

Three to five plants to each cultivar were planted in a plastic bucket with a capacity of about 11.4 liters. At booting stage, the tillers of each plant were tied into four groups by using vinyl ties of different colors. Each cultivar was inoculated with Philippine race 1 (isolate PXO61), race 2 (isolate PXO86), race 3 (isolate PXO79) and race 4 (isolate PXO71), and later some cultivars were inoculated with Philippine race 5 (isolate PXO112) and race 6 (isolate PXO99). One group of tillers of each plant was inoculated with one race. Scoring was done at 18 days after inoculation (DAI). The lesion length of every plant was measured, and lesion symptom were recorded for every cultivar. Detailed procedures of inoculation and scoring for resistance were desribed by OGAWA *et al.* (1990).

The cultivars were assigned to different groups on the basis of their reaction to four BB races. They were then crossed with IR24 (susceptible to four BB races) and IR1545-339, having *xa-5*. The F_1 hybrids were inoculated with four BB races following the method described above.

Morphological observations on the cultivar groups were recorded. Allelic variation at 6 isozyme loci (*Pgi-1, Pgi-2, Amp-1, Amp-2* and *Amp-3*) of some cultivars was examined following the method described by GLASZMANN (1986, 1987) and GLASZMANN *et al.* (1988).

Table 1. Rice bacterial differentials and their reaction to six races of bacterial blight from Philippines (MEW 1987)

Differential Cultivar	Reaction[1] to Philippine BB races					
	1	2	3	4	5	6
IR8	S	S	S	S	S	S
IR20	R	S	S	X	R	S
IR1545-339	R	R	R	S	R	S
CAS 209	S	R	S	S	R	S
DV85	R	R	R	R	R	MS

[1] R = resistant, S = susceptible, MR = moderately resistant, MS = moderately susceptible, X = variable reaction.

Results

Out of 1,441 cultivars studied, 56 were heterogeneous for resistance to four Philippine races. These cultivars were divided into distinct lines depending upon their reaction to different races. The test cultivars were initially classified into five groups based upon the reaction patterns to four Philippine races as follows:

Java 14 group

The cultivars of this group are resistant to four Philippine races and develop brownish margins around the BB lesions (Fig. 1). The lesion length was variable from cultivar to cultivar but the lesion development stopped about 18 to 21 days after inoculation. This reaction pattern is very similar to those of Java 14, Zenith, Semora Mangga and Sateng which have the gene allelic to *Xa-3*. The cultivars of this group show similar morphology. Most of them have bold grains, long awns, large panicles and a few tillers. These characteristics are similar to those of bulu or javanica group of rice cultivars. This group was designated as Java 14 group. Representative cultivars of this group are listed in Table 2.

TKM 6 group

Cultivars of this group are resistant to race 1 and moderately resistant to race 4, but are susceptible to race 2 and 3 (Fig. 1). This reaction pattern is very similar to that of IR 20 which has *Xa-4*. IR20 inherited its resistance to BB from TKM 6. Therefore, we designated this group as TKM 6 group. The cultivars of this group show typical *indica* type morphology. Representative cultivars of this group listed in Table 2.

DZ 192 group

Cultivars of this group have relatively stable reaction to Philippine races. They are resistant to races 1, 2, and 3 but do not form brownish margins around lesions (Fig. 1). The cultivars of this group show variable level of resistance to race 4. This reaction pattern was first noted in IRRI differential IR1545-339 which has *xa-5*. IR1545-339 inherited *xa-5* from DZ 192. Some cultivars showed stable resistance to four races but without brownish margins around lesions. These cultivars were included in DZ 192 group and not in Java 14 group. Cultivar of this group resemble aus or boro rices of Bangladesh. Representative cultivars of this group are also listed in Table 2.

CAS 209 and Mond Ba groups

Cultivars of a group are resistant to race 2 only (Fig. 1). This reaction pattern was first noted in IRRI differential CAS 209. Some cultivars showed resistance to race 1, high resistance to race 2, moderate resistance to race 4, and susceptibility to race 3. Cultivars with this reaction have *Xa-4* and *Xa-10* (Sahu and Khush 1989). This reaction pattern was first noted in Mond Ba. Therefore cultivars with this reaction pattern were assigned to Mond Ba group.

Table 2. Reaction of rice cultivar to Philippine races of bacterial blight pathogen. IRRI, 1983–1986

Cultivar name	Acc. no.	Lesion length upon inoculation with BB races				Origin
		1	2	3	4	
Java 14 group (n=389)						
Abi Manyu	26294	3.6	2.6	2.7	3.6	Indonesia
Akondi Balam	31693	10.6	7.0	6.3	7.9	Bangladesh
Beiao	13144	2.7	3.1	4.3	2.3	Malaysia
Bitti Seke	15119	5.1	4.2	3.1	2.6	Ivory Coast
Blue Bonnet/Rexark	2106	8.2	4.0	4.6	5.5	USA
Kenteng	29966	8.4	5.1	10.7	8.3	Laos
Kyeni	33283	3.2	3.0	2.6	3.6	Myanmer
TKM 6 group (n=272)						
Amane	11973	7.9	24.6	25.6	14.8	Sri Lanka
Apolo	25168	7.8	23.6	21.0	9.5	Indonesia
Arya 66	19925	6.2	38.9	31.2	12.3	India
Gokaung	33079	3.3	15.1	21.9	5.0	Myanmer
Hom Thong	12969	1.45	13.6	17.7	3.5	Laos
Kading Thong	29753	0.8	13.6	19.0	3.9	Cambodia
Tolil 14	13936	1.2	17.8	18.1	3.3	Malaysia
DZ 192 group (n=404)						
AUS 1	28864	5.9	4.4	3.5	17.8	Bangladesh
Ba Kieu	16855	5.8	4.9	4.7	9.2	Vietnam
Babuniya Saroo	16263	1.5	4.0	2.7	15.2	Nepal
Munji 220	28051	3.0	5.4	6.5	13.9	Pakistan
Myawutyi	33416	1.8	1.3	1.8	2.4	Myanmer
BJ 1	3711	2.4	4.7	3.3	3.0	India
Chinsura Boro II	11484	0.9	4.4	2.6	1.3	India
Cas 209 group (n=16)						
Aghanisail	25827	18.2	0.6	17.2	15.4	Bangladesh
Arai Raj	26536	10.8	2.9	10.8	9.6	Bangladesh
Bhua Balam	31729	17.9	1.5	18.4	13.2	Bangladesh
Ganga Sagar	31650	24.0	0.4	28.6	26.5	Bangladesh
HR 12	674	39.3	0.4	36.9	35.5	India
Huson Dhaw	26644	11.0	1.1	12.8	9.4	Bangladesh
Kanchanchari	31837	12.6	1.4	6.8	11.3	Bangladesh
Monda Ba group (n=22)						
Bais Moti	26293	5.2	1.8	14.8	10.9	Bangladesh
Gutti-Akkullu	26850	5.5	1.1	12.0	10.3	India
Khoia Motor 2	26380	4.0	0.3	10.4	4.7	Bangladesh
Mond Ba	15813	10.8	2.4	24.4	23.7	Senegal
SLO 2	678	4.8	0.4	29.6	16.3	India
Sheel Komal	31689	2.7	0.6	12.3	7.6	Bangladesh
Tellathokka Vadlu	28615	4.5	1.0	20.6	9.2	India

Score is average lesion length (3 leaves × 3 plants).

Table 3. Distribution of rice cultivars according to their reaction patterns to four Philippine BB races. IRRI, 1983–1986

Country of origin	No. of cultivars belonging to each group			
	Java 14 group	TKM 6 group	DZ 192 group	CAS 209/Mond Ba group
Korea	5			
China	5			
China, Taiwan	5	1		
Vietnam	2	2	2	
Cambodia		1	1	
Laos	9	9	9	
Thailand	8	4		
Malaysia	1	1		
Myanmer	1	9	3	1
Philippine	11			
Bangladesh	72	46	360	24
Nepal		1	17	
India		61	74	8
Pakistan		1	10	
Sri Lanka	1	59	2	
Indonesia	204	42	4	2
Egypt	3			
Ivory Coast	9			
Liberia	13	9		1
Malagasy	4			
Iran	2			
USA	3			

The geographical distribution of different groups is shown in Table 3. The cultivars of Java 14 group have wider distribution than cultivars of other groups. Cultivars of TKM 6 group mainly come from Bangladesh, India, Sri Lank and Indonesia and cultivars of DZ 192 group mainly come from Bangladesh, Nepal, India and Pakistan.

About 100 cultivars could not be classified into any of the above groups. These cultivars were reinoculated and were also crossed with various testers for genetic analysis.

Reaction of F_1 hybrids between selected cultivars and IR24

The reaction to four BB races of F_1 hybrids between IR24 and selected cultivars is shown in Table 4. On the basis of these reactions, 3 additional groups of rice cultivars were identified. The reaction pattern of F_1 hybrids of each group is as follows.

Java 14 group

The F_1 hybrids between IR24 and cultivars of Java 14 group showed resistance to four

Table 4. Reaction of F_1 hybrids of IR24 and resistant cultivars to four Philippine races of bacterial blight pathogen IRRI, 1986—1987

Cross	Lesion length[1] upon inoculation with BB races				Cultivar group	Estimated gene
	1	2	3	4		
IR24/Akuku Do	15.3	8.9	7.6	4.7	Java 14	*Xa-3*
IR24/Zoo Ji Do	12.3	6.1	5.2	6.0	Java 14	*Xa-3*
IR24/Basful 714	11.1	9.7	5.1	8.0	Java 14	*Xa-3*
IR24/Kalilfira 286	14.2	9.7	4.9	9.9	Java 14	*Xa-3*
IR24/Charib	9.0	3.8	0.9	6.5	Java 14	*Xa-3*
IR24/Moragollagama	11.5	29.5	36.3	30.7	TKM 6	*Xa-4*
IR24/Panaimara Sambo	5.7	25.6	20.2	18.8	TKM 6	*Xa-4*
IR24/Halsudu Heenati	5.5	32.9	31.9	18.7	TKM 6	*Xa-4*
IR24/TKM 6	5.8	22.9	25.4	15.5	TKM 6	*Xa-4*
IR24/Muhudukiriel	8.1	28.2	26.3	17.6	TKM 6	*Xa-4*
IR24/Mond Ba	11.2	2.5	23.4	21.4	Mond Ba	*Xa-4+Xa-10*
IR24/ADT 22	6.0	2.9	29.7	8.4	Mond Ba	*Xa-4+Xa-10*
IR24/ARC 5793	12.5	2.5	23.6	20.1	Mond Ba	*Xa-4+Xa-10*
IR24/Aghanissail	5.4	0.7	19.9	16.6	Mond Ba	*Xa-4+Xa-10*
IR24/Bais Moti	6.8	1.8	29.1	13.0	Mond Ba	*Xa-4+Xa-10*
IR24/Hashakumira	33.7	26.4	29.2	23.7	DZ 192	*xa-5*
IR24/Laksmi Dia	29.4	20.8	20.0	23.3	DZ 192	*xa-5*
IR24/Loroi	27.4	24.8	22.1	26.0	DZ 192	*xa-5*
IR24/Aus 45	25.2	28.5	28.3	27.5	DZ 192	*xa-5*
IR24/Bathuri	26.1	27.4	22.3	27.6	DZ 192	*xa-5*
IR24/Aus 71	10.7	1.4	0.5	26.7	DZ 192	*xa-5+Xa-7*
IR24/Aus 295	2.4	5.4	4.0	23.0	DZ 192	*xa-5+Xa-7*
IR24/DV 139	13.0	1.2	0.7	28.2	DZ 192	*xa-5+Xa-7*
IR24/Bokai	3.8	3.3	2.7	22.5	DZ 192	*xa-5+Xa-7*
IR24/DV 32	5.0	2.3	0.9	22.7	DZ 192	*xa-5+Xa-7*
IR24/Poongar	11.2	32.0	35.4	27.1	DZ 192	*xa-5+Xa-4*
IR24/Kalonchi	4.5	25.4	25.3	15.7	DZ 192	*xa-5+Xa-4*
IR24/Makhmal Mehi	7.2	18.0	18.5	19.2	DZ 192	*xa-5+Xa-4*
Ir24/Bhaturi	5.4	26.8	24.9	18.2	DZ 192	*xa-5+Xa-4*
IR24/Aus 25	5.2	27.6	20.4	18.3	DZ 192	*xa-5+Xa-4*
IR24/Bazail 372	36.8	3.2	26.7	26.0	CAS 209	*Xa-10*
IR24/Mugi	21.2	2.7	34.1	31.8	CAS 209	*Xa-10*
IR24/Gutti-Akkulu	21.4	3.2	22.8	21.0	CAS 209	*Xa-10*
IR24/Bhorgelam	27.5	5.2	23.2	23.3	CAS 209	*Xa-10*
IR24/Khar Mao	18.0	1.8	36.2	30.3	CAS 209	*Xa-10*

1) Score is the average lesion length (3 leaves × 3 plants) at 18 DAI.

Philippine races, with relatively long lesion to race 1, and brownish margins around lesions. These reactions are similar to those of cultivars with *Xa-3*, such as Java 14, Zenith and Sateng. The reaction pattern of F_1 hybrids that cultivars classified into Java 14 group have at least one dominant gene for resistance which was estimated to be *Xa-3*.

TKM 6 group

All F_1 hybrids showed resistance to race 1, moderate resistance or susceptibility to race 4 and susceptibility to races 2 and 3. This reaction is very similar to that of IR20 which has *Xa-4*. Therefore, the resistance in this group was considered to be controlled by at least one dominant gene which appears to be identical to *Xa-4*.

DZ 192 group

A great majority of F_1 hybrids showed susceptibility to four Philippine races. Therefore, most of the cultivars classified into DZ 192 group were considered to have recessive gene(s). However, F_1 hybrids of some cultivars showed resistance or moderate resistance to race 1, resistance to races 2 and 3 and susceptibility to race 4. This reaction was similar to that of F_1 hybrids between a susceptible cultivar and DV85 which is known to have *Xa-7* in addition to *xa-5* (SIDHU *et al.* 1978). These cultivars consitute a distinct group and presumably have *xa-5* and *Xa-7*. The F_1 hybrids of another group of cultivars showed resistance to races 1, to moderate resistance to race 4 and susceptibility to races 2 and 3. This reaction pattern is similar to that of IR20 and suggests that cultivars belonging to this group have *Xa-4* as well as *xa-5*.

CAS 209 group

The F_1 hybrids of some cultivars showed resistance to race 2 only. This reaction pattern is similar to that of CAS209 and presumably these cultivars have *Xa-10* for resistance.

Mond Ba group

The F_1 hybrids of some cultivars showed resistance to races 1 and 2 and moderate races 1, to moderate resistance to race 4 and susceptibility to races 2 and 3. This reaction pattern is similar to that of IR20 and suggests that cultivars belonging to this group have *Xa-4* as well as *xa-5*.

Reaction of hybrids between cultivars of DZ 192 group and IR1545-339

On the basis of reaction to four BB races, of their F_1 hybrids with IR24, the cultivars of DZ 192 group were estimated to possess either *xa-5* alone, or *xa-5* and *Xa-4* or *xa-5* and *Xa-7*. However, differences in reaction to race 4 of cultivars of DZ 192 were noted. Some cultivars were only moderately resistant whereas others were highly resistant to race 4. We crossed several cultivars of this group with IR1545-339 which has *xa-5* only. The result of inoculation tests of F_1 hybrids with four races are given in Table 5. Most of the F_1 hybrids showed resistance to races 1, 2 and 3 and moderate susceptibility to race 4. These results confirmed that all of these cultivars have *xa-5*. BJ1, one of the cultivars of DZ 192 group with strong resistance to race 4 was genetically analyzed by OGAWA *et al.* (1987) and was found to have another recessive gene for resistance to race 4. This gene was designated *xa-13*. Thus, we assume that cultivars of DZ 192 group with strong resistance to race 4 belong to BJ 1 group (Table 5, Fig. 1). These cultivars are presumed to have *xa-5* and

xa-13.

Isozyme analysis of some cultivars belonging to different groups

Rice cultivars have been classified into six groups (Table 6) based on allelic variation at isozyme loci (GLASZMANN 1986, 1987, GLASZMANN *et al.* 1988). We classified some of the BB resistant cultivars into isozyme groups. The results of two way classification based on reaction pattern to BB races and isozyme allelic combination are shown in Table 6. The results show that the distribution of BB resistance genes appears to correspond with the varietal grouping based on isozyme allelic combinations. The cultivars of Java 14 group mainly belong to isozyme group VI, but a few are in groups II and V. Cultivars of TKM 6 and CAS 209 groups belong only to group I. The cultivars of DZ 192 group belong primarily to group II, but some are in groups I, III, and IV. Therefore, there is a predominance of a specific BB resistance gene in each rice ecotype.

Discussion

This is the first attempt to categorize a large number of rice cultivars into groups on the basis of their reaction to four BB races from Philippines. The varietal reactions in general

Table 5. Reaction of F_1 hybrids of IR1545-339 and cultivars of DZ 192 group. IRRI, 1986~1987

Cross	Lesion length[1] upon inoculation with BB races				Cultivar group	Estimated gene
	1	2	3	4		
IR1545-339/Aus142	5.4	4.3	4.1	16.6	DZ 192	*xa-5*
IR1545-339/Dular	0.8	4.1	2.6	14.4	DZ 192	*xa-5*
IR1545-339/Sultanjota	0.6	4.2	3.2	16.8	DZ 192	*xa-5*
IR1545-339/Bhoturi	0.6	1.8	1.6	17.6	DZ 192	*xa-5*
IR1545-339/Gojal Goria	0.8	3.1	1.3	14.2	DZ 192	*xa-5*
IR1545-339/Aus176	0.4	2.2	0.3	18.9	DV 85	*xa-5*+*Xa-7*
IR1545-339/Gambir	0.6	4.6	3.0	20.1	DV 85	*xa-5*+*Xa-7*
IR1545-339/Makhmal Mehi	0.3	2.0	2.0	4.4	Makhmal Mehi	*xa-5*+*xa-4*
IR1545-339/Bazail924	1.2	4.8	3.9	20.9	Makhmal Mehi	*xa-5*+*xa-4*
IR1545-339/Aus274	3.4	4.5	4.9	16.5	BJ 1	*xa-5*+*xa-13*
IR1545-339/Chinsura Boroll	1.3	3.0	3.0	8.4	BJ 1	*xa-5*+*xa-13*
IR1545-339/Tepal (Boro)	1.4	2.9	4.0	10.0	BJ 1	*xa-5*+*xa-13*
IR1545-339/BJ1	1.3	3.0	3.0	6.5	BJ 1	*xa-5*+*xa-13*
IR1545-339/Ehadoia 648	2.0	2.1	3.0	13.5	BJ 1	*xa-5*+*xa-13*

1) Score is the average lesion length (3 leaves×3 plants) at 18 DAI.

correspond to reactions of cultivars with known genes for resistance. On the basis of this study, rice cultivars were divided into eight groups. Four of the groups are based on the reaction patterns characterizezd by single genes. These are: Java 14 group (*Xa-3*), TKM 6 group (*Xa-4*), DZ 192 group (*xa-5*), and CAS 209 group (*Xa-10*). Remaining four groups are based on two genes each. Thus Mond Ba group has *Xa-4* and *Xa-10*, DV 85 group has *xa-5* and *Xa-7*, Makhmal Mehi group has *Xa-4* and *xa-5* and BJ 1 group has *xa-5* and *xa-13*. The number of cultivars allocated to each group, their reaction pattern to four BB races from Philippines and the corresponding varietal grouping based on ecological adaptation and isozyme analysis are given in Table 7.

These results suggest that the differentiation of BB resistance genes probably linked with the differentiation of cultivars into distinct ecotype.

Table 6. Relationships between cultivar groups based on reaction to BB races and the groups based on allelic composition at isozyme loci. IRRI, 1987—1988

Cultivar group for resistance to BB races	Groups based on isozyme allelism						
	I	II	III	IV	V	VI	M[1)]
Java 14		15			10	83	12
TKM 6	52						9
DZ 192	23	305	3	1			16
CAS 209	6						

1) I = typical *indica* rices, II = aus and boro, III = deepwater cultivars from Bangladesh, IV = floating rices from Bangladesh (rayada), V = Basmati rice from Iran to Burma, VI = *japonica* rices (ken, bulu, upland), and M = unclassified (GLASZMANN 1986).

Table 7. Rice cultivar groups based on reaction to Philippine BB races, their reactions to BB races, genes for resistance and corresponding grouping based on isozyme analysis and corresponding ecotypes. IRRI, 1983—1987

Cultivar Group	No. of cultivars	Reaction[1)] to BB races 1	2	3	4	Estimated gene	Isozyme grouping	Ecotype
Java 14	389	R^B	R^B	R^B	R^B	*Xa-3*	II,VI	*japonica*
TKM 6	272	R	S	S	MR	*Xa-4*	I	aman tjereh
DZ 192	356	R	R	R	MS	*xa-5*	II	aus boro
CAS 209	16	S	HR	S	S	*Xa-10*	I	
Mond Ba	22	R	HR	S	MR	*Xa-4+Xa-10*	I	
DV 85	8	HR	HR	HR	R	*xa-5+Xa-7*	II	
Makhmal Mehi	20	R	R	R	R	*xa-5+Xa-4*	II	
BJ 1	21	R	R	R	R	*xa-5+xa-13*	II	

1) HR = highly resistant, R^B = resistant with browning margins around lesions, R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible.

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イネ品種のフィリピン産白葉枯病菌レースに対する反応型による分類

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IRRIの植物病理部がフィリピン産白葉枯病菌レースを接種して3,000余の抵抗性品種をスクリーニングしていた．これらの抵抗性品種のうち，比較的高度の抵抗性を示していた1,441品種について，新しい白葉枯病抵抗性遺伝子を探索する目的でフィリピン産白葉枯病菌4レースの接種検定を行った．その接種検定の過程で，イネ品種はフィリピン産白葉枯病菌4レースに対する反応型により類別でき，イネの生態型と類似している傾向があったので，まず，既存の白葉枯病抵抗性遺伝子をもつ品種の反応と比較しながら，イネ品種をフィリピン産白葉枯病菌4レースに対する反応型により類別した．

その結果，イネ品種の接種検定からまず5反応群を類別した．(1) JAVA 14群：4レース全てに抵抗性を示し，病斑の周縁部が褐色化し，*Xa-3* をもつJAVA 14の反応型によく類似している．(2) TKM 6群：レース1に抵抗性，レース4に中度抵抗性を示すが，レース2と3には感受性で，*Xa-4* をもつIR 20に類似した反応を示す．IR 20はその抵抗性がTKM 6に由来していることから，この群をTKM 6群となずけた．(3)DZ 192群：レース1から3に抵抗性を示し，レース4に対しては，中度抵抗性ないし中度感受性を示すが，病斑の周縁部が褐色化することはない．この反応型は *xa-5* をもつIR 1545-339によく類似している．IR 1545-339の抵抗性はDZ 192に由来するので，この群をDZ 192群とした．レース4に対しても抵抗性を示すが，病斑の周縁部が褐色化しない品種もこの群に含めた．(4)CAS 209群：レース2に対して高度抵抗性を示すが，レース1，3及び4に対しては感受性を示す．この反応型は *Xa-10* をもつCAS 209とよく類似したものである．(5)Mond Ba群：レース2に対して高度抵抗性を示し，レース1に対して抵抗性，レース4に対して中度抵抗性を示すが，レース3に対しては感受性を示す．その反応型は *Xa-4* と *Xa-10* 双方を持つMond Baによく類似している．(Table 2)

次に，フィリピン産白葉枯病菌4レース全てに感受性を示すIR 24と各品種群のいくつかの品種との間で交配し，得られたF_1雑種に対して接種検定を行い，その反応型をみた．その結果，JAVA 14，TKM 6，CAS 209及びMond Ba群の品種とIR 24とのF_1雑種は抵抗性親と同じ反応型であった．従って，これらの品種群品種は優性遺伝子を持つことが確認された．一方，DZ 192群品種とIR 24とのF_1雑種はほとんど4レース全てに感受性を示した．従ってこの品種群のほとんどの品種は劣性遺伝子をもつことを確認した．しかし，そのF_1の反応型からこの群の品種は更に3つに群別された．(6) DV 85群：IR 24とのF_1雑種が，レース1に対して中度抵抗性，レース2及び3に対して高度抵抗性，レース4に対しては感受性を示す．この反応型は *xa*-5とXa-7をもつDV 85と感受性品種とのF_1雑種の反応型とよく類似する．(7) Makhmal Mehi群：IR 24とのF_1雑種が，レース1に対して抵抗性，レース4に対して中度抵抗性，レース2及び3に対して感受性を示し，*Xa-4* をもつ品種とその反応が類似する．(8)BJ 1群：IR 24とのF_1雑種は4レース全てに対して感受性を示すが，4レース全てに対して同じ程度の抵抗性を示し，xa-5と *xa-13* の双方をもつBJ 1にその反応が類似する (Tables 4, 5 & 7)．

また，*xa-5* を持つIR 1545-339とDZ 192群の品種とのF_1雑種も接種検定した結果，DZ 192群の品種は *xa-5* をもつことを確認した(Table 5)．類別した各品種群の品種のいくつかについて，アイソザイムを分析し，Glaszmann (1986) の方法に従って品種を分類したところ，JAVA 14群は主にアイソザイムグループVI (*japonica*) に、TKM 6群及びCAS 209群はアイソザイムグループI (典型的 *indica*) に、DZ 192群は主としてアイソザイムグループII (aus) に含まれた (Table 6)．この結果はイネ白葉枯病抵抗性遺伝子の分化と品種の生態的分化に強い関係があることを示唆する．