IRRI RESEARCH PAPER SERIES
Number 53 November 1980

RESISTANCE OF JAPANESE AND IRRI DIFFERENTIAL RICE VARIETIES TO PATHOTYPES OF *XANTHOMONAS ORYZAE* IN THE PHILIPPINES AND IN JAPAN

O. HORINO, T.W. MEW, G.S. KHUSH, and A. EZUKA

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

RESISTANCE OF JAPANESE AND IRRI DIFFERENTIAL RICE VARIETIES TO PATHOTYPES OF *XANTHOMONAS ORYZAE* IN THE PHILIPPINES AND IN JAPAN[1]

ABSTRACT

The correlation coefficient between scoring systems developed in Japan and IRRI, based on infection by *Xanthomonas oryzae* caused by two methods of inoculation, was highly significant.

Five differential rice varieties from Japan -- Kinmaze, Kogyoku, Tetep, Wase Aikoku 3, and Java 14 -- and five from IRRI -- IR8, IR20, IR1545-339, DV85, and Cas 209 -- with specific genes for *X. oryzae* resistance identified in respective countries, were evaluated in Japan and in the Philippines for resistance to local pathotypes. Kogyoku, Tetep, and Kinmaze were susceptible and Wase Aikoku 3 and Java 14 were resistant to the four Philippine pathotypes. IRRI differential varieties, however, showed different reactions to Japanese pathotypes. IR8, carrying no gene for resistance to the Philippine pathotypes, was resistant to pathotypes II, III, and V in Japan. IR20 was resistant to pathotypes I and V, but susceptible to pathotypes II, III, and IV. IR1545-339 and DV85 were resistant to all five Japanese pathotypes. The results indicate that differential rice varieties developed in Japan and at IRRI are individually distinct in their reaction to the pathotypes in Japan and in the Philippines.

Forty-eight varieties from Japan and the Philippines, classified into varietal groups according to reactions to Japanese pathotypes, were tested for resistance to four Philippine pathotypes. Kogyoku-group varieties, except 70X-37, which was resistant to pathotype I, were susceptible to all pathotypes. Most Rantai Emas-group varieties, except Zenith, which was resistant to pathotype III, and Nigeria 5, which was resistant to pathotype I, were susceptible to all Philippine pathotypes. Two of the ten varieties of the Wase Aikoku group were susceptible and six were resistant to all Philippine pathotypes. Three varieties of the Java group were resistant to the four pathotypes. The reaction patterns of 48 varieties to Philippine pathotypes did not coincide with their respective varietal groups in Japan against the Philippine pathotypes.

The virulence of 62 isolates collected in the Philippines was evaluated on 10 differential rice varieties of Japan and IRRI. Sixty-one were similar to isolate T7133 (pathotype III of Japan) on Japanese differential varieties, but showed different reactions to IRRI differential varieties. It appears that the Philippine isolates are not comparable to any pathotype of Japan.

---

[1]A collaborative research project on bacterial blight between the International Rice Research Institute, Los Baños, Laguna, Philippines, and the Tropical Agriculture Research Center in Japan. By O. Horino, visiting plant pathologist, T. W. Mew, plant pathologist, G. S. Khush, plant breeder, IRRI; and A. Ezuka, plant pathologist, National Institute of Agricultural Sciences, Tsukuba, Japan. Submitted to the IRRI Research Paper Series Committee June 1980.

RESISTANCE OF JAPANESE AND IRRI DIFFERENTIAL RICE VARIETIES TO PATHOTYPES OF *XANTHOMONAS ORYZAE* IN THE PHILIPPINES AND IN JAPAN

Bacterial blight, caused by *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson, is a serious rice disease in Asia (Alim 1967, Ou 1972, Wakimoto 1975). Some bactericides have been formulated and used in Japan to control the disease but none is very effective. Varietal resistance is still considered the most appropriate countermeasure against bacterial blight.

The virulence of *X. oryzae* varies in Asia. The variation, claimed to be continuous, is based on the fact that the lesion length caused by bacteria on certain varieties gradually increases from Japan to tropical Asia (Buddenhagen and Reddy 1972, Goto 1965, Ou et al 1971, Wakimoto 1967, Wakimoto et al 1969). A vertical host-bacterium interaction was noted by other researchers (Ezuka and Horino 1974, Mew and Vera Cruz 1979). The discrepancies may be attributed to the different varieties used in the studies, whose resistance might be either similar or diverse in the reaction to the strains of the bacterium. Other possible sources of variation could be the mode of infection initiated by different methods of inoculation, different plant ages at the time of inoculation, and the different scoring systems used for denoting host-parasite interactions.

Studies of the inheritance of bacterial blight resistance in rice by different research programs have identified different major genes for resistance. Strains of the bacterium with distinct virulence in some regions have also been identified and assigned to virulence groups or pathotypes using varieties with specific resistance in the host-bacterium studies. Most of the genetic investigations were in Japan and at the International Rice Research Institute (IRRI). Nine different genes for resistance to bacterial blight have been identified (Ezuka et al 1975, Ogawa et al 1978, Petpsist et al 1977, Sakaguchi 1967, Sidhu and Khush 1978, Sidhu et al 1978). But genes for resistance to bacterial pathotypes in some areas may not be effective against pathotypes in other areas (Horino and Ha tini 1978, IRRI 1979, Yamamoto et al 1977). A major effort is, therefore, needed to develop a set of differentials incorporating individual genes for resistance into an isogenic background and to use these differentials to compare the virulence of pathotypes from different localities.

In 1979 IRRI and the Tropical Agriculture Research Center (TARC) of Japan initiated collaborative research on bacterial blight. This paper reports on a study at IRRI from December 1979 to April 1980 to compare the differential interactions between Japanese and IRRI differential varieties and the Philippine pathotypes. Reactions of these differential varieties to the Japanese pathotypes included in the report were determined earlier in Japan.

MATERIALS AND METHODS

Bacterial isolates

Seventy-one bacterial isolates were studied. They included strains representative of five different pathotypes of Japan exemplified by T7174 for group I, T7147 for group II, T7133 for group III, H75373 for group IV, and H75304 for group V; four Philippine pathotypes exemplified by isolate PX061 for group I, isolate PX086 for group II, isolate PX079 for group III, and isolate PX071 for group IV, and 62 isolates collected from different areas in the Philippines. All isolates were evaluated for their virulence on the Japanese and IRRI differentials.

Inoculum preparation and inoculation

Bacterial strains were cultured individually on Wakimoto's potato semisynthetic agar medium and incubated at 28 C. The 48-hour-old cultures were used to prepare the inoculum adjusted to a concentration of 10^8-10^9 cells/ml.

Inoculation of 10 flag leaves at the booting stage was with individual bacterial isolates. Two methods were used for specific experiments:

- clipping off the leaves of the rice plant 1-2 cm from the tip with scissors dipped in the bacterial suspension, and
- gently pricking the middle part of the leaf blades on both sides of the midrib with the double needle instrument dipped in the bacterial suspension.

Disease scoring

Disease reactions were assessed 2 weeks after inoculation. Leaves infected by clipping were scored according to IRRI's Standard Evaluation System (SES) for Rice (IRRI 1975) based on lesion area over leaf area. Leaves infected by the pin-pricking method were scored according to the disease reaction rating indices of Ezuka and Horino (1974).

RESULTS AND DISCUSSION

Comparison of scoring systems and inoculation methods

Disease reactions of 20 varieties from Bangladesh, China, Indo-China, Indonesia, and IRRI to infection of representative isolates with distinct virulence of the 4 Philippine pathotypes were scored according to the SES and the Japanese scoring systems. Both systems were based on the proportion of lesion area to the total leaf area.

The coefficient of correlation between the two scoring systems based on infection initiated by the two inoculation methods was highly significant (Fig. 1). Response of a specific variety to infection of a strain of specific virulence was dependent on the specific host-parasite interaction. Based on the methods of inoculation (Table 1), DV85, Wase Aikoku 3, Chugoku 45, 70X-46, and Java 14 were resistant to the four isolates representing the four pathotypes in the Philippines, whereas IR8, Jukkuko, Kogyoku, Tokai 12, and Zenso 26 were susceptible to all four isolates. Disease development from either pin-pricking or clipping inoculation was comparable to natural infection as reported by different scientists (Morinaka et al 1978, Muko and Yoshida 1951, Muko et al 1952, Reitsma and Schure 1950).

Interactions of Japanese and IRRI differential rice varieties to the virulence of X. oryzae

The IRRI and Japanese differential rice varieties were evaluated for resistance to Japanese pathotypes in Japan, and to the Philippine pathotypes at IRRI. Sakaguchi (1976) and Ezuka et al (1975) reported that resistance of Kogyoku to pathotype II-bacteria in Japan was governed by a single dominant gene, *Xa-1*, and the resistance of Tetep to groups I and II was conveyed by two dominant genes, *Xa-1* and *Xa-2*, which are closely linked with each other. The reactions of the five Japanese differential varieties to the five Japanese pathotypes of *X. oryzae* were similar to those obtained earlier by Horino (1978) and Yamada et al (1979b). Reactions of the Japanese differential varieties to Philippine isolates indicated that Kogyoku, Tetep, and Kinmaze were all susceptible (Table 2). On the other hand, Wase Aikoku 3 and Java 14 with *Xa-w* (*Xa-3*), and *Xa-1*, *Xa-3*, and *Xa-kg* (Ogawa et al 1978) were resistant to all four Philippine pathotypes.

The reactions of IRRI differential varieties to the Philippine pathotypes were similar to those reported by Mew and Vera Cruz (1979). Their reactions to the Japanese pathotypes, however, varied. IR8 was very susceptible to the Japanese pathotypes I and IV but resistant to II, III, and V, although it is very susceptible and has no gene for resistance to the Philippine pathotypes (Mew and Vera Cruz 1979). Resistance of IR8 to the Japanese pathotypes differed from an earlier report (Ezuka and Horino 1974) although it has always been susceptible to the Philippine pathotypes. Confirmation of the reactions and sources of IR8 seeds is under way.

Table 1. Bacterial blight reactions of selected japonica and indica rice varieties to the infection caused by 4 strains with distinct virulence of *Xanthomonas oryzae* as a result of the two methods of inoculation.[a]

Variety	Clipping inoculation[b]				Pin-prick inoculation[c]			
	PXO61 I	PXO86 II	PXO79 III	PXO71 IV	PXO61 I	PXO86 II	PXO79 III	PXO71 IV
IRRI differential varieties								
IR8	4.7	4.1	5.0	4.5	6.5	4.8	6.3	5.1
IR20	1.3	5.7	6.9	3.1	1.9	5.9	5.9	3.0
IR1545-339	1.5	1.8	1.0	2.2	1.9	2.0	1.8	3.1
DV85	1.0	1.0	1.0	1.0	2.0	1.9	2.0	2.0
Cempo Selak	2.3	1.7	1.7	2.2	2.3	0.9	2.1	3.1
Test varieties								
Jukkoku	7.0	6.3	6.7	5.5	6.9	5.9	6.6	6.9
Nipponbare	5.8	4.6	7.0	5.0	6.6	5.5	5.5	6.7
Kinmaze	7.0	6.3	6.9	4.5	7.0	6.7	6.7	6.9
Kogyoku	6.6	5.4	6.9	4.3	7.0	6.7	6.9	7.0
Tokai 12	6.2	7.0	7.0	5.8	7.0	7.0	6.5	6.9
Zensho 26	7.0	6.3	7.0	6.2	7.0	6.9	6.7	6.9
Tetep	4.6	3.6	4.1	3.3	6.3	4.8	4.1	4.1
Rantai Emas 2	4.2	3.5	4.3	4.1	6.2	5.2	5.2	5.4
54BC-68	5.3	4.5	4.3	4.6	6.5	5.1	4.7	5.6
Wase Aikoku	2.3	2.3	2.1	1.7	1.7	1.8	0.9	1.6
Chugoku 45	2.1	1.3	1.9	1.1	2.0	1.5	1.1	1.7
70X-46	2.2	1.7	1.7	1.5	2.0	1.7	1.3	1.9
Java 14	2.8	2.7	2.7	1.7	1.5	1.3	1.5	1.7
Himekei 16	2.3	1.3	3.0	1.5	1.7	1.6	1.5	1.9
Amareriyo	3.7	2.9	4.3	2.9	4.9	2.3	2.8	1.8

[a]Numerals denote average values of disease rating indices of 3 replications at 10 leaves/replication.
[b]An IRRI method done by cutting the leaves 1-2 cm from the tip. [c]A Japanese method (Ezuka and Horino) done by pricking the central part of leaf blade with a double-needle prick.

IR20, with a dominant gene, *Xa-4*, for resistance, was resistant to Japanese pathotypes I and IV and susceptible to II, III, and IV, but the degree of susceptibility was not comparable to that of Kinmaze.

Two varieties -- IR1545-339 with a recessive gene, *xa-5*, and DV85 with *xa-5* and *Xa-2* for resistance -- were resistant to the five Japanese pathotypes.

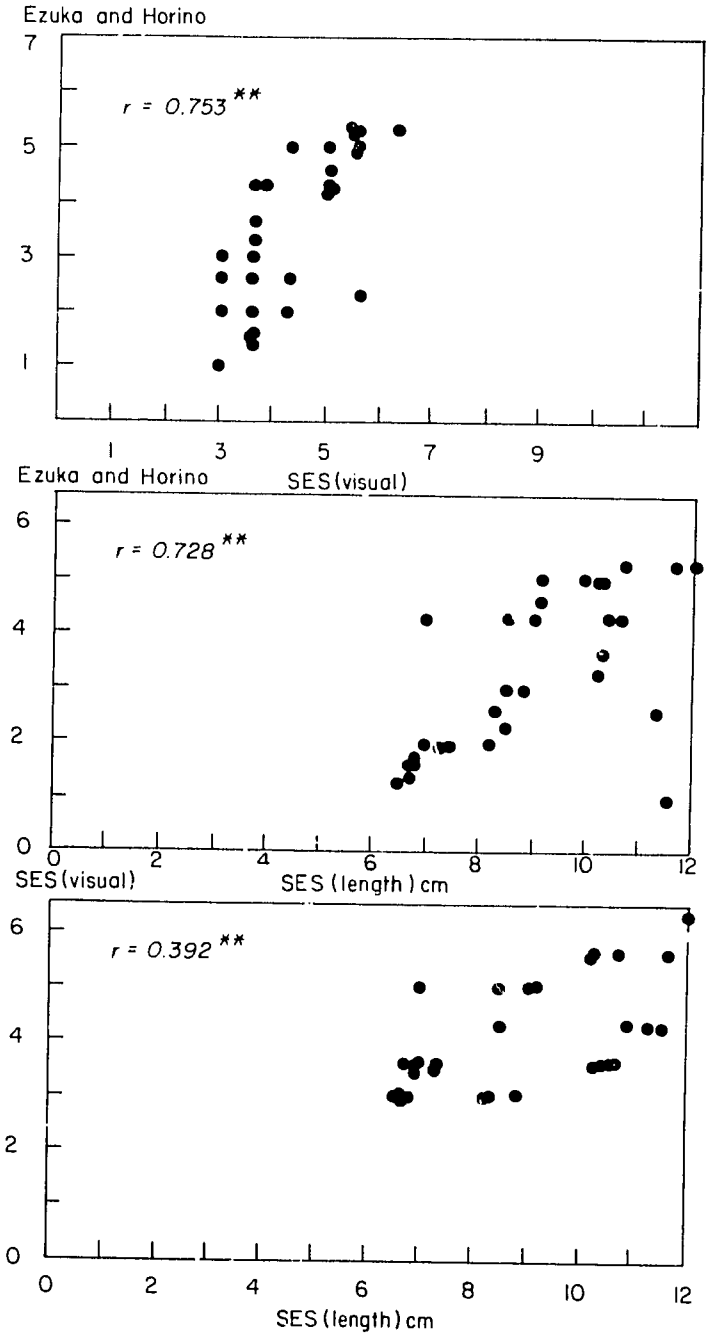

Fig. 1. Coefficient of correlation between three methods of evaluation for resistance to bacterial blight of rice by two methods of inoculation. *Significant at the 5% level, **significant at the 1% level.

Cas 209 apparently has a resistance gene different from those in other IRRI differentials because it was resistant only to Philippine pathotype II. It was, however, susceptible to all Japanese pathotypes.

Cempo Selak was resistant to Philippine pathotypes I and II but susceptible to III and IV, although the susceptible reaction was not always distinct. Its reaction to Japanese as well as to Philippine pathotypes, in addition to the two sets of rice differentials, is summarized in Table 2.

The differentials developed by Japanese scientists and those by IRRI scientists showed completely different reactions to each bacterial isolate representing specific-virulence groups of Japanese and Philippine bacterium. Resistance of these differential varieties were different and the gene or genes for resistance identified in these varieties are probably different from each other. These varieties also differentiate the bacteria of known virulence in the two countries into nine distinct pathotypes of distinct virulence (Table 3).

Japanese and IRRI differential varieties may, therefore, provide a fundamental set of varieties for the standard differential varieties with specific genes for resistance.

Response of the Japanese varietal groups to the distinct virulence of X. oryzae *in the Philippines*

Forty-eight varieties belonging to the different varietal groups identified in Japan were tested for their resistance to four isolates of *X. oryzae* with specific virulence in the Philippines. These varieties (japonicas and indicas) are being used as sources of resistance in the breeding programs at IRRI and in Japan.

Table 4 shows that Kogyoku-group varieties, except 70X-37 which was resistant to PX061 of pathotype I, were resistant to Japanese pathotypes I and V but susceptible to the four Philippine pathotypes. Rantai Emas-group varieties were resistant to pathotypes I, II, and V in Japan, but susceptible to III and IV. The varieties in the Rantai Emas group, except Zenith, which was resistant to group IV, and Nigeria 5, which was resistant to group I, were susceptible to all the four Philippine pathotypes (Table 4).

Two of the ten varieties of the Wase Aikoku group -- Shin 2 and Lead Rice -- were susceptible to all four Philippine pathotypes, and six -- Nagomasari, Ortiglia, Chukei 314, Kuntulan, Chugoku 45, and 70X-46 -- were resistant. TKM6 was resistant to group I but susceptible to the three others whereas Nakashin 120 was resistant to groups I, II, and III but susceptible to IV.

Three varieties -- Jamica, Zenith G713, and Himekei 16 -- that belong to the Java group were resistant to the four Philippine pathotypes. Amareriyo of the same varietal group was moderately susceptible.

Seven IRRI varieties -- IR22, IR26, IR28, IR29, IR30, IR32, and IR34, which have the dominant gene *Xa-4* for resistance -- were resistant to Philippine pathotype I, moderately resistant or moderately susceptible to pathotype IV, vut susceptible to pathotypes II and III. Pathotype III usually caused longer lesions on those varieties than did pathotype IV (Table 4). These results agree with earlier reports from IRRI (IRRI 1980, Mew and Vera Cruz 1979). This study indicates that IRRI varieties are highly resistant to Japanese pathotypes I and V, but unstable to pathotypes II, III, and IV as indicated by the disease indices which ranged from 1.8 to 7.0 (Horino and Yamada 1979, Yamada et al 1979a).

Uchiyamada et al (1977, 1978) did an extensive survey on the various characteristics of thousands of rice varieties collected from different parts of the world. They tested 3,449 varieties for resistance to representative isolates of *X. oryzae* belonging to pathotypes I, II, III, and IV of Japan. They found that the reaction patterns of many varieties do not coincide with those of known varietal groups. Our results may confirm this finding. The genetic of resistance of Wase Aikoku and Java-group varieties to the Philippine pathotypes should be further analyzed.

Table 2. Interactions between Japanese and Philippine pathotypes of *Xanthomonas oryzae* and differential rice varieties of Japan and IRRI.[a]

Differential variety	Gene for resistance[b]	Japanese pathotype[c]					Philippine pathotype[d]			
		T7174 I	T7147 II	T7133 III	H75373 IV	H75304 V	PX061 I	PX086 II	PX079 III	PX071 IV
Japanese differential										
Kinmaze	None	7.0[e]	7.0	6.8	7.0	6.6	6.7	6.4	6.7	6.9
Kogyoku	*Xa-1, Xa-kg*	0.3	6.7	7.0	6.6	0.1	6.9	6.6	6.4	6.9
Tetep	*Xa-1, Xa-2*	0.0	0.2	6.6	6.6	0.0	4.8	6.3	6.0	4.9
Wase Aikoku 3	*Xa-3*	1.0	0.7	0.2	6.7	5.1	0.9	0.5	0.8	0.3
Java 14	*Xa-1, Xa-3, Xa-kg*	0.0	2.0	1.3	6.1	0.1	0.7	0.4	2.0	1.2
IRRI differential										
IR8	?	6.3	1.2	1.9	6.5	1.1	6.6	6.4	6.2	5.9
IR20	*Xa-4*	0.0	2.3	3.9	4.5	0.0	1.9	6.3	7.0	3.0
IR1545-339	*xa-5*	1.5	2.0	2.0	1.4	1.8	1.9	2.0	1.7	5.6
DV85	*xa-5, Xa-7*	0.0	2.0	1.8	1.9	0.0	1.5	1.5	1.8	1.8
Cas 209	?	6.5	6.8	7.0	7.0	3.1	6.0	0.0	6.8	6.8
Cempo Selak	?	1.7	1.2	0.1	6.0	6.1	1.6	1.2	2.6	3.1

[a]Inoculated by the pin-prick method at heading stage. [b]? = not yet identified. [c]Data recorded in Japan. [d]Data recorded in the Philippines. [e]Represent average values of disease rating indices of 3 replications at 10 leaves/replication.

Table 3. Differential interactions of pathotypes of *Xanthomonas oryzae* in Japan and the Philippines to differential rice varieties identified in Japan and at IRRI.[a]

Variety	Gene for resistance[b]	Japanese pathotype					Philippine pathotype			
		T7174 I	T7147 II	T7133 III	H75373 IV	H75304 V	PX061 I	PX086 II	PX079 III	PX071 IV
Kinmaze	None	S	S	S	S	S	S	S	S	S
Kogyoku	*Xa-1, Xa-kg*	R	S	S	S	R	S	S	S	S
Tetep	*Xa-1, Xa-2*	R	R	S	S	R	S	S	S	S
Wase Aikoku 3	*Xa-3*	R	R	R	S	S	R	R	R	R
Java 14	*Xa-1, Xa-3, Xa-kg*	R	R	R	S	R	R	R	R	R
IR8	?	S	R	R	S	R	S	S	S	S
IR20	*Xa-4*	R	S	S	S	R	R	S	S	V
IR1545-339	*xa-5*	R	R	R	R	R	R	R	R	S
DV85	*xa-5, Xa-7*	R	R	R	R	R	R	R	R	R
Cas 209	?	S	S	S	S	S	S	R	S	S

[a]S = susceptible, R = resistant, V = variable reaction. [b]? = not yet identified.

Table 4. Reactions of different Japanese rice varietal groups to Philippine and Japanese pathotypes of *Xanthomonas oryzae*.[a]

Variety	Origin[b]	Varietal group in Japan[c]	Philippine pathotypes[d]				Japanese pathotypes[e]				
			PX061 I	PX086 II	PX079 III	PX071 IV	T7174 I	T7147 II	T7133 III	H75373 IV	H75304 V
Sachikaze	Japan	Kinmaze	6.6	6.7	6.8	7.0	S	S	S	S	S
Koshihikari	Japan	Kinmaze	6.1	6.2	6.6	6.9	S	S	S	S	S
Kuju	Japan	Kinmaze	6.9	6.3	6.2	6.7	S	S	S	S	S
Gohyakumangoku	Japan	Kinmaze	6.3	4.6	5.0	5.7	S	S	S	S	S
Koshijiwase	Japan	Kinmaze	6.9	6.5	6.9	6.9	S	S	S	S	S
Koshihomare	Japan	Kinmaze	6.7	4.9	6.1	6.3	S	S	S	S	S
Todorokiwase	Japan	Kinmaze	6.3	6.5	6.9	6.3	S	S	S	S	S
Koshiyutaka	Japan	Kinmaze	6.5	4.1	4.9	6.1	S	S	S	S	S
Jukkoku	Japan	Kinmaze	6.4	5.0	5.7	7.0	S	S	S	S	S
Nipponbare	Japan	Kinmaze	4.7	3.8	3.7	5.9	S	S	S	S	S
Tokai 28	Japan	Kogyoku	7.0	5.2	5.5	6.9	R	S	S	S	R
PI 1	Japan	Kogyoku	6.1	5.2	5.8	5.9	R	S	S	S	R
Asakaze	Japan	Kogyoku	5.0	5.5	5.2	6.9	R	S	S	S	R
Toboshi	Japan	Kogyoku	7.0	6.1	6.6	6.9	R	S	S	S	R
Hoyoku	Japan	Kogyoku	6.5	6.8	7.0	7.0	R	S	S	S	R
70X-37	Japan	Kogyoku	2.0	5.5	5.4	4.5	R	S	S	S	R
Asominori	Japan	Kogyoku	3.8	3.7	3.9	3.8	R	S	S	S	R
Zensho 26	Japan	Kogyoku	5.3	5.3	4.8	5.1	R	S	S	S	R
Tadukan	Phil.	Rantai Emas	6.6	5.1	6.1	6.9	R	R	S	S	R
Sensho	Japan	Rantai Emas	5.7	6.5	6.7	6.8	R	R	S	S	R
Kannonsen	Japan	Rantai Emas	5.1	4.3	5.1	6.7	R	R	S	S	R
Tokusho-daisuto	Japan	Rantai Emas	5.1	5.7	5.5	6.7	R	R	S	S	R
Zenith	USA	Rantai Emas	3.5	3.1	1.4	2.3	R	R	S	S	R
Ou 244	Japan	Rantai Emas	5.1	5.4	4.5	5.7	R	R	S	S	R
Nigeria 5	Sri Lanka	Rantai Emas	1.1	3.7	4.4	3.4	R	R	S	S	R
Rantai Emas 2	Indonesia	Rantai Emas	5.1	5.7	6.1	6.0	R	R	S	S	R
54 BC-68	Japan	Rantai Emas	5.2	4.8	5.7	6.0	R	R	S	S	R
Shin 2	Japan	Wase Aikoku	4.9	3.5	3.1	4.7	R	R	R	S	S
TKM 6	Indonesia	Wase Aikoku	1.5	5.1	4.0	3.9	R	R	R	S	S
Nagomasari	Japan	Wase Aikoku	1.7	1.2	0.9	1.8	R	R	R	S	S
Ortiglia	?	Wase Aikoku	1.3	0.8	1.2	1.0	R	R	R	S	S
Chukei 314	Japan	Wase Aikoku	1.7	0.4	0.2	1.0	R	R	R	S	S
Kuntulan	Indonesia	Wase Aikoku	1.9	1.2	1.0	1.3	R	R	R	S	S
Nakashin 120	Japan	Wase Aikoku	1.4	1.7	1.6	3.5	R	R	R	S	S
Lead Rice	Burma	Wase Aikoku	4.0	5.1	4.3	5.7	R	R	R	S	S
Chugoku 45	Japan	Wase Aikoku	1.5	1.3	1.6	1.6	R	R	R	S	S
70X-46	Japan	Wase Aikoku	0.8	0.9	0.9	0.5	R	R	R	S	S
Jamaica	?	Java	2.0	1.6	1.7	1.8	R	R	R	S	R
Zenith G713	?	Java	1.8	2.0	2.0	1.8	R	R	R	S	R
Himekei 16	Japan	Java	0.7	0.9	0.5	0.7	R	R	R	S	R
Amareriyo	?	Java	2.5	2.8	3.2	2.3	R	R	R	S	R
IR22	IRRI	Kogyoku	2.0	4.5	4.6	2.0	R	S	S	S	R
IR26	IRRI	Kogyoku	1.0	3.5	5.1	1.0	R	S	S	S	R
IR28	IRRI	Kogyoku	1.6	5.6	5.4	2.7	R	S	S	S	R
IR29	IRRI	Kogyoku	1.5	4.9	5.6	2.0	R	S	S	S	R
IR30	IRRI	Kogyoku	1.8	4.5	5.5	2.6	R	S	S	S	R
IR32	IRRI	Kogyoku	1.7	3.9	5.5	2.6	R	S	S	S	R
IR34	IRRI	Kogyoku	1.7	3.7	4.9	2.5	R	S	S	S	R

[a]Inoculated at the reproductive stage. R = resistant, S = susceptible. [b]? = origin not known. [c]Data recorded in Japan. [d]Data recorded in the Philippines based on the Japanese scoring system of 0 to 7, where 0 = complete resistance and 7 = complete susceptibility.

Virulence of selected field isolates of X. oryzae *to the Japanese and IRRI differential rice varieties*

Sixty-two isolates collected by IRRI scientists in 1978 and 1979 from naturally infected rice plants in different areas of the Philippines were evaluated for their virulence pattern on the ten differential varieties of Japan and IRRI (Table 5). All except one infected IR8. The avirulent one was also avirulent on the other varieties evaluated. It is likely that this isolate had lost its pathogenicity. Fifty-six (90%) of the isolates infected IR20, and an additional 4 (6.5%) caused moderate infection. One isolate infected IR1545-339 and DV85 and about 9.7% caused moderate infection of IR1545-339 and DV85 (Table 6).

The virulence of the 61 isolates on Japanese differential rice varieties was similar to that of isolate T7133 (group III of Japan). There were, however, different virulence reactions to Philippine differential rice varieties. Most of the Philippine isolates were not comparable to any pathotype in Japan when tested on Japanese differential varieties. Only isolate 212 was avirulent to all 10 differential varieties, perhaps because it had lost its aggressiveness. Intermediate reactions of some of the isolates were recorded on IRRI differential varieties, such as on IR1545-339. IR20, IR1545-339, and DV85 were not always resistant to the bacterial isolates in the Philippines. The Japanese differential varieties Wase Aikoku 3 and Java 14 were resistant to these isolates.

Nagomasari, Ortiglia, Chukei 314, Kuntulan, Chugoku 45, and 70X-46 of the Wase Aikoku group, and Jamica, Zenith G713, and Himekei 16 of the Java group were also resistant to all the pathotypes of *X. oryzae* in the Philippines. However, Java 14 and Chugoku 45 were susceptible to some isolates in the Indian Subcontinent (IRRI 1979). Genetic analysis is needed to confirm resistance of Wase Aikoku and Java group varieties to virulence of the bacteria in the Philippines.

Table 5. Virulence of some bacterial isolates of *Xanthomonas oryzae* collected from various sites in the Philippines in 1978 and 1979 to Japanese and IRRI differential rice varieties.[a]

Isolate record no.	Site	Japanese differential varieties					IRRI differential varieties				
		Kinmaze	Kogyoku	Tetep	Wase Aikoku 3	Java 14	IR8	IR20	IR1545-339	DV85	Cempo selak
201	Apoc-Apoc	S	S	S	R	R	S	S	R	R	R
203	"	S	S	S	R	R	S	S	R	R	R
206	Ilagan	S	S	S	R	R	S	S	R	R	R
207	"	S	S	S	R	R	S	S	R	R	R
208	Tigbauan	S	S	S	R	R	S	S	R	R	R
209	"	S	S	S	R	R	S	S	R	R	R
210	"	S	S	S	R	R	S	S	R	R	R
211	"	S	S	S	R	R	S	S	R	R	R
212	"	R	R	R	R	R	R	R	R	R	R
213	"	S	S	S	R	R	S	S	R	R	R
214	"	S	S	S	R	R	S	S	R	R	R
215	"	S	S	S	R	R	S	S	R	R	R
216	"	S	S	S	R	R	S	S	R	R	R
221	Maligaya Rice Research Training Center	S	S	S	R	R	S	M	R	R	R
222	Santo Tomas	S	S	S	R	R	S	S	R	R	R
223	" "	S	S	S	R	R	S	S	S	R	R
224	Davao	S	S	S	R	R	S	S	S	R	R
225	"	S	S	S	R	R	S	S	R	R	R
226	"	S	S	S	R	R	S	S	R	R	R
227	"	S	S	S	R	R	S	S	R	R	R
228	"	S	S	S	R	R	S	S	M	R	R
229	"	S	S	S	R	R	S	S	M	R	R
230	"	S	S	S	R	R	S	S	R	R	R
231	Maligaya Rice Research Training Center	S	S	S	R	R	S	S	R	R	R
232	"	S	S	S	R	R	S	S	R	M	R
233	Bulacan	S	S	S	R	R	S	S	R	M	S
237	Bitas	S	S	S	R	R	S	M	R	R	R
243	Banaue	S	S	S	R	R	S	M	R	R	R
245	"	S	S	S	R	R	S	S	M	R	R
246	Isabela	S	S	S	R	R	S	S	M	R	R

Continued on next page.

Table 5. continued.

Isolate record no.	Site	Japanese differential varieties					IRRI differentia varieties				
		Kinmaze	Kogyoku	Tetep	Wase Aikoku 3	Java 14	IR8	IR20	IR1545-339	DV85	Cempo selak
247	Banaue	S	S	S	R	R	S	S	R	R	R
248	"	S	S	S	R	R	S	S	R	R	R
249	Maligaya Rice Research Training Center	S	S	S	R	R	S	S	R	M	R
250	"	S	S	S	R	R	S	S	M	R	R
256	"	S	S	S	R	R	S	S	M	R	R
257	"	S	S	S	R	R	S	S	M	R	R
259	"	S	S	S	R	R	S	S	R	R	R
260	"	S	S	S	R	R	S	S	R	M	R
261	"	S	S	S	R	R	S	S	R	M	R
262	"	S	S	S	R	R	S	S	R	R	R
263	"	S	S	S	R	R	S	S	R	R	R
264	"	S	S	S	R	R	S	S	R	R	R
265	"	S	S	S	R	R	S	S	R	R	R
267	Buguey	S	S	S	R	R	S	M	R	R	R
268	San Mateo	S	S	S	R	R	S	S	R	R	R
269	Polangui	S	S	S	R	R	S	S	R	R	R
280	Bitas	S	S	S	R	R	S	S	S	S	R
281	Bicol Rice and Corn Exp. Stn.	S	S	S	R	R	S	S	R	R	R
282	"	S	S	S	R	R	S	S	R	R	R
283	"	S	S	S	R	R	S	S	R	R	R
284	"	S	S	S	R	R	S	S	R	R	R
285	"	S	S	S	R	R	S	S	R	R	R
286	"	S	S	S	R	R	S	S	R	R	R
287	"	S	S	S	R	R	S	S	R	R	R
288	"	S	S	S	R	R	S	S	R	M	R
289	"	S	S	S	R	R	S	S	R	R	R
290	"	S	S	S	R	R	S	S	R	R	R
291	"	S	S	S	R	R	S	S	R	R	R
292	"	S	S	S	R	R	S	S	R	R	R
293	Bay	S	S	S	R	R	S	S	S	S	S
294	Maligaya Rice Research Training Center	S	S	S	R	R	S	S	R	R	R
295	Pagadian	S	S	S	R	R	S	S	R	R	R

[a]S = susceptible, R = resistant, M = moderately resistant.

Table 6. Virulence groupings of *Xanthomonas oryzae* isolates collected from the Philippines during 1978-79.[a]

Variety	Bacterial group							
	A	B	C	D	E	F	G	H
Japanese								
Kinmaze	S	S	S	S	S	S	S	R
Kogyoku	S	S	S	S	S	S	S	R
Tetep	S	S	S	S	S	S	S	R
Wase Aikoku 3	R	R	R	R	R	R	R	R
Java 14	R	[illegible]	R	R	R	R	R	R
IRRI								
IR8	S	S	S	S	S	S	S	R
IR20	S	S	S	M	S	S	R	R
IR1545-339	R	M	R	R	R	S	R	R
DV85	R	R	M	R	M	S	R	R
Cempo selak	R	R	R	R	S	R	R	R
Total	43	6	5	4	1	1	1	1
%	69.3	9.7	8.1	6.5	1.6	1.6	1.6	1.6

[a]S = susceptible, R = resistant, M = moderately resistant.

ACKNOWLEDGMENT

We are grateful to Dr. N. C. Brady, director-general of IRRI, and Dr. S. Okabe, director-general of TARC, for the support and approval of this collaborative research project. We also wish to express our sincere thanks to Dr. M. D. Pathak, director for research and training coordination, IRRI, and Dr. T. Kajiwara, associate director for research, TARC, for their kind arrangement to enable the senior author to stay at IRRI for 4 months.

REFERENCES CITED

Alim, A. 1967. Breeding of rice for resistance to major diseases in East Pakistan. Pages 199-207 *in* Proceedings of the symposium on rice diseases and their control by growing resistant varieties and other measures. Tokyo.

Buddenhagen, I. W., and A. P. K. Reddy. 1972. The host, the environment, *Xanthomonas oryzae*, and the researcher. Pages 289-295 *in* International Rice Research Institute. Rice breeding. Los Baños, Philippines.

Ezuka, A., and O. Horino. 1974. Classification of rice varieties and *Xanthomonas oryzae* strains on the basis of their differential interactions. Bull. Tokai-kinki Natl. Agric. Exp. Stn. 27:1-19.

Ezuka, A., O. Horino, K. Toriyama, H. Shinoda, and T. Morinaka. 1975. Inheritance of resistance of rice variety Wase Aikoku 3 to *Xanthomonas oryzae*. Bull Tokai-kinki Natl. Agric. Exp. Stn. 28:124-130.

Goto, M. 1965. Resistance of rice varieties and species of wild rice to bacterial leaf blight and bacterial leaf streak disease. Philipp. Agric. 48:329-338.

Horino, O. 1978. Distributions of pathogenic strains of *Xanthomonas oryzae* (Uyeda et Ishiya a) Dowson in Japan in 1973 and 1975 /in Japanese, with English summary/. Ann. Phytopathol. Soc. Jpn. 44:297-304.

Horino, O., and R. H. Hartini. 1978. Resistance of some varieties to bacterial leaf blight and a new pathogenic group of the causal bacterium, *Xanthomonas oryzae*. Contrib. Cent. Res. Inst. Agric. Bogor 44:1-17.

Horino, O., and T. Yamada. 1979. Resistance of rice varieties bred at IRRI to five pathotypes of *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson existing in Japan /in Japanese, with English summary/. Proc. Assoc. Plant Prot. Hokuriku 27:12-18.

IRRI (International Rice Research Institute). 1975. Standard evaluation system for rice. Los Baños, Philippines.

IRRI (International Rice Research Institute). 1979. Rice diseases in north and eastern India, Nepal, and Bangladesh (with focus on bacterial blight). A report on an IRTP monitoring tour. Los Baños, Philippines. 25 p.

IRRI (international Rice Research Institute). 1980. Research highlights for 1979. Los Baños, Philippines. 133 p.

Mew, T. W., and C. M. Vera Cruz. 1979. Variability of *Xanthomonas oryzae*: specificity in infection of rice differentials. Phytopathology 69:152-155.

Morinaka, T., H. Kaku, M. Horino, and T. Kimura. 1978. Applying condition of the clipping inoculation technique evaluation resistance of rice to *Xanthomonas oryzae*. Bull. Chugoku Natl. Agric. Exp. Stn., Ser. E, 13:1-16.

Muko, H., and K. Yoshida. 1951. A needle inoculation method for bacterial blight disease of rice /abstr. in Japanese/. Ann. Phytopathol. Soc. Jpn. 15:179.

Muko, H., K. Yoshida, T. Kusaba, H. Tabei, and Y. Tsuchiya. 1952. Varietal difference in resistance to acterial leaf blight of rice plant. 2. Results of multi-needle-prick inoculation /abstr. in Japanese/. Ann. Phytopathol. Soc. Jpn. 17:42.

Ogawa, T., T. Morinaka, K. Fujii, and T. Kimura. 1978. Inheritance of resistance of rice varieties of Kogyoku and Java 14 to bacterial group V of *Xanthomonas oryzae*. Ann. Phytopathol. Soc. Jpn. 44:137-141.

Ou, S. H. 1972. Rice diseases. Commonwealth Mycological Institute, Kew, Surrey, England. 363 p.

Ou, S. H., F. L. Nuque, and J. P. Silva. 1971. Pathogenic variation among isolates of *Xanthomonas oryzae* of the Philippines. Plant Dis. Rep. 55: 22-26.

Petpsist, V., G. S. Khush, and H. E. Kauffman. 1977. Inheritance of resistance to bacterial blight in rice. Crop Sci. 17:551-554.

Reitsma, J., and P. S. J. Schure. 1950. "Kresek," a bacterial disease of rice. Contrib. Gen. Agric. Res. Stn. Bogor 177:1-17.

Sakaguchi, S. 1967. Linkage studies on the resistance to bacterial leaf blight, *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson, in rice /in Japanese, with English summary/. Bull. Natl. Inst. Agric. Sci., Ser. D, 16:1-18.

Sidhu, G. S., and G. S. Khush. 1978. Dominance reversal of a bacterial blight resistance gene in some rice cultivars. Phytopathology 68:461-463.

Sidhu, G. S., G. S. Khush, and T. W. Mew. 1978. Genetic analysis of bacterial blight resistance in seventy-four varieties of rice. *Oryza sativa* L. Theor. Appl. Genet. 53:105-111.

Uchiyamada, H., H. Fujita, K. Kimura, K. Takayanagi, and T. Yamada. 1977. Survey of characteristics of domestic and introduced rice varieties (1)/in Japanese/. Res. Mater. Hokuriku Natl. Agric. 3: 13.

Uchiyamada, H., H. Fujita, K. Kimura, K. Takayanagi, and T. Yamada. 1978. Survey of characteristics of domestic and introduced rice varieties (2)/in Japanese/. Res. Mater. Hokuriku Natl. Agric. 4: 16.

Wakimoto, S. 1967. Strains of *Xanthomonas oryzae* in Asia and their virulence against rice varieties. Pages 19-24 *in* Proceedings of the symposium on rice diseases and their control by growing resistance varieties and other measures. Tokyo.

Wakimoto, S. 1975. Bacterial leaf blight disease of rice in Southeast Asian countries. Pages 11-18 *in* Rice in Asia. University of Tokyo, Japan.

Wakimoto, S., T. Uematsu, and T. Mizukami. 1969. Standard for rating virulence of *Xanthomonas oryzae* and resistance of rice varieties /abstr. in Japanese/. Ann. Phytopathol. Soc. Jpn. 35: 114-115.

Yamada, T., O. Horino, and S. Sameto. 1979a. Studies on genetics and breeding for resistance

to bacterial leaf blight in rice. IV. Inheritance of IR28 to bacterial groups I, II, III, IV, and V of *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson from Japan /in Japanese, with English summary/. Jpn. J. Breed. 29:279-286.

Yamada, T., O. Horino, and S. Samoto. 1979b. Studies on genetics and breeding for resistance to bacterial leaf blight in rice. I. Discovery of new varietal groups on the basis of reaction patterns to five different pathotypes of *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson in Japan /in Japanese, with English summary/. Ann. Phytopathol. Soc. Jpn. 45:240-246.

Yamamoto, T., R. H. Hartini, M. Muchammad, T. Nishiyama, and D. M. Tantera. 1977. Variation in pathogenicity of *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson and resistance of rice varieties to the pathogen. Contrib. Cent. Res. Inst. Bogor 28:1-22.

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

02 0 US 10 00557 1079

LIBRARY
USAID
DEV SUPPORT BUR
WASHINGTON DC
USA 20523

AIR MAIL

ISSN 0115-3862

Other papers in this series

No. 7 Multi-site tests environments and breeding strategies for new rice technology
No. 8 Behavior of minor elements in paddy soils
No. 9 Zinc deficiency in rice: A review of research at the International Rice Research Institute
No. 10 Genetic and sociologic aspects of rice breeding in India
No. 11 Utilization of the Azolla-Anabaena complex as a nitrogen fertilizer for rice
No. 12 Scientific communication among rice breeders in 10 Asian nations
No. 13 Rice breeders in Asia: A 10-country survey of their backgrounds, attitudes, and use of genetic materials
No. 14 Drought and rice improvement in perspective
No. 15 Risk and uncertainty as factors in crop improvement research
No. 16 Rice ragged stunt disease in the Philippines
No. 17 Residues of carbofuran applied as a systemic insecticide in irrigated wetland rice: Implications for insect control
No. 18 Diffusion and adoption of genetic materials among rice breeding programs in Asia
No. 19 Methods of screening rices for varietal resistance to *Cercospora* leaf spot
No. 20 Tropical climate and its influence on rice
No. 21 Sulfur nutrition of wetland rice
No. 22 Land preparation and crop establishment for rainfed and lowland rice
No. 23 Genetic interrelationships of improved rice varieties in Asia
No. 24 Barriers to efficient capital investment in Asian agriculture
No. 25 Barriers to increased rice production in eastern India
No. 26 Rainfed lowland rice as a research priority – an economist's view
No. 27 Rice leaf folder: Mass rearing and a proposal for screening for varietal resistance in the greenhouse
No. 28 Measuring the economic benefits of new technologies to small rice farmers
No. 29 An analysis of the labor-intensive continuous rice production systems at IRRI
No. 30 Biological constraints to farmers' rice yields in three Philippine provinces
No. 31 Changes in rice harvesting systems in Central Luzon and Laguna
No. 32 Variation in varietal reaction to rice tungro disease: Possible causes
No. 33 Determining superior cropping patterns for small farms in a dryland environment: Test of a methodology
No. 34 Evapotranspiration from rice fields
No. 35 Genetic analysis of traits related to grain characteristics and quality in two crosses of rice
No. 36 Aliwalas to rice garden: A case study of the intensification of rice farming in Camarines Sur, Philippines
No. 37 Denitrification loss of fertilizer nitrogen in paddy soils – its recognition and impact
No. 38 Farm mechanization, employment, and income in Nepal: Traditional and mechanized farming in Bara District
No. 39 Study on kresek (wilt) of the rice bacterial blight syndrome
No. 40 Implication of the international rice blast nursery data to the genetics of resistance
No. 41 Weather and climate data for Philippine rice research
No. 42 The effect of the new rice technology in family labor utilization in Laguna
No. 43 The contribution of varietal tolerance for problem soils to yield stability in rice
No. 44 IR42: A rice type for small farmers of South and Southeast Asia
No. 45 Germplasm bank information retrieval system
No. 46 A methodology for determining insect control recommendations
No. 47 Biological nitrogen fixation by epiphytic microorganisms in rice fields
No. 48 Quality characteristics of milled rice grown in different countries
No. 49 Recent developments in research on nitrogen fertilizers for rice
No. 50 Changes in community institutions and income distribution in a West Java village
No. 51 The IRRI computerized mailing list system
No. 52 Differential response of rice varieties to the brown plant-hopper in international screening tests