TARC Repot

Selection of Recurrent Parents to Develop Near-Isogenic Lines Resistant to Bacterial Leaf Blight of Rice

By TSUGUFUMI OGAWA* and TSUYOSHI YAMAMOTO

Research Division II, Tropical Agriculture Research Center
(Yatabe, Ibaraki, 305 Japan)

Introduction

Bacterial leaf blight caused by *Xanthomonas campestris* pv. *oryzae* brings about heavy damage to rice in rice-growing countries of Asia. There is considerably high reliance on the use of resistant cultivars for controlling the disease due to the scarcity of effective bactericidal agents.

Since the pathogenic specialization in the causal bacterium of rice bacterial leaf blight was first reported in Japan by Kuhara et al.[4], a number of reports have been published on the variability of pathogenicity in the bacterium and of the resistance in rice cultivars.

Recent researches on bacterial leaf blight were carried out mostly in Japan and at IRRI (The International Rice Research Institute). Since the differential cultivars and bacterial groups used in both locations were different, the two groups of scientists had a difficult time in distinguishing the resistance gene.

Thus, it is desirable at this stage to compare and analyze the results of the studies conducted in Japan and at IRRI, so as to devise effective methods of control. In order to control the disease, it is important to set up a common base to define the relationship between the virulence of the groups of the bacterial leaf blight pathogens and the resistance of rice cultivars to these races.

International differentials that would be developed by breeding near-isogenic lines with a different resistance gene would be used to carry out studies on the races of bacterial leaf blight. In order to achieve this objective, it is necessary to identify the genes first and search for resistant ones. Thus, MAFF (Ministry of Agriculture, Forestry and Fisheries, Japan), and IRRI decided to collaborate in the following subjects:

1. Breeding of international differentials,
2. Gene analysis using races and differentials of Japan and IRRI,
3. Specific reactions between rice cultivars and races of bacterial leaf blight pathogen in various Asian countries,
4. Testing cultivars for horizontal resistance.

This paper deals with the experiments on the selection of the recurrent parent to develop near-isogenic lines, which were carried out before the collaborative project between MAFF and IRRI started.

Materials and methods

Five rice cultivars, IR24, Milyang 23, Taichung Native 1 (TN1), IR9101-46 and Toyonishiki were selected as the possible recurrent parents to develop near-isogenic lines. Original seeds of IR24, Milyang 23 and Toyonishiki came from National Agriculture Research Center, Japan and IR9101-46 and TN1 from Plant Breeding Department, IRRI.

Present address:
* The International Rice Research Institute
(P. O. Box 933, Manila, Philippines)

Seven standard isolates (*X. campestris* pv. *oryzae*) which came from Japanese races, and 14 ones from Philippine isolates[2,5,6] were used in this experiment. The origin of each Japanese standard isolate is shown as follows:

T7174 for race IA, National Institute of Agricultural Sciences (NIAS)
T7147 for race II, NIAS
T7133 for race IIIA, NIAS
H75373 for race IV, Hokuriku National Agricultural Experiment Station (HOKURIKU)
H75304 for race V, HOKURIKU
T7156 for race IB, NIAS
Q6803 for race IIIB, NIAS

On the other hand, four Philippine isolates, PXO 61, PXO 86, PXO 79, and PXO 71, used in this experiment have been identified at IRRI as races 1, 2, 3 and 4, respectively[5,6]. The other ten isolates of the Philippines were used by Horino et al.[2] at IRRI and were reported to show different pathogenecity from each other. These Philippine isolates were sent to TARC by Dr. O. Horino from IRRI.

Five proposed rice cultivars were transplanted at the isolation greenhouse at TARC, and then inoculated with the 21 isolates.

The methods of the inoculation test were as follows:

1. Inoculation technique: Clipping inoculation method developed by Kauffman et al.[3],
2. Concentration of inoculum: 10^7–10^8 cells/m*l*,
3. Inoculation time: Heading stage of the earliest cultivar,
4. Disease assessment: Measuring the lesion length in each cultivar when the lesion of the most susceptible cultivar reaches the length of 10–15 cm,
5. Number of leaves used for estimation: More than 6 leaves in three plants for each isolate.

Results and discussions

1) The reaction of five rice cultivars proposed as recurrent parents to Japanese races

As shown in Table 1, IR24 and Milyang 23 apparently showed a susceptibility to all Japanese races. The reaction of Toyonishiki, when the five cultivars were measured at the same time, varied from moderately resistant to moderately susceptible. But, its lesion length expanded continuously even after it was measured. Therefore, Toyonishiki could also be evaluated as susceptible to all Japanese races.

On the other hand, IR9101-46 showed a high resistance to races IA, IB, II and V while it showed susceptibility to races IIIA, IIIB and IV. TN1 was also resistant to races IA, IB and II, though TN1 was susceptible to races IIIA, IIIB and IV, and was moderately resistant or moderately susceptible to race V.

Six Japanese standard isolates, T7174(IA),

Table 1. Reaction of proposed five cultivars of rice to Japanese seven races

Cultivar	Race						
	IA T7174	IB T7156	II T7147	IIIA T7133	IIIB Q6803	IV H75373	V H75304
IR24	9.3—18.7 S	6.0—13.2 S	8.9—12.4 S	12.2—14.8 S	14.0—18.7 S	13.7—17.2 S	3.7—6.0 S
Milyang 23	7.6—12.0 S	16.1—18.6 S	10.8—16.5 S	15.9—20.9 S	12.1—12.5 S	13.2—18.4 S	3.8—11.1 S
IR9101—46	0.7—0.9 R	0.8—1.0 R	2.0—3.5 R	16.7—22.8 S	13.2—20.4 S	16.9—19.1 S	0.4—0.5 R
TN1	1.0—1.7 R	0.3—2.2 R	0.5—2.9 R	14.6—20.5 S	17.0—25.0 S	14.3—21.2 S	0.8—3.5 *
Toyonishiki	9.0—9.9 MS	6.9—8.2 MS	5.6—6.1 MS	6.2—9.4 MS	3.9—7.2 MS	5.4—10.3 MS	3.3—4.7 MS

Upper row: Minimum-maximum lesion length (cm).
Lower row: R-resistant, S-susceptible, MS-moderately susceptible.
* Coulld not be decided.

T7156(IB), T7147(II), T7133(IIIA), Q6803(IIIB) and H75373(IV), showed enough virulence in this experiment. But, one Japanese isolate H75304(V) was weak in virulence; thus, it may be unsuitable as a standard for the race V.

2) The reaction of the five proposed rice cultivars as recurrent parents to the Philippine races

Mew and Vera Cruz[5], and Mew et al.[6] divided Philippine isolates into four races, but recently Horino et al.[2] classified Philippine isolates into 8 groups, from A to H. However, in their article[2], no isolate was mentioned for the group G. Furthermore, three isolates mentioned could not be classified into any of the described groups. Therefore, these 10 isolates (7 isolates which belonged to each of the groups A to F, and H, and 3 unclassified isolates) were used for the inoculation to the four cultivars except TN1.

One classified isolate, IRN161, used in this experiment showed substantial weakness in virulence. Table 2 shows the result of inoculation test using four Philippine races while Table 3 shows the result of inoculation test using the remaining 9 isolates.

IR24, Milyang 23 and IR9101-46 were apparently susceptible to all the Philippine races and isolates in this experiment while Toyonishiki showed slightly lower lesion length than the other cultivars.

For developing near-isogenic lines, it is necessary to select a recurrent parent susceptible to all bacterial groups of rice bacterial leaf blight. Since it is impossible for us to use all existing groups, we had to

Table 2. Reaction of the four proposed rice cultivars to the four Philippine races

Cultivar	Race			
	1 PXO 61	2 PXO 86	3 PXO 79	4 PXO 71
IR24	10.8—15.2 S	14.3—17.8 S	10.6—14.5 S	8.5—14.7 S
Milyang 23	12.5—15.3 S	10.1—17.7 S	13.1—19.2 S	9.9—15.4 S
IR9101-46	16.7—23.7 S	21.0—38.9 S	20.5—21.0 S	13.0—21.3 S
Toyonishiki	4.3—4.9 MS	3.7—4.7 MS	4.4—6.7 MS	4.9—6.8 MS

Legend: See Table 1.

Table 3. Reaction of the four proposed rice cultivars to Philippine isolates used by Horino et al. (1980)

Cultivar	Race							Unclassified isolate	
	A IRN210	B IRN246	C IRN249	D IRN243	E IRN237	F IRN280	H IRN212	IRN293	IRN223
IR24	13.0—18.3 S	12.3—16.4 S	14.3—15.0 S	8.6—9.5 S	8.5—17.0 S	13.7—19.3 S	17.9—21.5 S	18.1—24.3 S	16.3—19.0 S
Milyang 23	17.1—19.8 S	15.2—15.4 S	14.3—19.3 S	23.1—29.3 S	11.7—18.3 S	11.5 S	18.0—23.9 S	19.2—22.8 S	9.4—13.7 S
IR9101-46	22.0—29.5 S	22.8—24.8 S	26.7—28.7 S	10.8—16.2 S	10.9—22.4 S	18.5—23.8 S	21.1—22.7 S	23.1—28.4 S	18.8—23.7 S
Toyonishiki	6.9—7.5 MS	6.2—8.7 MS	4.3—7.4 MS	6.2—7.2 MS	4.7—8.3 MS	8.3—9.3 MS	5.7—11.1 MS	6.0—7.8 MS	6.2—9.0 MS

Legend: See Table 1.

select the cultivar by using inoculation tests with Japanese and Philippine races, as well as by making use of published information.

In past inoculation tests conducted by several researchers, IR24 and Milyang 23 were susceptible to all Japanese races[7,8] and to the inoculated Indonesian races[9]. Milyang 23 was also reported to be susceptible to all Korean isolates tested[1]. We selected IR24 and Milyang 23 as possible recurrent parents because of the above information on inoculation tests as well as their improved plant type.

On the other hand, TN1 and IR9101-46 were selected as alternative parents and were sent to TARC for testing with Japanese races. TN1 was recognized to be susceptible to all isolates distributed in Southeast and South Asian countries. In the IRRI Germplasm Evaluation and Utilization Program, it was discovered that IR9101-46 was susceptible to all Philippine races but resistant to other diseases and insects.

Toyonishiki, a cultivar with low photosensitivity in Japan, was selected as a possible recurrent parent to develop differentials for areas where japonica rice presently cultivated.

In our experiments mentioned above, TN1 and IR9101-46 showed resistance to some Japanese races. Therefore, these two cultivars can not be used as recurrent parents to develop near-isogenic lines for international differentials. IR24 and Milyang 23 showed susceptibility to all Japanese and Philippines races used. Thus, based on our experimental results and published information, we selected initially IR24 and Milyang 23 as recurrent parents to develop near-isogenic lines for international differentials. We also concluded that Toyonishiki was suitable as a recurrent parent for near-isogenic lines although this cultivar seemed to have quantitative resistance.

Summary

To develop near-isogenic lines having each resistance gene to bacterial leaf blight (*X. campestris*. pv. *oryzae*), we carried out an inoculation test to select recurrent parents.

In the inoculation test using seven Japanese races and 13 Philippine ones, three cultivars, IR24, Milyang 23 and Toyonishiki, showed susceptibility to all races. However, two other cultivars, TN1 and IR9101-46, were resistant to some Japanese races.

Based on this result and past published data given by several researchers, we selected IR24, Milyang 23 and Toyonishiki as recurrent parents to develop near-isogenic lines.

The purpose of developing near-isogenic lines is to establish a set of international differentials with monogenic base of the resistance to bacterial leaf blight pathogen and to supply reliable materials to breeding programs for resistant varieties.

Acknowledgement

The authors wish to express sincere thanks to Rice Breeding Laboratory of National Agriculture Research Center in Japan and to Dr. G. S. Khush of the International Rice Research Institute in the Philippines for supplying the seeds of rice cultivars.

Our sincere gratitude is due to the 1st Laboratory for Bacterial diseases of National Institute of Agricultural Sciences* in Japan and to Dr. O. Horino of Tohoku National Agricultural Experiment Station in Japan for supplying the bacterial isolates.

Furthermore, the authors wish to express thanks to the participants in the MAFF meeting held in TARC in preparation for the workshop of the collaborative project between MAFF and IRRI for their valuable advice and suggestions given to the authors.

References

1) Choi, Y. C.: The outbreak and control of bacterial diseases in Korea. Proc. Seminar Pest Management Rice East Asia, 9-1-9-36 (1981).
2) Horino, O. et al.: Resistance of Japanese and IRRI differential rice varieties to pathotypes of *Xanthomonas oryzae* in the Philippines and in Japan. *IRRI Research Paper Series*, **53** (1980).
3) Kauffman, H. E. et al.: An improved technique for evaluating resistance of rice varieties to *Xanthomonas oryzae*. *Pl. Disease Rep.*, **57**, 537–541 (1971).
4) Kuhara, S., Sekiya, N. & Tagami, Y.: On the pathogen

* Present name: Laboratory of Bacteriology, National Institute of Agro-Environmental Sciences

of bacterial leaf blight of rice isolated from severely affected area where resistant variety was widely cultivated. *Ann. Phytopathol. Soc. Jpn.*, **23**, 9 (1958) [Abstract in Japanese].

5) Mew, T. W. & Vera Cruz, C. M.: Variability of *Xanthomonas oryzae*. Specificity in infection of rice differentials. *Phytopathol.*, **69**, 152–155 (1979).
6) Mew, T. W., Vera Cruz, C. M. & Reyes, R. C.: Interaction of *Xanthomonas campestris* pv. *oryzae* and a resistant rice cultivar. *Phytopathol.*, **72**, 786–789 (1982).
7) Ogawa, T.: Pathogenic specialization in bacterial group I and III of *Xanthomonas campestris* pv. *oryzae* in Japan. *Ann. Phytopathol. Soc. Jpn.*, **49**, 69–72 (1983).
8) Uchiyamada, H. et al.: Survey of characteristics of domestic and introduced varieties. Res. Rept. Agr. Development in Hokuriku Area., No. 3, 137., Hokuriku Nat. Agr. Exp. Sta., (1977) [In Japanese].
9) Yamamoto, T. et al.: Variation in pathogenicity of *Xanthomonas oryzae* (Uyeda et Ishiyama) Dowson and resistance of rice varieties to the pathogen. *Contribution Centr. Res. Inst. Agr.*, **28**, 1–22 (1977).

(Received for publication, October 6, 1986)