Wild Species Oryza spp.:  
A Prospective Source of Bacterial Blight Resistance for Rice Breeding

Buang Abdullah

Research Institute for Agricultural Biotechnology and Genetic Resources, Bogor

ABSTRACT. Bacterial blight (BB) disease caused by Xanthomonas oryzae pv. oryzae is one of the problems in rice production. Wild species of rice is an important source of gene resistance for diseases and insect pests. Seventy-four accessions of 13 diploid and tetraploid wild species and three accessions of African rice (O. glaberrima) were tested for BB resistance in the greenhouse by clipping method. Thirty-one accessions were found to be resistant to race IV and 25 accessions resistant to race IV and VIII of BB; and one accession of African rice was also found to be resistant to both races. Those resistant accessions could be used in the breeding program as source of resistant genes for the disease.

Keywords: Oryza spp., resistant gene, Xanthomonas oryzae pv. oryzae.

Bacterial blight of rice caused by Xanthomonas oryzae pv. oryzae is one of the important rice production constraints (Mackill 1986). It reduces grain yield to varying levels depending upon the stage of the crop affected and the degree of susceptibility of cultivar. Losses due to bacterial blight in the tropics are higher than in temperate regions (Mizukami and Reddy 1972). In Indonesia the disease had been reported in 1950 known as Kresek (Reitsma and Schure 1950); and could reduce rice yield from 21 to 36% in the wet season and from 18 to 28% in the dry season (Suparyono and Sudir 1992).

Xanthomonas oryzae pv. oryzae (Xoo) produces bacteriocin like substances on solid media (Mew 1987). These proteins are recorded by the avr/pth gene family of Xoo. The proteins function as signal molecules which affect host-specific plants responses such as cell division, water soaking (i.e., filling of the cellular spaces in the leaf mesophyll with water instead of air) and the hypersensitive response. The first evidence for pathogenic specialization was reported by Vera-Cruz and Mew (1979). They recognized four bacterial groups where interaction was confined to a specific cultivar-isolate combination. "Race" or "strain" was adopted to classify the bacterial isolates. Each race had specific virulence to varieties with different resistance genes following a gene-for gene concept in the host pathogen interaction. In the Philippines, 10 races are currently recognized (Angeles, personal communication), while in Indonesia, 12 races of BB have been reported by Kadir (2000), and races IV and VIII have been more prevalent in the field since 1996.

Sources of genes for resistance to BB have been intensively explored and studied, mainly in Japan and at the International Rice Research Institute in the Philippines (Kaku 1997). Therefore, the determination of the genes depended on the reaction of the genes to Japaneese and Philippines races of BB. Twenty-four major genes for BB resistance have been designated, of which six are recessive (Table 1).

The genus Oryza to which cultivated rice belong to has 24 wild species. These wild species have 2n = 24 or 48 chromosomes representing ten genomes, AA, BB, BBCC, CC, CCDD, EE, FF, GG, HHJJ and HHKK (Vaughan 1994, Aggarwal et al. 1997, Ge et al. 1999). Wild species is an important reservoir of useful genes for rice breeding program, especially for resistance to insect pests and diseases (Heinrichs et al. 1985, Sitch 1990). Therefore, wild species of Oryza offers potential gene source for incorporation of diverse genes for resistance to BB in rice breeding. A number of useful genes have been introgressed into cultivated rice, such as, genes resistance for grassy stunt virus, BB, brown planthopper (BPH), blast, and tungro (Brar and Khush 1997). Two alien genes for BB resistance introgressed into rice has been identified their action (Table 1).

Race development of the disease is very fast especially due to resistant cultivar force selection. Twelve and 10 races have been identified in Indonesia and the Philippines, respectively. Twenty-four genes for
resistance have been identified, however, the races may not the same in Indonesia, the Philippines and other countries. Therefore, the objective of this study is to identify wild species of rice having genes for resistance against Indonesian bacterial blight that would be useful for rice breeding program in Indonesia.

**MATERIALS AND METHODS**

Investigation was carried out in the greenhouse of Research Institute for Agricultural Biotechnology and Genetic Resources, Bogor in 2002. Plant materials consisted of seventy-four accessions of wild species, three of African rice and two of Asian rice. The Asian rices were IR64 and BP364B-MR-33-3-PN-5-1 used as checks. IR64 was resistant to race IV but susceptible to race VIII, while BP364B-MR-33-3-PN-5-1 was susceptible to both races. Seeds of the wild species were dehulled by hand and germinated in petridishes. Germinating seeds were sown on soil in plastic trays. Two weeks later, three-leaf healthy seedlings were transplanted in the pots. The materials were planted in pots containing 15 kg soil. Each accession was planted in 3 pots, 3 plants per pot. Three pots represented replications. Fertilizer of 5 g urea, 2 g SP36 (super phosphate) were applied to each pot as basic fertilizer, and 2 g of Urea as well as phosphate were added 21 days after transplanting.

Two Indonesian BB races, namely race IV (Xoo 8821) and VIII (Xoo 8817) were used for inoculation. The bacteria were transferred from skim-milk medium to Wakimoto medium (A. Nasution, personal communication) and incubated at 30°C for 2 days. Inoculum was prepared by suspending the bacterial mass with sterilized water to concentration of about $10^9$ cells per ml, counted in a count chamber under microscope. Inoculation was done at 40 days after transplanting by clipping 5 leaf blades per plants (Kauffmann et al. 1973). Scoring was performed at 14 days after inoculation by lesion length measurement. Lesion of inoculated leaves was measured from the cut tip to the end of the lesion. Final lesion length was the average lesion length of three replications. Since the objective of this research was to identify the source of resistant genes, therefore, plants were classified into two categories, resistant (R) when the lesion < 3 cm and susceptible (S) when the lesion > 3 cm.

**RESULTS AND DISCUSSION**

The result of the investigation is shown in Table 2 and 3. Out of 74 wild species and three African rice accessions, 31 and 25 accessions showed resistance against BB race IV and both races (IV and VIII), respectively. In the two checks, BP364 was susceptible to both races and IR64 was resistant to race IV but susceptible to race VIII (Table 3). The accessions, which were resistant to race VIII, were also resistant to

---

### Table 1. Identified genes for resistance to bacterial blight, their sources and person(s) discovered in rice.

<table>
<thead>
<tr>
<th>Gene(s)</th>
<th>Source</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xa1</td>
<td>Kogyoku</td>
<td>Sakaguchi 1967</td>
</tr>
<tr>
<td>Xa2</td>
<td>Rantai Emas</td>
<td>Sakaguchi 1967</td>
</tr>
<tr>
<td>Xa3</td>
<td>Wase Aikoku</td>
<td>Ezuka et al. 1975</td>
</tr>
<tr>
<td>Xa4</td>
<td>TKM6</td>
<td>Petpisit et al. 1977</td>
</tr>
<tr>
<td>xa5</td>
<td>DZ129</td>
<td>Petpisit et al. 1977</td>
</tr>
<tr>
<td>xa7</td>
<td>DV85</td>
<td>Sidhu et al. 1978</td>
</tr>
<tr>
<td>xa8</td>
<td>PI 231129</td>
<td>Sidhu et al. 1978</td>
</tr>
<tr>
<td>xa10</td>
<td>CAS209</td>
<td>Yoshimura et al. 1983</td>
</tr>
<tr>
<td>xa11</td>
<td>IR8</td>
<td>Ogawa and Yamamoto 1986</td>
</tr>
<tr>
<td>xa12</td>
<td>Kogyoku</td>
<td>Ogawa et al. 1987; Ogawa 1987</td>
</tr>
<tr>
<td>xa13</td>
<td>BJ1</td>
<td>Ogawa 1987</td>
</tr>
<tr>
<td>xa14</td>
<td>TN1</td>
<td>Taura et al. 1987 1992</td>
</tr>
<tr>
<td>xa16</td>
<td>Tetep</td>
<td>Noda and Ohuchi 1989</td>
</tr>
<tr>
<td>xa17</td>
<td>Asominori</td>
<td>Ogawa et al. 1989</td>
</tr>
<tr>
<td>xa18</td>
<td>IR24</td>
<td>Yamamoto and Ogawa 1990</td>
</tr>
<tr>
<td>xa19</td>
<td>XM5</td>
<td>Taura et al. 1991</td>
</tr>
<tr>
<td>xa20</td>
<td>XM6</td>
<td>Taura et al. 1992</td>
</tr>
<tr>
<td>xa21</td>
<td>O. longistaminata</td>
<td>Khush et al. 1990</td>
</tr>
<tr>
<td>xa22</td>
<td>Zhachanglong</td>
<td>Lin et al. 1996</td>
</tr>
<tr>
<td>xa23</td>
<td>O. rufipogon</td>
<td>Zhang et al. 1998</td>
</tr>
<tr>
<td>xa24</td>
<td>DV86</td>
<td>Khush and Angeles 1999</td>
</tr>
</tbody>
</table>

### Table 2. Wild species and African rice tested for resistance against Indonesian bacterial blight.

<table>
<thead>
<tr>
<th>Species</th>
<th>Genome</th>
<th>Access. tested</th>
<th>Resistant to race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IV</td>
<td>VIII</td>
</tr>
<tr>
<td>O. glaberrima</td>
<td>AA</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>O. nivara</td>
<td>AA</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>O. rufipogon</td>
<td>AA</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>O. barthi</td>
<td>AA</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>O. glumaepatula</td>
<td>AA</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>O. punctata</td>
<td>BB, BBCC</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>O. officinalis</td>
<td>CC</td>
<td>19</td>
<td>9</td>
</tr>
<tr>
<td>O. rhizomatis</td>
<td>CC</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>O. australiensis</td>
<td>EE</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>O. minuta</td>
<td>BBCC</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>O. grandiglumis</td>
<td>CCDD</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>O. malapuzhaensis</td>
<td>CCDD</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>O. alta</td>
<td>CCDD</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>O. latifolia</td>
<td>CCDD</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>O. sativa(cultivars)</td>
<td>AA</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Total 79 31 0 25
race IV but not vice versa. This means that race VIII is more virulent than that of race IV. Of the three African rice accessions, one accession (O. glaberrima, Acc. 101297) showed resistance to both races, while the other two were susceptible (Table 3). This means that the accession is a good gene source for BB resistance in rice breeding. The African rice has the same genome as Asian rice, therefore, it would be easy to transfer their useful genes to Asian cultivated rice (O. sativa). Out of 10 accessions of AA wild species tested, five showed resistance against BB race IV only (Table 2). Those accessions were three accessions of O. rufipogon and one accession of O. barthii (Table 2, 3). O. rufipogon was the ancestor of O. sativa, while O. barthii was the ancestor of O. glaberrima (Matsuo 1997). O. rufipogon was also known as O. perennis (Matsuo 1997) and O. barthii was also known as O. longistaminata for the perennial and O. breviligulata for the annual plant (Ghesquiere 1986). O. longistaminata had resistant gene for Xa21 (Khush et al. 1990).

### Table 3. Reaction of wild species of rice against Indonesian bacterial blight.

<table>
<thead>
<tr>
<th>Species (accession)</th>
<th>Reaction to race</th>
<th>Species (accession)</th>
<th>Reaction to race</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IV</td>
<td>VIII</td>
<td>IV</td>
</tr>
<tr>
<td>O. glaberrima (Acc.100156)</td>
<td>S (3.8)</td>
<td>S (4.9)</td>
<td>O. officinalis (W81)</td>
</tr>
<tr>
<td>O. glaberrima (Acc.101297)</td>
<td>R (0.9)</td>
<td>R (1.3)</td>
<td>O. officinalis (Acc.100178)</td>
</tr>
<tr>
<td>O. glaberrima (Acc.101914)</td>
<td>S (3.5)</td>
<td>S (3.3)</td>
<td>O. officinalis (Acc.100181)</td>
</tr>
<tr>
<td>O. ninvara (Acc.102164)</td>
<td>S (3.9)</td>
<td>S (10.8)</td>
<td>O. officinalis (Acc.100896)</td>
</tr>
<tr>
<td>O. ninvara (Acc.102175)</td>
<td>S (3.2)</td>
<td>S (6.9)</td>
<td>O. officinalis (Acc.10460)</td>
</tr>
<tr>
<td>O. ninvara (Acc.103821)</td>
<td>S (4.4)</td>
<td>S (13.6)</td>
<td>O. officinalis (Acc.105100)</td>
</tr>
<tr>
<td>O. ninvara (Acc.103840)</td>
<td>S (4.2)</td>
<td>S (8.2)</td>
<td>O. officinalis (Acc.105220)</td>
</tr>
<tr>
<td>O. rufipogon (Acc.100211)</td>
<td>S (3.5)</td>
<td>S (8.7)</td>
<td>O. officinalis (Acc.105365)</td>
</tr>
<tr>
<td>O. rufipogon (Acc.102186)</td>
<td>R (1.5)</td>
<td>S (5.0)</td>
<td>O. officinalis (Acc.106319)</td>
</tr>
<tr>
<td>O. rufipogon (Acc.105308)</td>
<td>R (1.3)</td>
<td>S (9.6)</td>
<td>O. officinalis (Acc.106520)</td>
</tr>
<tr>
<td>O. rufipogon (Acc.105349)</td>
<td>R (2.0)</td>
<td>S (9.4)</td>
<td>O. officinalis (Acc.106524)</td>
</tr>
<tr>
<td>O. barthii (Acc.104384)</td>
<td>R (1.0)</td>
<td>S (4.5)</td>
<td>O. punctata (Acc.100892)</td>
</tr>
<tr>
<td>O. glumaepatula (K)(Acc.101960)</td>
<td>S (3.6)</td>
<td>S (8.2)</td>
<td>O. punctata (Acc.101409)</td>
</tr>
<tr>
<td>O. grandiglumis (Acc.105560)</td>
<td>R (1.5)</td>
<td>S (3.5)</td>
<td>O. punctata (Acc.101409)</td>
</tr>
<tr>
<td>O. grandiglumis (Acc.105156)</td>
<td>S (1.8)</td>
<td>S (4.2)</td>
<td>O. punctata (Acc.101417)</td>
</tr>
<tr>
<td>O. malampuzensis (Acc.100957)</td>
<td>R (0.6)</td>
<td>R (0.2)</td>
<td>O. punctata (Acc.101419)</td>
</tr>
<tr>
<td>O. malampuzensis (Acc.105223)</td>
<td>R (1.2)</td>
<td>R (1.3)</td>
<td>O. punctata (Acc.103896)</td>
</tr>
<tr>
<td>O. malampuzensis (Acc.105329)</td>
<td>R (0.4)</td>
<td>S (3.2)</td>
<td>O. punctata (Acc.104056)</td>
</tr>
<tr>
<td>O. australiensis (Acc.100882)</td>
<td>S (4.0)</td>
<td>S (13.5)</td>
<td>O. punctata (Acc.104059)</td>
</tr>
<tr>
<td>O. australiensis (Acc.103318)</td>
<td>S (5.2)</td>
<td>S (15.5)</td>
<td>O. punctata (Acc.104074)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105219)</td>
<td>S (3.1)</td>
<td>S (13.5)</td>
<td>O. punctata (Acc.105153)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105264)</td>
<td>S (4.8)</td>
<td>S (15.1)</td>
<td>O. punctata (Acc.105920)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105266)</td>
<td>S (3.2)</td>
<td>S (12.1)</td>
<td>O. rhizomatis (Acc.103410)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105269)</td>
<td>S (4.1)</td>
<td>S (15.5)</td>
<td>O. rhizomatis (Acc.103417)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105273)</td>
<td>S (3.2)</td>
<td>S (10.8)</td>
<td>O. rhizomatis (Acc.105432)</td>
</tr>
<tr>
<td>O. australiensis (Acc.105623)</td>
<td>S (4.0)</td>
<td>S (14.7)</td>
<td>O. latifolia (Acc.100165)</td>
</tr>
<tr>
<td>O. alta (Acc.100888)</td>
<td>R (1.7)</td>
<td>S (3.7)</td>
<td>O. latifolia (Acc.100170)</td>
</tr>
<tr>
<td>O. alta (Acc.100925)</td>
<td>S (4.3)</td>
<td>S (10.5)</td>
<td>O. latifolia (Acc.100885)</td>
</tr>
<tr>
<td>O. alta (Acc.105138)</td>
<td>S (2.2)</td>
<td>S (3.7)</td>
<td>O. latifolia (Acc.100168)</td>
</tr>
<tr>
<td>O. alta (Acc.105143)</td>
<td>R (1.0)</td>
<td>S (3.5)</td>
<td>O. latifolia (Acc.100914)</td>
</tr>
<tr>
<td>O. alta (Acc.105222)</td>
<td>R (1.7)</td>
<td>S (3.7)</td>
<td>O. latifolia (Acc.100966)</td>
</tr>
<tr>
<td>O. alta (Acc.120952)</td>
<td>R (1.4)</td>
<td>S (4.1)</td>
<td>O. latifolia (Acc.101392)</td>
</tr>
<tr>
<td>O. officialis (Acc.100878)</td>
<td>R (0.1)</td>
<td>R (0.5)</td>
<td>O. latifolia (Acc.102164)</td>
</tr>
<tr>
<td>O. officialis (Acc.101112)</td>
<td>R (0.4)</td>
<td>R (1.3)</td>
<td>O. latifolia (Acc.105141)</td>
</tr>
<tr>
<td>O. officialis (Acc.101118)</td>
<td>R (0.6)</td>
<td>S (3.3)</td>
<td>O. minuta (Acc.101089)</td>
</tr>
<tr>
<td>O. officialis (Kathiri)</td>
<td>R (0.4)</td>
<td>S (4.3)</td>
<td>O. minuta (Acc.101141)</td>
</tr>
<tr>
<td>O. officialis (purple)</td>
<td>R (0.4)</td>
<td>R (2.3)</td>
<td>O. minuta (Acc.101386)</td>
</tr>
<tr>
<td>O. officialis (W38)</td>
<td>R (0.9)</td>
<td>S (3.2)</td>
<td>BP364B-MR33-3-PN5-1 (rice line)</td>
</tr>
<tr>
<td>O. officialis (W46)</td>
<td>R (0.5)</td>
<td>S (3.3)</td>
<td>IR64 (rice variety)</td>
</tr>
<tr>
<td>O. officialis (W51)</td>
<td>R (0.8)</td>
<td>S (3.2)</td>
<td></td>
</tr>
</tbody>
</table>

R, resistant < 3.0 cm; S, susceptible > 3.0 cm
Although they were wild species but they are closely related to cultivated rice, therefore, effort to transfer the genes would not be so difficult. Hybrids would be produced without embryo rescue and introgression lines would be resulted through backcross program to cultivated rice parent. Useful genes have been introgressed from closely related species into rice, such as gene for grassy stunt virus resistance from O. nivara, BB resistance from O. longistaminata, blast from O. rufipogon, cytoplasmic male sterility from O. sativa f. spontanea, O. perennis, and O. glumaepatula (Khush et al. 1977, Khush et al. 1990, Utami et al., 2001, Lin and Yuan 1980, Damalcio et al. 1995, 1996).

Out of 41 diploid non-AA genomes tested, 11 and 18 accessions resistant against race IV and both races, respectively, were found the CC genome species was likely to be a good source for BB resistant genes, because all of 22 accessions tested had genes for BB resistance. While none of eight accessions of EE genome, O. australiensis had gene for BB resistance (Table 2). Out of 23 accessions of tetraploid species, 15 accessions showed resistance against race IV and five resistance against both races. O. minuta was the most resistant among the wild with lesion of 0.0 to 0.3 cm (Table 3). Therefore, this species was a good source for BB resistant gene. Genes for BB resistance have been introgressed from O. minuta Acc. 101141 (Amante-Bordeos et al. 1992, Mariam et al. 1996) and from O. minuta Acc. 101089 (Abdullah et al. 2001) into cultivated rice.

Gene transfer from those species is quite difficult. The more distant the species, the more difficult to transfer genes into rice. Several crossability barriers such as high sterility, limited the homologous chromosome pairing and recombination between the genome of cultivated and the wild species, and hybrid breakdown restricted alien introgression and transfer of useful genes into cultivated rice (Brar and Khush 1997). Therefore, extra efforts, such as embryo rescue and the use of hormones, must be utilized. Many useful genes have been successfully transferred from those species, such as genes for BPH resistance from O. officinalis and O. australiensis (Jena and Khush 1990; Multani et al. 1994).

CONCLUSION

Wild species of rice has been identified as gene source for Indonesian bacterial blight resistance. Thirty-one accessions were resistant against race IV only, and 25 accessions for race IV and VIII. One accession of African rice (O. glaberrima) was found to be resistance to both races. Those resistant accessions could be used in rice breeding program to broaden genetic variability for BB resistance that would enhance breeding program, especially for resistance to Indonesian BB.

ACKNOWLEDGEMENT

The author would like to express his thanks and appreciation to Mrs. Anggiani Nasution who had prepared bacterial blight inoculum.

REFERENCE


