SHORT COMMUNICATION

Non-hypersensitive Leaf Rust Resistance of Bread Wheat Cultivar PBW65 Conditioned by Genes Different from Lr34

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Abstract: The bread wheat (Triticum aestivum L.) cultivar PBW65 has shown high levels of resistance to the most frequent and highly virulent Indian race 77-5 of leaf rust (Puccinia triticina). The infection type and disease severity indicated a non-hypersensitive type of resistance against the race 77-5 in PBW65. The cultivar PBW65 was crossed with the leaf rust susceptible cultivar WL711 to determine the mode of inheritance of the resistance. The segregation for resistant and susceptible plants in the F2 and F3 generations revealed, that two genes, each showing additive effects, were likely to confer resistance to leaf rust in PBW65. Intercrossing of PBW65 with Cook (Lr34), RL6058 (Lr34) and HD2009, possessing a similar resistance level like PBW65, revealed that the genes for leaf rust resistance in PBW65 were non-allelic to Cook (Lr34), RL6058 (Lr34) as well as to the gene(s) in HD2009. It is concluded that the cultivar PBW65 is a novel source of non-hypersensitive leaf rust resistance.

Keywords: Puccinia triticina; allelic test; durable resistance; Triticum aestivum L.
resistance (APR). Both these genes are also linked to stripe rust resistance (Singh 1992a, b; Singh & Rajaram 1992; Singh et al. 1998; Martinez et al. 2001; William et al. 2003; Suenaga et al. 2003; Rosewarne et al. 2006). Of these only the Lr34-Yr18 gene pair is effective in India. Durable adult plant resistance to leaf rust and stripe rust was reported to be quantitatively inherited in the cultivar Cook and based on slow-rusting genes Lr34 and Yr18 and the temperature-sensitive stripe rust resistance gene, YrCK (Navabi et al. 2005). The gene Lr46 is considered in India as ineffective. Because of the almost complete absence of avirulence to Lr34 the detection of this gene is based on a morphological marker leaf tip necrosis (Ltn), which is also believed to be tightly linked to this gene (Singh 1992a). Kaur et al. (2000) reported many wheats in which Ltn was not present and the non-hypersensitive resistance (NHR) to leaf rust could be ascribed to gene(s) different from Lr34. The present paper reports on the genes conferring non-hypersensitive resistance in the Indian cultivar PBW65.

MATERIALS AND METHODS

Cultivar PBW65 (USA225/K816/3/S738// C306/ Kalyansona) was crossed with a leaf rust susceptible cultivar WL711 (S308/Chris/Kalyansona), the reference line RL6058 (6*Thacher/PI58548) for the gene Lr34, cultivar Cook (Timgalen/Condor Sib/Condor) and the cultivar HD2009 (Lerma Rajo 64A/Nainari 60), each of these showing non-hypersensitive resistance to leaf rust (Saini & Amita 2000; Khanna et al. 2005). The landrace Agra Local was used as a susceptible check. The inoculum of leaf rust race 77-5 having virulence to all the known genes for leaf rust resistance originating from bread wheat was kindly supplied by the Head of the Wheat Rust Research Station, Directorate of Wheat Research, Indian Council of Agricultural Research, Flowerdale, Shimla, Himachal Pradesh. The F1 and segregating F2, and F3 populations obtained from crosses were assessed for disease severity in field tests (percentage of leaf area covered with rust) using the modified Cobb scale (Peterson et al. 1948). In total 200 individual F3 plants were harvested to develop their respective F3 families. The leaf rust scores of only 154 F2 plants could be obtained during the season because the remaining plants were severely infected with stripe rust.

Table 1: Segregation for leaf rust resistance in field tests against race 77-5 for crosses of cultivar PBW65 with WL711, Cook, RL6058 (Lr34) and HD2009

<table>
<thead>
<tr>
<th>Cross†</th>
<th>Generation F2</th>
<th>Generation F3</th>
<th>χ²</th>
<th>Expected ratio</th>
<th>χ²</th>
<th>Expected ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBW65 (30S) × WL711 (80S-90S)</td>
<td>142</td>
<td>12</td>
<td>154</td>
<td>151</td>
<td>0.62</td>
<td>106</td>
</tr>
<tr>
<td>PBW65 (30S) × Cook (20S)</td>
<td>1337</td>
<td>8</td>
<td>1345</td>
<td>1345</td>
<td>1.44</td>
<td>F3 not tested</td>
</tr>
<tr>
<td>PBW65 (30S) × RL6058 (20S)</td>
<td>311</td>
<td>7</td>
<td>318</td>
<td>318</td>
<td>0.84</td>
<td>F3 not tested</td>
</tr>
<tr>
<td>PBW65 (30S) × HD2009 (30S)</td>
<td>307</td>
<td>3</td>
<td>310</td>
<td>310</td>
<td>2.65</td>
<td>F3 not tested</td>
</tr>
</tbody>
</table>

†Figures in parenthesis give the percent disease severity, *significance at a 5% probability level.
RESULTS

Disease severity of 30S was recorded in the cultivar PBW65, which is comparable to the disease severity observed on the cultivar Cook (20S), line RL6058 (20S) both carrying the gene Lr34 and cultivar HD2009 (30S) (Table 1). The disease severity in the susceptible cultivars WL711 and Agra Local was estimated to lie between 80S and 90S. The F₁ plants from the cross PBW65 × WL711 showed the percent disease severity of 40S as compared to 80S to 90S recorded in the susceptible parent WL711. The F₂ generation of this cross segregated 142 resistant (R):12 susceptible (S, the score lower than in WL711) which fits to the two gene ratio of 15 (R):1(S) with chi-square = 0.62. The F₃ families from this cross segregated 106 homozygous resistant (HR):84 segregating (Seg):10 homozygous susceptible (HS). The leaf rust severity observations from F₃ families probably also fitted to two gene ratio of 7 (HR):8 (Seg):1 (HS) though the chi-square value (6.52) was significant at a 5% probability level. The high chi-square value could result from misclassification of some segregating F₂ families as resistant because such families contained less than ten plants. The F₂ generations (318 plants) of the cross PBW65 × RL6058 (Lr34), 1345 plants of the cross PBW65 × Cook (Lr34) and 310 plants from the cross of PBW65 with HD2009 segregated for leaf rust susceptible plants at three gene (63:1), four gene (255:1) and four gene ratios (255:1), respectively. This indicates that gene(s) present in PBW65 are non-allelic to Lr34 and also to the genes for leaf rust resistance in HD2009. The comparative rate of leaf rust progress of cultivars PBW65, RL6058, Cook, HD2009, WL711 and Agra Local is shown in Figure 1.

DISCUSSION

The leaf tip necrosis (Ltn) considered as a phenotypic marker for detecting the leaf rust resistance gene Lr34 was not evident in the cultivar PBW65. The Ltn associated with Lr34/Yr18 is quantitatively expressed and it shows a variable expression in different genetic backgrounds when tested under different environmental conditions (Messmer et al. 2000; Rosewarne et al. 2006). Owing to the absence of Ltn in cultivar PBW65 it can be suggested that the cultivar PBW65 does not carry the gene Lr34. The F₁ generation of the cross between PBW65 and WL711 showed the percent leaf rust severity of 40S, which is higher than in the resistant parent (30S) indicating that the loss of alleles for resistance in the F₁ could increase susceptibility. This is a characteristic of genes showing additive effects. Therefore, based on inheritance studies and the F₁ reaction it can be concluded that two genes conferring the leaf rust resistance of cultivar PBW65 to race 77-5 are additive in nature. Pandher (1993) also reported more than one gene with small cumulative effect governing resistance to leaf rust in cultivar PBW65. Because PBW65 provides protection from leaf rust...
that is similar to cultivar HD2009 and the gene Lr34 in Cook and RL6058 (Figure 1) it could be used as a diverse source of non-hypersensitive leaf rust resistance genes. Enhanced levels of resistance, close to almost near immunity can be obtained when genes from PBW65 are used in combination with other diverse genes, particularly Lr34. Those genes can further be utilized when used in different backcrossing programmes for their transfer in popular wheat varieties to broaden the genetic base for defence against the leaf rust fungus.

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References


Spilmeyer W., McIntosh R.A., Kolmer J., Lagudah E.S. (2005): Powdery mildew resistance and Lr34/Yr18
genes for durable resistance to leaf and stripe rust co-segregate at a locus on the short arm of chromosome 7D of wheat. Theoretical and Applied Genetics, 111: 731–735.


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