Resistance to Whitebacked Planthopper in Elite Lines of Cultivated × Wild Rice Crosses

Z. H. Ye and R. C. Saxena*

ABSTRACT

Wide hybridization is an important breeding tool for incorporating alien genetic variation and transfer of useful traits from wild species of Oryza to commercial rice (O. sativa L.) cultivars. We evaluated two elite lines, 'IR54742-23-1-29-18' (hereafter called IR54742) and 'IR54751-2-41-10-5' (hereafter called IR54751), selected from 243 lines derived from BC2F3 progenies of crosses between cultivated rice and wild rice (O. officinalis Wall) for resistance to the whitebacked planthopper Sogatella furcifera (Horváth). The insect's behavioral and physiological responses were tested on the two elite lines and their parents 'IR31917-45-3-2' (hereafter called IR31917) and wild rice. 'IR2035-117-3' (hereafter called IR2035) was the resistant check, while 'Taichung Native 1' (TNI) was the susceptible check. Insect food intake and assimilation, growth, longevity and fecundity, and population increase were least on wild rice. The level of insect resistance of IR54751 was comparable to that of IR2035, but insect growth was significantly more on IR54751. IR54742 was comparably less resistant than IR54751. There was no significant difference in insect responses to IR31917 and TNI. The interspecific transfer of gene(s) for planthopper resistance from wild rice to cultivated rice was confirmed.

The whitebacked planthopper (WBPH) is an important pest of rice. It is widely distributed throughout South and Southeast Asia, China, the South Pacific Islands, and the northern part of Australia. Under favorable conditions, the insect can completely destroy rice plants, a condition known as hopperburn (Suenaga, 1963). In the last decade, WBPH outbreaks and occurrences have been frequently reported from both temperate and tropical countries such as Japan (Hirano, 1981), China (Dung, 1981), India (Verma et al., 1979), and Malaysia (Ooi et al., 1980). Fortunately, unlike other hoppers that infest rice, WBPH is not known to be a vector of any rice virus.

Because of the high cost of insecticides and the problem of insecticide-induced WBPH resurgence (Nagata, 1979), varietal resistance is considered as the most promising and practical approach in the integrated control of this pest (Khan and Saxena, 1986a). Breeding programs at the International Rice Research Institute (IRRI) and in several countries focus on the development of pest-resistant rice varieties. So far, about 300 resistant varieties have been identified from the screening of more than 40 000 rice cultivars (Heinrichs and Rupasas, 1983). Genetic analysis of resistant varieties has identified five genes for WBPH resistance. Four of the genes are dominant and designated as Wbph 1, Wbph 2, Wbph 3, and Wbph 5; the other one is recessive and designated as wph 4 (Angeles et al., 1981; Saini et al., 1982; Wu and Khush, 1985).

In the event of a possible exhaustion and limitation of the genetic variability of cultivated rice, plant breeders at the IRRI have resorted to wide hybridization as an important plant breeding tool for incorporating alien genetic variation and transfer of useful traits from wild species of Oryza to commercially useful varieties.

The chromosomes of cultivated rice (AA genome) and the wild rice (CC genome) are morphologically similar (Kurata and Omura, 1984), but there is very little pairing between the two species. Using embryo rescue techniques, interspecific hybrids were successfully produced between wild rice and a cultivated breeding line IR31917 (Jena and Khush, 1986). Wild rice accessions from several locations show high resistance to three biotypes of the brown planthopper, Nilaparvata lugens (Stål), and WBPH but they possess undesirable agronomic characteristics. IR31917 has a good plant type with high yield potential, but is highly susceptible to planthoppers. Genetic evaluation of the BC2F3 progenies of the above mentioned cross has demonstrated that genes for resistance to N. lugens have been transferred from wild into cultivated rice (Jena and Khush, 1986). A preliminary test of the BC2F3 progenies also has shown that some of the progenies are resistant to WBPH (K. K. Jena, 1987, personal communication).

The objectives of this study were to investigate elite lines of BC2F3 progenies of wild × cultivated rice crosses for resistance to WBPH and to examine the behavioral and physiological responses of WBPH to the resistant lines.

MATERIALS AND METHODS

Progenies derived from wide hybridization between wild rice (IRRI Accession no. 100896) and an improved rice breeding line IR31917 were screened for WBPH resistance using the conventional, free-choice seedling bulk test (Pablo, 1977; Saxena and Khan, 1984). Of 600 elite lines, 243 lines showing uniform resistance or segregating resistance in BC2F3 progenies were selected. Lines showing resistance to WBPH in preliminary screening were retested thrice using seeds derived from BC2F3 progenies along with wild rice and IR31917 in each replicate and TNI and IR2035 as the resistant and susceptible checks, respectively. Damage was graded on a 0 to 9 scale as soon as susceptible TNI seedlings were killed: 0 = highly resistant, 1 = resistant, 3 = moderately resistant, 5 = moderately susceptible, 7 = susceptible, and 9 = highly susceptible (Pathak and Saxena, 1980).

Insect Responses to Resistant Lines

Behavioral and physiological responses of WBPH to plants of two selected lines (IR54742 and IR54751 and their parents), wild rice, and IR31917 were tested in a greenhouse; TNI and IR2035 were the susceptible and resistant checks, respectively.

Oriental and Settling Responses

Test plants were randomly but equidistantly planted in a circle at 8-cm distance from the center of a plastic tray and covered with a transparent, cylindrical mylar-film cage (40
cultivar at different time intervals was calculated. After release, the percentage of females that settled on each plant was recorded at 1, 4, 8, 24, and 48 h. A median hole through which 100 brachypterous females (1-cm high, 20 cm diam.) were introduced. The number of females that settled on the plants was recorded at 1, 4, 8, 24, and 48 h or 2-d-old) were weighed individually on a microbalance.

**Adult Longevity**

This parameter was determined by the nymphs to reach the adult stage. The growth index expresses the number of nymphs that became adults and the time taken due to catabolism. A control was similarly established in which the insect was given access to a moist cotton swab to prevent desiccation. The amount of food being ingested and which the insect was given was calculated according to the following formula derived from Saxena and Pathak (1977):

\[
\text{Food ingested} = \text{Food assimilated} + \text{Weight of excreta},
\]

\[
\text{Food assimilated} = \frac{I_4}{2} - W_1 \left( \frac{C_2}{C_1} \right)
\]

where \(C_1\) = initial weight of control insect, and \(C_2\) = final weight of control insect.

**Population Increase**

Population increase was examined using mylar-film cages. The caged adults were observed daily for their eggs. The eggs were counted under a binocular microscope. Nymphs and adults were counted 30 d after infestation. The mean development period also varied among entries; being longer on resistant and shorter on susceptible entries. The number of nymphs being referred to as the number of nymphs that became adults and the time taken was calculated as the ratio of percentage of nymphs that developed into adults to mean growth period in days (Saxena et al., 1974) and was referred to as a parameter indicating resistance to WBPH; these were selected for studies of insect resistance. Due to poor agronomic traits, 3 of the 13 lines were discarded from grading in the retest. Two lines, IR54742-6-20-3-22 and IR54751-2-41-1-0-5, were consistently resistant to WBPH. Only 13 lines showed resistance (Table 1). According to the final damage assessment, 3 of the 13 lines were discarded from further evaluation. The resistant IR2035, although IR54751 was not statistically significantly different from that on the resistant IR2035. Significantly fewer nymphs became adults on IR54742 and IR54751 than on susceptible TN1 (Table 2). Females gained significantly more body weight on resistant plants. Due to longer growth period and reduced assimilated food, significantly more food was ingested and assimilated the least amount of food. The mean development period also varied among entries; being longer on resistant and shorter on susceptible entries. The mean development period also varied among entries; being longer on resistant and shorter on susceptible entries. Significant differences in nymphal settling were observed. Females showed a significant difference in nymphal settling.

**Fecundity and Hatchability**

The results showed that initial nymphal settling was observed in the observations before analysis of variance. The results showed that initial nymphal settling was observed in the observations before analysis of variance. The results showed that initial nymphal settling was observed in the observations before analysis of variance. The results showed that initial nymphal settling was observed in the observations before analysis of variance. The results showed that initial nymphal settling was observed in the observations before analysis of variance.
Table 2. Percentages of WBPH females recorded on plants of selected elite lines derived from cultivated × wild rice crosses and control genotypes. * indicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- dicating its lower suitability for WBPH oviposition significantly, but fewer eggs were laid on wild rice, in- indicat
Table 5. The WBPH longevity, fecundity, egg hatchability, ovipositional response, and population increase on plants of selected elite lines

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Longevity</th>
<th>Fecundity</th>
<th>Egg Hatchability</th>
<th>Oviposition</th>
<th>Population Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>TN1 (susceptible check)</td>
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<td>IR54751-2-41-10-5</td>
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<tr>
<td>IR2035-117-3 (resistant check)</td>
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<td>IR54742-23-1-29-18</td>
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Average of five replicates.

Table 6. Relative intensity of WBPH responses on selected elite lines derived from cultivated rice X wild rice crosses and control genotypes.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Relative Intensity</th>
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<tbody>
<tr>
<td>TN1 (susceptible check)</td>
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<tr>
<td>IR2035 (resistant check)</td>
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</tr>
<tr>
<td>IR31917 (susceptible parent)</td>
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<tr>
<td>Wild rice (resistant parent)</td>
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<tr>
<td>IR54751</td>
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<td>IR54742</td>
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Based on number of nymphs and adults recovered. Average of five replicates; four pairs of 1-d-old males and females were caged on 30-d-old plants in each replicate. Calculated as the ratio of insect response to test plant: insect response to susceptible check, TN1.

ACKNOWLEDGMENTS

YE & SAXENA: RESISTANCE TO WHITEBACKED PLANTHOPPER IN RICE CROSSES

DISCUSSION

Ye and Saxena (1989) discuss the resistance of rice cultivars to WBPH and highlight the importance of selecting cultivars with resistance to this pest. The study indicates that wild rice is a rich source of resistance to WBPH, with wild rice showing consistent resistance to the insect, but resistance in cultivated rice was confirmed in the present study. The WBPH population increase on IR54751 was significantly less than on susceptible TN1 and IR3197 parent and highest on susceptible TN1 and IR3197 parent and lowest on wild rice, followed by the resistant check. This indicates that wild rice is a suitable source of resistance to WBPH and that the resistant check is suitable for WBPH establishment (Table 6). This was reflected in the low population build-up of the insect at 30 d after infestation. Thus, wild rice is a rich source of resistance to WBPH. Even at the seedling stage, wild rice deterred the settling response of WBPH nymphs. A comparison of the relative intensity of WBPH responses on selected elite lines derived from cultivated rice X wild rice crosses and control genotypes showed that wild rice was less susceptible to WBPH than the resistant check and the susceptible TN1 and IR3197 parent. The resistance of wild rice to WBPH is not commonly associated with interspecific hybridization and introgression. The extent and nature of alien introgression would be valuable. Further examination and evaluation of pest resistance in elite lines also is necessary. Elucidation of the long-term stability of resistance in elite lines is important. The instability of resistance in elite lines was not stable. In the BC F2 progenies, consistent resistance remained in only 2 of 10 promising lines selected for mass screening test. This indicated that about 90% of resistant lines found in BC F2 progenies were found to be susceptible to WBPH in the present study.

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