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Evaluation of Rice Germplasm for Resistance to the Small Brown Planthopper (*Laodelphax striatellus*) and Analysis of Resistance Mechanism

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Abstract: One hundred and thirty-eight rice accessions were screened for resistance to the small brown planthopper (SBPH) (*Laodelphax striatellus* Fallén) by the modified seedbox screening test. Twenty-five rice accessions with different levels of resistance to SBPH were detected, accounting for 18.1% of the total accessions, which included 2 highly resistant, 9 resistant and 14 moderately resistant varieties. Compared with indica rice, japonica rice was more susceptible to SBPH. Antixenosis test, antibiosis test and correlation analysis were performed to elucidate the resistance mechanism. The resistant check Rathu Heenati (RHT), highly resistant varieties Mudgo and Kasalath, and resistant variety IR36 expressed strong antixenosis and antibiosis against SBPH, indicating the close relationship between resistance level and these two resistance mechanisms in the four rice varieties. Antibiosis was the dominant resistance pattern in the resistant varieties Daorenqiao and Yangmaogu due to their high antibiosis but low antixenosis. Dular, ASD7 and Milyang 23 had relatively strong antixenosis and antibiosis, indicating the two resistance mechanisms were significant in these three varieties. The resistant DV85 expressed relatively high level of antixenosis but low antibiosis, whereas Zhaiyeqing 8 and Guiyigu conferred only moderate antibiosis and antixenosis to SBPH, suggesting tolerance in these three varieties. Antibiosis and antixenosis governed the resistance to SBPH in the moderately resistant accession 9311. Antixenosis was the main resistance type in V20A. Tolerance was considered to be an important resistance mechanism in Minghui 63 and Yangjing 9538 due to their poor antibiosis and antixenosis resistance. The above accessions with strong antibiosis or antixenosis were the ideal materials for the resistance breeding.

Key words: rice germplasm; the small brown planthopper; evaluation for resistance; resistance mechanism; antixenosis; antibiosis

The small brown planthopper (SBPH), *Laodelphax striatellus* Fallén (Homoptera: Delphacide), is an economically important and wide-spread insect pest of rice (*Oryza sativa* L.) in China, in which heavy infestation occurs in the middle and lower reaches of the Yangtze River and North China. In recent years, the SBPH population has been drastically rising, which leads to more and more serious damage to rice. When the outbreak occurred in Jiangsu and Anhui Provinces, China in 2004 and 2005, the insect density of SBPH reached 74.1 million per hectare and 123.6 million per hectare of rice respectively, causing 30% of yield reduction in the areas without pesticide treatment [1-3].

The adults and nymphs of SBPH in large number suck rice sap. The leaves infested by SBPH turn yellow, become wilting, and even die, resulting in yield loss and grain quality decline. In addition, this planthopper also transmits rice viral diseases such as rice black-streaked dwarf virus (RBSDV) and rice stripe virus (RSV). RSV is one of the most serious diseases and often causes more severe yield losses than the feeding damage [4-6].

Nowadays, pesticides are widely used to control the SBPH, which leads to natural enemy death, environment pollution and chemical resistance. Furthermore, the controlling effect is not satisfying due to the migration and resistance of SBPH [7-9].

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Host-plant resistance has been recognized as one of the most economic and effective measures in controlling the planthopper and rice stripe disease. Therefore, breeding rice varieties resistant to SBPH is a viable alternative to chemical methods [10-11]. The resource of resistance is the basis of breeding, however, screening for germplasm resistance to SBPH has not been reported to date.

In this experiment, we modified the standard seedbox screening test (SSST) [6] based on the SBPH trait and established a screening program for the resistance to SBPH. And 138 rice accessions were used to screen the resistance to the SBPH by the modified seedbox screening test (modified SSST) and their resistance mechanisms were preliminarily analyzed by antixenosis and antibiosis tests.

MATERIALS AND METHODS

Plant materials

One hundred and thirty-eight rice accessions were provided by the National Key Laboratory of Crop Genetics and Germplasm Enhancement, Nanjing Agricultural University; the China National Rice Research Institute; and Institute of Crop Sciences and Institute of Plant Protection, the Chinese Academy of Agricultural Sciences. 'Rathu Heenati (RHT)' and 'Wuyujing 3' were used as resistant and susceptible controls, respectively.

Insect population

The SBPH population used for infestation was first provided by Institute of Plant Protection, the Chinese Academy of Agricultural Sciences, and maintained on barley for four generations before transferred to rice Wuyujing 3 in the greenhouse of Institute of Crop Sciences, the Chinese Academy of Agricultural Sciences. The population was confirmed to be nonviruliferous by dot-immunobinding assay and PCR detection [12].

Modified SSST

Considering relatively less feeding capacity of SBPH than that of brown planthopper (*Nilaparvata lugens*) or the whitebacked planthopper (*Sogatella furcifera*), we modified the SSST to suit the SBPH resistance screening. The procedure was as follows: i) at the 1.5-leaf stage, to infest rice seedlings with second- to third-instar SBPH nymphs by 15 insects per seedling; ii) to use 'Rathu Heenati' and 'Wuyujing 3' as resistant and susceptible controls, respectively; and iii) to perform scoring when about 90% seedlings of the susceptible variety Wuyujing 3 become dead after (15±1)-day infestation according to the standard evaluation systems described by IRRI [13]. The resistance scale of each accession was then calculated based on the weighted average of the seedlings tested (Table 1).

Resistances of the 138 rice accessions were evaluated by the modified SSST. Twenty-five germinated seeds were sown in a plastic pot (8 cm in diameter and 9 cm in height) with a hole in the base and two pots per accession. Generally, 28 pots, together with resistant and susceptible control varieties, were randomly placed in a 65-cm × 44-cm × 14-cm plastic seedbox with about 2-cm depth of water on the soil surface. All the plants for evaluation were grown at 26±1°C with sunlight and natural ventilation.

Antixenosis test

Antixenosis to nymphs of SBPH in the rice seedling

According to the method described by Hiroshi et al [14], germinated seeds were sown as above with 15 seeds for each accession in a row and two rows of each accession. At the 1.5- to 2.0-leaf stage, the seedlings were transferred into the cages covered with nylon net and infested with second- to third-instar SBPH nymphs by 5 insects per seedling. The insects were counted after 24-hour infestation, and then

Table 1. Evaluation criteria for resistance to SBPH at the rice seedling stage.

Damage symptom	Resistance scale	Resistance level [a]
No visible damage	0	I
Very slightly damage	1	HR
Partial yellowing of the first and second leaves	3	R
Pronounced yellowing, and some seedlings slight stunning	5	MR
Seedlings showing signs of severe stunning or wilting	7	S
90% seedlings dead	9	HS

[a] Resistance level: I, Immune; HR, Highly resistant; R, Resistant; MR, Moderately resistant; S, Susceptible; HS, Highly susceptible.