Inheritance of Whitebacked Planthopper Resistance in Chinese Japonica Rice Chunjiang 06

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中国粳稻春江06抗白背飞虱的遗传

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摘 要:分析了高抗白背飞虱、对白背飞虱的抗性表现为拒取食性和杀卵作用的中国粳稻春江06和感虫籼稻品种TN1正反交获得的F_1和F_2代拒取食性和杀卵作用的遗传方式。所有的F_1稻株都具有拒取食和杀卵作用。两种抗性在F_2代中以3∶1的抗感比例独立分离。具有拒取食和杀卵抗性的不同组合的4种表现型以9∶3∶3∶1分离。表型分离说明春江06中的拒取食性和杀卵抗性分别受一个显性基因控制。采用常规的杂交方法可以容易地将春江06中的拒取食抗性导入日本粳稻品种日本晴、北陆-153和越光中。

关键词: 白背飞虱; 品种抗性; 粳稻; 拒取食抗性; 杀卵抗性; 遗传
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Abstract: Whitebacked planthopper (WBPH) resistance in Chinese japonica rice Chunjiang 06 (CJ-06) was expressed by sucking inhibitory and ovicidal traits. Modes of inheritance of both these traits were analyzed by using F_1 and F_2 progenies from reciprocal crosses between CJ-06 and a susceptible indica variety TN1. All the F_1 progeny were resistant, having both the sucking inhibitory and ovicidal traits. The two resistant traits of F_2 progeny segregated independently at the ratio of 3 (resistant) : 1 (susceptible). Four phenotypes with differential combinations of sucking inhibitory and ovicidal traits segregated into the ratio of 9 : 3 : 3 : 1, indicated that respective single dominant genes independently governed both the sucking inhibitory and ovicidal traits in CJ-06. The sucking inhibitory trait in CJ-06 could easily be introduced into Japanese japonica rice, Nihonbare, Hokuriku-153 and Koshihikari by conventional crossing.

Key words: whitebacked planthopper; varietal resistance; japonica rice; sucking inhibitory trait; ovicidal trait; inheritance

1 Introduction

The whitebacked planthopper (WBPH), *Sogatella furcifera*, emerged as an economic insect pest of rice since around 1980s after the extension of hybrid rice in China[3,11]. It has been well documented that Chinese hybrid rice created new paddy habitats favorable for propagation of WBPH. Japonica rice in temperate China is also being increasingly damaged by massive displacements of WBPH from distant epidemic areas[18]. Varietal resistance is an ecologically sound approach to keep the WBPH infestations below the economic threshold without depending upon insecticides that may cause undesirable side effects to paddy ecosystems and environments.

So far little information is available about WBPH resistance in japonica rice in China. We discovered that Chinese japonica rice Chunjiang 06 (CJ-06) is highly resistant to WBPH, which is expressed by sucking inhibition and ovicidal response[12]. The present experiments were conducted to examine the mode of inheritance of these two different resistance traits in CJ-06.

2 Materials and Methods

2.1 Plant materials

Phenotypic expression of sucking inhibitory and ovicidal traits in F_2 progenies from the crosses between CJ-06 and WBPH-susceptible Japanese japonica rice, Nihonbare (NHB), Hokuriku-153 (HR) and Koshihikari (KH) were observed. Modes of inheritance of both the resistance traits were analyzed by using F_1 and F_2 progenies from reciprocal crosses between CJ-06 and a susceptible indica variety TN1.

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Table 1. Segregation of WBPH resistance traits in F_1 plants from CJ-06/TN1.

Progeny	Sucking inhibitory			Ovicidal reaction		
	No. of plants	R	S	No. of plants	R	S
F_1 (CJ-06/TN1)	15	15	0	12	12	0
F_1 (TN1/CJ-06)	13	13	0	9	9	0
Total	28	28	0	21	21	0

R—Resistant; S—Susceptible.

In order to prevent outcrossing, F_2 seeds were obtained by bagging the panicles of F_1 plants.

2.2 Evaluation of WBPH resistance

All the rice plant materials were individually grown in disposable plastic cups (7 cm in diameter, 9 cm in height) untill early tillering stage. Gravid WBPH females were individually introduced into parafilm sachets (2 cm×2 cm) placed at the upper portion of leaf sheaths, and allowed to suck and lay eggs for a day at room temperature (26—30℃).

Sucking inhibition was evaluated by weighing honeydew excreted in parafilm sachets. Ovicidal response was phenotyped by egg mortality and necrotic lesions at oviposition sites. Egg mortality was calculated by counting live and dead eggs at 5 — 6 days after oviposition by dissecting the leaf sheath tissues at oviposition sites. The eggs with reddish eyespots were recorded as developing live eggs, and white opaque eggs as dead ones.

3 Results

3.1 Mode of inheritance of WBPH resistance

Segregation of sucking inhibitory and ovicidal traits to WBPH in CJ-06 was examined by using F_1 and F_2 progenies from the reciprocal crosses of CJ-06 with a susceptible indica variety TN1. WBPH females excreted honeydew of 15.6 mg/(female · day) ($n=34$) on TN1, where 82% of individuals excreted honeydew of 10 mg/(female · day) or more (Fig. 1-A). On the other hand, only 5.0 mg/(female · day) ($n=35$) of honeydew was excreted on CJ-06, and 91% individuals excreted 9 mg/(female · day) or less. Average of egg mortality was 94.5% ($n=35$) on CJ-06, and 30.7% ($n=31$) on TN1 (Fig. 1-B). Based on the mean and deviation for the amount of honeydew excreted and egg mortality in the parents, the progenies on which the honeydew excreted was 9 mg/(female · day) or less, and egg mortality was higher than 45% were phenotyped as sucking inhibitory and ovicidal resistance, respectively. Ovicidal trait was also phenotyped based on the necrotic ovicidal symptoms. All the F_1 progeny were resistant, and had both the sucking inhibitory and ovicidal traits (Table 1). The two resistance traits segregated independently at F_2 generation. The ratio of resistant and susceptible F_2 plants was 3 : 1 for each resistance trait (Table 2). The F_2 plants were classified into four phenotypes by the differential combinations of sucking inhibition and ovicidal activity. Their segregation ratios fit statistically the ratio of 9 : 3 : 3 : 1 (Table 2).

3.2 Inheritance of WBPH resistance from CJ-06 to Japanese japonica rice

Majority of F_2 plants from the crosses between CJ-06 and three varieties of Japanese japonica expressed sucking inhibitory trait in addition to the ovicidal trait which they originally possessed (Table 3, Fig. 2).

4 Discussion

We have reported that CJ-06, a Chinese japonica rice,

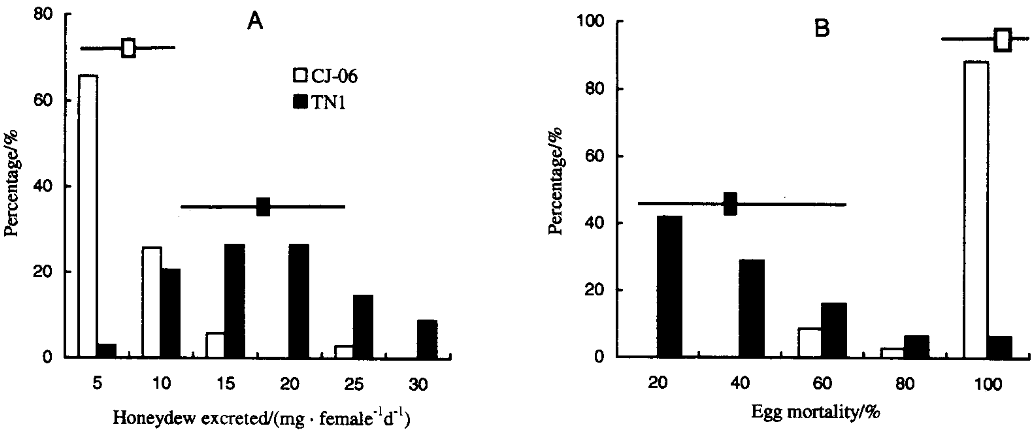

Fig. 1. Frequency distribution of honeydew excretion (A) and egg mortality (B) in CJ-06 and TN1.
Horizontal bars indicate mean and S.D. for amount of honeydew excreted(A) and egg mortality (B).

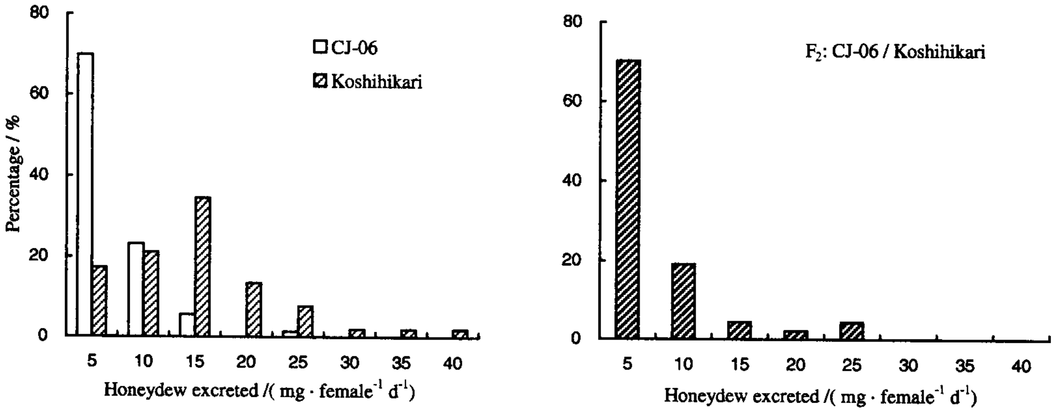

Fig. 2 . Frequency distributions of honeydew excretion in CJ-06, Koshihikari, and their F_2 plants.

Table 2 . Segregation of WBPH resistance traits in F_2 plants from CJ-06/TN1.

Progeny	No. of plants	Sucking inhibitory R	Sucking inhibitory S	χ-square[1] (3 : 1)
F_2(CJ-06/TN1)	131	93	38	0.91
F_1(TN1/CJ-06)	114	89	25	0.42
Total	245	182	63	0.03

Progeny	No. of plants	Ovicidal reaction R	Ovicidal reaction S	χ-square[1] (3 : 1)
F_2(CJ-06/TN1)	127	104	23	2.86
F_1(TN1/CJ-06)	105	80	25	0.03
Total	232	184	48	0.09

Progeny	No. of plants	Sucking inhibitory /Ovicidal reaction RR	RS	SR	SS	χ-square[2] (9 : 3 : 3 : 1)
F_2(CJ-06/TN1)	112	67	14	24	7	3.02
F_2(TN1/CJ-06)	93	58	16	12	7	2.68
Total	205	125	30	36	14	2.93

[1] Significant limit of χ-squared value=3.85 (P =0.05, df = 1);

[2] Significant limit of χ-squared value=7.81 (P =0.05, df = 3);

R—Resistant; S—Susceptible.

had a high level of resistance to WBPH[11]. The WBPH-resistance in CJ-06 was conferred not only by japonica-specific ovicidal trait, but also by a sucking inhibitory antibiosis that had seldom been found in japonica rice. Sucking inhibitory trait plays a decisive role in the expression of consistent field resistance to WBPH in CJ-06. Japanese japonica rice commonly has ovicidal properties, by which WBPH populations are effectively kept below the tolerable densities under the normal infestations with WBPH[7,10,12,14,15]. However, it could suffer considerable damages under outbreak conditions caused by massive immigrations, because induced ovicidal response does not exert any antibiosis against WBPH adults and nymphs[16]. Thus, sucking inhibitory trait is a useful genetic trait to strengthen WBPH resistance in Japanese japonica rice. The present preliminary crossing trials showed that sucking inhibitory trait in CJ-06 was easily introduced into Japanese japonica varieties. Most of the F_2 progenies showed sucking inhibition as well as ovicidal response against WBPH like CJ-06.

Mode of inheritance of WBPH resistance traits was investigated in the reciprocal crossings between CJ-06 and susceptible indica variety TN1. Phenotypic segregation in F_1 and F_2 progenies indicated that both the sucking inhibitory and ovicidal traits appeared to be independently governed by single dominant major genes. Six major genes for resistance to WBPH have been identified in indica rice by the seedbox screening test[1,2,4,5,8,17]. A single or combinations of more than two major genes mediate varietal resistance to WBPH in indica rice[1,6,9]. Allelic relationships of WBPH-resistance

Table 3. Honeydew excretion and egg mortality on CJ-06, three Japanese japonica varieties, and their F_2 progenies.

Host plant	Honeydew excreted/(mg · female⁻¹d⁻¹) No. of plants	Mean±SD	Egg mortality/% No. of plants	Mean±SD
CJ-06	35	5.0±4.4 a	35	94.5±15.2 a
Nihonbare(NHB)	30	12.1±8.2 b	30	89.1±15.6 a
Koshihikari(KSH)	52	13.6±8.5 b	48	82.3±26.8 a
Hokuriku-153(HKR)	29	18.2±8.7 b	29	59.0±34.9 ab
CJ-06/NHB	46	4.9±4.0 a	44	61.8±32.4 b
CJ-06/KSH	47	5.2±6.5 a	43	85.5±26.8 a
CJ-06/HKR	43	5.3±6.0 a	41	78.9±30.2 ab

In a column, means followed by the same letter are not significantly different (P <0.05, Kruskal-Wallis test).

genes in CJ-06 and thosegenes that have been identified in indica rice need to be investigated.

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