Virulence of the Populations of the Whitebacked Planthopper, *Sogatella furcifera* Reared on Different Resistant Rice Varieties

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Abstract: ARC and ND colony were obtained by rearing the whitebacked planthopper (WBPH), *Sogatella furcifera* (Horváth), exclusively on ARC10239 (ARC, carrying resistance gene *Wbph2*) and N'Diang Marie (ND, carrying resistance gene *Wbph5*) till 15 generations. Taichung Native 1 (TN1) and Rathu Heenati (RHT) served as susceptible and resistant check, respectively. The results of electronic recording revealed that duration of salivation and X-waveform of the two colonies on their corresponding hosts was short while the duration of phloem ingestion was long. The amount of honeydew excreted by ARC and ND colony did not differ on their corresponding host varieties from TN1 and was much higher than that of RHT. The number of eggs laid on their host varieties and TN1 were significantly higher than that on RHT. No distinct change was observed for these two colonies in term of percentage of developed eggs. The nymph survival rate of ND colony on its selection host was 45.0%, significantly different from that on TN1(71.4%) and RHT(21.0%), while that of ARC colony was 68.3%, not significantly different from that on TN1(77.5%), but much higher than that on RHT(22.6%). The nymphal development duration of these two colonies on the corresponding hosts was not different from that on TN1, but significantly shorter than that on RHT. In brief, these two colonies had almost adapted to their corresponding host varieties based on feeding and oviposition, but the nymphal survival rate of ND colony was still low.

Key words: *Sogatella furcifera*; electronic monitoring; feeding; oviposition; virulence

Utilization of resistant varieties is an important component of the sustainable pest management in rice. Rice varieties with the gene *Bph1* resistant to the brown planthopper (BPH), *Nilaparvata lugens*, such as hybrid Shanyou 6, in which IR26 was used as the restorer line, had controlled effectively BPH populations[1]. However, due to the strong selection pressure that result from resistant varieties, the differentiation between the biotypes (virulence type) occurred obviously in BPH field populations. Before 1987, BPH populations in China belonged to biotype 1[2]. Thereafter, the populations in southern China had shifted into the race mixture of biotype 1 and 2[3,4]. This caused some resistant rice varieties to lose their resistance to BPH. Similarly, BPH reared continuously on resistant varieties for certain generations in laboratory can also develop the adaptation and the populations with different virulence abilities[5,6]. The preliminary studies on the whitebacked planthopper (WBPH), *Sogatella furcifera* suggested that the virulence differentiation in WBPH populations in China had not occurred yet[7]. Now the question arises, would the virulence of WBPH field populations change correspondingly with the release of resistant varieties such as Zhong 86-44[8] and Ganzaoxian 28[9]? So far, the related information is not available.

Electronic monitoring system (EMS) was designed specially for recording the feeding behavior of piercing and sucking insects. The specific waveforms would reflect the locations of sucking and feeding, and the movement of ovipositor in rice plants. In combination with other techniques, the actual causes of insect resistance could be clarified. So far, EMS has been widely employed for studies on plant resistance to insect pests[10－14]. In addition, EMS provides a new guidline for studies on BPH biotypes[15]. This technique has been extended to the studies on the biotypes of *Therioaphis maculata*[16], *Bemisia tabaci*[17], *Schizaphis graminum*[18－20] and *Trialeurodes vaporariorum*[21,22]. Due to the limitation of experimental conditions in China, EMS was employed for very few studies on the feeding behavior of insect pests in rice[23], neither for studies on insect biotypes.

In this study, rice varieties of ARC10239 and N'Diang Marie, carrying the resistance gene *Wbph2* or *Wbph5*, were used to rear WBPH continuously for 15 generations. We monitored the changes in the virulence of different WBPH populations by electronic recording of insect feeding activities and measuring honeydew excretion, oviposition and egg and nymphal development.

MATERIALS AND METHODS

Rice varieties and insects

ARC10239 (ARC) and N'Diang Marie (ND) were used

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as selection hosts. Rathu Heenati (RHT) and Taichung Native 1 (TN1) served as resistant and susceptible check, respectively. Rice seeds were singly seeded in small plastic cups (8 cm×9 cm), and rice plants were utilized for tests at 30 d after sowing.

WBPH populations, reared exclusively on ARC and ND till 15 generations in Plexiglas cages (33.5 cm×25.2 cm×33.5 cm) in the net houses at the Fuyang Experimental Station, China National Rice Research Institute (CNRRI), Hangzhou, were designated as ARC and ND colony, respectively. Nymphs or gravid females from these two colonies were tested for their virulence.

Electronic monitoring feeding behavior

Behavioral activities were recorded with AC electronic monitoring system (Tsukuba Rika Seiki Co. Ltd.). Gravid females were anesthetized with a light gas stream of carbon dioxide after being starved and water-satiated for 2 h. A gold wire with a diameter of 20 μm and 2—3 cm long was glued on the dorsum of a female with electro-conductive silver paste. The opposite end of the gold wire was linked to a larger copper wire (5 cm long, 1 mm in diameter) leading to the input of the amplifier. The insect was placed on the leaf sheath of a healthy rice plant in a 100 mL flask with water electrified with an electric current of 500 Hz, 0.5 V. Each variety was triplicated and each replicate lasted for 6 h. All recordings were conducted under the conditions of (27±1)℃, (65±5)% RH and 12 h light/12 h dark photoperiod.

IEM and IEM-AT software were used for electronic monitoring, identifying insect activities and data analysis. The waveforms were recognized and analyzed according to Hattori[24].

Honeydew measurement

One gravid macropterous female was introduced into a parafilm sachet (3.2 cm×3.2 cm) which was attached to the leaf sheath of a healthy rice plant at 30 d after sowing. Each female was allowed to feed on the rice plant for a duration of 24 h. The sachet was removed and the amount of honeydew was weighed using an electronic balance of Sartorius® BP190S. Each variety was replicated for 15 times and one plant represented one whole replicate.

Observation of egg development

One gravid macropterous female was introduced into a parafilm sachet (3.2 cm×3.2 cm) which was attached to the leaf sheath of a healthy rice plant at 30 d after seeding. After laying eggs for 24 h, the insect was removed and a small transparent plastic cage (Φ2 cm×8 cm) was used to cage the oviposition section on leaf sheath. Both openings of the cage were closed with urethane foam. The number of eggs laid on the rice plant was counted under a binocular microscope at five days after oviposition. Eggs with red eyespot were recognized as the developed eggs. The percentage of the developed eggs was calculated as the number of the developed eggs divided by the total number of eggs. Each variety was replicated for 10 times and one plant stood for one replicate.

Determination of nymphal development duration and nymph survival rate

A transparent plastic cage (Φ2 cm×8 cm) was used to cage the main stem of a healthy rice plant at 30 d after sowing. Ten newly hatched nymphs were introduced into the cage and both openings of the tube were closed with urethane foam. Nymphal development was monitored daily and the number of adults was counted at last. The nymphal development duration and survival rate were calculated. Each variety was replicated for 10 times.

RESULTS

Electronic recording of feeding activities

Three distinct waveform patterns of S (salivation), A (X-waveform) and I (phloem ingestion) were recorded during feeding. For ARC colony, duration and times of salivation and X-waveform on its corresponding host were short and not significantly different from that on TN1, but variable from that on RHT. The phloem ingestion durations by ARC colony on ARC and TN1 were 251.3 min and 316.3 min every six hours, showing no significant difference (Table 1). ARC colony had the shortest phloem ingestion duration of 53.9 min on RHT every six hours. For ND colony, duration and times of salivation were very close to those on TN1 and RHT. Duration and times of X-waveform on ND were not significantly different from those on TN1, but shorter and less than those on RHT, respectively. The phloem ingestion durations by ND colony on ND and TN1 were 274.4 min and 283.6 min every six hours, respectively, showing no significant variation.

Honeydew excretion

Honeydew excreted by ARC colony on ARC plants at 11.74 mg/female·24 h was not significantly different from that on TN1 at 12.78 mg/female·24 h (Fig. 1). ND colony released 11.23 and 12.40 mg/female·24 h on its corresponding host ND and TN1, respectively. They were almost similar. These two colonies excreted the least honeydew on RHT (Fig. 1).

Oviposition and egg development

The number of eggs laid by ARC colony on its host (10.3 no./female·24 h) and TN1 (10.5 no./female·24 h) was not significantly different (Fig. 2), similarly by ND colony on its host (16.9 no./female·24 h) and TN1 (19.4

Table 1. Electronic monitoring feeding behavior of ND and ARC WBPH colonies, Hangzhou, 2001.

Statistical parameter for feeding behavior	ARC colony			ND colony		
	ARC	TN1	RHT	ND	TN1	RHT
Salivation duration (min)	6.7±3.5 ab	4.7±2.2 b	18.8±4.7 a	7.1±7.0 a	12.4±9.9 a	22.6±9.2 a
Salivation(no.)	10.5±4.9 b	9.0±5.2 b	25.3±7.4 a	12.3± 10.1 a	8.0±4.4 a	25.5±9.2 a
X-waveform duration(min)	33.9±14.7 b	16.9±11.4 b	229.0±25.8 a	19.8±9.5 b	43.7±11.8 b	189.6±30.8 a
X-waveform(no.)	18.5±10.6 b	11.0±4.0 b	57.0±9.5 a	9.3±3.8 b	18.3±9.3 b	53.0±12.7 a
Phloem ingestion duration(min)	251.3±87.3 a	316.3±25.9 a	53.9±17.8 b	274.4±64.6 a	283.6±20.9 a	41.9±20.0 b
Phloem ingestion (no.)	17.0± 9.9 b	10.7±3.2 b	42.0±11.5 a	7.7±2.1 b	7.3±5.5 b	36.5±6.4 a

In a column, means (±SD) followed by the same lowercase letters are not significantly different by least significant difference (LSD) test, $P=0.05$.

Table 2. The nymph survival rate and developmental duration of ARC and ND colony, Hangzhou, 2001.

Rice variety	ARC colony		ND colony	
	Nymph survival rate(%)	Nymphal developmental duration(d)	Nymph survival rate(%)	Nmphal developmental duration(d)
ARC	68.3±7.5 ab	10.5±1.2 c		
TN1	77.5±21.2 a	10.4±0.8 c	71.4±14.6 a	11.9±4.8 c
RHT	22.6±21.3 c	14.4±1.7 a	21.0±20.3 c	14.3±1.9 a
ND			45.0±17.3 b	12.9±0.9 bc

In a column, means (±SD) followed by the same lowercase letters are not significantly different by least significant difference (LSD) test, $P=0.05$.

no./female • 24 h). These two colonies laid relatively fewer eggs on RHT. The percentages of the developed eggs for these two colonies were in the range of 81.3—99.2% (Fig. 2).

Developmental duration and survival rate of nymphs

The nymphal survival rate of ARC colony on its host ARC was 68.3%, not significantly distinct from TN1 of 77.5% and much higher than that on RHT of 22.6% (Table 2). The nymphal survival rate of ND colony on its host ND was 45.0%, significantly lower than that on TN1 of 71.4%, and higher than that on RHT of 21.0%. The nymphal developmental durations of these two colonies on their corresponding host plants were not significantly different from that on TN1, being significantly shorter than that on RHT (Table 2).

DISCUSSION

Insect biotypes referred to different insect populations which showed variable virulence abilities when infesting on

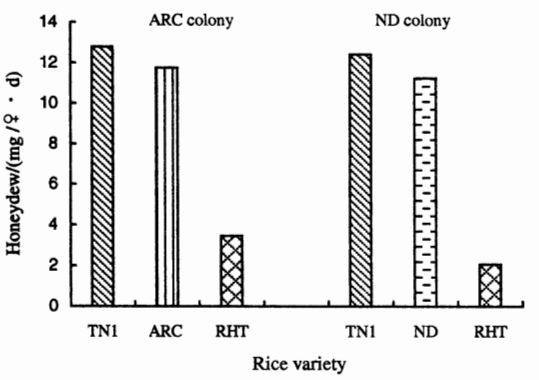

Fig. 1. Honeydew excreted by the different colonies of *S. furcifera*, Fuyang, 2002.

The same letters above the bars indicate no significant difference by least significant difference (LSD) test, $P=0.05$.

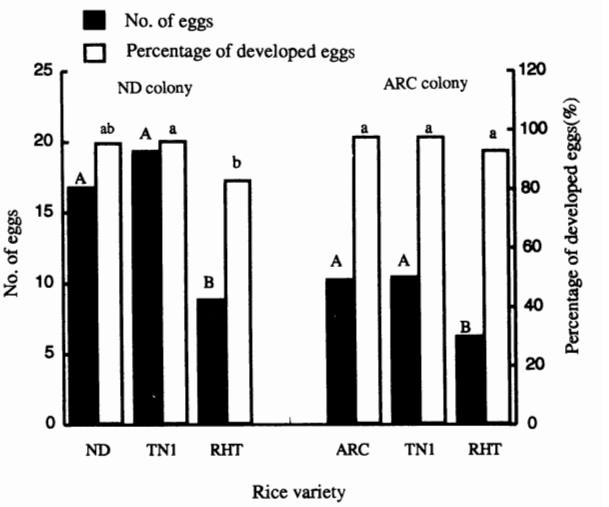

Fig. 2. Number of eggs and percentage of the developed eggs of *S. furcifera* colonies, Fuyang, 2002.

The same letters above the bars indicate no significant difference by least significant difference (LSD) test, $P=0.05$.

variety "Ganzaoxian 28" to *Sogatella furcifera*. *Acta Agric Jiangxi*, 1993, 5(1):44－48. (*in Chinese with English abstract*)

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