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The Current Status of Occurrence and Forecasting System of Rice Planthoppers in Japan

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Abstract The highest brown planthopper *Nilaparvata lugens* stål (BPH) damage in the past decade was recorded in western Japan in 1998. The BPH occurrence in 1998 was characterized by early arrivals of immigrants and a moderate BPH immigrant density. Recent studies revealed a new factor that greatly affects BPH population dynamics, i.e., the effect of the whitebacked planthopper *Sogatella furcifera* Horváth (WBPH) on wing-form determination of BPH. Evidence for the effect of WBPH density on BPH population dynamics also comes from a significantly negative correlation between the density of immigrant WBPH and the population growth rate of BPH by analysis of light trap data. The BPH population immigrating into Japan rapidly became virulent to ASD7 carrying the *bph 2* resistance gene beginning in 1997, and the virulence remained at that high level through 1999. Current forecasting systems of rice planthoppers in Japan are also reviewed, i.e., monitoring of immigration by analysis of weather data, monitoring of immigrant density by light and net traps, and field surveys.

Key Words *Nilaparvata lugens*, *Sogatella furcifera*, wing-form, interspecific interaction, resistant variety, forecasting

Introduction

The brown planthopper *Nilaparvata lugens* Stål (BPH) and the whitebacked planthopper *Sogatella furcifera* Horváth (WBPH) are widely distributed throughout Asia and are the two major insect pests of rice in Japan. These species are unable to overwinter in Japan and migrate to Japan each year from Chinese mainland during the early part of the ricegrowing season (Kisimoto, 1976). Annual fluc tuationsin the occurrence of migratory pests, such as the rice planthoppers, are unpredictable and are higher than those in native pests. Thus, monitoring and forecasting technologies are necessary and have been developed as a base for management of these migratory pests. In this paper, current status of occurrence and forecasting system of rice planthoppers in Japan are outlined and discussed.

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Current status of occurrence of rice planthoppers in Japan

The immigration of BPH and WBPH into Japan occurs early in the season and total immigrant density has increased since the mid 1970's (Sogawa and Watanabe, 1989; Watanabe *et al.*, 1994). In particular, WBPH density increased from mid 1980's to early 1990's (Fig. 1). In this period, the occasional second generation WBPH outbreaks, which cause BPH-like "hopperburn" damage, occurred along the northern coast of Honshu, Japan (Matsumura, 1996b, 1997). In contrast, the occurrences of BPH and WBPH decreased from mid 1990's. In 1998, however, the highest BPH damage in the past decade was recorded in western Japan.

The BPH outbreaks in 1998

The BPH occurrence in western Japan in 1998 was characterized by early arrivals of immigrants and a moderate BPH immigrant density. In this year, the immigration of BPH occurred from late April in southern Kyushu, and from early June in northern Kyushu and western Honshu. The immigration continued until late July in both areas. Because the immigrant density of BPH was moderate, the percentage of brachypters was high in the first and second generations. Weather conditions such as a high temperatures and moderate rainfall from July to August were suitable for BPH population growth. Consequently, a high population growth rate in reproductive generations was observed especially in western Honshu. Many prefectures in western Japan released outbreak alarms and warn-ingand warning reports from July to August. Severe damages of BPH were observed on both early season (transplanted in April) and normal season (transplanted from May to June) rice fields.

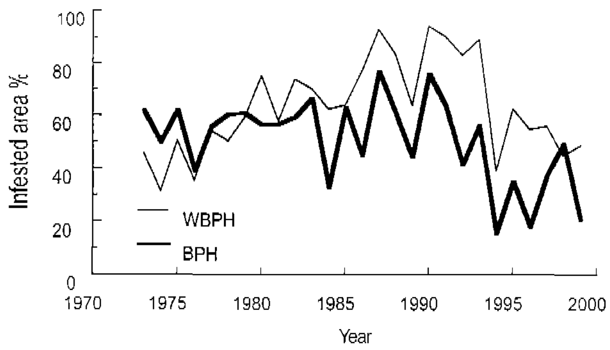

Fig. 1. Percentages of infested areas (infested paddy fields / total paddy fields) by BPH and WBPH in Kyushu, Japan in 1973-1999.

In 1998, WBPH density was relatively low, and the infestation area was lower than that of BPH (Fig. 1). The WBPH density itself has never been mentioned in forecasting BPH occurrence. However, recent studies at KNAES revealed a new factor that greatly affects BPH population dynamics *(i.e.*, the effect of WBPH on wing-form determination of BPH) as described bellow.

BPH and WBPH

Females of WBPH and both sexes of BPH exhibit wing dimorphism and occur in two forms, longwinged macropters and short-winged brachypters. The production of macropters of both species is influenced mostly by nymphal density of their own species (Kisimoto, 1956; Matsumura, 1996a). However, no information is available for an interspecific interaction on wing-form between the two species. Therefore the, interspecific interaction on wing dimorphism between the two symtric species was examined by a series of laboratory experiments.

If the total number of planthopper nymphs per rearing tube was the same, the proportion of BPH macropterous adults was higher in a mixed population of BPH and WBPH than in a pure population of BPH (Matsumura and Suzuki, 2000). This suggests that interspecific effects on wing dimorphism are more than intraspecific ones for BPH. In contrast, for WBPH, interspecific effects were less than intraspecific ones. Further experiments revealed that the interspecific interaction on wing dimorphism between the two planthoppers occurs not directly but indirectly through the feeding of rice plants (Matsumura and Suzuki, 2000).

Although the quantity of rice phloem sap consumed per insect is much less in WBPH than in BPH (Arimura, unpublished data), WBPH may exert greater effects on rice plant physiology on which the wing-form of BPH females depends.

Matsumura and Suzuki (2000) also analyzed yearly changes in the occurrence of WBPH and BPH from light trap data recorded at Chikugo, Kyushu, Japan for 40 years from 1951-1990. They found a significantly negative correlation between the density of immigrant WBPH and the population growth rate of BPH. The result strongly suggests that WBPH density affects the population dynamics of BPH in the fields. Thus, the data of WBPH density should be incorporated into forecasting of BPH occurrence.

Change in virulence to resistant rice varieties in BPH

Another finding of recent BPH research in Japan is the change in virulence to resistance rice varieties in BPH. The BPH immigrating into Japan became virulent to a resistance gene *Bph 1* around 1988-1990 (Sogawa, 1992), and this change has been documented through 1999 (Tanaka, 1999b; Tanaka and Matsumura, 2000). In contrast, there have been no apparent changes in the virulence of BPH population to other resistance genes until 1996 (Tanaka, 1999b). However, Tanaka and Matsumura (2000) revealed that BPH population rapidly became virulent to ASD7 carrying the *bph 2* gene beginning in 1997, and the virulence remained at that high level through 1999 (Fig. 2). This is the first observation that has indicated a change in virulence of BPH occurring in East Asia to a rice variety carrying *bph 2*.

Although no distinct changes were observed in the virulence of BPH population to Norin PL10 (carrying *Bph 3*) or Babawee (*bph 4*), there were rather high proportions of virulent BPH (20 - 25 %) in the 1997 to 1999 immigrants than in those before 1997 (< 10 %) (Tanaka, 1999b; Tanaka and Matsumura, 2000). Thus, monitoring of the virulence of BPH population to these genes should be continued carefully.

In north Vietnam, a rice variety CR203 (IR8423)

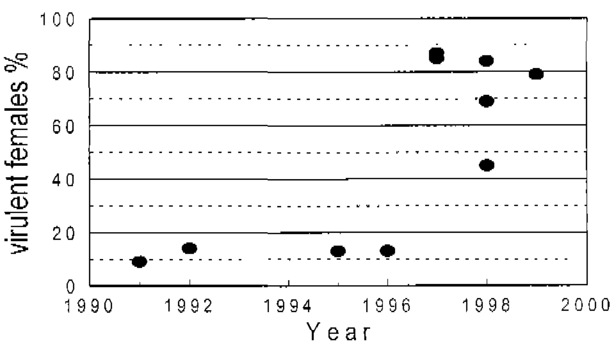

Fig. 2. Change in percentages of virulent females of BPH populations, immigrating into Japan, on ASD7 carrying the *bph 2* resistance gene (Tanaka and Matsumura, 2000).

(carrying the *bph 2* gene) has been cultivated since 1984-1985 (Suzuki and Wada, 1994; Viet, 1999). In southern China, mainly in Guandong Province, a new rice variety, Jingxian89 (carrying the *bph 2* gene) has been cultivated since 1996, and its cultivated area was extended for more than one million ha (Huang *et al.*, 1999; Sogawa, personal communications). The observed changes in virulence to *bph 2* in Japan may have resulted from the evolution of the BPH population as it adapted to these varieties.

Monitoring and forecasting system in Japan

General Japanese nation-wide pest forecasting system has been outlined in Suzuki (1999). Here I will focus on monitoring and forecasting methods for long-distance migration of the rice planthoppers.

Monitoring of immigration by analysis of weather data

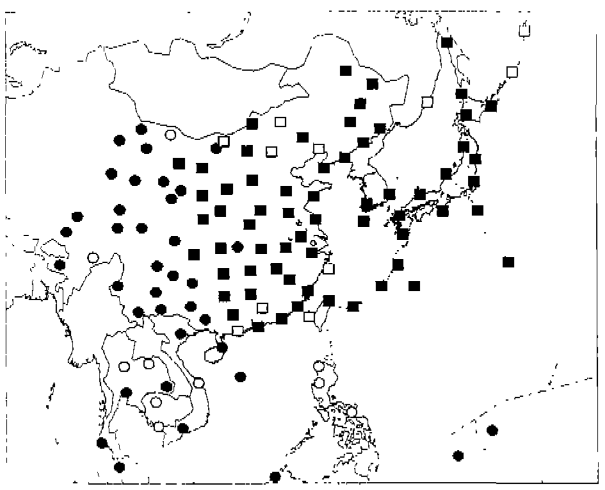

Fig. 3. Locations of the meteorological stations gathering information from 850 hPa level used for the original LLJET program by Watanabe *et al.* (1998, 1990) (black squares) and used for the extended version by JPP-NET (black circles). Open squares and open circles show the stations where the on-line data from Japan Meteorological Agency are often missing.

Watanabe *et al.* (1988, 1990) developed a computer program LLJET to localize accurately low-level jet streams related to long-distance migration of the rice planthoppers. In the basis of the LLJET program, real-time graphical information on the development of low-level jet stream has been available on JPP-NET (Japan Plant Protection General Information Network System hosted by Japan Plant Protection Association) since 1997.

The upper-air (850 hPa) weather data recorded at 74 meteorological stations were used in the original LLJET program (Watanabe et al, 1988, 1990) (Fig. 3). The extended version of LLJET by JPP-NET uses additional data stations including Indochina Peninsular and the Philippines (Fig. 3).

Twice a day weather data from these stations are provided on-line by Japan Meteorological Agency (JMA). However, the on-line data from JMA are often missing in several stations around Indochina Peninsular and the Philippines (Fig. 3). Another problem of the current LLJET program is that there are few meteorological stations around the East China Sea, the most important area to forecast BPH immigration into Japan.

JMA also provides twice a day numerical weather prediction charts for wind, and equivalent potential temperature at 850 hPa (the FXJP854 chart). The chart gives not only information of wind but also temperature and humidity. Syobu and Mikuriya (2000) reported that the analysis of the FXJP854 chart could efficiently forecast the BPH immigrations into Kyushu from 1996-1998. A sophisticated simulation model to forecast the rice planthopper migration by using boundary layer atmospheric model (BLAYER) and the Geographic Information System (GIS) has been developed in Korea (Tuner *et al.*, 1999; Zhu *et al.*, 2000). International collaborations for use and exchange of these data and information are needed among Asian countries.

Monitoring of immigrant density by light and net traps

Daily catches of light and net traps data for rice planthoppers have been collected by Agricultural Research Center and Plant Protection Offices of each prefecture in Japan. Locations of net and/or light trap sites (138 light traps and 14 net traps in 1999) are illustrated in Fig. 4. Based on these trap data, the JPP-NET provides nation-wide planthopper monitoring database and forecating information.

Field survey

Plant Protection Offices of each prefecture have fixed points for monitoring occurrences of insect pests and diseases. For example, in Saga prefecture, there are 25 points (100 paddy fields) for periodic field observations of rice pests in 1999 (Wakibe, 2000). The periodic observation is conducted twice a month. Population survey of rice planthoppers has been carried out by sweeping net and/or a sticky board. In addition, wing-form ratio and number of eggs are observed optionally. On the basis of these data, periodic forecasting information reports, outbreak alarm and warning reports

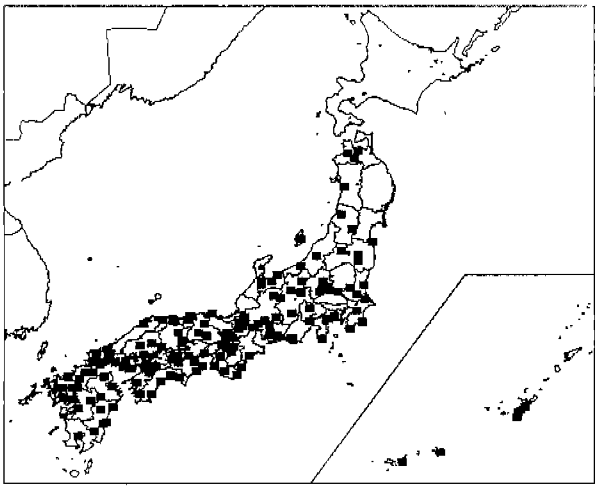

Fig. 4. Locations of net and/or light trap sites for collecting the rice planthoppers in 1999.

(if necessary) are issued. The reports are delivered to related organizations and Agricultural Extension Stations.

Concluding Remarks

Although rice planthoppers are widely distributed throughout Asia, the Asian planthopper populations have considerable intraspecific variations in many characteristics such as insecticide resistance (Nagata, 1999), virulence to resistant varieties (Tanaka and Matsumura, 2000), wing-form expression (Nagata and Masuda, 1980, Matsumura, 1996a), flight propensity (Matsumura, unpublished data), migration-related characters (Wada *et al.*, 2000) and mitochondrial DNA patterns (Mun *et al.*, 1999). Some of these characters are heritable (Matsumura, 1996a; Tanaka, 1999a) and have changed rapidly with changes of cultivated varieties (Tanaka and Matsumura, 2000). International collaboration and network system are needed for monitoring not only timing and number of immigration but also population characteristics of rice planthoppers in Asia.

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