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Note

Current Status of Insecticide Susceptibility in the Brown Planthopper, *Nilaparvata lugens* Stål, in Japan

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INTRODUCTION

The yearly infestation of the brown planthopper (BPH) in Japan, *Nilaparvata lugens* Stål, depends on the immigration from abroad during the rainy seasons. Serious outbreaks of the BPH after the heading stage of rice plant causing severe damage in rice production have occurred in the past. The BPH have been known to have developed resistance to the organophosphates (OPs) and carbamates during the second half of the 1970's[1-4]; its level fluctuated slightly through the 1980's. Extremely high resistance to OPs and carbamates was observed in 1984 and 1985[5] and the BPH could not be controlled effectively by any insecticides available on the market. The change in the insecticide susceptibility of the BPH in Japan is thought to be related to the type and frequency of insecticide usage in its native habitats in the tropical and subtropical areas which are the sources of immigrant insects coming over to Japan. Therefore, it is very important to understand the actual trend of insecticide susceptibility in each migration wave and/or each migration year in order to control of the BPH effectively.

This paper reports findings on the insecticide susceptibility of the BPH collected in several districts from 1988 to 1991.

MATERIALS AND METHODS

The 1988 immigrant populations of the BPH were collected by Nagasaki Agricultural and Forestry Experiment Station in its forecasting paddy field on June 13 and 24, July 22 and August 23. Each date represented a migration wave. The samples were delivered to CIBA-GEIGY at Takarazuka in the middle of September, and were reared since then on insecticide-free rice seedlings (Variety: Nihonbare) in our laboratory under artificial conditions of 16-hr daylight and 25±2°C. The other populations were collected from untreated fields in August in Isahaya city, Nagasaki Prefecture and in Ono and Takarazuka city, Hyogo Prefecture. They were kept under similar conditions as in the case of the 1988 immigrant populations above.

Macropterous female adults within 5 days after emergence from F2–F5 generations were used for bioassays to determine the differences in susceptibility at different migration waves, year of migration and localities. After anesthetization with carbon dioxide, a 0.06 micro-liter droplet of acetone solution of the technical grade of insecticides was applied to the dorsal side of the thorax of each female adult according to the micro-topical application technique of Fukuda and Nagata.[6] The treated females were transferred to untreated rice seedlings and kept in the laboratory under the same conditions as in the rearing. Each test was replicated twice with 15 females each. Mortality was recorded 24 hr after treatment and the LD_{50} values were calculated by probit analysis by combining data from 2–3 tests.

RESULTS

1. Migration Wave

The results of susceptibility tests on the adults of the BPH collected from June to August of 1988 by the forecasting field in Nagasaki are shown in Table 1. For a given product, there was no significant difference in the LD_{50} values

Table 1 LD_{50} values of each immigrant population of the BPH collected in 1988 by the Nagasaki Agricultural and Forestry Experiment Station.

Insecticide	LD_{50} values in μg/g			
	June 13	June 24	July 22	August 23
BPMC	7.0	7.2	5.9	6.9
MTMC	6.2	8.5	7.1	6.0
Carbaryl	4.3	4.5	4.0	3.9
Carbofuran	0.72	0.69	0.43	0.51
Diazinon	32	43	35	26
Malathion	94	94	70	56
Propaphos	7.6	10	8.6	7.5

among the four immigrant populations; the ratio of maximum/minimum values never exceeded two. The susceptibility of each immigrant population to OPs and carbamates tested was almost similar to that of the population collected in 1987.[5]

2. Local Difference

The comparison between the insecticide susceptibility of the BPH collected in Isahaya, Nagasaki Prefecture and in Ono and Takarazuka, Hyogo Prefecture in 1990 is presented in Table 2. The Ono population was only slightly more susceptible to the OPs tested than the Isahaya and Takarazuka populations; the Ono LD_{50} values did not fall below 50% of those of Isahaya and Takarazuka which in turn were about equal for malathion and propaphos. The Isahaya population, however, had a higher LD_{50} for diazinon. As for the carbamates, there was no significant difference among the three populations.

3. Annual Change

The susceptibility of the BPH population collected in Isahaya, Nagasaki Prefecture from 1988 to 1991 is shown in Table 3. Although there was a slight fluctuation in susceptibility of the BPH to the carbamates and OPs tested during the 4 years of monitoring, the LD_{50} values were almost equal to the results obtained in 1987[5] and no further obvious increase of resistance was observed from 1986 to 1991. However, when compared with the data obtained in 1967 by Fukuda and Nagata,[6] the LD_{50} values for MTMC were 4–5 times higher and those for carbaryl, 4–9 times higher during the 4-year period from 1988 to 1991. In 1989 BPMC had a value of 13.3 μg/g which was over the critical level of 10 μg/g for the green rice leafhopper.[7] The values for all other carbamates were also slightly higher in 1989 than the other years. On the other hand, malathion and diazinon showed a relatively higher LD_{50}' in 1990 (51.2 and 103 μg/g respectively). The difference between the 1989 values and other years for all insecticides was not significant.

Table 2 Comparison of LD_{50} values of the BPH collected from 3 districts in 1990.

Insecticide	LD_{50} values in μg/g		
	Isahaya	Ono	Takarazuka
BPMC	9.7	7.6	11
MTMC	7.3	6.6	7.7
Carbaryl	4.6	4.9	4.2
Carbofuran	0.48	0.51	0.73
Diazinon	51	26	36
Malathion	100	63	110
Propaphos	8.1	6.7	7.4

DISCUSSION

The susceptibility of the 4 immigrant populations of the BPH collected in Isahaya in 1988 to carbamates and OPs tested did not differ significantly from each other. Inoue and Fukamachi[8] also obtained similar results in their survey conducted in Kagoshima in 1988. According to their report, migration waves were recorded 7 times by the forecasting trap from the middle of June to the beginning of August in the Kagoshima Agricultural Experiment Station. The last 2 waves which appeared at the end of July and the beginning of August were very small. The infestation of the BPH in this district in 1988 seemed to be caused mainly by the immigrants from the first 5 waves. Kagoshima and Isahaya are about 150 km apart, yet the susceptibility of the BPH in the different migration waves found in the two surveys was quite

Table 3 LD_{50} values of the BPH collected in Isahaya in 1988–1991.

Insecticide	LD_{50} values in μg/g				
	1988	1989	1990	1991	1967[a]
BPMC	5.9	13	9.7	9.1	—
MTMC	7.1	8.4	7.3	6.5	1.8
Carbaryl	4.0	5.5	4.6	3.1	0.67
Carbofuran	0.39	0.92	0.51	0.48	—
Diazinon	35	37	51	25	7.3
Malathion	70	—	100	44	6.9
Propaphos	8.6	8.1	8.1	6.1	—

[a] Data quoted from Fukuda and Nagata.[6]

similar. Therefore, it is most likely that the BPH populations which migrated to Japan up to the end of July 1988 had similar susceptibility and originated from the same locality in the Asian continent.

Although the susceptibility of the BPH had fluctuated slightly during 4 years from 1988 to 1991, it was almost similar to that observed in 1987.[5] Furthermore, the difference between Isahaya, Ono and Takarazuka in 1990 was negligible.

Endo *et al.*[9] reported that the susceptibility of the BPH collected in Chikugo, Fukuoka Prefecture in 1988 to diazinon and carbaryl had reverted to the level of the 1967 data.[6] In the present survey, however, when the LD_{50} values obtained from 1988 to 1991 were compared with those of Fukuda and Nagata[6] they were 3–5 times higher for MTMC, 4–7 times higher for carbaryl and diazinon, and 6–15 times higher for malathion. It may safely be said that the BPH which had developed resistance to carbamates and OPs in the second half of the 1970's has remained moderately resistant from the beginning of the 1980's to the present. The only exception was in 1984 and 1985 when unusually high resistance was observed.[5,10,11] The insecticide application for the control of rice insect pests in the native habitats of the BPH on the Asian mainland is a common practice which would contribute to the continuous selection pressure on the latter. Therefore, it is inconceivable that the BPH which once developed resistance in the second half of the 1970's would revert to the level of susceptibility shown in 1967 under natural conditions.

When a serious outbreak of the BPH occurs in paddy fields, it is essential to apply effective chemicals adequately and timely for its control because the BPH causes destructive damage to rice production. Since the infestation of the BPH in Japan is attributable to the long distance migration from abroad, it is possible that its susceptibility differs in each migration wave and/or in each migration year. Therefore, we must always expect that the populations which have high resistance could occur suddenly in paddy fields in Japan. The proper understanding of the current tendency of the resistance development in the BPH remains as essential as ever.

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要　約

トビイロウンカの殺虫剤感受性の現状

平井勝義

トビイロウンカの殺虫剤感受性を飛来波別，地域別および年次別に微量局所施用法で検討した．1988年に長崎県諫早市で採集した4波の飛来波間で感受性に差異は見られなかった．また1990年に長崎県と兵庫県で採集した3個体群間で感受性の地域差は見られなかった．諫早市で1988年から1991年の4年間採集された個体群の感受性の年次変動はほとんど見られなかった．