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Insecticide Resistance of the Small Brown Planthopper, *Laodelphax striatellus* FALLÉN (Hemiptera: Delphacidae), Collected in Kyushu and on the East China Sea

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Topical LD₅₀ values for eight insecticides were determined in five populations of the small brown planthopper, *Laodelphax striatellus* FALLÉN, (SBPH), collected in fields in districts of Kyushu and on the East China Sea in 1980. No significant local variabilities in LD₅₀ values were observed with the SBPH collected from the four localities in Kyushu but they showed the most remarkable increase of resistance ratios to malathion. The tested population had developed 90- to 270-fold resistance as compared with the Chikugo population tested in 1967, and also showed 20- to 70-fold resistance to fenitrothion, diazinon, MTMC, carbaryl and MIPC. The SBPH population collected on the East China Sea gave LD₅₀ values coincident with these four populations.

The small brown planthopper, *Laodelphax striatellus* FALLÉN, (SBPH), is one of the major rice insect pests in Japan and causes severe damage by transmitting several rice viruses such as stripe virus and black-streaked dwarf virus. Many studies have been conducted, especially on malathion and BHC resistance of the SBPH in the 1960's. A decrease in areas planted in wheat, one of the favorite hosts of the SBPH, caused remarkable reduction in the occurrence of this insect pest and the resistance problem has been virtually ignored since then. However, enlargement of the areas of wheat production in accordance with the government's 1970 recommendation caused a resurgence of the SBPH. Therefore, topical LD₅₀ values of eight insecticides including chlorinated hydrocarbons, organophosphates and carbamates were examined in several SBPH populations collected in the fields of districts of Kyushu and on the East China Sea in 1980.

MATERIALS AND METHODS

In Kyushu the insects were collected in the field in September and October 1980 and reared in the laboratory with rice seedlings under 25°C, 16 hr photoperiod. Collection sites were: Nagasaki strain: Ono, Isahaya City, Nagasaki Pref.; Kumamoto strain:

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Yatsushiro City, Kumamoto Pref.; Kagoshima strain: Izumi City, Kagoshima Pref.; Miyazaki strain: Ebino City, Miyazaki Pref.. Female adults within 4 days after emergence were collected from insect cages with a mouth aspirator and anaesthetized with carbon dioxide, a 0.05 microliter droplet of insecticide dissolved in acetone was applied to the dorsal side of the thorax with a microapplicator (Kiya Co. Tokyo) fitted with a 50 microliter syringe (MSN-50, Jintan®, Tokyo). Rice seedlings were given to the treated insects, and they were kept at 25°C. Mortality was recorded 24 hr after treatment and results were calculated according to BLISS's probit analysis. Forty adults were used for each concentration and there were two replicates.

The insects collected in June 1980 on the East China Sea (Permit number: MAFF55-Yokoshoku-1609, 1980) were also multiplied and tested following the same procedures. The number of generations reared in the laboratory prior to the bioassay was 6–7 for the East China Sea population and 4–5 for the Kyushu populations. In the laboratory they were maintained without exposure to insecticides.

RESULTS AND DISCUSSION

The five populations collected in Kyushu and on the East China Sea showed no remarkable local variabilities of LD₅₀ values to the eight insecticides examined in this experiment, the difference being 1.2–4.7 times (Table 1). However, when these data are compared with those obtained in 1967 by FUKUDA and NAGATA (1969), all the tested populations showed remarkably increased resistance to organophosphates and carbamates.

The resistance ratios to malathion ranged from 89-fold in the Miyazaki population to 272-fold in the East China Sea population and the resistance ratios to fenitrothion and diazinon ranged 22- to 43-fold and 15- to 32-fold, respectively. The resistance ratio to carbaryl ranged from 15-fold in the Kagoshima population to 71-fold in the Miyazaki population. These populations also showed more than 14-fold resistance to MTMC, MIPC. The resistance ratios to BHC and DDT were relatively small ranging from 4- to 8-fold.

The LD₅₀ values to insecticides in the SBPH have been monitored in Kyushu districts by the topical application method since 1962 (MIYAHARA and FUKUDA, 1964;

Table 1. Topical LD₅₀ values for the small brown planthopper (1980)

| Insecticides | Nagasaki | Kumamoto | Kagoshima | Miyazaki | E. China Sea | Max/Min ^b |
|--------------|-------------------------|--------------|-------------|-------------|--------------|----------------------|
| BHC | 151.6*/5.5 ^a | 100.8*/3.7 | 280.5*/10.2 | 105.4 /3.8 | 122.8*/4.4 | 2.8 |
| DDT | 36.4 /4.9 | 50.0*/6.8 | 98.5 /13.3 | 53.8*/7.3 | 47.0*/6.4 | 2.7 |
| Malathion | 191.0*/119.4 | 370.7*/231.7 | 288.0/180.0 | 141.7*/88.6 | 435.0*/271.9 | 3.1 |
| Fenitrothion | 28.0*/36.0 | 23.5*/29.4 | 17.4*/21.8 | 29.6*/37.0 | 34.6*/43.3 | 2.0 |
| Diazinon | 53.8 /28.3 | 44.7*/23.5 | 28.8/15.2 | 56.1*/29.5 | 60.6 /31.9 | 2.1 |
| MTMC | 62.2*/33.9 | 27.3 /14.9 | 40.2*/21.9 | 50.0*/27.3 | 40.2*/21.9 | 2.3 |
| Carbaryl | 53.8*/33.6 | 61.4*/38.4 | 24.2 /15.1 | 113.7*/71.1 | 99.3*/62.1 | 4.7 |
| MIPC | 115.2 /19.9 | 131.9*/22.7 | 129.6*/22.3 | 122.8 /21.2 | 138.0*/23.8 | 1.2 |

^a LD₅₀ (μg/g)/Times increase of LD₅₀ as compared with the 1967 data (FUKUDA and NAGATA, 1969). Asterisk indicates that regression line fitted at *Pr*=0.05.

^b Ratios of maximum LD₅₀/minimum LD₅₀ among the five populations for local comparisons.

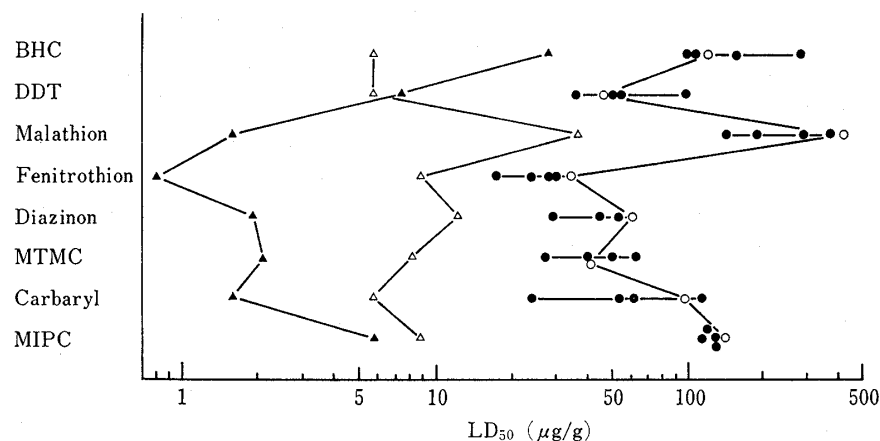


Fig. 1. Development of insecticide resistance in the small brown planthopper.

▲: 1967 Fukuoka population (FUKUDA and NAGATA, 1969), △: 1976 Fukuoka population (NAGATA et al., 1979), ●: 1980 Kyushu populations, ○: 1980 East China Sea population.

FUKUDA and NAGATA, 1969), and development of resistance to organophosphorus and carbamate insecticides was observed in 1976 (NAGATA et al., 1979). Thus, an even further increase of resistance levels was demonstrated in this experiment (Fig. 1).

HAMA (1984) also reported that the Kyushu populations collected in 1982 showed 34-, 37-, 89- and 11-fold resistance to diazinon, fenitrothion, propoxur and carbaryl and observed local variabilities of resistance levels comparing the Kyushu populations with those collected in central Japan (Gunma Prefecture). Although development of insecticide resistance in the SBPH has also been reported earlier by many other scientists in Japan (KIMURA, 1965; KASSAI and OZAKI, 1966; YOKOYAMA and OZAKI, 1968; OZAKI and KASSAI, 1971; KIMURA, 1973), these data were obtained by specified bioassay methods such as residue-film method or comparison of esterase activity hydrolyzing β -naphthyl acetate, which are not comparable with those obtained by topical application.

An interesting result was the coincidence of LD_{50} values between the East China Sea population and the populations collected in Kyushu districts. Distribution of the SBPH is wide in Japan, ranging from Kyushu to the northern island, Hokkaido. This species has been known to be able to overwinter in abundance as second-instar nymphs and is regarded as a resident insect. NODA (1984) recently found cytoplasmic incompatibility of this species by crossing various populations collected in Japan, and showed that such populations are divided into two geographical groups: one from the north-eastern part and the other from the western part of Japan. Therefore, insecticide resistance in the SBPH developed as a result of insecticide usage in respective areas of Japan, as suggested by malathion resistance (KIMURA, 1965). In fact, the SBPH populations collected in northern Japan, where insecticide use is less, were more susceptible to insecticides (KIMURA, 1965, 1973; TAKITA, 1979). On the other hand, a considerable number of these insects have been caught on every monitoring voyage on the East China Sea suggesting the possibility of their transoceanic migration (KISIMOTO, 1975). Thus, influence of migratory SBPH on our resident populations and the presence of geographical groups should be taken into consideration when insecticide resistance of the SBPH is discussed.

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