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Changes of Insecticide Susceptibility of the White Backed Planthopper *Sogatella furcifera* HORVÁTH (Homoptera: Delphacidae) and the Brown Planthopper *Nilaparvata lugens* STÅL (Homoptera: Delphacidae)

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Insecticide susceptibility of the white backed planthopper, *Sogatella furcifera* HORVÁTH, (WBPH), and brown planthopper, *Nilaparvata lugens* STÅL, (BPH), was surveyed by the topical application method in 1980 and 1987. Comparing the data obtained in these experiments with previous data, the susceptibility of the WBPH to organophosphate and carbamate insecticides was found to have decreased with years. Susceptibility of the BPH to organophosphates in 1987 was greater than that in 1980. The susceptibility of both insects to *p,p'*-DDT decreased with years, but that to lindane was almost the same as in 1967. In 1987 LD_{50} values of the WBPH and BPH to synthetic pyrethroids were also evaluated.

INTRODUCTION

The white backed planthopper, *Sogatella furcifera* HORVÁTH, (WBPH), and the brown planthopper, *Nilaparvata lugens* STÅL, (BPH) immigrate to Japan in June–July every year. Although a large number of WBPH immigrate to rice fields they leave there with the heading stage of the plant; therefore, the damage to rice plants by this insect is not serious. Reports on insecticide susceptibility of WBPH (FUKUDA and NAGATA, 1969; NAGATA et al., 1979; NAGATA and MASUDA, 1980). NAGATA et al. (1979) indicated that there was no change during the period of 1967 to 1976 to organochlorine, organophosphorus and carbamate insecticides. Changes in the susceptibility of BPH, however, have appeared in several reports: organophosphorus insecticide resistance by NAGATA et al. (1979), organophosphorus and carbamate insecticides by KILIN et al. (1981), by OZAKI and KASSAI (1982) and by HOSODA (1983). These reports indicate the seriousness of insecticide resistance in BPH which may hinder chemical control of the insect.

We studied the susceptibility of populations of WBPH and BPH which were collected at weather observation spot in the East China Sea, Chikugo, Usa, and Isahaya in 1980 and 1987.

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MATERIALS AND METHODS

Insects. The WBPH and BPH were collected on the East China Sea and at several spots in the Kyushu district in 1980 and 1987. The insects were reared on rice seedlings (variety: Reiho) in our laboratory under 25°C, 16 hr illumination period.

Insecticidal test. Macropterous adult female WBPH and BPH were used. After anesthetization with carbon dioxide, a 0.05 μl droplet of insecticide dissolved in acetone was applied to the dorsal side of the thorax with a microapplicator fitted with a 50 μl syringe. The mortality was recorded 24 hr after the treatment. LD_{50} values were calculated by statistical analysis according to BLISS's formula (BLISS, 1935). The average body weight of the WBPH and BPH females was 1.3 mg and 2.4 mg, respectively.

Insecticides. The following insecticides of technical grade were used: lindane (>99%), *p,p'*-DDT (>99%), malathion (95.5%), fenitrothion (97.2%), propaphos (92.3%), diazinon (99.6%), isoxathion (97.2%), Tsumacide® (*m*-tolyl methylcarbamate) (97%), isoprocarb (99.5%), Bassa® (*o-sec*-butylphenyl methylcarbamate) (98.5%), Macbal® (3,5-xylyl methylcarbamate) (99%), propoxur (99.3%), carbaryl (99.0%), carbofuran (97.3%), carbosulfan (90.6%), ethofenprox (96.6%), deltamethrin (>99%), fenvalerate (94.9%).

RESULTS AND DISCUSSION

The insecticide susceptibility of WBPH is shown in Table 1. The WBPH col-

Table 1. Insecticide susceptibility of the white backed planthopper

Insecticide	LD_{50} (μg/g)			
	Chikugo[a] (Fukuoka) 1967	East China Sea July 1980	Usa (Oita) June 1987	Isahaya (Nagasaki) July 1987
lindane	15 /1.6[b]	31 /2.8[b]	35 /2.2[b]	30 /2.4[b]
p,p'-DDT	5.6 /2.0	30 /2.2	65 /2.3	85 /1.7
malathion	1.9 /7.4	7.2/2.4	120 /2.3	73 /3.3
fenitrothion	0.72/5.3	1.9/2.7	48 /2.1	52 /2.1
propaphos	—	—	5.1/4.9	5.2/4.7
diazinon	2.1 /6.5	4.0/4.3	25 /3.4	24 /2.1
isoxathion	—	—	130 /1.0	130 /1.8
Tsumacide®	1.4 /4.3	2.9/2.3	11 /4.1	14 /2.9
isoprocarb	0.89/5.8	2.2/3.3	4.9/2.7	5.5/4.6
Bassa®	—	—	12 /2.0	11 /3.3
carbaryl	0.55/3.8	1.5/3.0	6.5/3.1	4.5/2.6
carbofuran	—	—	1.5/3.7	1.6/3.3
carbosulfan	—	—	3.5/2.2	4.9/2.4
ethofenprox	—	—	1.5/3.1	1.0/4.2
deltamethrin	—	—	2.5/1.7	1.3/1.7
fenvalerate	—	—	12 /1.6	12 /2.3

[a] Data from FUKUDA and NAGATA (1969).
[b] Figures indicate the slope of regression line.

Table 2. Insecticide susceptibility of the brown planthopper

Insecticide	LD50 (μg/g)				
	Chikugo[a] (Fukuoka) 1967	Chikugo (Fukuoka) June 1980	Chikugo (Fukuoka) July 1980	East China Sea July 1980	Chikugo (Fukuoka) Oct. 1987
lindane	25 /2.2[b]	15 /2.0[b]	21 /1.7[b]	54 /2.8[b]	39 /2.0[a]
p,p′-DDT	17 /2.2	41 /2.0	33 /2.0	40 /1.7	120 /2.0
malathion	6.9 /2.8	350 /1.9	280 /1.6	220 /1.8	71 /2.3
fenitrothion	9.6 /3.4	170 /3.4	50 /2.7	63 /3.6	67 /4.7
propaphos	—	—	—	—	5.8/5.1
diazinon	7.3 /2.7	54 /5.3	50 /3.3	46 /4.8	26 /2.4
isoxathion	—	—	—	—	58 /1.8
Tsumacide®	1.8 /5.6	8.8/3.1	6.7/3.2	6.7/4.7	5.4/4.7
isoprocarb	1.1 /4.8	11 /3.2	10 /2.7	8.3/3.0	12 /2.4
Bassa®	—	—	—	—	10 /3.1
Macbal®	—	—	—	—	7.9/3.6
propoxur	0.44/3.6	—	—	—	5.8/2.7
carbaryl	0.67/4.1	7.5/3.2	4.2/2.7	5.8/4.1	3.0/1.8
carbofuran	—	—	—	—	0.96/1.1
carbosulfan	—	—	—	—	5.0/3.0
ethofenprox	—	—	—	—	2.8/2.6
deltamethrin	—	—	—	—	30 /1.2
fenvalerate	—	—	—	—	33 /1.8

[a] Date from Fukuda and Nagata (1969).
[b] Figures indicate the slope of regression line.

Table 3. Development of insecticide resistance in the white backed planthopper and brown planthopper

Insecticide	White backed planthopper		Brown planthopper	
	1980/1967	1987[a]/1967	1980[a]/1967	1987/1967
lindane	2.0	2.2	1.2	1.6
p,p′-DDT	5.4	13	2.2	7.1
malathion	3.8	50	41	10
fenitrothion	2.7	69	9.7	6.9
diazinon	1.9	12	6.9	3.6
Tsumacide®	2.1	8.8	4.1	3.0
isoprocarb	2.5	5.8	8.8	9.1
carbaryl	2.8	9.9	8.7	4.5

[a] The average values of susceptibility data in each year were used.

lected on the East China Sea in 1980 was susceptible to most insecticides except organochlorine insecticides. The susceptibilities of the two strains of WBPH collected in Kyushu in 1987 to all the insecticides used did not greatly differ from each other. The LD_{50} values to carbofuran, ethofenprox, and deltamethrin were small, but those to most organophosphates except propaphos and organochlorine insecticides were large.

The insecticide susceptibility of BPH is shown in Table 2. The LD_{50} values to carbaryl, carbofuran and ethofenprox for BPH of the 1987 Chikugo strain were small.

Table 4. Ratio of the susceptibility of brown planthopper to white backed planthopper

Insecticide	Ratio		
	1967	1980[a]	1987[a]
lindane	1.6	0.99	1.2
p,p'-DDT	3.0	1.3	1.6
malathion	3.6	40	0.75
fenitrothion	13	48	1.3
propaphos	—	—	1.1
diazinon	3.5	13	1.1
isoxathion	—	—	0.45
Tsumacide®	1.3	2.6	0.44
isoprocarb	1.2	4.3	1.9
Bassa®	—	—	0.90
carbaryl	1.2	3.8	0.55
carbofuran	—	—	0.61
carbosulfan	—	—	1.2
ethofenprox	—	—	2.2
deltamethrin	—	—	16
fenvalerate	—	—	2.8

[a] The average values of susceptibility data in each year were used.

Ratios of the LD_{50} values in 1980 and 1987 to those in 1967 (FUKUDA and NAGATA, 1969) were calculated and are shown in Table 3. The susceptibility of WBPH to *p,p'*-DDT in 1980 decreased greatly compared to that in 1967, but for other insecticides the difference in susceptibility between the two years was not as large. In 1987 the susceptibility of WBPH to malathion and fenitrothion was only 1/50 and 1/69 that of the 1967 data, respectively. The development of resistance to organophosphates during the past 7 years (1980–1987) was found to be faster than in the preceding 13 years (1967–1980). The susceptibility of WBPH to carbamate insecticides decreased to between 1/10 and 1/6 in 1987. In organochlorines the susceptibility to *p,p'*-DDT in 1987 decreased to approximately 1/10 of that in the 1967 data, but the susceptibility to lindane did not change during 1967–1987.

The change of insecticide susceptibility in BPH was different from that of WBPH. BPH susceptibility to malathion in 1987 increased four-fold over that in 1980. Also, the susceptibility of BPH to diazinon and carbaryl recovered a little in 1987. This tendency was strengthened by comparing with the data of KILIN et al. (1981). HEINRICHS et al. (1984) recognized that the WBPH and BPH reared on moderately resistant rice varieties showed smaller LD_{50} values to carbofuran, acephate and ethylan than those reared on susceptible varieties. Recently the cultivation area of resistant rice varieties has enlarged in Southeast Asia (DALRYMPLE, 1986), and the difference in insecticide susceptibility among several strains collected in various areas has sometimes been observed (LIN et al., 1979; NAGATA and MASUDA, 1980). The influence of host plant on insecticide susceptibility and the migration of BPH requires further study. The susceptibility of BPH to *p,p'*-DDT decreased to 1/7 in 1987, as was true of WBPH.

Ratio of the LD_{50} values of BPH to that of WBPH varied annually (Table 4). In organochlorines the ratio did not change between 1980 and 1987, that is, the susceptibility to those two insecticides was almost the same between BPH and WBPH. In organophosphates the ratios of LD_{50} values in 1967 were 3.5–13 (FUKUDA and NAGATA, 1969), followed by large ratios of 13–48 in 1980, and finally in 1987 they became small and went down to about 1. In carbamates the ratio was 2.6–4.3 in 1980, and was as small as 0.42–1.9 in 1987. The development of insecticide resistance in WBPH was slower than in BPH. This phenomenon might be the result of WBPH not being selected by insecticides in the fields because of its high migratory ability.

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