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Note

Insecticide Susceptibility of the Brown Planthopper and the White-backed Planthopper Collected from Southeast Asia

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INTRODUCTION

The brown planthopper, *Nilaparvata lugens*, Stål (BPH) and the white-backed planthopper, *Sogatella furcifera*, Horvāth (WBPH) are still keeping status as serious destructive insect pests on rice in rice-growing countries in Asia.[1,2] And insecticides are playing an important role as major control measures as well as varietal resistance and cultivation method and so forth.

Development of insecticide resistance in these long-distance migratory rice planthoppers has been documented in Japan. BPH has been developing insecticide resistance for the organophosphates and carbamates after the late 1970's.[3,4,5,6] WBPH has been also developing insecticide resistance after the late 1980's as well.[7,8]

The earliest topical LD_{50} of BPH and WBPH in the tropics were determined by Nagata and Masuda[9] for the Philippine, Thai and Taiwanese populations in 1977. It was reported that those hoppers collected from the tropics, especially from Thailand was generally more susceptible than the Japanese populations. Endo *et al*.[10] reported that there was no significant difference on the topical LD_{50} of BPH and WBPH between Indonesian and Japanese populations for the organophosphates and carbamates in 1988. However, there are only few other reports comparing insecticide susceptibility of those hoppers collected in Japan and Southeast Asian countries. In this report, we described insecticide susceptibility of BPH and WBPH collected from Southeast Asia during 1989–1992.

MATERIALS AND METHODS

The planthoppers were collected from Japan, Vietnam, Malaysia, and Thailand. More than 50 females and appropriate number of males were collected for each population. The collection sites and date are shown in Table 1. The insects were multiplied on the rice seedlings (Variety: Reiho) at 25°C under 16 hr photoperiod. Topical application was conducted by anaesthetizing the insects with carbon dioxide and treating individual insects topically with 0.05 μl of acetone solution of insecticides by micro-topical applicator (Burkard®). Treated insects were maintained in a plastic box (11×8×3.3 cm) and fed with rice seedlings. Mortality was recorded 24 hr after the treatment at 25°C. LD_{50} were calculated by Bliss's formula.[11] Each test was carried out in 2–4 replicates using 15 females for each concentration. The insecticidal tests were conducted on 3–7 generations after collection. When LD_{50} of several insecticides were measured on 3rd and 6th generations, the differences between these LD_{50}s were less than 1.6 times.

The insecticides used in this study were lindane, *p,p'*-DDT, malathion, fenitrothion, diazinon, monocrotophos, carbaryl, metolcarb, isoprocarb, fenobcarb, XMC (3,5-xylyl methylcarbamate), propoxur, carbofuran, carbosulfan, etofenprox, deltamethrin, fenvalerate, and imidacloprid. Purity of these technical insecticides was higher than 95% except monocrotophos (73%) and carbosulfan (91%).

Rice seedling dipping method was adopted to determine LC_{50} for buprofezin[12]: 20% buprofezin wettable powder was dissolved with 0.02% Rabiden® (spreader). Rice seedlings (5–10 cm) were dipped in buprofezin solution for 30 sec. After the seedlings were air-dried, their roots were wrapped with wet cotton. And 3–5th instar nymphs, mainly 4th-instar nymphs, were kept with the treated seedlings in a test tube (2.6×20 cm) at 25°C under 16 hr photoperiod. Mortality was recorded 3–6 days after treatment to calculate LC_{50}. Number of insects recorded at 2 days after treatment was removed from the total number of insects used.

RESULTS AND DISCUSSIONS

1. BPH

Topical LD_{50} for BPH collected from Malaysia in 1989–1990 and Japan in 1989 were shown in Table 2. There was no significant difference in LD_{50} of the tested insecticides between the two Japanese populations (NA, FU). LD_{50} of organophosphates and carbamates for these Japanese populations mostly coincided with those reported by Hirai (1994)[13] for BPH collected on another location of Japan in the same year. LD_{50} of malathion for the Malaysian populations (SP, BB, AS) were significantly larger than those for the Japanese populations (NA, FU) with 7.4 times difference in LD_{50} averaged for each country. LD_{50} of diazinon and carbosulfan for the Malaysian populations (SP, BB, AS) were also slightly larger than those for the Japanese populations (NA, FU). But LD_{50}s of the other insecticides were almost the same between the Japanese and the Malaysian populations with difference in LD_{50} less than 2 times. However, LD_{50}

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Table 1 Tested population of the brown planthopper and white-backed planthopper.

Insect	Population	Locality and date collected
BPH	NA	Nagasaki, Japan, Jul. 1989
BPH	FU	Fukuoka, Japan, Sep. 1989
BPH	SP	Sebrang Perak, Malaysia, Dec. 1989
BPH	BB	Bukit Besar, Malaysia, Dec. 1989
BPH	AS	Alor Setar, Malaysia, Dec. 1990
BPH	KU	Kumamoto, Japan, Jul. 1992
BPH	HH	Hai Hung, Vietnam, Apr. 1992
BPH	HA	Hanoi, Vietnam, Mar. 1992
BPH	TG	Tien Giang, Vietnam, Apr. 1992
BPH	HG	Hau Giang, Vietnam, Apr. 1992
BPH	TH	Suphan Buri, Thailand, Apr. 1992
WBPH	FUW	Fukuoka, Japan, Jul. 1989
WBPH	SPW	Sebrang Perak, Malaysia, Dec. 1989
WBPH	ASW	Alor Setar, Malaysia, Dec. 1990

BPH and WBPH was indicated the brown planthopper and white-backed planthopper, respectively.

Table 2 Insecticide susceptibility of the brown planthopper collected from Japan and Malaysia in 1989 and 1990.

Insecticide	LD_{50}, $\mu g/g$														
	Japan						Malaysia								
	NA(1989)			FU(1989)			SP(1989)			BB(1989)			AS(1990)		
Lindane	12	(9.4-14)[1]	3.0[2]	11	(8.8-13)[1]	3.0[2]	8.2	(5.7-11)[1]	1.8[2]	9.7	(7.4-13)[1]	2.0[2]	8.4	(6.9-10)[1]	3.1[2]
p,p'-DDT	100	(82-140)	2.3	200	(150-300)	2.0	73	(50-120)	1.4	54	(36-81)	1.3	70	(46-130)	1.1
Malathion	75	(54-99)	1.6	120	(97-160)	2.5	930	(690-1700)	2.6	780	(580-1300)	2.4	470	(340-730)	1.7
Fenitrothion	61	(49-74)	2.9	100	(81-130)	2.4	170	(140-230)	3.7	140	(120-170)	4.0	150	(120-190)	2.5
Diazinon	34	(28-41)	3.1	37	(30-50)	2.8	150	(120-190)	3.4	110	(90-130)	3.5	75	(63-92)	4.0
Carbaryl	4.8	(4.0-5.7)	2.9	4.2	(3.3-4.9)	3.3	7.4	(6.0-9.5)	3.0	5.6	(4.6-7.1)	3.0	11	(9.1-14)	3.7
Metolcarb	7.7	(6.7-8.9)	5.2	12	(9.9-14)	4.1	13	(11-14)	5.6	9.3	(7.8-11)	5.7	6.3	(5.4-7.4)	4.3
Isoprocarb	—[3]			—			15	(12-18)	3.2	12	(9.4-16)	2.1	14	(11-20)	2.2
Fenobcarb	16	(11-25)	1.6	13	(10-19)	3.6	35	(30-43)	3.5	24	(19-30)	2.4	11	(9.5-14)	3.2
Carbofuran	1.6	(1.3-1.9)	3.0	0.92	(0.63-1.1)	3.0	3.3	(2.8-4.1)	3.7	1.9	(1.5-2.3)	3.1	2.7	(2.2-3.3)	3.2
Carbosulfan	5.8	(4.6-7.5)	2.6	3.0	(2.0-4.0)	1.8	16	(10-23)	1.6	6.7	(5.6-8.2)	2.8	9.8	(7.9-12)	2.6
Etofenprox	2.6	(2.2-3.2)	2.7	2.2	(1.6-2.8)	1.9	0.97	(0.82-1.1)	4.2	0.93	(0.78-1.1)	3.4	1.1	(0.90-1.3)	3.2
Deltamethrin	—			—			6.6	(5.0-8.7)	1.9	—			7.3	(5.8-9.8)	2.4
Fenvalerate	—			—			4.9	(3.5-6.5)	1.6	8.3	(6.6-11)	2.3	10	(7.4-13)	1.7
Buprofezin[4]	—			15[5]	(12-18)	4.2	4.5[5]	(3.9-5.3)	2.9	7.0[5]	(5.2-9.1)	2.2	3.4[5]	(2.9-4.0)	2.4

[1] 95% fiducial limits were shown in parentheses. [2] Figures were shown slope of regression line. [3] not tested. [4] Susceptibility for buprofezin was carried out by rice seedling dipping method (Kazano *et al.*,1989). [5] LC_{50} values were calculated using insecticide concentration of dipping solution(ppm).

of malathion, diazinon and etofenprox[8] for the Indonesian population (Bogor) determined in 1988 were 1/12–1/5 times as large as those for the 1989 Malaysian populations (SP, BB, AS). This remarkable difference may suggest that BPH migration between Indonesia and Malaysia is not frequent.

LC_{50} of buprofezin determined by the rice seedlings dipping method[12] was 3.4–15 ppm (Table 2).

LD_{50} for BPH collected from Japan, Vietnam and Thailand in 1992 were shown in Table 3. LD_{50} of malathion for the Japanese population (KU) was almost the same with those for northern Vietnamese populations (HH, HA). LD_{50} of malathion for the Japanese (KU) and northern Vietnamese populations (HH, HA) were significantly smaller than those for the southern Vietnamese (TG, HG) and Thai (TH) populations. However, LD_{50} for the other insecticides were almost the same among these three populations.

Nagata and Masuda[9] reported in 1977 that LD_{50}s for the tested organophosphates and carbamates, except for metolcarb, of the Thai population were remarkably smaller than those of the Japanese population. However, LD_{50} of the 1992 Thai population (TH) were almost the same as those of the 1992 Japanese population (KU). Furthermore LD_{50} of TH population for malathion was lager than those of KU population. Patterns of insecticide susceptibility of BPH in 1976–1977 and 1988–1992 were shown in Fig. 1. LD_{50} of malathion, fenitrothion, diazinon and carbaryl for the 1992 Thai population (TH) were 21, 16, 12 and 12 times as large as those reported by Nagata and Masuda[9] for the 1977 Thai populations, respectively. It indicates obviously that BPH in Thailand has developed remarkable insecticide resistance to organophosphates and carbaryl during 1977–1992.

2. *WBPH*

Topical LD_{50}s for WBPH were shown in Table 4. Nagata and Masuda[9] determined the earliest topical LD_{50} for the Thai populations of WBPH in 1977 and found LD_{50} of *p,p'*-DDT and organophosphates were significantly smaller than those determined for the 1976 Japanese population (1/24 times, 1/5–1/12 times respectively). Endo *et al.*[10] also determined LD_{50}s of the 18 insecticides for Indonesian population (Bogor) in 1988 and comparison with the 1988 Japanese population showed higher susceptibility of the Indonesian population for *p, p'*-DDT (1/5 times) again with other 17 insecticides being equal each other. LD_{50}s of malathion for the 1989 and 1990 Malaysian populations (SPW, ASW) were significantly (4 and 7 times) larger than those for the Japanese population (FUW) with the LD_{50} of the other insecticides being not different among these three populations.

LD_{50} of organophosphates and carbamates for the 1989 Japanese populations of WBPH were 17–28, 7–9 times as large as those determined in 1976 by Nagata and Masuda,[9] respectively. As reported in Japan, WBPH had not shown any sign of resistance development until 1980.[9] But, it has developed marked resistance between 1980 and 1984.[7,8,13]

Table 3 Insecticide susceptibility of the brown planthopper collected from Japan, Vietnam and Thailand in 1992.

Insecticide	LD_{50}, μg/g					
	Japan	Vietnam				Thailand
	KU	HH	HA	TG	HG	TH
Malathion	91 (78–110)[1] 3.9[2]	48 (29–64)[1] 2.8[2]	110 (81–140)[1] 2.5[2]	450 (340–820)[1] 2.8[2]	360 (270–580)[1] 2.4[2]	360 (290–490)[1] 3.2[2]
Fenitrothion	130 (99–170) 2.5	43 (34–55) 2.6	77 (60–97) 2.6	99 (80–120) 2.9	130 (97–190) 2.5	110 (92–140) 3.4
Diazinon	26 (22–31) 3.6	20 (17–24) 4.2	26 (22–31) 3.9	30 (25–36) 3.7	39 (32–46) 3.4	48 (42–55) 2.1
Carbaryl	6.8 (4.6–9.1) 1.8	3.3 (2.7–4.0) 2.8	9.9 (7.9–12) 2.6	8.9 (7.4–11) 3.5	10 (8.1–13) 2.5	7.4 (6.2–9.1) 3.8
Metolcarb	11 (8.7–13) 3.3	—[3]	17 (13–24) 2.7	—	8.9 (7.6–10) 4.3	14 (12–16) 5.5
Fenobcarb	12 (9.1–14) 2.9	8.8 (6.8–12) 2.4	23 (19–27) 4.2	13 (10–16) 3.3	20 (17–23) 4.4	26 (22–30) 5.0
Propoxur	9.6 (6.2–15) 1.6	3.4 (1.0–5.4) 1.4	7.8 (6.6–9.1) 4.2	9.0 (7.2–12) 2.6	—	9.4 (7.8–11) 3.4
Carbofuran	1.7 (1.4–2.0) 3.8	0.90 (0.72–1.1) 2.7	1.8 (1.4–2.3) 2.3	1.8 (1.5–2.1) 3.7	1.3 (0.87–1.7) 2.0	2.3 (1.8–2.8) 2.3
Carbosulfan	6.0 (4.7–8.2) 2.3	5.3 (4.3–6.5) 3.0	6.9 (5.4–8.5) 2.8	13 (9.8–21) 2.4	13 (8.6–45) 1.5	17 (13–23) 2.2
Etofenprox	1.1 (0.68–1.5) 1.9	1.6 (1.3–1.9) 2.9	2.7 (2.1–3.4) 2.4	1.0 (0.84–1.3) 3.3	1.1 (0.74–1.4) 2.6	1.2 (0.99–1.5) 3.2
Deltamethrin	—	—	29 (22–44) 1.9	—	—	—
Fenvalerate	—	35 (26–54) 2.2	22 (18–28) 2.8	25 (18–35) 2.0	27 (20–39) 1.9	28 (20–45) 1.6
Imidacloprid	0.16 (0.13–2.0) 2.9	0.092 (0.068–0.12) 2.0	0.090 (0.070–0.11) 2.4	0.10 (0.082–0.13) 2.3	0.093 (0.071–0.12) 2.3	—

[1] 95% fiducial limits were shown in parentheses. [2] Figures were shown slope of regression line. [3] not tested.

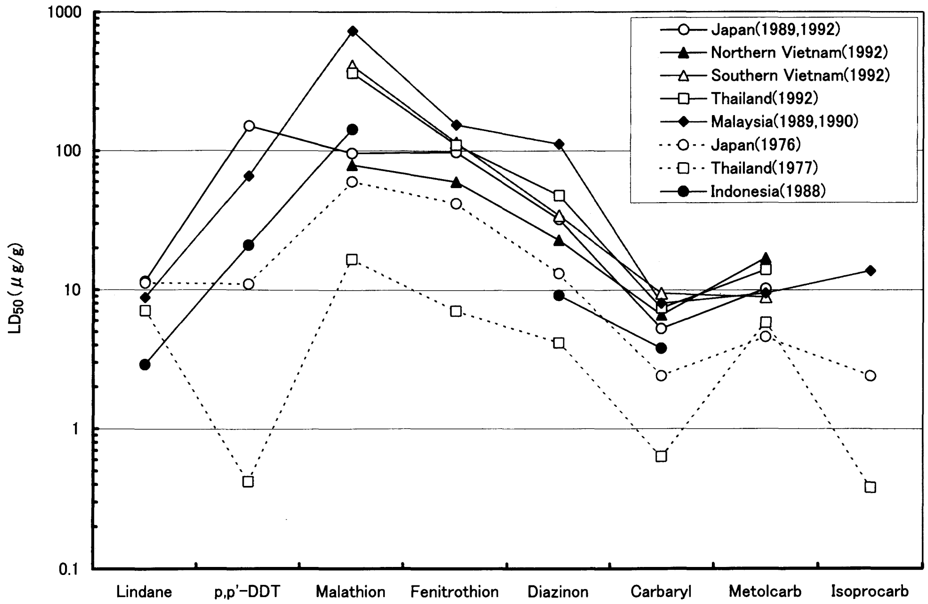

Fig. 1 Variation of insecticide susceptibility of the brown planthopper.

Table 4 Insecticide susceptibility of the white-backed planthopper collected from Japan and Malaysia in 1989 and 1990.

Insecticide	LD$_{50}$, μg/g								
	Japan			Malaysia					
	FUW (1989)			SPW (1989)			ASW (1990)		
Lindane	11	(9.9-13)[1]	5.5[2]	32	(25-45)[1]	2.1[2]	17	(13-21)[1]	2.4[2]
p,p′-DDT	62	(50-79)	2.7	36	(29-47)	3.2	46	(35-63)	1.6
Malathion	51	(44-59)	4.8	220	(180-270)	3.1	380	(320-460)	3.8
Fenitrothion	42	(34-51)	2.7	35	(29-41)	3.3	64	(49-96)	2.1
Diazinon	40	(34-47)	3.4	16	(14-19)	5.1	12	(9.9-14)	3.3
Monocrotophos	3.0	(2.4-3.7)	2.4	2.7	(2.3-3.1)	5.8	—[3]		
Carbaryl	4.6	(3.9-5.4)	3.4	3.4	(2.9-4.0)	4.8	7.0	(5.6-8.8)	2.6
Metolcarb	16	(14-19)	5.4	9.6	(8.3-11)	4.4	11	(9.4-13)	3.6
Isoprocarb	4.9	(3.9-6.0)	2.7	12	(9.8-14)	4.8	4.8	(3.6-6.0)	2.5
Fenobcarb	19	(16-22)	4.5	7.3	(6.3-8.4)	5.2	9.9	(8.4-12)	4.2
XMC[4]	—			—			12	(9.8-14)	3.4
Propoxur	2.2	(0.83-3.5)	1.1	5.0	(4.2-6.0)	3.4	4.1	(3.3-5.0)	2.7
Carbofuran	2.7	(2.1-3.3)	2.5	1.1	(0.92-1.2)	5.5	2.1	(1.8-2.5)	3.3
Etofenprox	1.5	(1.3-1.8)	3.1	1.7	(1.4-2.2)	2.4	3.1	(2.4-3.9)	2.6
Deltamethrin	3.4	(2.6-4.6)	1.7	6.3	(5.0-8.4)	2.5	10	(7.4-14)	1.7
Fenvalerate	12	(8.6-16)	1.5	14	(11-19)	2.3	19	(15-25)	2.4
Imidacloprid	0.21	(0.16-0.28)	2.1	—			—		

[1] 95% fiducial limits were shown in parentheses. [2] Figures were shown slope of regression line. [3] not tested. [4] 3,5-xylyl methylcarbamate.

Also in China, Mao and Liang[14] reported LD$_{50}$ of 11 insecticides for Chinese populations determined in 1987-1991 were almost equal to those determined in Japan in corresponding years. Patterns of insecticide susceptibility of WBPH in 1976-1977 and 1989-1990 were shown in Fig. 2. The 1989 and 1990 Malaysian populations showed increase in LD$_{50}$ by 52-340 times for the organophosphates, 4-15 times for the carbamates and 52-66 times for *p,p′*-DDT as compared with the earliest topical LD$_{50}$ determined for WBPH in the tropics with the 1977 Thai population.[9] Thus it is evident that WBPH has developed remarkable insecticide resistance to organophosphates, carbamates and *p, p′*-DDT in the tropics as well.

When the results on these two hopper species are overviewed, the tropical populations of these hoppers seems to have developed remarkable degree of insecticide resistance

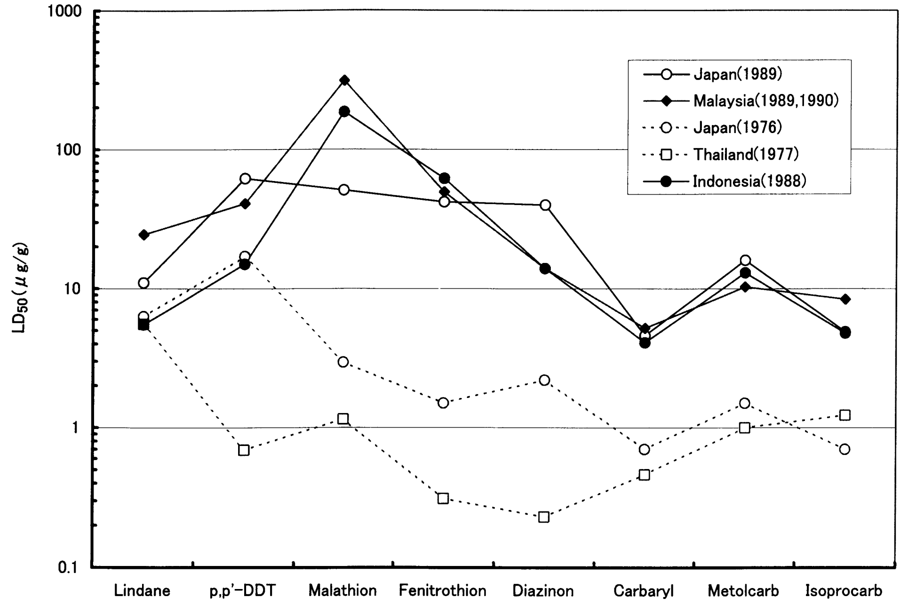

Fig. 2 Variation of insecticide susceptibility of the white-backed planthopper.

between the 1970's and the 1990's provided that all of the Thai, southern Vietnamese and Malaysian populations form a single population, the tropical population. We may have to change the conventional concept that BPH and WBPH in the tropics are generally more susceptible to insecticides compared with those in temperate regions due to less chance of exposure to insecticides in tropics.

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要　　約

東南アジアで採集したトビイロウンカとセジロウンカの殺虫剤感受性

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1989～1992年に東南アジアと日本で採集したトビイロウンカとセジロウンカの感受性を比較した．トビイロウンカ：1989, 1990年に採集したマレーシア個体群のマラソン感受性は日本のそれの約1/7と低く，ダイアジノン，カルボスルファン感受性も若干低い傾向が認められた．また1992年の検定結果では，ベトナム南部及びタイ個体群のマラソン感受性は，日本及びベトナム北部のそれより若干低かった．しかし，他の薬剤に対する感受性はこれらの個体群間で大きな差はなかった．セジロウンカ：1989～1990年個体群の薬剤感受性を比較した結果，マレーシア個体群のマラソン感受性は日本のそれの約1/6と低かった．しかし，他の薬剤に対する感受性はこれらの個体群間ではとんど差はなかった．また，熱帯地域においてもこれら2種のウンカは1977～1992年の間に各種薬剤に抵抗性が発達したことが確認された．