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Evaluation of 12 Insecticides Against Green Leafhopper for Preventing Rice Tungro Virus Disease

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Evaluation of 12 insecticides against green leafhopper for preventing rice tungro virus disease[1]

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ABSTRACT

Laboratory and field trials were conducted from 1984 to 1986 at IRRI to determine the effect of various insecticides against green leafhopper (GLH) and in preventing rice tungro virus (RTV) disease. In laboratory tests, 12 insecticides — 4 synthetic pyrethroids (alphamethrin, cypermethrin, deltamethrin, and ethofenprox), 4 organophosphates (acephate, monocrotophos, phosphamidon, and triazophos), and 4 carbamates (BPMC, carbaryl, MIPC, and MTMC) — were tested at 0.15% ai for conventional insecticides and 0.01% ai for pyrethroids (except deltamethrin at 0.005% ai) as foliar sprays and by the contact toxicity test using rice cultivar Taichung Native 1 (TN1). Twenty GLH adults were caged after insecticide treatment, and mortality readings were recorded at 1-24 h after treatment (HAT) with foliar sprays and at 5-60 min after treatment (MAT) in contact toxicity tests.

Six insecticides — alphamethrin, cypermethrin, deltamethrin, ethofenprox, monocrotophos, and MIPC — were further tested in field experiments to assess GLH population, level of RTV infection, and timing and frequency of insecticide application as 4-8 foliar sprays at 0.0125-0.4 kg ai/ha at 10-d intervals using 21-d-old seedlings of resistant (IR64), moderately resistant (IR42), and susceptible (TN1 or IR22) cultivars.

Of the 12 insecticides tested, 2 organophosphates (monocrotophos and triazophos) and 4 carbamates (BPMC, carbaryl, MIPC, and MTMC) gave higher adult mortalities (73-86%) at 1 d after treatment (DAT) than the untreated control (1-3%), whereas 3 pyrethroids (cypermethrin, deltamethrin, and ethofenprox) gave higher adult mortality and a quicker knockdown effect (100%) at 1 HAT than any of the 8 conventional insecticides as foliar sprays. Six insecticides (cypermethrin, deltamethrin, ethofenprox, triazophos, BPMC, and MTMC) gave 75-100% mortality at 48 HAT in contact toxicity tests.

In field tests, significantly lower adult and nymphal populations and RTV-infected hills were observed in plots treated with either cypermethrin, deltamethrin, or ethofenprox than in the untreated control. Cypermethrin showed the lowest RTV infection (10%) at 60 d after transplanting (DT).

Timing and frequency of insecticide application affected RTV incidence. First applications at 1, 5, and 10 DT produced RTV-infected hills at 60 DT of 5.2, 7.4, and 31.0% in cypermethrin; 7.4, 12.3, and 41.0% in monocrotophos; and 30.4% in the untreated control (IR64). However, timing of application did not affect RTV incidence on TN1 except in plots treated with cypermethrin at 1 DT. Three sprays of cypermethrin or monocrotophos and 4 of MIPC at 10-d intervals starting at 5 DT significantly reduced RTV infection in IR42.

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Evaluation of 12 insecticides against green leafhopper for preventing rice tungro virus disease

The green leafhopper (GLH) *Nephotettix virescens* (Distant) (Homoptera: Cicadellidae) is one of the major rice pests in South and Southeast Asia. It damages the rice plant in two ways: directly by sucking sap from the plant, and indirectly by transmitting virus diseases. As a secondary effect, the feeding and ovipositional marks predispose plants to fungal and bacterial infection, and the honeydew encourages sooty molds (Pathak 1977). GLH is a major vector of rice tungro virus (RTV) disease, which severely reduces yields (Heinrichs 1979, Palomar and Ling 1966, Rivera and Ling 1968, Rivera and Ou 1965). It also transmits yellow dwarf (Ou and Rivera 1967, Palomar and Rivera 1967) and transitory yellowing (Hsieh et al 1970).

Outbreaks of RTV and GLH have occurred repeatedly in the Philippines, Bangladesh, India, Indonesia, Malaysia, and Thailand. In the Philippines, RTV outbreaks occurred in 1957, 1962, 1969-71, 1975, and 1977 (Bergonia 1978). In 1984, rice cultivars IR36 and IR42 (both moderately resistant to GLH) were highly infected in Central Luzon. In 1985 and 1986, high RTV incidences were observed on IR cultivars in South Cotabato (H. Rapusas and A. Romena, IRRI, pers. comm.).

The most common method of controlling GLH on rice is applying insecticides. Hopperborne virus diseases are generally difficult to control on susceptible rice cultivars with insecticides when vector populations are high (Mochida et al 1978). The best way to prevent RTV is to combine chemical control and cultivars resistant to the vectors or virus agents. However, vector resistant cultivars may succumb to RTV because of the development of GLH populations that are virulent to them.

Large rice yield increases have been attributed to insecticide use under various conditions in nearly all rice-growing countries, as reviewed by Heong (1983) and Lim and Heong (1984). Greater use of insecticides is expected because other control measures — such as using resistant varieties and intensifying the role of biocontrol agents — are slow to develop and limited in scope. Despite the numerous natural biological control agents present in the field (Chandra 1979), rice yield losses caused directly by GLH and indirectly via virus diseases have alarmed rice growers. Until 1955, GLH was considered a minor pest in Bangladesh, but subsequently it caused 50-80% yield reductions in certain areas because of direct feeding (Pathak 1968). In the last few years, the importance of GLH in Indonesia has been increasing. During the 1968-69 wet season, an estimated 2,000 ha were damaged by direct feeding (Soehardjan 1973). In India, GLH often destroys rice in eastern Uttar Pradesh (Misra and Prasad 1980).

Some of the commonly used insecticides in the organophosphate and carbamate groups caused 90-100% GLH mortality 24 h after treatment (HAT) in the laboratory (IRRI 1982, 1983, 1985) as foliar sprays, but they cannot prevent RTV infection, because GLH may transmit virus particles before dying. We need effective insecticides with a rapid knockdown effect. Some synthetic pyrethroids have a quick knockdown effect and are effective at very low dosages of 10-200 g ai/ha compared with the 500-1,000 g ai/ha required in conventional insecticides (Ozaki et al 1984a, Prasad and Mohan 1983). Thus, the level of residue may be low on crops. These chemicals are biodegradable and do not pose undue environmental problems.

MATERIALS AND METHODS

Twelve insecticides were evaluated in this study (Table 1). Standard laboratory and field techniques for insecticide evaluation (Heinrichs et al 1981) were followed.

Greenhouse tests

Residual toxicity to adult GLH. Thirty-day-old potted seedlings of a GLH-susceptible cultivar, Taichung Native 1 (TN1), were cleaned and placed on an electrically operated rotating table to provide uniform distribution of sprays. Different sets of seedlings were sprayed with 12.5 ml of a 0.005-0.15% solution of each test chemical — equivalent to a rate of 0.025-0.75 kg ai/ha in a volume of 500 liters of water/ha.

The insecticidal solutions were sprayed using an Arthur Thomas spray bottle connected to an air pressure pump. The spray was aimed at the stems and foliage of the potted plants. Control plants were sprayed with water. The sprayed plants were placed in an insectary at 25-27 °C, 60-80% relative humidity, and 12-h daily illumination. The treatments were laid out in a randomized complete block design (RCBD) with 4 replications; 1, 5, and 10 d after treatment (DAT), 20 GLH adult females were placed in a mylar film cage on the potted plants. Insect mortality was recorded 48 h after caging. In another trial, insect mortality caused by 6 insecticides was recorded 1, 2, 3, 6, 12, and 14 h after infestation when GLH adults were caged 10 min after treatment (MAT).

Table 1. Insecticides used.

Insecticide	Class[a]	Formulation[b]	Brand name	Chemical name
Cypermethrin	P	5 EC	Cymbush	α-cyano-3-phenoxybenzyl 2, 2-dimethyl-3- (2,2-dichlorovinyl) cyclopropane carboxylate
Deltamethrin	P	2.5 EC	Decis	(IUPAC) (s) – cyano-3-phenoxybenzyl (1R, 3R) -3- (2,2-dibromovinyl)-2 dimethylcyclopropane carboxylate
Ethofenprox	P	20 EC	Trebon	2- (4-ethoxyphenyl)-2-methyl propyl 3-phenoxybenzyl ether
Alphamethrin	P	5 WP	Fastac	alpha-cyano-3-phenoxybenzyl-3-(2,2-dichlorovinyl) -2,2-dimethyl cyclopropane
Acephate	OP	75 SP	Orthene	O, S-dimethyl acetylphosphoramido-thioate
Monocrotophos	OP	30 EC	Azodrin 202R	O, O-dimethyl-O- (2-methylcarbamoyl-1-methyl-vinyl) phosphate
Phosphamidon	OP	50 EC	Dimecron	O, O-dimethyl (2-chloro-2- (diethylcarbamoyl)-1-methylvinyl) phosphate
Triazophos	OP	40 EC	Hostathion	1-phenyl-3- (O-O-diethylthionophosphate)-1,2,4-triazole
BPMC	C	50 EC	Hopcin	2-sec-butyl phenyl N-methyl-carbamate
Carbaryl	C	85 SP	Sevin	1-naphthyl methylcarbamate
MIPC	C	50 WP	Hytox	2-isopropyl-phenyl-N-methyl-carbamate
MTMC	C	30 EC	Tsumacide	m-tolyl-N-methylcarbamate

[a]P = pyrethroid, OP = organophosphate, C = carbamate. [b]EC = emulsifiable concentrate, WP = wettable powder, SP = soluble powder.

Contact toxicity to adult GLH. To evaluate contact toxicity, GLH adults were placed in vials, anaesthetized with CO_2 for 10 s, and transferred into petri dishes lined with filter paper and placed at the bottom of a Potter's spray tower; 2 ml of insecticidal solution was sprayed from the spray tower reservoir using air pressure. Control insects were treated with an equal volume of distilled water. All insects were then transferred to 15-d-old, potted, untreated TN1 seedlings in the insectary.

Cumulative mortality was recorded at 1, 4, 24, and 48 HAT in one experiment and at 5, 10, 20, 30, 45, and 60 MAT in another.

Field tests

Of 12 insecticides tested in the greenhouse, 4 synthetic pyrethroids and 3 others were selected and tested on IR22 in the field to determine their effects on a field population of GLH and on RTV incidence.

Foliar spray at 7-d intervals. The wet seedbed was covered with fiberglass mesh right after sowing to protect it against birds and early insect infestation. Plots (5 × 6 m) were laid out in RCBD with 4 replications. Twenty-one-day-old seedlings were transplanted at 2-3 seedlings/hill. Fertilizer was applied as basal at 30-30-30 NPK/ha and as topdressing at 45 d after transplanting (DT) at 50-0-0 NPK/ha. Herbicide was applied at 1.0 kg ai/ha at 4 DT.

Foliar sprays of cypermethrin, alphamethrin, deltamethrin, and ethofenprox were applied at the recommended rates to the canopy at 1-wk intervals starting at 1 DT with a spray volume of 300 liters/ha (first 6 sprays) to 500 liters/ha (last 2 sprays).

Insects were sampled weekly using a FARMCOP machine from 1 wk after transplanting (WT) to 8 WT.

Foliar spray at 14-d intervals. Experimental plots were arranged as in the 7-d-interval trial, but the number of insecticide applications was reduced to 5. RTV incidence was scored by visual absolute count and the iodine test (IRRI 1983). Insects were sampled using a sweep net in each plot at 6 and 13 d after insecticide application.

Plots (5 × 9.75 m) were also arranged as in the 7-d-interval trials, and cypermethrin, monocrotophos, and BPMC were applied at the full rate and at half the recommended rate biweekly starting at 2 DT.

Insects were sampled by sweeping the sweep net 10 times in each plot at 1 d before and at 1, 5, and 10 d after every insecticide application.

To determine the residual toxicity of the insecticides, 20 GLH adults were caged on 1 hill at 1, 5, and 10 d after the second insecticide application. Mortality readings were taken 48 h after infestation.

Effect of timing of insecticide application on RTV. IR64, (resistant to GLH and showing field resistance to RTV) and TN1 (highly susceptible to GLH and RTV) were sprayed with cypermethrin and monocrotophos 4 times at 10-d intervals starting at 1, 5, and 10 DT. The percentage of RTV-infected hills was recorded at 60 DT.

Table 2. Laboratory evaluation of 12 insecticides applied as foliar sprays against *Nephotettix virescens* on TN1, IRRI insectary.[a]

Insecticide[b]	Adult female mortality (%) 48 h after caging		
	1 DAT	5 DAT	10 DAT
	Synthetic pyrethroids		
Alphamethrin	86.3 a	86.3 a	12.5 a
Deltamethrin	71.3 a	32.5 c	11.3 ab
Cypermethrin	78.8 a	28.8 c	5.0 abcde
Ethofenprox	27.5 b	8.8 d	3.8 bcde
	Organophosphates		
Monocrotophos	86.3 a	58.8 b	7.5 abcd
Triazophos	77.5 a	35.0 c	10.0 abc
Acephate	20.0 b	3.8 d	3.8 abcde
Phosphamidon	18.8 b	2.5 d	1.3 e
	Carbamates		
MIPC	77.5 a	42.5 bc	2.5 cde
Carbaryl	73.8 a	31.2 c	5.0 abcde
BPMC	36.3 b	12.5 d	2.5 cde
MTMC	27.5 b	10.0 d	1.3 e
Control	2.5 c	1.3 d	1.3 e

[a]Av of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. DAT = d after treatment. [b]Insecticides were applied at 0.15% ai (0.75 kg ai), except synthetic pyrethroids, which were applied at 0.01% ai (0.05 kg ai), and deltamethrin at 0.005% ai (0.025 kg ai). Spray volume was based on 500 liters water/ha.

Effect of frequency of insecticide application on RTV. IR64, TN1 and IR42 (moderately resistant to GLH) were treated with cypermethrin, monocrotophos, and MIPC in 0, 2, 3, and 4 sprays at 10-d intervals starting at 5 DT. The percentage of RTV-infected hills was recorded at 60 DT.

RESULTS AND DISCUSSION

Greenhouse tests

Residual toxicity to adult GLH. At 1 DAT, high adult mortality was observed on plants treated with cypermethrin, deltamethrin, alphamethrin, monocrotophos, triazophos, MIPC, and carbaryl (Table 2). At 5 DAT, alphamethrin gave significantly higher mortality. At 10 DAT, mortality was low in all treatments.

In the second experiment, even at 1 h after release, high adult mortality or knockdown was observed on plants sprayed with all 6 insecticides used (Table 3). However, adults fed on plants treated with synthetic pyrethroids generally showed higher mortality than those fed on plants sprayed with the other insecticides.

Contact toxicity to adult GLH. Three synthetic pyrethroids (cypermethrin, ethofenprox, and deltamethrin), one organophosphate (triazophos), and two carbamates (MTMC and BPMC) were found effective on GLH adults (Table 4) when sprayed directly on them. Their residual toxicity was significantly longer than that of the other insecticides. The 3 pyrethroids showed high knockdown activity as little as 1 HAT.

In the second experiment, deltamethrin and cypermethrin had significantly higher knockdown activity than 4 other insecticides at 5 MAT (Table 5).

Field tests

Foliar spray at 7-d intervals. The adult GLH population was consistently lower in all plots sprayed with the four insecticides (Table 6). Nymphal populations were consistently low in all plots.

RTV incidence was lower in all plots treated with insecticides than in the control plot (Table 7). The incidence was lowest in cypermethrin-treated plots, confirming the findings of Satapathy and Anjaneyulu (1984) in India.

Foliar spray at 14-d intervals. When four pyrethroids were applied at the recommended doses, adult GLH populations were generally lower in the plots sprayed with cypermethrin, deltamethrin, and ethofenprox (Table 8). No significant difference was obtained between the alphamethrin and control plots. Nymphal populations in treated plots were generally lower than those in the control.

RTV incidence in the treated plots, except in the alphamethrin-treated plot, was lower than in the untreated plots (Table 9). There was no significant difference among the four pyrethroids. Yields were higher in treated plots, except in the alphamethrin-treated plot.

When cypermethrin, monocrotophos, and BPMC were applied at the full rate and at half the recommended rate, adult GLH populations were not significantly different between treatments within each insecticide, although the

Table 3. Laboratory evaluation of 6 insecticides applied as foliar sprays against *N. virescens* on TN1, IRRI insectary.[a]

Insecticide[b]	Adult female knockdown/mortality (%)					
	1 HAR	2 HAR	3 HAR	6 HAR	12 HAR	24 HAR
Cypermethrin	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
Deltamethrin	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
Ethofenprox	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
MIPC	97.5 b	100.0 a	100.0 a	100.0 a	100.0 a	100.0 a
Monocrotophos	78.8 c	96.3 b	100.0 a	100.0 a	100.0 a	100.0 a
Alphamethrin	77.5 c	83.8 c	78.8 b	80.0 b	83.8 b	90.0 b
Control	0.0 d	0.0 d	0.0 c	0.0 c	0.0 c	0.0 c

[a]Av of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. HAR = h after release. [b]Insecticides were applied at 0.15% ai, except synthetic pyrethroids, which were applied at 0.01% ai, and deltamethrin at 0.005% ai. Spray volume was based on 500 liters water/ha.

Table 4. Laboratory evaluation of 12 insecticides against *N. virescens* by contact toxicity using Potter's spray tower. IRRI insectary.[a]

Insecticide[b]	Adult female cumulative mortality (%)			
	1 HAT	4 HAT	24 HAT	48 HAT
		Synthetic pyrethroids		
Cypermethrin	95.0 a	100.0 a	100.0 a	100.0 a
Ethofenprox	92.5 a	100.0 a	100.0 a	100.0 a
Deltamethrin	92.5 a	96.3 ab	96.3 ab	97.5 a
Alphamethrin	6.3 bcd	15.0 def	25.0 de	28.8 cd
		Organophosphates		
Triazophos	0.0 e	6.3 fg	81.3 bc	87.5 ab
Monocrotophos	5.0 bcd	26.3 de	38.8 d	47.5 c
Phosphamidon	0.0 e	1.3 g	1.3 f	17.5 d
Acephate	0.0 e	1.3 g	5.0 f	3.8 e
		Carbamates		
MTMC	8.8 bc	81.3 b	96.3 ab	96.3 a
BPMC	17.5 b	65.0 c	75.0 c	76.3 b
MIPC	2.5 cde	32.5 d	45.0 d	50.0 c
Carbaryl	0.0 e	8.3 efg	28.8 de	36.3 cd
Control	0.4 e	0.8 g	3.3 f	10.4 e

[a]Av of 4 replications, 20 GLH/replication. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. HAT = h after treatment. [b]Insecticides were applied at 0.15% ai (0.75 kg ai), except synthetic pyrethroids which were applied at 0.01% (0.05 kg ai) and deltamethrin at 0.005% ai (0.025 kg ai). Spray volume was based on 500 liters water/ha.

Table 5. Laboratory evaluation of 6 insecticides against *N. virescens* on TN1 by contact toxicity using Potter's spray tower. IRRI insectary.[a]

Insecticide[b]	Adult female knockdown/mortality (%)					
	5 MAT	10 MAT	20 MAT	30 MAT	45 MAT	60 MAT
Deltamethrin	78.8 a	95.0 a	100.0 a	100.0 a	100.0 a	100.0 a
Cypermethrin	70.0 a	92.5 a	100.0 a	100.0 a	100.0 a	100.0 a
Ethofenprox	15.0 b	21.3 b	36.3 b	40.0 b	47.5 b	48.8 b
Alphamethrin	2.5 cd	3.8 c	15.0 c	12.5 c	15.0 c	16.3 c
MIPC	2.5 cd	3.8 c	0.0 d	2.8 d	13.8 c	18.8 c
Monocrotophos	5.0 cd	3.8 c	2.5 d	2.5 d	2.5 d	2.5 de
Control	0.0 d	0.0 c	0.0 d	0.0 d	0.0 d	0.0 e

[a]Av of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. MAT = min after treatment. [b]Insecticides were applied at 0.15% ai, except synthetic pyrethroids, which were applied at 0.01% ai, and deltamethrin at 0.005% ai. Spray volume was based on 500 liters water/ha.

Table 6. Field evaluation of 4 synthetic pyrethroids applied as foliar sprays against *N. virescens* on TN1. IRRI, 1984 WS.

Insecticide[a]	Rate (g ai/ha)	Hoppers (no.) caught/10 hills by FARMCOP[b]							
		1 WT	2 WT	3 WT	4 WT	5 WT	6 WT	7 WT	8 WT
				Adults					
Cypermethrin	50.0	3.0 a	0.0 a	1.0 ab	4.0 a	0.0 b	0.0 b	0.0 b	0.0 b
Deltamethrin	12.5	2.0 a	0.0 a	1.0 ab	6.0 a	0.0 b	0.0 b	0.0 b	0.0 b
Ethofenprox	100.0	3.0 a	1.0 a	2.0 a	5.0 a	1.0 b	0.0 b	0.0 b	0.0 b
Alphamethrin	12.5	1.0 a	1.0 a	1.0 ab	4.0 a	1.0 b	1.0 a	0.0 b	0.0 b
Control		2.0 a	1.0 a	0.0 b	6.0 a	7.5 a	1.0 a	1.0 a	5.0 a
				Nymphs					
Cypermethrin	50.0	0.0 b	0.0 b	1.0 c	0.0 c	2.0 c	1.0 b	0.0 b	1.0 b
Deltamethrin	12.5	0.0 b	0.0 b	9.0 ab	1.0 c	7.0 b	1.0 b	0.0 b	0.0 c
Ethoproxyfen	100.0	1.0 a	0.0 b	6.0 b	1.0 c	6.0 b	1.0 b	6.0 b	0.0 c
Alphamethrin	12.5	0.0 b	0.0 b	3.0 c	6.0 b	7.0 b	1.0 b	0.0 b	1.0 b
Control		0.0 b	3.0 a	18.0 a	39.0 a	84.0 a	46.0 a	46.0 a	18.0 a

[a]Insecticides were applied at 1, 8, 15, 22, 29, 36, 43, and 50 d after transplanting. [b]Insect sampling by FARMCOP machine was done weekly starting 1 wk after transplanting (WT). Within adults or nymphs, means in a column followed by a common letter are not significantly different at the 5% level by DMRT.

Table 7. Field evaluation of 4 synthetic pyrethroids applied as foliar sprays to prevent RTV on TN1. IRRI, 1984 WS.

Insecticide[a]	Rate (g ai/ha)	Hills (%) showing RTV symptoms[b]	
		40 DT	60 DT
Cypermethrin	50.0	4.9 c	9.5 c
Deltamethrin	12.5	8.9 bc	29.6 b
Ethofenprox	100.0	11.1 b	21.7 bc
Alphamethrin	12.5	8.6 bc	21.2 bc
Control		22.1 a	81.8 a

[a]Insecticides were applied at 1, 8, 15, 22, 29, 36, 43, and 50 d after transplanting (DT). [b]In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

GLH population was generally lower in treated plots (Table 10).

RTV incidence at 40 and 60 DT was significantly lower in treated plots than in the control (Table 11). There was no significant difference in RTV incidence between the full rate and half the recommended rate for any insecticide tested. Cypermethrin gave the lowest RTV incidence and the highest yield (Table 11).

Even at half the recommended rate, GLH mortality on treated hills at 10 DAT was higher than on untreated hills. There was no significant difference in mortality between the full rate and half the recommended rate irrespective of time after treatment. Cypermethrin was slightly superior to the others (Table 12).

Effect of timing of insecticide application on RTV. Timing of insecticide application affected RTV incidence on IR64 and TN1 (Fig. 1). Significantly lower incidence was obtained on IR64 than on TN1 in insecticide-treated plots when the first application was at 5 DT.

Effect of frequency of insecticide application on RTV. More frequent insecticide applications resulted in significant differences only on the moderately resistant IR42, and not on the highly resistant IR64 or the susceptible TN1 (Fig. 2).

Table 9. Effect of synthetic pyrethroids applied as foliar sprays on RTV incidence on and yield of TN1. IRRI, 1985 WS.

Insecticide[a]	Rate (g ai/ha)	Hills showing RTV symptoms at 60 DT[b]	Yield[b] (t/ha)
Cypermethrin	50.0	29.5 b	1.30 a
Deltamethrin	12.5	24.1 b	1.49 a
Alphamethrin	12.5	39.4 ab	0.57 b
Ethofenprox	100.0	22.9 b	1.65 a
Control		43.3 a	0.59 b

[a]Insecticides were applied at 1, 20, 34, 49, and 63 d after transplanting (DT). [b]In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

SUMMARY

Greenhouse tests

- Of 8 conventional insecticides applied as foliar sprays, 2 organophosphates (monocrotophos and triazophos) and 4 carbamates (BPMC, carbaryl, MIPC, and MTMC) caused higher GLH adult mortality (73-86% at 1 DAT) than the untreated control (1-3%).
- Cypermethrin, deltamethrin, and ethofenprox caused higher adult mortality and a quicker knockdown effect (100% at 1 h after release) than any of the 8 conventional insecticides as foliar sprays.
- Cypermethrin, deltamethrin, ethofenprox, triazophos, BPMC, and MTMC caused higher mortality (75-100%) than the untreated control (1-11%) in the contact toxicity test.

Field tests

- Foliar sprays of cypermethrin, deltamethrin, and ethofenprox reduced adult and nymphal GLH populations and RTV incidence (10-30% at 60 DT) compared with a RTV incidence of 82% in the untreated control.
- Cypermethrin reduced RTV incidence most (10%).

Table 8. Field evaluation of 4 synthetic pyrethroids applied as foliar sprays against *N. virescens* on TN1. IRRI, 1985 WS.

Insecticide[a]	Rate (g ai/ha)	Hoppers caught (no.)/10 hills by FARMCOP[b]									
		1st application at 1 DT		2d application at 20 DT		3d application at 34 DT		4th application at 49 DT		5th application at 63 DT	
		6 DAT	13 DAT	6 DAT	13 DAT	6 DAT	13 DAT	6 DAT	13 DAT	6 DAT	13 DAT
Adults											
Cypermethrin	50.0	0.3 a	3.8 a	2.0 a	0.8 b	1.8 ab	1.3 ab	0.3 b	0.0 b	0.3 b	3.0 b
Deltamethrin	12.5	0.5 a	0.8 b	2.8 a	1.5 ab	0.5 b	1.3 ab	0.3 b	1.8 b	2.5 ab	2.3 b
Alphamethrin	12.5	0.5 a	1.8 ab	2.3 a	1.5 ab	3.0 a	3.0 ab	8.3 a	9.5 a	6.0 a	7.8 ab
Ethofenprox	100.0	0.5 a	1.3 b	2.8 a	1.5 ab	1.0 ab	0.5 b	1.0 b	0.5 b	1.5 ab	2.0 b
Control		0.3 a	0.5 b	2.0 a	4.3 a	1.0 ab	4.3 a	9.0 a	7.5 a	5.5 a	12.3 a
Nymphs											
Cypermethrin	50.0	0.0 a	1.3 a	1.5 b	2.5 b	13.8 a	24.5 a	1.0 c	0.8 c	0.8 c	4.3 a
Deltamethrin	12.5	0.0 a	0.0 a	2.8 b	9.0 ab	0.8 b	6.5 b	3.3 c	2.8 c	2.3 bc	2.5 a
Alphamethrin	12.5	0.0 a	0.0 a	2.0 b	6.8 ab	16.3 a	19.8 ab	10.5 b	7.5 ab	7.3 b	12.8 a
Ethofenprox	100.0	0.0 a	0.0 a	2.0 b	6.0 ab	3.3 b	5.5 b	0.0 c	3.3 bc	4.0 bc	3.0 a
Control		0.0 a	0.0 a	6.8 a	12.0 a	18.0 a	26.8 a	20.8 a	11.8 a	16.0 a	11.5 a

[a]Insecticides were applied at 1, 20, 34, 49, and 63 d after transplanting (DT). [b]Leafhoppers were sampled at 6 and 13 d after insecticide application (DAT). Within adults or nymphs, means in a column followed by a common letter are not significantly different at the 5% level by DMRT.

Table 10. Effect of 3 insecticides applied as foliar sprays on *N. virescens* on IR22. IRRI, 1986 DS.

Insecticide	Rate (g ai/ha)	No. of adults/10 sweeps[a]			
		1 DBT	1 DAT	5 DAT	10 DAT
		1st application, at 2 DT			
Cypermethrin	500	4.8 a	1.3 b	4.8 b	12.0 ab
	250	4.0 a	2.5 b	6.3 b	7.5 bc
Monocrotophos	750	6.5 a	2.8 b	4.3 b	4.5 c
	375	6.5 a	2.0 b	5.8 b	7.3 bc
BPMC	750	6.3 a	3.8 b	7.8 b	7.8 bc
	375	4.8 a	5.0 ab	5.3 b	6.8 bc
Control	–	6.8 a	8.5 a	13.8 a	15.0 a
		2d application, at 16 DT			
Cypermethrin	500	7.8 b	1.5 d	11.5 a	12.0 a
	250	10.5 ab	3.0 cd	15.3 a	15.3 a
Monocrotophos	750	7.5 b	5.8 bcd	13.5 a	11.8 a
	375	10.3 ab	8.8 bc	9.5 a	14.0 a
BPMC	750	6.8 b	8.0 bc	13.3 a	16.5 a
	375	8.0 b	10.3 ab	11.3 a	12.5 a
Control	–	14.5 a	14.8 a	14.5 a	17.3 a
		3d application, at 30 DT			
Cypermethrin	500	7.0 abc	3.0 c	8.8 cd	6.5 b
	250	4.5 c	6.5 bc	7.3 d	8.5 b
Monocrotophos	750	7.0 abc	6.8 bc	10.5 cd	7.3 b
	375	10.5 ab	9.0 b	14.5 bc	13.5 a
BPMC	750	5.8 bc	9.8 b	19.0 ab	8.0 b
	375	7.3 abc	9.0 b	18.0 ab	8.0 b
Control	–	11.3 a	16.3 a	22.3 a	13.3 a
		4th application, at 44 DT			
Cypermethrin	500	5.5 b	4.0 b	0.3 d	6.8 c
	250	4.8 b	3.3 b	1.3 d	7.8 c
Monocrotophos	750	7.0 ab	4.8 b	2.8 cd	11.8 bc
	375	8.0 ab	5.3 b	6.0 bc	16.0 ab
BPMC	750	8.0 ab	4.0 b	9.3 b	14.0 abc
	375	9.8 ab	7.5 b	6.5 bc	20.0 a
Control	–	12.0 a	13.0 a	15.5 a	18.0 ab
		5th application, at 58 DT			
Cypermethrin	500	5.5 c	0.3 b	1.5 d	0.3 b
	250	7.0 bc	0.0 b	1.8 d	0.5 b
Monocrotophos	750	11.5 ab	1.3 b	3.3 cd	0.8 b
	375	12.0 ab	1.3 b	4.0 cd	1.3 ab
BPMC	750	9.5 abc	2.8 b	5.3 bc	2.0 ab
	375	13.0 a	8.0 a	8.0 b	1.5 ab
Control	–	13.8 a	9.8 a	13.0 a	3.8 a

[a]Av of 4 replications. In a column and within an application, means followed by a common letter are not significantly different at the 5% level by DMRT. DT = d after transplanting, DBT = d before treatment, DAT = d after treatment.

Table 11. Effect of 3 insecticides applied as foliar sprays on RTV incidence on and yield of IR22. IRRI, 1986 DS.[a]

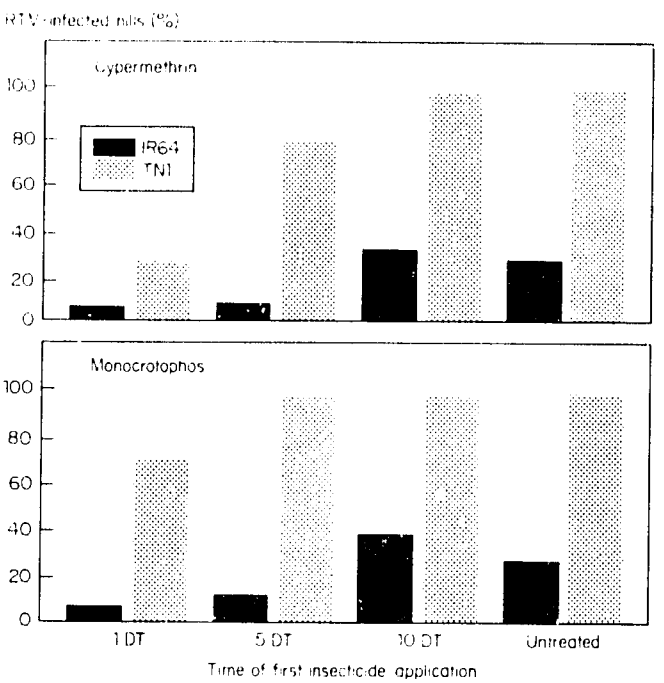
Insecticide[b]	Rate (g ai/ha)	Hills (%) showing RTV symptoms		Yield (t/ha)
		40 DT	65 DT	
Cypermethrin	250	13.0 b	35.5 bc	2.81 a
	500	10.0 b	24.9 c	2.95 a
Monocrotophos	375	13.1 b	45.2 b	2.40 ab
	750	16.1 b	36.9 bc	2.52 ab
BPMC	375	17.8 b	46.2 b	2.13 b
	750	19.6 b	41.1 b	2.20 b
Control		43.3 a	64.7 a	1.66 c

[a]Av of 4 replications. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. DT = d after transplanting. [b]Insecticides were applied at 2, 16, 30, 44, and 58 DT.

Table 12. Residual toxicity of 3 insecticides applied as foliar sprays on *N. virescens* on IR22. IRRI, 1986 DS.

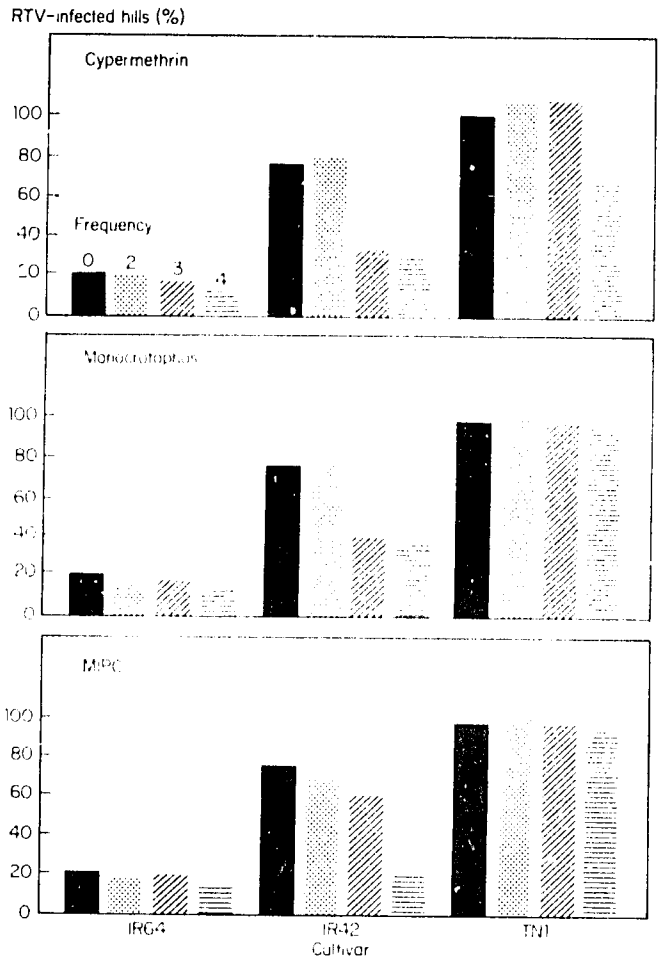
Insecticide[a]	Rate (g ai/ha)	Female adult mortality (%) 48 h after caging[b]		
		1 DAT	5 DAT	10 DAT
Cypermethrin	250	85 ab	80 ab	25 ab
	500	93 a	85 a	35 a
Monocrotophos	375	79 b	59 c	13 b
	750	88 ab	69 bc	23 ab
BPMC	375	76 b	53 c	23 ab
	750	81 b	61 c	10 b
Control		3 c	5 d	3 c

[a]Insecticides were applied at 2, 16, 30, 44, and 58 DT. Adult mortality was recorded after 2d application only. [b]Av of 4 replications, 20 adults/replication. In a column, means followed by a common letter are not significantly different at the 5% level by DMRT. DAT = d after treatment.



1. Effect of timing of insecticide application on RTV incidence at 60 d after transplanting (DT) in IR64 and TN1. Cypermethrin (0.05 kg ai/ha) and monocrotophos (0.40 kg ai/ha) were applied 4 times at 10-d intervals. IRRI, 1986 wet season.

- RTV incidence was significantly lower in plots treated with cypermethrin (24-35%), monocrotophos (37-45%), and BPMC (41-46%) than in untreated (43-64%) plots. There was no significant difference between RTV incidence in plots treated with the three insecticides at the full rate and at half the recommended rate.
- First application at 1, 5, and 10 DT produced RTV incidence at 60 DT of 5.2, 7.4, and 31.0% in cypermethrin-treated plots, and 7.4, 12.3, and 41.0% in monocrotophos-treated plots, respectively.
- Application of insecticides significantly reduced RTV infection on moderately resistant IR42 but not on highly resistant IR64 or susceptible TN1.



2. Effect of frequency of insecticide application on RTV incidence at 60 d after transplanting (DT) in 3 rice cultivars. Monocrotophos and MIPC (0.40 kg ai/ha) and cypermethrin (0.05 kg ai/ha) were applied 0, 2, 3, and 4 times at 10-d intervals starting at 5 DT. IRRI, 1986 wet season.

CONCLUSIONS

The 12 insecticides tested can be classified into 3 groups — most effective (cypermethrin, deltamethrin, ethofenprox, and monocrotophos), effective (BPMC, MIPC, triazophos, carbaryl, and MTMC), and ineffective (alphamethrin, acephate, and phosphamidon) — by knockdown effect and mortality.

Timing and frequency of insecticide application are very important. To reduce RTV incidence, application should be started within 5 DT and repeated at least 2 times at 7- to 10-d intervals.

Application of insecticides can significantly reduce RTV incidence only on a moderately resistant cultivar like IR42.

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ICI Chemical Industries	cypermethrin 5EC
Mitsui Toatsu	ethofenprox 20 EC
Nihon Nohyaku Co.	MTMC 30EC
Planters Products	MIPC 50WP
Shell Chemical Co.	monocrotophos 30EC alphamethrin 5WP
Union Carbide Philippines, Inc.	carbaryl 85SP

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