Evaluation of Systemic Insecticides for Control of Rice Tungro

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ABSTRACT

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Of seven granular systemic insecticides—carbaryl plus gamma isomer of hexachlorocyclohexane (HCH), carbofuran, disulfoton, fensulfothion, mephosfolan, phorate, and thiodemeton—tested under field conditions, carbofuran at 2 kg a.i./ha effectively controlled rice tungro virus and its vector, *Nephotettix virescens*, in susceptible rice cultivar Taichung Native 1. Carbofuran at 1 and 2 kg a.i./ha and fensulfothion at 2 kg a.i./ha effectively controlled the disease in the less susceptible cultivar Pankaj. Treatment with these insecticides also increased plant height, 1,000-grain weight, and grain yield relative to other insecticides and control. Rate of infection was strongly negatively correlated with plant height and grain yield in both cultivars; plant height and grain yield were positively correlated.

Rice tungro disease has become one of the major constraints limiting rice production in Southeast Asia, especially since the introduction of the new high-yielding semidwarf cultivars. Outbreaks of this disease extended over 600,000 ha in Thailand in 1966, 10,000 ha in West Malaysia in 1969, 100,000 ha in the Philippines in 1971, and several thousand hectares in northeastern India and Bangladesh in 1968, 1969, and 1973 (5). Since the causal agent, rice tungro virus (RTV), is transmitted by the leafhoppers *Nephotettix virescens* and *N. nigropictus* (3), insecticides can limit disease spread (6,7). Pathak et al (6) reported that the insecticide phorate was very effective in controlling RTV under field conditions. Rao and Anjaneyulu (7), however, found phorate less effective than carbofuran in preventing RTV infection in screenhouse studies. We tested seven granular systemic insecticides—carbofuran, fensulfothion, thiodemeton (O,O-diethyl *S*-2-(ethylthio)ethyl phosphorodithioate), carbaryl plus gamma isomer of hexachlorocyclohexane (HCH), phorate, mephosfolan, and disulfoton (O,O-diethyl-*S*-2-(ethylthioethyl)-ethyl-dithiophosphate—at 1 and 2 kg a.i./ha for control of tungro disease under field conditions.

MATERIALS AND METHODS

The insecticides were applied every 15 days from 5 days to 65 days after transplantation. We tested two high-yielding semidwarf cultivars, Taichung Native 1 (TN1) and Pankaj. Treatments were arranged in a randomized complete block design with three replications. An outer zone of 2 m was left around each 3 ×3 m plot (used for one treatment). One infected plant of the cultivar Jaya, an excellent inoculum source (8), was planted 5 days after transplantation in the center of each plot.

Disease incidence and vector populations were recorded weekly, beginning 1 wk after introducing the inoculum (Tables 1 and 2). Four observations for TN1 and five for Pankaj were recorded. We estimated the percentage of infected plants, which were identified by orange leaf discoloration and stunting symptoms. The vector was monitored directly by counting adults and nymphs present on 20 plants selected at random. Height, grain yield, and 1,000-grain weight were also recorded (Table 3).

The data were analyzed by randomized complete block design methods after disease incidence observations were transformed into angular values. The rate of infection of the disease per unit per day

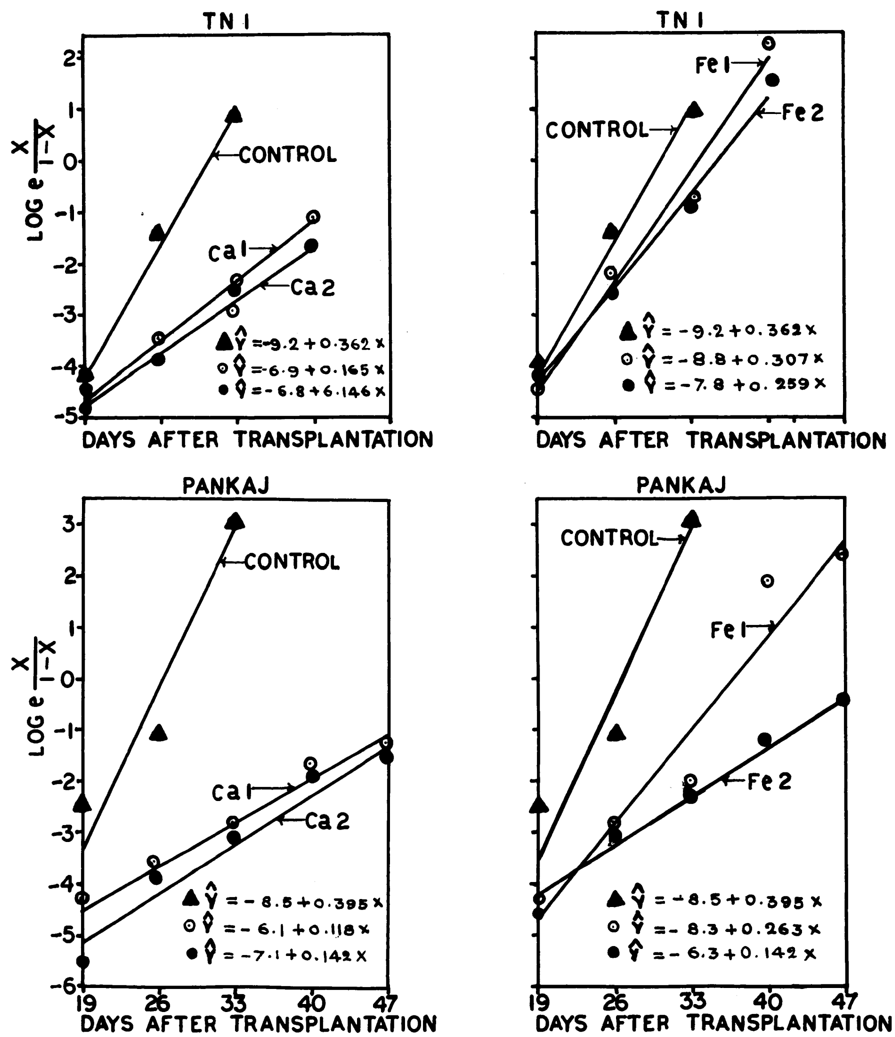

Fig. 1. Progress of tungro disease epidemic in Taichung Native 1 (TN1) and Pankaj rice treated with 1 and 2 kg a.i./ha of carbofuran (Ca_1,Ca_2) and fensulfothion (Fe_1,Fe_2).

Table 1. Percent infection[x] of rice tungro virus in Pankaj (P) and Taichung Native 1 (T) rice treated with insecticides

Insecticide	kg a.i./ ha	Days after transplantation[y]									Mean[z]	
		19		26		33		40		47		
		P	T	P	T	P	T	P	T	P	P	T
Carbofuran	1	1	1	2	3	5	9	15	24	23	9 a	9 b
	2	0	1	2	2	4	7	13	15	18	9 a	6 a
Fensulfothion	1	1	1	5	10	11	34	87	91	93	39 cdef	34 de
	2	1	2	4	7	9	27	21	82	39	15 b	30 c
Thiodemeton	1	1	2	5	8	20	37	86	94	96	42 hi	35 defgi
	2	1	2	5	9	19	36	84	93	91	40 cdefg	35 defg
Carbaryl plus gamma isomer of HCH	1	2	2	7	14	22	47	91	98	98	44 jk	40 k
	2	2	2	7	9	17	40	85	97	98	42 hi	37 fghij
Phorate	1	2	2	3	20	10	61	86	96	94	39 cdef	45 k
	2	1	1	3	10	11	31	83	89	92	38 cd	33 cdd
Mephosfolan	1	1	2	5	13	18	39	94	97	97	43 hijk	38 ghijk
	2	1	1	5	12	13	42	88	96	94	40 cdefg	38 ghij
Disulfoton	1	2	1	5	11	18	37	95	96	97	43 hijk	36 efgh
	2	1	1	3	11	11	40	83	95	93	38 cd	37 fghij
Control	...	2	2	7	19	26	71	95	100	100	46 l	48 l

[x] Average of three replications.
[y] Only four observations were made of Taichung Native 1 plots.
[z] In each column, values followed by the same letter do not differ significantly according to LSD comparison test ($P = 0.05$).

(r) was calculated by the formula suggested by van der Plank (9). The correlations between r and grain yield, r and height, and height and grain yield were also calculated.

RESULTS AND DISCUSSION

All seven insecticides reduced disease incidence compared with the control (Table 1). Although carbofuran was most effective on both cultivars, fensulfothion applied at 2 kg a.i./ha also reduced disease incidence significantly in the cultivar Pankaj. Application of 2 kg a.i./ha of carbofuran on TN1, and 1 or 2 kg a.i./ha of carbofuran or 2 kg a.i./ha of fensulfothion on Pankaj significantly increased height, 1,000-grain weight, and grain yield (Table 3). The disease infection rate (r) was also lowest in these treatments (Table 4). Figure 1 depicts the progress of the disease epidemic in plots treated with carbofuran and fensulfothion compared with control plots, using van der Plank's method (9). The slopes indicate that the course of the epidemic was delayed in insecticide-treated plots.

The evidence suggested that 2 kg a.i./ha reduced disease incidence to a greater extent than 1 kg a.i./ha of carbofuran, fensulfothion, carbaryl plus gamma isomer of HCH, and phorate in TN1 and fensulfothion, thiodemeton, carbaryl plus gamma isomer of HCH, mephosfolan, and disulfoton in Pankaj. However, grain yield was not significantly different between the two concentrations of fensulfothion, carbaryl plus gamma isomer of HCH, mephosfolan, and disulfoton in TN1 and carbofuran, thiodemeton, carbaryl plus gamma isomer of HCH, and phorate in Pankaj.

Table 2. Average leafhopper population in Pankaj and Taichung Native 1 (TN1) rice treated with insecticides

Insecticide	kg a.i./ ha	Number of hoppers/20 plants[a]			
		Adult		Nymph	
		Pankaj	TN1	Pankaj	TN1
Carbofuran	1	10	15	0	0
	2	7	9	0	0
Fensulfothion	1	20	29	0	0
	2	11	17	0	0
Thiodemeton	1	32	43	2	4
	2	22	34	0	0
Carbaryl plus gamma isomer of HCH	1	50	57	33	28
	2	36	49	21	24
Phorate	1	22	38	0	0
	2	16	27	0	0
Mephosfolan	1	35	55	18	12
	2	28	40	6	7
Disulfoton	1	27	42	1	4
	2	20	30	0	0
Control	...	83	93	47	62

[a] Average of four observations in TN1 and five observations in Pankaj.

All insecticides reduced the adult vector population in both cultivars; carbofuran was the most effective, followed in declining order of effectiveness by fensulfothion, phorate, disulfoton, thiodemeton, mephosfolan, and carbaryl plus gamma isomer of HCH (Table 2). The nymph populations, although checked by all insecticides, were least controlled by carbaryl plus gamma isomer of HCH. No nymph population developed in plots treated with carbofuran, fensulfothion, or phorate, or with disulfoton or thiodemeton at 2 kg a.i./ha. The higher concentration of all the insecticides controlled adults and nymphs better than the lower concentration.

The rate of infection per unit per day was negatively correlated with grain yield in both TN1 ($R = -0.881$) and Pankaj ($R = -0.943$) and with plant height ($R = -0.909$ in TN1 and -0.911 in Pankaj), indicating the seriousness of the disease in reducing height and grain yield. Plant height and grain yield were positively

Table 3. Plant height, grain yield, and 1,000-grain weight of Pankaj and Taichung Native 1 (TN1) rice treated with insecticides

Insecticide	kg a.i./ha	Pankaj Height (cm)	Pankaj Yield (g/plot)	Pankaj 1,000-grain weight (g)	TN1 Height (cm)	TN1 Yield (g/plot)	TN1 1,000-grain weight (g)
Carbofuran	1	94.7	4,250.0	24.2	62.9	1,050.0	22.1
	2	97.6	4,480.0	24.2	84.3	2,190.0	23.8
Fensulfothion	1	86.5	2,365.0	22.7	56.3	886.3	20.4
	2	88.3	3,687.3	23.4	60.4	990.0	20.9
Thiodemeton	1	68.3	1,275.0	21.9	47.7	262.3	19.9
	2	78.6	1,482.3	22.9	48.9	375.0	20.3
Carbaryl plus gamma isomer of HCH	1	63.6	1,191.7	20.7	42.3	156.7	18.7
	2	74.7	1,595.0	21.4	43.5	180.0	19.2
Phorate	1	79.9	2,311.7	22.1	47.8	283.0	20.6
	2	78.6	2,420.0	22.3	54.7	670.0	20.0
Mephosfolan	1	76.6	1,960.0	22.0	47.8	457.0	19.9
	2	75.9	2,018.3	22.7	49.6	487.0	19.9
Disulfoton	1	72.6	1,100.0	21.8	46.4	300.0	19.1
	2	77.5	2,087.3	23.1	46.7	324.3	20.5
Control	...	55.9	276.3	20.8	38.6	59.7	17.2
LSD (P=0.05)		10.2	391.3	1.35	5.45	111.40	0.86

Table 4. Rate of rice tungro virus infection in Pankaj and Taichung Native 1 (TN1) rice treated with insecticides

Insecticide	kg a.i./ha	Rate of infection per unit per day (r)[a] Pankaj	TN1
Carbofuran	1	0.111	0.147
	2	0.082	0.121
Fensulfothion	1	0.244	0.298
	2	0.146	0.244
Thiodemeton	1	0.274	0.324
	2	0.230	0.285
Carbaryl plus gamma isomer of HCH	1	0.296	0.373
	2	0.279	0.366
Phorate	1	0.242	0.319
	2	0.257	0.289
Mephosfolan	1	0.289	0.361
	2	0.278	0.361
Disulfoton	1	0.274	0.363
	2	0.249	0.373
Control	...	0.342	0.362

[a] $r = \frac{1}{t_2 - t_1}\left(\log_e \frac{x_2}{1-x_2} - \log_e \frac{x_1}{1-x_1}\right)$, where t_1 is the first day of observation, t_2 is the last day of observation, x_1 is the disease incidence on t_1, and x_2 is the disease incidence on t_2.

correlated in both TN1 (R = 0.992) and Pankaj (R = 0.941), suggesting that greater grain yield in different treatments is due to increased height of the plant.

Pathak et al (6) reported that lindane, carbaryl, phosphamidon, and particularly phorate applied to the soil surface or paddy water under field conditions not only killed leafhoppers but also prevented RTV infection. Phorate treatment was not very effective in our tests, resulting in a maximum incidence of 96 and 89% in TN1 and 94 and 92% in Pankaj when applied at 1 and 2 kg a.i./ha, respectively. Carbofuran was very effective on RTV-susceptible cultivar TN1; both carbofuran and fensulfothion effectively controlled the disease in the less susceptible cultivar Pankaj, indicating an interaction between insecticides and cultivar. Several other researchers (1,2,4,10,11) have reported the efficacy of carbofuran in controlling rice green leafhoppers.

We recommend application of carbofuran or fensulfothion in paddy fields when green leafhoppers are associated with tungro virus inoculum, especially in early growth stages of the crop.

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