CHEMICAL CONTROL OF GREEN LEAFHOPPERS TO PREVENT VIRUS DISEASES, ESPECIALLY TUNGRO DISEASE, ON SUSCEPTIBLE/INTERMEDIATE RICE CULTIVARS IN THE TROPICS

Osamu Mochida*, Salvador L. Valencia**
and Ruperto P. Basilio***

ABSTRACT

Sanitation in and around seedbed and field, covering wet seedbed with nylon screen at a height of 60 cm, and simultaneous cropping were recommended. Seedbox treatment (with carbofuran, carbosulfan, or cartap G), soil incorporation of carbofuran G, frequent and alternative foliar sprays (with MIPC, cypermethrin, deltamethrin, and monocrotophos), and dusting of MIPC with a pipe duster showed promising results. Broadcasting of isazophos G also showed good results. Different methods should be integrated for this purpose.

Introduction

It is well known that it is very difficult to prevent hopper-borne virus diseases on susceptible rice cultivars by applying insecticides when vector populations are at very high levels (Mochida *et al.,* 1978). In farmers' fields accordingly, the best way to prevent virus diseases is to select and plant rice cultivars resistant to both vectors and virus diseases.

Regarding rice tungro virus disease (RTVD), seven genes for resistance to green leafhoppers (GLH), vector of RTVD, have been identified (Angeles *et al.,* 1983) and two genes may convey resistance to RTVD (Khush, 1977). Among the IR rice cultivar series, IR28, 29, 30, 34, 50, 52, 54, 56, 58, 60, 62, 64, and 65 are resistant to *Nephotettix virescens* (GLH-V) (Entomology Department, IRRI, 1985 unpublished; Khush, personal communication). IR64 and 65 may be resistant to RTVD (Khush, personal communication). Thus, IR64 and 65 only may be resistant to both GLH-v and RTVD.

On the other hand, susceptible rice cultivars to RTVD are frequently being grown in experimental farms for germplasm collections, supply of breeding materials, plant physiological studies, etc. In such cases, application of insecticides with combination of different methods is the key for preventing RTVD infection, regardless of the cost.

Information on vectors and RTVD spread

1 Transmission of RTVD

RTVD is transmitted by GLH-v, *Nephotettix malayanus, N. nigropictus, N. parvus,* and the zigzag leafhopper (ZLH), *Recilia dorsalis* (Ling and Tiongco, 1979). However, GLH-v is considered to be the main vector in the field.

2 Inoculation feeding period

RTVD is not persistent and is transmitted within 5-minute feeding of GLH-v adults even at low infection levels (Ling, 1974).

*Entomologist, **Senior Research Assistant, and ***Research Assistant, respectively, IRRI, P.O. Box 933, Manila, Philippines.

3 Migration of GLH

Adults of *Nephotettix* spp. were collected on ships farther than 200 nautical miles from any island or land on the East China Sea and their migration distance with movement of air masses or fronts is considered to be less than that of the brown planthopper (BPH), *Nilaparvata lugens,* and the whitebacked planthopper (WBPH), *Sogatella furcifera* (Mochida, 1974, unpublished).

4 Spread of virus diseases in paddy fields

Waika disease, transmitted by *N. cincticeps,* spread within a radius of maximum 11 m by adults of *N. cincticeps*/13 days and within 1 m by nymphs/18 days in Japan (Inoue, 1977). RTVD spread within 0.75 m by 5th-instar nymphs of GLH-v/23 hr in India (Anjaneyulu, 1975) and within a radius of 9 m by adults/month in India (Kordaiah *et al.,* 1976).

Suppression of RTVD on susceptible rice cultivars

1 Possibility to protect susceptible cultivars from RTVD by applying insecticides

Figure 1 shows the fluctuations in hopper-borne virus diseases on susceptible rice cultivars at IRRI farm in 1964—1981. Based on the data shown in Fig. 1, the effectiveness of insecticide application in preventing virus disease occurrence on susceptible cultivars is illustrated in Fig. 2. It is clear that insecticide application was less effective in the wet season than in the dry season, and that it is possible to protect susceptible cultivars from RTVD or hopper-borne virus diseases by applying insecticides. Based on the results obtained in the most effectively controlled plots with insecticide application listed in Fig. 2, the effectiveness of insecticide applications for preventing virus diseases on susceptible rice cultivars is shown in Fig. 3.

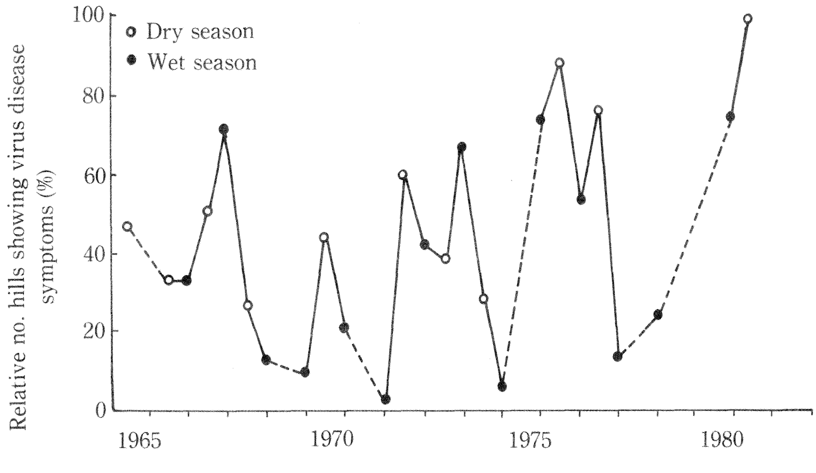

Fig. 1 Occurrence of rice plant virus diseases on susceptible cultivars in IRRI. Entomological trial plots from 1964 to 1981 (From IRRI Ann. Repts., 1965—1982).

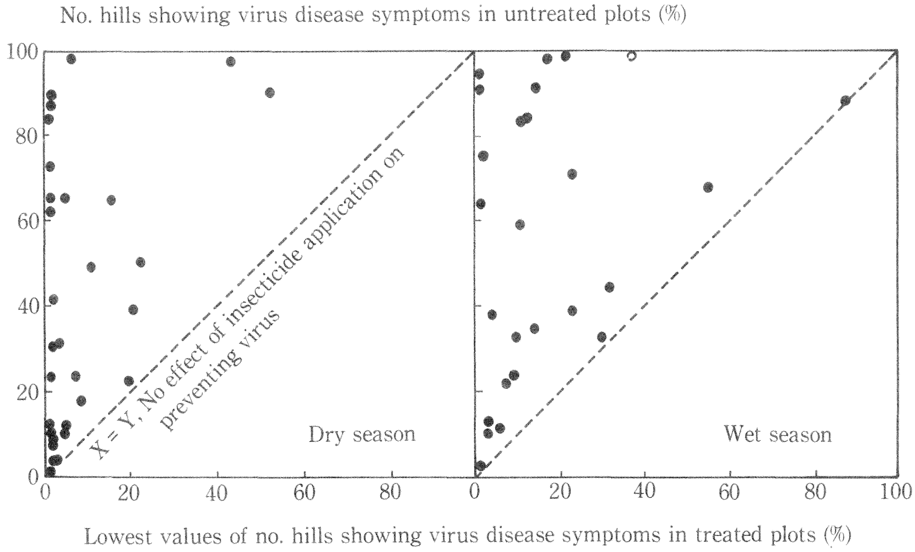

Fig. 2 Effects of insecticide application on protecting virus disease occurrence on rice susceptible cultivars at IRRI, 1965—82 (IRRI Ann. Repts. For 1965—82).

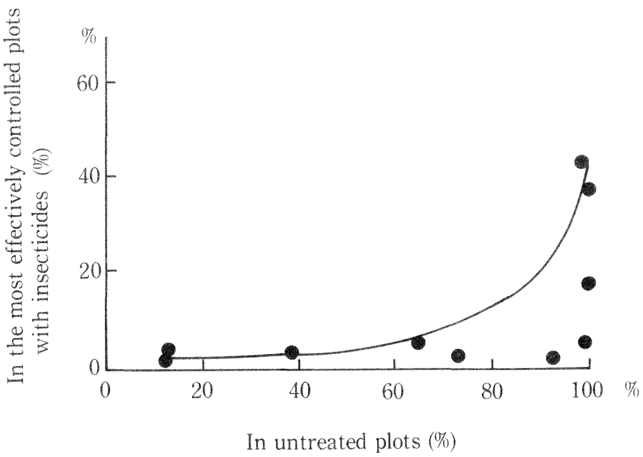

Fig. 3 No. rice hills showing tungro symptoms on susceptible rice cultivars under natural conditions for IRRI entomological trials from 1964 to 1981.

2 Relationships between rice cultivars and insecticide application

Figure 4 shows that insecticide application was effective in preventing RTVD on IR36 (intermediate) but not effective on IR22 (susceptible) and IR28 (resistant).

Figure 5 shows the relationships between the frequency of diazinon G application and yield. IR22 and IR28 showed no correlations between them. IR36 only showed a high correlation.

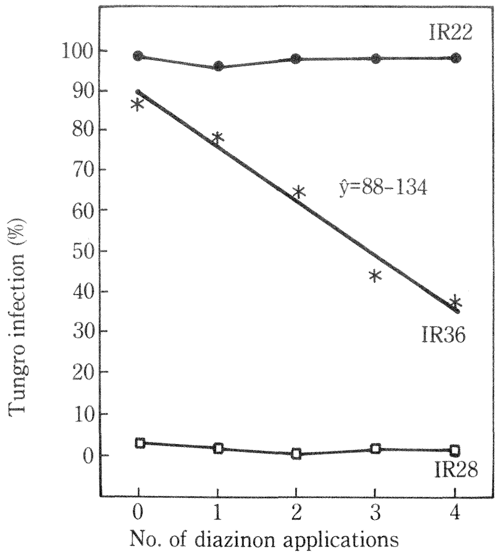

Fig. 4 RTVD infection as affected by levels of GLH-v resistance and frequency of diazinon G application (1.5 kg ai/ha/once) at IRRI, 1983 wet season (Heinrichs *et al.*, unpublished).

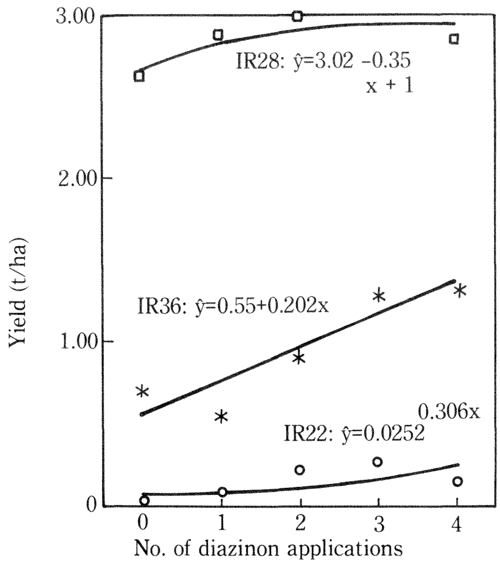

Fig. 5 Yields of 3 rice cultivars having different levels of resistance to GLH-v/RTVD as affected by frequency of diazinon G application at IRRI, 1983 wet season (Heinrichs *et al.*, unpublished).

3 Insecticide treatments

Table 1 shows insecticides with high GLH mortalities by foliar spray at IRRI. It is known that such insecticides as fenitrothion, vamidathion, malathion, phosalone, pyridaphenthion, etc. frequently are not effective in preventing RTVD occurrence in spite of their high mortality effect on GLH.

Table 2 shows the insecticides which were highly effective in preventing RTVD when field trials were conducted in the Philippines, Indonesia, Malaysia, and India.

Dusting of MIPC with a pipe duster (Table 3), foliar spray (Table 4), and seedbox treatment with foliar spray (Table 5) gave promising results. Table 6 summarizes these results.

Table 1 Insecticides recommended to prevent RTVD

Authors	Insecticide*	Rate (kg ai/ha/ once)	% Rice hills showing RTVD symptoms	
			Treated	Untreated
Pathak *et al.* (1967)	<u>Phorate EC</u>	3	1.0	93.4
Halteren and Sama (1974)	carbofuran G cartap G mephosfolan G BPMC G	2 2 2 2	0.0 0.0 0.5 1.7	37.0 37.0 37.0 37.0
Lim *et al.* (1974)	BPMC		30.0	ca70.0
Pathak *et al.* (1974)	carbofuran G aprocarb	2 2	1.1 6.1	68.0 68.0
Rao and Anjaneyulu (1979)	carbofuran G	1	20.0	100.0
Shukla and Anjaneyulu (1980)	<u>carbofuran G</u>	2	15.0	100.0
Chang *et al.* (1982)	<u>carbofuran G</u>	2	10.1	99.1
Satapathy (1982)**	cypermethrin EC carbosulfan EC phosphamidon EC			
Satapathy and Anjaneyulu (1982)	<u>cypermethrin EC</u>		3.0	100.0
Satapathy and Anjaneyulu (1982)	carbofuran G MIPC G acephate WP bendiocarb WP carbaryl WP MIPC WP	2 2		
Anjaneyulu *et al.* (1983)	<u>carbofuran G</u>	2	18.0	100.0
John and Satyanarayana (1983)	carbofuran G	0.75-1.0	29.7	90.0
Satepathy and Anjaneyulu (1983)	bendiocarb WP carbosulfan EC		30.3 33.7	100.0 100.0
Rahman *et al.* (1985)	carbofuran G	0.68	8.7	50.8

* Underlined insecticide showed excellent results. **Same results were reported by Satapathy and Anjaneyulu (1984).

Table 2 Insecticides showing more than 80% GLH mortality for 24 hr (IRRI. 1980—1984)

Insecticide		Rate (kg ai/ha)
A-41286	48EC	0.75
Acephate	75WP	0.75
Bendiocarb	20WP	0.75
Benfuracarb	40EC	0.75
Carbaryl	85WP	0.75
Carbofuran	12F	0.75
Cypermethrin	5EC, 10EC	0.025-0.075
〃 + diazinon		0.75
〃 + profenofos		0.75
Dioxacarb	50WP	0.75
Dixathion	81EC	0.75
DPX 5188	20EC	0.75
Deltamethrin	2.5EC	0.0125
FMC 67868	10EC	0.05
FMC 4428	5F	0.05
Formetanate	50WP	0.75
Furathiocarb	40EC	0.75
Isazophos	50EC/WP	0.75
M 10604200E	200E	0.75
Methiocarb	50WP	0.75
Methidathion	40EC	0.75
Methyl parathion	25/50EC	0.75
Monocrotophos		0.75
Mexacarbate	24EC	0.75
NS 826575EC	75EC	0.75
OK-135	30EC	0.75
OK-38530EC	30EC	0.75
Permethrin	10EC	0.050
Perthane	10EC	0.75
Primiphos methyl + carbophenothion		0.75
PP 321	2.5EC	0.025
PP 563	10EC	0.025
PH 0994	48EC	0.75
RH 0308	48EC	0.75
Thiodicarb	34F	0.75
UC 27867	50WP	0.75
UC 54229	100SP	0.75
UC/MO 19779	40F	0.75
WL 85871	5WP	0.05

Table 3 GLH populations at the Maximum Yield Trial plots. IRRI before and after dusting MTPC 2% dust. 1984 dry season[a]

	No. GLH adults/10 sweeps	
	Before dusting (March 26)	After dusting (April 2)
N13/N14		
V1	13.7	9.8
V2	13.7	9.4
V3	17.4	1.0
V4	18.5	1.0
V5	29.4	1.3
V6	5.3	1.5
V7	4.2	2.2
V8	4.3	1.8
V9	20.2	6.1
V10	23.7	6.0
Avg	15.0	4.0
UB2		
V1	23.3	11.7
V2	24.6	10.7
V3	29.6	2.4
V4	29.6	1.2
V5	41.9	1.0
V6	6.2	2.8
V7	6.3	2.3
V8	9.3	3.1
V9	33.1	7.4
V10	32.7	9.1
Avg	23.5	5.1

a Implementation was as follows:

1) Site	:	MYT fields (N13/N14 and UB2)
2) Date and time	:	0600-0630, 29 March 1984
3) Machine	:	Knapsack-type power applicator (Maruyama NP 150) with a 25 m plastic pipe
4) Rate of insecticide/ha	:	22 kg
5) Weather	:	Fine without wind during dusting but with a rising air current especially after sunrise. In the evening it rained slightly
6) Collaborators	:	O. Mochida, M. Ariyoshi, F. V. Ramos and their staff
7) Actual application	:	(8 + 14 kg/ha/(4 + 8 minutes)/ 2 + 1* persons *One person assisted the other to put the dust into the power applicator
8) Conclusion	:	- Very effective for GLH population suppression - Dusting should be done before sunrise to avoid rising air current

Table 4 Field evaluation of 4 synthetic pyrethroids to prevent RTV on IR22 and TN1 by foliar spray after transplanting. IRRI, Transpl.: 26 Oct. 1984. No harvest

Insecticide[a]		Rate (kg ai/ha)	Hills showing RTV symptoms			
			IR22		TN1	
			40 DT[c]	60 DT	40DT	60DT
MTI 500	20EC	0.100	3.99 bc	7.75 c	11.15 b	21.73 bcd
Cypermethrin	5EC	0.050	3.34 c	7.80 c	4.93 cd	9.55 d
Alphamethrin	10EC	0.0125	3.63 c	11.54 bc	8.67 bc	21.29 bcd
Deltamethrin	2.5EC	0.0125	5.41 abc	14.38 abc	8.98 bc	29.65 bc
Control		–	9.48 ab	30.34 a	22.19 a	81.86 a

a Applied at 1, 8, 15, 22, 29, 36, 43, and 50 DT in October 1984 to January 1985.
b In a column, means followed by a common letter are not significantly different at 5% level by DMRT.
c Days after transplanting.

Table 5 Field evaluation of 8 granular insecticides to prevent RTV on IR22 by seedbox treatment followed by foliar spray. IRRI, Transpl.: 19 July 1984; Harvest: 20 Oct. 1984

Insecticide		Rate for seedbox treatment[a]		Additional foliar spray and frequency[b]	RWM rating		GLH adult mortality (%) 48 HAC at indicated DT		No. GLH adults/ 10 sweeps				RTV infected hills
		kg ai/ha	g Formulation/ seedbos (30×60×3 cm)		25 DT	35 DT	5 DT	10 DT	1 WT[c]	2 WT	3 WT	4 WT	60 DT
Disulfoton	5G	278	100	+ FS, 9	3.30 c	4.43 d	97.5 a	100.0 a	0.25 a	6.25 ab	3.75 ab	0.50 c	1.25 b
Carbosulfan	5G	278	200	+ FS, 9	3.75 c	4.93 cd	80.0 abc	81.3 ab	0.50 a	5.25 ab	4.25 ab	0.0 c	0.47 b
Carbofuran	3G	167	100	+ FS, 9	3.43 c	5.03 cd	95.0 ab	96.3 a	0.50 a	12.25 a	3.50 ab	1.00 c	0.47 b
Cartap	4G	222	100	+ FS, 9	3.68 c	5.80 bc	100.0 a	72.5 b	0.25 a	3.50 ab	1.75 b	0.50 c	0.47 b
Disulfoton	5G	278	100	—	6.08 b	6.03 abc	100.0 a	97.5 a	0.25 a	4.00 ab	3.75 ab	5.50 b	2.34 b
Carbosulfan	5G	278	100	—	7.30 ab	6.15 abc	95.0 a	66.3 b	0.25 a	8.25 ab	2.50 ab	7.25 b	4.38 b
Carbofuran	3G	167	100	—	7.01 ab	6.38 ab	75.0 bc	73.8 b	0.50 a	7.50 ab	3.00 ab	9.00 b	1.72 b
Cartap	4G	222	100	—	6.83 ab	6.48 ab	60.0 c	32.5 c	0.25 a	2.25 b	2.75 ab	11.50 ab	2.50 b
Control		—	—	—	7.65 a	7.23 a	15.0 cd	20.0 c	0.75 a	7.25 ab	6.50 a	36.50 a	29.22 a

a Granules were applied on the seedlings grown in seedboxes a day before transplanting.
b Foliar sprays (FS) of deltamethrin (0.012 kg ai/ha), monocrotophos (0.75 kg ai/ha), and MIPC (0.75 kg ai/ha) were alternately and weekly applied starting 2 WT up to 66 DT (10, 17, 24, 31, 38, 45, 57, 59, and 66 DT).
c Weeks after transplanting.

Table 6 Chemical treatment for preventing RTV on susceptible rice cultivars. IRRI farm, 1984

Treatment	Treated/best chemical	Rate (kg ai/ha/once)	Frequency of application	No. RTV-infected hills (%) 60 DT		Evaluation**
				Untreated	Treated	
Dusting	MIPC 2D	4.4	1	—	1—6	++
Foliar spray	cypermethrin	0.050	8	81.9	9.6	++ repellent?
Broadcast	isazophos 3G	1.0	5	49.0	12.0	+
Soil incorporation + foliar spray	carbofuran 3G + (deltamethrin + buprofezin)	2.0 + (0.025 + 0.125)	1 + 4	81.7	35.9	+
Seedling root-soaking + spray	S534*	0.236 + 200 ppm	1 + 2	78.3	44.4	
Seedbox treatment + foliar spray	carbofuran 3G + deltamethrin/ monocrotophos/ MIPC	87.0 + 0.0125/ 0.75/0.75	1 + (9)	22.9	0.5	++
”	carbosulfan 5G + deltamethrin/ monocrotophos/ MIPC	277.0 + 0.0125/ 0.75/0.75	1 + (9)	22.9	0.5	++
”	cartap 4G + deltamethrin/ MIPC	222.0 + 0.0125/ 0.75/0.75	1 + (9)	22.9	0.5	++ repellent?
”	cartap 4G	222.0	1	97.7	26.7	++
”	cartap 4G + deltamethrin/ monocrotophos	222.0 + 0.0125/ 0.75	1 + (2)	71.4	5.3	++

* A mixture of deltamethrin + an insecticide. Root-soaking 200 ppm for 2 minutes. ** + = Good; ++ = Promising.
Note: Different combinations can be tested using best chemicals. The same chemical should not be used several times/crop to avoid development of resistant populations.

4 Combinations of insecticide application and cultural control methods

Cultural control methods suggested by Chakrabarti and Padmanabhan (1976), Anjaneyulu and Shukla (1980), Shukla and Anjaneyulu (1982), and Mukhopadhyay (1984) are as follows: dry bed, selection of planting time, lower level of nitrogen (30 kg N/ha), closer spacing (10 × cm), and mixture of susceptible cultivars with resistant ones.

At IRRI we suggested covering wet seedbed by nylon screen, sanitation in and around seedbed and rice fields from 2 weeks before land preparation, and cropping susceptible cultivars among/between resistant ones. Integration of different methods is necessary for preventing effectively the occurrence of RTVD susceptible cultivars.

5 Tentatively recommended methods at IRRI

1) Seedbed preparation and seedling protection
   - Remove weeds, grasses, and voluntary rice plants/ratoons within 20 m around the seedbed by applying glyphosate (Roundup) at 1.0—1.5 kg ai/ha 2 weeks before seeding.
   - Apply MIPC (= isoprocarb) 50WP at 0.75 kg ai/ha once in and around seedbed at seeding.
   - Cover wet seedbed with nylon screen at a height of 60 cm just after seeding or preparing insect-free (dry) seedbed in screenhouse.
   - If covering is impossible, broadcast carbofuran (Furandan) 3G at 1.0 kg ai/ha or 15 g of Furadan 3G/M^2 or isazophos (Miral) 3G after seeding, plus 2 sprays of cypermethrin (0.05 kg ai/ha) and deltamethrin (0.0125 kg ai/ha), first after seedlings emerged above water surface around 5 days after seeding, and second, 10 days after the first spray.
2) Maximum protection in the field
   - Remove weeds, grasses, and voluntary rice plants/ratoons within 20 m around the field by applying glyphosate 2 weeks before land preparation.
   - Apply MIPC 50WP at 0.75 kg ai/ha to rice plant/weeds in and around the field 1 or 2 days before transplanting.
   - Soil incorporation of carbofuran (Furadan) 3G at 1.5 kg ai/ha during the final harrowing or broadcast isazophos 3G 3 days after transplanting (DT).
   - Spray deltamethrin in/around the field 5 DT.
   - Spray cypermethrin 2 weeks after transplanting (WT).
   - Spray monocrotophos 3 WT.
   - Spray buprofezin (Applaud) 25WP at 0.125 kg ai/ha on the basal parts of rice plants once or twice from 5 to 8 WT, based on monitoring results on BPH and WBPH, when the number of BPH and/or WBPH nymphs exceeds 40/hill on susceptible cultivars like TN1.
   - Spray cypermethrin/acephate/monocrotophos or deltamethrin alternately and weekly from 5 to 9 WT, based on monitoring results when more than 2 GLH adults/10 sweeps and more than 2 eggmasses and/or 2 adults of stem borers/m^2.
   - Spray diazinon EC at 0.75 kg ai/ha/once for stem borer 9—11 WT.

   The cost for pesticides (mainly insecticides) and screen for covering wet seedbeds was US$420.9 (Table 7) and US$129.5 (Table 8)/ha.Tungro was completely prevented in a 4 ha rice field with suceptible cultivars/lines at Bangyas, Laguna, Philippines in the 1985 wet season.

Table 7 Cost (US$/4 ha) of pesticides for preventing tungro on susceptible rice cultivars/lines, Victoria, Laguna, Philippines, 1985 DS/WS.

Common name	Brand name	Formulation	Rate (kg ai/ha)	Li/kg formulation/4 ha	Freq./season	Total li/kg	Total US$*
Acephate	Orthene	75WP	0.75	4 kg	1 + ?	4 +	54.05
Buprofezin	Applaud	25WP	0.1-0.125	1.6-2.0 kg	1 - 2	3.2-4	101.20
Carbofuran	Furadan	3G	1.0**-1.5	16.5 = 12	1	12 bags	311.40
Cypermethrin	Cymbush	5EC	0.5	4 li	2 + ?	8 +	246.49
Deltamethrin	Decis	2.5EC	0.25	4 li	2 + ?	8 +	314.38
Diazinon	Bacudin	20EC	0.75	15 li	1 + ?	15 +	138.65
Glyphosate	Roundup	35.6EC	1-1.5	11 li***	1	11	347.24
Monocrotophos	Azodrin 202R	30EC	0.75	10 li	1 + ?	10 +	111.89
MIPC	Mipcin/Hytox	50WP	0.75	6 kg***	1	6	58.38
						Total	1,683.68

* US$1.00 = Philip. 18.50, September 1985.
** 1 kg ai/ha for seedbed treatment.
*** Indicated amount only for field application, excluding levee, seedbed and surrounding area.

Table 8 Cost for nylon screen covering 20 m^2 (38 seedbeds) for transplanting 4 ha rice field, Victoria, Laguna, Philippines, 1985 DS/WS.

	P	US$
Screen	9,458.00	512.70
Bamboo	100.00	5.40
Total	9,585.00	518.10

US$1.00 = Philip. P18.50

Discussion

Many trials on the suppression of RTVD have been carried out in South and Southeast Asia. But most of them have dealt with resistant cultivars to GLH and/or RTVD itself.

At IRRI farm, susceptible/intermediate cultivars have frequently suffered from virus diseases, especially RTVD. We have been conducting many trials in the laboratory and field at IRRI to evaluate chemicals including conventional insecticides, synthetic pyrethroids, and growth regulators for preventing the occurrence of RTVD on susceptible cultivars and to establish integrated methods of control. Susceptible cultivars may be expected to show less than 10% RTVD-infected hills in protected plots and more than 90% in unprotected ones.

Unfortunately, no method superior to the covering with nylon screen was found in wet seedbed. Integrated method(s) with combinations of seedbox treatments (with carbofuran, carbosulfan and cartap) or soil incorporation (of carbofuran G), frequent and alternate foliar applications (with MIPC, cypermethrin, deltamethrin, monocrotophos, etc.), and dusting of MIPC indicated promising results. Sanitation in and around seedbed and field, and simultaneous cropping are also necessary. Though no evident field data showing relationships between GLH populations and RTVD infection on susceptible cultivars are supplied, we recommend to apply insecticide(s) when GLH adult populations exeed 2/10 sweeps on susceptible cultivars, irrespective of cost for insecticide treatment.

Further studies are needed for improving the current methods tentatively recommended.

Acknowledgement

We express our sincere thanks to Dr. E. A. Heinrichs for his permission to use his unpublished data shown in Figs. 4 and 5.

References

1) Angeles, E. R., Bacalangco, E. H. and Khush, G. S. (1983): Inheritance of resistance to planthoppers and leafhoppers in rice. IRRI Saturday Seminar, 19 March 1983. 21 pp.
2) Anjaneyulu, A. (1975): *Nephotettix virescens* (Distant) nymphs and their role in the spread of rice tungro virus. Current Science, 44, 357-358.
3) Anjaneyulu, A. and Shukla, V. D. (1980): Prevention and control of rice tungro virus. Aspects of Plant Sciences, 4/5, 173-183.
4) Anjaneyulu, A., Shukla, V. D. and Mohana Rao, G. (1983): Insecticidal control of rice tungro virus disease. p. 1-11. *In*: Pest management in rice. Edited by: Chelliah, S. and Balasubramaniam, M., Coimbatore, India. 379 pp.
5) Chakrabarti, P. M., Supaad, M.A., Abdul Latif, A. Z., Ng, K. J. and Zakaria, A. (1982): The effects of some insecticides on the green leafhopper, *Nephotettix virescens* (Homoptera: Cicadellidae), and the transmission of tungro. Bengkel Padi, MARDI, 5-6 January. 11 pp.
6) Halteren, P. Van and Shagir Sama (1974): The tungro virus disease of 1972-1973 in South Sulawesi. LPM Bull., 3. 2 pp.
7) Heinrichs, E.A., Rapusas, H. R., Aquino, G. B. and Palis, F. (Unpublished): Integration of host plant resistance and insecticides in the control of *Nephotettix virescens* (Distant) (Homoptera: Cicadellidae), a vector of rice tungro virus.
8) Inoue, H. (1977): Occurrence of the green leafhopper, *Nephotettix cincticeps* Uhler, in relation to spreading of the rice Waika disease in field. Proc. Assoc. Pl. Prot. Kyushu, 23, 88-91.
9) John, V. T. and Satyanarayana, K. (1983): Chemical control of rice virus disease. p. 12-15. *In*: Pest management in rice. Edited by: Chelliah, S. and Balasubramaniam, M., Coimbatore, India. 379 pp.
10) Khush, G. S. (1977): Disease and insect resistance in rice. *In*: Advances in Agronomy, 29, 265-341.
11) Kordaiah, A., Rao, A. V. and Srinivasan, T. E. (1976): Factors favoring spread of rice "tungro" disease under field conditions. Pl. Dis. Reptr., 60, 803-806.
12) Lim, G. S., Ting, W. P. and Heong, K. L. (1974): Epidemiological studies of tungro virus in Malaysia. Lapuran MARDI Rept., 21, 1-12.
13) Ling, K. C. (1974): The capacity of *Nephotettix virescens* to infect rice seedlings with tungro. Philip. Pythopath., 10, 42-49.
14) Ling, K. D. and Tiongco, E. R. (1979): Rice virus diseases in the Philippines, IRRI. 57 pp.
15) Mochida, O., Tatang, Suryana, Hendarsih and Ayuk Wahyu (1978): Identification, biology, occurrence, and appearance of the brown planthopper. p. 1-39. *In*: The brown planthopper (*Nilaparvata lugens* Stal). Indon. Inst. Sci. Jakarta. 133 pp.
16) Mukhopadhyay, Md. Mohasin and Ghosh, P. K. (1976): Behaviour of rice virus vectors under different cultivational conditions. Proc. Nat. Acad. India, 46(B) I/II:72-76.
17) Mukhopadhyay, S. (1984): Ecology of rice tungro virus and its vectors. *In*: Virus ecology. Edited by: Misra, A. and Plasa, H., New Delhi, India. pp. 139-164.
18) Pathak, M. D., Vea, E. and John V. T. (1967): Control of insect vectors to prevent virus infection of rice plants. J. Econ. Ent., 60, 218-225.

19) Pathak, M. D., Encarnacion, D. and Dupo, H. (1974): Application of insecticides in the root zone of rice plants. India J. Pl. Prot., 1(2), 1-16.
20) Rahman, M. M., Nahar, M. A. and Miah, S. A. (1985): Control of tungro by applying chemicals against GLH. 2 pp. (Unpublished).
21) Rao, G. M. and Anjaneyulu, A. (1979): Carbofuran prevents rice tungro infection. Current Science, 48, 116-117.
22) Shukla, V. D. and Anjaneyulu, A. (1980): Evaluation of systemic insecticides for control of rice tungro. Pl. Disease, 64, 790-792.
23) Shukla, V. D. and Anjaneyulu, A. (1982): Spread of tungro virus in mixed populations of susceptible and tolerant rice cultivars. Z. PflKrankh, 89, 200-204.
24) Shukla, V. D. and Anjaneyulu, A. (1982): Effects of number of leafhoppers and amount and source of virus inoculum on the spread of rice tungro. Z. PflKrankh, 89, 325-331.
25) Satapathy, M. K. (1982): Insecticide control of rice tungro virus disease. IRRN, 7(6), 9-10.
26) Satapathy, M. K. and Anjaneyulu, A. (1982): Greenhouse evaluation of granular, wettable powder, and flowable insecticide formulations for tungro prevention. IRRN, 7(6), 11.
27) Satapathy, M. K. (1982): Greenhouse evaluation of emulsifiable concentrate insecticides against tungro virus infection. IRRN, 7(6), 11-12.
28) Satapathy, M. K. and Anjaneyulu, A. (1983): Evaluation of emulsifiable concentrate and wettable powder insecticides for control of rice tungro virus disease and its vector. Z. PflKrankh., 90, 269-277.

Discussion

Tantera, D.M. (Indonesia): The cost of insecticides is too high for the ordinary farmer. In Indonesia, carbofuran applied to seedbeds was found to protect the crop during a period of one and a half months. What is the situation of the Philippine farmer?

Answer: For the farmers the optimum method of control is achieved by the use of resistant varieties. In the Philippines, to prevent tungro, one application of 1kg ai carbofuran per hectare or 750g per hectare if the farmer uses a carabao or a machine, respectively would be effective.

Anjaneyulu, A. (India): Tungro is a disease of economic importance. The insect can be controlled from the standpoint of being a pest or the vector of the virus. In the latter case, insecticides with a repellent and knockdown effect such as cypermethrin are effective in protecting varieties, particularly the tolerant ones. It is easier to protect varieties with intermediate resistance using carbofuran sprays or cypermethrin.