UTILIZATION OF VECTOR RESISTANCE TO CONTROL TUNGRO VIRUS DISEASE IN RICE AND BREEDING STRATEGY TO OVERCOME OUTBREAKS OF NEW BIOTYPES IN MALAYSIA

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ABSTRACT

Tungro virus (RTV) is one of the most serious diseases of rice (*Oryza sativa* L.) in Malaysia. This report aims at outlining a breeding strategy for promoting RTV resistance.

Green leafhopper (GLH: *Nephotettix virescens* Distant) is the main vector of RTV. There was a very close correlation ($r = -0.763$) between the mortality of GLH nymphs and susceptibility to RTV infection under forced inoculation tests on host plants. This finding suggests that the vector resistance can be used to control RTV disease.

However, the occurrence of outbreaks of new biotypes after the release of varieties resistant to the vector is a serious problem. To alleviate this shortcoming the authors first developed five GLH biotypes which were able to reproduce on the resistant varieties, i.e. Pankhari 203, ASD 7, Ptb 8, TAPL 796 and IR 42. The existence of a specific or vertical resistance of rice varieties to GLH biotypes was observed. Pankhari 203, Ptb 8 and IR 42 were each resistant to all the biotypes developed on other varieties but susceptible to the biotype developed on the same variety.

Most of the resistant varieties or lines from West Malaysia and IRRI were considered to harbor the same resistance gene as that of IR 42 derived from Ptb 18. Pankhari 203 had one dominant resistance gene to GLH and IR 36 while the sister line IR 42 had two dominant resistance genes. Of the two genes, one was highly resistant and the other was only moderately resistant. The highly resistant gene of IR 42 was independent of the resistance genes present in TAPL 796 and ASD 7.

On the basis of the results of this study, the authors suggest that Pankhari 203, Ptb 8 and TAPL 796 should be used as gene sources of GLH resistance after the breakdown of IR 42 which has been planted in Malaysia for several years.

Introduction

Tungro virus (RTV) is one of the most serious diseases of rice (*Oryza sativa* L.) in Malaysia. It has been reported that the loss of yield associated with RTV was remarkable and substantial between 1981-1983 in the MUDA region, the largest paddy farming area in Malaysia.

Utilization of varieties resistant to RTV disease is obviously one of the best methods of control and it is known that there are two ways to make varieties resistant. One is the use of virus resistance and the other is the use of vector resistance. The main vector of RTV is the green leafhopper (GLH : *Nephotettix virescens* Distant). Several resistant varieties are available and some promising improved resistant varieties have already been developed. However, the occurrence of outbreaks of resistance-breaking biotypes after using the varieties resistant to the vector continuously for a long period of time is a serious problem. On the other hand, improved resistant varieties to the virus are not available although the resistance of such varieties has been reported by Ling (1972). The breeding for virus resistance appears to have started only recently.

In this report, the utilization of resistance to the vector and a breeding strategy to overcome the outbreaks of the new biotypes in Malaysia will be outlined. However, no data will be supplied on the virus resistance.

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Relationship between vector resistance and virus resistance in host plants

Ling (1972) reported that the resistance of a plant to RTV infection could be divided into four categories, i.e. (i) Resistance to the vector only, (ii) Resistance to the virus only, (iii) Resistance to both or (iv) Susceptibility to both the vector and the virus.

In Malaysia, the relationship between vector resistance and virus resistance was first analysed by Kobayashi *et al.*, (1983). They used F_3 lines from the combination between IR 42 and Setanjung. In these parents, IR 42 was resistant to GLH and Setanjung was susceptible to both GLH and RTV in Malaysia. They showed that lines resistant to GLH were also resistant to RTV disease. Habibuddin *et al.*, (1983) reported the same relationship using IRRI lines in Malaysia. There was a very close correlation (r=0.763) between the mortality of GLH nymphs and susceptibility to RTV infection under forced inoculation tests (Fig. 1).

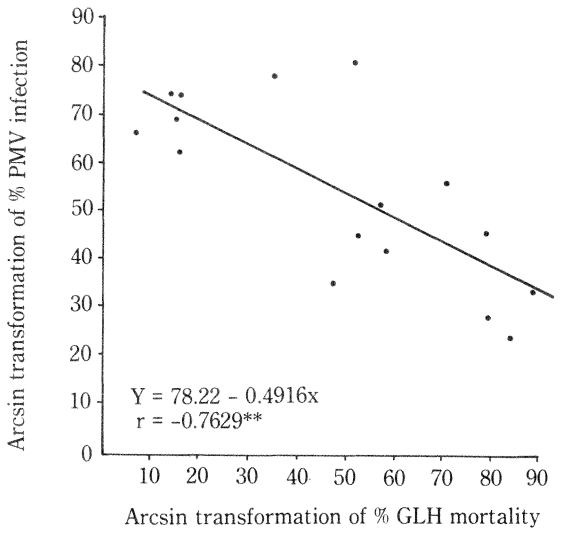

Fig. 1 Relationship between mortality of GLH and incidence of PMV infection under forced inoculation tests among IRRI varieties.

Auclair *et al.*, (1982) reported that GLHs feed predominantly on phloem sap in susceptible varieties, but in resistant varieties, they feed on the xylem and cannot survive long due to the lack of nutrients in xylem. As a result, GLHs prefer susceptible varieties and transmit the virus more frequently on such varieties, as is the case in other virus diseases. For instance, Kobayashi (1983) showed that varieties resistant to GLH (*Nephotettix cincticeps* Uhler) were resistant to rice dwarf virus disease in Japan. Therefore, it is concluded that generally varieties resistant to GLH are also resistant to RTV and GLH resistance may be one of the breeding targets for RTV disease resistance.

Biotype selection and relationship between laboratory-developed biotypes and resistant varieties

Rezaul Karim and Pathak (1982) have shown that there are some varietal differences in resistance to GLH between IRRI and BRRI (Bangladesh Rice Research Institute). For instance, Pankhari 203 and several varieties are resistant to GLH at IRRI but susceptible at BRRI. Chelliah *et al.*, (1981) and Sama (1984) also revealed differences in biotypes in India and Indonesia and at IRRI.

In Malaysia, Habibuddin *et al.*, (1983) showed the existence of a relationship of GLH biotypes between Malaysia and IRRI, and IR 42 was found to be more resistant than IR 28 to GLH in Malaysia while the reverse was observed at IRRI.

IRRI (1982) reported that it is possible to select resistance-breaking biotypes of GLH in the laboratory by raising GLH on resistant varieties continuously. In Malaysia, Kobayashi *et al.*, (1983) selected a biotype which can develop and reproduce on the resistant variety IR 42 by raising GLH on IR 42 and a susceptible variety alternatively. In addition, Takita and Habibuddin (1985a) found that when GLH were fed continuously on each highly resistant variety, the population decreased remarkably in the first two generations but then increased steadily and resistance-breaking biotypes appeared (Table 1). On the other hand, when GLH were fed on the moderately resistant variety IR 28, the population was able to increase from the next generation onward. Takita and Habibuddin eventually developed five resistance-breaking biotypes from five resistant varieties, i.e. Pankhari 203, ASD 7, Ptb 8, TAPL 796 and IR 42. The biotype developed from Pankhari 203 was named Pankhari 203 colony, for instance.

Table 1 Change of GLH population on resistant varieties

Varieties	First GLH number (2nd or 3rd instar nymphs)	Adult GLH number Generation			
		G_1	G_2	G_3	G_3
Pankhari 203	2,000	64	24	>200	>1,000
IR 42	1,000	36	80	>500	—
IR 28	100	30	>200	—	—

Note: G_1 is the first generation on resistant varieties.

In addition, Takita and Habibuddin (1985a) analysed the relationship between five biotypes and five resistant varieties (Table 2). There was a specific or vertical resistance of the rice varieties to the GLH biotypes. Pankhari 203, Ptb 8 and IR 42 were each resistant to all the biotypes developed on other varieties but susceptible to the biotype developed on the same variety. In addition, Pankhari 203, Ptb 8 and TAPL 796 were resistant to the IR 42 colony. This finding suggests that these varieties should be recommended as the next gene source of GLH resistance to be used after the breakdown of IR 42 which has been planted in Malaysia for several years.

Table 2 Relationship between resistant varieties and resistance-breaking biotypes

Varieties	Unselected	GLH biotypes: Pankhari 203 colony	ASD 7 colony	Ptb 8 colony	TAPL 796 colony	IR 42 colony
Pankhari 203	R	S	R	R	R	R
ASD 7	R	R	S	R	R	M
Ptb 8	R	R	R	S	R	R
TAPL 796	R	S	R	R	S	R
IR 42	R	R	R	R	R	S

Note: S=0—30%, M=31—70% and R=71—100% in GLH mortality.

Inheritance of resistance genes in IR 42 and resistance gene sources in IRRI lines

IR 42 is highly resistant to GLH in Malaysia and it appears to be a useful source of resistance genes for breeding because it has already been improved unlike other sources of resistance genes.

Kobayashi *et al.*, (1983) demonstrated that IR 42 has two dominant resistance genes and Takita and Habibuddin (1985b) showed that IR 42 and the sister line IR 36 have two dominant resistance genes (Table 3). In addition, it was observed that one of the genes is highly resistant and the other is moderately resistant. For example, when the biotype IR 28 colony which was developed from the moderately resistant variety IR 28 was used, IR 42 exhibited a single dominant gene. The gene with high resistance in IR 42 was independent of the resistance genes present in TAPL 796 and ASD 7. On the other hand in that study, the highly resistant variety Pankhari 203 had one dominant resistance gene.

Table 3 Reaction to GLH of F_2 populations

F_2 combinations		GLH colony used for test	Number of F_2 plants: R	S	Total	P value (3:1 or 15:1)
Pankhari 203/Seribu Gantang		Non-selected	43	17	60	0.50-0.75 (3:1)
Sekencang /IR 36		〃	54	6	60	0.25-0.50 (15:1)
IR 42 /Seribu Gantang		〃	54	6	60	0.25-0.50 (15:1)
IR 42 /Seribu Gantang		IR 28 colony	44	16	60	0.75-0.90 (3:1)
IR 42 /ASD 7		〃	55	5	60	0.50-0.75 (15:1)
IR 42 /TAPL 796	(1)	〃	58	2	60	0.25-0.50 (15:1)
〃	(2)	〃	59	1	60	0.25-0.50 (15:1)
〃	(3)	〃	56	4	60	0.75-0.90 (15:1)

Note: R: resistant=40-100% and S: susceptible=0-20% in GLH mortality.

Rezaul Karim and Pathak (1982) reported that the resistance genes of Pankhari 203, ASD 7, Ptb 8 and TAPL 796 are GlH1, Glh2, Glh4 and Glh6, respectively, and that IR 36 and TAPL 796 have the same resistance gene Glh6. However, the results obtained by Takita and Habibuddin (1985 a and 1985b) showed that IR 36 and the sister line IR 42 had the same genes and that IR 42 and TAPL 796 had different genes (Table 3). In addition, IR 42 was resistant to the biotype TAPL 796 colony and TAPL 796 was also resistant to the IR 42 colony (Table 2). These results suggest that there are differences between the GLH used in the studies carried out in both Bangladesh and Malaysia.

Takita and Habibuddin (1985a) analysed the resistance of Malaysian varieties and IRRI lines, and found that all of the varieties and lines resistant to standard GLH were susceptible to the IR 42 colony (Table 4). This suggests that the varieties and lines have the same resistance gene as that of IR 42. It is evident that the resistance genes of the Malaysian varieties originate from Ir 36 of IR 42 because they are the direct parents of these varieties. On the other hand, Rezaul Karim and Pathak (1982) reported that Ptb 18 and IR 36 have the same resistance gene. Since all of the resistant IRRI lines have the same ancestor Ptb 18 we can consider that the resistance gene is definitely derived from Ptb 18 (Fig. 2.)

Table 4 Resistance to non selected GLH and IR 42 colony in some varieties from Malaysia and IRRI

	Varieties from Malaysia	Resistance (S-R)		Varieties from IRRI		Resistance (S-R)	
		Unselected	IR 42 colony			Unselected	IR 42 colony
1	Mahsuri	M	S	27	IR 5	S	
2	Mat Candu	M	M	28	IR 8	S	
3	Setanjung	S		29	IR 20	S	
4	Sekencang	S		30	IR 22	S	
5	Kadaria	S		31	IR 24	S	
6	MR 68	S		32	IR 26	S	
7	MR 69	M	S	33	IR 28	M	S
8	MR 70	M	S	34	IR 29	M	S
9	MR 71	S		35	IR 30	S	
10	MR 72	S		36	IR 32	R	S
11	MR 73	S		37	IR 34	M	S
12	MR 74	S		38	IR 36	R	S
13	MR 75	S		39	IR 38	S	
14	MR 76	S		40	IR 40	R	S
15	MR 77	M	S	41	IR 42	R	S
16	MR 78	S		42	IR 43	S	
17	MR 79	S		43	IR 44	R	S
18	MR 80	S		44	IR 45	S	
19	MR 81	R	S	45	IR 46	S	
20	MR 82	R	S	46	IR 48	R	S
21	MR 83	S		47	IR 50	M	S
22	MR 84	S		48	IR 52	R	S
23	MR 85	R	S	49	IR 54	R	S
24	MR 86	R	S	50	IR 56	R	S
25	MR 87	S		51	CR 94-13	R	S
26	MR 88	S					

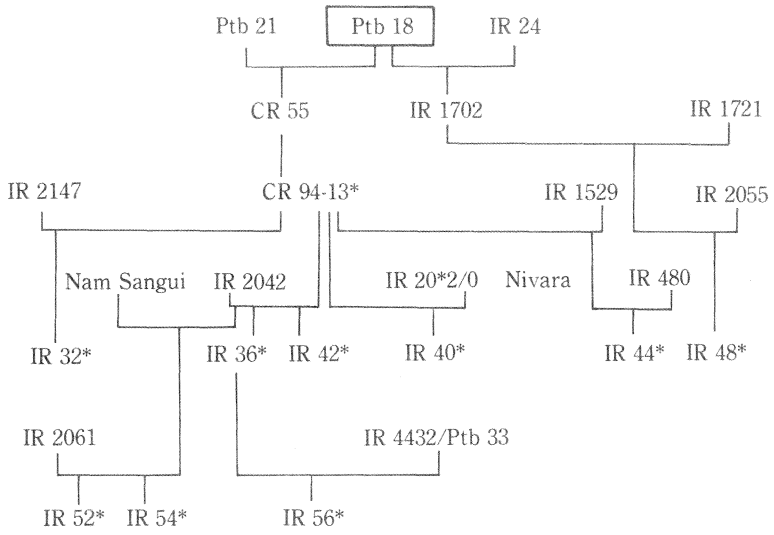

Fig. 2 Inheritance of GLH resistance gene of Ptb 18 in IRRI lines.
*: Resistant lines confirmed in this study.

Breeding strategy to overcome outbreak of new biotypes

Since there is a genetic relationship between GLH biotypes and resistant varieties, the prevention of outbreaks of resistance-breaking biotypes is the main problem to solve in order to be able to use vector resistance for the control of RTV disease.

Manwan *et al.*, (1985) reported that rotation of GLH resistant varieties was quite effective in controlling RTV disease in areas of Indonesia with severe outbreaks. They showed that if one GLH resistant variety is planted continuously it will become increasingly susceptible with the passage of time. Their report suggests that the rotation of resistant varieties is one of the methods to make varietal resistance durable.

In the case of Malaysia, however, where the RTV disease does not occur every year but only once or twice in ten years, it is possible to consider that the occurrence of the disease could be prevented if a variety which is resistant to the new GLH biotype for more than two years were to be developed. Since the GLH resistant variety IR 42 has been planted for more than two years over about 40% of the cultivated area in the MUDA region, the largest rice farming area in Malaysia, it is likely that an outbreak of a new biotype adapted to IR 42 may occur. However, we found that Pankhari 203, Ptb 8 and TAPL 796 are resistant to the biotype IR 42 colony. In addition, we may consider that these varieties will remain resistant for at least two years, because the breakdown of insect resistance of varieties usually takes place after two years. Therefore, we can conclude that it is possible practically to use the resistance genes of these varieties after the breakdown of IR 42 resistance even though outbreaks of new biotypes are likely to occur in future.

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