TARC Repot

Variation and Inheritance of Resistance of Rice to Green Leafhopper in Malaysia

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Introduction

Green leafhopper (GLH: *Nephotettix virescens* Distant) is an important pest of rice (*Oryza sativa* L.) because it transmits the tungro virus disease, one of the most serious diseases in the tropics. As GLH-resistant variety can be tungro-resistant variety,[4] breeders are trying to develop GLH-resistant varieties to control tungro virus disease in Malaysia.

In breeding for GLH resistance, the simple screening method using young seedlings has to be used. However, it is known that the resistance level is influenced by seedling conditions. Therefore, the most suitable plant condition for the screening must be identified.

In Malaysia, IR 42 is known highly resistant and very useful as resistance source, because it is an improved variety, unlike other resistance gene sources. IR 42 has 2 resistance genes.[1] The authors[7] also reported that IR 42 and its sister line IR 36 have the same resistance genes, but they may be different from the genes of Pankhari 203, ASD 7, Ptb 8 and TAPL 796, although IR 36 is reported to have the same resistance gene as TAPL 796.[6]

In this paper, the resistance to GLH as influenced by seedling age and some treatments given to the seedlings, and inheritance of resistance genes of IR 36 and IR 42 are presented.

Materials and methods

1) *Resistance level as related to seedling age*

Ten varieties known to have different resistance genes[6] were used (Table 1). They were seeded in a tray (30 × 23 × 3 cm) containing soil at a spacing of 1 × 2 cm per plant without fertilizer. The seedlings were used 10, 17 and 24 days after seeding.

GLH was collected from rice fields of MARDI Bumbong Lima and reproduced on a susceptible variety Kadaria in cages (31 × 25 × 28 cm).

Six replications were made for each variety. In each replication, one seedling and 5 second or third instar nymphs were placed in a test tube (18 × 1.8 cm), top of which was covered by net. The mortality was recorded 4 days after infesting. The resistance levels were classified by mortality (%) as susceptible (S: 0–30%), moderate (M: 31–70%) and resistant (R: 71–100%).

The above method of antibiosis test and classification of the resistance level were employed throughout the whole experiment reported in this paper, unless otherwise stated.

2) *Resistance level expressed by cut leaves and rootless seedlings*

From 26-day old seedlings of 6 varieties, cut leaves were prepared by cutting the base of leaf sheath, and rootless seedlings by

Table 1. Resistance level to GLH as influenced by seeding age

Varieties (resistance gene)	Resistance level* at indicated seedling age (in days)			Average mortality (%)
	10	17	24	
Pankhari 203 (Glh1)	R	R	R	95
ASD 7 (Glh2)	S	R	R	61
IR 8 (Glh3)	S	S	S	0
Ptb 8 (glh4)	S	M	R	58
ASD 8 (Glh5)	S	S	M	30
TAPL 796 (Glh6)	M	R	R	73
Maddai Karuppan (Glh7)	S	M	R	45
IR 28	S	M	M	32
IR 42	R	R	R	86
Sekencang	S	S	S	33
Average mortality (%)	32	53	61	49
Leaf number**	2.5	3.2	4.0	-

* Resistance level; S=0–30%, M=31–70% and R=71–100% in GLH mortality
** Leaf number including bladeless first leaf

removing roots. The rootless seedlings were able to produce new roots after the treatment. The test (Table 2) was made with 4 replications.

Table 2. Resistance level to GLH of cut leaves, rootless seedlings and intact seedlings

Varieties	Resistance level*		
	Cut leaves	Rootless seedlings	Intact seedlings
Pankhari 203	M	R	R
ASD 7	S	M	M
Ptb 8	S	M	R
TAPL 796	S	R	R
Maddai Karuppan	S	M	M
IR 42	R	R	R
Average mortality (%)	33	74	82

* Resistance level; S=0–30%, M=31–70% and R=71–100% in GLH mortality

3) Inheritance of resistance genes to GLH

Resistant varieties, IR 36, IR 42 and Pankhari 203, were crossed with susceptible Seribu Gantang or Sekencang (Table 3). In addition, resistant ASD 7 and TAPL 796 were crossed with IR 42 for an allele test between the resistance genes. Resistance level of 60 F_2 seedlings and 5 seedlings of the parents was examined by using seedlings of 20–25 days of age. The combination of IR 42/TAPL 796 was examined 3 times.

Unselected standard GLH was used to 3 combinations, Pankhari 203/Seribu Gantang, Sekencang/IR 36 and IR 42/Seribu Gantang. A GLH biotype, IR 28 colony, capable to develop and reproduce on IR 28 which is moderately resistant to GLH, was used for IR 42/Seribu Gantang and 2 other combinations. The IR 28 colony was used to eliminate the effect of moderately resistance gene in the resistant varieties.

Results

1) Resistance level as related to seedling age

Average GLH mortality shown at 10, 17 and 24 days of age was 32, 53 and 61%, respectively (Table 1). The older seedlings were more resistant than youngest seedlings.

The resistance level of ASD 7, Ptb 8, ASD 8, TAPL 796, Maddai Karuppan and IR 28 was S or M in the youngest seedlings and M or R

Table 3. Distribution of F_2 plants in GLH resistance

F_2 combination and parents	GLH colony	GLH mortality (%)*						Total number
		0	20	40	60	80	100	
Pankhari 203	Unselected						5	5
Seribu Gantang	do	3	2					5
Pankhari 203/Seribu Gantang	do	9	8	0	2	9	32	60
Sekencang	Unselected	4	1					5
IR 36	do						5	5
Sekencang/IR 36	do	5	1	2	8	24	20	60
IR 42	Unselected				1	3	1	5
Seribu Gantang	do	4	1					5
IR 42/Seribu Gantang	do	3	3	5	11	16	22	60
IR 42	IR 28 colony			1	3	1		5
Seribu Gantang	do	4	1					5
IR 42/Seribu Gantang	do	11	5	11	24	5	4	60
IR 42	IR 28 colony			1	1	2	1	5
ASD 7	do					4	1	5
IR 42/ASD 7	do	4	1	7	9	15	24	60
IR 42	IR 28 colony			1	3	6	5	15
TAPL 796	do				1	3	11	15
IR 42/TAPL 796 (1)	do	1	1	6	7	14	31	60
do (2)	do		1	6	7	19	33	60
do (3)	do	3	1	7	13	16	20	60

* Each mortality corresponds to GLH number killed in a test tube, i.e. 1=20% to 5=100%.

in the oldest seedlings. On the other hand, the resistance level of Pankhari 203 and IR 42 was R at all seedling ages and that of IR 8 and Sekencang was S at all seedling ages.

2) Resistance level of cut leaves and rootless seedlings

Average GLH mortality on cut leaves, rootless seedlings and intact seedlings was 33, 74 and 82%, respectively (Table 2). The cut leaves were less resistant than intact seedlings.

Pankhari 203 gave the mortality of 45% (M) on cut leaves and 100% (R) on intact seedlings. The resistance level of ASD 7, Ptb 8, TAPL 796 and Maddai Karuppan was S on cut leaves and M or R on intact seedlings. On the other hand, the resistance level of IR 42 was always R.

3) Inheritance of resistance genes to GLH

A good fit to a monogenic ratio of 3-resistant: 1-susceptible was obtained in the F_2 segregation of Pankhari 203/Seribu Gantang (Tables 3 and 4). On the other hand, F_2 segregation of Sekencang/IR 36 and IR 42/Seribu Gantang agreed with ratio of 15-resistant: 1-susceptible. However, when the GLH biotype IR 28 colony was used for the test, the segregation of IR 42/Seribu Gantang agreed with a monogenic ratio. In addition, when the IR 28 colony was used for the allele test, F_2 segregation of IR 42/ASD 7 and IR 42/TAPL 796 agreed with the ratio of 15-resistant: 1-susceptible. With IR 42/TAPL 796, the same results were obtained 3 times.

Discussion

1) Variation of antibiosis

Kishino and Ando (1979)[3] reported that resistance to Japanese GLH (*Nephotettix cincticeps* Uhler) varied with the growing

Table 4. Reaction to GLH of F_2 populations

F_2 combinations	GLH colony used for test	Number of F_2 plants*			P value (3:1 or 15:1)
		R	S	Total	
Pankhari 203/Seribu Gantang	Unselected	43	17	60	0.50–0.75 (3:1)
Sekencang /IR 36	do	54	6	60	0.25–0.50 (15:1)
IR 42 /Seribu Gantang	do	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	do	55	5	60	0.50–0.75 (15:1)
IR 42 /TAPL 796 (1)	do	58	2	60	0.25–0.50 (15:1)
do (2)	do	59	1	60	0.25–0.50 (15:1)
do (3)	do	56	4	60	0.75–0.90 (15:1)

* R: Resistant=40–100% and S: Susceptible=0–20% in GLH mortality.

stage of rice plants, showing the highest resistance 20 days before heading. Rapusas and Heinrichs (1982)[5] showed that the resistance to GLH varied with plant age and insect survival generally decreased with plant age. In the present study, effect of seedling age was investigated in detail and it was found that very young seedlings with 2.5 leaves were not resistant in some varieties whereas seedlings with 3.2–4.0 leaves were resistant. It suggests that seedling age must be taken into account in screening for GLH resistance.

It was also reported that the use of cut leaves was effective in screening varietal resistance to Japanese GLH.[3] However, the present study showed that cut leaves of most of resistant varieties were not resistant. There may be some differences between the used Japanese and Malaysian GLH in this point.

2) Mechanism of antibiosis

Auclair et al. (1982)[1] reported that GLH fed predominantly on phloem sap in susceptible varieties, but in resistant varieties, GLH was not able to do it, so that it had to feed on xylem sap. As a result GLH could not survive long due to lack of nutrients in xylem sap.

Kishino and Ando (1978)[2] reported that upper leaves are more resistant than lower leaves to Japanese GLH. In the present study, cut leaves of most of the resistant varieties were not resistant but rootless seedlings were resistant.

It seems that inhibited feeding on phloem sap and aging or activity of plants may be involved in the resistance mechanism.

3) Inheritance of resistance genes to GLH

Kobayashi et al. (1983)[4] analysed that IR 42 has 2 resistance genes. The present study also revealed that IR 42 and the sister line IR 36 have 2 resistance genes. In addition, when a more virulent GLH biotype, IR 28 colony which can attack the moderately resistant variety IR 28, was used, it was shown that IR 42 has one gene. This result suggests that one of the genes of IR 42 is highly resistant and the other gene is moderately resistant like that of IR 28.

On the other hand, Rezaul Karim and Pathak (1982)[6] reported that TAPL 796 has the same resistance gene as Glh 6 in IR 36, which seemed to have the same resistance genes as those of IR 42 according to the present study. However, a high resistance gene in IR 42 was independent of the gene in TAPL 796 unexpectedly.

The authors (1985)[7] reported that the GLH biotype which can survive on IR 36 and IR 42 can not survive on TAPL 796 and the reverse is also true. In addition, it was shown in the present study that the youngest seedlings of TAPL 796 were moderately resistant when those of IR 42 were resistant, and cut leaves of TAPL 796 were susceptible when those of

IR 42 were resistant. These facts suggest that the resistance character of IR 42 is different from that of TAPL 796 or there may be some differences between GLH in Malaysia and that used by Rezaul Karim and Pathak.[6]

Summary

The resistance level of rice seedlings (*Oryza sativa* L.) to green leafhopper (GLH: *Nephotettix virescens* Distant) varied with age of the seedlings: seedlings of 3.2–4.0 leaf age were more resistant than 2.5 leaf age seedlings. However, Pankhari 203 and IR 42 were consistently resistant at all seedling ages examined. The resistance level of cut leaves was markedly lower than that of intact seedlings and rootless seedlings. However, IR 42 did not show, exceptionally, such changes in the resistance level.

It was shown by the inheritance study that Pankhari 203 has one dominant resistance gene to GLH, while IR 36 and its sister line IR 42 have 2 dominant resistance genes. Of the 2 resistance genes of IR 42, it seems that one has high resistance and the other moderate resistance. The high resistance gene of IR 42 seemed to be independent of resistance genes in TAPL 796 and ASD 7.

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References

1) Auclair, J. L., Baldos, E. & Heinrichs, E. A.: Biochemical evidence for the feeding sites of the leafhopper, *Nephotettix virescens* within susceptible and resistant rice plants. *Insect Sci. Application*, 3(1), 29–34 (1982).
2) Kishino, K. & Ando, Y.: Insect resistance of the rice plant to the green rice leafhopper *Nephotettix cincticeps* Uhler. I. Laboratory technique for testing the antibiosis. *Jpn. J. appl. Entomol. Zool.*, 22, 169–177 (1978) [In Japanese with English summary].
3) Kishino, K. & Ando, Y.: Insect resistance of the rice plant to the green rice leafhopper *Nephotettix cincticeps* Uhler. II. Fluctuation of antibiosis with growing stage of the resistant rice varieties. *Jpn. J. appl. Entomol. Zool.*, 23, 129–133 (1979) [In Japanese with English summary].
4) Kobayashi, A., Supaad, M. A. & Othman, O.: Inheritance of resistance of rice to tungro and biotype selection of green leafhopper in Malaysia. *JARQ*, 16, 306–311 (1983).
5) Rapusas, H. A. & Heinrichs, E. A.: Plant age and levels of resistance to green leafhopper, *Nephotettix virescens* (Distant) and tungro virus in rice varieties. *Crop Protection*, 1, 91–98 (1982).
6) Rezaul Karim, A. N. M. & Pathak, M. D.: New genes for resistance to green leafhopper *Nephotettix virescens* (Distant) in rice, *Oryza sativa* L. *Crop protection*, 1, 483–490 (1982).
7) Takita, T. & Habibuddin, H.: Relationship between laboratory-developed biotypes of green leafhopper and resistant varieties of rice in Malaysia. *JARQ*, 19, 219–223 (1985).

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