Japan. J. Breed. 39 : 23~28 (1989)

New Genes for Resistance to Brown Planthopper, *Nilaparvata lugens* Stål, in Rice

Hiroshi NEMOTO, Ryoichi IKEDA[1] and Chukichi KANEDA[2]

National Agriculture Research Center, Tsukuba, Ibaraki, 305

Genetic studies on resistance to brown planthopper in some rice varieties, in which resistance genes had been found but not identified, were conducted. Allelism tests revealed that resistance of 'Col. 5 Thailand', 'Col. 11 Thailand' and 'Chin saba' was governed by a recessive gene that was designated *bph 8(t)*, and that resistance of 'Balamawee', 'Kaharamana' and 'Pokkali' was governed by a dominant gene that was designated *Bph 9(t)*.

KEY WORDS: *Oryza sativa* L., *Nilaparvata lugens* Stål, insect resistance, gene identification.

Introduction

The brown planthopper (*Nilaparvata lugens* Stål., abbr. BPH) is one of the most serious insect pests of rice (*Oryza sativa* L.) throughout Asia. In southern Japan, it is also one of serious threats to rice production. BPH sucks plant sap and causes the damage on rice such as reduction of crop vigor, plant height, productive tillers and filled grains. 'Hopperburn' is complete drying and death of crops by heavy infestation of BPH. BPH is also a vector of ragged stunt and grassy stunt viruses which seriously decrease rice production in the South Asia.

ATHWAL *et al.* (1971), and LAKSHMINARAYANA and KHUSH (1977) reported that four types of BPH resistance in rice varieties, represented by 'Mudgo', 'ASD 7','Rathu Heenati' and 'Babawee' was controlled by single genes *Bph 1*, *bph 2*, *Bph 3* and *bph 4*, respectively. These resistance varieties were used as sources of resistance in our breeding program, and several lines Norin PL 3 with *Bph 1* (1985), Norin PL 4 with *bph 2* (1986), Norin PL 7 with *bph 4* (1988) and Norin PL 10 with *Bph 3* (1988) have been developed and registered as germplasm line by the Ministry of Agriculture, Forestory, and Fisheries (MAFF), Japan.

KANEDA *et al.* (1981) and IKEDA (1985) screened rice germplasm from foreign countries for BPH resistance and estimated their genotypes by reactions to BPH biotypes. IKEDA (1985) proved that the resistance of two varieties from Thailand and 'Chin saba' from Burma was controlled by a new recessive gene different from *bph 2* and *bph 4*, and resistance of 'Kaharamana', 'Balamawee' and 'Pokkali' was controlled by a new dominant gene different from *Bph 1* and *Bph 3*.

The objective of the present study is to identify new recessive and dominant genes in these varieties through allelism tests.

Materials and Methods

Six varieties that had been proved to have new resistance genes by IKEDA (1985) were

Received July 30, 1988

[1] Present address: *International Rice Research Institute*, P. O. Box 933, Manila, Philippines

[2] Present address: *Tropical Agriculture Research Center*, Tsukuba, Ibaraki, 305

Table 1. Used varieties in this examination and their seed sources

Variety	Seed source	NIAR[1] Acc. No.	Origin
Col. 5 Thailand	Plant Germp. Intro. Lab.,[2] NIAR	69-5	Thailand
Col.11 Thailand	ditto	69-11	ditto
Chin saba	Genet. Resources Stor. Cen.,[3] NIAR	190004	Burma
Balamawee	Plant Germp. Intro. Lab., NIAR	70-164	Sri Lanka
Kaharamana	ditto	70-505	ditto
Pokkali	ditto	70-189	ditto

[1] NIAR : National Institute of Agricultural Resources
[2] Plant Germplasm Introduction Laboratory, NIAR
[3] Genetic Resources Storage Center, NIAR

Table 2. Reaction of rice varieties to different biotypes of the brown planthopper

Varieties	Gene	Reaction to Biotypes[1]				Reference
		1	2	3	4	
Mudgo	*Bph 1*	R[3]	S	R	-	IKEDA (1985)
ASD 7	*bph 2*	R	R	S	-	ditto
Rathu Heenati	*Bph 3*	R	R	R	R	KHUSH *et al.* (1985)
Babawee	*bph 4*	R	R	R	R	ditto
TN 1	None	S	S	S	S	KHUSH *et al.* (1985)
Col. 5 Thailand	unknown, rec.[2]	R	R	R	-	IKEDA (1985)
Col. 11 Thailand	unknown, rec.	R	R	R	-	ditto
Chin saba	unknown, rec.	R	R	R	-	ditto
Balamawee	unknown, dom.	R	R	R	-	ditto
Kaharamana	unknown, dom.	R	R	R	-	ditto
Pokkali	unknown, dom.	R	R	R	-	ditto
ARC 10550	*bph 5*	S	S	S	R	KHUSH *et al.* (1985)
Swarnalata	*Bph 6*	S	S	S	R	KABIR and KHUSH (1988)
ARC 15831 (b)	*bph 7*	S	S	S	R	ditto

[1] Biotype 1 : the predominate type in Japan, Biotype 2 : the colony is able to survive on 'Mudgo', Biotype 3 : the colony is able to survive on 'ASD 7', Biotype 4 : the predominate type in Bangladesh
[2] rec. : single recessive gene, dom. : single dominant gene
[3] R : Resistant, S : Susceptible and - : Not tested.

used in this study (Table 1) and their reactions to different biotypes of BPH are shown in Table 2. Two unknown varieties from Thailand were collected in 1969 by AKIHAMA, and were named Col. 5 Thailand (hereafter Col. 5 T) and Col. 11 Thailand (hereafter Col. 11 T). Col. 5 T was from Saraburi, Phra Phutthab, Thailand. Col. 11 T was from Mae Hongson, Munag, Thailand. Chin saba was an introduction from Burma. Kaharamana, Balamawee and Pokkali were introduced from Sri Lanka in 1970. For allelism test, reciprocal crosses including Col. 5 T/Col. 11 T, Col. 5 T/Chin saba and Col. 11 T/Chin saba were made in

1983 and 1984. Reciprocal cross of Kaharamana/Balamawee and a cross of Kaharamana/Pokkali were made in 1984.

The bulk seedling test devised by KANEDA (1984) was used to identify BPH resistance of plant individuals. The pregerminated seeds were sown in 20 rows including two rows of check varieties with 13 seeds per row in a 15.5×26 cm plastic tray. One row was allotted to each F_3 line in the F_3 test. The Japanese variety 'Nipponbare' was used as the susceptible check, and 'BP 4' with *Bph 1* as the resistant check. Second- to third-instar nymphs of BPH of biotype 1 were released to seedlings at the first-leaf stage. The insects were evenly distributed to the rows, with an average of six to seven individuals per seedling. The reaction of seedlings was recorded about seven days after infestation when the susceptible check was wilted while the resistant seedlings had slightly visible injury. Each seedling of the F_1 and F_2 populations was classified as resistant (non wilted), moderately resistant (wilted after unfolding the next leaf) or susceptible (wilted). The F_3 lines were classified on a row basis as either resistant, segregating or susceptible.

Results and Discussion

In this seedling test, resistant seedlings showed slightly visible injury, but continued to grow normally, while susceptible seedlings were stunted then died. The difference between these reactions was clearly detected. A few seedlings showed wilting at the next leaf stage, then died. Such reaction was sometimes observed in the resistant check, too. This reaction was different from a category of resistant reaction (R) and that of susceptible reaction (S) and was classified as moderately resistant reaction (M). This moderately resistance may be caused by unfavorable conditions especially as the result of deterioration of plants under low light intensity in the test room. Therefore, the M reaction was dealt as a kind of the resistance reaction.

Table 3 shows reactions of the F_1 and F_2 plants of reciprocal crosses of Col. 5 T/Col.

Table 3. Reactions to the BPH biotype 1 in the F_1 and F_2 populations of crosses among varieties with a new recessive gene

Cross	Number of F_1 plants			Number of F_2 plants		
	R	M	S[1)]	R	M	S
Col. 5 Thai. / Col. 11 Thai.	7	0	0	769	34	14
Col. 11 Thai. / Col. 5 Thai.	13	0	0	535	38	13
Col. 11 Thai. / Chin saba	20	0	0	380	9	0
Chin saba / Col. 11 Thai.	16	3	0	140	18	5
Col. 5 Thai. / Chin saba	3	0	0	300	10	10
Chin saba / Col. 5 Thai.	26	0	0	169	11	2
Nipponbare (Susceptible check)	0	0	39	0	0	143
BP 4[2)] (Resistant check)	36	2	0	130	3	8

[1)] R : Resistant, M : Moderately resistant, S : susceptible
[2)] BP 4 is a resistant line with *Bph 1*.

Table 4. Reactions to the BPH biotype 1 in the F_3 lines of crosses among varieties with a new recessive gene

Cross	Number of F_3 lines		
	Resistant	Segregating	Susceptible
Col. 5 Thai. / Col. 11 Thai.	66	0	0
Col. 11 Thai. / Col. 5 Thai.	65	0	0
Col. 11 Thai. / Chin saba	63	0	0
Chin saba / Col. 11 Thai.	66	0	2
Col. 5 Thai. / Chin saba	66	0	1
Chin saba / Col. 5 Thai.	61	0	0
Nipponbare (Susceptible check)	1	0	23
BP 4[2)] (Resistant check)	21	0	0

[1)] BP 4 is a resistant line with *Bph 1*.

Table 5. Reactions to the BPH biotype 1 in the F_2 populations of crosses between varieties with a new dominant gene

Cross	Number of F_2 plants		
	R	M	S[1)]
Kaharamana / Balamawee	125	22	2
Balamawee / Kaharamana	215	10	0
Kaharamana / Pokkali	118	10	2
Nipponbare (Susceptible check)	0	0	39
BP 4[2)] (Resistant check)	36	2	0

[1)] R : Resistant, M : Moderately resistant, S : Susceptible
[2)] BP 4 is a resistant line with *Bph 1*.

11 T, Col. 5 T/Chin saba and Col. 11 T/Chin saba. None of F_1 plants was susceptible. There were a few plants that were classified moderately resistant in the cross of Chin saba/Col. 11 T. Almost all F_2 plants were resistant, but a few F_2 plants showed susceptible reaction. From the results of F_1 and resistant check, it was estimated that these susceptible seedlings were not geneticaly susceptibility but maybe occurred by some non-genetic factors such as unfavarable growth condition. Table 4 shows reactions of F_3 lines. In almost crosses, all F_3 lines were resistance. In the crosses of Chin saba/Col. 11 T and Col. 5 T/Chin saba, a few F_3 lines were killed and were classified as susceptible. But fewer lines died than expected on the basis of independent assortment of resistance gene and such reaction wasn't observed in receprocal crosses. Therefore it is guessed that lines were not genetically susceptible similar to F_2 generation, and we will confirm this result to retest same materials. This estimation that the resistance gene of these varieties was identical was confirmed by the reactions of F_1, F_2 and F_3 generations.

Table 5 shows reactions of the F_2 plants of the crosses of Kaharamana/Balamawee and

Kaharamana/Pokkali. All plants except two out of 130 plants of Kaharamana/Pokkali were resistant. Though there were no data for F_3 progeny, it was considered that dominant resistance gene of the three varieties was identical.

IKEDA (1985) has proved that the recessive gene found in Col. 5 T, Col. 11 T and Chin saba are non-allelic to the gene *bph 4*, and the dominant gene found Kaharamana, Balamawee and Pokkali are non-allelic to the gene *Bph 3*, and the newly identified resistance genes show different biotype reactions from *Bph 1* and *bph 2*. Therefore, the new recessive gene and dominant gene are different from *Bph1*, *bph 2*, *Bph 3* and *bph 4*. Their allelic relation to the genes *Bph 1* and *bph 2* is to be studied.

KHUSH *et al.* (1985) and KABIR and KHUSH (1988) reported that new resistance genes *bph 5*, *Bph 6* and *bph 7* were found from ARC 10550, Swarnalata and ARC 15831 (b), respectively. These genes convey the resistance to biotype 4 that is the predominate type in Bangladesh, but not to biotype 1 that is the predominate type in the Far East (Table 2). Therefore, the new recessive gene identified from Chin saba, Col. 5 T and Col. 11 T and dominant gene identified from Kaharamana, Balamawee and Pokkali are different from *bph 5*, *Bph 6* and *bph 7*.

Following the standard rules for gene nomenclature, the recessive gene of Chin saba, Col. 5 Thailand and Col. 11 Thailand is designated as *bph 8 (t)* and the dominant gene of Kaharamana, Balamawee and Pokkali is designated as *Bph 9 (t)*.

Acknowledgement

The authors are grateful to Dr. G. S. KHUSH for his kind suggestions in preparing this paper.

Literature Cited

ATHWAL, D. S., M. D. PATHAK, E. H. BACALANGCO and C. D. PURA 1971. Genetics of resistance to brown planthopper and green leafhopper in *Oryza sativa* L. Crop Sci. **11** : 747～750.

IKEDA, R. 1985. Studies of the inheritance of resistance to the rice brown planthopper (*Nilaparvata lugens* Stål) and the breeding of resistance rice cultivar. Bull. Natl. Agric. Res. Cent. **3** : 1～54.

KABIR, M. A. and G. S. KHUSH 1988. Genetic analysis of resistance to brown planthopper in rice, *Oryza sativa* L. Plant Breed. **100** : 54～58.

KANEDA, C. 1984. Studies on breeding japonica rice resistant to the brown planthopper, *Nilaparvata lugens* Stål. Bull. Natl. Agric. Res. Cent. **2** : 1～74.

————, K. ITO and R. IKEDA 1981. Screening of rice cultivars of resistance to the brown planthopper, *Nilaparvata lugens* Stål., by three biotypes. Japan. J. Breed., **31** : 141～151.

————, H. NEMOTO, R. IKEDA, M. YOKOO and A. KOBAYASHI 1985. Breeding of Rice Norin-PL 3, a new germplasm with brown planthopper resistance. Bull. Natl. Agric. Res. Cent. **5** : 93～103.

————, ————, ————, ————, ————, H. IKEHASHI and T. TAKITA 1986. Breeding of Rice Norin-PL 4, a new germplasm with the brown planthopper resistance gene '*bph 2*'. Bull. Natl. Agric. Res. Cent. **6** : 19～32.

KHUSH, G. S., A N M Rezaul KARIM and E R ANGELES. 1985. Genetics of resistance of rice cultivar ARC 10550 to Bangladesh brown planthopper biotypes. J. Genet. **64** : 121～125.

LAKSHMINARAYANA, A. and G. S. KHUSH 1977. New genes for resistance to the brown planthopper in rice. Crop Sci. **17** : 96～100.

NEMOTO, H., C KANEDA and R. IKEDA 1986. Identification of a new resistance gene to brown planthoppers in Japan. Rice Genet. Newsl. **3** : 87～88.

————, M. YOKOO, C. KANEDA, E. SHIMURA, R. IKEDA and A. KOBAYASHI 1988. Breeding of Rice

Norin-PL 7, a new germplasm with the brown planthopper resistance gene *'bph 4'*. Bull. Natl. Agric. Res. Cent. **9**: 93~105.

————, ———— ———— ————, ———— and ———— 1988. Breeding of Rice Norin-PL 10, a new germplasm with the brown planthopper resistance gene *'Bph 3'*. Bull. Natl. Agric. Res. Cent. (in press)

イネにおけるトビイロウンカ抵抗性の新しい遺伝子

根本　博[1)]・池田良一[2)]・金田忠吉[3)]

([1)]農業研究センター，茨城県つくば市，〒305)

([2)]現　国際稲研究所，P. O. Box 933，マニラ，フィリピン)

([3)]熱帯農業研究センター，茨城県つくば市，〒305)

IKEDA (1985) はバイオタイプによる再検索と既知遺伝子をもつ品種を用いた検定交配によってトビイロウンカ抵抗性品種の遺伝子型を推定し，新しいトビイロウンカ抵抗性遺伝子をもついくつかの外国品種を発見した．本報では，そのうち未同定の劣性1遺伝子をもつCol. 5 Thailand (69-5)，Col. 11 Thailand (69-11) およびChin saba (190004) と，未同定の優性1遺伝子をもつBalamawee (70-518)，Kaharamana (70-505) およびPokkali (70-189)を用いて，トビイロウンカ抵抗性遺伝子の対立性検定をおこなった．優劣各抵抗性遺伝子ごとに3品種間の交雑をおこない，雑種後代におけるトビイロウンカ抵抗性の分離を調べた．劣性遺伝子をもつ3品種間の交雑では，F_1，F_2，F_3世代における感受性個体の出現が極めて低く，これらの3品種の劣性遺伝子は同じ遺伝子座にあると推定された．また，優性遺伝子をもつ3品種でもF_2世代の検定で感受性個体がほとんどみられず，これらの品種の優性遺伝子も同じ遺伝子座にあると推定された．このトビイロウンカ抵抗性に関する劣性遺伝子を *bph 8(t)*，優生遺伝子を *Bph 9(t)*それぞれ命名した．