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Screening of Rice Cultivars for Resistance to the Brown Planthopper, *Nilaparvata lugens* Stal., by Three Biotypes

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Abstract

To identify rice cultivars resistant to the brown planthopper, *Nilaparvata lugens* Stal., 2,904 introductions of indigenous cultivars and breeding lines and 383 domestic, mostly old indigenous, cultivars were screened by the bulk seedling method with biotype I (wild type) of the insect. Except for the breeding lines most of the resistant indigenous cultivars were found to originate from Sri Lanka and southern India. While only a few originated from northern India, Burma and Thailand. Tolerant but not resistant cultivars distributed rather widely within Asia, while almost no one was detected in Europe, Africa, America and Australia. Biotype groups II and III of the brown planthopper, selected through rearing on the resistant cultivars, were found to be effective for estimating the genotypes of resistant cultivars. A total of 120 cultivars were classified according to their pattern of biotype reactions. About 60 per cent of the Sri Lanka cultivars were found to possess the resistance gene *bph* 2, in contrast with only 10 per cent among the Indian cultivars.

Introduction

Damage to rice by the brown planthopper, *Nilaparvata lugens* Stal, (abbr. BPH), was first recorded in 697 A.D. and has been one of the greatest hazard to rice farmers especially in western Japan. The most serious damage was recorded in 1732, when almost 72 per cent of the total rice production of Japan was devastated due to hopperburn and nearly one million of people died of hunger (SUENEGA and NAKATSUKA 1958). Chemical control of BPH which has been commonly practised after World War II became responsible for pollution of the environment and the development of planthoppers and leafhoppers resistant to insecticides.

In 1967 a new era started when dozens of rice cultivars resistant to BPH were identified at IRRI (International Rice Research Institute). In less than 10 years, several rice cultivars with two different genotypes of BPH resistance were introduced into several tropical countries for large scale cultivation. On the other hand, biotypes of BPH were experimentally bred, and also found in farmers fields, some of which causing breakdown of the resistance to insects of recommended cultivars in several countries (PATHAK and KHUSH 1979, KHUSH 1979).

With a view to widening the genetic base so as to enable the reliable use of BPH resistance, the identification of a larger number of cultivars with BPH resistance along with that of their genotypes is desirable. Much progress in this area has been made at IRRI and in Taiwan by using BPH biotypes bred experimentally in the laboratory (CHENG and CHANG 1979, PATHAK and KHUSH 1979).

In Japan, during the five year-period, 1975-1979, through the special research program on plant resistance to leafhoppers and planthoppers, coordinated by the Ministry of Agriculture, Forestry and Fisheries, entomologists of our station succeeded in breeding

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BPH biotypes capable of attacking cultivars with either *Bph 1* or *bph 2*, which so far had been considered as resistant. This achievement enabled us to phenotypically classify cultivars, which had been found resistant after 1973, according to their genotypes.

This paper reports the results of screening of rice cultivars from different areas of the world, along with their classification according to their reaction to BPH biotypes.

Materials and Methods

Mass rearing of biotypes of BPH

The biotype I (wild type) of BPH was first introduced to our insectary by Dr. KISIMOTO in our Station in 1973 for mass-rearing using young seedlings of the susceptible Japanese cultivars, 'Akitsuho' or 'Nipponbare', grown without soil (like 'dapog' seedlings in the tropics) in plastic trays placed in cages. The conditions inside the insectary were as follows : 16 Hr daylength with illumination of 500 to 600 lux supplied by fluorescent lamps, air temperature of 27°C-light and 22°C-dark. Each year, BPH immigrants caught in Kyushu Agric. Expt. St. were sent to us for identification of the biotype. After confirming that they belonged to biotype I, they were mixed with the old colony.

Biotype IIa, bred on '$F_8$262' (KANEDA and KISIMOTO 1979) and biotype IIb, bred on 'Mudgo' for more than 45 generations (ITO and KISIMOTO 1981) had been mass-reared since 1978 and 1980, respectively by the above-described method on 'Kanto PL 1' or 'Kanto PL 2', both being descendants of crosses involving primary breeding lines with Mudgo gene (*Bph 1*).

Biotype III was bred on 'ASD 7' (*bph 2*), for more than 35 generations (ITO and KISIMOTO 1981). Since 1979 the biotype has been mass-reared for nearly one year on 'IR 1154-243' (*bph 2*) and then on our breeding line 'Kanto PL 5', derived from the IR 1154 cross.

The method of mass-rearing is described in detail elsewhere (KANEDA 1975 a, b).

Screening of rice cultivars

Initial screening of rice cultivars was conducted in Japan from 1973 by using the biotype I. Bulk seedling method (PATHAK *et al.* 1969) was modified to meet the conditions of Japan and to be performed more easily and precisely. Fifteen seeds of each entry pregerminated in Petri dishes were planted in a row of 6.5 cm in a plastic tray measuring 26×15×3.3 cm filled with shallow soil (about 2～3 mm deep). Each tray accommodated a total of 20 rows including 2～4 resistant and susceptible check cultivars. Resistant check cultivars were 'Mudgo', 'IR 1414-67' or 'Kanto PL 1', each being of *Bph 1* resistance gene, and susceptible ones were 'Akitsuho', 'Nippon bare' or 'Taichung (N) 1'.

At the stage immediately preceeding the unfolding of the first leaf blade, 5 to 7 nymphs of BPH per seedling were caged so as to infest the seedlings. Such procedure enabled to discriminate plant resistance to BPH after 5 days under the conditions of the insectary. Infestation period beyond one week often caused wilting of plants even in the case of the resistant cultivars.

For such cultivars that showed reaction type (2) and (3) as described later, a further test was applied in a growth cabinet consisting of a longer infestation period under higher intensity of sunlight. The susceptible check 'Taichung (N) 1' was planted every

other row so that each entry could be compared with the check side by side.

Resistant cultivars, including those with mixed reaction, were retested for confirmation with the same biotype, and then screened for reaction to biotypes II and III in the same manner as in the case of biotype I.

Results

As shown in Table 1, a total of 3,287 rice cultivars excluding our own breeding lines were initially screened during the eight year-period, 1973-1980. Out of these, 2,881 were germ plasm collections of the National Institute of Agricultural Sciences (NIAS), and 287 were supplied by IRRI either through the Tropical Agriculture Research Center or directly as entries of IIRN (International Insect Resistance Nursery) in 1974 and of IRBPHN (Int'l Rice Brown Planthopper Nursery) after 1976.

Table 1. Number of rice cultivars rated for brown planthopper (biotype I or wild type) resistance, 1973-1980.

Region	Country, or group of cultivars	Reaction to BPH			Total
		R	M	S	
Japan	Indigenous, scented or red rice	0	10	153	163
	Indigenous, others	0	1	195	196
	Modern	0	0	24	24
Far East	Korea and China including Taiwan	27[a]	21	495	543
Southeast Asia	Philippines through Indonesia and Burma	117[b]	27	559	703
South Asia	India and Sri Lanka	235[c]	26	618	879
	Nepal, Bhutan, Bangladesh and Pakistan	1[d]	4	156	161
Near East and East Europe	Iran through U. S. S. R.	1[d]	1	161	163
West Europe	Italy through Spain	0	0	133	133
Africa	Egypt, Malagasy and West Africa	0	0	165	165
America and Oceania	North and South America and Australia	0	0	157	157
Total		381	90	2,816	3,287

R : resistant M : intermediate, or tolerant S : susceptible

(a) all cultivars are hybrid lines bred for BPH resistance in Korea and Taiwan

(b) most of these are hybrid lines bred for BPH resistance

(c) out of these, all of the 172 cultivars from Sri Lanka are indigenous

(d) not consistently resistant

The reaction of rice plants to BPH infestation was originally classified as follows:

(1) Resistant—no visible damage or growth inhibition, with the second leaf blade normally developing.

(2) Moderately resistant—very similar to (1) for the first 5 days or so, but plants start wilting without discoloration usually after one week of infestation.

(3) Intermediate or tolerant—the first leaf blade remains green, but the second leaf blade does not develop or displays poor development.

(4) Susceptible—the first leaf blade remains folded, and is killed after 5 days.

Several of cultivar groups of reaction type (2) and (3) were further evaluated in a growth cabinet to identify their BPH resistance. Under such high light intensity conditions, wilting of plants was not observed, and the evaluation became easier. After

Table 2. BPH resistance rating, under high light intensity conditions, of cultivars with doubtful reactions in the insectary.

Cultivar	Seed source (NIAS)	Rating (insectary)	2 weeks after infes.			3 weeks after infes.		
			Rep. 1	Rep. 2	ck	Rep. 1	Rep. 2	ck
Toboshi (Getta)	090182	M	2.7	5	4.9	5	5	
Dairyuu Seiyu	130101	M, M/S	4.5	1.7*	4.6	5	4.3	5
Bankoku	110320	M, S/M	4.1*	4.2	4.7	5	5	
Sentou (Youshuu)	110107	M, M/S	4.7	3.7*	4.9	5	5	
Shinhasen	110019	M-MS	4.1	1.0*	4.2	5	5	
Yourizou	110324	M	5	2.2*	4.7	5	5	
Chin saba	190004	MR/S, w.	1.0	2.1	5	3.4*	2.7*	5
Dawn	610027	M	5	3.9*	4.1	5	5	
Kaeu N. 651	320025	R, R	3.2*	1.8*	5	5	3.9*	5
Remadja	1967-83	MR/S	2.1	1.7*	4.7	4.3*	4.1*	5
Dewi Tara	1967-80	MR, MR	1.8*	4.3	5	3.3*	5	5
IR 4-93	1967-30	w., w.	0*	0*	5	0*	1.0*	5
Chhuthana	1967-15	R, R	3.5	3.3*	4.6	5	4.6	5
Ham Thong	1969-80	MR, MR	2.7*	3.5	2.3	5	5	
Snguon Thang	1969-97	M/S, MR	2.3*	5	2.3	5	5	
H 8	1968-30	R, M, MR	1.0*	0.3*	5	1.0*	1.0*	5
Adt 3	(a)	R, R	1.0*	0.5*	5	1.0*	1.0*	5

Rating (insectary) : M (tolerant type), S (susceptible), M/S (segregating ?), w. (wilting)
Numerical rating : average of all plants, 0 (no damage) to 5 (totally killed). The rating of ck (susceptible check TN 1) is for comparison with the rating of Rep. 1 or Rep. 2 marked with *, planted to the next row of the check.
Seed source : 090182, etc. are from Seed Storage Lab. and 1967-83, etc. are from 7th Lab., Division of Genetics, NIAS
(a) is from Shizuoka Pref. Agric. Expt. St.

two and three weeks of BPH infestation, most of the cultivars of reaction (3) proved to be susceptible, and cultivars of reaction (2) to be resistant (Table 2). Thus, 'resistant' in Table 1 includes the cultivars of reaction type (1) and (2), while 'intermediate' corresponds to type (3), most of which likely to be rated as susceptible if tested under high BPH population density.

Almost all of the BPH resistant indigenous cultivars originated from India especially South India, and Sri Lanka. All resistant cultivars in the Far East and most of the resistant cultivars in Southeast Asia were breeding lines selected for BPH resistance. Two indigenous cultivars from Thailand and one from Burma were resistant. One each from Cambodia, Nepal and U. S. S. R. showed a comparatively low level of resistance and reacted inconsistently.

In the beginning of the screening at IRRI, many of the resistant cultivars were found to be of the red kernel type. Therefore, traditional local cultivars in Japan with red kernels and/or scented rice unlike modern typical *japonica* were first screened. Through these tests no resistant cultvars were detected, but some 'tolerant' ones could be observed. The tolerant type was found rather widely in the region extending from Japan to Southeast and South Asia. However, the value of these cultivars as gene sources of BPH resistance was considered neglibible (KANEDA, IKEDA and KOBAYASHI 1977).

There are reports in India that several cultivers from Korea, Laos, Vietnam or the U. S. A. are highly resistant to the BPH. Therefore, we obtained some of them from IRRI and Tamil Nadu Agriculture University. As shown in Table 3, none of them were resistant in Japan, confirming that cultivars which are resistant to the BPH in Japan originate mostly from the southern part of the Indian subcontinent including Sri Lanka, and not from East Asia or other continents.

Table 3. Confirmation of BPH (biotype I) resistance in Korean, Vietnamese and other cultivars reportedly resistant in India.

Cultivar	Country of origin	Seed source[c]	Resistance rating in India[d]	Resistance in Konosu
Un Sun[a]	Korea	Acc. 19878	1.3*	S
Djawa Sredek	Indonesia	Acc. 17517	1.5*	S
Lua Ngu[b]	Vietnam	Acc. 16852	0.6*	S
Nang Lay	Vietnam	Acc. 16876	1.5*	S
Ngane Tie	Laos	Acc. 13010	1.0*	S
Ptb 33 (resistant check)			0.6*	R
MR 1523 (resistant check)			1.3—2.0*	—
T (N) 1			4.7—5.0*	S
Nira	U. S. A.	T. N. A. U.	0**	S
ASD 11	India	〃	1**	S

(a) japonica (b) red rice

(c) Acc. numbers refer to cultivars from IRRI, T. N. A. U. was supplied by Tamil Nadu Agric. U.

(d) * by KALODE *et al.* (1977), ** by Balasubramanian *et al.* (1978), both by rating of 0 (no damage) to 5 (killed).

It must be noted that entries with the same cultivar name sometimes reacted in an opposite way to the BPH. For example, 'Babawee' from IRRI was resistant to the BPH while 'Babawee' of NIAS Collection, 70-395, was susceptible. 'Pokkali' from IRRI was susceptible while 'Pokkali' from NIAS 70-189 was resistant. 'Hondarawala' NIAS 70-86, 70-117, 70-128, 70-131, 70-135, were resistant, while NIAS 70-48, 70-141, and 70-443 were susceptible.

Table 4 lists the selected indigenous cultivars resistant to BPH biotype I, and their reaction pattern to biotypes II and III. Most of the modern breeding lines and recommended cultivars are omitted, because their reaction to BPH biotypes can only be estimated from their parentage.

The infestation ability of our biotypes can be summarized as follows: biotype IIa can infest those cultivars with the gene *Bph 1* but can not kill 'Mudgo', biotype IIb can infest 'Mudgo' but only kill it when released very abundantly. Both biotypes IIa and IIb cannot infest cultivars with resistance genes other than *Bph 1*. Biotype III infests cultivars with the gene *bph 2* except for a few of them. 'PTB 18' and its derivative 'CR 94-13', as well as its progeny 'IR 36' are resistant to biotype III. With these exceptions, our biotypes could discriminate well between the various cultivars with regard to the genotypes of BPH resistance, as shown in Table 4.

Table 4. Classification of selected BPH resistant rice cultivars according to the reaction pattern to biotypes II and III.

(1) Cultivars from India

Cultivar[1]	Seed source[2]	Col. No.[3]	Heading[4]	Pattern[5]	Gene[6]	Ref.[7]
ARC 6650	IIRN 35	50-30	×	1		
〃	BPHN 79-4	—		3		
ASD 7	TABC	49-56	0	2	2	1
ADT 3	Shizuoka	50-54	0	2		
CO 10	Acc. 3691	51-142	0	1	1	4
CR 94-13	BPHN 76-38	51-137	0	3	2	
H 2871	200001			1		
HS 19	200025			1		
I-21	72-21	55-G1	×	3		
MTU 15	Acc. 6365	49-G	×	1	1	1
Mudgo	TARC	49-30	0	1′	1	1
PTB 7	67-112	50-61	0	3		
PTB 10	67-115	55-G2		3		
PTB 12	67-116	55-G3	×	3		
PTB 18	67-119	54-66E	×	3	2	2
PTB 19	IIRN 31	54-67E	×	3	3	6
PTB 20	67-120	55-G4	×	3		
PTB 21	67-121	54-68E	×	3	2, 3	3
PTB 31	67-131	50-70	0	1		
PTB 33	67-133	54-69E	×	3	*	6, 3
PTB 34	67-134	50-72	0	2	2	3
PTB 36	79-52	54-155E	0	3		
PTB 39	79-55	54-157E	0	3		
PTB 41	79-57	54-159E	0	3		
SLO 12	Acc. 6300	51-128	×	1	1	4
unknown	76-224	53-200	×	1		
WC 1252	Acc. 13743	51-131	×	1		
WC 1253	Acc. 11054	51-136	×	1		
WC 1259	Acc. 13745	51-132	×	1		

(2) Cultivars from Sri Lanka

Cultivar[1]	Seed source[2]	Col. No.[3]	Heading[4]	Pattern[5]	Gene[6]	Ref.[7]
Alagiyawannam	70-472	55-G6	×	2		
Alwee	70-143	53-67	×	2		
Andaragahawewa	Acc. 11974			1	1	3
Babawee	Acc. 8978	54-65E	×	3	4	4
Balamawee	Acc. 7752	—			1	4
〃	70-164	55-G7	×	3		
〃	70-518	55-G8	×	3		
Balarunga	70-259	53-98	×	2		
Deveredderi	70-54	53-35	×	1		
Dikwee	Acc. 7814	51-96E	0	2		
Dikwee 328	70-55	53-36	×	2	(2)	4
Gamanuraja	70-109	55-G10	×	2		
H 2	70-168	53-74	0	1		

Cultivar[1]	Seed source[2]	Col. No.[3]	Heading[4]	Pattern[5]	Gene[6]	Ref.[7]
H 102	70-204	53-82	×	2		
H 103	70-201	53-81	×	2		
H 105	70-191	53-78	×	2	(2)	5
H 106	70-62	53-39	×	2		
Hathiel	Acc. 7730	51-82 E	×	2	2	4
Heenati	70-237	53-90	0	1		
Heendurawala 502	70-41	53-30	×	2		
Heendurawala	70-86	53-48	×	2		
〃	70-135	53-65	×	2		
Heenakkulama	Acc. 11978	51-138 E	0	1	1	4
Heenwee	70-368	53-107	×	2		
Hetadawee	70-214	53-86	×	1		
Hondarawala	70-117	54-145	×	2		
〃	70-128	53-60	×	2		
〃	70-131	55-G 17	×	2		
Hondarawala II	70-118	53-57	×	3		
Hondarawala 378	70-43	53-34	×	3		
〃 378	70-162	55-G 20	×	3		
Hondarawala 502	70-161	53-71	×	3		
H. sudu Henaderawala	70-142	53-66	×	2		
Kaharamana	70-505	53-142	×	3		
Kettiyaran	70-99	53-53	×	1		
Kokuvellai	70-444	54-159	×	2		
Kosatawee	Acc. 11677	51-145 E	0	2	2	4
Kurulutuduwee	70-35	53-27	×	2		
M. 104	70-66	53-40	×	2		
M. 304	70-75	53-44	×	2		
Madael	70-498	53-141	0	1		
Mahadikwee	70-360	53-104	×	2		
〃	Acc. 11956	51-146 E	0	2	2	4
Mahahondarawala	70-132	53-64	×	2		
Makadabapu samba	70-90	53-50	×	2		
Malawariya	70-241	53-95	×	1		
Manalavari	70-222	53-89	×	1		
Mawee	70-421	53-125	×	2		
M. I. 329	Acc. 12089	51-147 E	0	2	2	4
Mihageda	70-106	53-54	×	2		
Moddai karuppan	70-493	53-139	×	1		
Mudukiriel	70-407	53-118	×	3	(3)	6
Muppangan	70-380	53-113	×	1		
Murunga 307	70-68	53-42	×	1		
Murunga 308	70-208	53-84	×	1		
Murungakayan	Acc. 8955	50-43 E	0	2		
〃	70-390	55-G 37		2		
〃	70-476	53-135	×	2		
〃	70-497	55-G 39		1		
Murungakayan 3	Acc. 12071	50-44 E	0	2		
Murungakayan 101	Acc. 12072	50-45 E	0	2		

Cultivar[1]	Seed source[2]	Col. No.[3]	Heading[4]	Pattern[5]	Gene[6]	Ref.[7]
Murungakayan 104	Acc. 12078	51-148 E	0	2		
Murungakayan 302	70-196	53-79	×	2	2	4
Murungakayan 303	Acc. 12074	50-46 E	0	2		
Murungakayan 304	Acc. 12073	51-149 E	0	2		
Murungawee	70-486	53-137	×	1		
Murunkan	70-221	53-88	×	2		
Muthumanikam	70-77	53-45	×	3	(3)	6
Ovar karuppan	Acc. 11963	51-151 E	0	2	2	4
Perum karuppan	70-362	53-105	×	1		
P. K. 1	70-353	53-103	×	2		
〃	Acc. 11703	51-152 E	0	2	2	4
Pawakkulama	Acc. 11983	51-139 E	0	1		
Pokkali	70-189	53-76	×	3		
Rathwee	70-95	53-51	×	2		
Rathu Balawee	70-238	53-94	0	1		
Rathu Heenati	70-403	53-231	×	3		
〃	Acc. 11730	54-64 E	×	3	3	4
Rathu Hondarawala	70-441	53-130	0	2		
Seruvellai	Acc. 8990	51-155 E	×	2	2	4
Sinnakaruppan	Acc. 11731	51-154 E	×	2	2	4
Sinna kayam B	Acc. 11687	51-140 E	0	1	1	4
Sudu Galkada	70-326	53-102	×	2		
Sudurvi 305	Acc. 3475	50-49 E	0	1	1	4
Suduwee 305	70-37	53-28	×	1		
Tibiriwewa	Acc. 11969	51-141 E	0	1	1	4
Vellai Ilankarayan	70-96	53-52	×	2		
V. I. 28061	70-58	55-G 49		2		
〃	70-190	53-230	×	2		
(3) Cultivars from other countries						
Col. 5, Thailand	69-5	54-107	×	3		
Col. 11, Thailand	69-11	54-114	×	3		
Chin saba	190004		×	3		

Notes for Table 4.

1) Listed here are, in general, only indigenous cultivars with uniform (not mixed) reactions to biotypes. In case many cultivars with the same name are available, some with the same reaction pattern are omitted.

2) IIRN, BPHN, and Acc. are from IRRI. TARC was given in 1973 by the Tropical Agriculture Research Center. 200001, etc. are from the Seed Storage Lab., Division of Genetics, NIAS, and 72-21 etc. are from the 7th Lab., Div. Genetics, NIAS.

3) Test No. in Central Agr. Expt. St., Konosu
E : 'early planting' culture, G : seed increase culture in the glasshouse.

4) Heading in Konosu under the field conditions described in 3)
o : positive, x : no heading

5) Reaction pattern to biotypes II and III
1 : S (susceptible) and R (resistant), 2 : R and S, 3 : R and R

6) BPH resistance gene decided by genetic studies
1 : *Bph* 1, 2 : *bph* 2, 3 : *Bph* 3, 4 : *bph* 4, * : two genes of unknown allelic relationships.

7) References for the genetic study of 6)
1 : ATHWAL *et al.* 1971, 2 : ATHWAL and PATHAK 1972, 3 : IKEDA and KANEDA 1981, 4 : LAKSHMINARAYANA and KHUSH 1977, 5 : MARTINEZ and KHUSH 1974, 6 : SIDHU and KHUSH 1978

Discussion

Round-the-year screening of rice cultivars for BPH resistance was successfully conducted inside a small pre-fabricated insectary 12 m^2 in size. However, due to the rather low capacity of the cooling unit, light intensity was too low to keep the rice plants vigorous enough, especially in the case of some tropical cultivars. As a result, approximately one week after the infestation, these exhibited wilting of the whole plant, which was not observed in our breeding lines, even though they are resistant to BPH.

When the infestation period requires more than one week, due to, for example, the smaller number of nymphs, the cages should be placed outdoors in the summer, or be maintained in the greenhouse in winter for preventing wilting. Installation of more lamps is also effective to reduce the percentage of wilted plants. At present, a small frame, set inside a glasshouse, covered by a plastic sheet and equipped with a heater, can be effectively used in winter for genetic studies requiring precise evaluation of BPH resistance for each plant.

Retesting and biotype testing showed that the distribution of BPH resistant cultivars appears to be location-specific. So far, the cultivars found to show a consistent resistance to BPH originated from the region of Sri Lanka, India, Burma and Thailand. Indigenous cultivars from Sri Lanka exhibited a BPH resistance in a very high probability. Most of the BPH resitant cultivars of India originated from Kerala, Tamil Nadu and Andhra Pradesh states. Some cultivars in China (including Taiwan), Indonesia, Thailand, etc., seemed to be tolerant to the BPH but not resistant.

However, reports from India (KALODE *et al.* 1977, BALASUBRAMANIAN *et al.* 1978) suggest that cultivars from other regions, such as Korea, the U. S. A. and Laos, could become gene sources of BPH resistance if the biotypes were different.

Comparison of two different seed sources in Japan might be interesting and also important from the standpoint of utilization of germ plasm. The Seed Storage Lab supplied us with 1,103 cultivars and the 7 th Lab, both of the Division of Genetics, NIAS, supplied us with 1,778 cultivars. Among these, we could identify 3 and 81 BPH resistant cultivars, respectively. Such a marked discrepancy in recovery percentage can be ascribed to the following reason. Cultivars which do not flower and mature in the fields in Japan were not included in the collection of the Seed Storage Lab., while the 7 th Lab which is responsible for germ plasm collection worldwide keeps cultivars from lower latitudes. Such cultivars cannot be sent to the Storage Lab due to insufficient seed amount. As seen in Table 4, many of the BPH resistant cultivars cannot flower or mature in Konosu perhaps bacause of their high photoperiod sensitivity. In spite of this limitation, we consider it important to send these cultivars to the Seed Storage Lab for better utilization of germ plasm by a larger number of scientists. An institution, specially assigned for securing a sufficient amount of seed from each of introduced germ plasm, is needed.

Comparison of the biotype reaction pattern and the genotype shown in Table 4 indicates that the two factors coincide well except for some cultivars. 'PTB 18' and its progeny 'CR 94-13' were not damaged by the biotype III. 'PTB 18' was reported to

have *bph 2*, leaving a question why it gave an inexplicable F_2 segregation of 90 resistant, 4 susceptible and 19 segregating when crossed with a susceptible cultivar 'Pankhari' (ATHWAL and PATHAK 1972). Biotype reaction of 'ASD 7' (*bph 2*) and'PTB 18' is quite different also in Taiwan (CHENG and CHANG 1979). Therefore, the genotype of 'PTB 18' is to be further studied. In the case of 'Mudgo', it showed an intermediate or tolerant reaction to the biotype II, but was finally killed when infested with abundant BPH.

'Balamawee' is considered to possess *Bph 1* (LAKSHMINARAYANA and KHUSH 1977), although the two collections of 'Balamawee' in Japan, 70-164 and 70-518, were resistant to both biotypes II and III. PATHAK and KHUSH (1979) also reported the same phenomenon in 'Balamawee' (Acc. 7752 and Acc. 8919). 'Murungakayan' and its selections usually behaved as susceptible to the biotype III, except for one, 70-497. Plant characteristics should be checked to determine whether they belong to the same group.

Based on these analyses, it seems very probable that cultivars with the pattern 1. of biotype reaction are those with the resistance gene *Bph 1* and cultivars of the pattern 2. harbour the gene *bph 2*. Considering the genetic interrelationship among the four named genes (ATHWAL *et al.* 1971, LAKSHMINARAYANA and KHUSH 1977, SIDHU and KHUSH 1978, IKEDA and KANEDA 1981), cultivars with the parrern 3. may possess *Bph 3*, or *bph 4*, or other gene(s), or multiple number of resistance genes.

The distribution of resistance genes *Bph 1*, *bph 2* and others in Sri Lanka and India seems not homologous. Fifty-nine percent of Sri Lanka cultivars tested were estimated to possess the gene *bph 2* contrasting with only 10 percent of Indian cultivars. On the other hand, only 15 percent of Sri Lanka cultivars showed the biotype reaction pattern 3. while as many as 48 percent of Indian cultivars did so, though many of them were PTB selections. This may be related to the fact that all the three resistant cultivars in Burma and Thailand showed the biotype reaction pattern 3. However, the inquisition into the origin of BPH resistance genes is to be continued.

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トビイロウンカの3種のバイオタイプによる抵抗性イネ品種の検索と遺伝子型分類

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イネのトビイロウンカ抵抗性の遺伝的基盤を拡げる目的で，世界のイネ品種系統3,287を主として昆虫飼育室内で，野生型ウンカ（バイオタイプⅠ）を用いた集団幼苗検定法により抵抗性検索を行なった。

わが国の赤米，香稲を含む各地在来品種，朝鮮半島，台湾，中国，フィリピン，インドネシア，西アジア以西，アフリカ，南北アメリカ，オーストラリアからは抵抗性遺伝子源品種は検索されず，抵抗性品種は主にスリランカ，南インドに集中し，北インド，ビルマ，タイに少数発見された。

日本在来赤米品種には数日間の幼苗検定で耐性を示すが，長期にわたると弱反応を示すものがあり，この反応型はアジア各地のイネに広く見られるが，他の地域には見られない。

バイオタイプⅠに対する抵抗性品種系統のうち，抵抗性目的の育成系統を除いて，バイオタイプⅡ（抵抗性遺伝子 *Bph* 1 をもつ 'Mudgo' または育成系統 'F_8 262' 上で継代飼育選抜したウンカ）とバイオタイプⅢ（遺伝子 *bph* 2 をもつ 'ASD 7' 上で継代飼育選抜したウンカ）で抵抗性の再検索を行なったところ，既知の抵抗性遺伝子型の品種は一定の反応型を示した。バイオタイプⅡ，Ⅲに弱・強，強・弱，強・強の反応型を，それぞれ 1, 2, 3 と分類したとき，それぞれの反応型の品種は *Bph* 1 品種群，*bph* 2 品種群，およびその他の品種群に属するものと考えられる。

総数 120 品種系統を起源国別に A, B, C 順に配列し，種子起源を明示して，それぞれのバイオタイプ反応型を表示し，遺伝子型の同定されたものはこれを併記して，今後の研究の便に供した。