Breeding for resistance to brown planthopper and grassy stunt virus in Indonesia

Z. Harahap

The brown planthopper (BPH) *Nilaparvata lugens* Stål has been a major rice insect pest in Indonesia since 1975. Pelita I-1, one of the popular varieties grown by farmers, was heavily damaged by BPH and heavy losses from grassy stunt virus (GSV) usually followed.

Damage by BPH has been significantly reduced by growing the BPH-resistant rices IR26, IR28, IR30, and IR34. To date IR26 is the leading BPH resistant variety grown by farmers.

Since late 1976, IR26, IR28, IR30, and IR34 became susceptible to BPH in North Sumatra. IR32, however, grown adjacent to those varieties, showed resistance. A new biotype of BPH has apparently developed in North Sumatra.

An active breeding program is underway to Incorporate into improved varieties resistant to BPH and GSV as well as to other insect pests and diseases. A modification of the single-seed-descent, bulked-hybrid method is used to cope with the rapid expansion of hybridizations and the limited mass-screening facilities. Several lines resistant to BPH and GSV are being tested throughout the main rice-growing areas in Indonesia. Some of the lines are resistant to BPH biotype 2.

BEFORE 1970, THE BROWN PLANTHOPPER (BPH) was considered a minor pest of rice in Indonesia. In 1954 insignificant hopperburn was reported on Sigadis at Genteng Station, East Java. In 1960 hopperburn was observed near Karawang, West Java, on about 10 ha of Bengawan and other local varieties. Then between 1968 and 1972 localized hopperburn occurred on IR5 and C4-63 in many fields in East and Central Java. In 1973 BPH outbreaks occurred in many rice-growing areas of Indonesia, especially on Pelita I-1, IRS, and C4-63 in Bali, East Java, Central Java, and North Sumatra.

The government immediately released and widely distributed resistant varieties such as IR26, IR28, and IR30. In a short time, IR26 became popular in hopper-affected areas. Later, IR34 was released. Because the resistant varieties lack the eating qualities preferred by Indonesians and because they are sus-

Plant breeder, Central Research Institute for Agriculture, Bogor, Indonesia.

ceptible to sheath blight and "brown panicle," some farmers were reluctant to grow them. IR30 is susceptible to bacterial leaf streak and IR34 lodges easily.

In the Banyuwangi area of East Java, hopperburn was significantly reduced through intensive control measures, including the growing of resistant varieties, application of recommended insecticides, and adoption of strictly enforced regulations on time of planting. Other crops were grown when rice could not be planted. IR26 has been the leading resistant variety grown. In April 1977 hopperburn was insignificant in the area and IR26 was still resistant.

In other areas of East, Central, and West Java, the disappearance of hopperburn caused by the use of resistant varieties encouraged farmers to again grow Pelita I-1, a high yielding variety that has preferred eating qualities but is highly susceptible to the BPH, grassy stunt virus, and tungro virus. Consequently, serious outbreaks of hopperburn were observed in parts of East and Central Java in March 1977. In West Java, where Pelita I–1 and traditional varieties were still the leading varieties, severe hopperburn occurred in late 1976 and early 1977.

In parts of North Sumatra, IR26 was widely planted starting in 1973. Considerable areas were later planted to IR28, IR30, and IR34. The destruction by hopperburn in late 1976 and early 1977 of about 15,000 ha of rice in North Sumatra, including fields of IR26, IR28, IR30, and IR34, indicated that a new biotype of the BPH had developed in North Sumatra. However, IR32 in adjacent fields showed strong resistance.

The government is expected to recommend soon either IR32 or IR36, or both, for release in North Sumatra.

The BPH today is one of the most destructive and dangerous rice pests in Indonesia. Associated with it is the grassy stunt virus, of which it is a vector. Heavy losses from the grassy stunt virus have followed the BPH epidemics. Efforts of Indonesian rice breeders to incorporate resistance to BPH and the grassy stunt virus into our leading varieties are briefly reviewed in this report.

BREEDING OBJECTIVES

The incorporation of resistance to the BPH, the grassy stunt virus, and tungro virus into improved-plant type varieties are major breeding objectives of the national rice varietal improvement program of Indonesia. Such varieties as Pelita I-1, C4-63, Adil, Makmur, and Gemar are being crossed and, in some cases, backcrossed to an array of resistant donor parent varieties.

Crosses used in the BPH program

Tables 1 and 2 list some of the important crosses that are being used to develop improved varieties resistant to BPH biotypes 1 and 2.

The parental sources used for incorporating biotype-1 resistance into improved-plant type varieties include advanced-generation breeding lines from IR2031, IR2061, IR2153, B2360, and B2361 (Table 1). Donor parents of

Table 1. Bogor crosses carrying resistance to BPH biotype-1 gene.

Cross no	Combination	Generation	Test site
B3063	IR2061-228-3-9/Pelita I-1	F_3	Pusakanegara
B3065	IR2061-228-3-9/Makmur	F_3	Kunmgan-Pusakanegara
B3066	IR2061-228-3-9/B541b-Kn-91-3-1	F_3	"
B3067	IR2061-228-3-9/Adil	F_3	"
B3313	B2360-6-1-2/8541b-Kn-19-3-4	F_3	Pusakanegara
B3318	B2360-6-5-1/Makmur	F_3	"
B3355	B2361-1-LR-4/B541b-Kn-19-3-4	F_3	"
B3356	B2361-1-1-LR-4/Makmur	F_3	"
B3389	Segon Beureum/IR2061-213-2-16	F_3	"
B3390	Segon Beureum/IR2153-159-1-4	F_3	"
B3391	Segon Beureum/IR3265-193-3-3	F_3	"
B3188	IR2031-238-5-2-5/Makmur	F_2	Kuningan
B3189	IR2031-238-5-2-5/Gama 318	F_2	"
B3195	IR2031-354-2-3/Gati	F_2	"
B3258	IR2153-26-3-5/Pelita I-1	F_2	"
B3261	IR2153-26-3-5/8541b-Kn-19-3-4	F_2	"
B3263	IR2153-159-1-4/Pelita I-1	F_2	"
B3215	IR2061-2-16/Jogo	F_3	Muara
B3216	IR2061-2-16/Cempo	F_3	"
B3217	IR2061-2-16/Bandang Salak	F_3	"
B3218	IR2061-2-16/Si Rumbia	F_3	"
B3307	B2360-6-1-2/Jogo	F_3	"
B3308	B2360-6-1-2/Lumut	F_3	"
B3309	B2360-6-1-2/Si Rumbia	F_3	"

biotype-2 resistance include CR94-13 and advanced breeding lines from IR2070, IR2071, and B3753. Other important hybridizations listed in Tables 1 and 2 include crosses between BPH-resistant varieties and such traditional varieties as Arias (upland); N. Tinuwu (stem borer resistant); Kewal (bulu); Lumut. Segon Beureum, and Jerak (high elevation); Balap Merah, Jogo, Cempo, Bandang Salak, and Si Rumbia (lowland); and Kencana, a bulu/indica hybrid variety of the traditional plant type developed at Bogor by Dr. H. Siregar in the 1940's. The traditional varieties are important sources for the development of improved rainfed and upland varieties.

BACKCROSS PROGRAM

Backcross programs have been started to transfer BPH resistance genes to such popular varieties as Pelita I-1 and Makmur. The F_2 plants of promising combinations B3063 (IR2061-228-3-9/Pelita) and B3065 (IR2061-228-3-9/Makmur) were infested with BPH in the greenhouse. Surviving resistant plants were transplanted to the field and selected plants were crossed back to Pelita I-1 and Makmur.

The second backcrosses have now been made. Also, tests of some BPH-resistant F_2 progenies of B3063 and B3065 were obtained at the Muara, Mojosari, and Kendalpayak stations in the 1976–77 wet season. Many of these F_3 lines gave resistant reactions to the grassy stunt virus at the Mojosari and Kendalpayak stations.

Table 2. Bogor crosses carrying brown planthopper resistance to biotype-2 gene.

Cross no.	Combination	Generation	Test site
B2589	IR2157-3/IR946-33-2-4//Pelita I-1	F_5	Muara
B2791	Pelita I-1//CR94-13/IR20	F_4	"
B3238	IR2070-132-3-3/Makmur	F_3	Pusakanegara
B3239	IR2070-132-3-3/Gama 318	F_3	Singamerta
B3240	IR2071-77-3-3/Pelita I-1	F_3	Kendalpayak
B3241	IR2071-7-3-3/Gata	F_3	"
B3242	IR2071-77-3-3/Gati	F_3	Singamerta
B3243	IR2071-77-3-3/Adil	F_3	Kendalpayak
B3244	IR2071-77-3-3/Makmur	F_3	"
B3252	IR2157-10-190-3-5/Pelita I-1	F_3	Singamerta
B3508	IR2071-669-3-6-5/C4-63Gb	F_3	Muara
B3515	IR442-2-58/Kencana	F_2	"
B3518	CR94-13/Kencana	F_2	"
B3520	IR2071-636-5-5/Kencana	F_2	"
B3541	It72071-636-5-5/Gernar	F_2	"
B3586	Arias/IR36	F_2	"
B3593	N. Tinuwu/IR36	F_2	"
B3594	Jerak/IR36	F_2	"
B3596	Remaja/IR36	F_2	"
B3603	Pelita I-1/Arias//IR2070-178-2-3-4	F_2	"
B3609	Lumut/IR2070-178-2-3-4	F_2	"
B3611	Gemar/IR2070-178-2-3-4	F_2	"
B3615	Balap merah/IR2071-178-2-3-4	F_2	"
B3650	IR2071-669-3-6-5/Kewal	F_2	"

Modified single-seed-descent bulk method

Because of the rapid expansion of hybridizations and because of limited facilities for mass screening of thousands of pedigree lines for resistance to diseases and insects, and other traits, a modified single-seed-descent bulked-hybrid method is being used. The F_2 through F_6 of many crosses are routinely transplanted at 5- × 5-cm plant spacing or at a population of approximately 6,000 plants/20 m^2. The tall and late-maturing plants are discarded, and four or five seeds from each remaining plant of each population are harvested. The seeds are bulked and used for growing the next generation.

Whenever a BPH epidemic occurs in a suitable area on one of the substations or in a farmer's field, the bulked hybrid populations are seeded in infested areas and surviving plants are transplanted at close or normal spacings. No insecticides are used.

Bulked hybrid populations and pedigree lines are screened in the field for reaction to the BPH, gall midge, neck blast, bacterial leaf blight, grassy stunt virus, and cold tolerance (by growing at high elevations), and for elongation ability. The very late-maturing photoperiod-sensitive genotypes required for tidal-swamp rice culture can also be identified by growing at close or conventional plant spacings.

BPH screening program at Pusakanegara

Severe hopperburn occurred during the 1976–77 wet season in the area surrounding the Pusakanegara station, so about 150 of the $F_2 - F_3$ bulk populations

carrying BPH and grassy stunt virus resistance were planted on the station at 5- × 5-cm spacing. Land, 0.3 ha or less, was required. Most of the susceptible plants were killed by BPH. Some of the surviving plants from promising crosses were harvested and their seed were planted in a pedigree nursery the next season. The remaining plants were also harvested and their seed were bulked, as described earlier. Those populations will be mass-screened again in the dry season of 1977.

Screening for resistance to BPH biotype 2

At Bogor and Sukamandi pedigree lines and bulked hybrid are being screened in the greenhouse for resistance to a BPH biotype-2 colony from North Sumatra. Field screening for biotype 2 resistance in farmers' fields was recently initiated in North Sumatra in cooperation with the Extension Service and North Sumatra University.

Horizontal resistance

The Kencana variety is a possible source of horizontal resistance to the BPH. Bogor entomologists have classified it as moderately resistant to moderately susceptible to both biotypes 1 and 2. It appears in several crosses listed in Table 2. Dr. I. N. Oka recently screened small F_2 populations of the crosses Kencana/Pelita I-1 and Kencana/Gati (B9c-Md-3-3) for resistance to both biotypes. He classified the F_2 populations of both crosses as varying from moderately resistant to susceptible plants. Further studies are necessary to determine if Kencana possesses general resistance to BPH.

The screening method for bulk populations described earlier might be suitable for use in identifying general resistance if the bulk populations are screened for several generations. If possible, the major gene resistance should not be present in populations being screened for general resistance.

YIELD TRIALS AND PROMISING LINES

During the 1975–76 wet season, advanced yield trials of lines resistant to the BPH, grassy stunt virus, and rice tungro virus were conducted at the Muara, Pusakanegara, Mertoyudan, and Singamerta stations of CRIA in Java. The trials consisted of 12 entries with randomized block design, 4 replications, 3- × 5-m plots, 25- × 25-cm spacing, and fertilizer rates of 120 kg N/ha + 60 kg P_2O_5/ha.

Both B3753-7-Pn-4-1 and B3753-8-Pn-2-2 produced higher yields than Pelita I-1 probably because they were resistant to BPH biotype 2 (Table 3). B1014b-Pn- 18-4 and B 1991 b-Pn-43-4-1 produced fairly good yields and matured earlier than Pelita I-1. They are resistant to BPH biotype 1. B1014b-Pn-18-1-4 appeared to be resistant to the narrow brown leaf spot disease (*Cercospora*).

In the dry season of 1976, preliminary yield trials of lines resistant to the BPH and grassy stunt virus were conducted at the CRIA stations in Genteng,

Table 3. Agronomic data and disease reactions of 12 promising lines in advanced yield trials grown at 4 sites in Indonesia. Wet season, 1975–1976.

Cultivar	Grain yield (kg/ha)			Ht (cm)	Maturity (days)	Reaction[a] to		
	Min	Max	Av.			Brown planthopper[b]	Grassy stunt virus[c]	Rice tungro virus[d]
B462b-Pn-1-3	2723	4275	3454	109	120	S	–	MR
B441b-126-2-3-1	2770	4617	3603	116	122	S	S	MR
B459b-Pn-132-3-5	2878	4797	3690	103	119	I	–	MR
E461b-Pn-3-2-5	2620	3903	3294	106	121	S	–	MR
B462b-Pn-31-2	3127	4753	3904	112	123	S	–	–
BKN 6809-74-40	3223	4013	3388	107	118	R	S	–
BKN 6809-74-6	2033	4312	3196	103	118	R	S	–
B1014b-Pn-18-1-4	3247	4457	3775	97	112	R/I	–	–
B1991b-Pn-43-4-1	2903	4330	3674	85	122	I	–	–
B3753-7-Pn-4-1	3384	5410	4527	101	126	I	R	–
B3753-8-Pn-2-2	2847	5034	4194	111	127	I	–	–
Pelita I-1	2435	5139	3975	118	128	S	S	S

[a] R = resistant, MR = moderately resistant, S = susceptible, I = intermediate. [b] Readings from Entomology Department, Bogor. [c] Results from field screening at Kendalpayak, E. Java. [d] Results from field screening at Lanrang, S. Sulawesi.

Kendalpayak, and Mojosari. The trials consisted of 49 entries with lattice design, 3 replications, 1- × 5-m plots, 25- × 25-cm spacing, and fertilizer rates of 120 kg N + 60 kg P_2O_5/ha.

The yield and agronomic data for the more promising entries are in Table 4. Heavy infestations of the grassy stunt virus at Kendalpayak and Mojosari stations were responsible for the very low yields of susceptible lines. B2360-8-

Table 4. Agronomic data and reactions to grassy stunt virus and the brown planthopper of 13 cultivars grown in yield trials at 3 sites. Dry season, 1976.

Cultivar	Yield (kg/ha) at			Average			Reaction[a] to	
	Genteng	Kendalpayak	Mojosari	Yield (kg/ha)	Ht (cm)	Maturity (days)	Grassy stunt virus(%) at Molosari	Brown planthopper (rating) from Entomology Department Bogor
B2360-8-5-LR-4-3	6447	7133	4154	6044	98	129	8	R
B2360-8-5-LR-5-5	5380	6233	3674	5096	96	123	5	I
B2360-11-3-2-2	6013	7367	3820	5401	106	130	3	R
B2360-11-3-2-6	5593	7233	4100	5809	105	127	7	I
B2360-11-3-2-9	5333	7433	4180	5622	100	130	3	R
IR26	4580	3809	2010	3466	91	138	11	I
IR28	3313	1733	2560	2502	87	114	3	I
IR30	3447	1435	2687	2522	86	117	8	I
IR32	4087	2032	4594	3571	98	143	7	R
IR34	5360	5310	4506	5055	111	133	0	I
IR36	4080	5067	3006	4031	84	120	6	R
C4-63Gb	3750	400	1660	1936	90	127	87	S
Pelltal-1	4353	167	360	1623	104	139	95	S

[a] S = susceptible, R = resistant, I = intermediate.

Table 5. Twenty promising lines being tested in advanced yield trials at 41 sites. Wet season. 1976–77.

Cultivar	Amylose content (%)	Plant height (cm)	Maturity (days)	Reaction[a] to		
				Brown planthopper[b]	Grassy stunt virus[c]	Rice tungro virus[d]
B1014b-Pn-18-1-4	26.7	91	128	R/I	–	–
B1187b-Pn-50-2	20.3	108	133	I	–	–
B1991b-Pn-43-4-1	24.3	79	125	I	–	–
B2360-8-9-5	29.0	99	128	I	R	–
B2360-2-9-3	24.0	109	114	I	R	S
B2360-6-7-1	28.0	95	121	I	R	R
B2360-6-9-5	28.0	98	130	I	R	–
B2360-8-5-LR-4-3	26.4	95	112	R	R	R
B2361-1-1-LR-4-5	26.7	91	130	R	R	R
B3753-7-Pn-4-1	25.4	101	126	R	R	–
B3753-8-Pn-2-2	29.0	111	127	R	R	–
IR1514A-E597-2	25.7	111	85	R	R	R
IR1909-1-3-3	28.0	94	131	R	R	S
IR2061-213-2-16	24.3	116	125	R	R	R
IR2071-486-1-2	16.0	–	140	R	R	R
IR2071-621-2-3	15.6	108	122	R	R	R
IR2153-43-2-3	24.0	84	116	R	R	MR
IR2172-64	29.0	84	125	R	S	–
IR32	30.0	88	149	R	R	MR
IR36	25 0	84	120	R	R	R

[a]S = susceptible, MR = moderately resistant, R = resistant, I = intermediate. [b]Readings from Entomology Department, Bogor. [c]Results from field screening at Kendalpayak, East Java. [d]Results from field screening plots at Lanrang, South Sulawesi.

5-LR-4-3 produced the highest average yield of 6 t/ha. Lines yielding higher than IR34 were three sister lines of B2360-11 and one sister line of B2360-8-5. IR34 was the highest yielding IRRI variety (5 t/ha), followed by IR36, IR32, and IR26. The early maturing varieties IR28 and IR30 produced relatively low yields (2.5 t/ha). The low yield of IR26 was caused by a rather heavy infection of grassy stunt virus. IR28 matured very early (114 days) while IR32, the variety with the longest growth duration, matured in 143 days. Pelita I-1 and C4-63 were very susceptible to grassy stunt virus and produced practically no grain at Kendalpayak station.

Although the three sister lines of B2360-11 had previously been classified as resistant to the BPH in the greenhouse, they showed severe hopperburn in the yield trials of Mojosari in the 1976-77 wet season. During the same season, 20 promising lines resistant to BPH and grassy stunt virus were planted at 41 sites throughout the main rice-growing areas of Indonesia.

Two groups of lines, early- and late-maturing, were tested. Lines from IR2071, IR2153, IR2172, and B3753 resistant to BPH biotype 2 were included. IR32 was used as check variety for the late-maturing group and IR36 for the early maturing group. The promising lines are listed in Table 5. The data from the 41 trials will be completed by May or June 1977.

It is expected that after the second season of multilocation testing, to be

conducted in the 1977 dry season (July seeding), some of the lines can be proposed for varietal release. At present, IR32 has been approved for release as a variety resistant to the BPH biotype 2 and IR36 is being considered for release.

In addition to the promising lines listed in Table 5, several very promising lines from IR4744 (RPW6-13/IR1721-11-6-8-3-2//IR2061-464-2), which are resistant to both the BPH and gall midge, are also under evaluation. The lines were selected from a group of lines of IR4744 sent to Indonesia for gall midge screening in 1975–76. The lines resistant to gall midge were identified by the Entomology Department, and have since been screened three or more times in the greenhouse and in the field. Several appear to have potentials as new varieties.