Genetics of and breeding for resistance to the brown planthopper

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The development and worldwide distribution of improved rice germplasm with resistance to the brown planthopper (BPH) are a major objective of the International Rice Research Institute's (IRRI) Genetic Evaluation and Utilization (GEU) program. In its varietal resistance research IRRI has emphasized the identification of resistant germplasm, genetic analysis of the resistant varieties to identify diverse genes for resistance, incorporation of those genes into an improved-plant type background, and synthesis of breeding lines with multiple resistance to major diseases and insects. The seeds of the IRRI donor parents, breeding lines, and improved varieties are supplied to rice scientists around the world for use in local hybridization programs and for evaluation as commercial varieties. This paper summarizes the various IRRI breeding strategies and the status of varietal resistance to BPH.

IRRI STUDIES ON THE GENETICS of resistance to BPH started in 1968. Plant breeders investigated the mode of inheritance of resistance in a large number of resistant varieties and determined the allelic relationships of the newly identified genes. The bulk seedling test is used for screening materials for genetic studies, although the tiller test was used to some extent in early work (Athwal et al 1971).

Four resistant varieties—Mudgo, ASD 7, CO22, and MTU 15—were initially analyzed. Mudgo, CO22, and MTU 15, each had a single dominant gene for resistance, which, allele tests revealed, was at the same locus. This locus was designated *Bph 1.* The resistance in ASD 7 was controlled by a single recessive gene, designated *bph 2.* No recombination between *Bph 1* and *bph 2* was observed. It was concluded that these two genes are either allelic or closely linked (Athwal et al 1971). Later studies revealed that varieties with *Bph 1* and *bph 2* react differentially to different biotypes and it was concluded that the two genes are different (Athwal and Pathak 1972). Two more varieties, MGL2 and Ptb 18, were analyzed by Athwal and Pathak (1972). MGL2 had *Bph 1,* and Ptb 18 had *bph 2* for resistance.

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In 1969 a serious outbreak of BPH occurred at IRRI and a yield trial with 55 early maturing entries was hopperburned. Two entries, IR747B_2-6 and IR1154-243, showed resistance (IRRI 1970). None of their parents were resistant to BPH. Martinez and Khush (1974), who investigated the inheritance of resistance in the two selections, found that *Bph 1* governed the resistance of IR747B_2-6, whereas *bph 2* conditioned the resistance in IR1154-243. TKM 6, one of the parents of IR747B_2-6, was susceptible but when crossed with other susceptible varieties such as TN1, IR20, or IR24, a small proportion of the F_2 progeny was resistant. It was hypothesized that TKM 6 is homozygous for *Bph 1* as well as for a dominant inhibitory gene, *I-Bph 1,* which inhibits *Bph 1.* Thus in the segregating progenies of crosses of TKM 6 with other susceptible varieties, those individuals that inherit *Bph 1* but not *I-Bph 1* are resistant to BPH.

A dwarf breeding line, IR4-93, from the cross H105/Dee-geo-woo-gen, was found to have *bph 2* (Martinez and Khush 1974). It was inferred that H105, the resistant parent of IR4-93, had *bph 2* for resistance.

To identify new genes for resistance, Lakshminarayana and Khush (1977) analyzed 28 resistant varieties. Nine of the varieties had *Bph 1* and 16 had *bph 2* for resistance (Table 1). Two new loci for resistance were discovered. A single dominant gene governs resistance in Rathu Heenati. It segregated independently of *Bph 1* and was designated as *Bph 3.* A single recessive gene conveyed resistance in Babawee. It segregated independently of *bph 2* and was designated *bph 4.* Resistance in Ptb 21 is controlled by one dominant and one recessive gene. The allelic relationships of the two genes in Ptb 21 to the other four genes are not known, but further studies are in progress.

The genetic analysis of 20 new varieties has been completed (Sidhu and Khush 1978). Seven of those varieties have *Bph 3* and 10 have *bph 4* for resistance (Table 1). Three varieties Ptb 33, Sudu Hondarawala, and Sinna Sivappu, have two genes for resistance. One gene appears dominant, whereas the second gene appears recessive. The allelic relationships of the genes for resistance in Ptb 33, Sudu Hondarawala, and Sinna Sivappu to other known genes are being investigated.

The inheritance of resistance to BPH is also being studied at several other rice research centers. In Taiwan, Chen and Chang (1971) investigated the inheritance in Mudgo and also found *Bph 1.* Three varieties, IR9-60, Kaosen Yu 12, and H5, had *bph 2* (Chang 1975).

In India, Prasada Rao et a1 (1976) reported that resistance in Leb Mue Nahng is governed by a recessive gene. They are studying inheritance of resistance in several other varieties.

In Japan, Kaneda and Kisimoto, and in Korea, Choi et a1 (see papers by those authors, this volume) studied the linkage relations of *Bph 1* with the representative markers of different linkage groups. *Bph 1* appears to segregate independently of *lg, g, bl,* d_{11}, and *tri.* However, data of Choi et a1 indicate that *Bph 1* may be linked to the *I-Bf—PS* linkage group.

Table 1. Brown planthopper resistant varieties analyzed to date and the resistance genes they possess.

Variety or selection	Resistance gene	Reference
Mudgo	*Bph 1*	Athwal et al (1971)
MTU 15	*Bph 1*	"
CO 22	*Bph 1*	"
ASD 7	*bph 2*	"
MGL 2	*Bph 1*	Athwal and Pathak (1972)
Ptb 18	*bph 2*	"
H 105	*bph 2*	Martinez and Khush (1974)
IR1154-243	*bph 2*	"
IR747B_2-6	*Bph 1*	"
Anbaw C7	*bph 2*	Lakshminarayana and Khush (1977)
Tibiriwewa	*Bph 1*	"
Balamawee	*Bph 1*	"
CO 10	*Bph 1*	"
Heenakkulama	*Bph 1*	"
MTU 9	*Bph 1*	"
Sinnakayam	*Bph 1*	"
SLO 12	*Bph 1*	"
Sudhubalawee	*Bph 1*	"
Sudurvi 305	*Bph 1*	"
ASD 9	*bph 2*	"
Dikwee 328	*bph 2*	"
Hathiel	*bph 2*	"
Kosatawee	*bph 2*	"
Madayal	*bph 2*	"
Mahadkikwee	*bph 2*	"
Malkora	*bph 2*	"
M.I. 329	*bph 2*	"
Murungakayan 302	*bph 2*	"
Ovarkaruppan	*bph 2*	"
Palasithari 601	*bph 2*	"
PK-1	*bph 2*	"
Seruvellai	*bph 2*	"
Sinna Karuppan	*bph 2*	"
Vellailangayan	*bph 2*	"
Rathu Heenati	*Bph 3*	"
Babawee	*bph 4*	"
H5	*bph 2*	Chang (1975)
IR9-60	*bph 2*	"
Kaosen-Yu 12	*bph 2*	"
Ptb 19	*Bph 3*	Sidhu and Khush (1978)
Gangala (Acc 7733)	*Bph 3*	"
Gangala (Acc. 15207)	*Bph 3*	"
Horana Mawee	*Bph 3*	"
Kuruhondarawala	*Bph 3*	"
Mudu Kiriyal	*Bph 3*	"
Muthumanikam	*Bph 3*	"
Gambada Samba	*bph 4*	"
Heenhoranamawee	*bph 4*	"
Hotel Samba	*bph 4*	"
Kahata Samba	*bph 4*	"
Kalukuruwee	*bph 4*	"
Lekam Samba	*bph 4*	"
Senawee	*bph 4*	"
Sulai	*bph 4*	"
Thirissa	*bph 4*	"
Vellai Illankali	*bph 4*	"
Ptb 21	[a]	Lakshminarayana and Khush (1977)
Ptb 33	[a]	Sidhu and Khush (unpubl)
Sudu Hondarawala	[a]	"
Sinna Sivappu	[a]	"

[a] These varieties have two genes for resistance but their allelic relationships are not known.

Thus, of 60 varieties analyzed to date (Table 1), 14 have the single dominant genes allelic to *Bph 1,* and 8 have single dominant genes allelic to *Bph 3.* Thirty-four varieties have single recessive genes for resistance. Of those 23 have *bph 2* and 11 have *bph 4.* Four varieties have two genes for resistance.

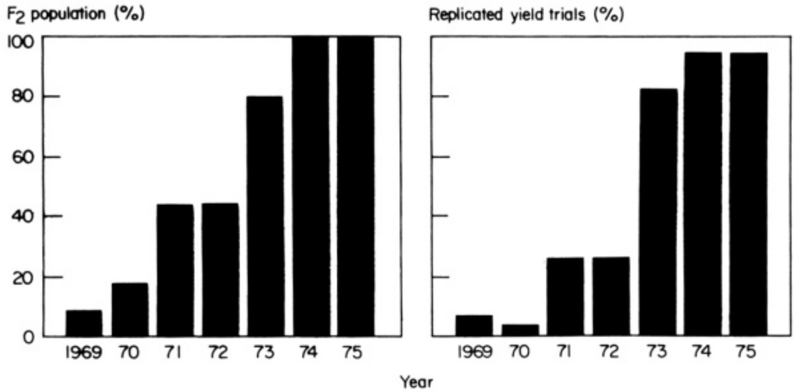
It is noted that varieties with *Bph 1* are resistant to IRRI biotypes 1 and 3, and varieties with *bph 2* are resistant to IRRI biotypes 1 and 2. However, varieties with *Bph 3* or *bph 4* are resistant to all the three IRRI biotypes. Varieties with *Bph 3* and *bph 4* are also resistant in India and Sri Lanka, whereas varieties with *Bph 1* and *bph 2* are susceptible there.

BREEDING FOR RESISTANCE AT IRRI

Breeding for resistance to the BPH at IRRI started as soon as the sources of resistance were identified. A cross between Mudgo and IR8 was made in 1967 and F_3 progenies were analyzed for resistance and other traits. Because those lines had poor grain quality, a resistant F_3 line was crossed with IR22 and IR24. Promising progenies, such as IR1614-138-3 and IR1614-389-1, were selected from the cross with IR22, and IR1539-260 and IR1539-823-4 were selected from the cross with IR24. Those lines had excellent grain quality, high yield potential, and resistance to the BPH and green leafhopper. They were susceptible to tungro and blast, however. Those selections and several other F_3 and F_4 selections of IR1539 were crossed with tungro- and blast-resistant breeding lines in 1970. Their F_1's were crossed with other F_1's in 1970 and 1971. From those double crosses—including IR2034, IR2035, 1R2038, and IR2058—several promising breeding lines with multiple resistance were selected and evaluated as varietal possibilities. IR2058-78-1-3 was the most promising line. It inherited its resistance from Mudgo.

Starting in 1969, IR747B_2-6 and IR1154-243 were used as sources of resistance to BPH. Promising lines, such as IR1561-149-1, IR1561-228-3, IR1561-243-5, and IR1561-250-2, were selected from the cross IR747B_2-6/IR579-48, and IR1628-632-1 from the cross IR24/IR1154-243. In 1970, IR1561-149-1 was crossed with IR1737, a grassy-stunt-resistant line from the fourth back-cross of *O. nivara* to IR24. The F_1 was topcrossed in 1971 with a tungro- and blast-resistant line, IR833-6-2, from the cross Peta^3/TN1//Gam Pai 15. Progenies from that cross were thoroughly evaluated for resistance to all the major diseases and insects, grain quality, and agronomic traits. Two lines, IR2061-214-3-8-2 and IR2061-464-4, were named IR28 and IR29 in 1974, and a third line, IR2061-213-2-17, was named IR34 in 1975.

As noted earlier, when TKM 6 is crossed with other susceptible varieties, a small proportion of the segregating progeny are resistant. Two resistant lines, IR1541-102-7-491 and IR1541-76-3, were selected from the cross IR24/TKM 6 made in 1969. IR1541-102-7-491 was named IR26 in 1973 and became the world's first BPH-resistant variety with improved-plant type. Similarly, two resistant breeding lines, IR1514A-E666 and IR1514A-E597, were selected



1. Changes in the proportion of F_2 populations and entries in the replicated yield trials with resistance to brown planthopper.

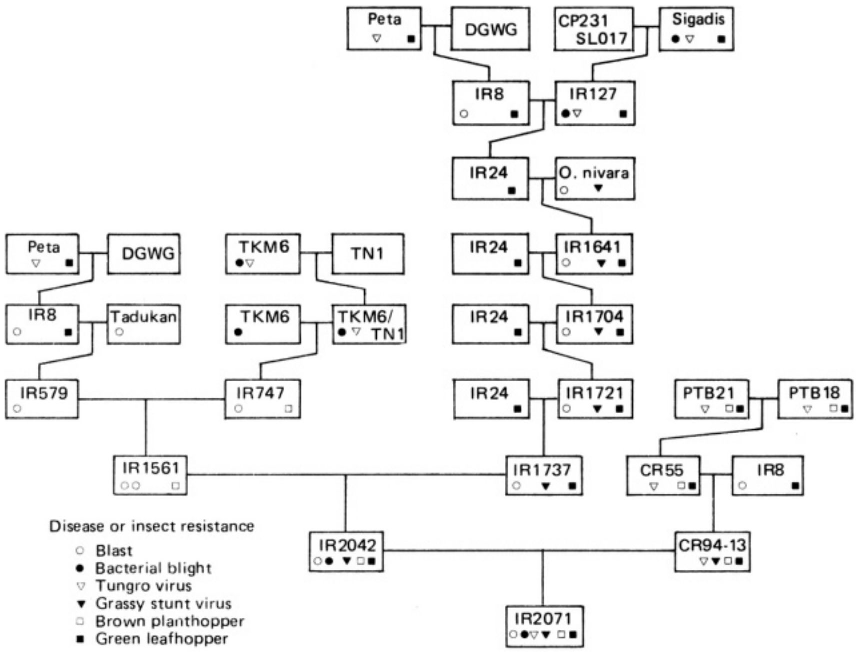
from the cross IR20/TKM6 and used extensively in the hybridization program. In 1971, IR1541-102-6, a close sib of IR26, was crossed with a plant from the fourth backcross of *O. nivara* to IR20, and BPH-resistant IR30 was selected from this cross.

IRRI obtained a gall-midge-resistant breeding line, CR94-13, from the Central Rice Research Institute (CRRI), Cuttack, India. CR94-13 was selected from the cross Ptb 21//IR8/Ptb 18. It inherited *bph 2* from Ptb 18. It was used extensively in IRRI's hybridization program. It is in the ancestry of most IRRI breeding lines and varieties with *bph 2.* Two crosses involving CR94-13, IR2070, and IR2071 have yielded several outstanding progenies. IR2070-747-6-3-2 was named IR32 in 1975.

Special attention was given to incorporating *Bph 1* as well as *bph 2* into IRRI breeding materials. About half of the entries in IRRI replicated yield trials have *Bph 1.* The other half have *bph 2.* IRRI now incorporates *Bph 3* and *bph 4* into improved-plant-type background. Rathu Heenati and Babawee, donors of *Bph 3* and *bph 4,* respectively, were crossed with several other elite breeding lines. Because they have poor plant type, two backcrosses were made with IR3403-267 and IR4432-53 as recurrent parents. Those recurrent parents are improved breeding lines with resistance to all the major diseases and insects except the BPH. Multiple-resistant progenies from these backcrosses are being evaluated.

The progress made in developing germplasm with resistance to BPH is shown in Figure 1. In 1969 less than 10% of the F_2populations segregated for resistance to BPH. That proportion increased to 100% in 1975. Similarly, only 5% of the entries in the 1969 replicated yield trials were resistant to BPH. That proportion rose to 98% in 1975.

Resistance to BPH was combined with resistance to other major diseases and insects. As many as 13 different parents are involved in the ancestry of



2. Pedigree of IR36 and IR42, which were selected from IR2071. Thirteen varieties are involved in the ancestry of these varieties.

IRRI's varieties with multiple resistance. As shown in the pedigree of IR2071 (Fig. 2), which yielded IR36 and IR42, resistance to diseases and insects was contributed by Ptb 18 (BPH, blast, tungro), Peta (green leafhopper), TKM 6 (bacterial blight), and *O. nivara* (grassy stunt).

BPH-resistant varieties released by IRRI

Six BPH-resistant varieties were released by IRRI. Five of them have *Bph 1,* with TKM 6 as donor. One variety, IR32, has *bph 2* from Ptb 18. The selection number, pedigree, year of release, and gene for resistance of these varieties are shown in Table 2.

BPH-resistant IRRI lines named in other countries

IRRI shared the seeds of BPH-resistant materials with scientists in national rice improvement programs. As of mid-1975, seeds of 7,487 BPH-resistant breeding lines had been sent to scientists of 19 countries (Table 3). Since 1975, seeds of breeding lines have been exchanged with scientists in national rice improvement programs through formalized international nurseries. Many of these lines have been extensively used as sources of resistance in the local breeding programs. Some have been named as varieties for commercial production (Table 4).

Table 2. Brown planthopper-resistant varieties released by IRRI.

Variety	Selection number	Cross	Year released	Gene for resistance
IR26	IR1541-102-7-491	IR24/TKM6	1973	*Bph 1*
IR28	IR2061-214-3-8-2	Peta^3/TN1//Gam Pai 15/4/IR8//Tadukan// TKM6^2/TN1///IR24^4/*O. nivara*	1974	*Bph 1*
IR29	IR2061-464-4	Peta^3/TN1//Gam Pai 15/4/IR8/Tadukan// TKM6^2/TN1///IR24^4/*O. nivara*	1974	*Bph 1*
IR30	IR2153-159-1-4	IR24/TKM6//IR20^4/*O. nivara*	1974	*Bph 1*
IR32	IR2070-747-6-3-2	IR20^2/*O. nivara* //CR94-13	1975	*bph 2*
IR34	IR2061-213-2-17	Peta^3/TN1//Gam Pai 15/4/IR8/Tadukan// TKM62/TN1///IR24^4/*O. nivara*	1975	*Bph 1*

Table 3. Number of seed packets of brown planthopper-resistant IRRI lines sent to different countries up to mid-1975.

Country	Seed packets sent (no)
Bangladesh	1,080
British Solomon Islands	19
Burma	123
Cambodia	54
China	39
Fiji	325
India	1,829
Indonesia	1,740
Japan	31
Korea	272
Laos	38
Malaysia	161
Nepal	157
Pakistan	46
Papua New Guinea	39
Sri Lanka	472
Taiwan	139
Thailand	304
Vietnam	619

Table 4. Brown planthopper-resistant IRRI lines named in other countries.

Country where named	Selection	Name
Bangladesh	IR2061-214-3-8-2 (IR28)	BR 6
British Solomon Islands	IR747B2-6-3	GPL1
	IR614-138-3-1	GPL 2
Fiji	IR1539-156	Bilo
Indonesia	IR1541-102-7-491 (IR26)	PB 26
	IR2061-214-3-8-2 (IR28)	PB 28
	IR2153-159-1-4 (IR30)	PB 30
	IR2070-747-6-3-2 (IR32)	PB 32
	IR2061-213-2-17 (IR34)	PB 34
Philippines	IR2071-625-1-252	IR36
	IR2070-423-2-5-6	IR38
	IR2070-414-3-9	IR40
	IR32071-586-5-6-3	IR42
Vietnam	IR1561-228-3	TN73-2
	IR1541-102-7-491	IR26
	IR2153-159-1-4	IR30

ROLE OF RESISTANT VARIETIES IN BROWN PLANTHOPPER CONTROL

Vast areas of rice are now planted to BPH-resistant varieties. In the Philippines, most of about 2.5 million ha grows IR26, IR28, IR30, IR32, IR34, IR36, or IR38. IR40 and IR42 are being multiplied for large-scale distribution to Filipino farmers during the 1977 wet season. Two experimental selections, IR1561-228-3 and IR747B_2-6, are also grown widely in the Philippines.

Indonesia approved IR26 for cultivation in 1975, IR28 and IR30 in 1976, and IR32 and IR34 in 1977. An estimated 2 million ha of Indonesia's rice land is planted to these varieties (pers. comm. with B. H. Siwi). In Vietnam, 1.8 million ha grows TN73-2 (IR1561-228-3), IR26, and IR30 (pers. comm. with V. T. Xuan). In Fiji, Bilo is planted on more than 10,000 ha. Thus, about 6.5 million ha of rice land in Southeast Asia grow BPH-resistant varieties.

Wherever the resistant varieties are grown, the incidence of BPH is drastically reduced. Before the introduction of resistant varieties, hopperburned fields were common in the Philippines, Indonesia, and Vietnam despite the extensive use of insecticides. With the resistant varieties farmers have either stopped using insecticides entirely or drastically reduced the frequency of insecticide application.

STABILITY OF RESISTANCE

IR26 was released for commercial production in the Philippines in November 1973, in Vietnam in 1974, and in Indonesia in 1975. It became one of the most widely grown varieties in those countries within 2 years of its release. It was planted on more than 1 million ha in the Philippines in 1975, and on about the same area in Vietnam in 1976 and in Indonesia in 1977. There were reports of damage to IR26 by the BPH early in 1976 in the Philippines. Insects were collected from the localities reporting damages, multiplied in the laboratory, and tested for virulence on differential varieties. They killed IR26 and other varieties with *Bph 1* and thus were considered biotype 2 insects. Similar reports of sporadic damage to IR26 came from several areas in the Philippines during late 1976 and 1977. In Vietnam, IR26 and TN73-2 were damaged in a few areas during 1977 (pers. comm. with V. T. Xuan). In the northern Sumatra region of Indonesia, where IR26 was first introduced in 1974, biotype 2 damaged fields of IR26 in 1977.

It thus appears that the useful life of varieties with *Bph 1* is about 3 years. In the Philippines, IR32, IR36, and IR38, which have *bph 2,* are fast replacing the varieties with *Bph 1.* Similarly, the Government of Indonesia has released IR32 as a substitute for BPH-resistant varieties with *Bph 1.*

BREEDING STRATEGIES FOR BROWN PLANTHOPPER RESISTANCE

Because the varieties with major genes for resistance have short life spans, IRRI adopted several strategies for utilizing host resistance to BPH.

Sequential release of varieties with major genes

The sequential release strategy involves incorporation of a single major gene into improved varietal backgrounds and making those cultivars available to farmers sequentially. Thus, varieties like IR26, IR28, IR29, and IR30, with *Bph 1* for resistance, were grown in the Philippines during 1973–76. As soon as the biotypes capable of damaging those varieties appeared, IR32, IR36, and IR38, with a different gene for resistance (*bph 2*), were released. These are now widely grown. IRRI has incorporated *Bph 3* and *bph 4* into lines with desirable agronomic background, and varieties with either of these new genes will be released as the presently grown varieties become susceptible due to appearance of new BPH biotypes. As new genes for resistance are identified, they will be incorporated into improved plant types.

Pyramiding the major genes

The strategy of pyramiding major genes aims at combining two or more major genes in the same improved variety. Because *Bph 1* and *bph 2* are closely linked, efforts to develop lines having both genes have been unsuccessful. However, *Bph 3* and *bph 4* segregate independently of *Bph 1* and *bph 2,* and crosses have been made to combine *Bph 1* and *Bph* 3, *bph 2* and *Bph 3, Bph 1* and *bph 4,* and *bph 2* and *bph 4.* Varieties with two genes for resistance are expected to have a longer useful life as they will slow the development of new biotypes.

Multiline varieties

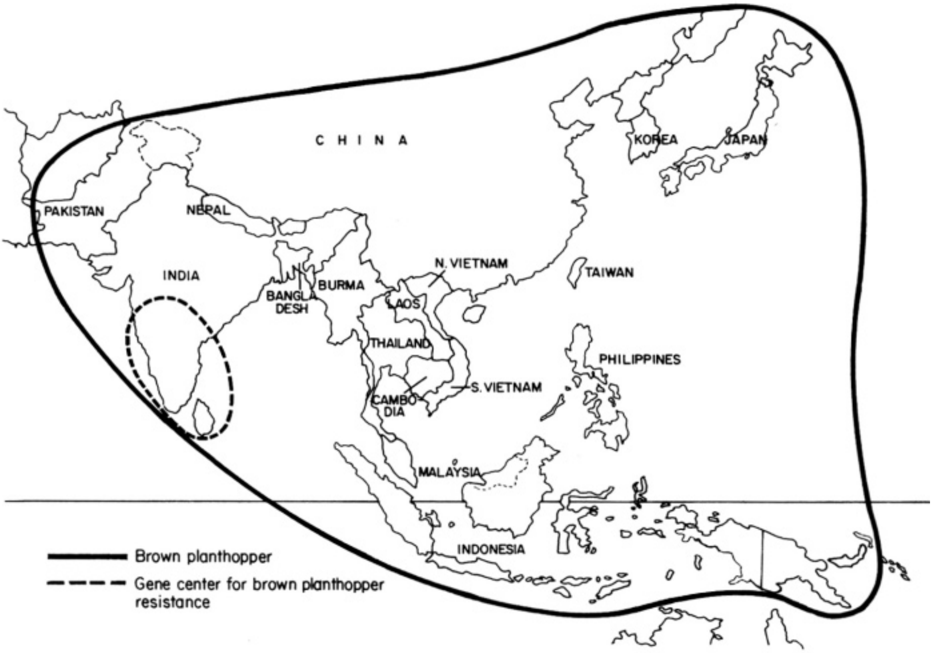
The multiline approach originally proposed by Borlaug (1958) envisages the incorporation of several major genes into an isogenic background and the mixing of these lines to form a multiline variety. This strategy was successfully applied to breeding oats for crown rust resistance in Iowa, USA (Browning and Frey 1969). The effectiveness of the technique for breeding for insect resistance is largely unknown. However, IRRI is transferring the known major genes for BPH resistance into an isogenic background. When appropriate materials become available, the feasibility of this technique will be tested.

Horizontal resistance

IRRI is exploring the possibility of incorporating minor genes for resistance into desirable agronomic background by a process of recurrent selection. Several unimproved varieties and a few improved breeding lines with low levels of resistance have been identified. Crosses between them should yield progenies with higher levels of horizontal resistance. This type of resistance may last longer, but developing improved germplasm with horizontal resistance will take much longer.

BREEDING FOR RESISTANCE IN OTHER COUNTRIES

The distribution of BPH in Asia and the Pacific is shown in Figure 3. Outbreaks of BPH have occurred in most countries where the insect is distributed.



3. Distribution of brown planthoppers in Asia and the gene center for brown planthopper resistance.

Most of the resistant germplasm comes from south India or Sri Lanka. Before resistant varieties were introduced to farmers' fields, the BPH populations consisted of two distinct biotypes. The BPH populations in all the countries of East Asia, Southeast Asia, and the Pacific Islands belong to biotype 1. But populations in the South Asian region belong to a different biotype, which can attack varieties with *Bph 1* and *bph 2.* The exact dividing line between the two biotypes is not clear but the differentiation may occur near the Burma-Bangladesh boundary.

Japan, Taiwan, and Korea have strong programs for developing varieties resistant to BPH. As reported by Kaneda (1971), *Bph 1* from Mudgo was transferred to a japonica background by backcrossing. The lines, called KC lines, had low crossability with other Japanese varieties. Plant height, threshability, and grain quality were not acceptable. Those defects, however, are being corrected by further backcrossing to Japanese varieties. IR1154-243 was used as a source of *bph 2* gene. This line seems to combine well with japonica varieties. *Bph 3* and *bph 4* are also being incorporated into a japonica background by backcrossing.

Resistant materials were first introduced into Korea by a trainee who made crosses and backcrosses between Mudgo and Korean varieties while at IRRI.

Lines derived from those crosses, called KR lines, were distributed to three experiment stations for crossing purposes. KC lines were also introduced into Korea. Many resistant lines from IRRI, particularly IR747B_2-6 and IR946, were extensively used in Korea's hybridization programs. Several BPH-resistant breeding lines are now being evaluated in advanced yield trials and some are likely to be named varieties. Most promising are Suweon 271 and Suweon 272, developed at Suweon, Iri 328 and Iri 329, bred at Honam, and Milyang 30, Milyang 34, and Milyang 36, developed at the Youngnam Crop Experiment Station.

Taiwan's breeding program aims at incorporating resistance into indica as well as japonica backgrounds. IR9-60, IR747B_2-6, IR1561-228-3, and IR1514A-E666 from IRRI, and Kaosen-Yu 12, a local resistant variety, have been used as sources of resistance. One resistant variety, Chianung Sen 11, has been released in Taiwan.

In Southeast Asia, Thailand's breeding program has incorporated *Bph 1* from W1257 and W1263 into breeding materials. A resistant variety, RD9, was released in 1976. IR32 is being used as source of *bph 2* in the Thai breeding program.

In Indonesia, several resistant lines have been developed. Selections from the crosses of IR2031, IR2070, IR2071, and IR2153 were used as sources of resistance. Several promising breeding lines with BPH resistance, such as B3753-7-Pn-4-1 and B375-8-Pn-2-2, are being evaluated in advanced yield trials.

In India and Sri Lanka, breeding lines and varieties with *Bph 1* and *bph 2* are susceptible. However, donor varieties with *Bph 3* and *bph 4* are resistant. Ptb 33, a variety resistant in both countries, is being extensively used as a donor parent. Early generation, resistant lines are available in both countries. In India, several other resistant donors, such as Ptb 21 and Manoharsali, are also being used in the crossing program.

Work on breeding for resistance to BPH has also started in Bangladesh, Burma, Malaysia, and the People's Republic of China. IRRI materials are used as sources of resistance. Fiji, British Solomon Island, Papua New Guinea, and Vietnam are continuing to grow IRRI-developed, resistant germplasm.

CONCLUSIONS

From the foregoing it is evident that varietal resistance plays an important role in the control of BPH. More than 6.5 million ha of rice land is now planted to BPH-resistant varieties. That area will increase rapidly because many national rice improvement programs have developed germplasm with BPH resistance.

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