Varietal resistance to brown planthopper in India

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The brown planthopper has assumed great importance in rice and all efforts are being made to identify resistant varieties and to understand host-plant resistance and utilize it in India's breeding programs. A mass-screening technique resulted in the identification of resistant or tolerant cultivars among 15,000 entries. Materials from Northeast India and Kerala offer great potential.

Studies of the host-plant-Insect interactton showed that in most resistant varieties an antibiosis type of mechanism was involved. There was a correlation between the resistance at seedling stage and that at other stages. Six-or seven-day-old nymphs caused more damage than those at other stages of development.

Preliminary genetic data indicate that resistance is predominantly qualitative. Both dominant and recessive genes for resistance seem to be involved.

Through an effective breeding program a number of resistant breeding lines have been evolved and are under test in endemic areas. The differential reactions of lines in the multilocation tests suggest the occurrence of biotypes.

IN SEVERAL RICE-GROWING tracts of India, the brown planthopper (BPH) *Nilaparvata lugens* (Stål) has assumed importance in recent times.

Extensive damage by BPH in India was first observed in Kerala during 1973. Subsequently reports were received from Andhra Pradesh, Bihar, Haryana, Orissa, Punjab, Tamil Nadu, and Uttar Pradesh (Kalode 1974; Kulshrestha et al 1974).

Although timely application of insecticides provides effective control, large-scale chemical control is difficult and expensive. Repeated sprayings upset the natural balance between the insect and its natural enemies. The logical approach to BPH control would be to use host-plant resistance as part of an integrated pest-management program. Efforts are in progress to tackle the BPH problem from various angles. The advances in developing resistant varieties are briefly discussed.

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Resistance to BPH in rice is being investigated at the All India Coordinated Rice Improvement Project (AICRIP), Hyderabad, Central Rice Research Institute (CRRI), Cuttack; Rice Research Station, Pattambi; Rice Research Station, Maruteru; Andhra Pradesh Agricultural University (APAU), Hyderabad; Agricultural University, Pantnagar; and a few other research centers in the country. The approach includes

- screening of varieties from different sources to identify donors,
- studies on the mechanisms of resistance,
- investigations on the genetics of resistance,
- a program for the transfer of genes for resistance to varieties possessing good agronomic characteristics, and
- biotype studies.

SCREENING FOR RESISTANCE

Screening methodology adopted

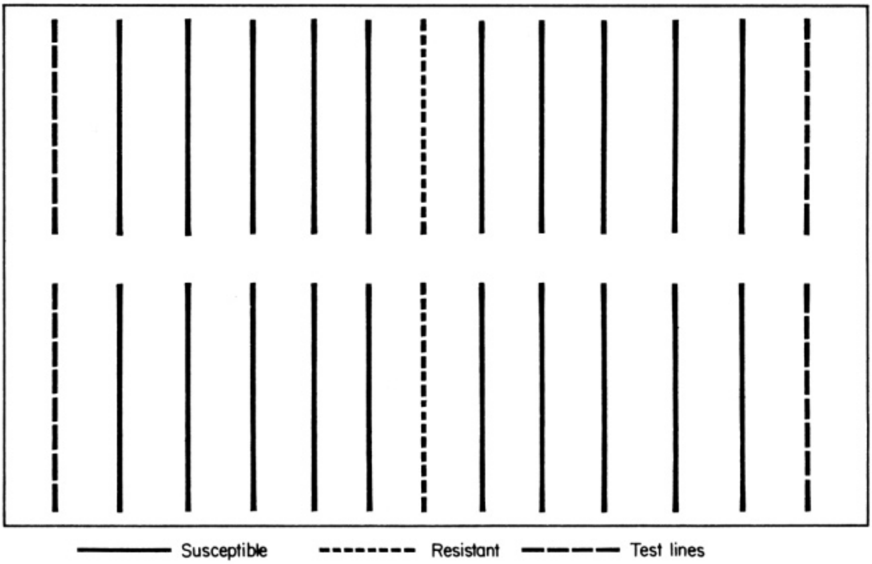
Mass-screening tests were conducted under controlled greenhouse conditions at the national headquarters of AICRIP, Rajendranagar, Hyderabad. Elsewhere screening was carried out in the laboratory or the cultivars were exposed to natural populations of BPH in the field.

The mass screening in the greenhouse is used to discard susceptible lines and identify possible resistant cultures. In early screenings, it was observed that test lines planted at either end of a tray was more likely than others to escape insect attack. Various methods and designs for planting test rows were evaluated and a modified layout that minimized the chances of escape (Kalode et a1 1975) was devised. The method involved the infestation of 7- to 10-day-old seedlings of test entries grown in puddled soil in wooden trays (50 x 40 x 8 cm). Each tray accommodated 20 test rows, each with 15 seedlings; 2 middle rows of a resistant check, and 4 susceptible border rows of TN1 (Fig. 1).

The wooden trays were placed in water in 7.5 cm deep trays to maintain a humidity suited to the insects and to keep away ants. Sufficient numbers of first- or second-instar nymphs were released on test entries so that each seedling was infested with at least 5 to 10 nymphs. When more than 90% of the susceptible-check seedlings were dead, the entries were scored for damage on a 0-to-5 scale: 0 = no apparent damage, 1 = initiation of wilting or yellowing in one leaf, 2 = initiation of wilting or yellowing in all leaves, 3 = complete wilting of 50 to 70% of the leaves, central leaf surviving, 4 = all leaves wilted, stem green, 5 = plant dead.

Test lines with damage scores below 3 were retested (randomized and replicated 4 to 5 times). An entry with an average score ranging from 0 to 1.5 was rated resistant; 1.6 to 3.0, moderately resistant; and above 3, susceptible.

A total of 15,026 varieties and breeding lines have been screened at Hyderabad since 1974 (Table 1).



1. Layout for mass screening of rice lines for resistance to the brown planthopper in India.

Evaluation of germplasm from different sources

Assam varieties. Nine hundred and fourteen cultivars from Northeast India were evaluated for BPH resistance; 69 were found resistant or moderately resistant in replicated tests. About 15 varieties showed a high level of resistance.

Table 1. Reactions of rice cultivars to the brown planthopper at All India Coordinated Rice Improvement Project (1974-76).

Cultivar source	Entries (no.) with damage score (%)			Total
	0–1.5	1.6-3.0	3.1-5.0	
Assam	39	30	845	914 [b]
Coimbatore	24	72	410	514 [a]
Pattambi	30	7	264	301 [b]
AICRIP	4	5	558	567 [b]
APAU	1	0	43	44 [b]
IRRI	29	44	590	663 [b]
National Screening Nursery (NSN)	17	88	3,075	3,180 [a]
International Rice Observation Nursery (IRON)	0	8	372	380 [b]
Elite breeding material from AICRIP	38	26	86	150 [b]
Breeding material from AICRIP	353	890	6,084	7,327 [b]
CRRI, Cuttack	0	9	219	228 [b]
Pattambi	12	31	75	118 [b]
Kapurthala	0	0	190	190 [b]
APAU	31	3	416	450 [b]

[a]Based on a single test. [b]Based on single and replicated test.

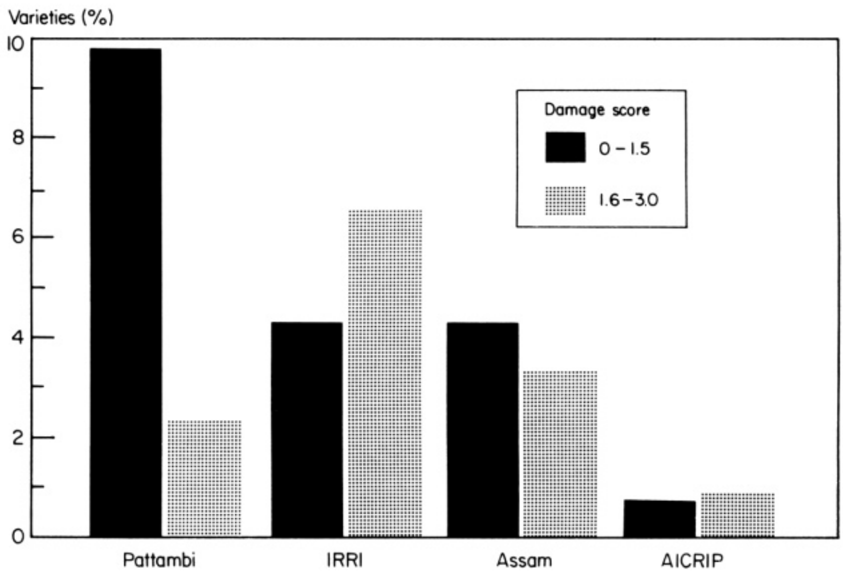
The distribution of the resistant cultivars from Northeast India showed that most had been collected from the hilly tracts of Assam, Meghalaya, and Manipur.

Germplasm from IRRI. Of 663 cultivars from IRRI, 73 exhibited varying degrees of resistance. Twenty-nine showed a high level of resistance, they were earlier found to be resistant or moderately resistant to biotype 1 at IRRI (Pathak 1976).

Germplasm from Pattambi and Coimbatore. About 301 entries from the Rice Research Station, Pattambi, and 514 from the Agricultural College and Research Institute, Coimbatore, were evaluated. Ninety-six entries from Coimbatore and 37 from Pattambi had damage scores under 3 in preliminary tests. Of those 30 from Pattambi and 24 from Coimbatore had scores ranging from 0 to 1.5. The reactions of entries from Pattambi have been confirmed in replicated tests; those from Coimbatore are still being confirmed.

Germplasm from AICRIP and Andhra Pradesh Agricultural University (APAU). A total of 567 traditional tall varieties from the AICRIP collection and 44 from the APAU collection were also tested. Seven from the AICRIP collection and one from APAU were resistant.

From such limited evidence, any conclusion about the relative contributions of germplasm from various Indian sources to resistance to the BPH has restricted value (Fig. 2). However, the evaluations give a broad view of promising sources. Materials from Kerala and Northeast India were most promising. The



2. Relative percentages of the varieties tested at AICRIP having resistance to the brown planthopper *Nilaparvata lugens.*

Table 2. Cultivars showing high resistance to the brown planthopper in greenhouse tests (All India Coordinated Rice Improvement Project).

Variety	Source	Damage score[a] (0–5 scale)	Variety	Source	Damage score[a] (0-5 scale)
ARC 5987	Assam	1.0	ARC 7327	IRRI	1.0
ARC 10550	"	0.6	Ngane Tie	"	1.0
ARC 10945A	"	0.9	ARC 6650	"	1.1
ARC 11354	"	0.6	Loku Samba	"	1.1
ARC 14203	"	0.8	ARC 7320	"	1.1
ARC 14342	"	0.4	ARC 1040	"	1.2
ARC 14394	"	1.0	Gapita	"	1.2
ARC 14529	"	0.2	Kalu Samba	"	1.2
ARC 14529A	"	0.3	Sinna Sivappu	"	1.2
ARC 14636A	"	0.5	Kalu Hathiyal	"	1.2
ARC 14766	"	0.3	Batia Sira	"	1.2
ARC 14766A	"	0.7	Madael	"	1.2
ARC 14988	"	0.7	Balamawee	"	1.3
ARC 15152	"	0.3	ARC 10834	"	1.3
ARC 15570A	"	0.6	Horana Mawee	"	1.3
Chennelu	Pattambi	0.9	Mudu Kiriyal	"	1.3
S 2204	"	0.9	ARC 5757	"	1.3
T 27	"	0.9	Sudurvi 305	"	1.3
T 3	"	1.0	Umsum	"	1.3
Company Chittari	"	0.9	Hathiyal	"	1.4
T 10	"	1.0	Rathu Heenati	"	1.4
Ennapatta	"	0.9	Senawee	"	1.5
5352	"	0.7	Mawee	"	1.5
T 1415	"	0.5	Djawa Sredek	"	1.5
T 1421	"	0.9	Nang Lay	"	1.5
T 1437	"	0.8	Ptb 28	AICRIP	1.5
T 1471	"	0.9	ARC 5918	"	1.0
Lua Ngu	IRRI	0.6	Manoharsali	"	1.2
Ptb 19	"	0.7	JBS 1168	"	1.1
Sinnanayam 398	"	0.8	Mtu 16	APAU	1.0
ARC 5839	"	1.0			

[a] Based on replicated test. 0 = no damage, 5 = plants killed.

increased contributions of IRRI germplasm is due to the earlier screening at IRRI for biotype I. The donors showing relatively high levels of resistance are listed in Table 2.

Screening for resistance at other centers. Screening of entries at CRRI revealed BPH resistance in the greenhouse in the cultivars Ptb 33, Ptb 21, Ptb 10, TKM 6, Murungakayan, ARC 5984, ARC 7239, ARC 18529, ARC 14729, ARC 14736, ARC 15223, ARC 15264, ARC 15821, ARC 12627, ARC 15284, ARC 14766, ARC 14529, ARC 10176, AC 131, AC 199, AC 357, AC 1224, AC 1619, AC 3070, and MNP 76. In addition, 20 cultivars derived from crosses involving Ptb 10, Ptb 18, Ptb 21, and Panbira have shown a high level of resistance (Prakasa Rao and Das 1976, unpubl.).

Evaluation of breeding material

Besides the general screening, a program was initiated at AICRIP to evaluate breeding lines developed at AICRIP and other locations, including the International Rice Observational Nursery (IRON).

Among the 3,180 National Screening Nursery entries tested so far, 17 were resistant (scoring 0 to 1.5); 88 exhibited moderate degrees of resistance (1.6 to 3.0).

Eight entries out of 380 cultures from IRON showed moderate resistance.

In the AICRIP breeding materials, 391 out of 7,476 selections had scores below 1.6, and 916 had scores ranging from 1.6 to 3.0. The material came from more than 40 cross-combinations; selections from crosses RP 31–49–2/Leb Mue Nahng, Vijaya/Ptb 21, Sona/Manoharsali, and ARC 5984/Pelita were very promising.

Two hundred and twenty-eight breeding lines from crosses involving resistant donors such as Ptb 10, Ptb 18, Ptb 21, and Panbira from CRRI, Cuttack, were tested against the BPH. Nine showed moderate degrees of resistance.

Of 118 breeding lines from Pattambi, 12 showed a high level of resistance while 31 lines were moderately resistant in a preliminary test. Among 450 selections from APAU involving crosses Sona/Manoharsali and Jaya/Manohar Sali, 31 were promising, with damage scores of less than 1.5, while 3 had moderate resistance (Lakshminarayana 1976, unpubl.).

Evaluation of BPH-resistant donors against other pests of rice

Current emphasis is on the development of lines with multiple resistance. Cultivars already identified as resistant or moderately resistant to BPH were tested by infestation in the greenhouse for the reaction to the whitebacked planthopper (*Sogatella furcifera*) and to gall midge (*Orseolia oryzae*) (Table 3). Fifty varieties possessed multiple resistance; among them, 14 were resistant or moderately resistant to all three insect pests. Twenty-six varieties were resistant to the whitebacked planthopper and the BPH; 10 lines had resistance to the gall midge and the BPH.

Studies by Sastry and Prakasa Rao (1975) at CRRI identified Ptb 18, Ptb 21, Leaung 152, TKM 6, and W 1263 as resistant to planthoppers, leafhoppers, gall midges, and stem borers.

STUDIES OF HOST-PLANT-INSECT INTERACTION

Preference or nonpreference

Ptb 33, Ptb 21, ARC 6650, and MR 1523, which possess varying degrees of resistance, and susceptible TN1, were grown in wooden flats, and first- and second-instar nymphs were released on 1-week-old seedlings; each seedling was originally infested by about 10 nymphs. The insect counts on different varieties after 24 hours showed significant differences (Table 4). TN1 attracted the most nymphs (17.9), Ptb 33 the fewest (9.6); Ptb 21, ARC 6650, and MR 1523 attracted 12.0, 12.2, and 13.5 nymphs respectively. These differential responses suggest the possible presence of some attractant in the susceptible variety and its absence in the resistant cultivars, or the presence of repellents in the resistant

Table 3. Rice cultivars with multiple resistance to insects (Kalode et al 1976, unpubl.).

Variety	Source	Reaction to [a]		
		BPH	WBPH [b]	Gall midge
ADR 52	Pattambi	R	R	R
Vellathil Chera	"	R	R	R
Pandi	"	R	R	R
Chennellu	"	R	R	R
T 1425	"	R	R	R
T 1471	"	R	R	R
Ptb 19	"	R	R	R
Ptb 21	"	R	R	R
Channinyakan	"	R	MR	R
Chemban	"	MR	R	R
T 1426	"	R	MR	R
Velutha Chera	"	MR	R	R
MR 1523	CRRI	R	MR	R
ARC 11704	Assam	R	MR	R
L x H/2-281	Pattambi	R	R	S
Lal Basumati	"	R	R	S
Valsarachampara	"	R	R	S
5332	"	R	R	S
IR 781-144-1-IR8/2 yukara x TN1 4C952	"	R	R	S
Eswaramangalam	"	R	R	S
Cheriya Chittari	"	R	R	S
Ptb 33	"	R	R	S
Kodiyam	"	R	R	— [c]
ARC 14539B	Assam	R	R	S
ARC 14766A	"	R	R	S
Podwi 48	IRRI	R	R	S
Sulai	"	R	R	S
Chemparam Pandi	Pattambi	R	MR	S
Kula Peruvela	"	R	MR	S
Siam 7	"	R	MR	S
T 1406	"	R	MR	S
Chetteri	"	R	MR	S
ARC 15570A	Assam	R	MR	S
ARC 14529	"	R	MR	S
Vellai Langayan	IRRI	R	MR	S
Gangala	"	R	MR	S
ARC 13788	Assam	R	MR	S
Chempan	Pattambi	MR	R	S
CS 531	"	MR	R	S
T 1477	"	MR	R	S
T 10	"	R	S	R
T 16	"	R	S	R
T 1421	"	R	S	R
T 1432	"	R	S	R
Karuth Vellathan	"	R	S	R
Parakulam	"	R	S	R
ARC 5984	Assam	R	–	R
Ptb 12	Pattambi	MR	S	R
710	"	MR	S	R
Vellachnipan	"	MR	S	R

[a] BPH = brown planthopper, WBPH = whitebacked planthopper, R = resistant, Mr = moderately resistant, S = susceptible. [b] Based on single test. [c] No test.

Table 4. Preference and antibiosis reaction of the brown planthopper on selected rice varieties (Kalode et al 1976, unpubl.).

Variety	Nymphs settled (av. no.)	Adults at 14th day (%)	Females 20 days after release (%)	Progenies (no.)[a]
Ptb 33	9.6	18	13	200
MR 1523	13.3	20	9	189
Ptb 21	12 0	15	9	197
Leb Mue Nahng	13.5	37	31	1300
ARC 6650	122	53	45	3105
TN1	17.9	61	52	7401

[a] Thirty-five days after infestation. [b] 24 h after release.

types. Similar observations were reported at IRRI and in Korea (Karim 1975, Choi 1974).

Antibiosis

To identify varieties possessing a high level of antibiosis, freshly hatched nymphs (10 per plant) were caged on 30-day-old plants, and their life cycle was studied. Survival and development of nymphs and population buildups on each variety were noted regularly.

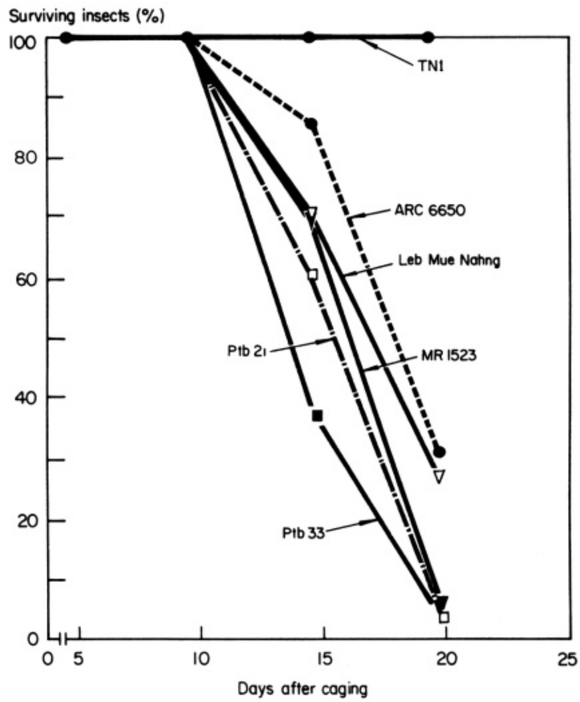
Survival of nymphs on resistant and susceptible cultivars. Survival of nymphs 15 days after they were caged on resistant and susceptible cultivars varied significantly (Fig. 3). On the 20th day after caging, 97.8% were alive on susceptible TN1; the survival rate was as low as 2.8, 3.3, and 4.8% on Ptb 33, Ptb 21, and MR 1523, respectively. The survival rates were intermediate on Leb Mue Nahng (26.1%) and ARC 6650 (29.2%). Survival was affected only after 10 days of caging. Mortality was high immediately before the adult stage was reached or shortly thereafter (Kalode et al 1976).

Population buildup of the brown planthopper on resistant and susceptible varieties. The population buildup from 100 original nymphs (from 10 replications) on Ptb 33, Ptb 21, and MR 1523 was significantly lower (189 to 200 nymphs) than that on TNl (7,401). Leb Mue Nahng and ARC 6650 were comparatively favorable to the insect (Table 4).

Other evidences of antibiosis included lower rates of nymphal development, lower production of females, and feeble development of adults. Similar effects had been reported by Sogawa and Pathak (1970) in populations reared on the variety Mudgo and on different rice varieties by Karim (1975).

Honeydew experiment

Honeydew deposition by leafhoppers and planthoppers has been used as a tool to measure the insects' food intake and the resistance of the host plant to insect attack (Sogawa and Pathak 1970; Karim 1975; Viswanathan 1975, unpubl.). In the current investigations, honeydew was collected on filter paper from 10



3. Survival of brown planthopper on selected rice varieties.

prestarved female adults that had been confined on each resistant cultivar for 24 hours. The amount of honeydew excreted was estimated by spraying filter paper with a 0.2% ninhydrin solution and reading the concentration with the help of a spectrophotometer after spots on the filter paper were dissolved in 80% ethanol.

Insect feeding on resistant cultivars Ptb 33, Ptb 21, MR 1523, and ARC 6650 was restricted (Table 5). Insects on Leb Mue Nahng and TNl excreted more heavily. The data also indicate a possible correlation between insect survival, population buildup, and honeydew excretion. Lower survival rates and less population buildup were thus associated with less feeding on the resistant varieties. The differences observed in honeydew excretion might be used as an indirect index of the degree of resistance. A similar possibility was earlier suggested by Sogawa and Pathak (1970), Choi (1974), and Karim (1975).

Effect of insect age on interaction with resistant and susceptible varieties

The time required by insects of different ages on a susceptible cultivar such as RP 31-49-2, RP 9-6, RP 9-4, or TNl and on a resistant cultivar. MR 1523, to destroy it was studied. The relatively shorter time taken by 6- to 7-day-old nymphs to destroy the susceptible varieties, compared with that taken by insects

Table 5. Total amino acid concentration in honeydew excreted by brown planthopper (10 females) fed on various rice varieties for 24 hours (Krishna, unpubl.).

Test variety	Total amino acid concentration (absorbance at 540/μ)
Ptb 21	0.34
Ptb 33	0.16
ARC 6650	0.47
MR 1523	0.24
Leb Mue Nahng	1.50
TN1	1.65

in other stages of growth, indicated their greater feeding requirement. The resistant variety MR 1523, although it recorded a slightly higher damage score with 6- and 7-day-old nymphs (3.0) than with adults (1.0) or 1- and 2-day-old nymphs (1.8) never suffered complete damage (Kalode et a1 1976, unpubl.).

Effect of different numbers of nymphs on resistant and susceptible varieties of different ages

Two rice varieties, TNl (susceptible) and MR 1523 (resistant), were caged with different numbers of nymphs and the extent of damage to MR 1523 was noted when all TN1 plants had been killed. The 10-, 15, and 20-day-old MR 1523 plants retained their resistance (0.5 to 1.3) even with increasing insect numbers (5 to 15, 15 to 25, and 25 to 35 insects/plant, respectively) while TNl plants were killed at all levels of insect population and at all plant ages.

In another experiment, Ptb 33, Ptb 21, Umsum, MR 1523, ARC 6650, and Leb Mue Nahng were infested at various ages (10, 30, 45, or 60 days after planting) with about equal numbers of insects (10, 30, 40 or 60 nymphs/plant, respectively). Results indicated that plant age did not influence the degree of resistance expressed (Kalode et a1 1976, unpubl.).

GENETICS OF RESISTANCE

Studies in India of the genetics of resistance to the BPH are few. Resistance to the BPH in Leb Mue Nahng was found to be qualitative and under single-gene control (Prasada Rao et a1 1976).

In studies of the genetics of resistance, 120 crosses were made in 1975. F_1 hybrid plants and F_2 materials were tested for reaction to the BPH by mass screening.

The results generally indicate that Ptb 33, ARC 6650, ARC 14636B, ARC 7080, and Lua Ngu possess dominant genes for resistance, whereas Ptb 21, MR 1523, Umsum, Leb Mue Nahng, ARC 14394, and ARC 15694 have the recessive gene for resistance (Krishna, unpubl.).

BREEDING FOR RESISTANCE

With the identification of four genes for resistance to the BPH (*Bph 1, bph 2, Bph 3,* and *bph 4*) (IRRI 1976), efforts to transfer the genes to varieties with desirable agronomic bases were most successful. The use of such varieties could control the BPH effectively in some countries (Freeman 1976).

Efforts to develop resistant cultivars with good agronomical backgrounds in India were successful. Some studies at AICRIP and CRRI on different crosses in successive generations have resulted in the identification of some resistant cultivars (Table 6). Entries in the RP 825 series seem to be resistant at IRRI to all three biotypes.

Table 6. Breeding lines resistant to or tolerant of the brown planthopper in studies in India.

Designation	Cross	Source
RP 1045-6-10-1 [a]	RP 31–49–2× Leb Mue Nahng	AICRIP
RP 1045-6-10-2 [a]	–do–	–do–
RP 1045-6-7-1 [a]	–do–	–do–
RP 1045-6-7-4 [a]	–do–	–do–
RP 1045-23-2-1 [a]	–do–	–do–
RP 825-24-7-1 [a]	Vijaya × Ptb 21	–do–
RP 825-24-7-1-1 [a]	–do–	–do–
RP 825-41-1-1	–do–	–do–
RP 825-71-4-4	–do–	–do–
RP 825-71-4-11	–do–	–do–
RP 825-71-4-11-1	–do–	–do–
RP 825-82-1-6-6 [a]	–do–	–do–
RP 825-82-4-1-6	–do–	–do–
RP 825-4-1-11 [a]	–do–	–do–
RP 1015-7-1 [a]	Sona × Manoharsall	–do–
RP 1015-29-7-1 [a]	–do–	–do–
RP 974-113-4-15 [a]	Sona × RP 9-4	–do–
RP 919-24-7-1-1 [a]	Sona × RP 8-8	–do–
RP 919-7-4-1-1	–do–	–do–
RP 899-3-6-9	IR8 × Tadukan	–do–
RP 899-3-6-9-1	–do–	–do–
CR 157-392-107-175	Vijaya × Ptb 10	CRRI
CR 157-392-11-4	–do–	–do–
CR 157-392-41-112	–do–	–do–
CR 157-389-12-47	–do–	–do–
CR 157-389-43-135	–do–	–do–
CR 157-392-21-185	–do–	–do–
CR 157-295	–do–	–do–
CR 157-389-43-120	–do–	–do–
CR 94-MR-1550-1075-690	(Ptb 21 × Ptb 18) × IR8	–do–
CR 94-MR-1550 white-90	–do–	–do–
S 11-52-626	IR20 × Panbira	–do–
S 11-78-629	–do–	–do–
CR 57-MR 1523	IR8 × Ptb 21	–do–
CR 57-11-2 [a]	–do–	–do–
CR 95-13-3 [a]	IR8 × Leaung 152	–do–
BPP 1235 [a]	IR8 × W 12787	APAU

[a] Lines presently under test in brown planthopper resistant variety trial.

Table 7. Reaction of selected rice varieties to the brown planthopper at different locations in India (preliminary report, International Rice Brown Planthopper Nursery. 1976).

Designation	Damage reaction[a] at		
	Cuttack	Hyderabad	Pattambi
Co 9	MR	S	S
Chianung-Sen-Yu 11	S	S	MR
Dikwee 2328	S	S	MR
Murungakayan 101 b	S	S	MR
Gangala	MR	S	S
Ptb 19	R	MR	R
Ptb 21	R	MR	R
Ptb 33	R	R	R
ARC 6650	R	R	R
Kentjana	S	S	MR

[a]R = resistant, MR = moderately resistant, S = susceptible

BIOTYPES

IR26 was resistant to the BPH in the Philippines and several other countries. However, it was susceptible at Kerala and AICRIP (Hyderabad) in India, and in Sri Lanka. The different reactions could be caused by different BPH populations in different areas. Data on the reaction of cultivars to the BPH at three locations in India are in Table 7. Varietal reactions show differences at different locations. Further critical supporting evidence is necessary. However, some of

Table 8. Brown planthopper damage to selected rice varieties from the Assam Rice Collection tested by the All India Coordinated Rice Improvement Project and the International Rice Research Institute.[a]

Designation	INDIA (AICRIP, Hyderabad)	PHILIPPINES (IRRI)[b]		
		Biotype 1	Biotype 2	Biotype 3
ARC 6650	2.0	3	1	9
ARC 7080	1.2	9	9	5
ARC 10550	0.6	9	9	9
ARC 14636	2.7	9	9	9
ARC 14342	0.4	7	7	9
ARC 14394	1.0	9	9	9
ARC 15570 A	0.6	9	9	9
ARC 14529	0.2	7	9	9
ARC 14766	0.3	5	9	1
ARC 14988	0.7	9	9	9
ARC 15152	0.3	9	9	9
ARC 15694	0.5	9	9	9
ARC 15831	1.8	9	9	9
Ptb 33 (check)	2.0	1	1	3

[a]Damage based on 0–9 scale: 0 = no damage, 9 = plants killed. [b]Personal communication with M. D. Pathak, 1976.

the ARC cultures that showed higher levels of resistance in earlier studies (Khrishna et al 1976) at Hyderabad (AICRIP) were tested at IRRI against three biotypes (Table 8). The data suggest that the biotype at AICRIP is entirely different from any of the three biotypes identified at IRRI.

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