Varietal resistance to the brown planthopper in Sri Lanka

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Two characteristics that emerge from seedling screening for *Nilaparvata lugens* resistance in Sri Lanka by the method described by Pathak (1971) are the frequent inconsistency of results, and the absence of a gradation of symptoms of damage leading to plant death. To illustrate these points, Ptb 33, which generally demonstrates a high level of resistance, may in some experiments have a survival range of 45 to 65% within four replications, and plant death is often observed as sudden wilting and not as progressive yellowing. Those features need further investigation.

Twenty varieties from Sri Lanka's indigenous rice collection of 985 varieties have been found resistant to *N. lugens.* Some are being studied in greater detail to elucidate the basis of their resistance, while others are being used in the current breeding program.

Studies on the effect of stage of plant growth on responses to *N. lugens* infestations indicate that seedling susceptibility or resistance does not necessarily continue until the later stages of plant growth.

Resistance to *N. lugens* in the seedlings of Ptb 33 and TR 26 was carried over into the 30- and 60-day-old plants. The seedling resistance noted in Iri 329, Jyoti, and Milyang 30 was lost in the later stages of plant growth. On the other hand, varieties such as Mudgo, Ptb 21, and Suduru Samba, which were susceptible in the seedling stage, proved resistant in later stages. The physiology and biochemistry of the rice plant vary with its growth stage, and findings of this nature are to be expected, at least with certain biotypes of an insect species. Such variability of resistance to an insect species, although not previously recorded for *N. lugens,* has been described for *Chilo suppressalis.* Resistance to *C. suppressalis* was present in Chianan 2 and Taitung 16 during the vegetative stage, but was lost when the plants flowered (Pathak 1972). *N. lugens* is a pest mainly of maturing rice plants Our findings emphasize the need for screening older rice plants for resistance, particularly to the biotype found in Sri Lanka.

N. lugens from Sri Lanka showed plant reactions and insect survival and development markedly different from those of the Philippines biotypes. Most of the rice varieties found resistant to the Philippine biotype originated in Sri Lanka, where for several hundred years they had been exposed to the *N. lugens* populations.

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Ptb 33 has to date been used as the principal donor parent for *N. lugens* resistance in our breeding program. Although its high level of resistance is transferable, its poor plant type and photoperiod sensitivity require several seasons to ensure combination of such resistance with other desirable agronomic characteristics. Resistance to *N. lugens* in Ptb 33 is controlled by a single dominant gene.

THE BROWN PLANTHOPPER (BPH) *Nilaparvata lugens* (Stål) was first recorded as a pest of rice under the name *Nilaparvata greeni* (Distant) in the Kulutara District, Sri Lanka, in 1912. Since then, sporadic outbreaks of the pest have occurred in several areas, mainly in southwestern Sri Lanka. In the late 1960's and early 19703, BPH incidence increased in most rice-growing areas, and in 1973 an extensive outbreak in the eastern province in the Ampari District affected more than 50,625 ha.

In field tests at the peak of the attack in 1973–74, all popular commercial varieties, including the recently introduced IR26, were highly susceptible and suffered hopperburn. Only one variety, known to local farmers as "H 501" (a misidentification), survived to maturity at the highest pest intensities and appeared to be a nonpreferred variety. Since then, the search for varietal resistance to BPH has continued in Sri Lanka as a major research effort at the Central Agricultural Research Institute (CARI), Peradeniya, and Central Rice Breeding Station (CRBS), Bathalagoda.

SCREENING TECHNIQUES

The methods of culturing *N. lugens* and of screening for resistance to the insect at the Bathalagoda station essentially followed those described by Pathak (1971). At CARI, the screening techniques were generally the same, but the BPH cultures were raised on rice seedlings, usually 4 to 6 days old. Adult insects were introduced on culture plants for 2 days, then withdrawn to oviposit on fresh culture plants. Bg 11-11 was initially used as the culture plant but it was so susceptible to the pest it had to be replaced with Bg 34-6, a somewhat more tolerant variety. Screening of lines followed the same procedure, but screening results had to be reported in terms of percentage of plants affected because BPH in Sri Lanka produced an "all-or-none reaction" "sudden wilting of green plants rather than the graded symptoms that precede plant death, observed with the Philippine biotypes.

Both 5- to 10-day-old seedlings and 30-day-old, and even 60-day-old, plants were screened in the laboratory. We argued that because considerable physiological differences exist between the 5- to 10-day-old seedlings and the older plants, screening only very young seedlings for resistance might give misleading results. We believe results have justified this thinking, but screening older seedlings presents a variety of practical problems.

Four 30-day-old plants of each of four varieties were grown in a 12- ×

12- × 12-inch pot. In the case of 60-day-old plants, 9 to 12 plants of one variety occupied a single pot. The test pots were placed one against the other and enclosed with a 45-cm-high, black, fine nylon mesh. After 30 days or 60 days of growth, plants were infested with first- and second-instar BPH nymphs.

Field screening was not reliable because sufficient pest populations rarely built up in the test areas.

SCREENING INDIGENOUS VARIETIES FOR RESISTANCE

The earliest laboratory screening of seedlings of varieties that, on the basis of the experience of workers in the Philippines and in India, were considered most likely to have resistance to BPH showed that IR26 was susceptible and Ptb 33 resistant.

Pathak (1971) screened 10,000 rice varieties for resistance to the Philippine strain of *N. lugens* and showed that 46 varieties, mainly from Sri Lanka and India, were highly resistant. The 985 accessions of local varieties collected from various parts of Sri Lanka were, therefore, screened in the hope that a wider range of resistance would be found. The cultures of *N. lugens* were from original collections made in the Amparai District, where large-scale BPH outbreaks had become almost routine.

In seedling screening, only 20 varieties showed more than 40% survival when the highly susceptible check Bg 11-11 had less than 10% survival (Table 1).

Table 1. Traditional Sri Lanka rice varieties showing over 40% plant survival in seedling screening of 985 varieties for resistance to *N. lugens*

Sri Lanka acc. no.	Variety	Surviving seedlings (%)
248	Thunmaswee	40
445	Panduruwee	41
630	Rata-thavalu	40
633	Cheenadi	63
645	Mawee	79
666	Kaluhandiran	50
701	Mudukiriel	50
782	Moddai Samba	42
793	Elewee	40
1094	Suduru Samba	72
1188	Rathu Hondarawala	40
1251	Kahata Keralla	56
1253	Heen Rathkunda	80
1255	Sudu Heenati	80
1256	Ele Samba	60
1326	Hal Suduwee	43
1480	Yakada Wee	40
1487	Batapolawee	44
2095	Murungakayan 303	46
2201	Balamawee	69

Table 2. Replicated seedling screening for resistance to *N. lugens* of five selected traditional Sri Lanka rice varieties.

Variety	Surviving seedlings (%) (mean of 4 readings)
Sudu Heenati	84
Heen Rathkunda	37
Suduru Samba	50
Mawee	49
Cheenadi	5
Ptb 33 (check)	51
IR26 (check)	24
Bg 11-11 (check)	0

Of the 20, five were selected on the basis of desirable agronomic characteristics for further screening in tests replicated four times, with Ptb 33, IR26, and Bg 11-11 as checks. The results are in Table 2.

The BPH resistance of the local varieties Sudu Heenati, Heen Rathkunda, Suduru Samba, and Mawee, and the Indian variety Ptb 33 was superior to that of IR26.

Of nearly 500 local and introduced varieties screened in the seedling stage, as described by Choi (this volume), seven showed high levels of resistance (Table 3).

After the field screenings at Bathalagoda, it was concluded that although all the seven varieties (Table 3) showed consistently high levels of resistance to BPH in the greenhouse tests, Ptb 33 performed best at all stages of growth in the field.

SCREENING THE SECOND INTERNATIONAL RICE BROWN PLANTHOPPER NURSERY

The screening of the Second International Rice Brown Planthopper Nursery (IRBPHN) at CRBS, Bathalagoda, suggested that the Indonesian varieties

Table 3. Seven varieties of rice showing high levels of *N. lugens* resistance in seedling screening of about 500 Sri Lankan and introduced varieties at Central Rice Breeding Station, Bathalagoda.

Variety	Seedlings surviving (%) 10-12 days after infestation
Ptb 33	84
ARC 6650	78
Suduru Samba	77
Rathu Heenati	75
Heenrath Kunda	74
MR 1523	71
Sudhu Heenati	65
TN1 (check)	9

Table 4. Variation of susceptibility or resistance to *N. lugens* with stage of rice plant growth.[a]

IRRI no.	Variety	5 days old		30 days old		60 days old	
		Surviving plants (%)	Ratio of surviving plants to total no.	Surviving plants (%)	Ratio of surviving plants to total no.	Test plants (no.)	Weeks (no.) until 100% kill
60	RD4	100	22:22	0	0:2	8	4.5
61	RD9	86	12:14	0	0:2	7	4.0
49	IR8 M 16	60	12:20	0	0:3	9	4.0
55	IRI 328	61	14:23	50	2:4	9	3.5
57	IRI 329	77	17:22	0	0:2	9	3.0
58	Jyoti (Ptb 39)	82	22:27	0	0:4	9	5.0
59	Milyang 30	67	16:24	0	0:4	8[b]	3.0[b]
66	WX 325-30-17-2	45	9:20	0	0:4	—	—
54	IR2307 - 72-2-2-1	42	10:21	0	0:2	9	3.0
82	Gangala	48	10.21	0	0:4	9	6
36	Ptb 33	53	10:19	100	4:4	9	6
62	TR 26	48	10:21	100[b]	4:4[b]	8[b]	6[b]
9	Bogor 14	50	4:8	—[b]	—[b]	—[b]	—[b]
71	ARC 11354	50	4:8	—[b]	—[b]	—[b]	—[b]
74	ARC 14529	60	6:10	—[b]	—[b]	—[b]	—[b]
78	ARC 14771	71	10:14	—[b]	—[b]	—[b]	—[b]
79	ARC 15831	67	4:6	—[b]	—[b]	—[b]	—[b]
81	Babawee	57	8:14	—	—	—	—
8	Mudgo	14	3:22	100	4:4	15	6.0
28	Mudgo	0	0:19	0	0:4	4	3.0
48	Mudgo	0	0:15	75	3:4	9	3.0
68	Mudgo	0	0:18	100	4:4	9	5.0
88	Mudgo	0	0:14	100	3:3	9	5.0
67	ARC 6650	0	1:23	100	4:4	9[b]	5.0[b]
89	Muthumantham	8	1:12	75	3:4	—[b]	—[b]
93	Ptb 21 (Tekkan)	0	6:17	100	4:4	—[b]	—[b]
97	Sudurusamba	0	0:20	100	4:4	—	—
	TN1 all 5 accessions	0		0		9	4

[a] Varieties selected from second International Rice Brown Planthopper Nursery. [b] Not tested due to lack of seed.

Bogor 6, 8, 12, 18, and 20 were BPH resistant, but it was felt that the tests should be repeated for confirmation.

Screening at CARI, Peradeniya, of the same varieties at seedling stage. and at 30 days, and at 60 days old gave results that suggest that seedling resistance or susceptibility is not necessarily carried over to the later growth stages of the rice plant (Table 4).

Of the varieties tested at all three stages, only Ptb 33 and TR 26 had seedling resistance that correlated with resistance at the 30-day and 60-day stages. Nine varieties with seedling resistance were susceptible in the later stages. On the other hand, of the 10 entries that showed marked seedling susceptibility, 8 were resistant at 30 days old, and at least 3—(8)[1] Mudgo, (68) Mudgo, (88) Mudgo, and (67) ARC 6650—carried the resistance through to the 60-day-old stage.

In a recent test, 19 varieties were tested by the seedling screening method. IR32 (57.1%), IR4432-52-6-4 (62.5%), and IR2071-586-5-6-34 (66.7%) were

[1]Numbers enclosed within parentheses are IRBPHN numbers.

resistant to BPH, but such varieties as IR28, IR34, and IR38 proved highly susceptible.

Numerous field screening of both indigenous and introduced varieties have been laid out, but only once did the test areas suffer BPH infestations severe enough to permit clear-cut and reliable evaluations. During the 1974 epidemic in the Amparai District, a replicated screening of the varieties Bg 94-2, Bg 90-2, Bg 66-1, and so-called H 501 was conducted in highly infested areas. The highest yields were obtained from Bg 94-2, a 3.5-month variety that matured early and escaped the third-generation BPH buildup. H 501 showed almost no signs of damage and supported an extremely low BPH population. All other varieties, including IR26, suffered severe hopperburn. Subsequently H 501 showed high seedling susceptibility in the seedling screening. But it seems possible that the variety would prove highly resistant if screened at later stages of growth.

BROWN PLANTHOPPER BIOTYPES

No detailed studies have been conducted to determine the biotype or biotypes of BPH found in Sri Lanka. However, some studies have been made of the survival and development of nymphs on specific rice varieties, of the period required for the nymphs to kill seedlings of certain varieties, and of the relative survival, with time, of certain varieties exposed to the nymphs. The studies confirm that the BPH found in Sri Lanka differs greatly from the biotypes found in the Philippines.

Three-day-old seedlings growing singly in test tubes were exposed to six first-instar BPH nymphs, and the number of days until the death of each plant was recorded (Table 5). The varieties Ptb 33, ARC 6650, Rathal 518,

Table 5. Number of days until death of seedlings of selected rice varieties exposed to 6 *N. lugens* nymphs.[a]

Variety	Days (no.) to death of					
	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6
Sudhu Heenati[b]	6	6	6	6	7	–
Bg 11-11[b]	14	5	8	9	12	–
IR36	7	10	10	10	12	10
IR38	11	8	11	7	7	7
ASD 7	10	10	10	10	7	7
Mudgo	10	10	11	10	11	11
Babawee[b]	10	10	13	16	–	–
Rathal 518[b]	20	16	20	16	20	–
Heenrathkunda	12	12	20	16	16	–
ARC 6650	20	20	15	20	20	–
Ptb 33	20	20	18	20	20	–
Sudurusamba	10	20	16	14	15	–

[a]In single-plant test-tube cultures, 6 nymphs/plant. [b]Only 5 plants were used in this test.

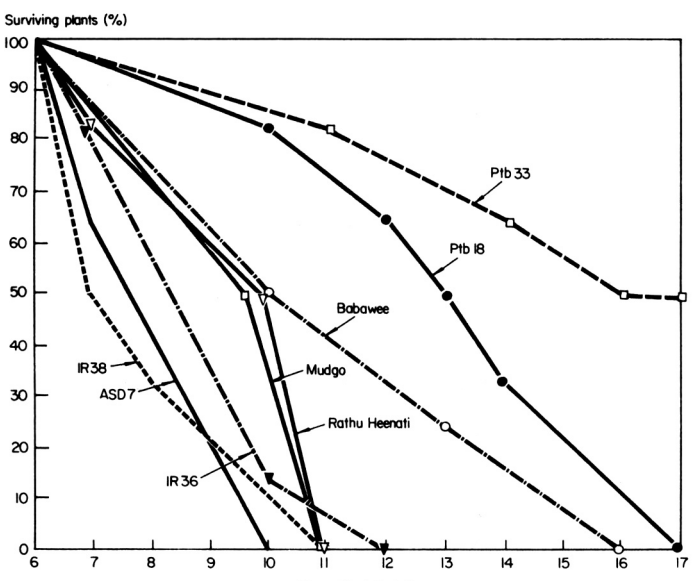
Table 6. Survival and development of *N. lugens* nymphs on 8 rice varieties.

Rice variety	Test nymphs (total no.)	Nymphs (no.) surviving to adulthood					Nymphal deaths (no.)
		Brachypterous (females)	Macropterous (females)	Brachypterous (males)	Macropterous (males)	Total	
Mudgo	35	18	0	0	12	30	5
ASD 7	18	4	0	0	9	13	5
Bg 34-6	54	29	2	0	13	44	10
IR8	30	17	0	0	6	23	7
Bg 11-11	59	19	0	0	15	34	25
Ptb 33	51	16	0	0	21	37	25
Sudhu Heenati	30	10	3	0	10	23	7
Suduru Samba	29	8	1	0	13	22	7

and Sudurusamba showed marked resistance to the pest, and ASD 7, Mudgo, IR36, and IR38, which had been found resistant to the Philippine races, were highly susceptible to the Sri-Lankan biotype.

Single first-instar nymphs were introduced on 3-day-old seedlings growing singly in test tubes. The number of nymphs that survived and the types of adults that developed were recorded (Table 6). If survival and development on Bg 11-11 are treated as an index of normal development on a susceptible variety, BPH developed normally on all the varieties, including ASD 7, Mudgo, and Ptb 33.

The rate at which certain rice varieties died or survived as single plants under attack by a fixed number of BPH nymphs in single test tubes was studied (Fig. 1). Seventeen days exposure to the pest, Ptb 33 showed 50% survival of



1. Effect of *N. lugens* infestation on rice varieties.

Table 7. Genetics of resistances to *N. lugens* in Ptb 33.

Cross or parent	Resistant	Susceptible	Total	X^2
TN1	0	16	16	—
Ptb 33	18	0	18	—
TN1/Ptb 33:F_1	44	0	44	—
TN1/Ptb 33:F_2	107	30	137	0.702(3:1)
TN1/Ptb 33/TN1 BCF1	10	10	20	0 (1:1)

seedlings. Other varieties resistant to the Philippine strain of BPH, such as Ptb 18, Rathu Heenati, Babawee, Mudgo, IR36, IR38, and ASD 7, suffered 100% mortality.

BREEDING FOR RESISTANCE

Breeding for BPH resistance in Sri Lanka was initiated in 1973 with IR26, H 105, Mudgo, and ASD 7 as donors for resistance. During the 1973–74 epidemic some of those varieties were found to be susceptible, suggesting biotype differences. With the discovery of new sources of resistance, the initial crosses were abandoned (Gunawardena et al 1975; Kudagamage 1976) and new crosses were made in 1975. Ptb 33 was used extensively as the resistant donor, and nearly 300 crosses were made. The crossing program was subsequently expanded with varieties such as Sudu Heenati, Suduru Samba, Heenrath Kunda, and MR 1523 as additional sources of resistance. The proportion of breeding material with BPH resistance continued to increase rapidly. During the last season almost 100% of the F_2 and F_3 and backcross materials had at least one resistant parent.

Ptb 33 consistently had the highest level of BPH resistance in our laboratory and field screenings. But because of its poor plant type and its sensitivity to photoperiod, several more seasons may be required to combine its high level of resistance with desirable agronomic and commercial traits.

In the last season about 1,000 B_1F_3 selections from 22 different backcrosses were evaluated for resistance. Preliminary data clearly indicate that the high levels of BPH resistance in Ptb 33 can be successfully transferred. About 100 F_2 and F_3 bulk populations were also grown and selections were made.

Genetics of resistance in Ptb 33

The genetics of BPH resistance was investigated in Ptb 33 and TN1. The F_1 plants of TN1 and Ptb 33 were resistant, indicating that the resistance is dominant. The F_2 and backcross data (Table 7) suggest that Ptb 33 has a single dominant gene for BPH resistance.

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