International Rice Research Newsletter

VOLUME **9** NUMBER **3** **JUNE 1984**

Published by the International Rice Research Institute, P.O. Box 933, Manila, Philippines

Contents

Guidelines and Style for IRRN Contributors

To improve communication and to speed the editorial process, the editors the *International Rice Research Newsletter (IRRN)* request that contributors use the following guidelines and style:

Style

- Use the metric system in all papers. Avoid national units of measure (such as cavans, rai.etc.).
- Express all yields in tons per hectare (t ha) or, with small-scale studies, in grams per pot (g pot) or grams per row (g row).
- Define in footnotes or legends any abbreviations or symbols used in a figure or table.
- Place the name or denotation of compounds or chemicals near the unlt of measure. For example. 60 kg N ha; not 60 kg ha N.
- The US dollar is the standard monetary unit lor the *IRRN.* Data in other currencies should he converted to US$.
- Abbreviate names of standard units of measure when they follow a number. For example: 20 kg ha.
- When using abbreviations other than for units of measure, spell out the full name the first tlme of reference, with abbreviations in parenthesis, then use the abbreviation throughout the remaining text. For example: The efficiency of nitrogen (N) use was tested. Three levels of N were .... *or* Biotypes of the brown planthopper (BPH) differ within Asia. We studied the biotypes of BPH in ....
- Express time, money, and measurement in numbers, even when the amount is less than 10. For example: 8 years: 3 kg ha at 2-week Intervals. 7%: 4 hours.
- Write out numbers below 10 except in a series containing some numbers 10 or higher and some numbers lower than 10. For example: six parts; seven tractors; four varieties. *But* There were 4 plots in India, 8 plots in Thailand, and 12 plots in Indonesia.
- Write out all numbers that start sentences. For example: Sixty insects were added to each cage: Seventy-five percent of the yield increase is attributed to fertilizer use.

Guidelines

- Contributions to the IRRN should generally be based on results of research on rlce or on cropping patterns involving rice.
- Appropriate statistical analyses are required lor most data.
- Contributions should not exceed two pages of double-spaced, typewritten text. Two figures (graphs, tables, or photos) per contribution are permitted to supplement the text. The editor will return articles that exceed space limitations.
- Results of routine screening of rice cultivars are discouraged. Exceptions will be made only if screening reveals previously unreported information (for example, a new source of genetic resistance to rice pests).
- Announcements of the release of new rice varieties are encouraged.
- Use common not trade – names for commercial chemicals and, when feasible, equipment.
- Do not Include references in IRRN contributions.
- Pest surveys should be quantified with data (% infection, degree of severity, etc.).

Genetic evaluation and utilization

OVERALL PROGRESS

Pant Dhan 4, a medium-maturing rice variety for irrigated lands

J. S. Nanda, S. C. Mani, H. Singh, and J. P. Singh, Plant Breeding Department, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttar Pradesh (UP), India

Pant Dhan 4, a medium-maturing, dwarf (93 cm) rice variety was released recently in UP for cultivation in irrigated fields. It was developed in Sri Lanka from the cross IR262/Remadja and tested in the International Rice Observational Nursery as BG90-2 in 1974. The plants have good tillering capacity, mature in 126-132 d, and have high yield potential. Grains are long, slender, and translucent, with good cooking quality. It is moderately resistant to bacterial leaf blight and will be a good substitute for Jaya, which has become susceptible.

Pant Dhan 4 was tested in station trials from 1976 to 1980 and in state variety trials from 1979 to 1982 (see table). □

Performance of Pant Dhan 4 in state variety trials in Uttar Pradesh, India.

Trial center	Grain yield (t/ha)				Days to maturity	
	Pant Dhan 4	Jaya	CD at 5%	CV in %	Pant Dhan 4	Jaya
			1981 kharif			
Azamgarh	4.6	4.6	0.1	1.8	134	131
Bareilly	7.0	6.7	0.2	2.1	133	141
Haldwani	7.2	5.4	1.2	12.4	139	143
Hardoi	4.1	4.3	0.2	4.3	124	135
Mathura	5.1	4.8	0.3	4.5	123	130
Meerut	2.0	1.7	0.3	12.6	140	141
Jhansi	2.1	2.5	0.6	16.1	123	127
Barabanki	3.2	3.6	0.4	7.9	122	129
Etawah	3.1	4.3	1.0	20.6	122	126
Varanasi	3.1	3.5	1.5	12.0	110	126
Average	4.2	4.2	–	–	126	133
			1982 kharif			
Azamgarh	3.8	4.5	0.09	1.73	131	133
Bareilly	5.9	5.6	0.07	0.75	132	139
Haldwani	5.8	5.5	0.9	9.8	152	154
Hardoi	4.8	4.7	0.3	5.3	130	138
Mathura	4.3	4.6	0.2	3.2	115	128
Mecrut	6.3	4.5	1.0	10.8	139	139
Jhansi	5.6	4.1	n.s.	22.2	129	137
Barabanki	–	–	–	–	–	–
Etawah	–	–	–	–	–	–
Varanasi	–	–	–	–	–	–
Average	5.2	4.9	–	–	132	138

Performance of IR50 during sornavari (summer) season

J. Venkatakrishnan, P. Vivekanandan, K. Neelakantapillai, and D. S. Aaron, Paddy Experiment Station, Tirur (CPT) 602025, Tamil Nadu, India

In Tamil Nadu, sornavari is from May to Sep. Short-duration (100-120 d) rice varieties are grown. TKM9 (TKM7/IR8)

Yield characteristics of short-duration varieties at Tirur, India.

Variety	Duration (d)	Productive tillers (no./m^2)	Yield (t/ha)
TKM9	111	450	5.6
IR50	113	415	5.1
ADT36	117	380	5.0
IET4786	118	380	4.6
PY2	108	405	4.5

is popular, but it has short, bold, red grains, and consumers prefer fine-grained, white rice. We tested IR50, with fine white grains, at Tirur.

TKM9, ADT36, PY2, and IET4786 were sown with IR50 on 5 May and transplanted on 6 Jun at 20- × 10-cm spacing. Fifty kg NPK/ha was applied basally before transplanting and 50 kg N/ha was applied in 2 equal splits 15 and 30 d after transplanting.

IR50 yielded less than TKM9 (see table), but it was resistant to mealybug and stem borer. It is becoming popular in sornavari. □

Influence of Zn on distribution and mobility of ^{59}Fe in two rice cultivars

C. P. Ghonsikar, D. C. Phulari, D. K. Jadhav, and G. U. Malewar, Agricultural Chemistry and Soil Science Department, Marathwada Agricultural University, Parbhani 431 402, India

We evaluated the effect of Zn on distribution and mobility of ^{59}Fe on 2 rice cultivars grown on a calcareous Vertisol with pH 8.2, 49.7% clay, 0.62% organic carbon, 0.65 ppm DTPA Zn, 0.5 M $NaHCO_3$ P_2O_5, 18.5 kg EDTA/ha, and 4.5 ppm Fe.

Two 6-wk-old seedlings of Tuljapur and Jaya were washed with demineralized water and placed in glass bottles with 250 ml of 1/2 strength Hoagland nutrient solution. Zn was added to 5, 10, or 15 µg Zn/ml. 5 µCi/plant of $^{59}FeCl_3$ in HCl was derived by root absorption, injection into the second internode of plant stems, or smeared on leaf blades. Plants were removed from the bottles on day 6, washed with distilled water, rinsed with 0.1 N HCl, and washed again with distilled water. Roots, stems, and leaves were separated and analyzed. Dried plant samples were digested with a triacid mixture and radioassayed.

Plant parts treated with ^{59}Fe retained maximum ^{59}Fe within them, and 41 to 51% was translocated to other plant parts (Table 1). A considerably higher proportion of leaf-smeared than stem-injected ^{59}Fe was retained in leaves of both the cultivars. Zn application levels had no consistent effect on ^{59}Fe translocations.

Mobility ratios (Table 2) showed that ^{59}Fe mobility was greatest in the stems of rice plants. The stem functioned as a sink for Fe, independent of application method. The two cultivars did not have markedly different Fe translocation patterns.

Studies on ^{59}Fe translocation indicate that foliar application of Fe gave better retention in functional or active parts (leaves and stems), and that it may protect against nutrient-induced Fe chlorosis. □

Table 1. Effect of Zn application on distribution or translocation of ^{59}Fe in various plant parts of rice cultivars, Parbhani, India.

Application	Zn (kg/ha)	Distribution/translocation of ^{59}Fe (% total activity in rice plant)		
		Root	Stem	Leaf
		Tuljapur		
Root	5	56.2	39.5	4.3
	10	49.1	45.2	5.7
	15	52.8	41.1	6.2
Stem	5	41.9	49.5	8.6
	10	46.7	50.4	2.9
	15	37.6	55.3	7.1
Leaf	5	5.4	43.2	51.5
	10	4.0	42.7	53.5
	15	5.9	34.9	59.2
		Jaya		
Root	5	58.9	34.5	6.6
	10	53.7	41.2	4.7
	15	53.7	40.4	5.9
Stem	5	43.7	48.3	8.0
	10	46.7	49.6	3.7
	15	38.4	54.8	6.8
Leaf	5	5.7	43.1	51.2
	10	4.6	41.5	53.9
	15	6.4	35.2	58.4

Table 2. Effect of Zn application on mobility ratio of ^{59}Fe in various parts of rice cultivars, Parbhani, India.

Application	Zn (kg/ha)	Mobility ratio (%)		
		Root	Stem	Leaf
		Tuljapur		
Root	5	–	0.7	0.1
	10	–	0.9	0.1
	15	–	0.8	0.1
Stem	5	0.8	–	0.2
	10	0.9	–	0.1
	15	0.7	–	0.1
Leaf	5	0.1	0.8	–
	10	0.1	0.8	–
	15	0.1	0.6	–
		Jaya		
Root	5	–	0.6	0.1
	10	–	0.8	0.1
	15	–	0.8	0.1
Stem	5	0.9	–	0.2
	10	0.9	–	0.1
	15	0.7	–	0.1
Leaf	5	0.1	0.8	–
	10	0.1	0.8	–
	15	0.1	0.6	–

GENETIC EVALUATION AND UTILIZATION

Disease resistance

Reaction to blast (Bl) and brown planthopper (BPH) of promising rice varieties for Cuu Long Delta

Luu Hong Man, Truong thi ngoc Chi, T. K. Kandaswamy, and Nguyen van Luat, Agricultural Technique Centre for the Cuu Long Delta, Omon, Hau Giang, Vietnam

Bl and BPH are constraints to rice production in Cuu Long Delta. Different physiological races of the Bl pathogen *Pyricularia oryzae* Cav. have been found at different locations in the rice growing area. We tested many rice varieties at 3 sites in standard Bl nurseries in 1981-83. BPH resistance was studied in the greenhouse using the IRRI Standard Evaluation System for Rice. Results are in Table 1. The reaction of a few local varieties was tested during 1983 *he thu* season (Table 2). □

Table 1. Reaction of rice varieties to B1 and BPH.

Variety	Duration (d)	B1			BPH
		An Giang	Hau Giang	Tien Giang	
IR2171742-1	95	2	1	3	3
BG367-7	95	2	2	0	3
IR19735-5-2-3-2	98	2	3	3	3
IR13240-10-1	115	3	3	3	1
IR13240-108-2-2-3	115	1	1	0	3
IR1820-52-24-1	125	2	1	1	1
IRl820-210-2	125	1	1	1	5
IR4547-61-3	125	1	1	1	5
IR13429-109-2-2-1 (IR56)	105	1	1	2	Not yet tested
IR13240-53-6	110	2	2	2	–
IR9852-93-2-2-2-3	140	2	1	3	5
IR48 (NN 5B), resistant check	130	1	1	1	5
IR9224-117-2-3-3-1 (IR50)	100	–	8	–	–
IR2307-247-2-2-3 (NN 6A)	115	–	8	–	–
IR9129-192-2-3-5 (NN 7A)	95	–	–	9	–

Table 2. Reaction of local varieties to B1. Cuu Long Delta, Vietnam.

Variety	Duration (d)	Reaction to B1		
		An Giang	Hau Giang	Tien Giang
Te tep	115	2	1	1
Bau quang Phu Tho	115	2	1	1
Bau Thanh Hon	115	1	2	1
Chah Phu Tho	115	2	2	1
Sai Duong Thai Nguyen	115	2	2	1
Di Huong Hai Phong	120	2	2	3

GENETIC EVALUATION AND UTILIZATION

Insect resistance

Rice varieties resistant to gall midge (GM) *Orseolia oryzae*

N. D. Delpachitra, research officer, Regional Agricultural Research Station, Bombuwela, Sri Lanka

GM attacks rice from seedling stage to panicle initiation and causes crop losses in the Low Country Wet Zone, especially from Apr to Aug. We evaluated experimental lines for GM resistance in 1981-83.

Three-wk-old seedlings were transplanted in 20 hills with 3 rows per test variety at 20- × 7.5-cm spacing in 3 replications. Resistant BG400-1/BW 266-7 and susceptible BG94-1 were planted at regular intervals. Recommended fertilization and weeding were practiced. Test varieties were scored 8 wk after transplanting when the susceptible check had severe infestation (about 40% galls). Galls and tillers/hill were counted, and resistance was rated by the Standard Evaluation System for Rice. About 30 varieties were screened every season. The most promising ones are given in the table.

The source of GM resistance in all the varieties in the table is OB678 or BG400, a line derived from OB678// IR20/H4. □

Promising GM-resistant varieties[a] after 3 yr of screening at Bombuwela, Sri Lanka.

Variety[b]	Cross	Donor parent	1981	1982	1983
BW293-1	IR2071-586/BG400-1	BG400-1	HR	HR	HR
BW288-2	BG90-2/BG400-1	BG400-1	HR	–	MR
BW293-2	IR2071-586/BG400-1		HR	HR	R
BW295-5	OB678/BW254-1	OB678	HR	HR	R
BW288-1	OB678/BBW254-1	OB678	MR	MR	MR
BW288-1	BG90-2/BG400-1	–	S	S	–
BW271-1	BG259-4BW 100	–	S	S	MS

[a]HR = highly resistant, R = resistant, MR = moderately resistant, S = susceptible. [b]BW = Bombuwela, 200 series = cross number, and last number = selection.

Effect of blast (Bl) on IR50 in late samba

M. Loganathan and V. Ramaswamy, research associates, Plant Clinic Centre, Tamil Nadu Agricultural University, Kancheepuram, Pin: 631 501, India

In late samba 1983 there was a severe Bl outbreak on IR50 in Kancheepuram taluk of Chingleput District. We observed lR50, IET1722, IR20, Ponni and CO 37, planted in a 25-ha area, for infection caused by *Pyricularia oryzae.*

Five 1-m^2 microplots were marked out in each 1-acre field. Five plots were selected 1 m away from the center of each bund and one plot was in the center of the field. Disease intensity was assessed by randomly selecting 25 leaves/plot and grading them on the scale shown in Table 1.

Table 1. Scaling system for Bl infection, Chingleput, India.

Grade	1	3	5	7	9
Intensity of infection (70 area affected)	<1	1-5	6-25	26-50	>50

After determining the level of infection, disease index was calculated:

$$DI = \frac{\text{Sum of } n \times (v)}{N \times V} \times 100$$

where n = number of leaves at each infection level, v = the grade for each group of leaves, V = the highest grade alloted in the score chart, and N = total number of leaves observed.

IR50 planted on 14 Sep escaped Bl infection, but the late samba crop was severely infected (Table 2). Other varieties, except IET1722, had a high degree of Bl resistance. □

Table 2. Bl incidence for different varieties, Chingleput, India.

Variety	Planting date	Crop stage	Disease index
IR50	14 Sep 1983	Maturity	16.9
IR50	13 Oct	Dough	66.8
IET1722	13 Oct	Dough	22.9
IR20	13 Oct	Dough	1.7
IR50	21 Oct	Dough	58.4
Ponni	21 Oct	Booting	1.7
IR20	21 Oct	Booting	0.8
C037	21 Oct	Booting	2.6

Screening rice for brown planthopper (BPH) resistance

Wu Jung-Tsung, associate professor; Zhang Liangyou, lecturer; and Qiu Xiguang, teaching assistant, South China Agricultural College, Guangzhou, China

BPH *Nilaparvata lugens* (Stål) is one of the most important rice pests in China. We studied the response to BPH of rice varieties at different ages in the field and in the greenhouse (Table 1).

In the field, test varieties were planted in a randomized block design in three replications. Two rows of susceptible TNl were grown between test varieties. Decamethrin, a BPH-resurgence-inducing insecticide, was sprayed on TN1 at 10 g ai/ha 30 d after transplanting (DT). Varieties were scored for resistance at 60, 65, and 70 DT (Table 2).

In the greenhouse test to determine the effect of plant age on BPH resistance, test varieties were sown in 60- × 45-× 10-cm seedboxes. Each line was planted in 20-cm rows at 5-cm spacing in 3 replications. Seedlings at different plant ages were infested with 2d- or 3d-

Table 1. Rice varieties with different genes for BPH resistance were evaluated in Guangzhou, China.

Variety	Resistance gene
IR26, IR46, 7105	*Bph* 1
ASD7	*bph* 2
Sinna Sivappu	2 unidentified genes
Kencana, Triveni, Utri Rajapan, Fubaoai 21, Baosyan 2	Minor gene
TN1	No resistance

Table 2. Field resistance of rice varieties to BPH, Guangzhou, China.

Variety	Damage rating			Insects [a] (no./hill)	
	60 DT	65 DT	70 DT	60 DT	70 DT
TN1	7	8.3	9	139.9 a	212.5 a
Kencana	1	1	5.7	48.7 ab	96.9 bc
Baosyan 2	1	1.7	5.7	87 a	82.6 be
Triveni	1	1	2.3	19.1 c	53 c
Utri Rajapan	1	1	1	22.7 ab	134.4 b
Fubaoai 21	1	1	5.7	61.9 ab	87.7 bc
ASD7	1	1	1.7	12.5 c	25.5 c
IR46	1	1	1	9 c	50 c
IR26	1	1	1.7	15.9 c	25.4 c
Sinna Sivappu	1	1	1	9.6 c	30.7 c
7105	1	1	1	9.9 c	41.5 c

[a]In a column means followed by a common letter are not significantly different at the 5% level.

Table 3. BPH resistance of rice varieties at six plant ages in the greenhouse, Guangzhou, China.

Variety	Damage rating 6 DI [a]						8 DI					
	7	10	15	20	30	45	7	10	15	20	30	45
TN1	9	9	5.7	9	6.3	4.5	9	9	9	9	8.3	7.7
Kencana	6.3	7.7	4.3	4.3	3.7	3.7	8.3	9	5	4.3	5.7	5.7
Baosyan 2	6.3	6.3	1.7	2.3	1.7	1.7	9	8.3	3	2.3	2.7	3
Triveni	3	3.7	1	1	1	1	7.7	6.3	1	1	1	1
Utri Rajapan	2.3	2.3	2.3	2.3	1	1	6.3	4.3	3.6	3.7	1	1
Fubaoai 21	5.7	6.3	1.7	2.3	1.7	2.3	9	8.3	3	2.3	2.3	3.7
ASD7	1	1	1	1	1	1	1.7	1	1	1	1	1
IR46	1	1	1	1	1	1	1	1	1	1	1	1
IR26	1	1.7	1	1	1	1	1.7	1.7	1	1	1	1
Sinna Sivappu	1	1	1	1	1	1	1	1	1	1	1	1

[a] DI = days after infestation.

instar BPH nymphs, and rated for resistance with the Standard Evaluation System for Rice (Table 3).

Results suggest that leaf stage, rather than days of plant growth, should be used to represent plant age. □

Rice seedling screening techniques to confirm brown planthopper (BPH) resistance

S. Velusamy, postdoctoral fellow, IRRI; and S. Chelliah, professor of entomology (Rice); Tamil Nadu Agricultural University, Coimbatore, India 641003

We evaluated 465 rice accessions for BPH resistance in the greenhouse at Coimbatore with the commonly used seedling bulk screening technique. Rice accessions ASD11, IET5741, IET6315, T7, and VP Samba were identified as resistant. Their resistance to BPH was further confirmed by two tests:

1. *Alternate row test.* Pregerminated seeds of resistant accessions were sown in wooden flats at 5-cm row spacing in a randomized block design in 6 replications. Each accession was flanked with the susceptible check TN1. Ten days after sowing, the seedlings were infested with 4 to 5 2d- and 3d-instar nymphs per seedling. They were rated for resistance by the Standard Evaluation System for Rice (SES) when TN1 died.

2. *Seedling screening in pots.* Ten-cm clay pots were filled with puddled soil and divided by a wooden plank. Pregerminated seeds of each test accession were sown on one side of each pot and TN1 was sown on the other side. There were six replications for each accession. Pots were placed inside galvanized iron trays. Ten days after sowing, seedlings were infested with 4 to 5 2d- and 3d-instar nymphs per seedling and test accessions were rated by SES (see table).

Rating of rice accessions' resistance to BPH, Coimbatore, India.

Accession	Damage rating [a]		
	Seedling bulk test	Alternate row test	Seedling screening in pots
ASD11	2.3 a	3.0 a	3.0 a
IET5741	3.0 a	3.0 a	3.0 a
IET6315	2.0 a	2.7 a	2.7 a
T7	3.0 a	3.0 a	3.0 a
VP Samba	2.7 a	3.0 a	3.0 a
TN1	9.0 b	9.0 b	9.0 b

[a] Mean of six replications. In a column means followed by a common letter are not significantly different at 5% level.

Results of all seedling screening methods were similar. ASD11, IET5741, IET6315, T7, and VP Samba were confirmed to be BPH resistant. □

Varietal reaction to rice gall midge (GM) in Tamil Nadu

R. C. Joshi and M. S. Venugopal, Entomology Department, Agricultural College and Research Institute, Madurai, India

GM *Orseolia oryzae* (Wood-Mason) is a major rice pest in Tamil Nadu in kharif. It now damages upland, deepwater, and summer rice crops in many parts of India.

We screened 35 promising cultures or varieties with drought, cold, and saline-alkaline tolerance for GM reaction at Madurai in 1981 kharif. Test varieties were grown in 20-m^2 plots in 2 replications. Recommended agronomic practices were followed, but there was no insect control. Infested hills were scored 60 d after planting using the Standard Evaluation System for Rice.

IR20 had maximum (41.7%) silvershoots and 15 entries had no damage and are drought resistant or tolerant of saline-alkaline conditions (see table). □

Evaluation of rice varieties for resistance to the gall midge and other stresses at Madurai, India.

GM resistance level	Variety			
	Cold tolerant	Drought resistant	Saline-alkaline tolerant	Promising cultures
Resistant (no damage)		CR143-2-2 CR289-1144 CR289-1222 RAU4000-16 N22 Kalakari Ambamohar-Local Brown gora Tuljapur Culture 62 Mottaikar Poongar	IET6999 SR. 26-B TNAU13223/7/2	IET7225
Moderately resistant (6-15% silvershoots)	Pushpa TNAU20997 TNAU20147 TNAU4372 DP1583	Red vaigai Ramnad local TKM9 Norungan Puzhithikar Ariyan	TNAU17005	IET6262 IET6263
Susceptible (16-50% silvershoots)	IR20 Bhavani	Chitraikar Chandrikar MDU-l		

IR13429-196-1-20 and IR17525-56-2-2-2: two promising brown planthopper (BPH)-tolerant lines

S. R. Das, N. K. Dhal, and H. K. Mohanty, Rice Research Station (OUAT), Bhubaneswar, Orissa; and G. S. Khush, IRRI

BPH causes substantial damage to the rabi (dry season) rice crop in Orissa. The popular rice cultivars Annapurna, Parijat, Keshari, Ratna, Kumar, and Jaya are highly susceptible to BPH, and

Table 1. Performance of 10 BPH-tolerant IR lines in Orissa, India.

Breeding line	Grain yield[a] (t/ha) Bhubaneswar 1980 K	Bhubaneswar 1981 R	Bhubaneswar 1982 R	Barachana 1981 R	Mathasahi 1981 R	Mean	Days to 50% flowering	Plant ht (cm)	Silver-shoots (no./hill)	BPH (no./hill)
IR13429-196-1-20	4.8	4.5	2.9	2.6	4.4	3.8	84	77	27	42
IR13429-109-2-2-1	3.8	4.6	3.0	3.0	5.4	4.0	84	73	61	106
IR13420-108-2-2-3	3.6	4.0	3.7	3.2	5.2	3.8	85	71	65	37
IR13429-94-3-2-2-2	–	3.7	–	4.0	4.5	4.1	83	78	–	86
IR15324-117-2-2-3	3.9	2.8	2.9	2.7	2.9	3.0	101	76	43	34
IR17494-32-1-1-3-2	3.8	2.9	2.2	2.5	2.2	2.7	105	78	23	101
IR17525-56-2-2-2	4.5	4.3	3.3	3.1	3.4	3.7	100	85	8	60
IR19657-84-3-2-2	3.3	4.3	2.1	3.0	3.3	3.2	105	80	29	115
IR19661-131-1-2	4.2	2.3	2.1	2.2	2.3	2.6	104	75	56	34
IR19661-364-1-2-3	3.1	4.9	2.2	2.6	2.3	3.0	104	68	58	18
Ratna	2.4	3.6	3.6	3.1	3.0	3.2	83	72	64	326
IR36	4.0	3.4	3.5	3.8	4.5	3.7	87	69	16	130
Jaya	3.3	4.1	3.7	3.3	3.1	3.5	99	85	–	196

[a]K = kharif, R = rabi.

their crops often fail. IR36, released in 1980, had moderate to heavy hopper-burn last season.

We tested 10 promising cultures from IRRI (Table 1) in 1980-82, using Ratna, IR36, and Jaya as checks. IR-13429-196-1-20 and IR17525-56-2-2-2 were found promising because of favorable grain yield and resistance to BPH and gall midge (GM). Both lines have PTB33 as a parent from which they got their BPH resistance. Table 2 shows similar results from later tests.

IR13429-196-1-20, like Ratna and IR36, matured in 115-120 d. It yielded more than Ratna but slightly less than IR36. It has high tolerance for BPH. IR17525-56-2-2-2 maturity was similar to that of Jaya, but it has a high level of tolerance for GM, BLB, and BPH. In kharif, it yields consistently higher than Jaya (Table 2).

The two breeding lines are being multiplied for distribution to farmers and for their assessment under the minikit program. □

Table 2. Performance of two promising BPH-tolerant IR lines in 1981-82 kharif in Orissa, India.

Year, location	Grain yield (t/ha) IR13429-196-1-20	Ratna (check)	IR36 (check)	IR17525-56-2-2-2	Jaya (check)
1981					
Bhubaneswar	3.1	2.6	3.4	4.2	2.1
Jeypore	4.6	4.5	3.9	3.7	5.1
Joshipur	2.4	2.3	3.7	5.8	3.4
Gombharipalle	2.9	2.5	3.4	4.4	1.9
Keonjhar	3.1	3.6	3.8	–	–
Berhampur	3.6	4.0	4.6	–	2.8
Mean	3.3	3.3	3.8	4.5	3.1
1982					
Bhubaneswar	2.6	2.8	3.2	2.4	3.0
Jeypore	4.4	4.8	3.7	5.8	5.4
Joshipur	3.4	3.9	4.5	4.7	3.3
Semiliguda	5.4	4.6	4.4	–	1.0
Berhampur	2.0	2.1	2.4	3.3	2.8
Mean	3.6	3.6	3.7	4.0	3.6

Gall midge (GM) susceptibility of medium- and long-duration rice varieties

A. Sen, N. Shi, and J. K. Mohanty, Regional Research Institute (OUAT), Chiplima, Sambalpur, Orissa, India

GM *Orseolia oryzae* is an annual problem in Orissa, particularly in wet Season (WS), when it severely damages the rice crop. In 1983 WS we evaluated medium-duration varieties IET5912 (Sona/Mahsuri), IET7575 (Sona/Manoharsali), IET7284 (Rajeswari/T141), IET7950 (OBS677/IR2071/RPW6-13/W1263), and long-duration varieties IET6315 (Sona/Manoharsali), and IET6903 (RP5-32/Pankaj) for GM resistance at 0, 40, 80, and 120 kg N/ha. Tillers and silvershoots were counted at maximum tillering stage (see table).

Of the six varieties tested, IET7950 produced the most tillers and was most resistant to GM, although it is susceptible to lodging. IET6315 was the most GM-susceptible variety.

Tiller number increased with N dose, but there was no significant difference in the number of silvershoots by N doses. □

GM resistance and effect of N fertilizer on GM infestation of six cultivars, Orissa, India.

Treatment	Tillers/hill	Silvershoots (%)
IET5912	3.6	5.0
IET7575	3.1	4.3
IET7284	3.5	4.7
IET7950	3.7	3.6
IET6315	3.5	5.5
IET6903	3.5	4.5
LSD	0.3*	0.7**
CV (%)	11.8	22.0
N_0	3.3	4.4
N_{40}	3.4	4.8
N_{80}	3.6	4.5
N_{120}	3.7	4.9
LSD	0.20**	ns
CV (%)	9.9	17.1

[a]Data were converted to square root (x + 0.5) then analyzed. * = significant at 5% level, ** = significant at 1% level, ns = not significant.

GENETIC EVALUATION AND UTILIZATION

Drought tolerance

A rapid method for determining plant water stress in upland rice

N. C. Basu Raychaudhuri, J. C. O'Toole, R. T. Cruz, and J. Padilla, IRRI

Water stress which can limit upland rice production needs to be measured and quantified. Commonly used methods can be grouped into those which measure water content and those which measure water potential.

In 1983 wet season, we used the pressure chamber and leaf disc techniques to determine the water status of rice leaves in the laboratory and on a toposequence on the IRRI upland farm. Leaf-water potential (LWP) was measured by the pressure chamber technique. In the laboratory study, a fully developed leaf, second from the top of the main culm of IR36 plants, was excised at the leaf collar. Leaves were allowed to dry in air for 1, 3, 5, or 7 min. After drying, each leaf was enclosed in a plastic bag, and LWP measured by the pressure chamber technique, in which the LWP was assumed equal to the equilibrium pressure required to bring water to the cut surface of the leaf collar cross-section. Relative water content (RWC) of each leaf was determined immediately after LWP measurements. Leaf discs, 4-mm-diam, were floated on distilled water to bring the stressed tissues to a fully turgid state. The RWC was determined as the mass of water in the tissue in the dried state relative to the mass held at saturation. In the field study, LWP of rice cultivars ITA235 and IR36 was measured by pressure chamber. Data were for plants grown at 10, 18, 30, 46, and 82 m from the bottom of the toposequence hill slope.

Laboratory findings showed a gradual increase in LWP as drying period increased. Similarly, RWC of the same leaves decreased with drying period, but not so strongly as LWP. In the toposequence study, LWP was strongly dependent on toposequence position, reflecting the drier soil-water conditions at higher slope elevations. ITA235, a typical upland variety from Africa, had higher LWP than the lowland cultivar IR36.

LWP measurement by pressure chamber was more rapid (2-3 min versus 48 h) and convenient than RWC measurement. RWC takes longer because of the hydration procedure. For a drought screening program involving perhaps up to 100 cultivars, LWP as measured by pressure chamber can effectively discriminate among varieties. □

GENETIC EVALUATION AND UTILIZATION

Adverse soils tolerance

Inheritance of salt tolerance in mangrove swamp rice

M. P. Jones and J. W. Stenhouse, Breeding Section, West Africa Rice Development Association, Special Research Project, Rokupr, Sierra Leone

In West Africa, traditional mangrove swamp varieties exhibit considerable variability in salt tolerance. Studies on the genetics of salt tolerance will assist breeders in incorporating this character into improved varieties.

We evaluated parents and F_1, F_2, B_1, and B_2 populations of two crosses for salt tolerance by comparing the rate of root growth in normal and in 80 mM NaCl culture solutions. All the generations were tested simultaneously and a tolerance ratio (TR) was calculated for each plant in each population.

The observed values of all the generation means and their weight, calculated as the reciprocal of the variance of the mean and the number of plants on which the means and variances were based, are in Table 1. The mean TR of F_1 plants from both crosses generally fell between the parental means. Heterosis in the F_2 may suggest the presence of a maternal effect on the progenies.

The minimum model in Table 2 indicated a highly significant additive effect [d] of the homozygous loci. The dominance effect [h] was apparently a major component in the genetic variation of salt tolerance in Pokkali/Djabon, but is nonsignificant in Pa Merr 108A/BG90-2 where the values were very small, indicating some net directional dominance for low tolerance.

Among the three types of epistatic gene effects, [i] (additive × additive) was the only significant effect. This interaction may be due to the presence of a maternal effect. In the final model in the

Table 1. Means, weight, and number of plants tested in each family.

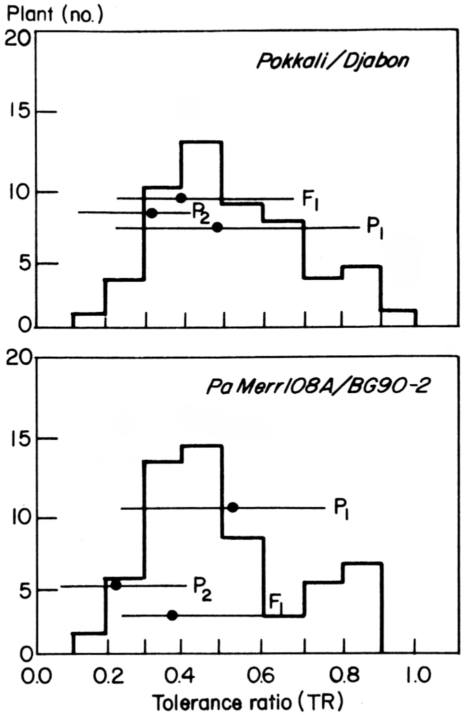
Generation		Pokkali/Djabon			Pa Merr 108A/BG90-2		
		Mean	Weight	No.	Mean	Weight	No.
P_1	=	0.510	2016.807	47	0.505	2181.818	47
P_2	=	0.306	4363.636	47	0.264	1118.012	17
F_1	=	0.433	1322.314	15	0.414	828.402	13
F_2	=	0.515	1458.967	47	0.480	1450.151	47
B_1	=	0.521	788.044	28	0.473	1441.860	30
B_2	=	0.343	558.376	10	0.369	1228.070	20

Table 2. Minimum model for each cross.

Parameter		Pokkali/Djabon			Pa Merr 108A/HG90-2		
		Estimate	Standard error	Probability	Estimate	Standard error	Probability
m	=	0.582	0.057	<0.001	0.447	0.016	<0.001
[d]	=	0.105	0.013	<0.001	0.118	0.017	<0.001
[h]	=	–0.155	0.075	<0.05			
[i]	=	–0.175	0.059	<0.01	–0.064	0.026	<0.05
$X^2_{(3)}$	=	2.729			$X^2_{(3)}$ = 2.994		
P	=	0.50 - 0.25			P = 0.50 - 0.25		

Table 3. Minimum model in the presence of a maternal effect.

Parameter		Pokkali/Djabon			Pa Merr 108A/BG90-2		
		Estimate	Standard error	Probability	Estimate	Standard error	Probability
m	=	0.418	0.011	<0.001	0.404	0.012	<0.001
[d]	=	0.110	0.013	<0.001	0.113	0.016	<0.001
[hm]	=	0.089	0.028	<0.001	0.077	0.029	<0.05
$X^2_{(3)}$	=	3.8171			$X^2_{(3)}$ = 1.985		
P	=	0.50 - 0.25			P = 0.75 - 0.50		



Distribution of means of parents, F_1, and F_2 plants. Solid horizontal lines show the range of the parents and F_1 plants about their means.

presence of a maternal effect (Table 3), three terms – m, [d], and [hm] – emerged as the most important parameters. The highly significant [d] confirmed that the variation observed in the generation means was mainly due to the additive genetic effects for salt tolerance, and [hm] represents the dispersion of the dominant genes determining the maternal effect of the F_1 mothers, which increased the tolerance of the progenies. In all cases, the X^2 is insignificant, showing that there are no nonallelic interactions.

The slight bimodal distribution of the F_2 (see figure) with a big peak at 0.40-0.49 TR and a minor peak at 0.80-0.89 TR suggests only a few genes determine salt tolerance. Transgressive segregation toward high tolerance was observed. The broad sense heritability ranged from 49.2% in Pokkali/Djabon to 83.3% in Pa Merr 108A/BG90-2, indicating the possibility of early selections of salt-tolerant individuals. □

Soil amendments for sodic conditions

U. S. Sadana, and P. N. Takkar, Soils Department, Punjab Agricultural University, Ludhiana 141004, India

We evaluated the effect of gypsum, farmyard manure (FYM), and $ZnSO_4$ application on rice yield on a Ghabdan loam soil (salic Natraqualf) in Sangrur district, Punjab, India. The soil had pH 10.3, 0.07% organic carbon, 1.55% calcium carbonate, 81.9% exchangeable sodium, and 0.43 ppm available Zn. Treatments (see table) were in a randomized block design with three replications. All plots received 120 kg N/ha as urea and 26 kg P/ha as superphosphate. Gypsum, FYM, or $ZnSO_4$, 40 kg N/ha, and P were broadcast and mixed in the top 15 cm of soil before submergence. Thirty-day-old PR106 rice seedlings were transplanted 1 d after submergence. Remaining N was topdressed in 2 equal splits, 21 and 45 d after transplanting.

In the no-treatment plots, rice plants grew poorly or died. Plants that lived had restricted growth, and severe Zn deficiency and Na toxicity. Applying gypsum significantly increased grain yield and Zn content and decreased Na content in grain and straw (see table).

Effect of gypsum, FYM, and $ZnSO_4$ on Zn and Na content and grain yield of rice, Ludhiana, India.

	Grain yield[a] (t/ha)	Grain content Zn (ppm)	Grain content Na(ppm)	Straw content Zn (ppm)	Straw content Na(%)	pH[b]
Treatment						
Control	0.1	8	2363	10	2.3	10.0
11.2 kg Zn/ha	0.1	10	2290	15	2.2	9.9
25% soil requirement of gypsum	1.5	9	975	10	1.5	9.2
25% gypsum + 11.2 kg Zn/ha	2.2	12	910	17	1.4	9.0
50% soil requirement of gypsum	2.0	10	585	13	1.0	8.6
50% gypsum + 11.2 kg Zn/ha	3.0	12	495	19	0.9	8.2
15 t FYM/ha	0.4	10	1948	14	2.0	9.7
15 t FYM/ha + 11.2 kg Zn/ha	1.0	11	1832	17	1.9	9.5
LSD at 5%	0.2	0.9	168	0.8	0.09	0.6
	Correlation coefficients (r values)					
Grain yield	1.0	0.65**	–0.94**	0.55**	–0.96**	–0.87**

[a]Oven-dry basis. [b]After rice crop harvest, 1:2 soil water suspension. **Significant at P = 0.01.

Gypsum (50% of the gypsum require-meat of the soil) plus 11.2 kg Zn/ha produced maximum grain yield. FYM alone or in combination with Zn was inferior even to 25% gypsum alone. □

Table 1. Effect of soil alkalinity on grain yield and straw-to-grain ratio of paddy, Kanpur, India.

Variety	Grain yield (t/ha)				Straw:grain			
	pH 8.7	pH 9.2	pH 9.6	Average	pH 8.7	pH 9.2	pH 9.6	Average
IR54	2.5	1.8	0.5	1.6	1.8	2.4	6.4	3.5
IR4563-52-1-1-3-6	4.2	3.7	2.5	3.5	1.2	1.1	1.6	1.3
IR9975-5-1	4.2	2.4	1.7	2.8	1.3	1.7	2.8	1.9
IR14632-22-3	2.6	2.0	2.1	2.3	3.3	3.7	3.8	3.6
IR19661-131-1-2	3.1	2.8	2.2	2.7	2.0	1.9	1.7	1.8
M242	2.4	2.3	2.5	2.4	2.2	1.7	1.9	1.9
Pokkali	4.7	3.6	2.9	3.7	1.8	1.9	1.7	1.8
Average	3.4	2.7	2.1		1.9	2.1	2.8	

Table 2. Effect of soil alkalinity on total P uptake and percentage translocation in grain, Kanpur, India.

Variety	Total P uptake (kg/ha)				% translocation of P in grain			
	pH 8.7	pH 9.2	pH 9.6	Average	pH 8.7	pH 9.2	pH 9.6	Average
IR54	13.2	12.9	8.1	11.4	62.9	40.2	21.8	41.6
IR4563-52-1-1-36	22.1	17.9	11.7	17.2	72.3	72.5	58.0	67.6
IR9975-5-1	24.2	14.3	13.3	17.3	67.0	57.1	44.8	56.3
IR14632-22-3	20.1	21.4	18.6	20.3	41.4	32.6	36.9	33.5
IR19661-131-1-2	19.6	16.6	11.7	15.9	56.2	56.3	60.3	51.6
M242	14.4	12.5	13.1	13.3	56.3	55.2	55.3	55.6
Pokkali	26.2	19.0	14.3	19.8	65.3	63.7	65.4	64.8
Average	19.9	16.3	12.9		60.2	53.9	48.6	

Varietal differences in P uptake of rice on sodic soils

O. P. Srivastava, B. Singh, and A. N. Pathak, Soils and Agricultural Chemistry Department, Chandra Shekhar Azar University of Agriculture and Technology, Kanpur, India

We screened salt-tolerant varieties IR54, IR4563-52-1-1-3-6, IR9975-5-1, IR146-32-22-3, IR19661-131-1-2, M242, and Pokkali for P uptake in sodic soils. Cultivars were transplanted in 4 replications in field plots with pH 8.5-8.9, 9.0-9.4, and 9.5-10.0. N, P, and K were applied at 120, 26, and 25 kg/ha as urea, single superphosphate, and muriate of potash. After harvest, grain and straw samples were analyzed for P content (Tables 1 and 2). Pokkali yielded best, followed by IR4563-52-1-1-3-6. IR54 yielded least. As pH increased, grain yield and P uptake decreased. Highest yielding varieties had comparatively higher translocation of P in grains (Table 2). □

Pest management and control DISEASES

A possible source of resistance to rice grassy stunt virus (GSV)

V. M. Aguiero, P. Q. Cabauatan, and H. Hibino, Plant Pathology Department, IRRI

The occurrence of a new GSV strain (GSV 2) that can overcome the resistance gene to ordinary GSV 1 prompted us to search for new sources of resistance.

A perennial rice plant, Guang-Keng A*/Oryza rufipogon/Oryza longistaminata* (IRRI acc. no. 104315), was introduced from China in 1980. Plants were propagated by dividing tillers, and seedlings obtained in a natural set of these plants were tested for GSV 1 and GSV 2 infection (see table). Twenty to 130 viruliferous brown planthoppers (BPH) were allowed inoculation access for 2 to 4 d on the tillers and seedlings. Virus recovery tests were conducted on inoculated plants using virus-free BPH and the latex test confirmed the presence or absence of the virus.

Reaction of divided tillers and seedlings of Guang-Keng A*/Oryza rufipogon/Oryza longistaminata* (acc. no. 104315) to GSV 1 and GSV 2, IRRI, 1984.[a]

Plant part tested	Plant type	Inoculated strain	Insects[b] (no./plants)	Plants (no.)		Virus recovery[c]			
						Plants (no.)		BPH (no.)	
				Inoculated	Infected	Tested[d]	Recovered	Tested	Infective
Tiller		GSV 1	20	18	0	–	–	–	–
		GSV 1	50	4	0	–	–	–	–
		GSV 1	130	4	1	1	0	20	0
		GSV 2	50	21	1	1	0	40	0
Seedling	Dwarf	GSV 1	20	1	1	1	1	16	1
		GSV 1	120	2	2	2	1	80	1
	Tall	GSV 1	20	3	1	1	0	17	0
		GSV 1	120	1	0	–	–	–	–
	Dwarf	GSV 2	25	9	9	–	–	–	–
		GSV 2	120	1	1	1	1	40	1
	Tall	GSV 2	20	4	3	2	1	123	1
		GSV 2	25	5	1	–	–	–	–
		GSV 2	120	2	0	–	–	–	–

[a]Inoculation was done 2 or 4 wk after sowing. [b]2 to 4 d inoculation access period. [c]Done at various times (15–210 d) after inoculation. [d]Only infected plants were tested.

None of the 22 tillers inoculated with GSV 1 at 20 or 50 insects/tiller was infected. However, 1 of 4 was infected when the number of insects/tiller was increased to 130. One of 21 tillers inoculated with GSV 2 at 50 insects/plant was infected. This result showed that the perennial rice plant was highly resistant to both GSV strains and became infected only at high insect pressure.

Seedlings segregated into dwarf and tall plant types. All dwarf plants inoculated with GSV 1 or GSV 2 developed symptoms. One of 4 tall plants was infected with GSV 1 and 4 of 11 were infected with GSV 2. Because it requires only 10-15 insects/seedling in infection of susceptible varieties, results indicate that the tall plants had considerable resistance to both GSV strains.

Recovery of the virus from the tillers infected with either GSV 1 or GSV 2 was unsuccessful, even with 60 BPH. Recovery of the virus from either dwarf or tall type seedlings infected with GSV 1 or GSV 2 was also extremely difficult. Both GSV 1 and GSV 2 were recovered from infected plants but percentage of BPH which acquired the virus was only 1.8% and 1.2%.

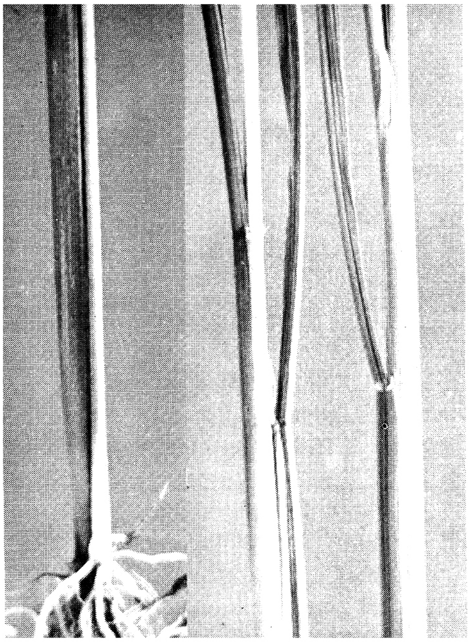
The presence of virus in all infected plants used as a virus source was confirmed by latex test. BPH survived and reproduced well on the tillers and seedlings. Hence it is not likely that the resistance of the tall plant type and the difficulty of virus recovery by the BPH are caused by plant resistance to BPH. □

Brown stripe (BSt), a new bacterial disease of rice

J. C. de Faira and A. S. Prabhu, plant pathologists, National Center for Research on Rice and Beans (CNPAF/EMBRAPA), Caixa Postal 179, 74.000 Goiania, Go – Brazil

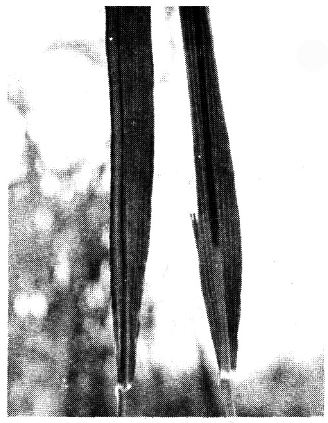
BSt is a new bacterial disease of rice in Brazil. Symptoms are pronounced, necrotic brown stripes along the midrib and lateral leaf veins. Early symptoms are 1- to 3-mm-wide light yellow water-soaked stripes along the midrib of the leaf blade, progressing from the base to the tip of the leaf. Similar brown stripes are found on the lateral veins and margins of leaf blades. In many cases, the stripes extend from the basal node to the leaf sheaths and leaves (Fig. 1). Usually, only one or two tillers in a plant are affected. As the disease progresses, leaves with stripes and the entire tiller wither. In severe infestation, the affected plants may die or become severely stunted. In the field, the disease symptoms appear from about 60 d after seeding to heading.

Microscopic examination of leaf bits with brown stripes showed streaming of bacteria through the vascular tissues of the cut end. However, there was no bacterial exudate on the leaf surface. Isolates from diseased leaf and sheath resulted in pure culture of the bacterium. On potato dextrose agar, colonies are creamy white and umbonate, and have undulate margins. The bacterium is facultatively anaerobic, gram-negative, rod-shaped, and peritrichous (Fig. 2). Its morphological and cultural characteristics suggest that it belongs to *Erwinia.* Preliminary biochemical tests indicate that it belongs to the 'amylovora' group.



1. Field symptoms showing brown stripes extending from the basal node to sheath (left) and leaf (right).

2. Bacterial cells showing flagella.



3. Brown stripes in the naturally infected (left) and artificially inoculated leaves (right).

Inoculations of a 24-h-old *Erwinia* culture by injecting a 10^9 – 10^{10} cfu/ml bacterial suspension into midribs of the healthy leaves in adult plants grown in pots produced symptoms typical of BSt (Fig. 3). The pathogen was readily isolated from artificially inoculated plants. Similar inoculations with water, *Xanthomonas campestris* pv *phaseoli,* and *Pseudomonas syringae* pv. *tabaci* did not produce BSt.

In 1971, a disease with similar symptoms was registered in the State of São Paulo, Brazil. However, its cause was not established. BSt occurs in all rice-growing uplands in Brazil, and the disease was recently observed in irrigated rice fields at Goiania. Preliminary evidence indicates that it is transmitted through seed. Further studies to identify species, and cultural and physiological characters of the pathogen are under way. □

Incidence of rice tungro bacilliform (RTBV) and rice tungro spherical virus (RTSV) on susceptible rice cultivars

P. Q. Cabauatan and H. Hibino, Plant Pathology Department, IRRI

Tungro is caused by RTBV and RTSV. Greenhouse and laboratory experiments have shown that the green leafhopper (GLH) *Nephotettix virescens* Distant vector transmits either both viruses together, or RTBV or RTSV alone from plants infected with both viruses. Plants infected with both viruses have severe symptoms; those infected with RTBV have mild symptoms, and those with RTSV have no clear symptoms. RTSV can be transmitted by GLH from plants infected with RTSV alone, but RTBV cannot be transmitted from plants infected with RTBV alone.

We studied the natural occurrence and incidence of these viruses at IRRI in 1983 wet season when there was high RTV incidence. A leaf sample (second or third leaf from the youngest) that showed discoloration was collected from plants with typical RTV symptoms of stunting and leaf yellowing. Samples also were collected from healthy looking plants in the same field. The virus or viruses in each sample were detected serologically using the latex test. Of 326 leaves from plants with RTV symptoms, 325 had both RTBV and RTSV and one had RTBV alone, indicating that susceptible plants with typical RTV symptoms usually were infected with both particles.

In contrast, 13 leaves from healthy looking plants had both RTBV and RTSV, 2 had RTBV alone, and 105 had RTSV. IR22 had the highest RTSV incidence and all varieties had plants infected with RTSV alone (see table).

Incidence of RTBV and RTSV on susceptible rice cultivars with and without RTV symptoms as detected by latex agglutination test.

Variety	With RTV symptoms					Without RTV symptoms				
	Leaves tested (no.)	RTBV+ RTSV	RTBV	RTSV	None	Leaves tested (no.)	RTBV+ RTSV	RTBV	RTSV	None
IR8	50	50	0	0	0	50	0	0	17	33
IR22	75	75	0	0	0	75	3	0	53	19
IR36	71	71	0	0	0	29	2	0	23	4
IR42	61	60	1	0	0	10	2	0	6	2
UPL-Ri 2	69	69	0	0	0	31	6	2	6	17
Total	326	325	1	0	0	195	13	2	105	75

Leaves from healthy looking plants that contained both particles might not have shown RTV symptoms at sampling although they were infected with both viruses. RTBV incidence was very low and the number of RTSV infected plants was unusually high. Generally, the number of RTSV-infected plants is very low when the virus source is infected with RTSV and RTBV in greenhouse tests. However, once RTSV is isolated, GLH can easily transmit it. High RTSV incidence in the field indicates that RTSV is spreading as an independent virus disease at the IRRI farm. This is the first report on natural RTSV occurrence outside Japan. □

Inhibitory effect of *Aspergillus terreus* Thom against *Rhizoctonia solani* f. sp. *sasakii*

A. K. Roy, Regional Research Station, Assam Agricultural University, Diphu 782460, Assam, India

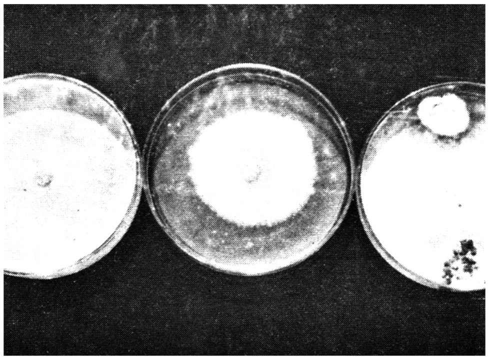
In in vitro and pot tests, *A. terreus* isolated from soil inhibited growth of *R. solani* Kühn f. sp. *sasakii* Exner [= *Thanatephorus sasakii* (shirai) Tu and Kimbrough], the rice sheath blight (ShB) fungus.

Eight-mm-diameter holes were made near the edge of previously layered PDA (15 ml) in 10-cm petri dishes. *A. terreus* was grown in potato dextrose broth for 9 d at room temperature (16-26°C, av 21°C), and 0.15 ml of cold or boiled metabolic solution was poured into a hole for each treatment. In the 3d treatment, an 8-mm-diam mycelial disc of *A. terreus* replaced the metabolic solution. Plain potato dextrose broth was used in the control treatment. A disc of *R. solani sasakii* was put in each petri dish and allowed to grow for 3 d. A 2.6 mm inhibitory zone developed in the 3d treatment (see figure).

In another test, a cold or boiled metabolic solution of *A. terreus* grown for 2 wk at 23 to 30°C (av 26.5°C) was mixed with PDA at 10% vol/vol. The medium was poured into petri dishes and a disc of *R. solani sasakii* was placed in the center. Treatment 3, above, was repeated. After 3 d, colony diameter was 59 mm for the treatment using the cold medium, 75 mm for the boiled solution, and 95 mm for the control.

In 20-cm-diam plastic pots with 2 kg sterilized soil, we inoculated 40 g of *A. terreus* and *R. solani sasakii* cultures grown on 3% maize-meal sand medium.

Inoculation was with *R. solani sasakii* alone, *A. terreus* alone, or *R. solani sasakii* + *A. terreus.* One-month-old seedlings of Pusa 2-21 were transplanted into the plots and disease development was rated using the Standard Evaluation System for Rice. ShB incidence was less with *A. terreus.* ShB score was 4.4 with *R. solani sasakii* alone and 0.3 with both organisms. Inoculation with *A. terreus* alone did not affect plant growth. □



Inhibitory effect of *A. terreus:* (from left) inhibitory zone against the colony of *R. solani sasakii,* reduced colony of *R. solani* sasakii in presence of cold extract of *A. terreus,* normal colony of *R. solani sasakii.*

Prophylactic chemical treatments for control of bacterial blight (BB)

Tran Thi Cuc Hoa, Thai Cong Binh, T. K. Kandaswamy, and Nguyen van Luat, The Agricultural Technique Centre for Cuu Long Delta, O Mon, Vietnam

BB is an important rice disease in the Cuu Long Delta. Many rice cultivars, especially medium and late (local) varieties grown, are susceptible to BB and yield loss is substantial.

We studied the effect of prophylactic chemical treatments for BB control in the greenhouse.

Streptomycin sulfate, ammonium sulfate, and IBP were sprayed on 20-d-old rice seedlings of moderately resistant varieties TKM6 and Zenith, and susceptible variety TN1 planted in pots. N was applied at 150 kg/ha. There were six replications with five plants/replication. Chemicals at 500 ppm concentration were sprayed 15 d after transplanting. Water-sprayed and unsprayed plants were maintained as control. The BB pathogen was inoculated 5 d after chemical application by clipping the leaves with scissors dipped in fresh bacterial suspension. Reaction was scored 10 d after inoculation using the Standard Evaluation System for Rice. The experiment was repeated twice and the disease index of the experiments are presented in the table.

Water spray tended to increase disease intensity. Spraying with ammonium sulfate 5 d before inoculation decreased disease intensity significantly in moderately resistant and susceptible varieties and was superior to the other treatments. □

Effect of prophylactic chemical treatments on bacterial leaf blight disease,[a] Cuu Long Delta, Vietnam.

Treatment	TKM6		Zenith		TN1			
	Test 1		Test 2		Test 1		Test 2	
	a	b	a	b	a	b	a	b
Ammonium sulfate	2.64	29.35	3.37	37.38	3.92	41.29	6.97	77.47
Streptomycin sulfate	3.40	37.47	4.25	47.89	4.90	45.43	7.72	85.78
IBP	3.43	37.43	3.45	39.90	4.80	50.31	7.69	85.07
Water	3.52	39.07	4.85	53.93	5.60	62.22	7.32	81.23
Unsprayed check	3.19	37.78	3.90	43.36	4.91	54.61	7.80	86.57

[a]a = disease scale (0–9), b = disease index (%).

Bacterial leaf blight (BB) pathotype at Pantnagar

H. Singh, J. S. Nanda, and S. C. Mani, Plant Breeding Department; and B. Das, Plant Pathology Department, G. P. Pant University of Agriculture and Technology, Pantnagar-263145, UP, India

BB caused by *Xanthomonas campestris* pv. *oryzae* is one of the most serious diseases in the tarai belt of UP. Recent studies at the All India Coordinated Rice Improvement Project, Hyderabad, showed there are 2 major BB pathotypes —I and II—in India. Isolates of pathotype I are characterized by resistant reaction on DV85. Isolates of pathotype II are characterized by resistant reaction on Cempo Selak. We sought to identify the prevalent BB pathotype in Pantnagar.

In 1982 and 1983 kharif, varieties with known BB resistance were artificially inoculated by clipping technique with naturally occurring BB inoculum. Disease reaction was scored by the Standard Evaluation System for Rice 14 d after inoculation. Disease reaction at Pantnagar was compared with that at other locations (see table). In Pantnagar, the BB pathotype appears to be pathotype I. □

Reaction[a] of some differential varieties to BB pathotypes, Pantnagar, India.

Variety	Pathotype I	Pathotype II	Pantnagar
DV85	R	S	R
Cempo Selak	S	R	S
TKM6	R[b]	–	R
BJI	R	S	R
IET4141	R	MS-S	R

[a]R = resistant, MS = moderately susceptible, S = susceptible. [b]Based on reaction at Coimbatore.

Pest management and control INSECTS

Fungicides to control green muscardine fungus, a disease of zigzag leafhopper in rearing cages

R. M. Agudu, D. B. Centina, E. A. Heinrichs, and V, A, Dyck, Entomology Department, IRRI

Zigzag leafhopper (ZLH) *Recilia dorsalis* (Motschulsky) frequently becomes infected with green muscardine fungus *Metarrhizium anisopliae* in rearing cages during the wet season. We evaluated fungicides for *M. anisopliae* control.

The fungus was cultured on YpSs Emerson agar. Spores were mixed with the fungicides in sterile water containing 0.05% detergent as an emulsifier. The suspension was vortexed and the spores were spread on YpSs agar culture medium in a petri dish. Fungicides tested were benomyl, mancozeb, thiophanate-methyl, and mebenil at 0.5, 1.6, 0.7, and 0.75 kg ai/ha, respectively, based on the area of the petri dish. Percent germination of 300 conidia counted randomly on each plate was determined after 24 h incubation at 25°C.

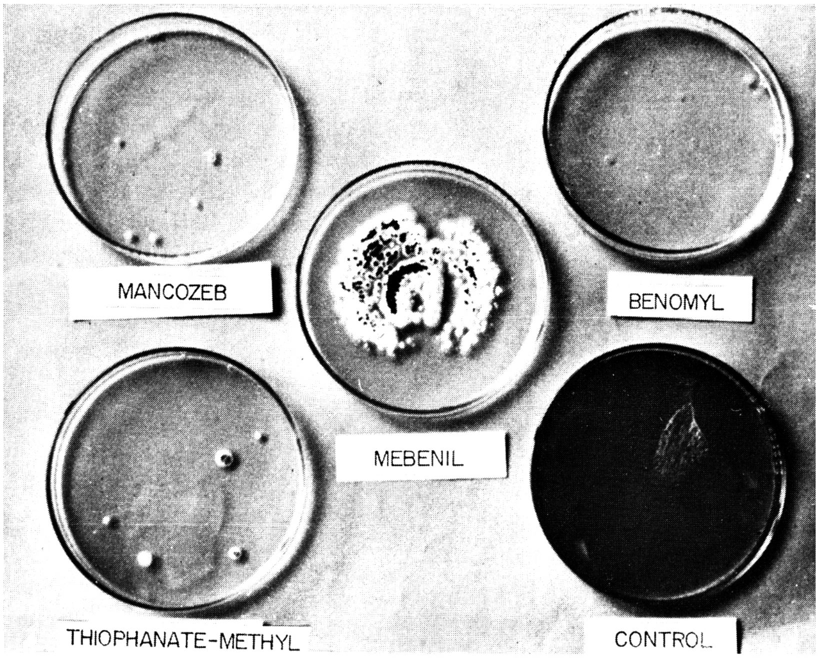
Benomyl, mancozeb, and thiophanate methyl did not allow fungus germi-

Germination of *M. anisopliae* spores on culture media treated with four fungicides, IRRI.

Fungicide	Spore germination at 24 h[a] (%)
Benomyl	0 c
Mancozeb	0 c
Thiophanate-methyl	0 c
Mebenil	11 b
Untreated	99 a

[a]Means followed by a common letter are not significantly different at 5% level.

nation and development. Mebenil was less toxic, allowing 11% germination (see table). Five-day-old cultures of *M. anisopliae* on media treated with fungicide are shown in the figure. Initial tests for direct toxicity of the fungicides to ZLH indicated no effect on the insect. Cages and rice plants used as food should be sprayed with either benomyl, mancozeb, or thiophanate-methyl to increase ZLH survival during mass rearing. □



Growth of green muscardine fungus on media treated with fungicide. Growth is complete on control and partial on mebenil.

Insect pest surveys in Chhatisgarh

R. K. Upadhyay and M. C. Diwakar, Directorate of Plant Protection, Quarantine and Storage, N. H. IV, Faridabad, Haryana, India

Chhatisgarh is the rice bowl of Madhya Pradesh, with 3.5 million ha under rice cultivation. About 75% is planted to local, tall varieties and 25% is planted to high yielding dwarf varieties such as Phalguna, RPW6-17, Surekha W 13400, Asha R 35-2752, Usha R 35-2750, and Bangoli, all of which are resistant to or tolerant of gall midge (GM). Only 12% of the paddy area has assured irrigation. Annual rainfall is 1,200-1,500 mm and temperature ranges from 11 to 43°C.

Rare rice insect pests at Chhatisgarh, India.

Insect	Abundance (no./hill)	Year
Miridae		
Trigonotylus doddi (Distant)	0-2	1981-82
Lygaeidae		
Cymodema basicornis (Motschulsky)	0-5	1980-82
Curculionidae		
Nanophyes sp. 1	0-5	1980-82
Nanophyes sp. 2	0-2	1981-82
Chrysomeldae		
Cryptocephalus ovulum Suffrian	0-2	1980-83
Cryptocephalus sehestedtii Fabricius	0-2	1980-83
Phyllotreta chotanica Duvivier	5-20	1981-83

In 1980-83, we regularly and intensively surveyed insect pest populations at 10-d intervals in kharif and rabi. In addition to major, commonly observed rice insects, we found several other insects that caused damage (see table). □

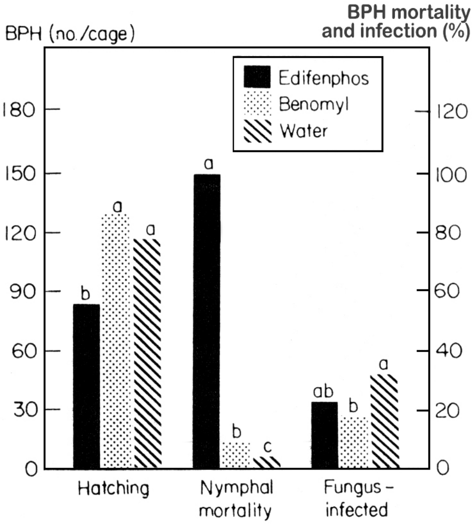
Control of *Metarrhizium anisopliae* in brown planthopper (BPH) rearing

F. Medrano, E. A. Heinrichs, and R. Aguda, Entomology Department, IRRI

Metarrhizium anisopliae fungus attacks BPH, green leafhopper (GLH), and zigzag leafhopper in wet season. When infection rate is high, the insect rearing program for evaluating rice germplasm and breeding lines for hopper resistance is severely disrupted. We evaluated two fungicides for *M. anisopliae* control and their effect on BPH.

To test the effect of fungicides on egg hatching, five gravid females were caged overnight on 30-d-old potted TN1 plants for oviposition. Each plant was sprayed with 2 ml of a 0.10% spray solution of benomyl, edifenphos, or tap water (control). Nymphs were counted 11 d after oviposition.

The effect of the fungicides on nymphal survival was determined by caging 20 of 2d- and 3d-instar nymphs on 40-d-old petted TN1 plants. At 1, 8, and 15 d after infestation, the



Effect of fungicides on BPH hatching, mortality, and percentage of *M. anisopliae* infection. For each test vertical bars sharing a common letter are not significantly different using Duncan's multiple range test.

insects and plants were sprayed with 2 ml of 0.10% benomyl or edifenphos. Living insects in each cage were recorded 1 d after the last fungicide application.

In the third test, we studied the effect of the fungicides on *M. anisopliae.* Infected BPH adults which were covered with whitish to greenish spores of the fungus were collected in the greenhouse and placed on moist filter paper in a petri dish. Each dish was sprayed with 1 ml of 0.10% benomyl, edifenphos, or water. Twenty-four hours after treatment, the BPH with fungus spores were placed in a flask and thoroughly mixed with 20 cc distilled water containing 0.05% detergent. The spore solutions were sprayed on 20 of 2d- and 3d-instar BPH nymphs caged on 35-d-old potted plants enclosed with a mylar cage. Each potted plant was sprayed with 2 ml of the solution. Seven days after spraying, the number of live BPH/cage was recorded. Treatments in each of the three tests were replicated four times.

Benomyl had no adverse effect on hatching, but edifenphos reduced hatching 34% below that with water (see figure). Benomyl was safe to BPH nymphs, producing mortality similar to that of water. Edifenphos caused 100% mortality. When nymphs were sprayed with the spore suspension, percentage of fungus-infected BPH was reduced from 33% in the control to 16% in the benomyl treatment. We are now using benomyl to control *M. anisopliae* in the BPH rearing program in wet season. □

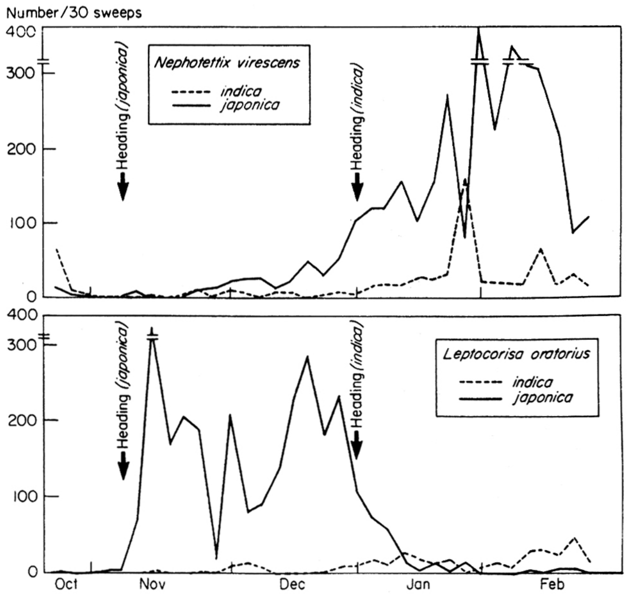
Comparative observations of rice insect populations on indica and japonica rices

T. Fujimura, Tropical Agriculture Research Center, Tsukuba, Ibaraki, 305 Japan; and P. H. Somasundaram, Entomology Division, Central Agricultural Research Institute, Gannoruwa, Peradeniya, Sri Lanka

We studied insect pest and predator population dynamics on indica and japonica rices in 1976-77 maha at Tismada, Sri Lanka, in pesticide-free fields. Two 10- × 2-m fields were transplanted on the same day, one with H-9 (indica) and one with Koshihikari (japonica). Both varieties are susceptible to brown planthopper (BPH) *Nilapavata lugens* and green leafhopper (GLH) *Nephotettix virescens.* Koshihikari is moderately resistant to stem borer (SB) *Chilo suppressalis.*

Insects were collected twice weekly until harvest by making 30 sweeps with a 36-cm butterfly net across the 2 fields. In the laboratory, specimens were killed, separated, and counted.

BPH, grasshopper, and *Leptispa pygmaea* populations did not differ. *Sogatella furcifera* was more abundant on the indica at early growth, but populations equalized at later stages. The GLH population was similar at early growth, but after heading was 10 times greater on the japonica (see figure). Cicadella spectra population was similar to that of GLH, being five times greater on the japonica after heading. There were few *Recilia dorsalis* on either variety, and slightly more *Thaia subrufa* on the indica at all stages. The *Leptocorisa oratorius* population was highest and lasted longest on the japonica because it headed early. The indica had a tenfold larger population of the predator *Ophionea indica.* □



Comparative population fluctuation of two insect pests (*Nephotettix virescens* and *Leptocorisa oratorius*) on two types (*indica* and *japonica*) of rice varieties.

Crop loss in deepwater rice caused by yellow stem borer (YSB)

B. Taylor and Z. Islam, ODA-BRRI Deepwater Rice Project, Bangladesh Rice Research Institute, Joydebpur, Dhaka, Bangladesh

We studied YSB *Scirpophaga incertulas* infestation and control in deepwater rice in 1982. In mid-Aug, when there were many moths, we sprayed monocrotophos 250 g ai/ha from a boat. YSB infestation was significantly reduced (see table).

Harvest data from two fields showed spraying increased yield 7.3 and 10% over the control.

More than 25,000 stems were dissected to determine the correlation between YSB infested stems at harvest and yield. Mean infestation was 27 to 60%, but no consistently significant correlations were found, perhaps because the stems dissected were less than 1% of the field population or because a younger crop is more sensitive to YSB damage (sampling was done at harvest).

We recorded and analyzed YSB infestation and grain sterility of the stems taken at harvest. Varieties differed in the internode most sensitive to damage. In variety Chamara despite 90% infestation (n = 254), grain loss was not significant unless the top internode was infested. In variety Sada Pankaish at lower infestation levels (37%, n = 254), infestation in either the lst, 3d, or 4th top internodes could significantly reduce grain filling. But in both varieties, whiteheads in the top internode caused greatest yield loss.

This result was verified in another study where varieties Chamara and Boron Bawalia showed that 94% of stems with whiteheads were infested in the top internode (n = 205) but few whiteheads were associated with infestation at the lower internodes (down to the 6th internode). □

Effect of monocrotophos (250g ai/ha) spray on YSB in deepwater rice. Dubail (Tangail) and DND Project area, Dhaka, 1982.[a]

Variety	Whitehead (%)		Infested stem (%)	
	Unsprayed	Sprayed	Unsprayed	Sprayed
Dubail				
Sonna digha	8.6	8.6 ns	74.6	50.5**
Chamara	5.9	2.1 **	58.0	28.2**
Boron Bawalia	10.8	2.4 **	54.0	21.0**
Sonna digha	8.2	6.1 ns	48.0	33.3*
Boron Bawalia	11.0	3.5 **	63.0	38.0**
DND				
Khama	10.3	4.7 **	57.0	45.0 ns
Khama	12.7	4.6 **	52.8	32.0**
Khama	11.8	6.3 **	70.0	59.1 ns

[a]The difference between sprayed and unsprayed areas, compared by t-test, are indicated as ns = not significant, * = significant at 5% level, and ** = significant at 1% level.

Rice gall midge (GM) (*Orseolia oryzae* Wood-Mason) biotypes in Guangdong Province

Kor-chow Lai, Yu-juan Tan, and Ying Pan, Plant Protection Research Institute, Guangdong Academy of Agricultural Sciences, China

GM is one of the most serious pests in South China. It is found in the mountain region, in some hilly areas, and in the central plains of Guangdong Province. Biotype studies were made in 1979-83

Adults are collected from the overwintering generation that infests the wild host plant *Leersia hexandra* and from infested rice at different sites. Damaged plants are put in pots in cages for symptom development. Adult insects are collected from the damaged plants and used to infest differential varieties.

To test for different biotypes we used Leaung 152, OB677, IET2911, W1263, Ptb21, and Muey Nahng 62M from IRRI. They were tested in 16 representative

Reactions of differential rice varieties to GM biotypes at various sites in Guangdong Province, China.

Location		Category[a]	China GM biotype	Differential reaction[b] to GM					
				Leaung 152	OB677	IET2911	W1263	Ptb21	Muey Nahng 62M
Guangzhou region	Huaxian	H	I	MR	MR	MR	MR	S	S
	Songhua	M	I	R	MR	R	MR	S	–
	Pengyu	P	II	R	R	R	S	S	S
Fozan region	Nanhai	P	II	R	R	R	S	S	S
	Xinhui	H	II	R	R	R	S	S	–
	Sanshui	P	II	R	MR	R	S	S	–
	Zhongzan	P	II	R	MR	R	S	S	–
Zantou region	Chaoan	P	II	R	MR	R	S	S	S
Huiyang region	Huizhou	H	II	R	MR	MR	S	S	S
	Dongwan	P	I	R	R	R	MR	S	S
Shaoguan region	Shaoguan	M	I	R	R	R	R	S	S
	Lianshan	M	III	S	S	S	R	S	S
Meixian region	Meixian	M	IV	S	S	S	S	S	S
	Wuhua	M	IV	S	S	S	S	S	–
Shaoqing region	Fenkai	M	IV	S	S	S	S	S	S
Zhanjiang region	Xinyi	M	IV	S	S	S	S	S	S

[a]H = hilly area, M = mountain region, P = plain. [b]MR = moderately resistant, R = resistant, S = susceptible.

localities in Guangdong: Huaxian, Songhua, Zhaozuan, Dongwan, Nanhai, Sanshui, Xinhui, Zhongzan, Pengyu, Huiyan, Chaoan, Lianshan, Fenkai, Xinyi, Meixian, and Wuhua. Experiments were repeated many times. The GM populations were classified according to varietal reaction.

Reactions of the differential varieties to GM differed among locations. Results indicated there are at least four GM biotypes in the province (see table). □

Detection of enzyme polymorphism among populations of brown planthopper (BPH) biotypes

R. C. Saxena, principal research scientist, International Centre of Insect Physiology and Ecology, Nairobi, Kenya, and associate entomologist, IRRI; and C. V. Mujer, research assistant, IRRI

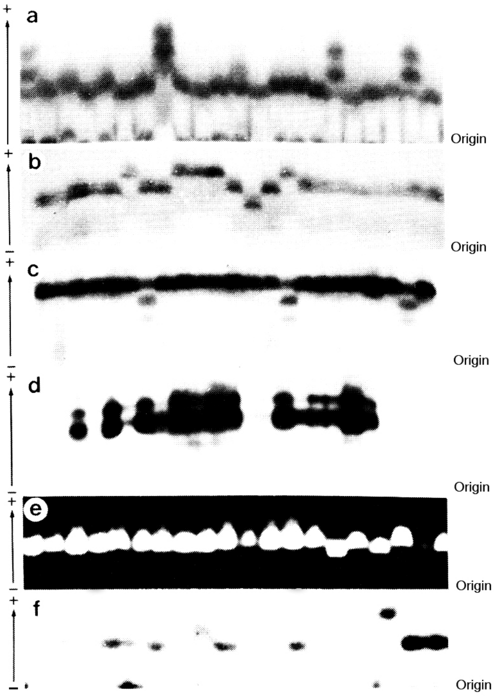
We found horizontal starch gel electrophoresis useful for surveying enzyme polymorphism among BPH biotypes. The procedure has three steps.

1. *Preparation of enzyme crude extracts.* Newly emerged male and female BPH biotype 1, 2, and 3 were obtained from stock cultures and frozen at –20ºC for at least 2 h before electrophoresis. Individual hoppers were placed in depressions on a spot plate and ground in 15 µ1 of the homogenizing solution (0.05M tris-histidine buffer, pH 8) using a glass rod. Whatman filter paper no. 3 bits (4 mm × 9 mm) were used to adsorb the crude extract and were inserted directly into the appropriate gel.
2. *Electrophoresis.* Standard horizontal starch gel electrophoresis was used. The starch gel (14%, Electrostarch) was prepared using 0.05M tris-histidine buffer pH 8 and was used to resolve all the enzymes except esterase, which separated more clearly at pH 6. Tris-citrate (0.4M, pH 8) was the electrode buffer, and was adjusted to pH 6 for esterase. Electrophoresis was conducted for 4 h in a refrigerator (0-4°C) at about 30 mA/gel slab. An ice pack was placed on top of the gel during electrophoresis; afterward, the gel was sliced horizontally into several sheets and stained.
3. *Histochemical staining.* We used the following enzyme assays. *Alcohol dehydrogenase (Adh):* 1 mg PMS, 10 mg NBT, 10 mg NAD, 0.25 ml EtOH in 50 ml 0.05M tris-HC1 buffer, pH 8.5, incubate gel for 30 min at 24°C. *Leucyl aminopeptidase (Lap):* 25 mg leucyl-ß-naphthyl in 5 ml N,N'-dimethyl formamide, 25 mg FBK salt, 25 ml tris-maleate buffer (0.2M, pH 3.3), 20 ml NaOH (0.1 M), incubate gel for 30 min at 40°C. *Acid phosphatase (AcPh):* 50 mg Fast garnet GBC, 50 mg a -naphthyl acid phosphate, 0.5 ml $MgCl_2$ (0.1M), 50 ml acetate buffer (0.2M, pH 4), incubate gel overnight at 24°C. *Catalase (Cat):* 50 ml H_2O_2 (7%) solution, incubate gel for 3 min, then wash with tap water, pour 50 ml KI solution (0.09M) with a drop of acetic acid. *Esterase (Est):* 50 mg a -naphthyl acetate, 10 mg Fast blue RR, 10 mg Fast garnet GBC in 50 ml phosphate buffer (0.1 M, pH 6.5), incubate gel for 15 min at 40°C. *Glucose-6-phosphate dehydrogenase (Gpd):* 1 mg PMS, 10 mg NBT, 5 mg NADP, 2 ml $MgCl_2$ (0.1M), 100 mg glucose-6-phosphate in 50 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel for 30 min at 24ºC. *Glutamate dehydrogenase (Gdh):* 250 mg sodium glutamate, 10 mg NAD, 10 mg NBT, 1 mg PMS in 50 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel for 30 min at 24ºC. *Glutamate oxaloacetate transaminase (Got):* 200 mg aspartic acid, 100 mg a -ketoglutaric acid, 1 mg pyridoxal 5, phosphate, 200 mg Fast blue BB salt in 50 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel for 30 min at 24ºC. *Isocitrate dehydrogenase (Idh):* 100 mg isocitrate tri-sodium, 5 mg NADP, 10 mg NBT, 1 mg PMS, 2 ml $MgCl_2$ (0.1M) in 0.05M tris-HC1 buffer, pH 8.5. *Lactate dehydrogenase (Ldh):* 1 mg PMS, 10 mg NBT, 10 mg NAD, 1M/80 lilactate in 0.05M tris-HC1 buffer, pH 8.5, incubate gel for 30 min at 24ºC. *Malate dehydrogenase (Mdh):* 1 mg

Enzymes investigated after horizontal starch gel electrophoresis. IRRI, 1983.

Locus	Enzyme activity[a]	Gene loci (no.)	Isoenzymes (maximum no.)	Migration
Polymorphic				
Catalase	+	1	2	Anodal
Esterase	+	3	6	Anodal
Isocitrate dehydrogenase	+	1	3	Anodal
Malate dehydrogenase	+	1	3	Anodal
Malic enzyme	+	1	4	Anodal
Phosphoglucose isomerase	+	2	8	Anodal
Monomorphic				
Acid phosphatase	+	1 or 2	2	Cathodal
Glucose kinase	+	1	1	Anodal
Glucosed-6-phosphate dehydrogenase	+	1 or 2	2	Anodal
Leucine aminopeptidase	+	1	1	Anodal
Phosphogluconate dehydrogenase	+	1 or 2	2	Anodal
Alcohol dehydrogenase	–			
Glutamate dehydrogenase	–			
Glutamate-oxaloacetate mutase	–			
Lactate dehydrogenase	–			
Peroxidase	–			
Shikimate dehydrogenase	–			
Tetrazolium oxidase	–			

[a] + = present, – = not detected.



Zymograms of (a) malate dehydrogenase, (b) phosphoglucose isomerase, (c) isocitrate dehydrogenase, (d) esterase, (e) catalase, and (f) malic enzyme.

PMS, 10 mg NBT, 10 mg NAD, 10 ml malate (0.05M, pH 6) in 40 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel in the dark for 15 min at 40°C. *Peroxidase* (*Pox*): 15 µl H_2O_2 solution (30%), 1 ml $CaCl_2$ solution (0.1M), 2.5 ml N,N'-dimethyl formamide, 20 mg 3-amino-9-ethyl carbazole in 42 ml acetate buffer (0.05M, pH 5). *6-Phosphogluconate dehydrogenase* (*Pgd*): 10 mg sodium phosphogluconate, 5 mg NADP, 10 mg NBT, 1 mg PMS, 2 ml $MgCl_2$ (0.1M) in 50 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel in the dark for 15 min at 40°C. *Phosphoglucose isomerase* (*Pgi*): 50 mg fructose-6-phosphate, 5 mg NADP, 10 mg NBT, 1 mg PMS, 2 ml $MgCl_2$ (0.1M), 3 µl glucose-6-phosphate dehydrogenase in 20 ml tris-HCl buffer (0.5M, pH 8.5). Mix with 25 ml 2% agar solution kept at 55°C and pour on the slice. Incubate in the dark for 15 min at 40°C. *Shikimate dehydrogenase* (*Sdh*): 25 mg shikimic acid, 5 mg NADP, 10 mg NBT, 1 mg PMS in 50 ml 0.05M tris-HCl buffer, pH 8.5, incubate gel in the dark for 15 min at 40°C. *Superoxide dismutase* (*Sod*): 15 mg NBT, 3 mg riboflavin, 4 mg EDTA, in 0.05M tris-HC1 buffer, pH 8.5, incubate at 37°C in dark for 30 min, then expose to UV light. *Tetrazolium oxidase* (*To*): 25 mg NAD, 20 mg NBT, 5 mg PMS, in 50 ml 0.05M tris-HCl, pH 8.5. Expose gel to light until white bands appear on blue background.

Using this technique, we investigated a total of 18 enzymes (see table). The figure shows the zymogram pattern of the 6 of 11 enzymes for which activity was noted. □

Cytogenetics of the whitebacked planthopper (WBPH) *Sogatella furcifera* (Horváth)

A. A. Barrion, research fellow, IRRI, and R. C. Saxena, associate entomologist, IRRI, and principal research scientist, International Centre of Insect Physiology and Ecology, Nairobi, Kenya

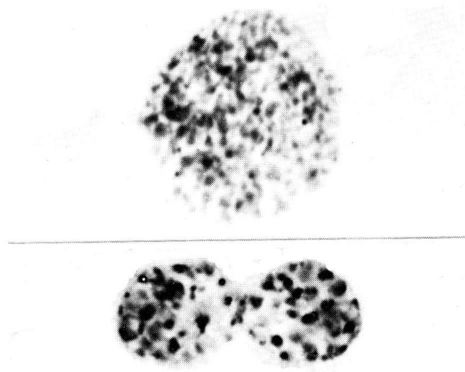
Cellular and karyotypic attributes such as chromosome number, morphology, morphometrics, and behavior involving position of chromosomes at various phases of cell division, differential contraction, bivalent configuration, etc., are important in understanding insect species relationships. We investigated the cytogenetics of WBPH. Oocytes and spermatocytes of insectary-reared, newly emerged adults were examined using the standard squash technique and lacto-aceto orcein staining method.

Reproductive cells simultaneously underwent both the conventional meiotic sequence and reverse meiosis, which led to the occurrence of uninucleated and binucleated meiocytes (Fig. 1). Binucleated cells resulted from failures of the tetrads of meiotic inversions to undergo complete cytokinesis. The frequency of occurrence of binucleated cells in 15 males that were examined was 21 per individual, or about 24% of the average total (88) meiocytes detected. Uninucleated cells averaged about 50 per insect or almost 56% of the total dividing cells.

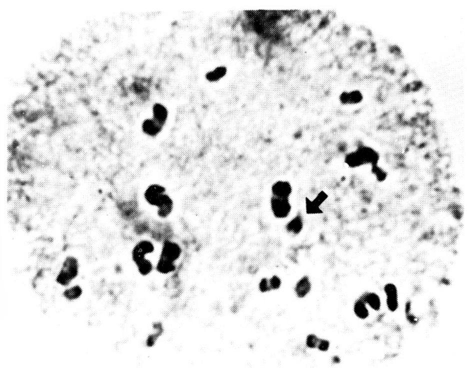
The uninucleated interphase cells were 47µ long and 30µ wide; the binucleated cells were 36µ long and 19µ wide. The nuclei of uninucleated cells were 5-10µ long and 8-9µ wide; the circular nuclei of binucleated cells had a 5µ diameter. Of the two nuclei in binucleated cells, only one survived and proceeded to the reductional division of meiosis. The other nucleus degenerated rapidly and was lost before metaphase I.

The mean number of dividing and nondividing testicular cells observed per individual was 88 and 94, giving a meiotic index of about 50%. Sperm length was 12 to 30µ.

WBPH chromosomes were holocentric. The kinetochores were diffused along the entire length of both autosomes and sex chromosomes. The diploid number was 2n=29, and 2n=30 in females. The sex chromosome in each testicular cell was a univalent X body, 2µ long and 1 to 1.5µ wide. The oogonial cells had XX bivalents,



1. Uninucleated (top) and binucleated (bottom) meiocytes (l000X) of *S. furcifera*



2. Complete genome in male *S. furcifera* (2n = 14_{II} A + X). Sex chromosome is indicated by an arrow.

each about 3μ long. The sex-determining mechanism was XX-XO type, the male being heterogametic and the female homogametic. Thus, the complete genome in males comprised 14 bivalent autosomes plus an X chromosome (Fig. 2), whereas females had 14 bivalent autosomes plus XX sex chromosomes. □

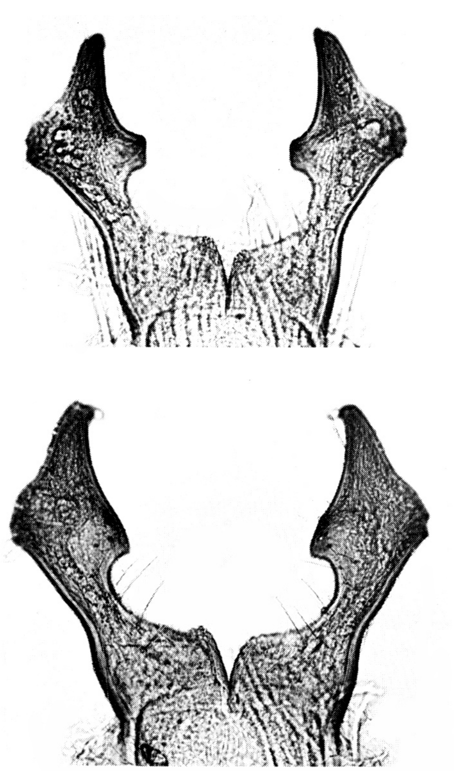
A *Leersia*-feeding brown planthopper (BPH) biotype in North Sumatra, Indonesia

K. Sogawa, D. Kilin, and A. Kusmayadi, Indonesia-Japan Joint Programme on Food Crop Protection; J. S. Sitio Balai Proteksi Tanaman Pangan I Medan Propinsi Sumatra Utara dan Daerah Istimewa Aceh

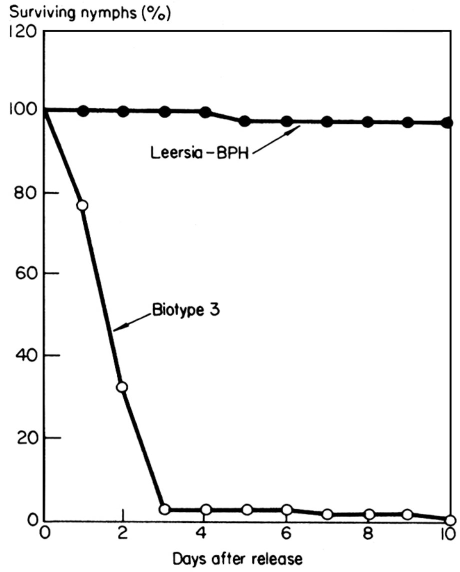
We found a large BPH population of macropterous and brachypterous adults and nymphs at various instars inhabiting *Leersia hexandra* in a fallow rice field at Petapahan, Lubuk Pakam, Deli Serdang, North Sumatra, in Sep 1983. Except for significantly smaller body size, morphological characters of BPH specimens collected on *L. hexandra* and on IR42 and Pelita I/1 at the same location were identical (Fig. 1).

Preliminary experiments compared the reactions of *Leersia*-BPH to host plants with the reaction of BPH biotype 3 which infests rice in North Sumatra. In a host preference test in a cage with *L. hexandra* and susceptible Pelita I/1, adult females of *Leersia*-BPH all settled on *L. hexandra* within 1 d, while biotype 3 females rejected it. Adult females of *Leersia*-BPH survived only a few days and reproduced little progeny on Pelita I/1. They survived normally and reproduced readily on *L. hexandra.* One *Leersia*-BPH female allowed to oviposit on *L. hexandra* for 1 wk produced about 120 nymphs. When the first-instar nymphs were reared on detached stems of *L. hexandra* in test tubes, 93-100% of nymphs emerged to adults within 2 wk. First-instar biotype 3 nymphs died (Fig. 2). Female *Leersia-BPH* excreted little honeydew on Pelita I/1 and IR42 (2-4 mg/female daily). Biotype 3 females excreted 30-40 mg honeydew/ female daily.

These results indicate that the *Leersia*-BPH is a distinct host-determined BPH biotype. □



1. Paramere of the *Leersia*-BPH(upper) and rice feeding BPH, biotype 3 (lower).



2. Survival trends of *Leersia*-BPH and biotype 3 nymphs on detached *L. hexandra.*

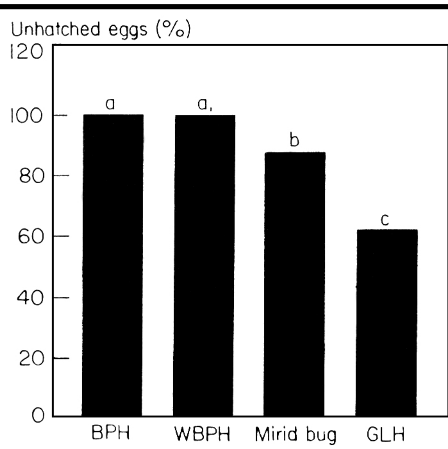
Hot water treatment to remove insects from rice plants used in the plant-hopper and leafhopper rearing program

F. Medrano, E. A. Heinrichs, G. S. Khush, and E. Baculangco, Entomology and Plant Breeding Departments, IRRI

In the IRRI GEU program, thousands of rice plants are grown each month as food for the hopper rearing program. Because greenhouse space is limited they must be grown outdoors, where they are often infested with eggs of the various hopper species and predators. This contamination leads to mixing of hopper biotypes and brings unwanted predators into the rearing cages. To eliminate those insects, plants are sprayed with water and placed in cages. Hatching nymphs are removed after 11 d. This is time-consuming and requires greenhouse space.

We evaluated hot water treatment for control of brown planthopper (BPH) *Nilaparvata lugens,* whitebacked planthopper *(WBPH) Sogatella furcifera,* green leafhopper (GLH) *Nephotettix virescens,* and the predatory mirid bug *Cyrtorhinus lividipennis.*

Gravid females of BPH, WBPH, GLH, and *Cyrtorhinus* were separately



Egg mortality caused by dipping rice plants in 44°C hot water for 30 min. Bars with different letters differ significantly at the 5% level by Duncan's multiple range test.

released on 40-d-old potted TN1 plants. After 24 h of infestation, the insects were removed and half the potted plants containing eggs were submerged in a 44°C hot water bath. The remaining half were submerged in ordinary tap water. Nymphs that hatched from all potted plants were counted 11 d after infestation.

Dipping the plants in hot water for 30 min caused 99% mortality of BPH and WBPH eggs (see figure) and had no adverse effect on the rice plants. Mortality of *C. lividipennis* eggs was 88%, but mortality of GLH eggs was only 63%. We are now using this technique for BPH rearing. □

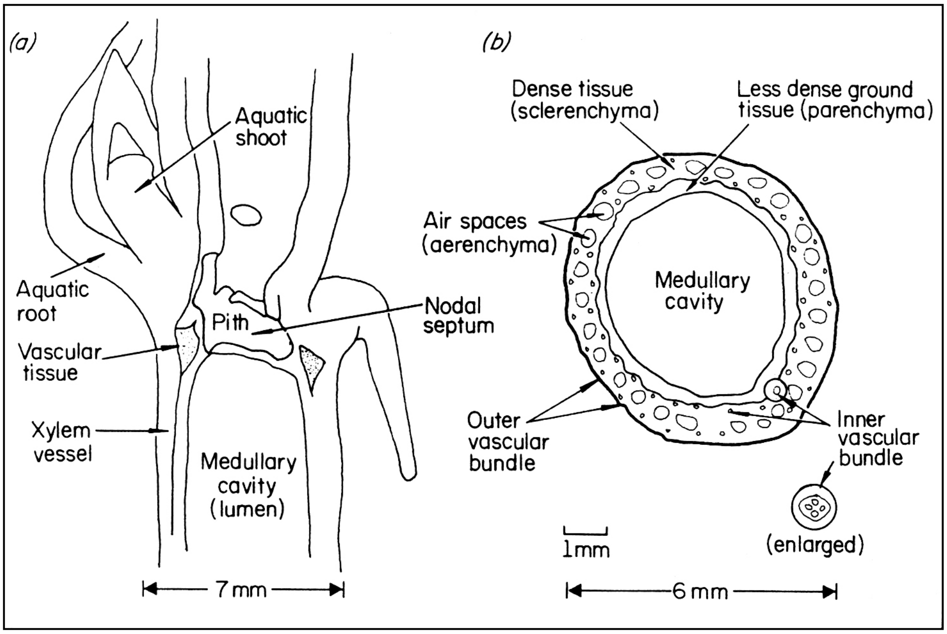
Deepwater rice and yellow stem borer (YSB) larvae

B. Taylor, ODA-BRRI Deepwater Rice Project, Bangladesh Rice Research Institute, Joydebpur, Dhaka, Bangladesh

There is relatively little information on the anatomy of elongated deepwater rice plants. We studied plant anatomy and the effect of YSB *Scirpophaga incertulas* (Walker) feeding on rice yield.

Cut ends of elongated Chamara stems were immersed in an aniline blue dye solution for 2-3 d and then examined for YSB larvae infestation. Stems were dissected longitudinally or sectioned to study the effect of larval feeding. Vascular tissue was stained blue and photographs and drawings were made of the damage (see figure).

The nodal septum is of undifferentiated tissue (no vascular tissue); therefore, larval passage through the septum did not disrupt conduction or reduce growth above an infested internode. Feeding in the internodes seldom penetrated into the parenchyma as far as the inner ring of vascular bundles, and even then conduction was disrupted in only few vascular bundles. At the node, vascular tissue forms a dense continuous ring that connects the incoming bundles from the internode. Although we found larvae actively feeding in the fourth or fifth internode below the stem growing point, there was never an obvious interruption of xylem flow to the apex. Even if the larva was feeding immediately below the panicle-bearing stem, the flow to the upper xylem was not interrupted and the panicle appeared normal.



Internal structure of a basal tiller of an elongated deepwater rice plant: a) longitudinal section of 5th node from the top; b) tissue section of 4th internode from the top.

Larval damage early in the season, where internode tissue at the base of the plant was severely damaged, caused the plant to produce aquatic roots and tolerate YSB. In one or two instances, deadhearts were caused by small first- or second-instar larvae that had bored between the flag leaf sheath and the stem and had entered just above the top node. Larval feeding had cut a ring around the narrow apical stem, almost severing it. That interrupted the vascular system and killed the apex. Later in the season, examination of many whiteheads showed similar excision of the apical stem. □

Incidence of gall midge (GM) ***Orseolia oryzivora*** **H & G in Edozhigi, Nigeria**

M. N. Ukwungwu, rice entomologist, National Cereals Research Institute (NCRI); M. S. Alam, rice entomologist, International Institute of Tropical Agriculture (IITA); and Kaung Zan, IRRI liaison scientist for Africa

In Africa, GM occurs in the Sudan, Cameroon, Mali, Upper Volta, Ivory Coast, Senegal, Guinea Bissau, and Nigeria. Except in Upper Volta, it is considered as a localized pest. In Upper Volta, GM is one of the most serious and widespread pests on irrigated and rainfed lowland rice. The African GM species is morphologically distinct from the Asian species *O. oryzae.*

In Nigeria, GM is found in Gnangnum (Plateau State) and Badeggi (Niger State). GM incidence is increasing at Edozhigi, a research farm for irrigated rice of the NCRI. Rice crops planted after mid-Oct often are seriously-affected. GM was also observed on farmer plots in Agaie and Jima in 1982 and 1983.

The 8th International Rice Gall Midge Nursery (90 entries) was planted at Edozhigi in 1982. Infestation was 0.5 to 23.6%. Only 6 entries, BW100, 0B677, Eswarakora, Cisadane, Ptb 10, and WGL 22397, had less than 2% infestation. □

Pest management and control WEEDS

Effect of time of herbicide application on crop damage and weed control in wet-seeded rice

M. O. Mabbayad and K. Moody, Agronomy Department, IRRI

Wet seeding rice (sowing pregerminated seed on puddled soil) is increasing in importance in several Southeast Asian countries. When herbicides are used for weed control in this type of rice culture, selectivity is often marginal because the rice and the weeds are at the same development stage. Herbicide selectivity may be improved by varying application time.

To determine the effect of time of herbicide application on weed control and crop damage in wet-seeded rice, residual herbicides were applied 3 d before seeding (DBS) and 0, 3, and 6 d after seeding (DAS), and propanil, a contact herbicide, was applied 6, 9, and 12 DAS. The field was saturated when the herbicides were applied 3 DBS and 0 and 3 DAS. Water depth was 3-4 cm when the herbicides were applied 6 DAS. Hand weeded (25 and 40 DAS) and unweeded checks were included for comparison.

Pregerminated IR36 seeds were broadcast at 100 kg/ha on 22 Aug 1983. Crop stand counts were determined 30 DAS and weed weights 45 DAS from two 0.5- × 0.5-m quadrats per plot.

Significant stand reductions occurred when thiobencarb and piperophos – 2,4-D were applied 0 and 3 DAS and when butachlor – 2,4-D were applied 0, 3, and 6 DAS (see table). No standard reduction was observed with other herbicides.

Eleven weed species occurred in the experimental area. The major ones, in order of decreasing importance, were *Paspalum distichum, Monochoria vaginalis, Sphenoclea zeylanica, Echinochloa glabrescens,* and *Cyperus difformis.*

None of the herbicides controlled weeds as well as the hand-weeded check (see table). Application 3 DBS of all the residual herbicides except DPX 5384 and piperophos – 2,4-D significantly reduced weed weight compared to the untreated check. When herbicides were applied 6 DAS, pretilachlor + safener at 0.75 kg/ha and DPX 5384 were superior to the untreated check. Propanil controlled weeds poorly at all application times.

When averaged across residual herbicide treatments, weed weights were significantly lower when the herbicides were applied 3 DBS than at the other times (50 g/m^2 vs an average of 111 g/m^2). When averaged across application times, pretilachlor + safener and butachlor were superior to piperophos-2,4-D in controlling weeds while pretilachlor + safener were superior to butachlor – 2,4-D.

Results indicate that for crop safety and superior weed control in wet-seeded rice, residual herbicides should be applied before seeding.

Effect of time of herbicide application on crop stand and weed weight, IRRI, 1983 wet season.

Herbicide and rate (kg ai/ha)	Time of application	Crop stand count (no./m^2)	Weed wt[a] (g/m^2)
Pretilachlor safener (0.5)	3 DBS	287 a	19 hi
	0 DAS	255 abc	21 ghi
	3 DAS	280 ab	47 c–i
	6 DAS	229 abc	82 a–i
Pretilachlor + safener (0.75)	3 DBS	211 a–d	45 c–i
	0 DAS	221 a–d	44 c–i
	3 DAS	247 abc	33 e–i
	6 DAS	279 ab	30 f–i
Butachlor (0.5)	3 DBS	193 a–f	39 d–i
	0 DAS	207 a–d	53 b–i
	3 DAS	257 abc	26 ghi
	6 DAS	250 abc	121 a–g
Butachlor (0.75)	3 DBS	233 abc	16 i
	0 DAS	287 a	33 e–i
	3 DAS	256 abc	100 a–h
	6 DAS	199 a–e	102 a–h
Thiobencarb (1.5)	3 DBS	220 a–d	44 c–i
	0 DAS	167 c–d	139 a–g
	3 DAS	101 gh	107 a–g
	6 DAS	239 abc	66 a–i
Butachlor-2,4-D (0.45-0.30)	3 DBS	235 abc	46 c–i
	0 DAS	108 fgh	101 a–h
	3 DAS	129 d–h	103 a–h
	6 DAS	184 b–g	180 a–d
Piperophos-2,4-D (0.33-0.17)	3 DBS	220 a–d	69 a–i
	0 DAS	115 e–h	222 abc
	3 DAS	90 h	176 a–e
	6 DAS	226 abc	51 a–i
DPX 5384 (0.5)	3 DBS	288 a	68 a–i
	0 DAS	247 abc	70 a–i
	3 DAS	205 a–d	36 d–i
	6 DAS	281 ab	52 c–i
Propanil (2.5)	6 DAS	241 abc	156 a–f
	9 DAS	239 abc	277 ab
	12 DAS	220 a–d	78 a–i
Hand weeded	25 + 40 DAS	259 abc	3 j
Not weeded	–	207 a–d	281 a

[a] Backtransformed means of the transformed means. In a column means followed by common letters are not significantly different at the 5% level.

Soil and crop management

Effect of different methods and time of threshing on IR6 grain losses

C. A. Khuhro, I. M. Bhatti, and M. H. Balock, Rice Research Institute, Dokri, Sind, Pakistan

Threshing is a source of substantial postharvest grain losses. Traditional threshing in Sind Province, Pakistan, is by animal trampling after paddy has been stacked for as long as 1-2 mo. This method leads to large grain losses and grain quality deterioration.

We studied the effect of different methods and time of threshing on grain losses at three locations. Hand, bullock, and mechanical threshing were tested at 4 d and 3, 6, and 9 wk after harvest, using grain at the top, middle, and bottom of the stacks (see table).

Analysis of individual threshing methods for different times of stacking in different portions showed that hand threshing and mechanical threshing produced minimum grain losses. However, with bullock threshing, grain losses increased when threshing was delayed. The bottom portion of the stack was most seriously affected. Those losses can be minimized to 4% if bullock threshing is not delayed beyond 4 d after harvest. □

Effect of threshing methods and timing on total grain loss, [a] **Sind, Pakistan.**

Threshing method	Total grain loss[b] (%)		
	Top of stack	Middle of stack	Bottom of stack
		4 d after harvest	
Hand	0.27 e	0.26 e	0.28 e
Bullock	4.23 de	4.00 de	4.37 de
Mechanical	0.55 e	0.55 de	0.56 e
		3 wk	
Hand	0.34 e	0.43 e	0.44 e
Bullock	5.54 cde	8.2 de	12.87 ab
Mechanical	0.40 e	0.50 e	0.64 e
		6 wk	
Hand	0.32 e	0.56 e	0.50 e
Bullock	4.95 de	4.11 de	13.06 ab
Mechanical	0.72 e	0.66 e	0.58 e
		9 wk	
Hand	0.27 e	0.51 e	0.60 e
Bullock	10.89 ab	4.04 bcd	16.09 a
Mechanical	0.92 e	0.97 e	0.73 e

[a] Means of 3 replications at 3 locations. [b] Separation of means by Duncan's multiple range test at 5% level.

Effect of organic and inorganic manuring on rice nurseries

M. S. Maskina, O. P. Meelu, and P. S. Sandhu, Soils Department, Punjab Agricultural University (PAU), Ludhiana 141004, India

A combination of organic manures and inorganic fertilizers can improve the root environment and release of nutrients to rice nurseries.

We studied the effect of using a combination of organic and inorganic nitrogen on the rice nursery at PAU farm in 1981 and 1982. Soil was a loamy sand (Ustochrept) with pH 8.4, low organic carbon (0.23%), and 87-8-86 kg available NPK/ha.

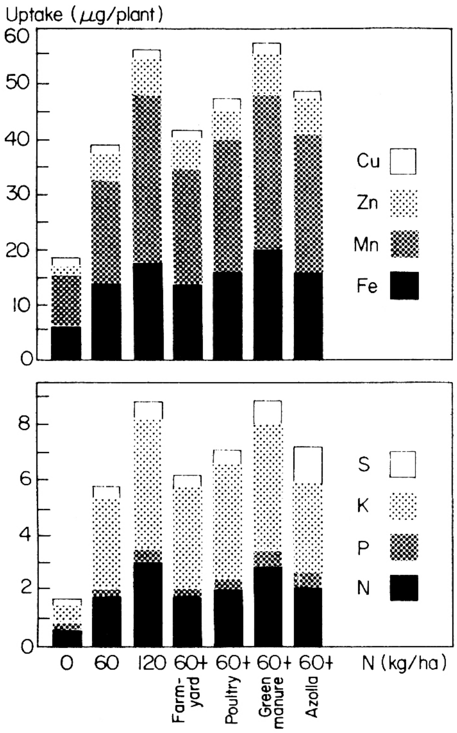
N was applied at 0, 60, and 120 kg/ha. Farmyard manure, poultry manure, and azolla were applied at 15, 4, and 10 t/ha. In one treatment, dhaincha *Sesbania aculeata* was raised for 1 mo and incorporated as green manure 3 d before sowing the rice nursery. Dhaincha fresh weight was 8 to 10 t/ha. Organic manures and 10 kg P/ha were applied before last puddling. Nitrogen was applied in equal splits at sowing and at 15 and 30 d after sowing. Nurseries were in 10- × 2-m^2 beds and planted with 1 kg seed. Beds were sown the last week of May and data were recorded 45 d later.

Green manure combined with 60 kg N/ha produced nursery plant biomass equal to that with 120 kg N/ha (see table). Height, color, and leaves of nursery plants were affected favorably by the application of green manure and poultry manure. Seedling strength (see table) was determined as dry matter per unit height

$$\left(\frac{\text{dry matter of the plant (mg)}}{\text{ht of the plant (cm)}} \right)$$

and was highest in the green manure treatment.

Uptake of essential macro- and micronutrients improved with application of organic manures (see figure). Uptake of



Effect of organic manures on uptake of essential nutrients by nursery plants (mean 1981-82), Ludhiana, India.

Effect of organic and inorganic nitrogen on growth of nursery (mean of 1981 and 1982), Ludhiana, India.

Treatment: N (kg/ha)	Treatment: Organic N	Dry matter (mg/plant)	Leaves/ plant	Plant ht (cm)	Color index[a] (A)	Seedling strength (mg/cm) (B)	Seedling quality (A × B)	Grain yield (t/ha)
0	–	76	6	18	1	4	4	–
60	–	152	8	25	2	6	12	5.6
120	–	212	9	30	3	7	22	6.6
60	Farmyard manure	153	8	27	2	6	11	5.5
60	Poultry manure	169	8	32	3	5	16	–
60	Green manure	215	8	28	3	8	24	6.5
60	Azolla	174	7	26	2	7	14	–

[a]1 = pale yellow, 3 = dark green.

N, P, K, S, Fe, Mn, Zn, and Cu in treatments receiving 60 kg N/ha and dhaincha green manure was higher than with 60 kg N alone and equaled that of 120 kg N. Nursery treatments that received 120 kg N/ha and green manure + 60 kg N/ha yielded significantly more grain than other treatments (see table). □

Individuals, organizations, and media who want additional details of information presented in IRRN should write directly to the authors.

Influence of phosphorus and pyrite on azolla growth

S. Venkataraman and S. Kannaiyan, Agricultural Microbiology Department, Tamil Nadu Agricultural University, Coimbatore 641 003, Tamil Nadu, India

We studied the effect of superphosphate (SSP), Mussorie rock phosphate (MRP), and pyrite on azolla growth in pot culture. Treatments were SSP alone, MRP alone, SSP and pyrite, MRP and pyrite, at 0, 5, 10, 15, and 20 kg P/ha. Azolla at 200 g/m^2 was inoculated and 20 ppm carbofuran was applied. Azolla fresh weight was recorded 10 d after inoculation.

All P treatments increased azolla growth over that of the control (see table). Results indicate that MRP + pyrite is superior for azolla growth. □

Influence of phosphorus (P), Mussorie rock phosphate (MRP) and pyrite on azolla growth, Tamil Nadu, India.

P (kg/ha)	SSP: Mean azolla wt (g)	SSP: % increase over control	SSP + pyrite: Mean azolla wt (g)	SSP + pyrite: % increase over control	MRP: Mean azolla wt (g)	MRP: % increase over control	MRP' + pyrite: Mean azolla wt (g)	MRP' + pyrite: % increase over control
Control (0)	90.0	–	111	–	101	–	100	–
5	129.0	43	138	24	108	6	133	32
10	142.0	58	146	31	114	13	141	41
15	151.5	68	157	41	120	19	153	52
20	166.0	84	177	59	120	19	159	59
LSD (P = 0.05)		LSD: 6.284		LSD: 8.019		LSD: 8.010		LSD: 5.824

Azolla as a substitute for fertilizer

N. Haq, and D. Rosh, Agricultural Research Station (ARS), Mingora (Swat); and P. Shah, NWFP Agricultural University, Peshawar, Pakistan

We sought to determine how much N fertilizer can be saved by growing azolla, using J.P.5 rice at ARS in Mingora in 1982. The station is at 35°N latitude and at 975 m altitude. Climate is cool and irrigation water is 15°C.

Azolla treatments, similar to those adopted for 1981-82 INSFFER trials (see table), were in a randomized complete block design with 3 replications in 5- × 3-m plots. Plant height, tillers/hill, and grain yield were recorded and statistically analyzed.

Yield with azolla culture was similar to that with 60 kg applied N/ha (see table). We found that azolla culture has a beneficial effect on soil structure, soil microflora, and micronutrient availability. The azolla effect may persist longer than N fertilizers on subsequent crops and its effect may increase over time to surpass those of commercial N fertilizers. □

Rice yield and other data from azolla experiments at ARS, Mingora (Swat), Peshawar, Pakistan.

Treatment (N/ha)	Panicles/hill	Plant ht (cm)	Grain yield (t/ha)
0 N, 0 azolla, 20- × 20-cm spacing	6	98	3.2
60 kg N, 20- × 20-cm spacing	7	98	3.7
60 kg N, 40- × 10-cm spacing	8	105	4.8
Azolla incorporation before transplanting, 30 kg N, 20- × 20-cm spacing	8	100	3.8
Azolla incorporation before transplanting, 30 kg N, 40- × 10-cm spacing	9	110	5.0
Azolla grown once before and once after transplanting and incorporated, 20- × 20-cm spacing	6	100	4.1
Azolla grown once before and once after transplanting and incorporated, 40- × 10-cm spacing	8	101	4.5
Azolla grown twice after transplanting, 40- × 10-cm spacing	8	101	4.7
90 kg N as urea in 3 splits, 0 azolla, 20- × 20-cm spacing	9	105	4.7
90 kg N as urea in 3 splits, 0 azolla, 40- × 10-cm spacing	9	105	5.5

Effect of blue-green algae (BGA) on rice yield

S. R. Patel, S. K. Shrivastava, and B. R. Chandravanshi, Jawarharlal Nehru Krishi Vishwa Vidyalaya, Zonal Agricultural Research Station (Rice Zone), Raipur (M. P.) 492 012 India

We conducted a field trial in clay loam soil in 1979, 1980, and 1981 wet seasons at Raipur to determine the N contribution of BGA in lowland rice dwarf variety K35-2752. Soil characteristics were as follows: pH, 7.8; organic carbon, 0.7%; and available N, P_2O_5, and K_2O, 0.01, 0.0016, and 0.018%. Treatments were in randomized block design with four replications. N was applied in 3 splits (1/4 basal, 1/2 at tillering, and 1/4 at panicle initiation), and 26 kg P and 33 kg K/ha were applied basally to all treatments. BGA inoculum was from the All India Coordinated Rice Improvement Project. Visual observations of BGA development were not recorded. Yield component was recorded.

BGA inoculation and N level significantly affected yield. Rice yield increased with N level from 25 to 75 kg N/ha. Application of 10 kg BGA/ha gave significantly higher yield over the control in 1979 and 1980. In 1981, heavy rains fell immediately after BGA inoculation, and reduced effect on yield (see table). Inoculation of 10 kg dried BGA/ha produced rice yield equivalent to that with 25 kg N/ha. □

Effect of BGA and N level on rice yield, Raipur, India.

Treatment	Yield (t/ha) 1979	1980	1981
Control	3.0	2.7	2.0
25 kg N/ha	3.5	3.4	2.5
50 kg N/ha	4.4	3.8	2.8
75 kg N/ha	4.7	4.2	3.2
10 kg dried BGA/ha	3.6	3.3	2.2
10 kg dried BCA + 25 kg N/ha	3.7	3.5	2.4
LSD (5%)	0.62	0.37	0.28

Effect of fertilizer rate on yield of rice cultivars

K. Sudo, research officer, Hyogo Prefectural Agricultural Experiment Station, and H. Tsuchiya and S. Ahmad, Laboratory of Crop Science, Kyoto University, Japan

Yield of Nipponbare, which averages 4.5 to 4.6 t/ha in northern Hyogo Prefecture, was compared to that of Milyang 23, Swong 258, and Chugoku 91 in different fertilizer treatments. Twenty-five-day-old seedlings were transplanted at 30- × 15-cm spacing and 3-5 seedlings/hill on 10 May, in a split-plot design with 2 replications.

Soil was a sandy clay loam with pH 6.8 (H_2O 1:5), EC 130 μS/cm, 4.0% organic matter, 0.16% total N, 2.32% total organic carbon, 17.0 mg/100 g available P (Bray-Kurtz No. 2 method), 16.9 meq/100 g CEC (1N-$CaCl_2$, pH = 8.2), and exchangeable cations 0.10 meq/100 g Na, 0.22 meq/100 g K, 9.67 meq/100 g Ca, 1.37 meq/100 g Mg, and 0.01 meq/100 g Al (1N-CH_3COONH_4).

In control plots, fertilizer was applied basally at 40, 29, and 40 kg NPK/ha and topdressed at 20, 14.3, and 20 kg NPK/ha at active tillering, panicle initiation, and reduction division and heading. Treated plots received 1.5 times more fertilizer at all stages except at heading, when an equal amount of fertilizer was applied to all plots. Total fertilizer applied was 120, 86, and 120 kg NPK/ha to control plots and 170, 122, and 170 kg NPK/ha to treated plots.

Top dry weight, yield components, and grain yield differed significantly among four rice cultivars and treatments (see table). Panicle number increased more than ripening percentage decreased; the result was increased grain yield. Fertilizer increased grain yield about 16% in all cultivars except Milyang 23, which was badly affected by a typhoon. □

Effect of fertilizer rate on grain yield and yield components of 4 rice cultivars, Hyogo Prefecture, Japan.

Cultivar	Treatment plot	Top dry wt (t/ha)	Yield component: Panicle (no./m^2)	1000-grain wt (g)	Ripening[a] (%)	Grains (no./panicle)	Grain[b] yield (t/ha)	Relative increase of grain yield (%)[c]
Nipponbare	Control	15.4	420	22.6	95	62	5.5	19
	Treated	18.7	502	22.0	93	65	6.6	
Milyang 23	Control	11.4	326	23.3	85	66	4.1	–14
	Treated	14.5	378	23.3	81	50	3.6	
Swong 258	Control	14.2	389	22.5	92	69	5.5	17
	Treated	16.2	451	22.5	91	70	6.4	
Chugoku 91	Control	14.4	325	21.2	87	98	5.9	11
	Treated	16.3	388	20.2	76	111	6.5	
Source of variation[d]								
Cultivar (C)		**	**	**	**	**	**	
Fertilizer (F)		**	**	ns	**	ns	**	
C × F		ns	ns	ns	ns	ns	**	

[a] Ripening (%) = no. filled grain × 100/(no. filled grain + no. unfilled grain). [b] Grain yield (t/ha) = panicle no./m^2 × 1000-grain weight (g) × ripening (%) × grain no./panicle/10^7. [c] Relative increase of grain yield (%) = (grain yield of T – grain yield of C) × 100/grain yield of C, where T and C are additional fertilizer treatment plot and control plot. [d] ** = significant at 1% level, ns = not significant.

Potassium fertilizer experiments in farmer fields

A. H. Gurmani, A. Bhatti, and H. Rehman, Agricultural Research Institute, Tarnab, Peshawar N.W.F.P., Pakistan

We studied rice response to potash application on farmer fields in Dera Ismail Khan district of the North West Frontier Province of Pakistan. Available potash at different sites was 100 to 250 ppm, and chloride content was 28 to 39 ppm. In the first experiment (Table 1) all levels of applied potash increased rice yields significantly. Some benefits may have been derived from K application.

In the second experiment, application of 135-40-37 kg NPK/ha produced the highest yield of 7.58 t/ha (Table 2).

Of two K sources (Table 2), K_2SO_4 was significantly better than KCl. □

Table 1. Effect of K application on paddy yield, Tamab, Pakistan.[a]

Treatment (kg/ha)			Yield[b] (t/ha)	Increase over N + P (t/ha)
N	P	K		
0	0	0	3.57 b	–
120	40	0	5.05 a	–
120	40	25	5.19 a	0.14
120	40	50	5.65 a	0.60
120	40	15	5.97 a	0.92
120	40	100	5.72 a	0.67
120	40	125	5.58 a	0.53

[a] As of 5 experiments in 1979-81. [b] Separation of means by Duncan's Multiple Range Test at 5% level.

Table 2. Effect of fertilizer applications on paddy yield. Tarnab, Pakistan.

Treatment (kg/ha)			Yield[a] (t/ha)	Increase over N + P (t/ha)	Value of increased yield[b] (US$)	Value-cost[c] ratio
N	P	K				
			NPK application[d]			
0	0	0	4.95 c	–	–	–
135	0	0	6.07 b	–	–	–
135	40	0	6.97 ab	–	–	–
135	40	37	7.58 a	0.61	74.20	12.97
			K_2SO_4 and KCl application[e]			
120	35	0	4.91 c	–	–	–
120	35	83 (KCl)	5.52 b	0.61	74.72	9.34
120	35	83 (K_2SO_4)	6.11 a	1.21	148.22	12.35

[a] Separation of means by Duncan's multiple range test at 5% level. [b] Value of paddy = US$l22.5/t. [c] Fertilizer cost = K_2SO_4: US$12/83 kg K, US$ = 8/83 kg K. Value-cost ratio is for KCl:potash only. [d] Av of 3 experiments in 1979-81. [e] Av of 25 experiments in 1979-81.

Dual cropping azolla in lowland rice

S. Ramasamy, O. S. Kandasamy, and A. Saravanan, Tamil Nadu Rice Research Institute (TNRRI), Aduthurai 612 101, India

We evaluated azolla as a substitute for N fertilizer for lowland rice IR20 in the field at TNRRI in winter 1982-83. The soil had pH 6.8 with CEC 24.5 meq/l00 g and 5.9 ppm available P (Olsen), dry soil basis. Eighty kg P and 31 kg potash/ha were applied basally.

Azolla was inoculated with 30 and 60 kg N/ha and results were compared with four N treatments (see table). Urea N was applied 50% basally and in 2 equal splits 20 and 40 d after transplanting, and 500 kg fresh *Azolla pinnata*/ha was applied 1 wk after transplanting. Azolla was allowed to multiply and decompose in the field. A maximum biomass of 790 g/m^2 was recorded at a multiplication rate of 195 g/m^2 per week. N content of fresh azolla was 0.37%.

Dual cropping 500 kg fresh azolla/ha with 60 kg N gave a yield equal to that with 90 kg N (see table). □

Effect of azolla on grain yield of IR20, Aduthurai, India.

Treatment (kg N/ha)	Grain yield (t/ha)
No N control	2.8
30	3.2
60	3.7
90 N	3.9
30 N + azolla	3.7
60 N + azolla	3.9
LSD (0.05)	0.7

Environment and its influence

Screening for shade tolerance in rice seedlings

G. Sahu, Central Rice Research Institute, Cuttack, India; R. M. Visperas, and B. S. Vergara, IRRI

Rice plants are subjected to various degrees of low light intensity when grown under coconut trees, in pockets of forest land, when mixed with other crops, and when grown during the wet season. Rice production in these situations is poor because solar radiation for crop growth is insufficient. Some degree of shade tolerance may overcome this situation. We sought to determine suitable morphological and physiological parameters to use in screening for shade tolerance and to develop a suitable screening method for use in the greenhouse.

Ten pregerminated seeds of 10 varieties were sown in a row in each 40- × 25- × 15-cm plastic tray filled with 6 cm of fine Maahas clay. The experiment was in three replications. For 14 d, the 10-d-old seedlings were subjected to 3 degrees of shading: 55, 72, and 86%. Two sets were given continuous dark treatment for 7 or 14 d.

Plants grown in 55% shade produced 50% less dry weight than those in full sun. Fifty-five percent shading was judged to be critical. IR52 and FR13A showed the least reduction in dry matter at that level (see table). At the end of the treatment, Leb Mue Nahng 111, Kurkaruppan, Nam Sagui 19, and FR13A had the highest dry weight and highest leaf area per plant. Based on dry matter produced, those four varieties should perform well in the shade. FR13A and Kurkaruppan also show the least reduction in plant weight at higher degrees of shading.

A set of plants was placed in total darkness for 7 d to test if this could be a faster way of screening for shade tolerance. Generally, the varieties with high dry matter weight at 55% shading had high survival rate in complete darkness (r = 0.578*). The correlation, however is not very high and screening at 55% shading would be a better method.

Thin leaves or low specific leaf weight (SLW), said to be characteristic of varieties suitable for low light intensities, is found in FR13A, IR52, and RD19. Growing the varieties to maturity to obtain grain yield would give the ultimate measure of their shade tolerance. Further studies, using more varieties, need to be made. □

Effect of shade on rice seedlings.[a]

Variety	Dry matter (mg/plant) at 55% shade	Decrease (%) in dry matter at 55% shade	Leaf area (cm^2) /plant at 55% shade	SLW[b] (mg/dm^2) in normal light	Survival (%) at 7 d darkness
IR1529-680-3-2	125 ef	56 a	28.75 g	3.27 a	37 bcd
IR52	156 de	39 b	39.42 ef	2.10 de	83 a
RD19	180 cd	52 ab	44.02 de	1.97 e	93 a
Thavalu (acc. 15314)	176 cd	54 a	34.70 f	2.91 b	70 abc
Leb Mue Nahng 111	213 bc	58 a	48.73 cd	2.55 c	63 abc
Kurkaruppan	233 ab	58 a	57.87 b	2.52 c	83 ab
Nam Sagui	226 ab	55 a	54.30 bc	2.31 cde	40 bcd
FR13A	263 a	42 ab	68.00 a	2.27 cde	73 abc
IR42	104 f	50 ab	27.07 gh	2.37 cd	27 cd
IR20	91 f	57 a	21.67 h	2.33 cde	30 cd

[a] In a column, means followed by the same letter are not significantly different at the 5% level. [b] Specific leaf weight.

Cropping systems

Potential of rice-based multiple cropping sequences for irrigated conditions in Uttar Pradesh

V. Prakash and J. P. Tandon, Vivekananda Parvatiya Krishi Anusandhan Shala (VPKAS), Almora, UP, India

Rice is the predominant crop in most medium-altitude irrigated valleys in the UP hills. The most popular crop rotations are rice (Jun-Oct) – wheat (Nov-May) and rice (Jul-Oct) – potato (Feb-Jun), with an intervening fallow period from late Oct to mid-Feb. Cropping intensity is restricted to 200%.

We conducted a fixed plot field study from 1978 to 1981 at the VPKAS experimental farms, Hawalbagh, to determine ways of increasing cropping intensity. Four crop sequences with 34 crops/year were compared with the popular 2 crop rice – wheat rotation. Data for the rice – potato rotation were also compiled.

Short-duration varieties were used in the intensive cropping sequences and medium-duration varieties were planted in the less intensive sequences. Recommended cultural practices were adopted for all crops.

Highest average annual net returns were from a rice – cabbage – maize (green cobs) rotation followed by rice – radish – pea (vegetable) – French bean (vegetable) and rice – rapeseed (*Brassica campestris* L. var. *toria*) – potato sequences. Rice – wheat yielded the lowest net return (see table).

From the benefit-cost ratio point of view, the rice – radish – pea (vegetable) – French bean (vegetable) sequence was best, followed by rice – cabbage – maize (green cobs). However, these sequences can be adopted only near marketplaces because vegetables are an important component. In places away from marketing centers, rice – rapeseed – potato can be adopted to increase profits. This pattern is being adopted by some cultivators. □

Yield, costs, and returns in 1978–81 for irrigated rice-based cropping systems in UP, India.

Cropping pattern	Yield (t/ha)	Total variable cost ($/ha)	Net return ($/ha)	Benefit-cost ratio
Rice (VL Dhan 8) - wheat	4.7	497	630	2.4
(VL Gehun 421)	4.9			
Rice (VLK Dhan 39) -	5.1	988	1,019	2.1
rapeseed (T9) -	1.2			
potato (K. Jeoti)	23.0			
Rice (VLK Dhan 39) -	3.9	940	1,485	2.6
cabbage (Golden acre) -	37.4			
maize for green cobs	62,666[a]			
(VL Makka 16)				
Rice (VLK Dhan 39) -	3.7	854	1,456	2.7
radish (Japanese white long) -	30.4			
pea (vegetable pod Arkel) -	13.3			
French bean (vegetable pod)	9.3			
VL Bauni 1				

[a] Number of cobs.

Announcements

New IRRI publications

The following new publications are available for purchase from the Communication and Publications Department, Division R, IRRI P. O. Box 933, Manila, Philippines:

- Research highlights for 1983
- Statistical procedures for agricultural research, 2d ed., by K. A. Gomez and A. A. Gomez
- CHEMRAWN II, perspectives and recommendations

Chang lectures on crop germplasm resources

T. T. Chang, geneticist and head of the IRRI International Rice Germplasm Center, was principal speaker for the 1984 Plant Science Lecture Series at Iowa State University, Ames, Iowa, USA. Theme of the series was Plant Genetic Resources – Key to Future Food Supplies. Chang's visit was sponsored by the Iowa State University Weseman Distinguished Foreign Scientist Award. □

ERRATUM

Xue-Bin Xu (Hsae-Pin Hsu), Li-Qing He, Hui-zhen Han, and B. S. Vergara. Preparation of *Oryza* pollen grains for scanning electron microscope analysis. 9(1) (Feb 1984), 3-4.

Replace the last paragrah on page 3, column 3, with the following:

A3. Samples were fixed in 4% glutaraldehyde for 16 hours (0-4°C), washed with phosphate buffer 1 or 2 times, and stored in the same solution; and

A4. Pollen grains were placed in vials and kept in the refrigerator. □

The International Rice Research Institute
P.O. Box 933, Manila, Philippines

ISSN 0115–0944