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Contents

Guidelines and Style for IRRN Contributors

To improve communication and to speed the editorial process, the editors of 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 unit 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 be 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 time 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 rice or on cropping patterns involving rice.
- Appropriate statistical analyses are required for 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

Tamil Nadu Agricultural University (TNAU) releases a brown planthopper (BPH)-resistant variety

TNAU in Coimbatore, India, has released Py3, a BPH-resistant rice, through Krishi Vigyan Kendra, Pondicherry. The variety, called *Bharathithasan,* is the IRRI culture IR13427-4-2,which inherits its resistance primarily from PTB33.

Py3 is resistant to BPH and white-backed planthopper, matures in 115-120 d, and has medium, slender, white grains. Its eating quality is good. The variety is gaining popularity among farmers particularly in BPH-endemic areas, and is suitable for the Jun-planted crop in Tamil Nadu and Pondicherry.

Py3 was selected from breeding lines introduced from IRRI and evaluated by a team of scientists led by Dr. S. Chelliah, Professor of Entomology, TNAU. ☐

Co 43, a salt-tolerant variety for Tamil Nadu

S. Subramanian, K. M. Balasubramanian, T. B. Ranganathan, V. Sivasubramanian, and J. Chandramohan, School of Genetics, Tamil Nadu Agricultural University (TNAU), Coimbatore 3, India

TNAU17005, a semidwarf, lodging-resistant rice with fine white grains and high yield potential, was released as Co 43 for general cultivation in Tamil Nadu in 1983. It performed well at the Paddy Breeding Station, TNAU, during navarai (Jan–May) and samba (Aug–Nov). From 1975 to 1981 at TNAU, it yielded an average 6.3 t/ha, 21.5% higher than IR20 (see table). Under saline-alkaline-water-logged conditions at Kaveripattinam, Barur, Paiyur, and Coimbatore (pH: 8.1 to 9.8 and EC: 0.3 to 1.3 dS/m), it yielded an average of 5.3 t/ha, or 56.6% higher than IR20. Co 43 also performed well at Machilipattam, Andhra Pradesh, with soil pH 8.2 and EC 9.9 dS/m and in International Rice Testing Program nursery trials.

The grain quality is good for raw and boiled rice. Co 43 is tolerant of green leafhopper and moderately resistant to blast, brown spot, and leaf blight. It can be grown in all seasons in Tamil Nadu. ☐

Yield performance of Co 43 in Tamil Nadu.

Year	Site	Trials (no.)	Av yield (t/ha)	Av % increase over IR20
1975–81	Paddy Breeding Station, Coimbatore	19	6.3	21.5
1978–80	Research stations	16	4.8	23.7
1981–82	Adaptive research trials in Tamil Nadu	43	3.4	19.5
1978	Saline-alkaline-waterlogged conditions	6	5.3	56.6

Disease resistance

Varietal resistance to stem rot (SR) and bacterial blight (BB)

H. Chand, R. Singh, and D. V. S. Panwar, Haryana Agricultural University Rice Research Station (HAURRS), Kaul, Haryana, India

SR, caused by *Sclerotium oryzae,* and BB, caused by *Xanthomonas campestris* pv. *oryzae,* are major rice diseases in Haryana. We evaluated 177 early- to mid-duration rices for their reaction to those diseases at HAURRS in 1983-84.

Each entry was planted in 2-m rows at 20- × 15-cm spacing. Plants were clip inoculated with a BB suspension at maximum tillering and scored for resistance using the Standard Evaluation System for Rice. SR screening was in field plots and also in the laboratory. In the laboratory, cut stem pieces were wound-inoculated with a small piece of agar-cultured *S. oryzae.* The inoculated stems were kept in standing position with a test tube rack in a tray with 2.5 cm of water. They were covered with plastic bags to retain high moisture and incubated at 28-30°C. Lesion length was measured 10 d after inoculation. Entries with lesions less than 10 mm long were considered resistant; those with 10-30 mm lesions, moderately resistant; and those with more than 30 mm, susceptible.

Disease pressure was high for SR (location severity index [LSI] 6.79 in the field and 6.05 in the laboratory), and moderate (LSI 3.12) for BB. Of the entries tested, 125 showed resistance to BB, 19 to field SR, and 44 to laboratory SR. Six entries were resistant to both BB and SR (see table) and had good agronomic traits. □

Rices with SR and BB resistance, Haryana, India.

Entry	Parentage	Reaction[a] to SR Field	Reaction[a] to SR Laboratory	Reaction[a] to BB
HAU118-87	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	R	R	R
HAU118-110	Nam Sagui 19/1R4215-301-2-2-6// IR5853-162-1-2-3	R	R	R
HAU118-111	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	R	R	R
BR51-282-8	IR20/IR5-114-3-1	R	R	R
IR42	IR1561-228//4*IR24/*O. nivara*///CR 94-13	R	R	R
IR2588-34-5-6	IR1544-238-2-3/IR1529-680-3	R	R	R
IR2681-90-4	CR94///IR20[3]/*O. nivara*//IR1541-102-6	R	R	MR
HAU118-163	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	MR	MR	R
HAU118-195	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	MR	MR	R
HAU118-752	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	MR	MR	R
HAU118-754	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	MR	MR	R
HAU118-755	Nam Sagui 19/IR4215-301-2-2-6// IR5853-162-1-2-3	MR	MR	R
IR54	Nam Sagui 19/IR2071-88// IR2061-214-3-6-20	MR	MR	R

[a]R = resistant, MR = moderately resistant.

Evaluation of hill rice germplasm for leaf blast (Bl) resistance

J. C. Bhatt and V. S. Chauhan, Vivekananda Laboratory for Hill Agriculture (VLHA), Almora 263601 India

Bl is a serious constraint to rice production in hilly regions. We evaluated 1,271 cultivars from the hill area of Uttar Pradesh for Bl resistance under artificial epiphytotic conditions at the VLHA experimental farm at Hawalbagh (1,250 mean sea level).

Cultivars were planted in the Uniform Blast Nursery pattern. VL8 was the resistant check and Ch 1039 and HR12 were the susceptible checks. Although the initial inoculum was sufficient to start infection, for heavy disease pressure we prepared a fresh conidial suspension from infected leaves and sprayed it on 15-d-old seedlings. The nursery was planted on 3 Jul 1982 and B1 incidence was recorded 30, 40, and 57 d after sowing (DAS). In

Reaction of 1,271 cultivars to B1 at 30, 40, and 57 DAS, Almora, India.

SES score	30 DAS Cultivar nos.	30 DAS Infection (%)	40 DAS Cultivar nos.	40 DAS Infection (%)	57 DAS Cultivar nos.	57 DAS Infection (%)
0	20	1.6	1	0.1	0	0
1	33	2.6	0	0.0	0	0
2	101	7.9	8	0.6	0	0
3	430	41.7	27	2.1	0	0
4	587	46.2	633	49.8	17	1.3
5	0	–	573	45.1	132	10.4
6	0	–	28	2.2	309	24.3
7	0	–	1	0.1	583	45.9
8	0	–	0	–	184	14.5
9	0	–	0	–	46	3.6

Aug, when disease incidence was recorded, weather favored B1. Average weekly maximum and minimum temperatures were 28.1 and 18.6°C and average relative humidity was 78%. There were 21 rainy days during the month, and intermittent drizzle and cloud cover encouraged disease development. B1 incidence was rated using the Standard Evaluation System for Rice (SES) 0-9 scale (see table).

At 30 d, 53.79% of the cultivars were resistant; at 40 d only 2.81% were resistant. At 57 d only the resistant check VL8 scored resistant. However, 17 cultivars had some resistance and displayed slow blasting. They were VHC85, VHC218, VHC976, VHC1080, VHC1098, VHC1296, VHC1404, VHC1487, VHC1488, VHC1493, VHC1494, VHC1508, VHC1583, VHC1759, VHC1760, VHC1761, and VHCl824. These have potential as commercial varieties and for breeding programs to incorporate B1 resistance into improved varieties. □

Negative selection in breeding for quantitative resistance to rice blast (Bl) under upland nursery conditions

S. W. Ahn, E. Tulande, and M. Rubiano, Rice Program, Centro Internacional de Agricultura Tropical, Colombia

In 1983 we evaluated 149 F_4 rice lines for reaction to B1 under upland nursery conditions in Colombia. The entries were derived from crosses between CICA4 (low resistance), IRl1-452-1-1 (intermediate resistance), and Tapuripa and Camponi (high resistance). Evaluations were made using the relative evaluation system for B1 and by measuring panicle B1 severity based on disease incidence and intensity.

In the nursery, 70% of the lines with low quantitative B1 resistance in earlier generations had the same reaction in F_5 (see table). However, the reactions of more than 60% of the lines with high or intermediate resistance and the no-infection type differed from those in previous generations.

Field evaluation of a limited number of lines showed that more than 60% of the intermediate-resistance and no-infection types reacted differently from the previous generations; however, more than 65% of those with high and low resistance gave the same reaction.

A highly susceptible reaction is a reliable indication that a low level of quantitative resistance, compatible races, and a favorable microclimate were all present. But reactions of high and intermediate quantitative resistance, or no-infection type plants alone cannot exclude possible cryptic errors, such as lack of compatible races, insufficient inoculum, or unfavorable microclimate during disease development, particularly in the field.

The results strongly suggest that to attain higher levels of quantitative resistance, which presumably will be more stable, vigorous negative selection made throughout all generations is preferable to positive selection — selection only for plants with less disease. Proper plot design and management are also important to provide a favorable disease environment. Use of diversified inoculum will reduce the masking effect of qualitative resistance on quantitative resistance. □

Change of quantitative resistance to rice blast, Colombia. [a]

Resistance in F_2, F_3, and F_4	Frequency (%) in F_5									
	Nursery [b]					Field [c]				
	Total no.	N	N	I	L	Total no.	N	H	I	L
H	28	46	32	18	4	6	17	66	0	17
I	38	10	21	37	32	9	0	22	33	44
L	49	6	8	16	70	19	0	0	5	95
N	34	32	9	26	33	12	33	33	17	17

[a] H = high, I = intermediate, L = low, N = no infection. Underlined values indicate % of lines that exhibit the same reaction as in previous generations. [b] Blast nursery at CIAT, Palmira, Colombia. [c] Santa Rosa Station, Villavicencio, Colombia.

Inheritance of moderate resistance to blast (Bl) in rice

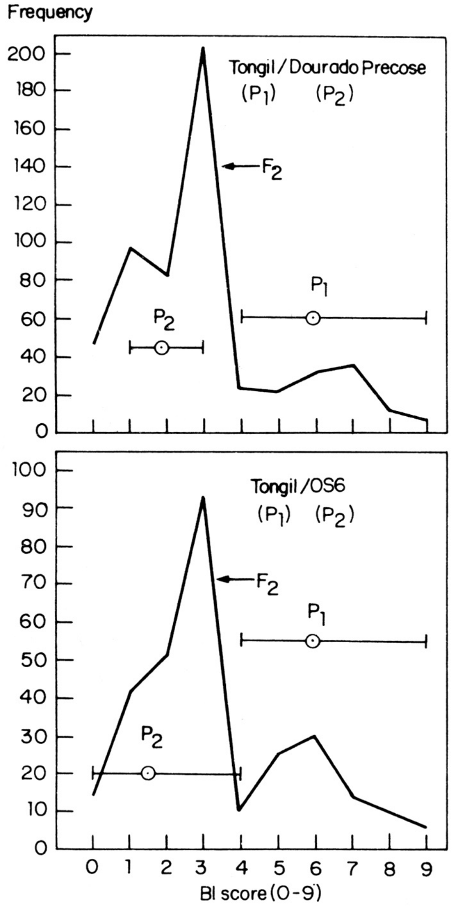
H. S. Suh, College of Agriculture and Animal Science, Yeungnam University, Gyeongsan, 632, Korea; F. L. Nuque and J. M. Bonman, Plant Pathology Department; and G. S. Khush, Plant Breeding Department, IRRI

We crossed the upland rice cultivars Dourado Precose from Brazil and OS6 from Nigeria, both with moderate resistance to B1 race IH-1 (isolate 43), with susceptible Tongil and highly resistant Milyang 54. The F_2 plants of the crosses and their parents were screened with the race IH-1. B1 reaction was scored 0 to 9 using the 1980 Standard Evaluation System for Rice.

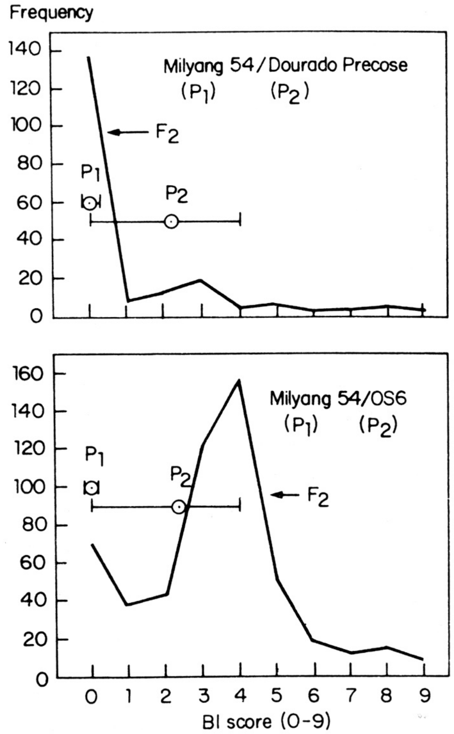
The reaction of the F_2 seedlings of the crosses Tongil/Dourado Precose and Tongil/OS6 are shown in Figure 1. The score of Dourado Precose was 1-3; that of OS6 was 0 to 4; and that of Tongil was 4 to 9. Both F_2 populations had reaction scores from 0 to 9, with an almost bimodal distribution. Those results indicated that their moderate B1 resistance is monogenic.

If we divide the F_2 segregants into two groups (resistant-moderately resistant and susceptible), based on the infection range of the parents, the segregation pattern is 3:1. However, the peaks of the distribution curves for the resistant and moderately resistant groups did not fit the average of the moderately resistant parents.

When the F_2 populations of the crosses of Dourado Precose or OS6 and Milyang 54 were screened with the same race, the distribution curves were also abnormal (Fig. 2). Milyang 54 scored 0, but the score of Dourado Precose or OS6



1. Frequency distribution of Bl scores to race IH-1 in the F_2 of crosses between susceptible Tongil and moderately resistant Dourado Precose and OS6. IRRI, 1984.



2. Frequency distribution of Bl score to race IH-1 in the F_2 of the crosses between the highly resistant Milyang 54 and moderately resistant Dourado Precose and OS6. IRRI, 1984.

varied from 0 to 4. Most of the F_2 plants of Milyang 54/Dourado Precose were highly resistant. The reaction scores of most of the F_2 plants of Milyang 54/OS6 ranged from 2 to 6. However, some highly susceptible segregants were observed for both.

We concluded that the moderate resistance to B1 race IH-1 in Dourado Precose and OS6 is conveyed by major genes with some modifiers. □

Sheath rot (ShR) in Chhatisgarh, Madhya Pradesh, India

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

ShR was first observed in Chhatisgarh in 1978 kharif. Disease incidence has increased, and has significantly reduced yields in some areas. In 1980-82, we field tested several important, commercially grown rice varieties for ShR resistance, based on the Standard Evaluation System for Rice (SES) 0-9 scale. Observations were recorded at late tillering to dough stage (see table).

Kranti, Phalguna, Surekha, Pragati, Jaya, Bangoli, and Ratna were infected most severely, particularly in 1981 kharif (20°-30°C temperatures, 65-80% relative humidity). There were many cloudy days during booting. In Phalguna and Kranti, 5-10% of the panicles did not emerge and extensive rotting of the sheaths enclosing the panicles caused significant yield losses. However, Asha, Usha, Safri 17, Dubraj, and Madhuri had some resistance (see table).

The ShR pathogen *Sarocladium oryzae* also causes glume discoloration alone or in combination with other fungi. Highly ShR-susceptible varieties such as Kranti and Phalguna were equally prone to grain discoloration. □

ShR incidence and glume discoloration (GlD) in Chhatisgarh, India.

Variety	Disease incidence score[a] during					
	1980		1981		1982	
	ShR	GlD	ShR	GlD	ShR	GlD
Safri	0	0	3	1	3	1
Kranti	7	1	9	7	7	5
Samridhi	3	1	5	3	3	1
Phalguna	5	1	9	7	5	7
Surekha	3	1	7	5	5	3
Pragati	7	3	–	–	5	3
Jaya	3	1	7	5	5	3
Bangoli	–	–	7	3	5	3
Asha	–	–	0	0	3	1
Usha	0	0	0	0	0	0
Ratna	5	1	7	5	5	3
Garima	–	–	–	–	3	1
Madhuri	–	–	3	1	3	1
Dubraj	–	–	0	0	0	1

[a] Based on 1980 SES scale.

GENETIC EVALUATION AND UTILIZATION

Insect resistance

Varietal reaction to rice panicle bug

R. Saroja and N. Raju, Paddy Experiment Station, Tirur 602025, Tamil Nadu, India

In 1982-83 kharif, we screened 37 entries from the Rice Coordinated Yield Trials for field reaction to rice bug *Leptocorisa acuta.* The trial was in a randomized block design with three replications. Twenty-five-d-old seedlings were planted in 20-m^2 plots at 20- × 10-cm spacing. Recommended agronomic practices were followed, but no insecticide was applied. Insect population was recorded in a 1-m^2 area at 4 sites in each plot early in the morning 70 d after planting. Resistance was scored using the 1980 Standard Evaluation System for Rice (SES).

IET5860, IRTP08506, IET5878, Pusa 312, TKM9 (popular variety of Chingleput District), and TNAU18580 were moderately resistant to the bug. The remaining 31 entries were either susceptible or highly susceptible (see table). □

Varietal reaction to rice panicle bug at Tirur, Tamil Nadu, India, 1982.

Variety	Parentage	Duration (d)	Mean no. of bugs/m^2	Resistance score[a]
IET5860	RPA 5824/RPA 79-9 – B	97	2	3
IRTP08506		113	2	3
IET5878	ala late mutant	105	3	3
Pusa 312	Karjat 35/N22	108	3	3
TKM9	TKM7/IR8	108	3	3
TNAU18580	IR20/Vani	107	4	3
TNAU18328/1	Kannagi/Cul2032	110	7	7
ACM3	Bhavani/CO36	107	9	7
TNAU80029	IR20/Balawi/IR2071-625-1-252	110	9	7
ADT36	Triveni/IR20	107	10	9
BPHR3	PTB33/IR3403-267-1-4	107	11	9
ACM2	Kannagi/IR28	110	11	9
IR50	IR2153-14-1-6-2/1R28//IR36	110	11	9
BS26	CO13/IR26	109	12	9
IET5253	Cauvery/W12787	109	12	9
AD18485	Triveni/Annapoorna	107	12	9
AS688	ADT31/Ratna//ASD8/IR8	97	13	9
AD24417	Kannagi/CH41	109	14	9
AS19703	ADT30/ADT16	110	15	9
ACMl	CO 13/IR26	107	15	9
TNAU2099	GEB24/IR30	110	16	9
BPHR10	Ratuhinati/IR3408-267-1-3	109	16	9
DPI962	IR26/TKM6	109	17	9
AD25723	CO 33/IR266/CO33//IET2222	109	18	9
DPI1091/1	IR20/Kannagi	110	19	9
CO 34	TN1/CO 29	109	19	9
IET4786	CR10-114/CR115	100	20	9
BPHR5	IR3403-267/PTB33/IR36	110	21	9
TNAU9426/6	Kannagi/Cul2032	98	23	9
TM8089	TKM9/selection	107	24	9
BS27	CO 13/IR26	107	24	9
AD24155	ADT31/CO40	109	24	9
BS36	CO 13/IR26	109	24	9
CO37	TN1/CO 29	110	27	9
TM8090	TKM9 selection	109	28	9
BS37	1R26/CO 13	109	36	9
DPI1091-5	IR20/Kannagi	110	47	9

[a] By 1980 SES.

Genetics of whitebacked planthopper (WBPH) resistance in IET5741

K. Gunathilagaraj and S. Chelliah, Tamil Nadu Agricultural University, Coimbatore 641003, India

IET5741 was identified as resistant to WBPH during screening of various rice accessions and varieties at the Paddy Breeding Station, Coimbatore. We studied the genetics of resistance of ET5741 by crossing it with IR36, a WBPH-susceptible variety. The F_1 seedlings were resistant to WBPH, indicating the dominant nature of IET5741 resistance (see table). The F_2 population segregated in a 3:1, resistant: susceptible ratio, indicating that the resistance is conditioned by a single dominant gene. The F_3 segregated to 1 resistant: 2 segregating: 1 susceptible, which further confirmed the monogenic nature of IET5741 resistance to WBPH. □

Reaction to WBPH in F_1, F_2, and F_3 progenies of the cross between IET5741 and IR36, Coimbatore, India.

Cross	Reaction[a] to WBPH						
	F_2 seedlings			F_3 families			
	R (no.)	S (no.)	X^2 3:1	R (no.)	Seg (no.)	S (no.)	X^2 1:2:1
IET5741/IR36	171	63	0.4616	44	105	51	0.99

[a] R = resistant, S = susceptible, Seg = segregating.

Resistance of Indonesian mutant lines to the brown planthopper (BPH) *Nilaparvata lugens*

P. S. Mugiono, National Atomic Energy Agency, Jakarta, Indonesia; and E. A. Heinrichs and F. G. Medrano, IRRI

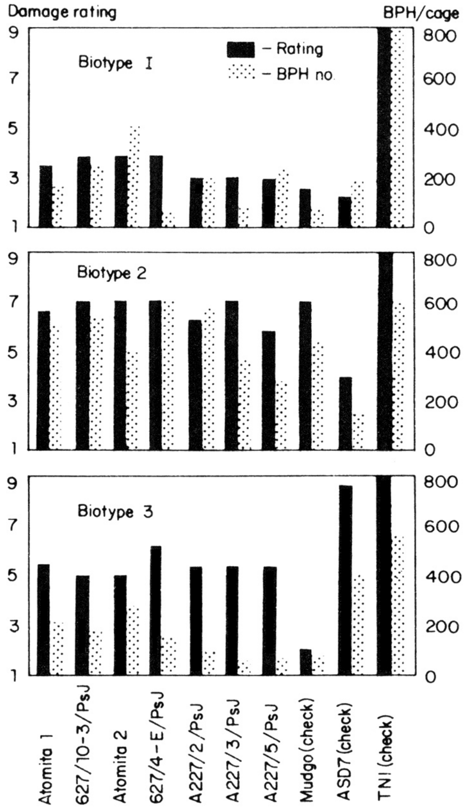
We tested seven mutant rice lines, derived from BPH-susceptible Pelita I/1, for resistance to BPH at IRRI. The lines came from the National Atomic Energy Agency in Jakarta, Indonesia. They were Atomita 1, 627/10-3/PsJ, Atomita 2, and 627/4-E/PsJ, derived from Pelita I/1 irradiated with 0.2 k Gy of gamma rays; and A227/2/PsJ, A227/3/PsJ, and A227/5/PsJ derived from an early-maturing mutant of Pelita I/l irradiated with 0.1 k Gy of gamma rays. We conducted two tests with five replications to measure their level of resistance to BPH: seedbox screening for plant damage, and population growth.

In the seedbox screening test, seeds of entries were planted in seedboxes. Seven days after sowing, they were infested with eight second- and third-instar BPH nymphs/seedling. Plant damage was rated when the susceptible check died.

In the second test, 30-d-old test plant were infested with 5 pair (male and female) of 2- to 3-d-old adult BPH and enclosed with mylar film cages. When their progeny reached adulthood on susceptible TN1 plants, the insects in all the cages were counted.

The Indonesian mutant lines were resistant to moderately resistant to biotype 1 and biotype 3, but susceptible to biotype 2 (see figure). Similar seedbox screening tests showed the mutant lines were moderately resistant to green leafhopper and whitebacked planthopper, as compared with susceptible TN1.

Atomita 2 has been released for commercial cultivation in Indonesia. In addition to its resistance to BPH biotype 1 and biotype 3, it has high yield potential, good eating quality, and salinity tolerance.☐



Resistance of Indonesian mutant lines to BPH. IRRI, 1984.

Individuals, organizations, and media are invited to quote or reprint articles or excerpts from articles in the IRRN.

Varietal resistance of rice to whitebacked planthopper (WBPH)

K. Gunathilagaraj and S. Chelliah, Tamil Nadu Agricultural University, Coimbatore 641003, India

We evaluated 22 rice accessions from 7 countries for resistance to WBPH *Sogatella furcifera* at the Paddy Breeding Station, Coimbatore. Using the seedling screening technique in the glasshouse, 86 accessions had a damage rating of 3 (Table 1). The resistant accessions were reevaluated in three replications.

Seven promising accessions — ARC10550, ARC6650, T7, IET5741, ET6315, IET6123, and ET6311 — were further evaluated using alternate row testing and seedling screening in pots. In all tests, their damage rating was lower than 4, confirming their resistance to WBPH (Table 2). All seven were indicas from India.

Table 1. Source of rice accessions and their reaction to WBPH, Coimbatore, India.

Source	Accessions screened (no.)	Accessions (no.) at each damage rating[a] 1	3	5	7	9
India	181	3	60	52	28	38
Indonesia	1	0	1	0	0	0
Nepal	2	0	2	0	0	0
Pakistan	5	0	3	1	0	1
Philippines	24	5	7	9	3	0
Sri Lanka	8	1	4	1	1	1
Taiwan	1	0	0	0	0	1
Total	222	9	77	63	32	41

[a]By the 1980 Standard Evaluation System for Rice scale.

Table 2. WBPH resistance in 7 rice accessions, Coimbatore, India.[a]

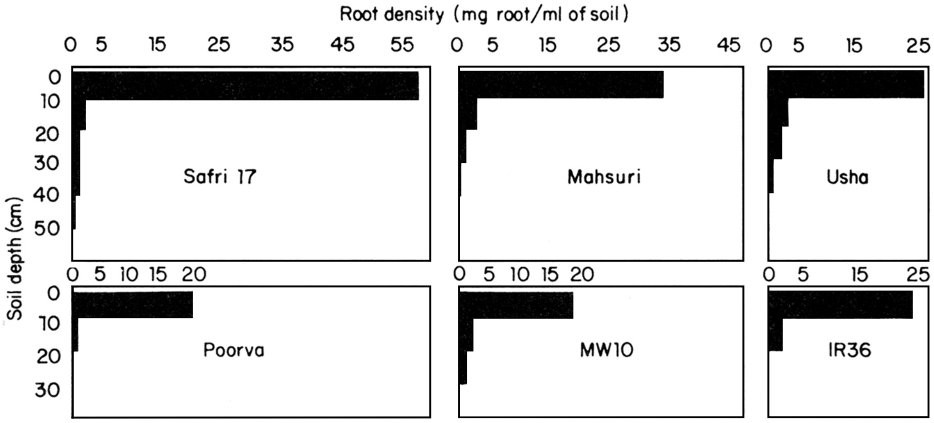
Accession	Damage rating (1-9 scale) Seedling screening technique[b]	Seedling screening in pots[c]	Alternate row test[d]
ARC10550	1.67 a	1.67 a	1.80 a
ARC6650	2.33 ab	2.67 b	2.60 ab
T7	3.00 ab	3.33 b	3.00 b
IET5741	3.00 ab	3.33 b	3.40 b
IET6315	3.00 ab	3.00 b	3.40 b
IET6123	3.00 ab	3.67 b	3.00 b
IET6311	3.67 b	3.67 b	3.40 b
TN1 (susceptible check)	9.00 c	9.00 c	9.00 c

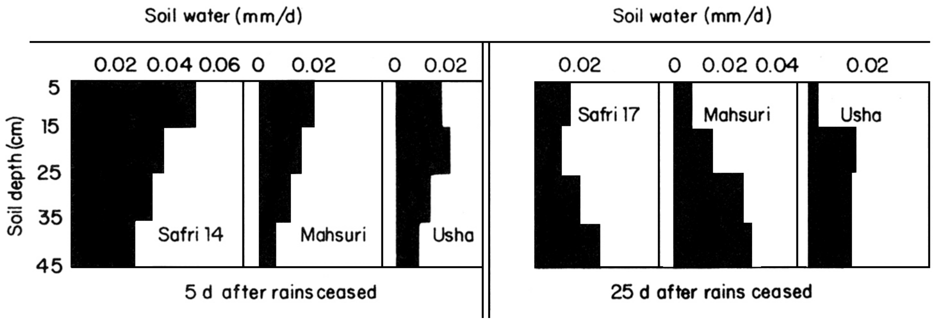
[a]In a column, means with a common letter do not differ significantly (P = 0.05). [b]Mean of 3 replications. [c]Mean of 6 replications. [d]Mean of 5 replications.

Drought resistance

Root growth and water extraction pattern of six rices in rainfed conditions

I. K. Jaggi and D. C. Bisen, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Zonal Agricultural Research Station, Raipur, India





2. Water extraction pattern of 3 rice varieties, Raipur, India.

In 1983 kharif we studied root growth and water extraction pattern of six rices grown in upland rainfed fields. Vertical rooting distributions of the varieties differed (Fig. 1).

Safri 17 had the highest root density (57 mg/cm^3) in the top 10 cm of soil, and MW10 had the lowest (19 mg/cm^3). Mahsuri, Usha, IR36, and Poorva were similar with intermediate density. Eighty-nine to 94% of roots were in the top 10 cm of soil, 4 to 9% were in the 10 to 20 cm layer, and the rest were 20 to 50 cm deep.

Figure 2 shows the water absorption patterns from flowering to maturity for Safri 17, Mahsuri, and Usha. The other varieties matured before rains ceased, preventing the study of their water extraction patterns.

Varietal differences in water extraction paralleled those of root growth. Root density in the 0 to 10 cm layer was highest for Safri 17, as was water extraction, which increased gradually with increasing depth to 45 cm – lowest depth measurement.

Five days after rains ceased, water extraction from the 5 to 45 cm soil layer was 1.6 mm/d for Safri 17, 0.8 for Mahsuri, and 0.8 for Usha. During the next 20 d, water extraction from the 5 to 15 cm layer diminished considerably, and extraction from 35 to 45 cm increased markedly.

A comparison of water extraction pattern (Fig. 2) and rooting pattern (Fig. 1) suggests that rooting density might not have been the sole determinant of water uptake. Soil water factors (soil water pressure and potential, and hydraulic conductivity) must also be considered. Five days after rains ceased, soil water factors favored water uptake from the surface layers. Twenty days later, when surface soil had dried, the crops extracted water from the deeper, wetter layers. Figure 2 shows that rice varieties differ in their ability to extract water from the deeper layers. Those differences can be exploited by choosing appropriate varieties for drought-prone upland environments. □

Deep water

Germination of seed from deep water varieties grown in deep water and field conditions

S. K. Datta and S. K. De, Operational Research Project, Pandua, West Bengal, India

Photoperiod-sensitive floating rices Jaladhi 1 and Jaladhi 2 were grown in deep water and normal field conditions at the Rice Research Station, Chinsurah, West Bengal. Weekly water level variations in two plots are in Figure 1.

The seeds were direct-seeded in wet soil (37-41% soil moisture) in late May. At harvest (Dec), the field had 25-30% soil moisture and the deep water plot had about 40 cm water. Seeds were thoroughly dried, cleaned, and stored in cloth bags.

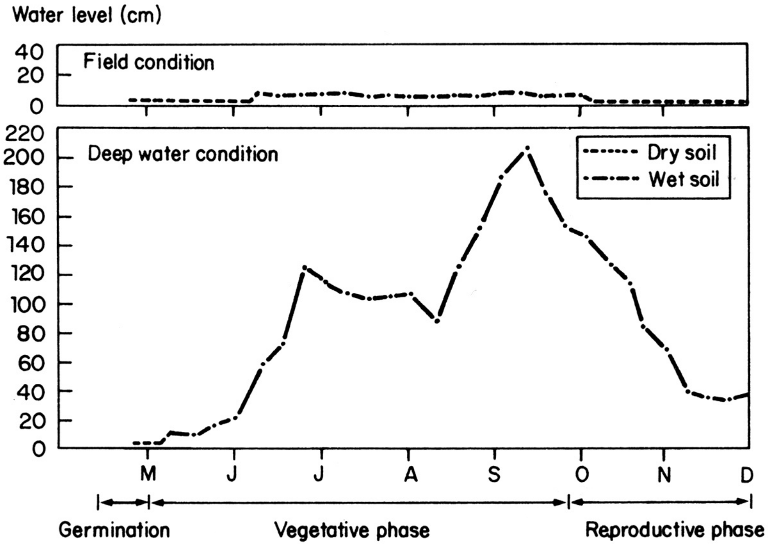
Seed viability was monitored for 12 mo. The average germination percentage from two replications is in Figure 2.

Seeds had varying dormancies. Those from shallow water plots generally had poorer viability retention than those from deep water plots (Fig. 2). But, irrespective of variety, germination up to 4 mo. after harvest was slightly higher for seeds from the shallow water plot. Viability of seeds from such fields was highest in Apr, then abruptly decreased.

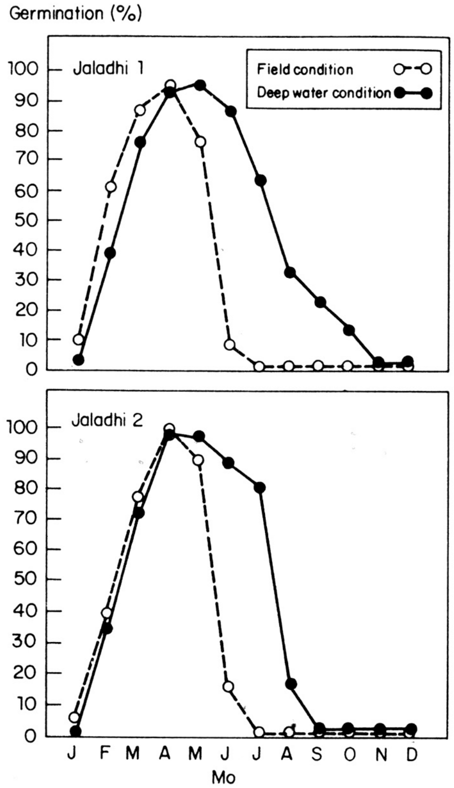
Seeds from the deep water plot maintained proper viability until Jul, after which viability decreased. They retained more than 80% germination ability beyond 7 mo. No remarkable varietal difference in germination was recorded for seeds from either water regime.

In shallow water, many seeds of both varieties were underdeveloped, with high grain sterility and low grain filling. This may have been caused by lodging and drought at the grain ripening stage. Abnormal grain formation probably reduced nutrient supply to the grain, which may have reduced seed viability. Drought and lodging normally do not occur at grain filling under deep water conditions.

The viability of rice seeds generally is controlled by genetic and environmental conditions. Our research emphasizes that, if high seed viability is to be maintained, multiplication of deep water rice seed should be done in native deep water environmental conditions rather than in lowland field conditions. □



1. Duration of crop growth phases and weekly variations in water level of 2 field conditions, Rice Research Station, Chinsurah, India.



2. Monthly changes in germination of seeds of 2 floating rice varieties from deep water and normal fields. Chinsurah, India.

Pest control and management DISEASES

Siratro, a new alternate host of *Thanatephorus cucumeris*

P. Lakshmanan and N. T. Jagannathan, Tamil Nadu Agricultural University Research Centre, Vellore 632001, Tamil Nadu, India

Sheath blight (ShB) of rice caused by *Rhizoctonia solani* Kuhn, imperfect state of *Thanatephorus cucumeris* (Frank) Donk, has been a minor disease in Tamil Nadu. In Nov–Dec 1983, however, siratro *Macroptilium atropurpureum,* a fodder crop grown after rice, was completely defoliated. Dark brown sclerotia were abundant on the dried leaves.

Infected plants were collected to isolate the causal organism. The fungus was identified as *R. solani.* The pathogenicity of the fungus was confirmed by artificial inoculation using mycelial bits from a culture or sclerotia collected from infected leaves of siratro. The first symptoms were 10 × 6 mm greenish grey, ellipsoidal spots on the leaves. Artificial inoculation on rice seedlings produced typical ShB symptoms in 7 d.

We compared the organism isolated from naturally infected rice seedlings with that from siratro. The morphological characters were similar and the relationship was further confirmed by the two isolates' ability to anastomose.

The isolated organism was cross-inoculated on potted rice seedlings and siratro plants. In 5-7 d, both plants developed symptoms similar to those observed in the fields.

Our information indicates the potential of siratro as source of ShB inoculum. Feeding infected fodder to cattle will also disseminate the pathogen through cow dung. □

Greenhouse evaluation of synthetic pyrethroids for tungro (RTV) control

G. Bhaktavatsalam, scientist S-1; and A. Anjaneyulu, virologist, Plant Pathology Division, Central Rice Research Institute, Cuttack 753006, India

We tested several synthetic pyrethroids (see table) for their ability to prevent RTV. Cypermethrin 1 and cypermethrin 2 at 0.05% concentration, and deltamethrin at 0.01% effectively prevented RTV infection (see table). With deltamethrin, even 0.005% was effective. All the insecticides tested caused 100% vector mortality 1 d after treatment (DAT). Cypermethrin 1, cypermethrin 2, and deltamethrin caused 100% vector mortality at both dilutions at 5 DAT.

Studies on the mechanism of prevention of infection by these insecticides are in progress. Preliminary results with cypermethrin indicate that it has powerful fumigant and repellent actions, in addition to contact toxicity.☐

Effect of synthetic pyrethroids on RTV prevention and vector *Nephotettix virescens* **mortality. Cuttack, India.**

Insecticide	Concentration (%)	% prevention[a] of infection		Vector mortality (%)[b]	
		1 DAT	5 DAT	1 DAT	5 DAT
Deltamethrin	0.005	93 c	62 c	100	100
	0.01	100 d	100 d	100	100
Fenvalerate	0.01	46 a	38 b	100	55
	0.05	95 c	91 d	100	100
FMC54800	0.01	49 a	11 a	100	45
	0.05	93 c	38 b	100	85
Cypermethrin 1	0.01	85 bc	56 bc	100	100
	0.05	100 d	100 d	100	100
Cypermethrin 2	0.01	71 d	47 bc	100	100
	0.05	100 d	100 d	100	100

[a] $\% \text{ prevention} = \frac{\% \text{ infected plants in control} - \% \text{ infected plants in treatment}}{\% \text{ infected plants in control}} \times 100.$ Values followed by the same letter do not differ significantly at P = 0.05. [b] Values adjusted with Abbott's formula.

The relative evaluation system - a quantitative technique for disease assessment of rice breeding materials in the field

S. W. Ahn, M. Rubiano, and G. Borrero, Centro Internacional de Agricultura Tropical, Colombia

Many resistance mechanisms of rice plants against various diseases are manifested not only in a qualitative way (absence of visible symptoms) but also in a quantitative manner (less amount of disease at a given time). Quantification of disease is complicated, laborious, and highly variable, particularly when a large number of breeding materials must be evaluated in the field. The *relative evaluation system* (RES) was developed to overcome those shortcomings.

RES recognizes that human eyesight is relatively good at comparison (equal to, less than, or more than) but poor in quantification, even with the help of pictorial guides. Each grade on the RES scale (Table 1) is based on the relative amount of disease instead of a predetermined disease level. The procedure (Table 2) is simple and can be easily followed by inexperienced observers. The key is to form and retain a mental image of disease intensity for grade 5 and for the standard entry. For better use of the system, a set of reference entries, which consist of several known materials with different ranges of quantitative resistance to particular disease, should be included. Use of an extremely susceptible cultivar for comparison should, however, be avoided.

RES can be used in assessing several foliar diseases of rice plants, including slow blasting, and panicle diseases such as grain discoloration or panicle B1 if the flowering period of test materials is synchronized. RES is particularly suitable for breeders because their main interest is not the absolute amount of damage but the relative performance of plants or lines as compared to reference materials or local checks.☐

Table 1. Scale for the Relative Evaluation System.

Grade	Description
0	Careful observation of a plant or plot reveals no lesions or infected plants.
1	Rapid observation does not detect lesions or infected plants, but careful observation detects a few lesions or infected plants.
3	Rapid observation easily detects a few lesions or infected plants.
5	Disease level is between grade 3 and 7. Distribution of lesions or infected plants is fairly uniform.
7	Disease level is clearly less than that of the standard entry.
9	Disease level is similar to that of the standard entry.

Table 2. Procedure for the Relative Evaluation System.

Step	Procedure
1	Carefully observe all the entries. If there are several entries showing disease levels higher than grade 3, proceed to step 2.
2	Select one entry with a higher level of disease at the time of evaluation, and assign grade 9. This entry is called the standard entry at the time of evaluation. This may vary from evaluation to evaluation.
3	Form a mental image of the standard entry, which serves as a guide for grade 9.
4	Evaluate individual entries comparing the relative level of disease with those of adjacent entries. Intergrades 2, 4, 6, and 8 can be used when necessary.
5	For actual quantification of disease, evaluate 4 or 5 randomly selected entries for each grade using a pictorial guide or any available method to compute the value for each grade using either arithmetic average or regression.
6	Transform all the grades into quantitative terms for further analysis.

Rice blast (Bl) pathogen *Pyricularia oryzae* Cav. in Tamil Nadu, India

V. Mariappan, associate professor of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore 3, India

B1 was a major problem in Tamil Nadu until resistant rice varieties were introduced in the 1960s. Even B1 incidence in susceptible varieties was low until 1980. Since 1980, B1 incidence has increased for all varieties and has become a serious constraint to rice production.

P. oryzae, the causal fungus, was isolated from the infected leaves and inoculated on the international differentials and other varieties to assess their reaction (see table). The isolate of *P. oryzae* did not infect Raminad Str. 3, NP125, Usen, and Dular, which are indicators of the IA, IC, ID, and IE international race groups. Earlier reports had indicated that the *P. oryzae* isolates in Tamil Nadu belong to the race groups IA, IC, ID, and IF, which infect Raminad Str. 3, NP125, Usen, and Kanto 51.

Our observations indicate some changes in the pathogen population, based on the susceptible reaction of Dular and the other varieties which were considered field resistant. □

Reaction of international differentials or varieties to the *P. oryzae* isolate of Tamil Nadu, India. [a]

Differential cultivars and varieties	Indicator	Type of reaction
Raminad	IA	Lesions, B type
Zenith	IB	No reaction
NP 125	IC	Lesions, D type
Usen	ID	Lesions, C type
Dular	IE	Lesions, D type
Kanto 51	IF	No reaction
CI 8970	IG	Not tested
Caloro	IH	No reaction
CI 5309		Flecks, A type
Fukunishiki		Lesions, D type
Aichi-Asahi		No reaction
Ishikari Shiroke		Lesions, C type
Chokoto		No reaction
Tsuyuake		No reaction
Taichung (TCWC)		Flecks, A type
Wagwag		Lesions, C type
Sha-tiao-tsao		No reaction
Khao-tah-haeng 17		Flecks, A type
CI 8985 Lacrosse		No reaction
Peta		No reaction
Pai-kan-tao		No reaction
Pi No. 4		No reaction
Yashiromochi		No reaction
Co 25 (xx)		Flecks, A type
Kataktara D42		Lesions, D type
CI 5309		Lesions, D type
IR5 0		Lesions, D type
Annapoorna		Flecks, A type
Akashi		Lesions, C type
Rasi (x)		No reaction
Co 41		Lesions, B type
Co 39		Lesions, B type
IR36		No reaction
IR28		No reaction
Co 29		No reaction
ADT31		No reaction
Ponmani (x)		Lesions, B type
TKM9		Lesions, D type
Co 43 (x)		No reaction
PY 1		Flecks, A type
MDU 1		Lesions, B type
Bhavani		No reaction
ASD15		Lesions, D type
Co 44		Lesions, C type
ADT36 (x)		Lesions, B type
ADT35 (x)		Lesions, B type
Co 42		Lesions, B type
TKM6		No reaction
Co 36		Lesions, D type
IR20		Flecks, A type
IR22		Lesions, B type
IR34		No reaction
IR54		No reaction
Jaya		Lesions, D type
Paiyur 1		Lesions, B type
Ponni		Lesions, B type
ACK 1		Lesions, D type
ACM 2		Lesions, C type
ACM 3		No reaction
TI 1334		No reaction
AS688		No reaction
AC19789		Lesions, B type
TP1974		No reaction
Py 2		No reaction
Vaigai (x)		Lesions, B type
Pennai		Lesions, D type
Kaveri		Lesions, D type
Co 33		Lesions, B type
Kannagi		Lesions, D type
Kanchi		Lesions, B type

[a] A = flecks, B = reddish brown spot, C circular spots (1 mm) with a central white speck, D = spindle lesions (2 mm). (x) = field resistant, (xx) = resistant.

Methods and timing of fungicide application to control rice blast (Bl) under favorable upland conditions in Colombia

S. W. Ahn and M. Rubiano, Rice Program, Centro Internacional de Agricultura Tropical, Colombia

Timing of foliar fungicide application to control B1 is based mainly on growth stage or a chronological schedule. However, timing can be flexible if it is based on actual disease development at a given growth stage as influenced by weather, particularly rain in the tropics.

Under favorable upland conditions in Colombia, most of the foliar fungicide applications can be replaced with seed treatment. Furthermore, field observations indicate that additional application

Effects of method and timing of fungicide application on B1 severity and yield of CICA4, Santa Rosa, Villavicencio, Colombia. [a]

Applications (no.)	Treatment [b]		B1 severity (%)		Yield (t/ha)
	For leaf B1	For panicle B1	Leaf	Panicle	
3-4	1. Seed treatment 2. Foliar application for more than 5% infection before maximum tillering	3. Booting stage 4. 50% panicle emergence	9.7 b	3.3 b	4.1 a
4	1. Initial symptom	3. Booting stage	14.3 b	5.7 b	4 a
	2. Maximum tillering	4. 50% panicle emergence	3.7 c	2 b	4.2 a
6	1. 30 d after sowing (DAS) 2. 40 DAS 3. 50 DAS 4. 60 DAS	5. 80 DAS 6. 60% panicle emergence			
0	No chemical application		51 a	40.7 a	2.4 b

[a] Means of 3 experiments, 3 replications/experiment. In a column, values with common letters are not significantly different at the 5% level. [b] Foliar application (300 g ai/ha) and seed treatment (1.1 g ai/kg of seeds) were made with tricyclazole (WP 75%).

is needed only if severity exceeds 5% diseased leaf area before maximum tillering, in the case of highly susceptible cultivars. This concept was tested under favorable upland conditions using CICA4, a highly susceptible cultivar in Colombia. The experiment was repeated three times at different periods.

Results showed that one application can be eliminated without serious damage or yield loss to rice (see table). Additional application was required only once.

Results from other experiments showed that application at 50% panicle emergence of moderately Bl-resistant cultivars could be eliminated if the average daily precipitation 10-1 5 d after flowering is less than 2 or more than 18 mm. Disease severity data indicated that the optimum average daily precipitation during this critical period is about 10 mm. □

Relationship between susceptibility to leaf blast (Bl) and panicle Bl severity

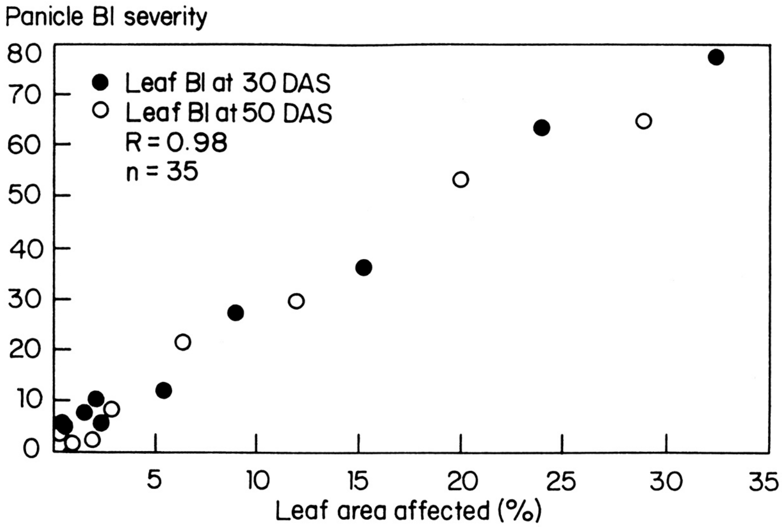
S. W. Ahn and M. Rubiano, Rice Program, Centro Internacional de Agricultura Tropical, Colombia

Differences in leaf B1 and panicle B1 susceptibility in the field may be caused by varying macro- or microclimate conditions during disease development. We studied 15 cultivars with different reactions to leaf and panicle B1 at Villavicencio.

Plantings were staggered to synchronize the evaluation of leaf and panicle B1 and to eliminate the effect of different weather on B1 development. Planting density was higher than normal (200 kg seed/ha) to provide a favorable microclimate for leaf Bl development.

There was a highly positive relationship between leaf Bl infection level and panicle Bl severity (see figure), which shows that cultivars genetically susceptible to a population of certain Bl races are susceptible to both leaf and panicle infection.

The frequently observed difference between leaf and panicle B1 reaction in the field may be due to the changes in micro- or macroclimates during distinct growth phases. Generally, the microclimate influence is greater on leaf B1 development than on panicle B1. Changes in the frequency of races in the population of *Pyricularia oryzae* in a crop season could also influence leaf and panicle reaction. □



Relationship between panicle and leaf B1 severity. Evaluations were made at the same time and place in synchronized plantings. DAS = days after sowing.

Influence of planting time on blast (Bl) incidence

S. Mohan, research associate;
P. Vasudevan, associate professor; and
B. Gururajan, associate professor, Tamil Nadu Agricultural University Research Centre, Vellore 632001, India

Environmental factors influence the epidemiology of B1 caused by *Pyricularia oryzae.* We studied the influence of environment on Bl incidence on IR50, which was recently introduced in North Arcot. IR50 matures early (105 to 110 d) and has high yield potential.

IR50 was transplanted on different dates in 1983 rabi. Total leaves and leaves with spindle-shaped Bl spots were counted from 50 randomly selected hills/field at tillering and percent Bl incidence was calculated (see table). Minimum and maximum temperatures and relative humidity (RH) were recorded when fields were scored.

Highest B1 incidence was in the crop planted in mid-Dec, followed by that planted in early Jan (see table). Bl incidence was lowest in the earliest sown crop perhaps because the temperature was higher and RH lower than with the crops sown later. □

Effect of planting time on Bl incidence, Vellore, India.

Planting date	Diseased leaves (%)	Max temp (°C)	Min temp (°C)	Relative humidity (%)
25 Oct	3	32.2	22.8	87
18 Nov	51	30.6	20.1	84
5 Dec	62	26.9	19.6	96
17 Dec	85	26.9	19.6	96
3 Jan	71	29.1	17.9	92

Effective control of sheath rot (ShR) disease

P. Lakshmanan, Tamil Nadu Agricultural University Research Centre, Vellore 632001, Tamil Nadu, India

ShR, caused by *Sarocladium oryzae* (Saw) Gem., is a serious disease in the North Arcot District of India. We studied the efficacy of different fungicides for ShR control in a field trial using ADT35.

There were seven treatments in a randomized block design with four replications. Fungicides were sprayed 40 and 60 d after transplanting. Disease intensity was measured by selecting 10 hills at random, from which 1 tiller with maximum infection was taken for grading (Table 1).

Table 1. Evaluation scale for ShR damage to rice in Tamil Nadu, India.

Sheath area affected	Grade
Less than 1%	1
1-5%	3
6-25%	5
26-50%	7
More than 50%	9

All treatments significantly reduced disease intensity and significantly increased the yield over the control (Table 2). Tridemorph at 100 ml + carbendazim at 100 g/ha or tridemorph at 200 ml/ha performed best at both application dates. □

Table 2. Efficacy of some fungicides for ShR control, Tamil Nadu, India.

Treatment/ha	Disease intensity (mean)	Mean yield (t/ha)	% yield increase over control	Cost[a] of treatment/ha ($)
Tridemorph (100 ml) + carbendazim (100 g)	0.87	4.6	37.4	11.55
Tridemorph (200 ml)	1.40	4.6	36.8	8.20
Tridemorph (100 ml) + mancozeb (500 g)	2.15	4.5	34.3	10.85
Carbendazim (100 g) + mancozeb (500 g)	2.40	4.3	28.9	14.30
Carbendazim (200 g)	2.97	4.3	27.6	15.00
Mancozeb (1000 g)	4.65	4.1	22.2	14.20
Control	6.80	3.4	–	–
CD (P = 0.05)	0.73	–	–	–

[a]Converted at the rate of $1 = Rs 11.44.

Pest control and management INSECTS

***Elaphropeza*, a new pupal parasite of rice gall midge (GM) in India**

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During a survey of GM *Orseolia oryzae* parasites in Orissa, we found a new pupal parasite. It was identified as *Elaphropeza* sp. (Diptera: Empididae) by Dr. K. G. V. Smith of the British Museum, London. The adult *Elaphropeza* is fragile, red, and 1.5 mm long. Its abdomen is 0.5 mm long, and wings are as long as the body. The parasite occurs infrequently in rice fields and parasitized less than 1% GM pupae in the field in Oct (wet season). In other months, it was not detected. The parasite maggot attacked the GM pupa externally. Pupation took place inside the gall. The maggots occasionally behaved as hyperparasites on pupae of *Platygaster oryzae* (Cameron), a dominant egg-larval parasite of GM in Bhubaneswar. □

Population dynamics of the brown planthopper (BPH) in the Mekong Delta

Nguyen Cong Thuat and Dias vun Thans, Entomology Department, Central Institute of Plant Protection, Hanoi, Vietnam

BPH is the most important rice pest in Vietnam, particularly in the Mekong Delta. BPH outbreaks occurred in 1969, 1971, 1973, and 1974 in almost all provinces in central and southern Vietnam.

Light trap collection data and field observations in Long An (1978-79) and Tien Giang (1977-78) provinces showed that BPH are active almost all year (see figure).

Cropping pattern determines seasonal BPH population in the Mekong Delta. Rainfed and irrigated rice areas significantly differ in seasonal BPH populations

In Long An, a rainfed area, there are two annual crops grown: May-Sep and Oct-Feb. There are 10 to 11 BPH generations from May to Feb. No rice is grown between Feb and Apr.

There are about 25-30 d from 1 generation peak to the next. Two population peaks usually develop each year, one in each crop season. Peak population generally occurs at or after panicle initiation – Jul-Aug and Dec-Jan.

In Tien Giang, an irrigated area, there are three crop seasons with short-duration varieties: summer, May-Aug; autumn, Sep-Dec; and winter, Dec-Apr. There are 11-12 BPH generations/yr with 3 population peaks – Aug, Dec, and Mar.

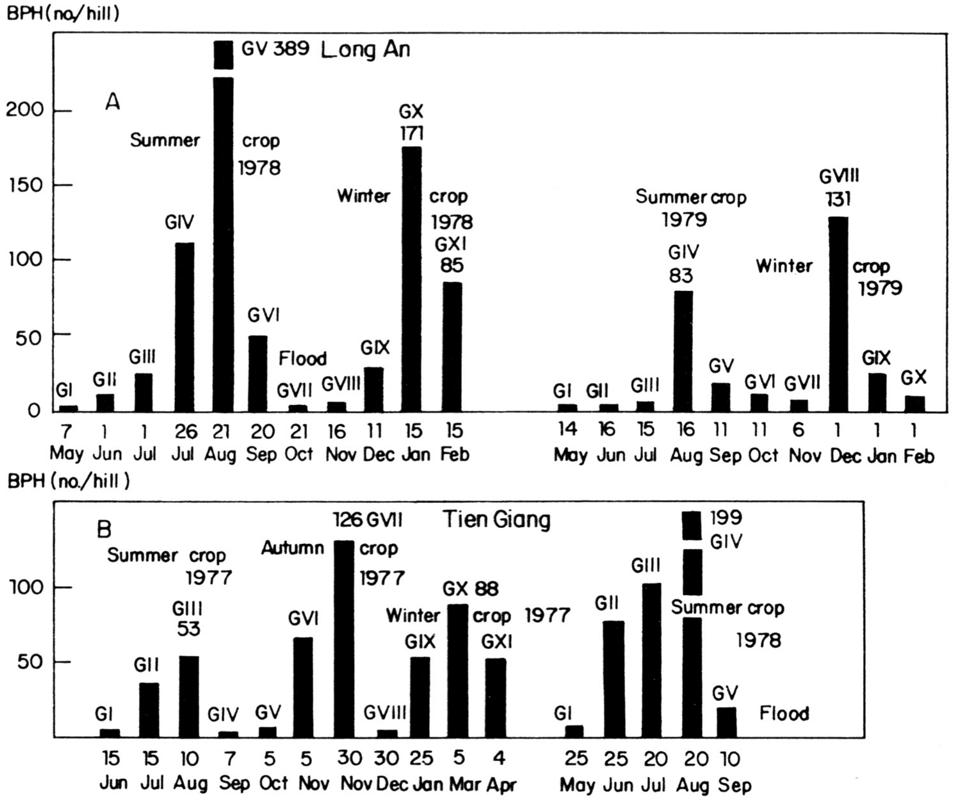
In both areas, light-trap catches of BPH are largest 12-15 d after high nymph populations in the field are observed.

Rainfall and humidity significantly affect BPH populations. Populations are low late in the dry season. Temperature in the Mekong Delta rarely falls below 22°C or exceeds 31°C, and therefore does not limit BPH.

Natural enemies reduced BPH population in fields where no insecticide was applied. Predators such as spiders, *Cyrtorhinus lividipennis* and *Synharmonia octomaculata* were common. Egg parasites, mainly *Anagrus* sp., sometimes parasitized more than 90% of BPH eggs.

Rice varieties with the *bph 2* gene for resistance — IR36, IR38, IR2070, IR2071 — reduced the BPH population in the field, but IR8 and varieties with the *Bph 1* gene such as IR26, IR30, and IR1561-228-3-3 were msceptible to the local BPH population.

BPH populations have decreased since 1979 because of the intensive cultivation of IR36 and other resistant varieties.



Seasonal occurrence of BPH on rice fields in Mekong Delta, Vietnam. A = two rainfed crop areas of Long An (1978-79), and B = three irrigated crop areas of Tien Giang (1977-78).

Feeding activity of the green leafhopper (GLH) and tungro (RTV) infection

E. A. Heinrichs and H. R. Rapusas, IRRI

We studied the relationship between feeding rate and number of feeding punctures by GLH and RTV infection on IR8, IR24, IR40, IR29, and IR22.

Two viruliferous GLH adults were caged in a honeydew collection chamber attached to the leaves of 20-d-old potted plants. Each variety was replicated 10 times, each chamber on a plant equaling 1 replication. The insects were allowed to feed for 22 h and the honeydew excreted by the insects was collected on filter paper treated with bromocresol green solution. The area of the honeydew spots on the paper was measured. Blue basic honeydew spots indicated phloem feeding, and were measured separately. The plants on which the hoppers fed were kept 20 d in the greenhouse for RTV symptom development and percent infection was computed.

To determine the number of feeding punctures made by GLH, 2 leaves on each of 10 plants/variety were enclosed in a parafilm sachet with 2 adult GLH females. Leaf portions fed upon by the insects were cut and dipped in 1 % rhodamine solution for 15 min to stain the feeding punctures pink. The punctures were counted under a binocular microscope.

Although significant differences were observed on the total honeydew excreted, percent basic honeydew, RTV infection, and feeding punctures among the varieties tested (Table 1), there was no significant correlation between total honeydew and RTV infection and between total honeydew and feeding punctures (Table 2). However, a positive correlation between basic honeydew and RTV infection indicated that phloem feeding is necessary for RTV infection.

Table 1. Feeding punctures, honeydew excretion, and RTV infection, IRRI.[a]

Variety	Feeding punctures (no.)	Total area (mm²) of honeydew spots	Area (%) of basic honeydew spots	RTV infection (%)
IR8	82 c	188 b	49 b	76 b
IR24	125 a	179 b	52 b	71 b
IR40	110 ab	172 b	43 b	43 c
IR29	88 bc	179 b	10 c	14 d
IR22	45 d	228 a	100 a	99 a

[a] Means in a column followed by the same letter are not significantly different at the 5% level.

Table 2. Correlation between RTV infection and GLH feeding activity, IRRI.

Feeding activity	Correlation coefficient[a] RTV infection
Feeding punctures	0.0062 ns
Total honeydew excreted	0.47 ns
% basic honeydew	0.92 **

[a] Significance at the 0.05 level = 0.666; significance at the 0.01 level (**) = 0.798. ns= not significant.

Trapping airborne insects aboard interisland ships in the Philippine archipelago, with emphasis on the brown planthopper (BPH)

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We studied the movement of airborne insects in the Philippines by trapping them aboard interisland ships during four voyages each in 1979 to 1981 dry and wet seasons. The study traced interisland movement of the BPH.

Airborne insects were collected using 6 wind-propelled, cone-shaped nylon nets (0.5 m diam, 2 m long) and 4 cross-shaped sticky board traps (0.45 × 0.45 m). During each voyage, one net was installed at the bow, two at the yardarms of the mast, two on each side of the flying bridge, and one at the stern. The sticky traps were operated from the front railing of the flying bridge. Traps were opened about 30 min after sailing from each port and closed about 30 min before docking. Insect catches were then placed in coded vials for later identification in the laboratory.

During the 8 voyages, 1,874 insects, 46 spiders, and an ixodid tick were collected. Dipterans (47.9%) were most numerous, followed by 31.4% hemipterans, 13.5% hymenopterans, 6.4% coleopterans, and 1.0% lepidopterans, orthopterans, a psocopteran, an embiopteran, and a collembolan. More arthropods (1,066 insects and 33 araneids) were trapped in wet season than in dry season (808 insects, 13 araneids, and an ixodid tick) (Table 1). Among the delphacids trapped, the whitebacked planthopper *Sogatella furcifera* was most abundant, followed by BPH and *Sogatodes pusanus* (Table 2).

Southwesterly winds, 23.6-33.2°C temperature, and 56.5-99% relative humidity prevailed in wet season. Calm to variable winds punctuated by northeasterly and southeasterly air currents, 22.4-34°C temperature, and 43.8-95.8% relative humidity prevailed in dry season.

The relatively higher insect catches in wet season indicate that warm, humid air masses are ideal for transporting insects over long distances in the Philippines. Sea between islands was not an effective barrier to migrant insects. The catches also indicate that the bulk of *N. lugens* originated from rice producing areas lying along the path of the southwest monsoon. ☐

Table 1. Arthropods caught in nylon nets and on sticky traps installed aboard interisland vessels sailing along different routes in the Philippine archipelago in 1979-81 dry and wet seasons.[a]

Insect order	Insects caught					
	Dry season (4 voyages)		Wet season (4 voyages)		S 8 voyages	
	No.	%	No.	%	Total	%
Diptera	381	47.2	516	48.4	897	47.9
Hemiptera	204	25.2	384	36.0	588	31.4
Hymenoptera	131	16.2	122	11.4	253	13.5
Coleoptera	83	10.3	36	3.4	119	6.4
Lepidoptera	6	0.7	6	0.6	12	0.6
Orthoptera	1	0.1	1	0.1	2	0.1
Psocoptera	0	0	1	0.1	1	0.1
Embioptera	1	0.1	0	0	1	0.1
Collembola	1	0.1	0	0	1	0.1
S	*808*		*1066*		*1874*	
Araneida	13		33		46	
Acari	1		0		1	

[a]Routes and duration of each voyage during dry and wet seasons. *Dry season:* I. Manila-Cagayan de Oro-Manila, 26 Jan-2 Feb 1980, II. Manila-Iligan-Manila, 7-15 May 1980, III. Manila-Cagayan de Oro-Manila, 14-22 Feb 1981, IV. Manila-Cagayan de Oro-Manila, 21-29 May 1981. *Wet season:* I. Manila-Butuan-Manila, 27 Jun-6 Jul 1979, II. Manila-Iligan-Manila, 3-11 Oct 1979, III. Manila-Iligan-Manila, 15-24 Jul 1980, IV. Manila-Iligan-Manila, 17-25 Oct 1980.

Table 2. Delphacids caught in nylon nets and on sticky traps installed aboard interisland vessels sailing along different routes in the Philippine archipelago during 1979-81 dry and wet seasons.

Species	Insects caught (no.)	
	Dry season (4 voyages)	Wet season (4 voyages)
Nilaparvata lugens	1	22
Sogatella furcifera	8	35
Euidellana	0	1
Harmalia anocharsis	1	0
Harmalia nr. *heitensis*	1	0
Harmalia spp.	1	2
Nilaparvata bakeri	2	2
Nilaparvata spp.	2	3
Opiconsiva dodona	2	0
Opiconsiva sp.	0	1
Perkinsiella sp.	0	1
Sogatella eupompe	0	1
Sogotella kolophon	0	2
Sogatella panicicola	2	3
Sogatella terryi	0	1
Sogatella spp.	0	7
Sogatodes pusanus	0	11
Sogatodes sp.	0	2
Toya close to *propinqua*	0	1
Unidentified delphacids	1	14
	S*21*	*108*

Influence of light traps on incidence of yellow stem borer (YSB) *Scirpophaga incertulas* Wlk. in the trap zone and field

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We studied the influence of a light trap on YSB infestation in surrounding fields. A Robinson light trap with a 125-W mercury lamp was operated from Dec 1981 to Feb 1982 on the Agricultural College Farm, Madurai, during which time YSB incidence was high. The trap operated from 1800 to 0600 h in a field cropped with IR20.

Each morning, 10 hills were randomly selected at 1 m from the trap and the number of YSB on the hills was estimated. Counts were made for 2 wk during peak infestation.

There was a significantly positive correlation (r = 0.79) between the number of YSB on 10 hills and the daily light trap catch (Table 1). Moths which were attracted to the light but did not enter the trap settled near it. Because moths are nocturnal, movement ceased after daylight.

We compared deadheart and whitehead incidence by selecting 10 hills in diagonal lines at 1,5, 10, and 20 m from the trap, and in fields located far away from the light traps where the light could not be seen by YSB. As distance from the light trap increased, percent deadhearts declined (Table 2).

The increased infestation at 1 m around the trap was due to the settlement of YSB. Moths also may have migrated to surrounding areas during the day and caused more damage in that area as indicated by higher incidences even at the distance of 10 m. Our data indicate it may be wise to spray around the trap area with a suitable insecticide to reduce field damage. □

Table 1. Relation between light trap catch and settlement of YSB around the trap, Madurai, India.

Date	Moths settled (no./10 hills)	Light trap catch (no.)
8 Dec 1981	63	242
9 Dec 1981	71	387
10 Dec 1981	68	342
11 Dec 1981	61	288
12 Dec 1981	51	220
13 Dec 1981	97	620
14 Dec 1981	81	420
15 Dec 1981	88	580
16 Dec 1981	32	36
17 Dec 1981	28	42
18 Dec 1981	31	86
19 Dec 1981	48	108
20 Dec 1981	58	280
21 Dec 1981	73	460
	$r = +0.79^{**a}$	

[a]Significant at 1% level.

Table 2. YSB incidence at different distances from the light trap, Madurai, India.

Date	Incidence (%) 1 m	5 m	10 m	20 m	Light shadow region
15 Dec 1981	22	20	11	6	7
22 Dec 1981	36	24	18	13	14
29 Dec 1981	57	49	37	23	24
6 Jan 1982	59	50	39	25	27
13 Jan 1982	67	52	43	26	29
20 Jan 1982	74	55	46	29	32
24 Jan 1982	82	57	46	29	31
3 Feb 1982	86	21	14	12	13
10 Feb 1982	91	24	15	12	15
17 Feb 1982	100	28	18	15	17
Meananalysis	T_1	T_2	T_3	T_4	T_5
F = 24.07^{**a}					
CD (P = 0.05) = 7.55					

[a] Significant at 1% level.

Population density of ***Sogatella furcifera*** **(Horvath) (WBPH) and** ***Nilaparvata lugens*** **(Stal.) (BPH)**

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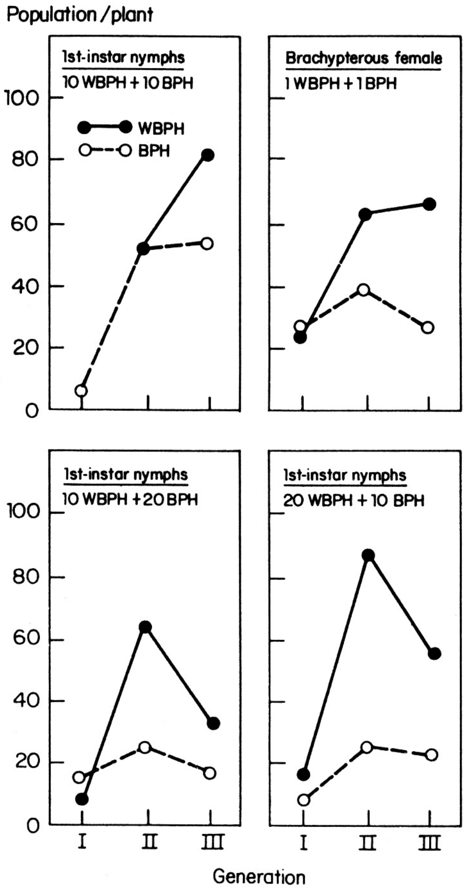
We compared changes in population density of WBPH and BPH in the greenhouse at the Paddy Breeding Station, Coimbatore. In 4 experiments with 12 replications, combinations of WBPH and BPH were placed on individually caged 30-d-old potted TN1 plants as follows: 10 WBPH and 10 BPH first instar nymphs; 10 WBPH and 20 BPH; 20 WBPH and 10 BPH; and 1 WBPH and 1 BPH brachypterous female. Insect population was monitored for three generations.

WBPH population increased more rapidly than that of BPH in all the experiments (see figure). There was no significant difference in population level during the first 2 generations when 10 first-instar nymphs of both species and one brachypterous female of both species were confined together in different experiments. However, the differences were highly significant in experiments with different numbers of first-instar nymphs.



Population density of WBPH and BPH, Coimbatore, India.

WBPH and BPH populations declined after the second generation. Crop age may have favored the buildup of WBPH over BPH, because BPH population usually increases after heading. The field population of WBPH usually is largest 70-90 d after seeding, which corresponds roughly with the age of TN1 plants during the third generation in this experiment. □

Electronically recorded disturbances in the feeding behavior of green leafhopper (GLH) on neem oil-treated rice plants

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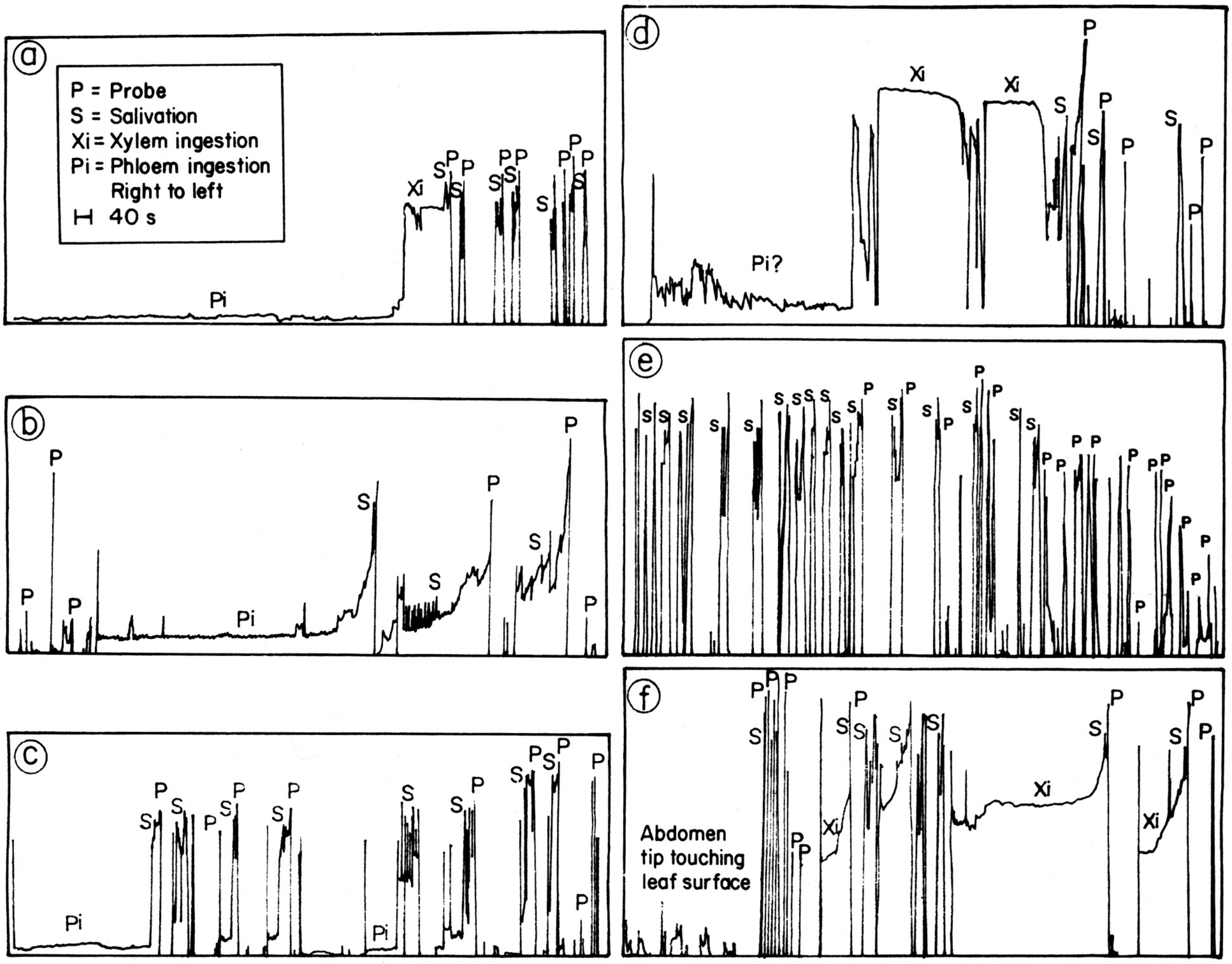
We electronically recorded aberrations in GLH feeding behavior on neem oil-treated rice plants.

A fine (1 8 mμ), 5-cm-long gold wire was attached by silver paint to the dorsum of an 8- to 10-h-old GLH female. The insect was starved for 2 h and then its normal feeding activity was recorded electronically for 180 min using a D. C.

chart recorder. Feeding on the leaf blade of a 30-d-old susceptible TN1 rice plant that had been sprayed with 1 ml of acetone was the control. Feeding activity of GLH females was recorded on TN1 plants sprayed with 1 ml of 1.25, 2.5, 5, or 10% neem oil in acetone, using a quick spray atomizer. For each treatment, 10 different females were tested, using 1 female/plant.

Waveform patterns recorded showed prolonged phloem feeding on control plants (Fig. a). Phloem feeding decreased on plants treated with increasing concentrations of neem oil (Fig. b, c). Decreasing phloem feeding was accompanied by a corresponding increase in the frequency of probing and salivation. On plants sprayed with 5% neem oil, the insect fed from the xylem, and phloem feeding was disrupted (Fig. d). The insect became restless, probed and salivated repeatedly, and fed from xylem on plants treated with 10% neem oil (Fig. e, f).

The change in GLH feeding from phloem to xylem can be attributed to the insect's effort to offset desiccation resulting from its repeated probing, profuse salivation, and restlessness. Increased restlessness on 10% neem oil-treated plants was also evidenced by the slanting posture of the insect and its abdominal tip touching the leaf surface (Fig. f). □



Electronically recorded waveforms during GLH feeding on TN1 rice plants sprayed with a) acetone (control), b) 1.25% neem oil (NO), c) 2.5% NO, d) 5% NO, and e,f) 10% NO.

Chemical control of rice hispa

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The rice hispa *Dicladispa armigera* (Oliv.) did not become a serious rice pest in Pakistan until 1983 wet season, when unusual weather conditions favored low to high infestations on about 2,500 ha in Alipur and Muridkey.

We evaluated four emulsifiable concentrate (EC), six dust, and three granular insecticide formulations for rice hispa control at Muridkey. Spray volume was 400 litres/ha.

Trials were in a completely randomized block design in three replications. Plot size was 84 m^2. Control level was determined by counting live adult rice hispa on 5 randomly selected plants in each plot before and 1, 3, 10, 20, and 30 d after pesticide application.

All EC insecticides were effective, but fenitrothion performed best (see table). All dusts were effective, but BHC 0.75 kg ai/ha was best. Of the granular insecticides, carbofuran and cartap were effective, but slow acting from 10 through 30 d after application. Diazinon was ineffective. □

Population and % control of rice hispa at different intervals[a] after pesticide applications, Muridkey, Pakistan.[b]

Insecticide and formulation	Dose (kg ai/ha)	Application method	Av no. of alive hispa adults/5 rice plants at						Percent control of hispa at				
			BA	1 DAA	3 DAA	10 DAA	20 DAA	30 DAA	1 DAA	3 DAA	10 DAA	20 DAA	30 DAA
Diazinon 60 EC	1.125	Spray	89	13 c	l0 e-g	33 c	62 c	91 ab	85	88	63	30	–2
Fenitrothion 20 EC	0.500	Spray	89	9 c	7 f-h	7 f - h	30 d	65 c-e	89	92	92	66	27
Malathion 57 EC	1.425	Spray	88	16 c	15 e	35 c	70 b	85 a-c	81	83	60	20	3
Phosphamidon 50 EC	0.688	Spray	90	7 c	5 f-h	14 d	37 d	75 b-d	92	94	84	59	16
BHC 10 D	0.500	Dust	86	8 c	7 f-h	9 e- f	11 f	14 hi	91	92	89	87	84
BHC 10 D	0.750	Dust	91	2 c	2 h	l i	2 h	4 i	98	98	99	98	96
BHC (10 D) + DDT (10 D) in 1:3 mixture	0.312 +0.937	Dust	83	4 c	4 gh	5 g-i	7 f-h	15 hi	95	95	94	92	81
Carbaryl 10 D	2.500	Dust	91	4 c	3 gh	9 fg	19 e	44 e-g	95	96	90	79	21
Cotton dust [c] (6.3% BHC + 10.4 % DDT + 83.3% sulfur	7.200	Dust	90	8 c	15 e	13 d	21 e	31 f-h	91	83	85	77	66
DDT 10 D	0.750	Dust	86	7 c	6 f-h	6 f-h	l0 fg	18 hi	92	93	93	88	79
Pyridaphenthion 2D	0.800	Dust	92	11 c	12 ef	15 d	21 e	53 d-f	88	87	84	77	42
Carbofuran 3 G	0.750	Broadcast	90	83 ab	29 d	9 fg	7 f-h	22 g-i	8	68	91	92	76
Carbofuran 3 G	1.125	Broadcast	87	73 b	24 d	4 hi	3 gh	5 hi	16	72	95	97	94
Cartap 10 G	1.250	Broadcast	90	79 ab	41 c	8 f-h	7 f-h	27 g-i	12	54	91	92	70
Diazinon 10 G	2.000	Broadcast	87	82 ab	67 b	52 b	37 d	65 c-e	6	23	40	57	24
Control	–	–	90	90 a	93 a	98 a	97 a	101 a	0	–4	–10	–8	13
LSD at 5%				14	7	4	7	24					

[a]BA = before application. DAA = d after application. [b]In a column, averages followed by common letters are significantly similar at 95% level of confidence. [c]Cotton dust is a brand name for BHC + DDT + sulfur mixture formulated by Ittehad Pesticides Ltd., Pakistan.

Pest control and management OTHER PESTS

Control of root-knot nematode in upland rice

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Root-knot nematode *Meloidogyne incognita* is an important upland rice pathogen in Nigeria. Infected plants are stunted and leaves become chlorotic. Roots have fewer root hairs and galls are formed.

Chemical seed treatment was tested for nematode control on variety FARO 11. Rice was grown in plastic pots in autoclaved sandy-loam soil under simulated upland conditions in the screenhouse. Each pot was inoculated with 1,500 *M. incognita* eggs at planting. Roots were washed free of soil at the end of the experiment and scored for galling, and the nematodes in a 200-g soil sample from each pot were counted.

Carbofuran was most effective in protecting the seedlings from root-knot nematode. Seed treated with PCNB and carbofuran had early seedling emergence (see table). PCNB, phenthoate, and EPN provided the best seedling protection against secondary pathogen infection, as indicated by the leaf damage index. All the test chemicals except phenthoate performed better than the control. EPN, however, is suspected to be phytotoxic. □

Chemical seed treatment for control of *M. incognita* in upland rice, Ibadan, Nigeria.[a]

Seed treatment	Rate (ai/ha)	Plant ht (cm) 14 DAS	Seedling vigor[b] 14 DAS	Leaf damage index (14 DAS)	Root galling index[c]	Final nematode count
Disulfoton	1 kg	14.70	7	4	4	1100
PCNB	40 g	19.83	6	2	3	1150
Carbofuran	1 kg	19.13	5	3	1	550
Phenthoate	0.75 kg	13.23	7	2	4	2700
EPN	0.50 kg	8.20	7	2	2	850
Control	–	13.40	7	5	5	2825

[a]Mean of 3 replications. DAS = days after seeding. [b]After the 1980 Standard Evaluation System for Rice. [c]After an international *Meloidogyne* project.

Effect of zinc on stem nematode-infected rice

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We studied the effect of Zn application on stem nematode-infected rice plants. Sixteen pots, each with 8 kg moist Zn-deficient soil (0.6 ppm), were fertilized with 200-66-83 kg NPK. Eight of the pots were fertilized with 50 ppm Zn as $ZnSO_4$. Four germinated seeds of BR3 were planted in each pot. BR3 is susceptible to Zn deficiency and ufra disease caused by the stem nematode *Ditylenchus angustus* (Butler) Filipjev. Pots were irrigated with pond water with no Zn contamination. Symptoms of Zn deficiency in plants grown in pots without added Zn were observed 20 d after planting.

Plants from 4 pots of each group (with and without added Zn) were inoculated with 200 ufra nematodes/plant, 25 and 35 d after planting, by seedling base and sheath inoculation methods. Immediately after inoculation, the plants were covered with polyethylene bags for 72 h to increase humidity. Soil in the pots was always submerged.

Splash-patterned chlorosis developed 2 to 4 wk after inoculation, followed by other ufra symptoms such as yellowing and twisting and crinkling of younger leaves. There were two different patterns of panicle emergence: panicles fully enclosed within the flag leaf sheath (UI), and partially emerged panicles with a few filled grains at the tip (UII).

Zn-deficient plants had less fertile tillers, fewer filled grains, and more severe ufra symptoms than plants with added Zn (see table). □

Zn content of plant and soil, and its effect on stem nematode-infected rice plants, BRRI. [a]

Treatment [b]	Zn content (ppm) In soil Initial	Zn content (ppm) In soil Final	Zn content (ppm) In plant at harvest	Fertile tillers (%)	UI (%)	UII (%)	Filled grains per panicle (%)	Av yield (g/pot)	Nematode multiplication rate at panicle initiation
Without added Zn	0.6	0.5	25.3	15.1	75.7	24.3	8.8	0.7	1:14
With added Zn	0.6	3.8	39.3	28.5	62.6	37.4	30.0	2.1	1:12
't' value [c]			9.2**	2.6*	3.9**	3.9**	4.1**	2.5*	0.3 ns

[a] Figures are av of 4 replications. [b] Zn was added as $ZnSO_4$ (50 ppm) at transplanting and the plants were inoculated with nematode, at 25 and 35 d after transplanting, by seedling base and sheath inoculation methods. [c] ** = 1% level of significance, * = 5% level of significance, ns = not significant.

Incidence of rice root nematode in Madurai

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The rice root nematode *Hirschmanniella* sp. significantly reduces rice growth and yield in India. We surveyed 33 blocks of Madurai district for rice root nematode incidence in 1981-82 and 1982-83.

IR20 and Ponni are the rice varieties grown in the area in samba. Root samples were collected from active tillering phase to heading from eight randomly selected fields from four villages per block. Ten 5-g root samples were taken from randomly selected clumps in each field and processed by the Baermann funnel technique. The population of rice root nematodes *H. oryzae* and *H. mucronata* was recorded. Damage level was considered to be more than 250 nematodes/5-g root.

Rice root nematode was found in all areas surveyed. Populations ranged from 49 to 521 nematodes/5 g of root. Infestation was most severe in Cumbum tract of the Periyar Irrigation Project, and population was above damage level in Alanganaloor, Bodi, Chinnamanoor, Cumbum, Dindigul, Palani, Periyakulam, Sanarpatti, Theni, Usilampatti, and Uthamapalayam. □

TKM9 is resistant to rice-root nematode

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IR20, IR50, Paiyur 1, and TKM9 were evaluated at different growth stages for resistance to rice-root nematode *Hirschmanniella oryzae.*

TKM9 was resistant to nematodes at all growth stages (see table). IR50 was more resistant than IR20 and Paiyur 1.

Rice varietal resistance to rice root nematode, Kancheepuram, India.

Variety	Nematode population in 2 g of root: Planting	30 d after transplanting	Boot leaf	Harvest
IR20	5	20	50	35
IR50	5	–	5	25
Palyur 1	30	240	10	10
TKM9	–	–	–	–

Insecticide root dip controls rice root nematode

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We evaluated insecticide root dips for control of rice root nematode *Hirschmanniella oryzae* during navarai season.

IR50 seedlings were dipped in 0.02% solutions of phosphamidon, chlorpyriphos, or monocrotophos for 20 min before planting.

Phosphamidon and chlorpyriphos root dips reduced the nematode population 30 d after transplanting (see table). □

Insecticide root dips evaluated for rice root nematode control at Kancheepuram, India.

Insecticide (0.02% solution)	Nematodes/2 g root
Phosphamidon	0.83
Chlorpyriphos	0.83
Monocrotophos	1.66
No treatment	5.83

SE = 0.34

Irrigation and water management

IR20 performance under different irrigation regimes

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We evaluated the effect of different irrigation regimes on grain and straw yield in an experiment at ARS, Bhavanisagar, in 1983 kharif. Three irrigation regimes were teasted: the standard water supply rate provided by the Public Works Department to rice in the command area — 3.1 cm deep on alternate days; the recommended rate of the Water Management Scheme — 2.5 cm deep on alternate days; and 50% of the Public Works Department supply rate — 1.55 cm deep on alternate days. The experiment was in eight replications in a randomized block design.

Grain and straw yields of IR20 were essentially equal for all treatments. The 1.55-cm rate produced highest grain and straw yield — 5.5, and 4.9 t/ha. Under that irrigation regime, total water consumption, excluding effective rainfall, was 749.5 mm and water use efficiency was much higher (7.34 kg/mm per ha) (see table). □

Effect of irrigation regime on yield and water use efficiency of IR20, Bhavanisagar, India.

Treatment	Water use for nursery (mm)	Water use for field preparation (mm)	Treatment irrigation (mm)	Total water applied[a] (mm)	Grain yield (t/ha)	Straw yield (t/ha)	Water use efficiency (kg/mm per ha)
3.1 cm on alternate days	62.5	200	1060	1322.5	5.2	4.7	3.93
2.5 cm on alternate days	62.5	200	838	1100.5	5.2	4.6	4.73
1.55 cm on alternate days	62.5	200	487	749.5	5.5	4.9	7.34
CD at 5%					ns		

[a]Excludes effective rainfall, which was less than 10% of irrigation water applied.

Soil and crop management

Application methods to improve phosphorus uptake in rice

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Rice crop recovery of added P seldom exceeds 20%. We sought to determine methods of P application that would improve plant uptake of P in a wet season experiment at Madurai.

IR20 was planted in a red sandy clay loam soil (Typic Haplustalf). Treatments are in the table. The recommended dose of 120-26-50 kg NPK/ha was applied. N was applied as urea in two splits and K was applied basally as muriate of potash. The phosphate slurry was prepared by mixing 13 kg P/ha as single superphosphate 1:1 in a puddled soil. Seedling roots were dipped before transplanting, and a foliar application of diammonium phosphate was applied.

Grain yield, and P uptake, response, and recovery are in the table. Grain yield was from 4.1 to 5.3 t/ha. Highest yield was with slurry dipping with P applied basally and in a foliar spray. That application method was estimated to save 67% of P fertilizer applied. High grain response to slurry dipping may have been because it placed P in the effective root zone and encouraged uptake.

P uptake ranged from 23 to 36 kg/ha. Highest uptake was with slurry dipping with P applied basally and as a foliar spray. P recovery varied from 8 to 18%. Basal application gave lowest recovery and slurry dipping gave highest recovery. □

Grain yield and response, uptake, and recovery of P as influenced by different application methods, Coimbatore, India.

Treatment	Grain yield (t/ha)	Response (kg /grain/ kg P)	Total uptake (kg/ha)	Recovery (%)
Control	4.1	–	23	–
Full dose as basal	4.6	20	28	8
Basal + foliar	5.0	34	34	12
Foliar	4.7	44	28	18
Slurry	5.2	85	28	19
Slurry + basal	4.8	18	32	11
Slurry + basal + foliar	5.3	30	36	15
Slurry + foliar	5.0	33	31	15
(CD P = 0.05)	0.1		3	1

Cultural and chemical methods to prevent lodging and stabilize yield of a tall indica rice

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Safri (BD200), a long-duration, tall indica rice, is popular in the Chhatisgarh region of Central India. It lodges severely because of excessive vegetative growth, particularly with heavy N fertilization, which limits yield.

In 1980 wet season, in a silt loam soil, we conducted a field trial to determine cultural and chemical methods to reduce lodging and increase yield stability. The experiment was in a randomized block design with four replications. Forty-five-day-old seedlings were planted at 15- x 15-cm plant spacing on 8 Aug 1980. Treatments are summarized in the table. Data were collected on plant height and rice grain yield.

Plant height was not influenced by increasing P or K levels, but was markedly affected by different cultural and chemical treatments. All treatments reduced plant height over the control. Double transplanting reduced plant height most, and also reduced final yield. Cycocel sprayed at 40 ppm at mid-tillering reduced plant height and plant vigor, and increased grain yield 6% over the control.

Cycocel, with optimum fertilizer application, helped minimize vegetative growth, thereby diverting the physiological activities toward grain production. □

Effect of chemical and cultural treatments on plant height and grain yield of the tall indica Bd 200. Raipur, India.

Treatment	Plant height (cm)			Grain yield (t/ha)		
	Fertility [a]		Mean	Fertility		Mean
	F_1	F_2		F_1	F_2	
Control	133	140	136	4.1	4.2	4.1
Leaf topping at maximum tillering	132	127	130	3.9	4.0	3.9
Cycocel (40 ppm) spray at mid-tillering	123	127	125	4.0	4.8	4.4
Cycocel (40 ppm) spray at maximum tillering	129	131	130	3.9	4.1	4.0
Double transplanting 25 d after first transplanting	126	122	124	3.4	3.3	3.3
Mean	128	129		3.9	4.1	
CD (5%)						
Lodging treatments	6 cm			0.4 t/ha		
Fertility	ns			ns		
Interaction	9 cm			0.5 t/ha		

[a] Fertility: F_1 = 80, 13, 17 kg NPK/ha. F_2 = 80, 26, 33 kg NPK/ha.

Response of rice varieties to applied nitrogen in saline soils

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Bangladesh has about 0.8 million ha of saline land with low N content. We studied the effect of different levels of applied N on growth and yield of direct-seeded (dibbled), rainfed BR9 rice at the BRRI farm in Sonagazi in 1983 aus (summer).

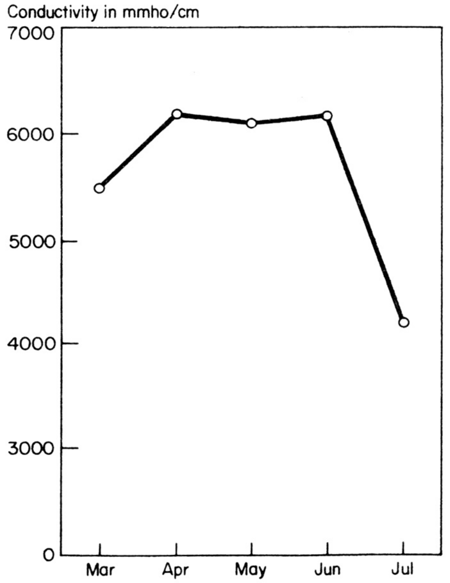
Zero, 20, 40, 60, or 80 kg N/ha was applied in 2 equal splits at 20 and 40 d after emergence. Salinity level was monitored throughout the growing period (see figure). N application significantly increased grain yield over that of the control. Eighty and 60 kg N/ha produced highest and similar grain yields (see table). N application also increased plant height, tillers/hill, and panicles/m^2.

Results suggest that even in saline soils modern varieties respond to increased N levels. □

Effect of different levels of applied N on growth and yield of direct-seeded (dibbled) BR9 grown in saline soils, BRRI. [a]

Treatment (kg N/ha)	Plant height (cm)	Panicles/m^2	Tillers/hill	Yield (t/ha)
0	106	157 c	5 c	1.4 c
20	110	204 bc	6 bc	2.2 b
40	117	256 ab	8 b	2.3 b
60	120	316 a	11 a	3.4 a
80	126	330 a	12 a	3.6 a

[a] In a column, means followed by the same letter are not different significantly at the 1% level.



Electrical conductivity of soil of the experimental applied N field during the growing period, BRRI.

Straw, lime, and manganese dioxide amendments for iron-toxic rice soils

Li, Jin-Pei, special research fellow, and F. N. Ponnamperuma, principal soil chemist, IRRI

A nutritional disorder of lowland rice associated with excess water-soluble Fe often occurs on strongly acid soils. It has been identified in the Philippines, Vietnam, Thailand, Malaysia, India, Sri Lanka, Liberia, Senegal, Colombia, and China. Lime and MnO_2 alleviate the disorder.

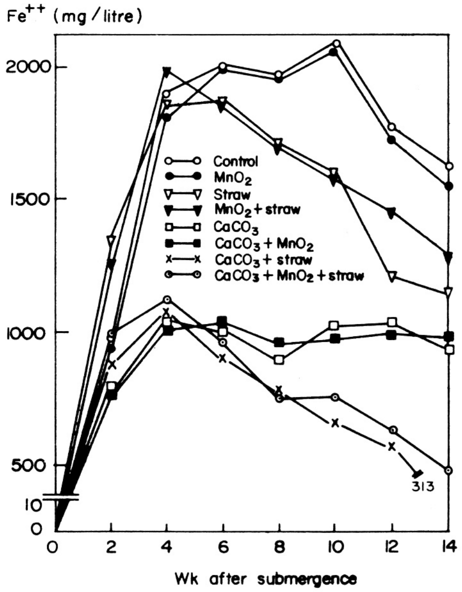
In the greenhouse, we evaluated the effect of straw (0 and 0.25%), $CaCO_3$ (0 and 0.25%), and MnO_2 (0 and 0.005%), in a 2 × 2 × 2 factorial, randomized complete block design in 4 replications on the growth and yield of IR26 in an iron-toxic acid soil. NPK was added to soil collected from the top 20 cm of a Sulfaquept from Malinao, Albay, Philippines. The soil had pH 3.4, 0.64% organic C, 0.049% total N, 2.4% active Fe, 1.3 mmol/kg exchangeable K, and 4.4 mg/kg available P (Olsen). Four 20-d-old IR26 seedlings were transplanted in each pot 2 wk after submergence. The soil solution was analyzed fortnightly.

Although 4 wk after transplanting (WAT), Fe concentrations in the soil solution differed mainly in the lime factor (Fig. 1), Fe toxicity symptoms were severe in untreated soil, moderately severe in straw-treated soil, mild in MnO_2-treated soil, and virtually absent in all lime treatments. Eight wk after transplanting, plants on straw-treated soil began to recover, which may be associated with declining Fe concentration in the soil solution.

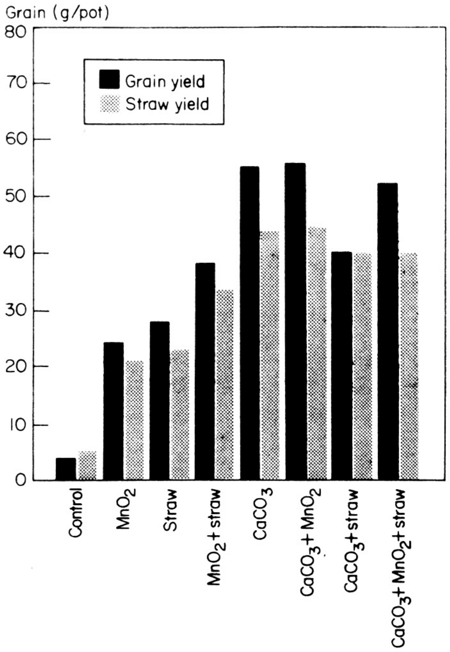
Lime alone or combined with MnO_2 produced the highest straw and grain yields (Fig. 2). The benefits of lime were associated with lower concentrations of Fe in the soil solution and in rice shoots (4 WAT) and mature straw (Fig. 3). Straw and MnO_2 alone or combined gave moderate yield increases which were associated with a lower Fe content of the shoots (4 WAT) than in the untreated plants.

As an inexpensive amendment for iron-toxic soils, straw merits further study. We need to ascertain

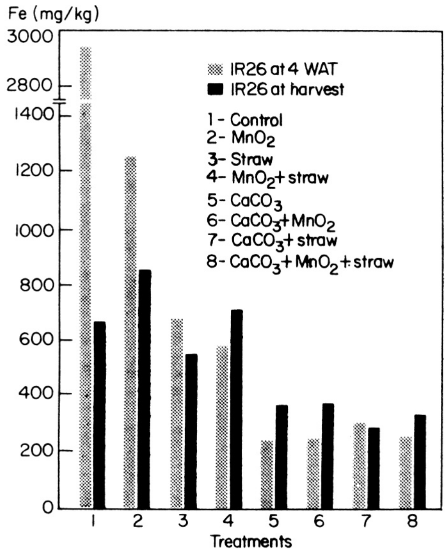
1. if smaller amounts of N, P, and $CaCO_3$ are sufficient, when combined with the straw, to prevent N and P deficiency and Fe toxicity in early stages of rice growth;
2. how long the residual effects of straw, lime, and MnO_2 incorporation will last; and
3. what is the optimum amount of straw and timing of transplanting. □



1. Influence of straw, $CaCO_3$, and MnO_2 on the kinetics of water-soluble Fe^{2+} in a submerged iron-toxic soil, IRRI.



2. Grain and straw yields as affected by different additive treatments, IRRI.



3. Fe content of shoots at 4 WAT and straw at harvest as affected by different additive treatments, IRRI.

Effect of soil moisture and seeding depth on seedling emergence of two rices

I. K. Jaggi and D. C. Bisen, Department of Soil Science and Agricultural Chemistry, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Raipur Campus, India

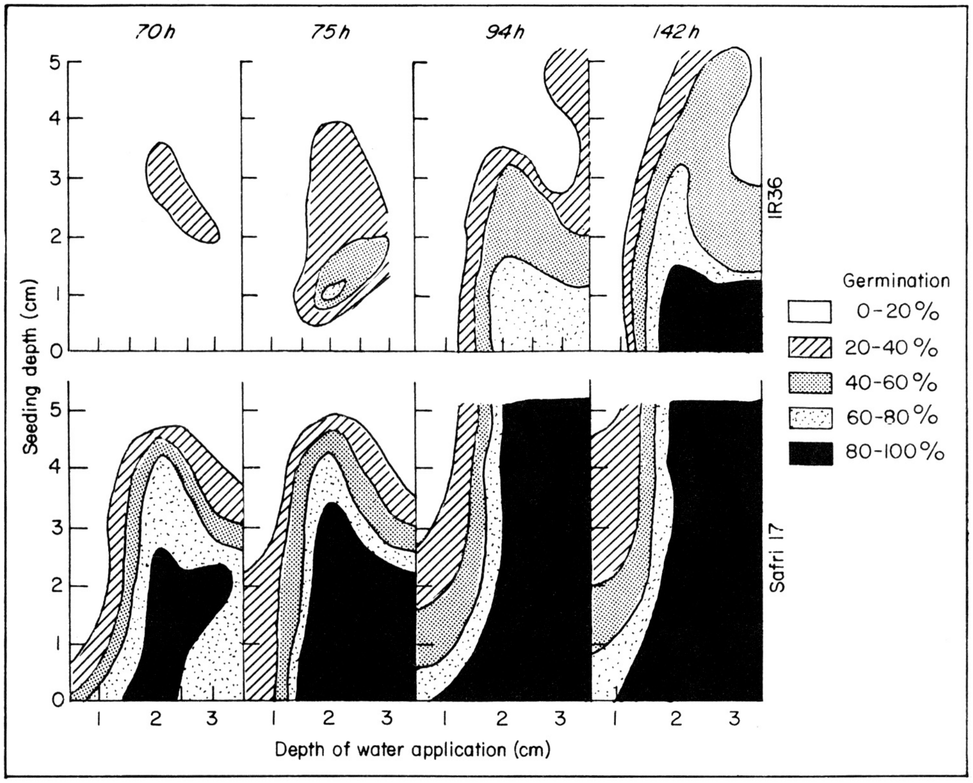
We evaluated the effect of soil moisture content and seeding depth on seedling emergence of Safri 17 and IR36. Seeds were planted in a loam soil in the laboratory at 1, 2, 3, and 5 cm deep and water was applied 1, 2, or 3 cm deep.

The figure gives percent seedling emergence as influenced by depth of water application based on isolines of percent emergence. When IR36 was planted 5 cm deep, seedling emergence was low. Percent emergence for Safri 17 was similar at seeding depths of 1 and 5 cm.

Soil moisture level corresponding to soil water potential between -0.5 to -2.0 bars was most favorable for seedling emergence, followed by the range – 1.5 to 2.0 bars.

Safri 17 germination at all depths and soil moisture levels was better than that of IR36.

Although farmers who direct seed their fields usually plant seeds deeper than normal to have good seedling emergence at the onset of the monsoon, our results show that increasing the planting depth of rice varieties sensitive to seed placement depth can adversely affect seedling emergence. Therefore, appropriate seeding depth for the variety to be planted should be practiced. □



Emergence dynamics of Safri 17 and IR36 as influenced by depth of water application and seeding depth.

Response of rice to zinc and sulfur

M. M. Islam, M. Kabir, and N. I. Bhuiyan, Soil Chemistry Division, Bangladesh Rice Research Institute, Joydebpur, Dhaka, Bangladesh

Zn and S deficiencies are major constraints to irrigated rice in the Joyertek (Joydebpur) boro project area of Bangladesh. We evaluated Zn and S deficiency in a farmer field at Joyertek in 1983 boro with IR8 as the test variety. Soil was sandy loam with pH 7.6, 30 ppm available S (Ca-P extractable), and 0.6 ppm available Zn (0.05 *N* HC1 extractable). All plots received the recommended 60-9-17 kg NPK/ha. $ZnSO_4$ and zinc oxysulfate at 10 kg/ha were applied to Zn-treated plots. For S, 200 kg gypsum/ha was applied. Both were broadcast and incorporated 4 wk after transplanting, when nutrient deficiencies were visible. Symptoms were brown spots and rusty streaks on the leaves, very poor growth, and light yellowing. Plants were harvested 7 wk after treatment. Chemical analysis and dry matter yield are in the table.

Applying gypsum and Zn in two forms dramatically increased the dry matter yield of IR8 as compared with the control. Deficiency symptoms disappeared in Zn-treated plots 2-3 wk after treatment. $ZnSO_4$ performed better than zinc oxysulfate. Plant analysis for Zn (1*N* HCl extraction) showed that plant Zn concentration in treated plots was still below the critical level, although it was relatively higher than in the control plots. Although S concentration (nitric-perchloric acid digestion) and N:S were satisfactory, applying gypsum also improved rice growth. □

Effect of Zn and S on the performance of IR8 at Joyertek, Bangladesh.

Treatment	Dry matter yield (g/m^2)	Total Zn (ppm)	Total S (%)	Total N (%)	N:S
Control	63	16	.250	1.96	7.8
$ZnSO_4$	554	25	.159	1.30	8.2
Zinc oxysulfate	112	19	.237	1.98	8.4
Gypsum	163	18	.219	1.58	7.2

Effect of N, P, and K on available P and K in sodic soil

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We evaluated the effect of N, P, and K on available P and K in soil and on rice and wheat yields in a long-term field experiment on a partially reclaimed sodic soil at Karnal.

The soil was naturally highly sodic, but 3 yr (1971-74) of cropping and gypsum amendments had reduced pH to 9.2 and exchangeable sodium percentage (ESP) to 32.0 in the 0.15 cm surface layer of soil. Soil was 24% clay, 24% silt, and 52% sand, with 8.8 meq cation exchange capacity/l00 g, 2.75% $CaCO_3$, 225 kg available N/ha, 0.25% organic carbon, 15.0 ppm available P, and 160 ppm K.

The 1974-82 experiment had eight treatments (Table 1) and was in a randomized block design with four replications. One-half N and all P and K were applied before transplanting rice or sowing wheat. The remaining N was topdressed in 2 equal splits at 3 and 6 wk of crop growth. Because of acute Zn deficiency, 25 kg $ZnSO_4$/ha was applied to both crops. N, P, and K sources were urea, single superphosphate, and muriate of potash. Recommended agronomic practices were followed, and yield data were separately recorded. Samples were collected from the 0-15 cm soil layer after the 1982 wheat harvest, ground to pass through a 2-mm sieve, and analyzed for available P and K.

N application significantly improved rice and wheat grain yields (Table 1). The increase was 2.7 to 4.2 t/ha for rice and 1.8 to 3.7 t/ha for wheat. Applying P did not increase yield of either crop earlier in the experiment because soil had high available P. After 1978, however, rice responded because soil P had declined in the N-alone treatment (Table 2). K application did not affect yield of either crop, indicating that continuous cropping of rice and wheat for 8 yr had not substantially depleted available K (Table 2). □

Table 1. Grain yield of rice and wheat in a long-term fertilizer experiment at Karnal, India.

Fertilizer treatments[a]		Yield (t/ha)					
		Rice			Wheat		
Rice	Wheat	1974	1981	Av of 8 yr	1974–75	1981–82	Av of 8 yr
$N_0P_0K_0$	$N_0P_0K_0$	3.8	3.4	3.4	0.8	2.4	1.2
N_{100}	N_{100}	6.6	6.4	7.0	4.1	5.4	4.2
$N_{100}P_{22}$	$N_{100}P_{22}$	6.6	7.6	7.5	3.7	5.6	4.1
$N_{100}P_{22}$	N_{100}	6.6	7.7	7.4	4.1	5.6	4.2
N_{100}	$N_{100}P_{22}$	7.2	7.5	7.5	3.9	5.7	4.2
$N_{100}P_{22}K_{42}$	$N_{100}P_{22}K_{42}$	7.1	7.1	7.3	4.1	5.9	4.2
$N_{100}P_{22}K_{42}$	N_{100}	6.4	7.7	7.4	4.0	5.6	4.2
N_{100}	$N_{100}P_{22}K_{42}$	6.8	6.8	7.1	4.1	5.6	4.2
CD at 5%		.10	.09	.05	.08	.03	.03

[a]Numbers refer to kg N, P, and K/ha. Dose of fertilizer N was raised from 100 to 120 kg/ha from the 1978 rice crop.

Table 2. Available P and K status of sodic soil after a continuous 8-yr rice - wheat sequence, Karnal, India.

Treatment		Available P	Available K
Rice	Wheat	(ppm)	(ppm)
Initial value 1974		15.0	160.0
after wheat 1981–82			
$N_0P_0K_0$	$N_0P_0K_0$	12.0	153.7
N_{100}	N_{100}	5.7	152.5
$N_{100}P_{22}$	$N_{100}P_{22}$	18.0	156.2
$N_{100}P_{22}$	N_{100}	13.5	157.5
N_{100}	$N_{100}P_{22}$	10.3	152.5
$N_{100}P_{22}K_{42}$	$N_{100}P_{22}K_{42}$	18.5	183.7
$N_{100}P_{22}K_{42}$	N_{100}	10.7	173.7
N_{100}	$N_{100}P_{22}K_{42}$	11.5	175.0
CD at 5%		3.3	15.2

Applying basic slag to increase yield of a rice — wheat rotation

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In 1981-1982 we evaluated the effect of applying basic slag and P fertilizer on rice and wheat planted in acid laterite soils of Purulia, West Bengal. The physicochemical characteristics of the soils in the experimental farmer fields are in Table 1.

Basic slag (100 mesh) containing 32.80% CaO and 1.61% P (2% citric acid soluble) was applied in 3 treatments: control; no basic slag; 1.25 to 2.50 t basic slag/ha, based on soil texture; and equal parts basic slag and well-rotted farmyard manure (FYM). Treatments were in 3 replications with 60-13-25 kg NPK/ha for rice IET2233 and wheat UP262. Sites I and II received 1.25 t basic slag/ha and site III received 2.50 t/ha. The mean pooled data for 1981-82 are in Table 2.

Basic slag alone and mixed with FYM increased rice yield 19.4 and 39.4%. The residual effects of the amendments increased wheat yield 24.0 and 31.6%. Yield always increased more with basic slag and FYM, but results were statistically significant only at sites I and II for rice and only at site I for wheat. □

Table 1. Physicochemical characteristics of acid laterite soils in Purulia, West Bengal.

Site	Texture	pH	Organic carbon (%)	Total soluble salts (mmho/cm)	Av P (kg/ha)	Av K (kg/ha)
I	Loamy sand	4.80	0.32	0.14	6.39	108.98
II	Loamy sand	4.70	0.20	0.06	5.40	99.62
III	Sandy loam	5.20	0.72	0.19	7.73	122.47

Table 2. Influence of basic slag on the yield of paddy and wheat in double crop sequences at Purulia, West Bengal.

Treatment	Yield (t/ha)			
	Site I	Site II	Site III	Mean
	Rice			
Control	2.7	2.6	3.2	2.8
1.25 or 2.50 t basic slag	3.0	2.9	4.1	3.4
Basic slag + FYM	3.9	3.8	4.1	3.9
CD at 5%	0.6	0.4	0.3	
	Wheat			
Control	1.9	1.9	2.2	2.0
1.25 or 2.50 t basic slag	2.1	1.9	3.4	2.5
Basic slag + FYM	2.6	2.2	3.2	2.6
CD at 5%	0.4	0.5	0.9	

Nursery age, field duration, and grain yield of rice

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We studied the effect of nursery age on the time of 50% flowering, maturity, and grain yield of rice. Seedlings aged 25, 30, 35, 40, and 45 d were transplanted on the same day in 1983-84 wet and dry seasons. In wet season, TKM9, a 105-d variety, was sown in Jun. In dry season, AD9408, a 125-d variety, was sown in Oct. NPK at 75-17-31 kg/ha was applied in wet season and 100-22-42 in dry season.

Effect of seedling age on 2 rice characteristics and yield, Aduthurai, India.

Seedling age (d)	Wet season			Dry season		
	Time to 50% flowering (d)	Time to maturity (d)	Grain yield (t/ha)	Time to 50% flowering (d)	Time to maturity (d)	Grain yield (t/ha)
25	51	82	6.0	64	95	4.3
30	48	81	5.9	62	94	4.2
35	45	79	5.7	61	93	4.2
40	43	77	5.7	57	92	4.0
45	42	77	5.2	57	92	4.0
CD (P = 0.05)	2	1	0.4	2	2	0.5

A 20-d difference in nursery age (25- to 45-d-old seedlings) produced a difference of 8 d in 50% flowering in wet season and 6 d in dry season. The difference in maturity was 4 d for both seasons (see table). It took less time (30 d) for seedlings planted at 25 d to go from 50% flowering to maturity than for those planted at 45 d (35 d).

Planting older seedlings reduced wet season yield, but did not affect yield in dry season. □

Evaluation of conventional, slow-release, and nitrification-inhibitor-treated fertilizers for rice in an alkali soil

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In India, crop growth is reduced on 2.5 million ha of alkali (sodic) soils that have excess exchangeable sodium, high pH, and poor hydraulic conductivity. To increase productivity, farmers apply gypsum or iron pyrites, after which rice is grown as the first crop because it tolerates soil alkalinity. Proper N management during and after reclamation is important.

We evaluated conventional, slow-release, and nitrification-inhibitor-treated fertilizers in a pot experiment in 1981 wet season. Ceramic pots were filled with 6 kg of surface soil from a barren alkali patch (sandy loam, Calciorthid aquic Natrustalf, pH 10.5, EC_2 0.57 mmho/cm, 12.1 meq cation exchange capacity/100 g, 3.02% $CaCO_3$, 0.12% organic carbon, 0.038% total N, 40 kg available N/ha, 40 ppm Olsen's P, and 332 kg available K/ha). Twenty-five percent of the required gypsum was surface-mixed, then leached for 28 d. Final in situ pH was 9.5. Forty five-d-old seedlings were transplanted after 12.5 ppm $ZnSO_4$ was mixed in the surface 5 cm and the pots were flooded with 2.5 cm water. Each pot had 4 hills with 2 Pusa 2-21 plants/hill, in 5 replications.

After 4 d, when only a film of water remained on the surface, N fertilizer (60 ppm N) was broadcast and incorporated in the surface 5 cm soil. The pots were immediately flooded to 5 cm depth, and

Effect of conventional, slow-release, and nitrification-inhibitor-treated fertilizers on rice yield and N uptake in an alkali soil, Haryana, India. [a]

Treatment	25 DT			45 DT			Maturity			
	DM (g)	N uptake (mg)	N uptake efficiency [b] (%)	DM (g)	N uptake (mg)	N uptake efficiency [b] (%)	Straw (g)	Grain (g)	N uptake (mg)	N uptake efficiency [b] (%)
No N	3.2	32.1	–	3.4	35.5	–	4.0	1.3	41.9	–
Urea	6.1	138.2	29.5	15.0	131.1	26.6	14.5	9.4	176.0	37.2
Urea [c]	4.1	57.7	21.3	9.5	101.7	27.6	16.4	12.1	245.5	56.5
Ammonium sulfate	5.2	141.2	30.3	11.3	139.2	28.8	17.4	11.8	218.7	49.2
Ammonium sulfate [c]	3.2	71.7	33.0	11.3	125.8	37.6	14.1	11.7	211.3	47.0
Sulfur-coated urea	3.4	73.3	11.5	8.4	92.9	16.0	9.8	8.6	179.8	38.3
Neem cake-blended urea	4.5	101.4	19.3	17.7	159.8	34.5	14.5	14.0	217.7	48.8
Coal tar extract-treated urea	6.0	121.8	24.9	16.8	159.8	34.5	14.7	11.1	179.5	38.2
N-serve treated urea	5.0	121.1	24.7	11.8	125.5	25.0	14.1	9.7	166.9	34.7
LSD (P = 0.05)							4.8	5.5		

[a] DT = d after transplanting, DM = dry matter. [b] Apparent N uptake efficiency = $\frac{\text{N uptake in treatment} - \text{N uptake in control}}{\text{N applied}} \times 100$. [c] Split application.

maintained there throughout the experiment. Urea and ammonium sulfate were applied singly or in 3 equal splits at 4, 25, and 45 d after transplanting (DT). Sulfur-coated urea (SCU) at 38.6% N, coal tar extract (4 ml/l00 g urea)-treated urea (CEU), neem cake (20% wt/wt of urea)-blended urea (NCU), and N-serve (1% of N in acetone)-treated urea were the other treatments (see table). One pot each was used at 25 and 45 d to record dry matter (DM) accumulation and N uptake.

Urea and ammonium sulfate had similar yields at all stages. Slow-release and nitrification-inhibitor-treated fertilizers had little effect except for the slight response to CEU and NCU at the second stage and NCU at maturity. N release from SCU did not meet the plant N requirements. Lack of response to nitrification inhibitors could be due to heat-labile components in the coal tar extract and N-serve, which decompose in tropical temperatures. □

Response of rice to phosphorus fertilizer in different crop rotations

R. S. Rekhi and O. P. Meelu, Soils Department, Punjab Agricultural University (PAU), Ludhiana, India

Most fertilizer recommendations are based on fertilizer response data for a single crop. For efficient use of a limited input like P, however, residual effects should be considered when formulating fertilizer use recommendations for different cropping sequences.

In 1979-83 we evaluated fertilizer P requirements for field rotations of wheat - rice, wheat - maize (fodder) - rice, and berseem - rice. The rabi crops of wheat and berseem *Trifolium alexandrinum* L. received the recommended dose of 120, 13, 25 and 25, 32.7, 0 kg NPK/ha. The following rice crop was grown with 0, 13, or 26 kg P/ha to determine the crop's relative response to residual P. Soil was a nonsaline loamy sand with pH 8.2, 0.17% organic carbon, and low available P. PR106 rice was transplanted the 4th wk of Jun in the wheat - rice and wheat - maize - rice rotations. In the berseem - rice rotation, short-duration Palman 579 was planted in 1980-82 and PR103 was planted in 1983. Rice was transplanted about 20 Jun to be harvested in late Sep to allow timely sowing of berseem.

Rice did not respond significantly to direct P application in the three rotations (see table), indicating that P need not be applied to rice if the preceding rabi crop (wheat or berseem) has received recommended P fertilization. □

Effect of P application on rice yield in different crop rotations at PAU, Ludhiana, India.

P level (kg/ha)	Rice grain yield (t/ha)				
	1980	1981	1982	1983	Mean
	Wheat - rice				
0	7.2	6.6	6.5	6.4	6.7
13	6.9	6.2	6.8	6.4	6.6
26	7.3	6.5	6.6	6.3	6.7
CD	ns	ns	ns	ns	
	Wheat - maize - rice				
0	7.1	6.3	6.2	6.0	6.4
13	7.3	7.0	6.2	6.4	6.7
26	7.3	6.2	6.3	6.4	6.6
CD	ns	ns	ns	ns	
	Berseem - rice				
0	5.8	5.5	5.3	7.4	6.0
13	5.3	5.7	5.3	7.4	5.9
26	5.4	5.9	5.7	7.2	6.0
CD	ns	ns	ns	ns	

Farmyard manure (FYM) in a rice - wheat rotation

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Organic manures can play an important role in soil productivity and crop yield. We sought to quantify N economy when FYM is applied to rice, and to ascertain the residual effect of the application on the succeeding wheat crop.

The 1979-83 experiment at the PAU Farm used a nonsaline loamy sand with pH 8.5, EC 0.25 mmho/cm, 0.24% organic carbon, and 90-70-146 kg available NPK/ha.

The FYM contained 0.63-0.30-0.90% NPK, and was applied at 12 t/ha, which added 76-36-108 kg NPK/ha to the soil.

Our data show that grain yield with 80 kg N and 12 t FYM/ha was comparable to that with 120 kg N/ha (Table 1).

Table 1. Effect of FYM application on rice yield, Ludhiana, India.

Treatment		Grain yield (t/ha)					
N (kg/ha)	FYM (t/ha)	1979	1980	1981	1982	1983	Mean
0	0	3.4	3.5	2.0	2.6	2.7	2.9
0	12	4.2	4.7	2.8	3.4	3.6	3.7
40	12	5.1	5.5	3.8	4.3	4.6	4.7
80	12	6.4	6.6	4.5	5.8	5.6	5.8
120	0	6.1	6.5	4.2	5.6	5.5	5.6

Rice - wheat is a common rotation in Punjab. A basal dose of 90-13-25 kg NPK/ha was applied to all wheat treatments except the control, and a standard 120-26-25 kg NPK/ha treatment.

Applying 90-13 kg NP/ha to wheat increased yield over the control (Table 2). Grain yield was 0.9 t/ha more if FYM was applied to the previous rice crop. This yield was comparable to that obtained with the recommended 120-26 kg NP/ha. The results indicate that applying 12 t FYM/ha to rice gave a residual effect equivalent to that from 30 kg N and 13 kg P/ha for the succedding wheat crop. □

Table 2. Residual effect of FYM applied to rice on a succeeding wheat crop, Ludhiana, India.

Site no.	Treatment N (kg/ha)	Treatment P (kg/ha)	Grain yield[a] (t/ha)
1	0	0	1.4
2	90	13	3.4
3	90	13	4.3 [b]
4	120	26	4.2

[a] Av of 4 yr. [b] 12 t FYM/ha was applied to the previous rice crop.

Response of rice and wheat to zinc fertilization in alkali soils

M. V. Singh and I. P. Abrol, Central Soil Salinity Research Institute (CSSRI), Karnal 132001, India

Large areas of alkali land in the Indo-Gangetic plains are not cultivated. At the Gudda experimental farm, CSSRI, we evaluated responses to Zn application of rice and wheat on an alkali soil with pH 10.45, EC 4.08 dS/m, 94% exchangeable sodium percentage, 3.73% $CaCO_3$, 20% clay, 26% silt, 54% sand, 28 t gypsum requirement/ha, and 0.44 ppm DTPA-Zn.

Zero, 10, 20, 40, 80, and 120 kg $ZnSO_4$/ha were applied in a randomized block design with 4 replications, and 14 t gypsum/ha was surface broadcast and mixed in the upper 8-10 cm soil. Jaya rice and HD2009 wheat were grown in sequence. $ZnSO_4$ and 75 kg N/ha as urea were applied basally and the remaining 75 kg N/ha was topdressed in 2 equal splits 3 and 6 wk after planting.

Rice plants in the Zn control plots were stunted and had visible Zn deficiency symptoms. Grain yield and Zn uptake by rice and wheat crops were significantly less in the control than in Zn-treated plots.

Applying 10 kg $ZnSO_4$/ha significantly increased available Zn and grain yield of both crops (see table). Applying 20 to 120 kg $ZnSO_4$/ha did not increase yield over that with 10 kg $ZnSO_4$.

Effect of Zn on the yield and Zn uptake by rice and wheat crops in alkali soil, Karnal, India.

$ZnSO_4$ added (kg/ha)	Grain yield (t/ha)							Zn uptake (g/ha)				DTPA-Zn (ppm) after	
	Rice				Wheat			Rice		Wheat		Wheat	Rice
	1980	1981	1982	1983	1980-81	1981-82	1982-83	1980	1983	1980-81	1982-83	1982-83	1983
0	5.1	5.0	6.6	5.0	1.2	1.4	2.0	144	151	28	41	0.44	0.41
10	6.0	6.1	7.5	6.0	1.6	2.2	2.9	198	302	66	105	1.87	2.06
20	6.0	5.8	7.7	6.2	1.7	2.4	2.9	221	319	73	129	3.09	3.54
40	6.0	5.9	7.5	6.1	1.6	2.2	3.1	235	273	79	139	6.05	7.00
80	6.0	5.7	7.5	6.2	1.7	2.3	3.1	244	407	108	163	10.95	12.58
120	6.0	5.7	7.5	6.1	1.6	2.4	3.0	253	414	113	193	15.45	18.13
CD (0.05)	0.61	0.62	0.67	0.26	0.36	0.60	0.32	25	29	7	22	.66	.89

Responses of rice to some trace elements

A. H. Gurmani, A. Bhatti, and H. Rehman, Agricultural Research Institute, Tarnab, Peshawar, Pakistan

We evaluated the effect of trace elements Zn, Cu, Fe, and Mn on yield at the Government Seed Farm Rakh Mangan, D. I. Khan, Northwest Frontier Province, Pakistan. Treatments were no fertilizer (control), NPK, NPKZn, NPKCu, NPKFe, NPKMn, NPKZnCu, and NPKFeMn. Zn, Cu, Fe, and Mn were applied at 5.0, 5.0, 2.5, and 2.5 kg/ha. NPK at 120, 40, and 50 kg/ha was applied as urea, single superphosphate, and potassium sulfate. Experiments were on two clay soils. One had pH 8.0, 11% $CaCO_3$, 0.79% organic matter, and 3 ppm Olsen's available P. The other had pH 8.2, 13% $CaCO_3$, 0.81% organic matter, and 3 ppm Olsen's available P.

With Cu and Fe application, yield increased more than 10% over NPK alone. There was some yield response to Zn and Mn, but the increase was not statistically significant (see table). Our preliminary studies show the soils are Cu and Fe deficient either in absolute quantity or in availability to rice.

Effect of trace elements on rice yield, Peshawar, Pakistan.

Treatment		Paddy yield[b] (t/ha)		Increase (%) over NPK
NPK (kg/ha)	Trace[a] element	1982	1983	
0-0-0	O	5.3 c	5.1 f	–
120-40-50	O	7.4 c	6.5 e	–
120-40-50	Zn	7.7 ab	6.6 de	3.2
120-40-50	Cu	8.7 ab	6.9 cde	12.0
120-40-50	Fe	7.8 ab	7.7 ab	12.0
120-40-50	Mn	7.8 ab	6.8 cde	5.8
120-40-50	Zn+Cu	8.8 a	7.2 bc	15.4
120-40-50	Fe+Mn	8.0 ab	8.0 a	15.4
120-40-50	Zn+Cu +Fe+Mn	–	7.1 cd	–

[a]Zn = 5 kg/ha, Cu = 5 kg/ha, Fe = 2.5 kg/ha, Mn = 2.5 kg/ha. [b]Means followed by similar letters do not differ significantly at 5% level.

Relative efficiency of simple and complex fertilizers for rice

A. H. Gurmani, A. Bhatti, and H. Rehman, Agricultural Research Institute, Tarnab, Peshawar, Pakistan

We compared the effects of simple and complex fertilizers on the yield of IRRI-6 on 2 soils at the Agricultural Research Station, Dera Ismail Khan, Northwest Frontier Province of Pakistan, in 1982 and 1983. Fertilizers were urea (46%N), urea plus single superphosphate (SSP) (8.8% P), urea plus diammonium phosphate (DAP) (18% N and 20% P), and urea plus nitrophos (NP) (23% N and 10% P). N and P rates were 120 and 40 kg/ha. Soil was a clay loam with pH 7.9, 16.0% $CaCO_3$, and 6 ppm Olsen's available P in 1982. In 1983, the soil had pH 8.2, 18.5% $CaCO_3$, and 11.5 ppm Olsen's available P.

Applying urea plus DAP produced better yields than urea plus NP. The urea plus DAP treatment yielded highest in 1982 (see table), but yields were similar in 1983. In 1983, urea plus DAP pro-

Effect of simple and complex fertilizers on rice yield, Peshawar, Pakistan.[a]

Treatment NPK (kg/ha)	Fertilizer	Grain yield (t/ha)			Straw[b] yield (t/ha)	Value cost ratio[c]	panicles[b]/m^2
		1982	1983	Mean			
0-0-0	No fertilizer	4.8 d	5.8 b	5.3 b	6.3 b	–	270 c
120-0-0	Urea	7.2 c	7.3 a	7.3 a	14.0 a	4.37	346 bc
120-40-0	Urea+ SSP	7.6 b	8.2 a	7.9 a	14.1 a	4.04	395 ab
120-40-0	Urea+ DAP	7.9 a	8.0 a	8.0 a	14.9 a	4.06	424 a
120-40-0	Urea + NP	7.1 c	7.3 a	7.2 a	12.3 a	2.58	387 ab

[a]Means followed by similar letters do not differ significantly at 5% level. [b]1983 data on a fresh weight basis. [c]Value of rice = $10/100 kg. Cost of fertilizers: urea, $19.00/100 kg; SSP, $14.14/100 kg; DAP, $17.28/100 kg; NP, $13.85/100 kg. Value of straw is not included.

duced the highest straw yield and panicles /m^2. Urea plus DAP yielded the highest net return – a value cost ratio of 4.06.

DAP is a better complex fertilizer for rice than the others tested. Response to NP was poor because it contains 9% nitrate N, which is susceptible to leaching and denitrification. □

Nitrogen fertilization for short-duration rices

P. Balasubramaniyan, assistant professor, Tamil Nadu Rice Research Institute (TNRRI), Aduthurai, India

Short-duration (105-110 d) rice varieties are grown Jun-Sep in the Cauvery Delta. We evaluated the response of ADT31 (1981) and ADT36 (1982) to 0, 30, 60, 90, and 120 kg N/ha. Soil at TNRRI is a clay loam with low available N and pH 7.5. Urea was applied 50% basal, 25% at tillering, and 25% at panicle initiation. P and K at 50 kg/ha were applied basally. Plant height and number of panicles/hill were recorded at flowering and the grain yield at 14% moisture.

Effect of different N levels on plant height and panicles/hill at flowering and grain yield of short-duration varieties, Aduthurai, India.

N (kg/ha)	ADT31			ADT36		
	Height (cm)	Panicles/ hill	Grain yield (t/ha)	Height (cm)	Panicles/ hill	Grain yield (t/ha)
0	75	4.0	3.4	68	4.9	3.5
30	82	4.6	4.5	74	5.4	4.1
60	87	5.3	4.7	76	5.9	4.8
90	91	5.6	5.2	78	6.2	5.1
120	93	5.9	6.1	81	6.5	5.5
CD (P0.05)	2	0.5	0.6	3	0.4	0.3

Both varieties grew taller with increased N. Maximum height was at 120 kg N/ha. Number of panicles/hill did not increase significantly between 90 and 120 kg N/ha. ADT31 yields at 90 and 120 kg N/ha were similar and ADT36 yielded significantly higher at 120 kg N/ha (see table). □

Preventing zinc deficiency in wetland rice

M. S. Maskina, Soils Department, Punjab Agricultural University, Ludhiana 141004, India

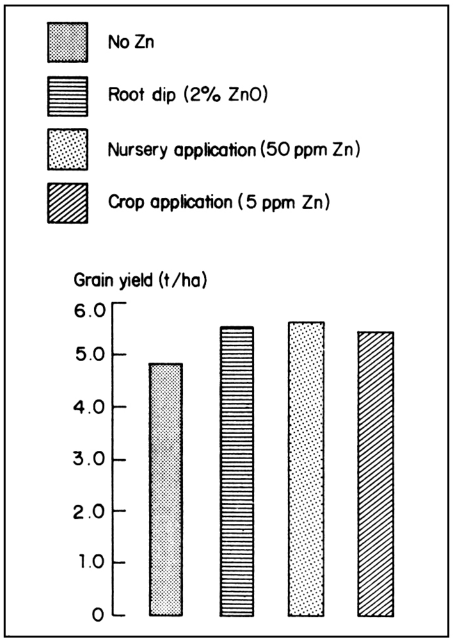
Zn fertilizer application is becoming important as more land with Zn deficiency is discovered. Cheap, efficient Zn sources must be identified and application methodology improved. We studied the

Table 1. Soil characteristics in Zn application trials in Ludhiana, India.

Soil characteristic	Pot experiment	Field experiment
pH	8.6	8.8
Organic C (%)	0.39	0.37
Ec (mmho/ cm)	0.20	0.13
Texture	Sandy loam	Sandy clay loam
Zn (ppm)	0.36	0.35

Table 2. Methods of Zn application and Zn content of wetland rice, Ludhiana, India.

Method	Zn content (ppm) at different plant ages				
	16 d	32 d	48 d	64 d	Grain maturity
No Zn	20	22	24	18	18
Root dip	85	46	38	34	29
Nursery application	112	35	31	28	28
Crop application	37	33	28	28	28
CD at 5%	5.6	6.5	3.9	4.7	2.7



Methods of Zn application and rice yield, Ludhiana, India.

relative efficiency of Zn sources and application methods for control of Zn deficiency in wetland rice PR106. The experiment was conducted for 1 yr in a greenhouse with ^{65}Zn and repeated for 2 yr in the field to test the validity of the greenhouse study. Soil characteristics are in Table 1.

Treatments were control (no Zn); 50 ppm Zn as $^{65}ZnSO_4$ at nursery sowing; dipping nursery seedlings in 2% ^{65}ZnO suspension before transplanting; and 4.5 ppm Zn as $^{65}ZnSO_4$ at transplanting. Recommended fertilizer doses were applied.

In the greenhouse, Zn content of treated plants was higher than in the control. Early in crop growth, nursery plants enriched with Zn at sowing or as a root dip had relatively higher Zn content than plants receiving Zn at transplanting (Table 2).

Percent Zn in plants was calculated using radioactive zinc (^{65}Zn):

$$\% \text{ Zn from the upland source} = \frac{\text{specific activity of the sample}}{\text{specific activity of the added source}} \times 100$$

Applied Zn contributed 69, 45, and 52% of the total Zn removed by 64-d-old plants in nursery dip, nursery bed application, and crop application treatments.

Rice grain yield in the field experiments confirmed the greenhouse results. Zn-treated plots yielded 0.6–0.8 t/ha more than the control, but there were no significant differences among Zn treatments (see figure). In the seedling dip treatment, 1 kg ZnO was enough to treat a nursery large enough to transplant 1 ha. Treatment efficiency was similar, but the seedling root dip was most cost efficient, followed by nursery bed application. □

Rice-based cropping systems

Rice - wheat rotation for higher production

R. N. Trikha, Agricultural Communication Department, G. B. Pant University of Agriculture and Technology, Pantnagar 263145, Uttar Pradesh, India

Rice - wheat rotations produced consistently high yields in 909 demonstrations conducted at 17 sites in farmer fields from 1966 to 1982. Sites were in different agroclimatic zones in Uttar Pradesh.

Rice varieties planted were TN1, IR8, and Jaya. Wheat varieties were Sonora 64, Kalyan sona, and Sonalika.

Mean annual yield was 10.6 t/ha (6.0 t rice and 4.6 t wheat). Rice yield ranged from 5.1 to 6.6 t/ha. In a long-range demonstration in a farmer field, the mean rotation yield was 10.4 t/ha (6.0 t rice and 4.4 t wheat). The highest rice yield was 7.5 t/ha in 1981–82.

Average production cost was $331.60 and net profit was $463.20/ha for the rotation. □

Announcements

Conklin awarded Fyssen Foundation prize

Harold C. Conklin, honorary visiting associate scientist at IRRI, was awarded the annual Fyssen Foundation prize for 1983.

The Fyssen Foundation of France, established in 1979, each year recognizes outstanding scientists for their work in such fields as anthropology, ethology, neurology, psychology, paleontology, and archeology. Among those who have received past awards are anthropologist Andre Leroi-Gourhan, ethologist William Thorpe, and neurologist Vernon Mountcastle.

Conklin is an American anthropologist and major innovator in ethnoscience, and a long-time IRRI cooperator. He is known for his work with the Hanunoo and Ifugao cultures in the Philippines and his *Atlas of Ifugao.*

During his acceptance speech, Conklin emphasized the importance of close work with informants and paid special tribute to them as "indispensable coinvestigators and interpreters of other cultural works . . . It is through their knowledge of the social and natural environment that we come to a better understanding of cultural patterns and their evolution." □

Ponnamperuma onored

F. N. Ponnamperuma, IRRI principal soil chemist, has been awarded the Doctor of Science degree by the University of London. Ponnamperuma has worked with IRRI since 1961 and is noted for his work on the chemistry of submerged soils and the nutrition of the rice plant. □

Swaminathan is awarded the R. B. Bennett Commonwealth Prize

M. S. Swaminathan, IRRI director general, has been awarded the 1984 R. B. Bennett Commonwealth Prize by the British Royal Society for the Encouragement of Arts, Manufactures, and Commerce. Swaminathan is cited for his contributions to agriculture through his work with IRRI, the Government of India, and the Food and Agriculture Organization.

The Prize was instituted in 1944 and is awarded every 3 yr for outstanding contribution to the promotion of the arts, agriculture, industries or commerce in the Commonwealth overseas. □

New IRRI publications

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

Cropping systems in Asia: on-farm research and management, by M. Z. Hoque
A farmer's primer on growing rice (in French), by B. S. Vergara
Annual report for 1983
Terminology for rice growing environments
Workshop on judicious and efficient use of insecticides on rice
International bibliography on azolla 1983 supplement □

The International Rice Research Newsletter and the IRRI Reporter are mailed free to qualified individuals and institutios engaged in rice production and training. For further information write: IRRI, Communication and Publications Dept., Division R, P. O. Box 933, Manila, Philippines.

ERRATA

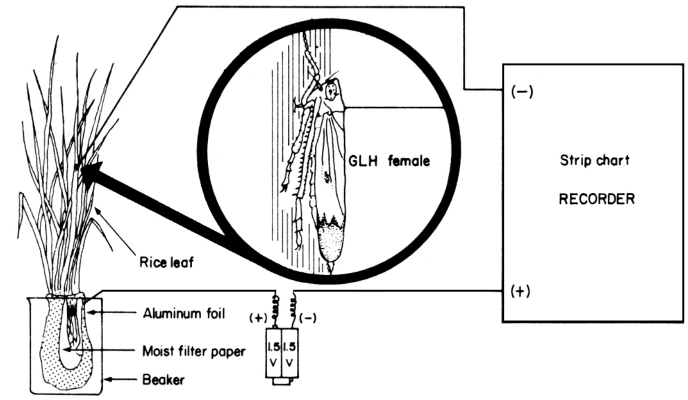
Reprinted, with corrections, from the August issue.

Electronically recorded waveforms associated with feeding behavior of green leafhopper (GLH)

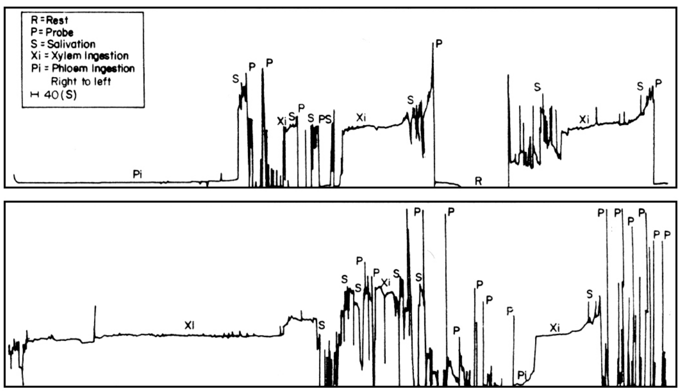
Z. R. Khan, postdoctoral fellow, Entomology Department, IRRI; and R. C. Saxena, principal research scientist, International Centre of Insect Physiology and Ecology, Kenya, and associate entomologist, IRRI

We used an electronic feeding recorder to monitor GLH *Nephotettix virescens* feeding on GLH-susceptible and resistant plants.

A fine (18mμ), 5-cm-long gold wire was attached to the dorsum of an 8- to 10-h-old GLH female by silver paint. The insect was starved for 2 h and then placed on the leaf blade of a 30-d-old susceptible TN1 or resistant ASD7 rice plant. The gold wire was connected to the negative input terminal of a D. C. chart recorder. The voltage source was two 1.5 V D. C. batteries connected in a series. The positive battery terminal was connected with the plant roots through aluminum foil and moistened filter paper (Fig. 1). The negative battery terminal was connected with the positive input terminal of the chart recorder. GLH feeding activity was monitored for 180 min at a chart speed of 1.5 cm/min.



1. Schematic diagram of circuit and equipment for recording GLH feeding on rice, IRRI.



2. Waveforms recorded during, GLH feeding on susceptible TN1 (top) and resistant ASD7 (bottom) rice varieties using an electronic monitoring device, IRRI.

The waveforms recorded for GLH showed distinct differences in the feeding activity on susceptible and resistant plants (Fig. 2). On susceptible TN1, the GLH probed readily and ingested for longer durations from the phloem (Pi), although initially the insect also sucked small amounts of xylem sap (Xi). On resistant ASD7, the insect made brief and repeated probes followed by salivation and feeding mainly from the xylem. □

A. K. Roy. Inhibitory effect of *Aspergillus terreus* Thom against *Rhizoctonia solani* f. sp. *sasakii.* 9(3) (Jun 1984):

Page 13: In the first line of the figure caption, "(from left)" should read "(from right)."

M. O. Mabbayad and K. Moody. Effect of time of herbicide application on crop damage and weed control in wet-seeded rice. 9(3) (Aug 1984):

Page 22: In column 1 of the table, "DPX 5384 (0.5)" should read "DPX 5384 (0.05)."

R. C. Saxena and C. V. Mujer. Enzyme polymorphism in rice brown planthopper (BPH). 9(4) (Aug 1984):

Page 19: First line of column 1: "Pgi^{35}" should read "Pgi^{95}." Last line of column 2: "PCI" should read "PGI."

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