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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 style and guidelines:

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 of 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 for the *IRRN*. Data in other currencies should he converted to US$.

• Abbreviate names of standard units of measure when they follow a number. For example: 20 kg ha.

• When using abbreviations other than for units of measure, spell out in full the first time of reference, with abbreviations in parenthesis, then use the abbreviation throughout the remaning 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 10 or some numbers 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, 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 have quantified data (% infection, degree of severity, etc.).

Genetic evaluation and utilization

OVERALL PROGRESS

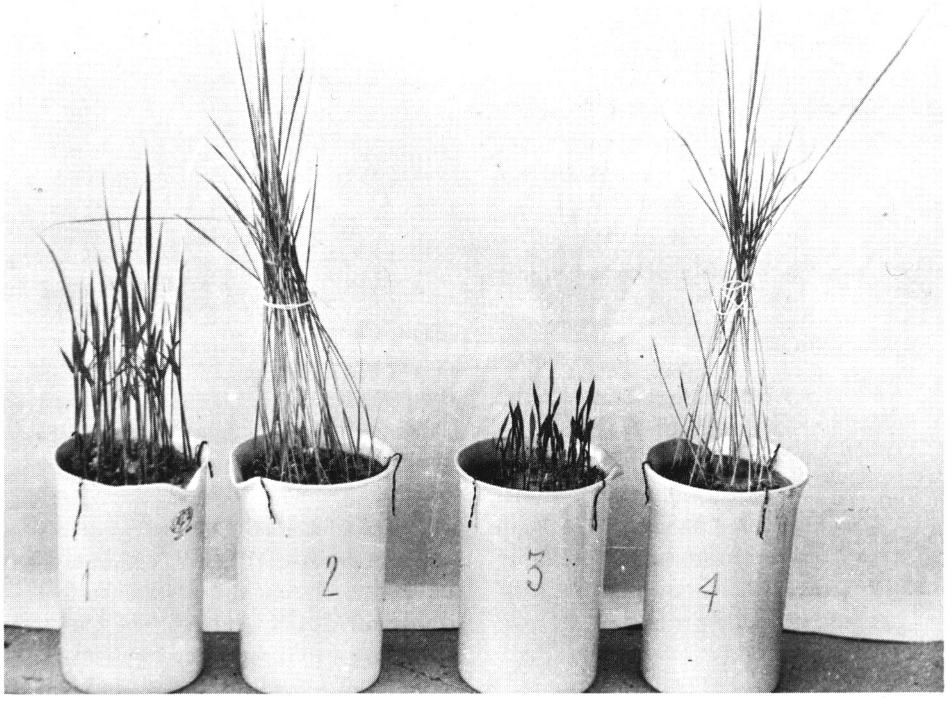
A new rice form with low endogenous gibberellin content

E. R. Avakyan, N. E. Alyoshin, E. V. Alexeenko, and E. P. Alyoshin, All-Union Rice, Research Institute (AURRI), P. O. Belozyornoe, Krasnodar 352204, USSR

AURRI has developed a rice mutant called Alexeenko from the traditional variety Krasnodarsky 424 by chemical mutagenesis. Alexeenko is an ultradwarf that is less than 25 cm tall at maturity and has 10-cm-long panicles (Fig. 1).

The physiological and biochemical properties of fifth-generation mutant plants (M_5) were compared with those of Krasnodarsky 424. To determine the endogenous gibberellins, the rice plants were grown in water culture without gibberellic acid (GA) and with 0.001% GA until 2-leaf stage (Fig. 2) and the

1. Alexeenko, an ultra-dwarf mutants.



2. Krasnodarsky (1) and Alexeenko (3) without gibberellic acid, compared with Krasnodarsky (2) and Alexeenko (4) treated with 0.001% gibberellic acid. Alexeenko showed 6 times more reaction.

Reaction of Alexeenko and Krasnodarsky to exogenous gibberellic acid.

	Krasnodarsky 424	Krasnodarsky 424 + GA (0.001%)	Alexeenko	Alexeenko + + GA (0.001%)
RNA, seedling leaves (mg/g fresh matter)	5.693	5.399	6.485	4.470
DNA, seedling leaves (mg/g fresh matter)	1.047	1.072	0.968	0.860
RNA/DNA, leaves	5.4	5.0	6.7	5.2
RNA, seedling roots (mg/g fresh matter)	6.417	9.313	4.612	7.375
DNA, seedling roots (mg/g fresh matter)	0.969	1.674	0.647	1.028
RNA/DNA, roots	6.6	5.6	7.1	7.2
Protein, seedling leaves (% of fresh matter)	6.4	5.2	7.1	4.3
Protein, seedling roots (% of fresh matter)	6.2	5.6	4.4	7.4
Chlorophyll, seedling leaves (mg/g fresh matter)	1.8	0.9	1.6	1.0
Carotenoids, seedling leaves (mg/g fresh matter)	0.4	0.2	0.4	0.3
Silica, mature plant straw (% of dry matter)	6.0		20.0	

length of the first real leaf sheath was measured.

Alexeenko had six times more reaction to exogenous GA than Krasnodarsky 424 (Fig. 2), perhaps because of the possible transformation of endogenous gibberellins biosynthesis genes which may have decreased gene activity. This transformation also changed plant morphology, nucleic acid and protein metabolism, pigment content, and silica content of straw from mature plants (see table).

Alexeenko will be used in breeding semidwarf rice varieties. ☐

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

GENETIC EVALUATION AND UTILIZATION

Disease resistance

Field screening for sheath blight and rice root nematode resistance

C. Gokulapalan and M. C. Nair, Plant Pathology Department, College of Agriculture, Vellayani, 695522, Kerala, India

Ten rice varieties were field screened for resistance to sheath blight (ShB) *(Rhizoctonia solani)* and rice root nematode *(Hirschmanniella oryzae* Soltwedel, Luc and Goodey) at the State Seed Farm, Adoor, Kerala, where both problems are common. It was observed that high nematode incidence encourages severe ShB infection.

Table 1. Reaction of rice varieties to sheath blight.

Variety	Hill infection (%)	Disease index
Bharati	57	1.34
Rohini	60	1.77
Sabari	58	2.04
CO 25	69	2.77
IR8	70	3.27
Annapurna	73	3.29
Jaya	74	3.37
Triveni	72	4.56
PTB12	77	5.06
Jyothi	78	6.73
CD	1.371	0.536

Table 2. Population of rice root nematode *Hirschmanniella oryzae* in roots of different rice varieties.

Variety	Nematodes/10-g root sample	
	Healthy plants	Diseased plants
PTB12	3.45	4.19
Annapurna	2.83	4.28
Triveni	4.04	4.32
Jaya	3.50	5.03
Bharati	3.81	5.37
Sabari	3.44	5.55
Rohini	4.98	5.65
CO 25	4.56	5.81
IR8	4.18	6.08
Jyothi	3.46	6.22
CD	0.445	0.853

Disease intensity and percent hill infection were recorded for both problems, using standard methods.

Bharati and Rohini had significantly lower levels of disease intensity, followed by Sabari, CO 25, IR8, Annapurna, and Jaya (Table 1). Maximum disease intensity was recorded for Triveni, PTB12, and Jyothi. Bharati, Sabari, and Rohini also had significantly lower hill infection. All varieties were susceptible to rice root nematode (Table 2). Roots of plants with ShB had significantly more nematodes than roots of healthy plants (Table 2).

Trials conducted at IRRI indicate only a few rice varieties have ShB resistance. In Kerala, not one of 36 evaluated have ShB resistance. ☐

Leaf scald disease of rice at Ponnampet, Karnataka, India

K. T. Pandurangegowda, N. A. Janardhanagowda, and R. C. Yaraguntaiah, Regional Research Station, V. C. Farm, Mandya, India

Ponnampet is a high-elevation area near the Malnad Mountains of India. Rice cultivation is intensive and blast disease is a serious problem. During 1982 kharif, leaf scald (LSc) (caused by Rhynchosporium oryzae) incidence was higher than normal in experimental plots and farmers' fields.

We tested 20 rice cultivars for resistance to LSc at the Agricultural Research Station, Ponnampet, during 1982 kharif. Plot size was 1.2 × 4.5 m and cultivars were planted at 20- × 15-cm spacing in a randomized block design with 4 replications. Intan and BKB were resistant checks and Cauvery and Tellahamsa were

Reaction of promising rice cultures to leaf scald disease.

Cultivar	Cross	Disease reaction[a]	Cultivar	cross	Disease reaction[a]
		Resistant			
5742	Imp. Sabarmathi/ Sona	3	574 1	Imp. Sabarmathi/ Sona	4
6903	RP5-32/Pankaj	3	6466	Dasal/IR20	4
7150	(PTB10/N136-19) Pankaj	3	7191	RP5-32/Pankaj	5
			BKB	BKB	4
VL8	–	2	KMP106	75-203/IR34	6
Rasi	TN1/Co 29	3	IR54	–	6
Jaya	TN1/T141	2			*Susceptible*
Intan	–	3	6 254	IR20/IR5-1143	7
KMS5914	Sona/Mahsuri	2	6919	Pankaj/RP270-63-3	8
		Moderately susceptible	7296	–	7
			Cauvery	–	8
6056	CR44-35/W12708	5	Tellahamsa	–	7

[a]CD at 5% = 1.89, SEM = 0.94, CV% = 7.23, GM = 18.40. [a] By 1980 Standard Evaluation System for Rice.

susceptible checks. Plants were exposed to natural infection and disease incidence was rated using the 1980 Standard Evaluation System for Rice. The results are in the table. □

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GENETIC EVALUATION AND UTILIZATION

Insect resistance

Brown planthopper-resistant japonica varieties developed in Korea

J. O. Lee, H. G. Goh, Y. H. Kim, and C. G. Kim, entomologists, Institute of Agricultural Sciences; and S. K. Lee, plant breeder, Yeongnam Crops Experiment Station, ORD, Korea

In Korea, where brown planthopper (BPH) is the most serious rice insect, only hybrid cultivars have been released to farmers as resistant varieties. Among the released cultivars are several japonica varieties, but they are all susceptible to BPH.

Japonica varieties Milyang 64, Milyang 65, and Milyang 66 were developed as new elite lines at Yeongnam Crops Experiment Station in 1981. Milyang 64 was produced from a cross between Milyang 15 and Chok 48-1, and Milyang 65 and 66 were developed from crosses between Milyang 15 and Chok 48-5.

Seedling reactions of rice varieties to BPH biotypes 1, 2, and 3 were studied using the seedling bulk test. BPH biotype population increase was tested in a screenhouse.

Milyang 64 and 66 were resistant to biotypes 1 and 2 at seedling stage and Milyang 65 was resistant to biotype 1 (Tables 1 and 2). □

Table 1. Reaction of japonica varieties to BPH biotypes 1, 2, and 3.

Variety	Damage rating[a] Biotype 1	Biotype 2	Biotype 3
Milyang 64 (Milyang 15/Chok 48-1)	R	R	S
Milyang 65 (Milyang 15/Chok 48-5)	R	S	S
Milyang 66 (Milyang 15/Ch0k 48-5)	R	R	S
Milyang 23 (check)	S	S	S
Cheongcheongbyeo (check)	R	S	R
Milyang 63 (check)	R	R	S

[a]Based on seedling bulk test. R = resistant, S = susceptible.

Table 2. Population buildup of BPH biotypes on rice plants infested at 30 days after transplanting in the nethouse.

Variety	Populations[a] (no.) Biotype 1 45 DT	Biotype 1 60 DT	Biotype 1 75 DT	Biotype 2 45 DT	Biotype 2 60 DT	Biotype 2 75 DT
Milyang 64	0.2	2.3	2.0	7.3	270.3	–
Milyang 65	3.0	3.8	3.5	55.0	950.0	HB
Milyang 66	1.3	0.6	3.5	1.4	160.0	–
Milyang 23 (check)	46.0	330.0	HB	125.0	HB	HB
Cheongcheongbyeo (check)	0.1	2.0	3.2	25.1	1200.0	HB
Milyang 63 (check)	0.1	1.4	0.2	0.1	110.01	–

[a]Total number of insects per hill. DT = days after transplanting. HB = hopperburned.

The International Rice Research Newsletter (IRRN) invites all scientists to contribute concise summaries of significant rice research for publication. Contributions should be limited to one or two pages and no more than two short tables, figures, or photographs. Contributions are subject to editing and abridgement to meet space limitations. Authors will be identified by name, title, and research organization.

Hybrid rice

Evaluation of hybrid rices for ratooning ability

J. S. Chauhan, S. S. Virmani, R. Aquino, and B. S. Vergara, IRRI

Hybrid rice was developed in China. About 6 million ha of irrigated land are planted to F_1 hybrids that yield 20-30% more than the best semidwarf, nonhybrid varieties. Hybrid rice also should yield well in some rainfed lowland conditions on account of their early seedling and vegetative vigor and strong, deep, root system. A successful ratoon from the hybrid rice crop under rainfed lowland conditions might help compensate for the extra cost of hybrid seed, which is estimated to be three to four times more than that of nonhybrid varieties.

We evaluated 57 rice hybrids and 5 check varieties for ratooning ability at the IRRI farm in the 1983 dry season.

Hybrids and checks were ratooned by cutting the stalks 15 cm above the ground at maturity. Immediately after cutting 40 kg N/ha was topdressed. Ratooning ability was rated 3 weeks later.

Ratooning ability varied widely. IR56 and 14 hybrids perfomed consistently well in 2 or more replications. Mean regeneration for hybrids varied from 62 to 97% (see table). However, all had 70% or higher regeneration in at least 2 replications. IR56 had 90 to 100% regenerations, except in 1 of 9 plots where it had only 40 to 50%. However, it had only 10-11 tillers/hill and 8-9 panicles/hill. In some hybrids with relatively poor regeneration, missing hills were compensated for by the many tillers and panicles per successful hill. Hybrid ratoons were more vigorous than those of IR56.

Ratoon height Varied from 51 cm to 70 cm. Hybrid IR19657-34-2-2-3-3A/IR36 had the most tillers and panicles/m^2. Because the experiment ended before maturity, number of tillers and panicles/m^2 may not truly reflect yield potential.

Hybrids with IR19657-34-2-2-3-3A in their parentage had high regeneration and vigorous ratoons. Because the parents of the hybrids were not evaluated, it is difficult to predict the bases of good ratooning ability. Whether this parent line has dominant genes for ratooning ability or whether ratooning resulted from heterosis needs further investigation. In one of the crosses (IR19657-34-2-2-3-3A/IR36), however, good ratooning ability seems to be due to dominant gene(s) in the parent line because IR36 showed consistently poor ratooning.

Different responses of some hybrids and IR56 in different replications suggested that besides genetic factors, cultural management factors may influence ratooning ability. F_2 populations of the hybrids and their parents should be evaluated for ratooning in subsequent studies. □

Plant characters of rice hybrids screened for ratooning ability. IRRI, 1983 dry season (av of 3 replications).

Hybrid, variety	Regeneration (%)	Plant ht (cm)	Total tillers (no./m^2)	Tillers (no./hill)	Total panicles (no./m^2)	Panicles (no./hill)	Viral disease rating
IR19657-34-2-2-3-3A/IR56 [a]	70	65	279	11	189	8	1
IR10154-23-3-3A/IR15795-232-3-3-2 [b]	69	51	323	13	149	6	1
1R56 (check)	81	62	284	10	179	6	0
IR19657-34-2-2-3-3A/IR36 [a]	97	65	515	15	423	12	1
IR19657-34-2-2-3-3A/IR48 [c]	81	60	389	14	145	6	0
IR19657-34-2-2-3-3A/IR19661-364-1-2-3 [b]	68	61	329	14	171	8	0
IR19657-34-2-2-3-3A/1RI9735-5-2-3-2-1 [a]	93	64	485	15	420	13	0
IR19657-34-2-2-3-3A/IR19729-67-3	83	68	301	10	246	8	0
IR19657-34-2-2-3-3A/IR13146-45-2-3 [d]	62	58	325	15	401 [d]	18	0
IR19657-34-2-2-3-3A/IR10781-143-2-3 [e]	68	–	346	15	–	–	0
IR19799-17-3-1-1A/IR13420-6-3-3-1	83	55	349	12	231	8	0
IR19799-17-3-1-1A/IR2797-125-3-2-2	81	70	353	12	274	10	1
IR56 (check)	93	60	348	11	294	9	0
MR365A/IR19661-364-1-2-3 [a]	68	69	327	14	218	9	0
MR365A/IR19661-131-1-2 [b]	64	67	337	15	213	10	0
MR365A/IR48	80	65	378	14	307	9	1
IR56 (check)	93	56	348	11	307	9	0

[a] In one replication, plants were mostly vegetative, flowering started. [b] In more than one replication, plants were mostly vegetative, flowering started. [c] Based on two replications; in third replication, plants were in Vegetative phase. [d] Based on one replication; in two other replications, flowering did not occur. [e] Vegetative plants only in all three replications.

New maintainers and restorers for Chinese cytoplasmic-genetic male-sterile lines

M. A. Hassan and E. A. Siddiq, Genetics Division, Indian Agricultural Research Institute, New Delhi, India

We sought to identify new maintainers and restorers for the Chinese male-sterile lines: Zhen Shan 97A, Er-Jiu- Nan lA, and V20A.

Bhavani, BPI 76-1/CO 42, Basmati mutant, and Pusa 169-33-1-1 are good maintainers. CRM 13-32-1 11 and ADT33 are partial maintainers which have not been reported until now (Table 1). We also identified three new restorers: IR30, Pusa 150-21-1-1, and Pusa 167- 120-3-2 (Table 2). Although they are good

Table 1. Maintainers to Chinese cytoplasmic-genetic male-sterile lines, New Delhi.

Test cross	Pollen sterility (%)
Er-Jiu-Nan 1A/ CRM13-32-111	83.3
Er-Jiu-Nan 1A/ Pusa 169-33-1-1	98.3
Er-Jiu Nan lA/Bhavani	100.0
Er-Jiu Nan lA/BPI 76-1	100.0
Er-Jiu Nan lA/CO 42	100.0
V20A/Basmati mutant	100.0
Er-Jiu Nan 1A/ADT33	83.3

restorers, they have not been evaluated for agronomic value in terms of exploitable hybrid vigor. They are, however, promising because they have stable yield performance, good maturity, and good cooking quality. □

Table 2. Restorer lines for Chinese cytoplasmic-genetic male-sterile lines, New Delhi.

Test cross	Pollen sterility (%)	Spikelet fertility (%)
Er-Jiu Nan 1A/IR30	4.8	93
Zhen Shan 97A/Pusa 167-120-3-2	8.5	92
Er-Jiu Nan lA/Pusa 150-21-1-1	5.0	93.5

Evaluation of some cytoplasmic male sterile (cms), maintainer, and restorer lines in Bangladesh

H. C. Sarkar, plant breeder; and N. M. Miah, principal plant breeder, Bangladesh Rice Research Institute (BRRI), Joydebpur, Dhaka, Bangladesh

Thirty-two rice varieties or lines including a set of 5 cms and 5 maintainer lines, and a set of 9 maintainer and 13 restorer lines supplied by IRRI were evaluated for stability, adaptability, and agronomic suitability under Bangladesh agroclimatic conditions. The tests were held at the BRRI-Joydebpur station in 1982 aman (Jul-Dec).

Each entry was transplanted in a 2.5-m single row at 25- × 25-cm spacing with one 30-day-old seedling per hill in a randomized complete block design with 2 replications. Fertilizer was applied at 60-25-15 kg NPK/ha. Agronomic and flowering traits were recorded and reaction to bacterial leaf blight and sheath rot was noted.

Only one cms line, Pankhari 203A, and its maintainer Pankhari 203B performed better under local conditions. However, pollen sterility in the cms lines was incomplete. Two other maintainers — IR19657-87-3-3 and IET3257 — and six restorer lines also showed good adaptability (see table). Performance of cms lines V20A, Wu 10A, and Ms 577A was poor although they had good stability (95-100% pollen sterility). □

Cms, maintainer, and restorer lines that performed well in Bangladesh.

Designation	Plant ht (cm)	Days to 1st flowering	Days to complete flowering	Panicles (no./plant)	Flag leaf length (cm)	Disease		Phenotypic acceptability		Pollen fertility (%)
						BLB	ShR	Vegetative stage	Maturity	
Pankhari 203A	115	17	88	21	27.3	5	5	3	5	15-25
Pankhari 203B	128	83	91	14	29.4	5	5	3	5	80-90
IR19657-87-3-3	97	93	111	13	31.5	1	2	4	4	85-95
IET3257	92	94	106	9	28.1	1	2	4	6	80-90
IR26	84	102	119	24	31.4	1	1	5	5	85-90
IR42	90	101	118	15	27.9	2	1	4	5	80-85
IR46	106	94	111	17	26.4	1	1	4	2	75-80
IR52	96	86	104	16	32.6	1	1	5	5	80-90
IR54	98	93	107	17	28.4	1	1	4	3	80-90
IR2307-247-2-2-3	83	88	107	17	31.3	1	1	5	5	80-85

Extent of natural outcrossing of V20A, a cytoplasmic male-sterile (cms) line, in Bangladesh

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BRRI initiated collaborative research on hybrid rice with IRRI in 1982. Successful hybrid rice production depends on large amounts of outcrossing of cms lines. We studied field production of hybrid seed using cms line V20A and its maintainer, V20B (pollen source).

Twenty-five 25-day-old V20B seedlings were transplanted 1 seedling/hill in 5 rows at 20- × 20-cm spacing in an isolated plot. At the same time 30-day-old V20A seedlings were planted around V20B seedlings at various distances — 20, 40, 60, 80, and 100 cm — to maintain the same spacing and seedlings/hill as in V20B. Only one panicle of each V20A plant was bagged before anthesis. The

Percent seed set on V20A at various distances from the pollen source V20B, BRRI, 1982.

Distance (cm) from V20B	Seed set (%) on V20A
20	2.51
40	1.45
60	0.93
80	0.79
100	0.59

other panicles were left for cross-pollination with V20B.

V20A plants were harvested individually at maturity and the seed set on bagged and open-pollinated panicles was counted to determine the extent of outcrossing. Seed set for V20A varied from 0.59% at 100 cm to 2.51% at 20 cm from the pollen source (see table).

Low seed set may have been caused by small number of pollen parents (25 plants), improper synchronization of flowering because there were only 5 days between planting of V20A and of V20B, poor panicle exsertion of V20A, and lack of supplementary pollination (e.g. rope pulling, flag leaf clipping). □

Temperature tolerance

A new cold-tolerant rice for Indonesia

Harmel, head, Plant Breeding Department, and A. Syarifuddin K., director, Sukarami Agricultural Research Institute for Food Crops (SARIF), P.O. Box 34, Padang, West Sumatra, Indonesia

An improved, cold-tolerant rice line was developed by IRRI and the Indonesian National Rice Improvement Program, and released as a commercial variety by the Indonesian Ministry of Agriculture in 1981 (see table).

The new cultivar, named Batang Agam, was selected from the cross Sirandah Merah/IR2153-159-1-4, made in 1975 at IRRI, and identified as IR7712. F2 seeds were sent to Indonesia and grown at the Sukarami and Ciwalen experimental stations as a bulk population (entry B29686) during the 1975-76 wet season. Selected progenies were advanced and tested until 1981 when an outstanding line, B29836-Sr-13-4-1-5, was selected and named for release.

Batang Agam is recommended as a cold-tolerant cultivar for the cool tropics between elevations 900 and 1,200 m or below 900 m where blast (Bl) is not severe. It is high yielding, but susceptible to B1 and brown planthopper; moderately resistant to bacterial leaf blight; and resistant to tungro virus. It has medium maturity and good grain quality. □

Agronomic characteristics of Batang Agam, compared with 2 local cultivars at several high elevation sites (900-1,500 m) in West Sumatra.

Agronomic characteristic	Batang Agam	Adil	Semeru
Tillers (no.)	19	20	30
Plant ht (cm)	90–95	76	72
Maturity (d)	153–159	163	165
Blast reaction[a]	S	S	S
Sterility (%)	18.3	27.5	40
1000-grain wt (g)	28	30	31
Amylose (%)	24	22	28
Straw wt (t/ha, wet)	28	35	16
Grain yield (t/ha)	4.69	2.35	3.12

[a]S = susceptible.

IR24 selections for cold tolerance

N. Ghosh and M. R. K. Singh, Genetics and Plant Breeding Department, Faculty of Agriculture, Bidhan Chandra Krishi Viswa Vidyalaya, Kalyani 741235, West Bengal, India

IR24 is a photoperiod-insensitive high yielding rice with long, slender, translucent grains; good cooking quality; and low amylose content. It also has good disease and insect resistance, but is susceptible to low temperatures. To induce cold tolerance we treated husked and dehusked seeds for 4 h with different concentrations of the chemical mutagens ethyl methane sulfonate (EMS) and diethyl sulfate (dES).

M_2 seeds were germinated at low temperatures (10 ± 1 ºC) and screened for low temperature tolerance. Reaction was compared to that of Japanese cold-tolerant varieties Ishikari and Matsomae and rated using cold tolerance value (CT):

$$CT = \frac{\text{percent emergence}}{\text{days of incubation}}$$

CT was low for almost all M_2 lines; a few had increased CT. When husked seeds were treated with 0.2 and 0.4% EMS and dehusked seeds were treated with 0.2% EMS and 0.4% dES, CT increased (see table). □

Germination capacity of treated M_2 lines of IR24 at low temperatures.

Treatment	CT[a]
Husked	
Only buffer solution	1.50
EMS	
0.2%	1.58
0.4%	1.67
0.6%	1.17
0.8%	1.33
dES	
0.02%	1.42
0.04%	1.08
0.06%	1.42
0.08%	1.50
Dehusked	
Only buffer solution	1.42
EMS	
0.2%	1.58
0.4%	1.33
0.6%	1.00
0.8%	1.17
dES	
0.02%	1.33
0.04%	1.50
0.06%	1.17
0.08%	1.08
Control	
Check (no mutagen)	
Ishikari	3.00
Matsomae	2.08

Continued in next column

Table continued.

[a]Cold tolerance value.

Tissue culture

Rice plantlets obtained from a somatic embryogenic cluster from immature panicle culture *in vitro*

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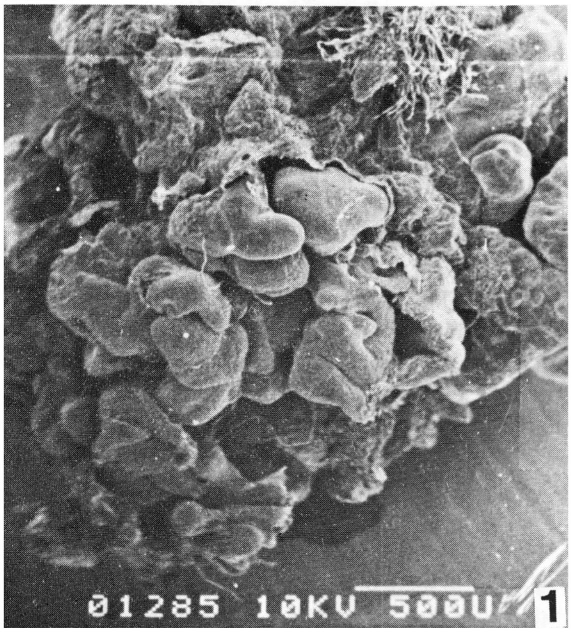
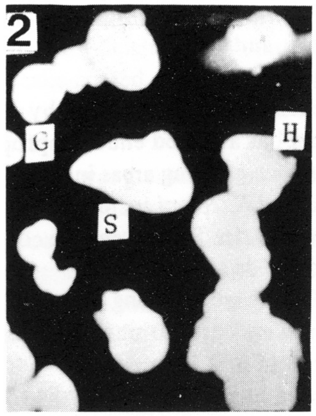
Immature panicles of a haploid rice plant, a diploid rice plant derived from anther culture of Guang-lu-ai 4 and Zhaung Youyi 2/(Zhen-shan 97A/IR24)F_1, and an interspecific hybrid */Oryzae sativa* (2n=24)/O. *latifolia* (2n=48)/F_1(2n=36) were used to study plantlet formation through somatic embryogenic cell culture of rice. Inoculation was from initiation of the secondary rachis branches to the late stage of spikelet differentiation, when the immature panicle was about 5 to 25 mm long.

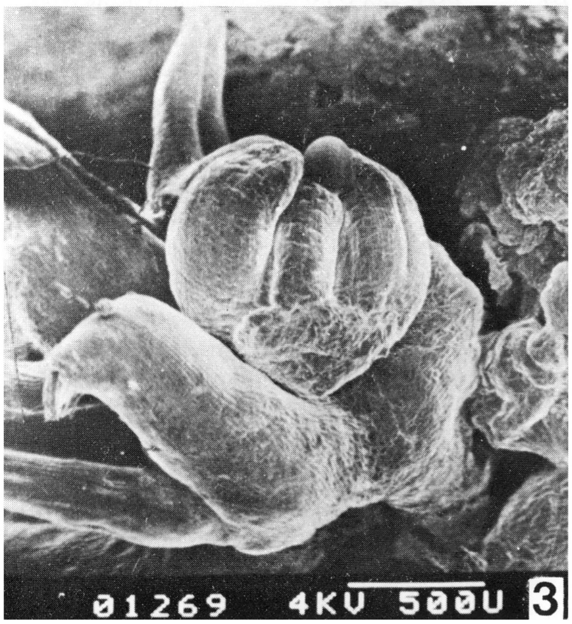
Calli were formed from swollen spikelets. Embryoids were formed from calli 50-60 days after inoculation in the medium HE_5+2,4-dichlorophenoxyacetic acid (2,4-D) 2mg/liter + naphthalene acetic acid (NAA) 2 mg/liter + kinetin 3 mg/liter. When embryoids were cultured in the inducing medium or transferred to a subculturing medium, new embryoids were continually formed and embryogenic cell clusters developed (Fig. 1). The embryogenic cluster in the interspecific hybrid F_1 was white and could easily be separated, but individual embryoids were firm. In the developmental stages there were globular-shaped, heart-shaped, scutellum-shaped, and mature embryoids within the embryogenic cluster (Fig. 2). Proliferation of the cluster of the specific hybrid F_1 was very fast in the MS medium + 2,4-D 2 mg/liter or in the HE_5 + 2,4-D 2 mg/liter + NAA 2 mg/liter + kinetin 3 mg/liter subculture medium, but embryoids of other rice varieties failed to proliferate. Embryoids proliferated and germinated quickly (Fig. 3) when they were transferred in the MS + kinetin 2 mg/liter differentiating medium. The average frequency of plantlet differentiation from the embryogenic cluster is 83-85% and differentiating ability can be maintained more than 10 months. New buds could be seen 2-3 days after transfer and new embryoids continually occurred as the buds were regenerated and plantlets were formed (Fig. 4). □



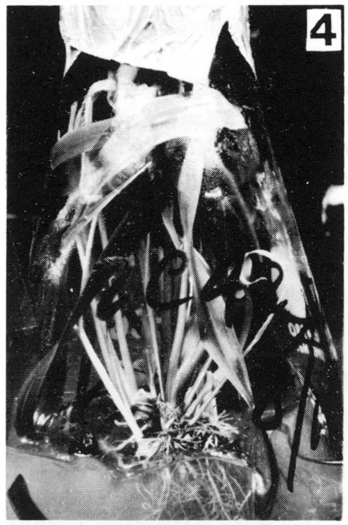
1. Embryogenic cluster of the interspecific hybrid F_1, electromicroscope scanning × 40.



2. Single embryoids separated from an embryogenic cluster. G : globular embryoid, H : heart-shaped embryoid, S : scutiform embryoid × 30.



3. A germinating embryoid, electromicroscope scanning × 300.



4. Plantlets regenerated from an embryogenic cluster.

Collateral hosts of *Rhizoctonia solani* Kuhn causing sheath blight of rice

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Sheath blight (ShB) caused by *Rhizoctonia solani* has assumed endemic proportions in most rice growing areas in Kerala. We recorded *R. solani* incidence on plants grown in rice fallows and on common lowland weeds at several sites.

Plant parts showing *R. solani* symptoms were cut into small pieces, surface sterilized in 0.1% mercuric chloride, washed in 3 changes of sterile water, and transferred to sterile petri dishes containing potato dextrose agar (PDA). The *R. solani* isolates obtained were purified using the hyphal tip method and maintained on PDA slants. Pathogenicity of the isolates was established by artificial inoculation on their respective host plants. The following plants were found to be collateral hosts of *R. solani: Sesamum indicum* L., *Arachis hypogaea* L., *Sesbania aculeata* Pers., wild colocasia, *Cyperus iria* L., *Fimbristylis miliaceae* Vahl, *Apluda aristata* L., and *Monochoria vaginalis* Burm. F. Presl.

R. solani produced severe collar rot symptoms on *Sesamum* and caused severely infected plants to wilt and die. The fungus caused severe leaf and stem blight on groundnut *A. hypogaea.* Badly infected leaves were shed prematurely. On *S. aculeata,* the fungus produced severe collar rot symptoms at all plant growth stages.

Infected wild colocasia plants growing in and around rice fields developed typical ShB symptoms on the petiole. The fungus caused leaf blight on *C. iria* and *F. miliaceae.* Dark-colored lesions were observed on the leaf sheath and leaves of *A. aristata.* The fungus caused typical ShB symptoms on the petioles of *M. vaginalis.* Cross-inoculation studies on rice plants showed that all the eight *R. solani* isolates listed, except that from *S. indicum,* produced typical ShB symptoms.

A. aristata and *M. vaginalis* are new weed hosts of *R. solani* in India. This is the first record of this fungus causing collar rot symptoms on *S. aculeata.* On groundnut in India, *R. solani* has not yet been recorded to cause leaf and stem blight under natural conditions.

Eliminating collateral weed hosts can help reduce the inoculum potential of the ShB pathogen. □

Morphology and serological relationship of penyakit merah virus in Malaysia and rice tungro virus in the Philippines

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Penyakit merah (red disease) (PMV) of rice plants in Malaysia and rice tungro (RTV) in the Philippines have several common properties, including symptoms, varietal reactions and transmission by the vector green leafhopper *Nephotettix virescens.*

When we examined leaf dip preparations of PMV using 2% phosphotungstic acid on carbon-coated grids under an electron microscope, two morphologically distinct viral particles were detected. One was isometric and about 31-37 nm in diameter. The other was bacilliform and about 35 nm in diameter, with length varying from 148 to 175 nm. There usually were more isometric particles. The particles are similar to those associated with RTV in the Philippines, penyakit hebang in Indonesia, and yellow-orange leaf in Thailand.

The serological relationship between PMV and RTV was examined using latex flocculation test. Positive reactions were detected when leaf extracts of PMV-infected rice plants were tested with latex sensitized with rice tungro bacilliform virus and/or rice tungro spherical virus, indicating that PMV and RTV are also caused by the two viruses. □

Sheath blight occurrence in rice nurseries

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Sheath blight (ShB) has damaged rice since 1979 in kharif and rabi seasons in West and East Godavari Districts. It reached epidemic levels in 1981 kharif and 1982 rabi, when it affected all varieties grown and significantly reduced yield. In early ShB infections, only adult plants at panicle initiation stage were affected. Since 1981 kharif wet nurseries have been affected at the research farm and in some farmers fields.

In 1981 and 1982 MTU8002 (Gouthami), MTU8089 (Vashista), MTU7029 (Swarna), MTU4569 (Sowbhagya), MTU-4407 (Vijaya Mahsuri), IR42, and IR36 and prerelease cultures MTU5 182, MTU-7633, IET6314, and IET7574 were severely affected in the nursery. In 1982-83 rabi no nursery infection was observed.

Most seedlings in the nursery had infected lower leaves but some had sheath and leaf infection. Seedling infection followed a normal pattern. Severe infection caused stunting. *Leersia hexandra* growing as a weed in the infected nursery also had typical ShB symptoms.

We studied the possible carry-over of nursery infection to adult plants by transplanting 30- to 35-day-old infected seedlings of 13 cultures. We recorded damage at regular intervals, starting 5 days after transplanting (DT). Healthy MTU7029 and MTU6024 (Laxmi) seedlings were planted to see if the inoculum was from the nursery or other sources.

No ShB infection was noticed until 52 DT, when most cultures showed symptoms (see table). Other cultures showed infection at 66 and 76 DT. Infection gradually increased for all cultures after 52 DT. At 100 DT some susceptible cultures showed almost 100% infection. The healthy MTU7029 and MTU6024 seedlings also developed infection, indicating that the inoculum might have been from a source other than the nursery. Late appearance of ShB symptoms (52 DT) also may indicate that carry-over of inoculum from nursery to adult plants is a remote possibility. □

Sheath blight infection carry-over from nursery to adult plants.

Culture	Hills observed (no.)	Sheath blight-infected hills (no.) at indicated time				
		52 DT	66 DT	76 DT	86 DT	100 DT
Infected						
MTU7029	152	24	67	131	140	150
MTU8002	152	1	24	59	86	88
MTU7633	152	15	41	79	96	142
MTU7030	152	4	25	58	100	147
MTU2281	152	3	18	60	96	145
MTU2292	152	1	1	14	38	74
MTU2066	80	1	8	25	36	36
MTU2194	152	0	2	5	25	81
MTU4865	114	0	0	5	26	76
MTU6117	76	0	0	10	26	50
MTU6613	152	8	43	93	125	152
IET6919	152	2	4	14	80	81
IET7235	152	2	4	8	25	51
Healthy						
MTU7029	152	25	69	120	130	152
MTU6024	152	20	60	115	128	150

Blast outbreak in Manipur

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Blast (Bl) caused by *Pyricularia oryzae* is the most important rice disease in the northeastern hill region of India. In Manipur, B1 severely damages crops when the weather is favorable. In 1982 kharif. B1 affected all the high yielding varieties (IR24, Pusa 33, and Punshi). Punshi was most damaged (Table 1).

Table 1. Neck blast in 5 varieties at Lamphalpat farm, Manipur.

Year	Neck blast (%)				
	Pusa 33	Punshi	IR24	Prasad	RCM2
1981	84.8	100	18.2	0.7	0
1982	36.9	98.9	15.0	0.7	11.9

We surveyed fields in 5 subdivisions (50 hills/field and 2 fields/subdivision, selected randomly). Percent neck B1 incidence was highest in Moidangpok and lowest in Sawombung (Table 2). □

Table 2. Neck blast incidence in Punshi during 1982 kharif in Central district, Manipur.

Subdivision	Village	Neck blast (%)
Thoubal	Thoubal	48.2
	Haothamamana	28.4
	Kakching	18.0
Bishenpur	Bishenpur	17.7
	Ningthoukhong	28.9
	Toubul	71.0
Imphal West I	Khumbong	85.0
	Moidangpok	100.0
	Lamphalpat	98.9
Imphal West II	Ningombam	84.0
	Wangoi	30.0
Imphal East	Sawombung	15.0
	Pungdongbam	18.0
Av		49.5

Occurrence of rice yellow dwarf disease in Patna (Bihar) India

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Rice yellow dwarf disease was discovered on ratooned Sita plants at the ARI Farm in Mithapur, Nov 1982. Infected plants were chlorotic with pronounced stunting and profuse tillering. Chlorotic leaves were a uniform pale yellow. Isolated patches of infected hills were observed in the field. IET5852 rice plants and stubble in adjoining plots were disease free.

A disease transmission test of suspected diseased plants from the field was conducted with second-instar nymphs of *Nephotettix virescens* (Distant). Nymphs were allowed to feed on test samples for 48 h and were incubated 25 days before 48 h of inoculation feeding on 10-day-old healthy TN1 seedlings. Yellow dwarf symptoms developed in about a month, confirming the disease.

This report confirms the presence of yellow dwarf disease in Patna Bihar as was first reported in 1967. Further spread of the disease should be monitored, diseased plants should be removed from fields and destroyed, and resistant varieties should be planted. □

Purification and serological properties of rice grassy stunt virus 2

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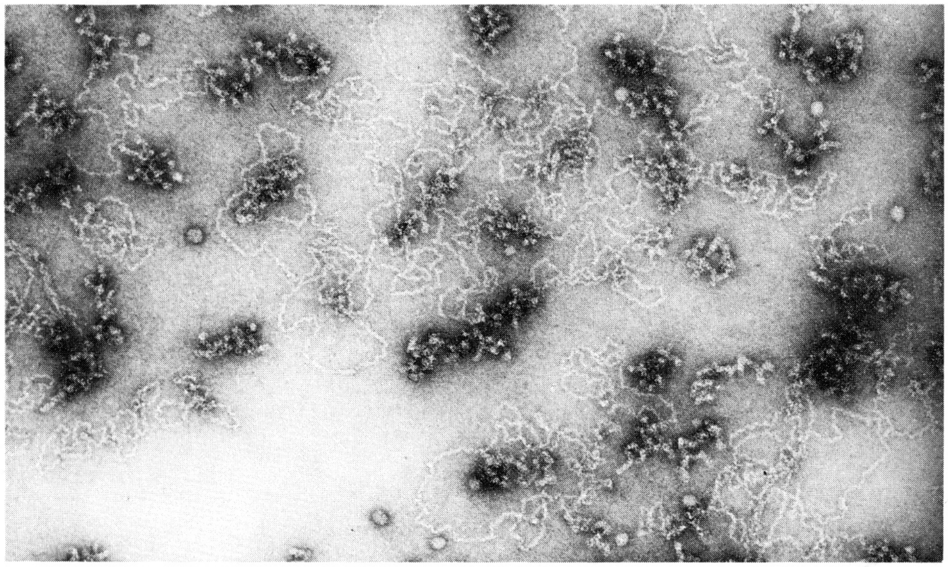
Rice grassy stunt virus 2 (RGSV 2), a strain of rice grassy stunt virus (RGSV l), was purified following the procedure for grassy stunt virus in Japan. The sap of infected plants was clarified with magnesium bentonite and carbon tetrachloride (CCl_4), treated with polyethylene glycol (PEG), and centrifuged in 10-45% sucrose density gradient. Electron microscopy of the purified fraction revealed numerous filamentous particles of various



Electron micrograph of RGSV 2 particles – 60,000 X.

lengths (see figure). The particles were similar to grassy stunt associated filamentous particles. The ultraviolet absorption spectrum of the purified fraction was maximum at 260 nm, and minimum at 246-247 nm, which is typical of a nucleoprotein. The OD 260/280 ratio was 1.29.

Serological reaction of RGSV 1 and RGSV 2 to antisera against RGSV 2 and grassy stunt virus in Japan.

Antiserum	Antigen	Titer of antiserum[a]
RGSV in Japan	RGSV 1	1280
	RGSV 2	640
RGSV 2	RGSV 1	640
	RGSV 2	640

[a]Reciprocals of the dilution endpoints of the antisera in a precipitin ring interphase test.

Antiserum to RGSV 2 was obtained by immunizing a rabbit with the purified virus. In a precipitin ring interphase test, the titer of the serum against both purified RGSV 1 and RGSV 2 was 1:640. The titer of serum to RGSV in Japan against RGSV 1 and RGSV 2 was 1 : 1280 and 1:640, respectively (see table). These results confirm a previous report of the close serological relationship between RGSV1 and RGSV 2. □

Unknown virus-like rice disease in Thailand

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Stunting and yellowing of rice plants similar to symptoms of yellow orange leaf virus (YOLV) and rice transitory yellowing virus (RTYV) affected dry season rice at tillering stage in Dec 1982 in Ban-Po, Chachoengsao, 60 km east of Bangkok. About 20 to 30% of infected hills were scattered in a field with 60% rice ragged stunt virus (RRSV) infection. About 50 ha planted to Morakot and Kaimookdum were infected by RRSV and the unknown virus. In Mar 1983 the same unknown disease symptoms appeared in an integrated pest control (IPC) experimental field at LumLook-ka, Pratum-thani, 40 km north of Bangkhen. Infected plants and possible vector insects were counted (Table 1).

Table 1. Disease-infected plants and insects found in an integrated pest control field, LumLook-ka District, Prathum-thani.

Date	Cultivar	Infected plants: RRSV No.	RRSV %	Unknown virus No.	Unknown virus %	Insects: N. lugens No.	N. lugens No./plant	N. virescens No.	N. virescens No./plant	Plants counted (no.)
24 Mar 1983	RD21	32	7.6	65	15.5	104	.25	0		420
	RD23	2	1	1	0.5	0		0		203
8 Apr 1983	RD7	44	26.7	104	63	102	.62	4	.02	165
	RD21	104	24.2	105	24.4	46	.11	9	.02	430

Table 2. Insect transmission test of unknown disease isolate.

Description of unknown disease	Vector tested	Plants: Total tested	Plants: With infection	Symptom
Stunted and yellow rice plants resembling those with yellow	*Nephotettix virescens*	329	0	
orange leaf virus disease collected from LumLook-ka,	*Nilaparvata lugens*	970	367	Unknown disease
Prathum-thani, Thailand		970	4	Rice ragged stunt virus

Disease symptoms and insect transmission were observed after inoculation of 7-day-old TN1 seedlings. Preliminary insect transmission tests indicated that brown planthopper (BPH) *Nilaparvata lugens* can transmit the disease (Table 2). Seven days after inoculation, infected plants showed yellowing with interveinal chlorosis. When they became older, chlorosis showed more distinctly. Plants were stunted and some tillered profusely. New leaves were narrow. With severe infection plants wilted and often died. Some infected plants recovered, but flowering was delayed and they produced poor panicles. □

WL 28325 for control of brown spot

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WL 28325 (2, 2, dichloro 3,3-dimethyl cyclopropane carboxylic acid) is non-fungitoxic, but reportedly has altered the host's metabolism and induced the synthesis of phytoalexins, mamilactone A and B in rice. These phytoalexins inhibit Pyricularia *oryzae. Because* phytoalexins are nonspecific against pathogens, we tested WL 28325 for control of brown spot (BS) caused by *Helminthosporium oryzae* Breda de Haan.

Three highly susceptible rice varieties — Benibhog, Co 40, and Ponni — were grown in the greenhouse at 20-25°C. When seedlings were 45 days old, 3 kg WL 28325/ha was applied to the soil (2.5 mg/pot of 8 kg soil). Ten, 20, and 30 days after application, plants were spray inoculated with a highly virulent *H. oryzae* isolate at 10^6 spores/ml. Lesion development was assessed (see table).

Applying WL 28325 markedly reduced disease incidence for all varieties. The chemical effect persisted for 30 days. ☐

Effect of WL 28325 control of brown spot of rice.

Variety	WL 28325 application[a] (3 kg/ha)	Disease intensity[b] at different days after application		
		10 d	20 d	30 d
Benibhog	+	3.0	3.1	4.7
	−	8.0	8.1	8.2
Co 40	+	2.6	2.7	4.9
	−	6.3	6.5	7.0
Ponni	+	1.1	1.6	3.1
	−	5.9	6.4	6.8

[a]+ = applied; − = not applied. [b]Assessed using the 1980 Standard Evaluation System for Rice.

Pest management and control INSECTS

Effect of moonlight on light-trap catches of brown planthopper

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Light-trap catches of many insects are affected by the efficiency of the trap in relation to moonlight. If flight activity is constant throughout the lunar cycle, catches should be lower at full moon, when light-traps are least effective.

Peak catches of brown planthopper (BPH) near full moon in three IRRI light-traps in 1976 and 1977 indicated that BPH flight behavior might be influenced by the lunar cycle. Weekly catches of BPH in the IRRI fluorescent-light traps from 1967 to 1979 (1978 data were not obtained) were analyzed for fluctuations related to the lunar cycle.

Each catch during a full moon week was compared to catches in preceding and following new moon weeks, and the number of occasions in which the new moon or full moon catch was greater was tested for significance using X^2.

The table shows X^2 values obtained when each full moon catch was compared to the following new moon catch. Results of comparisons with the preceding new moon were similar.

Chi-square heterogeneity test comparing catches during full moon and the following new moon.

Year	Full moon catch greater than new moon catch	New moon catch greater than full moon catch	N		DF	χ^2	
1979	11	1	12		1	8.333	P<0.005
1977	11	1	12		1	8.333	P<0.005
1976	12	0	12		1	12	P<0.001
1975	9	2	11		1	4.454	P<0.05
1974	5	7	12		1	0.333	ns
1973	7	5	12		1	0.333	ns
1972	10	2	12		1	5.333	P<0.025
1971	12	0	12		1	12	P<0.001
1970	5	3	8		1	0.5	ns
1969	8	4	12		1	1.333	ns
1968	7	2	9		1	2.778	ns
1967	3	4	7		1	0.142	ns
				Total	12	55.872	P<0.001
	100	31	131	Pooled	1	36.343	P<0.001
				Heterogeneity	11	19.529	ns

In 6 of the 12 years examined, there was a significant difference between BPH catches at full moon and those at new moon. Highest catches were during the full moon. This was confirmed by the 12-year data (see table),

When BPH populations were low (1967–70), or in years with large BPH catches (1973 and 1974), the numbers caught at new moon and at full moon did not differ significantly. Only in 1967 and 1974 were there more occasions when the full moon catch was smaller than that for the following new moon (see table).

The larger BPH catches near full moon probably reflect a genuine increase in flight activity during this moon phase because light-traps are least effective at that time. The findings of this study are supported by suction-trap catches at Liliw near IRRI. A general association between flight activity and moon phase might be expected because the lunar cycle and a BPH generation have similar duration; however, the relationship may diminish when there are major differences in the sizes of successive generations. When an association does occur, however, BPH dispersal and subsequent colonization of new rice crops will tend to be synchronized over large areas. ☐

Trichornalopsis apanteloctena (Crawford) [Hymenoptera: Pteromalidae]: correct name for the larval parasite of the rice skipper

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Eupteromalus parnarae Gahan is an important larval parasite of rice skipper *Pelopidas mathias* (F.), leaffolder *Cnaphalocrocis medinalis* (Guenie), leaf beetle *Oulema oryzae* (Kuwayama), and whorl maggot *Hydrellia griseola* (Fallen) in South and Southeast Asia. It is also a recorded hyperparasite of *Apanteles rifucrus* Haliday on *Naranga aenescens* Moore, *A. parnarae* Watanabe and *A. booris* Wilkinson on *Parnara guttata* Bremer & Grey, *A. chilonis* Munakata on *Chilo suppressalis* (Wlk.), *A. plutellae* Kurdjumov on *Plutella xylostella* (L.), *Apanteles* sp. on *Grapholitha molesta* Busck., and *Meteorus* sp. on *Sesamiu inferens* (Wlk.). Recent examination, however, indicates that specimens of the three known species of *Trichomalopsis* Crawford [May] 1913, *Eupteromalus* Kurdjumov [Jul] 1913 became synonymized with *Trichomalopsis* following the rule of priority in zoological nomenclature. In the same manner, *E. parnarae* Gahan and *T. apanteloctena* Crawford were discovered to be one species (ref. Kamijo, K. and E. E. Grisell. 1982. Species of *Trichomalopsis* Crawford [Hymenoptera: Pteromalidae] from Rice Paddy, with descriptions of Two New Species. Kontyu 50 (1): 76-87). Therefore, the correct name for E. parnarae Gahan is *Trichomalopsis apanteloctena* (Crawford). □

Effect of some granular insecticides on rice gall midge

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The effectiveness of seven granular insecticides to control rice gall midge (GM) *Orseolia oryzae* (Wood-Mason) was evaluated at Raipur. Quinalphos 5G, phorate l0G, mephosfolan 5G, diazinon 10G, carbaryl +γ- BHC (Sevidol 4G), chlorpyriphos 5G, and carbofuran 3G were applied at 1.0 kg ai/ha during the 1980 wet season. Chemicals were applied 3 times at 20, 40, and 60 days after transplanting (DT) in a randomized block design with 3 replications. Two-three seedlings/hill were planted in 4- × 6-m plots at 20- × 15-cm spacing. Each plot was divided into 4 subplots, and 9 hills/subplot were examined 10 days after each application for damaged tillers and silvershoots. At 30 DT GM incidence was low and uneven; therefore, differences among treatments after the first application were insignificant (see table). GM incidence increased by 40 DT. Percentage of affected tillers was significantly lower for chlorpyriphos than for the control. Other treatments were similar to the control. Chlorpyriphos also controlled GM best at 60 DT. Mephosfolan, phorate, and carbofuran also reduced damage.

Only the phorate treatment yielded significantly more (1.6 t/ha) than the untreated control (0.3 t/ha) but chlorpyriphos, diazinon, and mephosfolan treatments also yielded slightly more. □

Effect of granular insecticides on rice gall midge infestation and rice yield. Raipur, India, 1980 we season.[a]

Treatment	Silvershoots (%)			Yield (t/ha)
	30 DT	50 DT	70 DT	
Phorate	6.8 a	9.2 b	8.5 c	1.6 a
Chlorpyriphos	6.5 a	4.5 a	2.4 a	1.5 ab
Diazinon	4.8 a	11.9 c	12.3 d	1.5 ab
Mephosfolan	3.0 a	9.1 b	5.6 b	1.3 ab
Carbaryl + Lindane	4.8 a	11.2 c	11.2 c	1.0 ab
Carbofuran	5.6 a	9.6 b	10.8 c	0.9 b
Quinalphos	4.6 a	15.8 e	18.6 f	0.9 b
Untreated	4.1 a	14.2 d	16.2 a	0.3 b

[a]DT = days after transplanting. Figures with similar letters do not differ significantly.

A leaf dipping method for testing insecticide toxicity

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Rice leaffolder *Cnaphalocrocis medinalis* Guenée is a serious rice pest in southwestern Japan. Insecticide toxicity to the larvae was laboratory tested by leaf dipping. Adult moths, which were collected from fields in mid-Oct 1980, oviposited inside a glass jar. They were fed rice seedlings after hatching. Leaf blades of 12- to 15-cm-high plants at tillering stage were dipped for 10 s into 100-ml insecticide solutions diluted with methanol, then airdried for 5 min. The roots were wrapped in moist paper. Larvae were released on treated rice seedlings in 3- × 20-cm test tubes in a growth chamber kept at 25°C and 16 L. Larval mortality was recorded

LC_{50} values of insecticides to rice leaffolder larvae using the leaf dipping method.

Insecticide	LC_{50} (ppm) at 25°C					
	1st instar		3d instar		5th instar	
	24 h	48 h	24 h	48 h	24 h	47 h
Cartap	1.2	0.70	2.0	1.3	8.2	6.4
Chlorpyrifos-methyl	2.1	1.9	7.8	7.2	31	21
Dimethylvinphos	4.3	3.7	17	15	27	16
Tetrachlorvinphos	11	9.5	26	22	34	21

24 and 48 h after insect release.

The LC_{50} values to larvae varied considerably among the test insecticides (see table). Cartap was most toxic at all instars.

LC_{50} values of 5 replications of dimethylvinphos on 1st-instar larvae ranged from 3.4 to 4.3 ppm at 24 h and 3.1 to 3.7 ppm at 48 h, indicating that leaf dipping method produces stable results and is a simple way of determining insecticide toxicity to rice leaffolder larvae. □

A technique for preparing rice plants for brown planthopper rearing

Esper Bacalangco, research assistant, and G. S. Khush, plant breeder, IRRI

Brown planthopper (BPH) colonies have been reared on susceptible TN1 since the host resistance breeding program began at IRRI in the late 1960s. Five TN1 plants are transplanted in 10-cm-high clay pots, 12 cm in diameter, which are put on tables in the open. Six- to eight-week-old plants are placed in cages and adult male and female BPH released on the plants. After 3 days the plants are transferred to other cages where nymphs emerge in about 1 week.

Until 1976 the BPH population was limited to BPH biotype 1, and occasional stray insects that laid eggs on the plants created no problem because they belonged to the same population as was being cultured for screening. However, when BPH biotype 2 became dominant on the IRRI farm in late 1976, the stray BPH biotype 2 adults laid eggs on the plants before they were used for collecting biotype 1 eggs. Nymphs collected from these plants were a mixture of biotypes 1 and 2. We have tried several ways of maintaining pure colonies. Washing the plants with a water jet before egg caging removed stray adults and nymphs, but not the eggs. Because BPH oviposits in the leaf sheaths, we removed the outer leaf sheaths of plants before egg caging. This minimized contamination, but did not eliminate it.

BPH egg hatchability on rice plants after hot water treatment.

Seedling age	Water temperature (°C)	Nymphs (no./plant) hatched after submergence in hot water			
		Control	20 min	30 min	40 min
6 wk	41	120	40	25	5
	44	110	30	0	0
8 wk	41	122	20	8	2
	44	125	25	0	0

We then evaluated hot water treatments to kill the BPH eggs within the plants. Six- and eight-week-old TNl plants were caged with BPH adults. After 3 d of egg laying the plants were submerged in hot water (41°C and 44°C) for 20, 30, or 40 min. Control was no-hot-water treatment. After the treatment, plants were put in the insect-free cages to evaluate egg-hatching after 9 d. The 30-minute treatment in 44°C water killed all the eggs (see table), and did not reduce the growth or vigor of rice plants. We are now using this technique. □

Chemical control of thrips in the rice nursery

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Rice thrips *Baliothrips biformis* (Bagnall) severely damage rice nurseries in the Imphal Valley, Manipur, in Jul and Aug. Nymphs and adults suck the sap of leaves, which turn yellowish and curl from the margin to the middle. Resowing often is necessary.

We tested 1 application of 6 commonly available insecticides for thrips control in 12-day-old P33 nurseries in Aug 1982. Carbaryl, endosulfan, chlorpyriphos, malathion, phosalone, and quinalphos were applied at 0.05% concentration in 5-m^2 plots with 4 replications. Insecticides were applied with a 3-liter compression sprayer. Initial adult and nymph populations were recorded separately for each treatment and replication. Thrips population was counted at 1, 3, and 7 d after spraying.

All insecticides caused significant population reduction, and by day 3 had reduced populations to a negligible level in all treatments. After 7 d, quinalphos followed by phosalone and carbaryl had best results (see table). □

Efficacy of insecticides on thrips.

Insecticide	Population of thrips[a]							
	Before treatment		1 DAT		3 DAT		7 DAT	
	A	N	A	N	A	N	A	N
Carbaryl	11	105	0 a	0 a	0.5 a	0.3 a	1.5 a	6 a
Endosulfan	19	77	0 a	0 a	0.5 a	0 a	1.5 a	32 a
Chlorpyriphos	24	13	0 a	0 a	0.3 a	0 a	1.3 a	13 a
Malathion	26	143	0.3 a	0 a	2.5 a	4.3 a	6 a	82 c
Phosalone	14	152	0 a	0 a	0.5 a	0 a	0.8 a	4 a
Quinalphos	19	160	0 a	0 a	0.8 a	0 a	0 a	0.3 a
Control	23	85	12	180	14	76	35	63 bc
CD (P = 0.05)	NS	NS	0.62	2.22	0.62	1.68	1.22	2.70

[a]A = adults, N = nymphs. DAT = days after treatment. In a column, values followed by a common letter are not significantly different at the 5% level.

Effect of rice stubble on stem borer hibernation

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Stem borers (SB) (*Scirpophaga* and *Sesamia* spp.) are serious rice pests in Pakistan. They hibernate in the stubble of harvested fields. The Agriculture Department recommends that stubble be destroyed soon after harvest. However, most farmers either don't till fields to destroy stubble, or else plant another crop such as wheat or shaftal (*Trifolium alexandrinum*) without thorough cultivation. Therefore, enough stubble remains for SB hibernation.

We assessed the level of SB hibernation in stubble from uncultivated fallow, cultivated fallow, and shaftal- and wheat-sown fields. One hundred stubble were collected from each of 5-7 sites at Muridkey and Narang in Dec-Jan 1981-82 and 1982-83. A subsample of 25 stubble from each collection was dissected. Number of live and dead larvae, larval species, larvae per stubble, and percent infestation were recorded. Another subsample of 25 stubble was placed in dark cages with moisture and temperature similar to those in fields. Killing bottles were attached to an exit-to-light where the emerging moths were trapped and counted (see table). The studies indicate that destroying rice stubble after harvest is essential to minimizing SB incidence. □

Hibernation of stem borers in rice stubble in 4 fields in Muridkey and Narang, Pakistan.[a]

Field	Larvae (no.) Alive	Dead	Av/stubble	*Scirpophaga* sp.	*Sesamia* sp.	Stubble infestation (%)	Moth emergence (%)
				Muridkey			
Shaftal sown	76.3	3.8	3.2	76.0	0.5	87.0	76.0
Wheat sown	22.3	16.2	1.5	21.0	1.3	39.7	52.1
Plowed fallow	16.0	24.1	1.6	15.5	0.5	24.7	30.5
Unplowed fallow	102.0	1.2	4.1	100.1	1.1	92.0	83.2
				Narang			
Shaftal sown	121.2	3.8	4.9	120.4	0.8	93.5	78.2
Wheat sawn	34.5	17.1	1.7	33.4	0.9	40.2	47.7
Plowed fallow	17.8	27.4	1.8	17.0	0.8	24.0	22.0
Unplowed fallow	146.4	4.0	6.1	140.1	1.3	98.0	87.0

[a]Av of 2 years data.

Effect of azolla on insect predators

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Azolla floats on paddy water and creates in the rice field ecosystem an additional niche that influences insect predators living on or in the water. Net samples including applied and naturally occurring azolla, paddy water, and bottom mud were taken 12 times from Oct to Dec 1982 from transplanted rice fields on the IRRI experimental farm. More predators were counted in samples taken from fields with applied azolla (303) than from other fields (19 1) (see table).

The water-surface inhabiting species most favored by azolla were rice hopper predators *Microvelia douglasi atrolineata* (Bergroth) [Veliidae], *Paraplea sobrina* (Stål) [Pleidae], and *Lycosa pseudoannulata* (Boes. et Str.) [Lycosidae]. The rice bund-inhabiting spiders *Pardosa birmanica* Simon, *Arctosa janetscheki* Buchar, and *Hippasa rimandoi* Baxion [Lycosidae] moved into the azolla. Among the subsurface species, azolla favored notonectid backswimmers, pleid water bugs, water treaders, and coenagrionid damselfly naiads.

Surface-dwelling gerrid water striders and the libellulid dragonfly preferred open water. Other groups of insect predators either were unaffected by azolla or were too few to allow comparisons. □

Effect of azolla on rice insect predator populations in a rice field, IRRI farm, 6 Oct to 16 Dec 1982.

	Predators (no./family)[a] Hemiptera A	B	C	D	E	F	G	H	Coleoptera I	J	K	L	M	N	Odonata O	P	Araneae Q	R	S	T	Total
With azolla	57	38	28	26	4	2	2	1	24	18	14	11	8	6	17	0	42	2	1	2	303
Without azolla	31	20	16	10	3	2	13	2	18	20	9	10	4	6	2	7	16	1	0	1	191

[a] Total of 12 net samples. A = Veliidae, B = Pleidae, C = Notonectidae, D = Mesoveliidae, E = Ochteridae, F = Nepidae, G = Gerridae, H = Belostornatidae, I = Dytiscidae, J = Hydrophilidae, K = Hydraenidae, L = Gyrinidae, M = Carabidae, N = Staphylinidae, O = Coenagrionidae, P = Libellulidae, Q = Lycosidae, R = Theridiosomatidae, S = Theridiidae, and T = Tetragnathidae.

Pathogens and nematodes for control of rice water weevil in Cuba

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Rice water weevil *Lissorhoptrus brevirostris* (Suffr.) has few natural enemies in Cuba. We conducted laboratory and field studies to identify fungi, bacteria, and nematodes with potential to control rice water weevil.

Various strains of *Beauveria bassiana* and *Metarrhizium anisopliae* fungi were tested in the laboratory. Because rice water weevils live below the water surface, fungi cannot be applied directly to adults. Some fungi were broadcast on the water surface in the laboratory and infected insects when they surfaced. When adult rice water weevils were contaminated with *B. bassiana* strain 32, mortality was 95% at 20 days (Table 1) and 100% at 32 days after infection. When 2 kg *B. bassiana* 32 was broadcast on a 2-ha rice field adult mortality was 88% 15 days after application.

None of the *Bacillus thuringiensis* biopreparations (Bitoxibacilin, Insectin, Den-

Table 1. Mortality of *Lissorhoptrus brevirostris* adults caused by *Beauveria bassiana* and *Metarrhizium anisopliae* fungi, Sur del Jibaro, SanctiSpiritus, Cuba, 1978.

Fungus and strain	Rice water weevil mortality (%) 20 days after infection	
	Female	Male
Beauveria bassiana 24	92	16
Beauveria bassiana 32	99	92
Metarrhizium anisopliae 12	83	79
Metarrlliziurn anisopliae 4	61	51

drobacilin, and Dipel) controlled rice water weevil when applied to 35-day-old rice plants as a foliar spray at 0.6, 1.2. and 2.4 kg/ha.

When *Neoplectana* nematodes were broadcast on the water surface in the laboratory, adult mortality was 82% between 8 and 18 days after application. In another test, three dosages of the nematode were applied. Rice water weevil damage was lowest with 36 nematodes/ ml water which caused 77% adult mortality (Table 2). When the same test was

Table 2. Mortality of rice water weevil adults caused by different rates of *Neoplectana* nematode, Havana, Cuba, 1981.

Dosage (nematodes/ml water)	Rice water weevil mortality (%)
3550	80
355	82
36	17

done on rice water weevil larvae, mortality ranged from 73 to 83% 12 to 15 days after application. □

Insecticide-resistant brown planthopper populations at the IRRI farm

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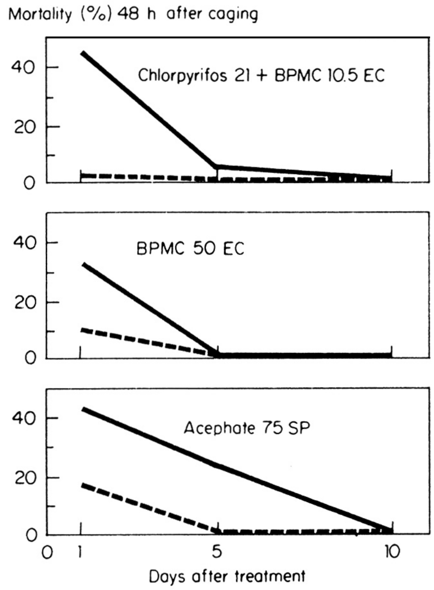
Brown planthopper (BPH) may develop resistance to some insecticides applied repeatedly. This has occurred in Japan and Taiwan, China. We found insecticide-induced BPH mortality to be much lower for populations collected from the IRRI research farm than for greenhouse colonies (see figure).

Chlorpyrifos + BPMC has been used at IRRI since 1978, and acephate has been used since 198 1. For 10 years BPH-susceptible cultivars usually received two granular and six foliar insecticide applications per season. Using such quantities of insecticide has undoubtedly hastened the development of insecticide-resistant BPH populations at the farm. □



Comparative mortality of greenhouse insecticide-free populations (---) and field populations (—) collected from IRRI farm in Apr–Jun 1982 when treated with foliar sprays at 0.75 kg ai/ha.

A new gall midge parasite in M. P., India

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Rice gall midge *Orseolia oryzae* (Wood-Mason), a destructive rice pest in India, Sri Lanka, Thailand, Vietnam, and Indonesia, has a large natural enemy complex. *Platygaster oryzae* is a dominant egg-larval gregarious parasite of gall midge. *P. oryzae* parasitism in Madhya Pradesh was 14.3% in the summer rice crop in Apr and May 1977.

During 1980 wet season a hymenopterous grub was found feeding on the pupae of *O. oryzae.* Adults were identified as *Neanastatus gracillarious* Masi (Eupelmidae: Hymenoptera) (identified by Z. Boucek). This is the first record of the parasite on *O. oryzae* in Madhya Pradesh. □

Influence of planting time on rice leaffolder incidence

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Rice leaffolder (LF) *Cnaphalocrocis medinalis* Guenée is a serious rice pest in samba season (Jul-Aug to Dec-Jan) at Tirur. We studied the effect of planting time on LF incidence.

IR20 was planted in 10-m^2 field plots on 7 dates with 4 replications during 1981-82 at PES, Tirur. Insecticide was not used. Total leaves and LF-damaged leaves on 25 randomly selected hills from each plot were counted 60 days after transplanting and damage percentage was calculated (see table).

Leaf damage was significantly lower

Effect of planting time on rice leaffolder incidence, 1981–82 samba, Tirur, India.

Planting date	Mean leaf damage[a] (%) 60 DT
05 Aug 1981	39.7
20 Aug 1981	39.3
05 Sep 1981	41.7
20 Sep 1981	08.5
05 Oct 1981	13.2
20 Oct 1981	15.3
05 Nov 1981	13.6
CD	5.8

[a]DT = days after transplanting.

(below the 20% economic threshold level) on crops planted from 20 Sep to 5 Nov. The early crop (5 Aug to 5 Sep) had heavy LF damage because maximum tillering and early flowering coincided with peak LF population (Oct–Nov).

Natural enemies of rice insect pests in Chhatisgarh (M.P.), India

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Natural enemies substantially reduce insect pest populations in rice fields. We began an intensive rapid roving monitor-

Natural enemies of rice insect pests in Chhatisgarh (M. P.), India, 1980-82.

Natural enemy	Host	Abundance (no./10 sweeps)	Incidence
	Predators		
MIRIDAE			
Tytthus parviceps (Reuter)	*Nilaparvata lugens*	2–8	Scattered
Cyrtorhinus lividipennis Reuter	-do-	5–15	Widespread
LAGAEIDAE			
Geocoris ochropterus Fieber	Mites (*Oligonychus* sp.)	1–5	Scattered
Graptostethus servus (Fabricius)	Host not determined	2–5	Scattered
NABIDAE			
Tropiconabis capsiformis Germer)	*Nephotettix* spp.	5–15	Widespread
REDUVIIDAE			
Coranus spiniscutis Reuter	Host not determined	1–5	Scattered
TETRAGNATHIDAE			
Tetragnatha spp.	Leaffolder and hopper	5–15	Widespread
THOMISIDAE			
Thomisus cherapunjesus Tikader	Host not determined	1–5	Scattered
STAPHYLINIDAE			
Paederus fuscipes Curtis	Nymphs of *Nephotettix spp.*	5–20	Widespread (more in summer
COCCINELLIDAE			
Scymnus (Pullus) victoris Motschulsky	Aphid (undetermined)	2–8	Isolated
Coccinella sp.	-do-	Rare occurrence	Isolated
	Parasites		
DRYINIDAE			
Gonatopus sp.	Nymphs of *Nephotettix virescens* *Sogatella furcifera* *Recilia dorsalis*	2–8	Sporadic
EUPELMIDAE			
Eupelmus sp. (urozonus-group)	Stem borer	2–8	Sporadic
PTEROMALIDAE			
Mesopolobus sp.	Stem borer	2–10	Scattered
EULOPHIDAE			
Tetrastichus schoenobii Ferr.,	*Tryporyza incertulas*	Rare occurrence	Scattered
PLATYGASTERIDAE			
Platygaster oryzae	*Orseolia oryzae*	1–5[a]	Scattered
BRACONIDAE			
Apanteles spp.	Stem borer	1–5[a]	Isolated

[a] Number/m^2.

ing of insects and their parasites, predators, and diseases in Chhatisgarh in 1980. An area 8,000 to 10,000 km^2 was covered and 900 to 1,200 paddy fields were surveyed annually during kharif. Several integrated pest management technology studies in farmer fields also provided data.

Most of the area surveyed was rainfed and no more than 150-200 g ai insecticide/ha was applied annually. Insecticides used by farmers were malathion, phosphamidon, carbaryl, and BHC. Varieties were 75% local and tall and 25% were the high yielding gall midge-resistant varieties Phalguna (R.P.W. 6-17), Surekha (W13400), Asha (R-35-2752), and Usha (R-35-2750), and popular varieties Kranti and Madhuri. The crop was 75–85% broadcast. Populations of beneficial insects were determined by the number of insects in 10 net sweeps or in l-m^2 areas.

We found large populations of *Cyrtorhinus lividipennis* Reuter, *Tropiconabis capsiformis* (Germer), *Gonatopus* sp., Tetragnatha spp., and *Paederus fuscipes* Curtis (see table). These parasites and predators can be useful tools to reduce populations of harmful insects. The names of possible hosts given in the table did occur with the beneficials and were listed as hosts based upon available literature. □

Cytology of *Nilaparvata bakeri* (Muir), a grass-infesting planthopper species

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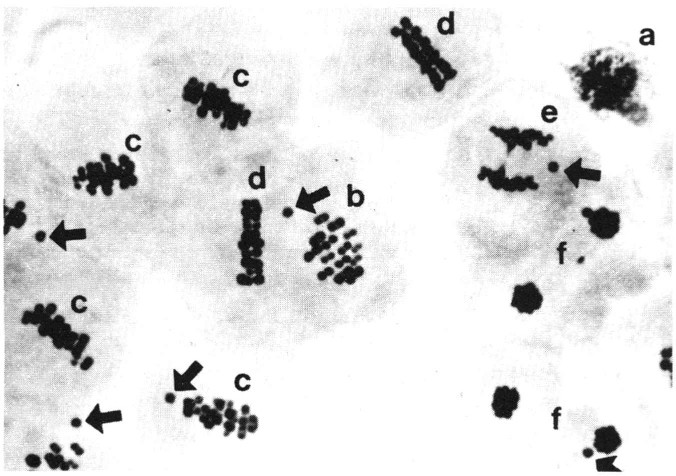
A grass-infesting planthopper, *Nilaparvata bakeri* (Muir), was found on the common weed *Leersia hexandra* (Swartz) at IRRI experimental farm. *L. hexandra* is a host of a distinct but nonrice-feeding *Nilaparvata lugens* (Stål) population. The two planthopper species could easily be distinguished by genitalic characters. Following is a description of *N. bakeri* cytology.



Different stages of the first meiotic division in *N. bakeri.* a = pachytene, b = diakinesis, c = prometaphase I, d = metaphase I. e = anaphase I, and f = telophase I. X-chromosomes are indicated by arrows. Magnification 1000 X. IRRI, 1983.

Fifty newly emerged brachypterous and macropterous *N. bakeri* males and a few females were scrutinized using standard cytological techniques for planthoppers. Data on cell cycle and cellular, nuclear, and chromosomal shapes and morphometrics are in the table.

Cell cycle and cellular, nuclear, and chromosomal shapes and morphometrics of *N. bakeri.*

Stage	Shape	Length (μ)	Width (μ)
Interphase cell	Oval to circular	45	32
Nucleus	Circular	12	12
Meiosis I (see figure)			
Prophase I			
a. Leptonema cell	Oval	13-25	10-17.5
nucleus	Oval	10	8
b. Pachytene cell		15	10
c. Diplotene			
Cell	Oval	31-45	20-31
X-chromosome (a univalent)	Oval	2.2	1.5
Autosomes (14 bivalents)	Irregular	3,3,3,3,3,3, 3.5,3.5,4,4, 4,4,5,5	
d. Diakinesis			
Cell	Oval	3545	26-38
X-chromosome	Circular	2	2
Autosomes	Dumbbell	2.1,2.4,2.8, 3,3,3.1,3.4, 3.7,4,4,4.1, 4.4,4.8,4.8	
Metaphase I			
X-chromosome	Circular	2	2
Autosomes	Dumbbell	2,2,3,3,3,3.5 4,4,4,4,4.2, 4.5,4.5,4.5	
Anaphase I			
X-chromosome	Circular	2	2
Autosomes	Clump	9-11	7-8
Telophase I			
X-chromosome	Circular	2	2
Autosomes	Clump	5	3
Meiosis II			
Nuclei (4)	Almost circular	9.5	8.2

The first meiotic division (see figure) was reductional and the second was equational. As attested by the orientation, broad spindle attachment, and parallel disjunction during anaphase I, *N. bakeri* chromosomes had diffused kinetochores or their centromeres were located along the entire length of the chromosomes.

The genomic complement was normally 2n=29 in males and 2n=30 chromosomes in females. These consisted of 28 autosomes (14 II) and a univalent X-chromosome in males and XX bivalents in females. The sex-determining mechanism was therefore XX-XO. Male morphs were heterogametic, yielding 14 I × X and 14 I + 0 sperm cells, and females were homogametic and yielded only 14 I + X ova.

Some karyological variations were observed. Meiocytes with more and less chromosomes were in the normal genomic constitution. Meiocytes with fewer chromosomes were smaller (27 μ long and wide) aneuploid cells with 6, 8, 10, 11, 12, and 13 bivalent autosomes. Those with more chromosomes were bigger (46 μ long, 38 μ wide) cells with 17, 19, and 20 bivalents.

Simple chromosome agmatoploidy could cause increased chromosome number. The holokineticity of chromosomes enabled chromosome fragments to divide and function as autonomous wholes because they have nonlocalized centromeres to direct them to the poles. Conversely, fusion of the major part of two chromosomes by reciprocal translocation reduced the chromosome number, *N. bakeri* is chromosomally polymorphic with ample genetic versatility, because of these atypical karyotypes. □

Weed hosts for *Cyrtorhinus lividipennis* (Reuter), a brown planthopper predator

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It is well documented that grasses and weeds conserve and enhance the multiplication of some important natural enemies of brown planthopper (BPH), but these grasses and weeds have not been identified.

Glasshouse studies investigated oviposition and egg hatchabflity if the mirid *Cyrtorhinus lividipennis,* an important predator of BPH eggs and adults. Potted cultures of several common weeds, collected from rice fields in Tanjung Karang, were enclosed in a 7.5- × 60-cm mylar cage and 5 freshly emerged adult mirid females were released. After about 48 hours. the insects were removed and the number of eggs laid were examined under a dissection microscope. Nymphs that hatched were counted and removed daily. When hatching terminated, plants were dissected and the number of unhatched

Oviposition and hatchability of eggs of *Cyrtorhinus lividipennis* **on some rice field weeds.**[a]

Species	Eggs laid (no)	Egg hatchability (%)
Echinochloa crus-galli	10.9 a	29.7 a
Cyperus diffusus	5.7 b	5.3 c
Brachiaria rnutica	0.4 c	2.5 c
Oryza sativa	12.7 a	53.6 b

[a]Mean values for 10 replications. Values followed by the Same letter do not differ significantly at P = 0.05.

eggs was recorded. Potted MR7 rice plants were used as control.

Oviposition occurred on only three of the seven species tested (see table). The highest oviposition and hatchability were observed in *Echinochloa crus-galli.* The mirid did not oviposit on *Setaria geniculata, Sacciolepis indica, Eleusine indica,* or *Paspalum conjugatum.* □

Parasites of white rice leafhopper *Cofana spectra* (Dist.) [Hemiptera: Cicadellidae] in the Philippines

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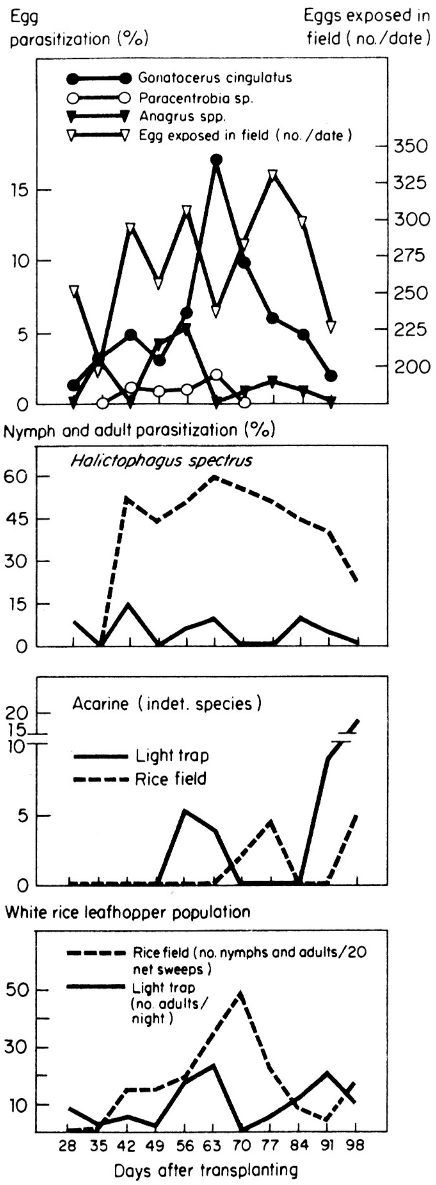
Numbers and kinds of parasites attacking the egg, nymphal, and adult stages of *Cofana spectra* (Distant) were recorded during the 1982 wet season at IRRI. Potted rice plants infested with white rice leafhopper eggs laid by a greenhouse colony were set in a rice field each week 29–98 days after transplanting. Four species of egg parasites were recovered, the most prevalent of which was a mymarid — *Gonatocerus cingulatus* Perkins — that parasitized up to 17% of eggs (see figure). *Anagrus flaveolus* Waterhouse, *A. optabilis* (Parkins) (Mymaridae), and *Paracentrobia* sp. (Trichogrammatidae) parasitized less than 6% of eggs.



Abundance of white rice leafhopper Cofana spectra (Dist.) in rice field, light trap collections, and parasitization of eggs, nymphs, or adults. IRRI, 1982 wet season.

White rice leafhopper nymphs and adults were parasitized by a strepsipteron — *Halictophagus spectrus* Yang — and an unidentified mite of the family Erythracidae. The parasites were recovered from nymphs and adults collected from fields by sweep net and from live adults collected in a walk-in light trap. The strepsipteron parasitized 40–60% of nymphs and adults collected in the field, but parasitized less than 15% of adults collected from the light trap, perhaps indicating that parasitized hoppers are those less capable of flying. The mite occurred less consistently on hopper nymphs and adults but parasitized up to 23% of adults collected in the light trap.

The most prevalent parasites of white rice leafhopper — *G. cingulatus, H. spectrus,* and the unidentified mite — do not attack the other commonly occurring rice leafhoppers and planthoppers. The egg parasites *A. flaveolus* and *A. optabilis* are most common on the brown planthopper. *Paracentrobia* sp. has a wide host range. □

Pest management and control

WEEDS

Weed control in direct-seeded upland rice

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Ten herbicides were evaluated for control of weeds in upland rice at the Malan Rice Research Station during the 1977 wet season. Soil was loamy with pH 5.8; 544 kg N, 41 kg P, and 265 K available per ha; and 0.593% organic carbon. Average annual rainfall was 2,500 mm. Weeds were 14% *Echinochloa* spp., 22% other grasses, 23% *Cyperus* spp., and 41% broadleaf weeds.

Himdhan was drilled at 100 kg seed/ha in rows spaced at 20 cm. Before sowing, 40 kg each of P and K were applied. N at 100 kg/ha was applied in 3 splits at sowing, tillering, and panicle initiation. All herbicides (see table) were sprayed 6 days after sowing.

Hand weeding controlled weeds best

Effect of weed control treatments on rice grain yield, contributory yield characters, weed dry weight, and toxicity to rice plants. [a]

Treatment	Dose (kg ai/ha)	Grain yield (t/ha)	Panicles (no./m^2)	Spikelets (no./panicle)	1000-grain (g)	Toxicity[b] 25 DS	Dry wt of weeds (g/m^2)
Diethatyl	1	2 ef	167 c	89 b	24 cd	4.4 a	157 b
Butachlor	2	3 bc	156 c	107 a	25 abc	3.9 a	98 ef
Butralin	2	3 b	195 c	85 b	25 abc	1.9 c	122 cd
Piperophosl 2,4-D	2	4 a	320 ab	106 a	26 abc	1.5 c	86 f
Dinitramine	1	4 a	319 ab	110 a	27 ab	1.5 c	83 f
X 150	4	2 ef	167 c	79 bc	24 cd	2.3 bc	147 b
Oxadiazon	1	2 de	176 c	85 b	23 d	2.3 bc	125 cd
Pendimethalin	2	3 cd	189 c	82 bc	24 bcd	1.9 c	138 bc
Oxyfluorfen	2	2 f	172 c	84 b	24 cd	3.6 ab	115 de

Continued on opposite page

(see table), followed by dinitramine, piperophos/2,4-D, propanil, and butachlor which provided statistically comparable control.

More panicles/m^2 were recorded for hand weeding, but results were similar to those with dinitramine and piperophos/2,4-D. Spikelets per panicle, 1,000-grain weight, and yield followed a similar trend. Diethatyl, butachlor, and oxyfluorfen were most toxic to the crop. □

Table continued.

Treatment	Dose (kg ai/ha)	Grain yield (t/ha)	Panicles (no./m2)	Spikelets (no./panicle)	1000-grain (g)	Toxicity[b] 25 DS	Dry wt of weeds (g/m^2)
Propanil	3	3 b	299 b	107 a	26 ab	1.6 c	90 f
Hand weeding	25 & 50 DS	4 a	352 a	112 a	27 a	1.0 c	60 g
Unweeded control	–	2 f	153 c	68 c	23 d	1.0 c	453 a

[a] In a column means followed by a common letter are not significantly different at the 5% level. [b] Toxicity rating: 1 = no toxicity, 10 = complete kill, DS = days after sowing.

Soil and crop management

Dry matter yield reduction caused by sulfur-coated urea application to low percolation soils

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Sulfur-coated urea (SCU) is a slow-release nitrogen (N) fertilizer which, when broadcast and incorporated before transplanting, can minimize N losses and improve N efficiency in lowland rice. However, soil texture, CEC, and percolation rate affect SCU efficiency. We studied the effect of SCU on dry matter yields and micronutrient concentration in rice plants in soils with and without good percolation.

The greenhouse experiment in 1982 kharif was on a sandy loam Typic Ustochrept with pH 8.5, EC 0.15 mmho/cm, 0.23% organic carbon, and 4.54 meq/100 g CEC. Ten-liter pots were filled with 8 kg of air-dried, sieved soil treated with 26 mg P and 50 mg K/kg. Soil was flooded, puddled, and treated with 115 mg N/kg as prilled urea splits (PUS), urea supergranule (USG), urea mudball (MBU), or SCU. USG and MBU were deep-placed at 5-7 cm. SCU was broadcast and incorporated at 5-7 cm. Four 27-day-old PR106 seedlings were planted in each pot. Pots were flooded to maintain 5 cm standing water. Percolation for appropriate pots was maintained at 5 mm/h using pinchcocks. Treatments were in a completely randomized design with three replications. Plants were harvested at 15, 30, 45, and 60 days after transplanting (DT) and dry matter yields were recorded. Zn, Fe, Mn, and Cu concentrations were determined for plants harvested at 60 DT.

Without percolation, dry matter yields, except at 15 DT, were less for SCU-treated plants than for PUS, MBU, and USG. With percolation, SCU-treated plants yielded significantly more dry matter at 60 DT than USG (Table 1). Dry matter yields from PUS and MBU equaled those from SCU.

Without percolation, SCU-treated plants generally had lower Zn, Fe, Mn, and Cu concentrations than other treatments (Table 2). With percolation, they had significantly higher Fe and Mn concentrations than USG. Plants with SCU, PUS, and MBU had similar Zn, Fe, Mn, and Cu concentrations. In the absence of percolation, sulfides of these metals or H_2S may have been formed and thus hindered micronutrient uptake and reduced dry matter yields. □

Table 1. Effect of percolation and urea fertilizer on rice dry matter yields.[a]

Urea fertilizer	Dry matter yield at indicated days after transplanting (DT)									
	Without percolation					With percolation				
	g/hill				g/pot 60 DT	g/hill				g/pot 60 DT
	15 DT	30 DT	45 DT	60 DT		15 DT	30 DT	45 DT	60 DT	
No N check	0.20	0.70	1.30	3.7	9.8 a	0.30	0.90	3.10	6.3	17.2 a
Prilled urea 3-split	0.50	2.95	5.90	17.6	37.2 c	0.50	2.20	6.10	15.0	36.3 b
Urea mudball	0.25	2.70	7.50	17.3	36.4 c	0.45	2.60	5.80	16.5	32.8 b
Urea supergranule	0.40	2.80	8.40	19.2	40.3 c	0.30	1.20	4.50	10.7	21.2 a
Sulfur-coated urea	0.35	1.80	4.30	12.5	29.3 b	0.25	2.20	5.50	18.7	32.9 b
Interaction[b]	–	–	–	–	(PXU)**	–	–	–	–	(PXU)**
CV (%)					9.9					9.9

[a] In a column, means followed by the same letter are not significantly different at P = 0.05, [b]** = significant at P = 0.01. P = percolation, U = urea material.

Table 2. Effect of percolation and urea fertilizer on micronutrient content of rice plants (60 DT). [a]

Urea fertilizer	Micronutrients (ppm)							
	Without percolation				With percolation			
	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Check	34.6 a	130 a	480 a	6.0 a	22.0 a	165 a	383 ab	4.0 a
Prilled urea 3-split	50.6 b	226 bc	591 bc	10.0 b	38.6 b	260 bc	421 ab	8.0 b
Urea mudball	53.0 b	240 c	580 bc	8.0 ab	39.3 b	256 bc	378 ab	6.0 ab
Urea supergranule	58.3 b	223 bc	651 c	9.3 b	35.3 b	231 b	343 a	7.3 b
Sulfur-coated urea	38.6 a	176 ab	545 ab	6.0 a	35.6 b	286 c	458 b	6.3 b
Interaction [b]	(PXU)**	(PXU)**	(PXU)**	(PXU)**	(PXU)**	(PXU)**	(PXU)**	(PXU)**
CV (%)	12.9	14.1	9.7	19.2	12.9	14.1	9.7	19.2

[a] In a column, means followed by the same letter are not significantly different at $P = 0.05$. [b] ** = significant at $P = 0.01$, P = percolation, U = urea material.

Fertilizer trials in West Bengal

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We compared farmer fertilizer use levels with recommended levels in Purulia, West Bengal, in 1981 kharif. Soil characteristics at 6 demonstration sites varied from pH 4.8 to 6.8, 0.28 to 0.83% organic matter, 5.5 to 38.1 kg available P/ha, and 116.2 to 160.5 kg available K/ha.

IET1444 (Rasi) was transplanted in rainfed fields at 4 fertilizer levels: farmer level of 20.0-4.4-8.3 kg NPK/ha; treatment 1, 27.0-7.0-12.4 kg NPK/ha; treatment 2, 45.0-8.4-20.8 kg NPK/ha; and treatment 3, 55.0-9.7-27.4 kg NPK/ha.

Treatment 3 yielded highest – 3.6 t/ha — (see table) but treatment 2, which yielded 3.4 t/ha, gave the highest benefit-cost ratio, 10.5. Economic analysis of treatments and yields showed that investing an extra $11.23 to $39.43/ha could increase returns from $100.23 to $311.62/ha. □

Economic analysis of added NPK compared to farmer fertilizer management level in Purulia, West Bengal.

Treatment	Fertilizer rate (kg/ha)			Yield range (t/ha)	Mean yield (t/ha)	Added yield over farmer level (t/ha)	Value of added yield ($/ha)	Cost of added inputs [a] ($/ha)	Added profit over farmer level ($/ha)	Benefit: cost
	N	P	K							
Farmer level	20	4.4	8.3	0.94-1.15	1.07	–	–	–	–	–
1	27	7.0	12.4	1.62-2.05	1.86	0.79	111.46	11.23	100.23	8.9
2[b]	45	8.4	20.8	3.12-3.65	3.36	2.29	323.01	28.14	294.87	10.5
3	55	9.7	27.4	3.46-3.61	3.56	2.49	351.05	39.43	311.62	7.9

[a] Cost/kg of fertilizer – N:$0.66, P:$2.00, K:$0.32; price of paddy/t = $141.10. [b] Recommended level.

Effect of azolla on the growth and yield of rice plants

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We evaluated azolla as a substitute for urea fertilizer for rice in a pot experiment at the Botanical Garden, University of Dhaka.

Urea was applied at 0, 25, 50, 75, and 100 kg N/ha (see table) with and without azolla. Triple superphosphate and muriate of potash, each at 50 kg/ha, were applied to all treatments except the control. Fresh azolla was inoculated 7 days after transplanting BR3 and incorporated when growth covered the pot, about 2 weeks after inoculation. Treatments were in a randomized block design with four replications.

Azolla incorporation alone or in combination with urea stimulated rice growth and increased grain yield. Highest yield was 72.3 g/pot with 100 kg N/ha + azolla (see table). Grain yield was similar for 75 kg N alone and 25 kg N + azolla. Azolla application also increased straw weight. Applying 75 kg N alone or 50 kg N + azolla gave the same straw yield (58 g/pot). □

Effect of azolla on rice grain and straw yield.

Treatment [a] (kg N/ha)	Av no. of grains/hill	Straw yield (g)	Grain yield (g)
No chemical fertilizer	1021	29.3	29.1
TSP + MP alone	1049	29.6	29.9
25	1478	43.0	42.1
50	1631	46.0	46.5
75	1965	58.0	56.0
100	2283	63.0	62.8
Azolla	1709	50.0	49.7
25 + azolla	1994	57.0	56.8
50 + azolla	2048	58.0	58.4
75 + azolla	2521	69.5	71.9
100 + azolla	2537	72.0	72.3

[a] All treatments except the first have TSP and MP, each at 50 kg/ha.

Use of slow-release fertilizers to reduce nitrification

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Rice land soils in Orissa are alternately submerged and drained, which encourages nitrification of applied fertilizers and reduces to 30% crop recovery of fertilizer nitrogen. We studied the effect of slow-release nitrogen fertilizers on Ratna growth and yield at Bhubaneswar.

Soil was a sandy loam with pH 5.4 and 756.4 kg N, 26.5 kg P, and 181.4 kg K/ha. Nitrogen was applied as isobutylidene diurea (BDU), AM fertilizer, lac-coated urea, and as urea mixed with karanj cake *(Pongamia pinnata),* a locally available, low-cost forest product suitable for mechanical blending with urea. Karanj contains 4% N, 0.79% P, and 1.3% K and retards nitrification.

The number of effective tillers per hill indicated the beneficial effect of slow-release nitrogen fertilizers (see table). Applying 100 kg N/ha as lac-coated urea or karanj cake-coated urea produced almost as many effective tillers/hill as 100 kg urea N/ha.

Maximum plant height was produced with karanj cake-coated urea, closely followed by lac-coated urea and 16-10-14 IBDU (see table).

Panicle length was greater for all slow-release nitrogen fertilizers at 100 kg N/ha. As urea application without slow-release treatment decreased, average panicle length declined. The control treatment had shortest panicles.

Lac-coated urea produced best grain filling and highest weight, followed by karanj cake-coated urea.

Lac-coated urea produced maximum grain yield of 5.1 t/ha, followed closely by karanj cake-coated urea. Nitrogen at 100 kg/ha applied as lac-coated or karanj cake-coated urea produced significantly better rice growth and yield than 200 kg N/ha applied as ordinary urea. □

Effect of slow-release nitrogen fertilizers and urea on rice growth and yield, Bhubaneswar, India. [a]

Treatment	Growth attributes		Yield attributes			Grain yield (t/ha)
	Tillers/ hill	Height (cm)	Panicle length (cm)	1000-grain wt (g)	Filled grains (no./ panicle)	
Urea 50 kg N/ha	6	62	20	27	56	3.1
Urea 100 kg N/ha	7	63	21	28	61	3.9
Urea 150 kg N/ha	7	64	22	28	65	4.2
Urea 200 kg N/ha	7	65	23	28	69	4.7
Sulfur-coated urea (S_1) (100 kg N/ha)	8	65	24	29	70	4.8
Sulfur-coated urea (S_2) (100 kg N/ha)	7	64	23	28	69	4.7
IBDU (10-10-10) (100 kg N/ha)	7	65	24	29	70	4.9
IBDU (16-10-14) (100 kg N/ha)	8	69	24	29	70	4.9
Lac-coated urea (100 kg N/ha)	8	70	25	29	72	5.0
AM (100 kg N/ha)	7	65	29	28	69	4.9
Karanj (100 kg N/ha)	8	70	24	29	71	5.1
Control	5	52	19	22	55	3.1
CD (0.05)	0.99	2.46	0.70	1.46	2.31	0.15

[a]All treatments received a basal application of 18 kg P and 33 kg K/ha.

Effect of blue-green algae and nitrogen levels on rice yields

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We conducted multilocation experiments to determine the effect of blue-green algae (BGA) inoculation on rice yields in sandy to clay loam soils in Chhattisgarh, Madhya Pradesh. Soil pH and available P at different locations are given in Table 1.

BGA was applied alone and in combination with nitrogen fertilizer, and 18 kg P and 12 kg K/ha were applied to all treatments. Kranti, a medium-duration cultivar, was transplanted at 20- × 10-cm spacing. The crop was affected by grasshopper *Hieroglyphus banian* and bacterial blight, and pest control practices were used.

Table 1. Soil pH and available P of experimental soils.

Location	Soil type	Soil pH	Available P (kg/ha)
	1981		
Regza	Sandy loam	7.6	16.6
Khoksa	Clay loam	7.8	15.9
Sarkanda	Clay loam	7.4	27.2
	1982		
Sarkanda	Clay loam	1.5	15.4

Table 2. Average grain yield of rice as affected by blue-green algae and nitrogen levels.

Treatment (kg/ha)	Grain yield (t/ha)			
	1981			1982
	Regza (sandy loam)	Khoksa (clay loam)	Sarkanda (clay loam)	Sarkanda (clay loam)
Control (no BGA, no fertilizer)	3.0	1.7	2.3	3.9
10 BGA	3.4	2.0	2.7	4.6
20 N	3.3	2.7	3.7	5.2
20 N + 10 BGA	3.7	2.8	3.0	5.9
40 N	3.8	2.6	3.2	5.5
40 N + 10 BGA	3.8	2.8	3.5	6.2
60 N	3.9	2.6	3.9	6.2
60 N + 10 BGA	3.9	2.9	3.9	6.5
CD (0.005)	0.4	0.6	0.3	1.2

Application of 10 kg BGA/ha significantly increased the 1981 rice yield over the no-fertilizer, no-BGA control at the Government Farm in Regza and Sarkanda Bilaspur (Table 2). Combining 20 kg N and 10 kg BGA/ha caused a significant yield increase over 20 kg N/ha alone at Regza.

BGA did not develop spontaneously in the experimental fields. Scanty green algae biomass was noticed on N-fertilized plots. □

Optimum transplanting time for rice: an agrometeorological approach

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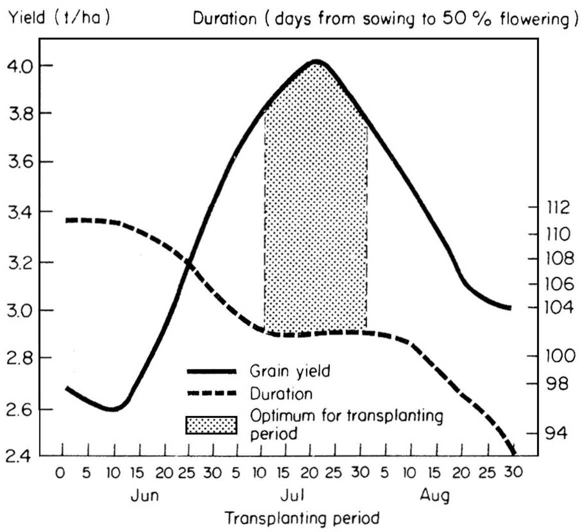
To maximize rice grain yield, it is necessary to determine optimum planting date. We used grain yield pattern and water and energy use efficiencies to determine correct planting date.

Our experiment at Raipur (2l°14'N, 81°39'E) in the 1981 monsoon season was on clay loam with pH 6.5. Asha (R-35-2752), a dwarf indica, was planted in 3 replications at 10- × 20-cm spacing on 10 dates at 10-day intervals between 1 Jun and 30 Aug. Fertilizer was applied at 100 kg N, 26 kg P, and 33 kg K/ha. Net radiation and potential evapotranspiration values were estimated by Penman's equation and meteorological parameters recorded at the Agricultural Meteorology Observatory.

Phenological data, grain yield, yield-contributing characters, and total dry matter production are shown in the table. Yield-contributing characters varied little among transplanting dates, but there was a marked difference in grain yield pattern (see figure). Yield pattern and duration from sowing to 50% flowering indicated that transplanting between 11 and 21 Jul will produce optimum yields.

Water use efficiency (kg/ha per mm of evapotranspiration) for grain yield was highest for rice transplanted between 11 and 31 Jul (see table). Water use efficiency for dry matter production was highest between 11 and 21 Jul.

Energy use efficiency did not vary significantly, but a definite relation existed between net accumulated radiation from flowering to maturity and grain yield pattern. Higher radiation produced higher yields. □



Optimum period of transplanting rice for stable rice grain yield.

Accumulated evapotranspiration during different physiological stages, yield contributing characters, and water use efficiency of rice crops.

Transplanting date	Accumulated evapotranspiration (mm) Sowing to planting	Planting to 50% flowering	50% flowering to maturity	Total	Effective tillers/ hill	Sound grains /panicle	Dry matter (t/ha)	Grain yield (t/ha)	Water use efficiency for Grain yield (kg/ha per mm)	Dry matter (kg/ha per mm)
1.6.81	206	349	82	641	6.9	82	11.5	2.7	4.2	17.9
11.6.81	221	310	86	614	7.2	82	13.3	2.6	4.2	21.6
21.6.81	225	270	92	587	6.6	81	13.4	3.0	5.0	22.9
1.7.81	176	258	98	532	7.2	83	13.3	3.4	6.5	25.1
11.7.81	139	244	115	500	7.6	92	11.9	3.8	7.6	25.5
21.7.81	99	250	119	468	7.9	94	12.6	4.0	8.6	26.9
31.7.81	108	252	130	489	6.9	92	9.8	3.8	7.7	20.0
10.8.81	98	267	107	472	5.6	88	8.0	3.5	7.3	16.9
20.8.81	106	250	97	453	5.4	68	7.4	3.1	6.9	16.3
30.8.81	107	229	86	422	4.4	59	7.0	3.1	7.3	16.6

The International Rice Research Newsletter (IRRN) invites all scientists to contribute concise summaries of significant rice research for publication. Contributions should be limited to one or two pages and no more than two short tables, figures, or photographs. Contributions are subject to editing and abridgement to meet space limitations. Authors will be identified by name, title, and research organization.

Nutrient status of some rice soils

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We evaluated fertilizer needs of high yielding rice varieties. Soil samples were collected from 23 locations in the districts of Dhaka, Tangail, Faridpur, Kustia, and Jessore. Low fertilizer levels as urea, triple superphosphate, and muriate of potash were applied for 2 to 6 years. Sometimes cow dung also was applied.

Leaf blade samples taken from boro crops of IR3 and IR8 at panicle inilia-tion and soil samples collected in May and Jun 1978 were dried and analyzed for nutrient content.

Table 1 presents average values for soil pH, percent organic matter, total N, available P, ammonium acetate extractable K, Ca, and Mg, Ca $(H_2PO_4)_2$ extractable S, and 0.1N HCl extractable Zn.

Soil pH varied from moderately acid 5.4 to moderately alkaline 8.2. Organic matter ranged from 1.16 to 2.86%, averaging 1.94%. Total N content varied between 0.08 and 0.16%, averaging 0.124%. Soils were generally poor in organic matter and total N, but C—N ratios favored rice production (Table 1).

Available P content ranged from low to high. Available K averaged 0.76 meq/ 100 g soil and available Ca, 14.13 meq/ 100 g soil. Available Mg ranged from 1.40

Table 1. Some physiochemical characteristics of the soils at 23 locations in Bangladesh.

Location	Textural class (with % clay)	pH	Organic matter (%)	Total N (%)	Available nutrients						C:N
					meq/100 g			ppm			
					K	Ca	Mg	Zn	P	S	
Ghumi$_1$, Tangail	Silty clay (45.7)	6.15	1.50	0.12	0.94	6.20	3.24	4.31	7.50	10.28	7.25
Ghumi$_2$, Tangail	Silty clay (44.8)	6.20	2.43	0.14	0.84	6.34	2.92	4.10	35.00	9.24	10.00
Kalihati$_1$, Tangail	Silty clay (44.2)	5.80	1.33	0.10	0.92	6.10	1.20	5.20	41.88	9.38	7.70
Kalihati$_2$, Tangail	Silty clay loam (38.7)	5.65	1.16	0.12	0.85	4.28	2.10	3.90	43.75	11.20	7.25
Sathalia, Tangail	Clay loam (39.2)	6.60	2.20	0.15	0.70	5.34	1.90	4.18	50.00	10.24	8.50
Kalmeshwar, Dhaka	Silty clay loam (27.7)	6.20	1.24	0.09	0.40	7.00	2.10	5.10	53.13	7.80	7.99
Majpara$_1$, Dhaka	Clay (63.0)	6.00	2.24	0.14	0.91	20.10	2.31	6.20	2.50	14.20	7.28
Majpara$_2$, Dhaka	Clay loam (35.6)	5.90	2.37	0.15	0.50	17.10	3.10	4.90	21.88	14.12	9.16
Rarikhal$_1$, Dhaka	Clay (62.1)	6.10	2.86	0.15	0.58	19.00	3.24	6.18	18.75	13.12	11.00
Rarikhal$_2$, Dhaka	Clay (62.0)	6.15	1.62	0.12	0.73	21.30	3.90	5.27	11.00	14.18	7.83
Matlagram$_1$, Dhaka	Clay (65.2)	5.50	2.24	0.14	1.20	17.30	2.39	5.70	11.00	15.10	9.28
Matlagram$_2$, Dhaka	Clay (69.3)	6.20	1.99	0.13	0.84	18.10	2.13	6.18	15.00	14.10	8.88
Juair, Faridpur	Silty clay loam (40.8)	7.80	2.37	0.12	0.70	18.70	3.10	4.28	8.75	29.20	10.60
Bhakindapur, Faridpur	Clay loam (42.3)	8.10	1.49	0.09	0.81	19.20	3.04	3.23	11.25	18.23	9.56
Alipur, Faridpur	Clay loam (38.5)	8.15	1.49	0.08	0.72	17.20	2.90	2.84	8.75	21.20	10.70
Bhakindagram$_1$, Faridpur	Clay (50.4)	8.20	1.37	0.08	0.84	18.50	2.49	5.20	10.00	18.30	9.88
Bhakindagram$_2$, Faridpur	Clay (49.7)	8.10	1.74	0.10	0.76	19.30	2.41	3.10	10.00	26.38	10.00
Amjupi, Kustia	Sandy clay (41.30)	7.15	2.61	0.12	0.64	17.20	2.29	2.18	21.25	19.32	12.60
Rajnagar, Kustia	Sandy clay (43.4)	8.00	1.49	0.12	0.81	21.00	3.10	3.38	10.00	22.14	8.25
Tetulia, Kustia	Clay loam (45.1)	7.10	2.49	0.13	0.59	13.10	2.20	2.58	5.00	20.13	11.10
Ulashi, Jessore	Clay loam (38.50)	5.40	1.97	0.14	0.60	9.13	1.04	3.30	3.80	12.34	8.16
Pathila, Jessore	Silty clay (45.9)	7.50	2.37	0.16	0.71	12.10	1.84	2.18	7.50	17.15	8.59
Dattanagar, Jessore	Clay loam (40.2)	7.00	2.12	0.16	0.84	11.10	1.90	3.29	5.00	30.14	7.69

to 3.90 meq/l00 g soil. These are adequate amounts for successful rice production.

Available S was between 7.80 and 30.14 ppm. Soils of Ghumi$_2$ and Kalihati of Tangail District and Kalmeshwar of Dhaka District were S deficient. Available Zn (2.18-6.20 ppm) is adequate for rice culture.

N content of the leaf blades ranged from 1.32 to 3.07% and P from 0.008 to 0.140% (Table 2). Almost all plants showed N and P deficiency. K content of the plant tissue ranged from 0.39 to 1.79%. Only plants from Majpara had K deficiency. Ca content of leaves ranged from 0.20 to 0.44%. The Ca content of leaves collected from Ghumi$_1$, Kalihati$_2$, and Sathalia was low. Mg varied between 0.10 and 0.17%, and all leaf samples showed deficiency. Leaf samples from Tangail and Kalemshwar were S deficient (Table 2). Zn concentration ranged from 12.3 to 58.7 ppm, averaging 29.6 ppm.

Table 2. Nutrient composition of rice leaf at panicle initiation stage.

Place	Dry matter yield in g (50 leaves)	Nutrient elements in leaf blades						
		N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Zn (ppm)
Ghumi$_1$	5.0524	1.78	0.014	1.56	0.28	0.14	0.04	32.70
Ghumi$_2$	6.3795	1.96	0.034	1.29	0.21	0.12	0.04	45.30
Kalihati$_1$	4.1650	1.54	0.014	1.64	0.24	0.12	0.05	40.00
Kalihati$_2$	5.7970	3.07	0.048	1.36	0.29	0.14	0.04	41.40
Sathalia	7.1834	2.05	0.018	1.48	0.22	0.10	0.05	31.30
Kalmeshwar	5.2680	1.72	0.027	1.01	0.20	0.12	0.03	33.00
Majpara$_1$	3.9700	3.06	0.008	1.48	0.38	0.15	0.11	55.70
Majpara$_2$	5.9030	2.31	0.014	0.39	0.30	0.15	0.13	27.70
Rarikhal$_1$	4.2365	2.60	0.014	1.68	0.32	0.14	0.10	58.70
Rarikhal$_2$	5.1780	2.65	0.009	1.72	0.34	0.15	0.12	42.00
Matlagram$_1$	6.4060	1.96	0.018	1.01	0.35	0.15	0.11	45.40
Matlagram$_2$	5.2665	2.81	0.008	1.60	0.35	0.14	0.14	45.00
Juair	5.4730	1.74	0.018	1.21	0.38	0.14	0.14	21.00
Bhakindapur	4.2470	1.72	0.014	1.21	0.41	0.15	0.10	15.30
Alipur	4.4180	1.79	0.019	1.20	0.38	0.16	0.12	17.30
Bhakindagram$_1$	4.3230	1.72	0.010	1.24	0.44	0.15	0.13	27.70
Bhakindagram$_2$	3.2370	1.73	0.008	0.94	0.42	0.16	0.14	24.00
Amjupi	4.3355	1.32	0.018	1.44	0.44	0.17	0.13	21.00
Rajnagar	3.6720	1.62	0.014	1.79	0.40	0.16	0.11	24.00
Tetulia	2.2795	2.22	0.012	1.48	0.38	0.16	0.14	12.30
Ulashi	5.7065	1.24	0.010	1.01	0.40	0.13	0.11	21.00
Pathila	5.3240	2.31	0.017	1.21	0.41	0.15	0.18	18.70
Dattanagar	3.4950	1.45	0.14	1.13	0.35	0.15	0.18	16.30

Data on soil and plant nutrients indicated that all the soils had N and P deficiency. With few exceptions, soils contained adequate K. Soil analysis indicated there was an adequate supply of available Ca and Mg in ail the areas, but plant analysis showed crops in Ghumi$_1$, Ghumi$_2$, Kalihati$_1$, Kalihati$_2$, and Sathalia to be Ca deficient. Plant analysis showed Zn deficiency in all the areas though soil analysis indicated adequate Zn supply. □

Nitrogen management in rainfed lowland transplanted rice grown on calcareous soil

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The effect of applying different nitrogen sources was studied at the RAU Research Farm during 1981 kharif. Nitrogen sources were prilled urea, lac-coated urea (LCU), sulfur-coated urea (SCU), and urea supergranules (USG). A no-nitrogen control and 29, 58, and 87 kg N/ha were applied in a randomized block design with 4 replications. Soil in the field was a calcareous silt loam with 0.76% organic carbon, 8.8 kg available P/ha, 0.12 meq/100 g exchangeable K, and pH 7.9.

Thirty-five-day-old Pankaj seedlings were transplanted at 15- × 20-cm spacing on 23 Jul 1981. Prilled urea was applied either basally or in 3 equal splits at transplanting, tillering, and panicle initiation.

Rough rice yield as influenced by sources and levels of nitrogen.

Source of N	Grain yield (t/ha)				LSD 5%
	29 (kg N/ha)	58 (kg N/ha)	87 (kg N/ha)	Mean	
Prilled urea (basal)	3.3	3.4	3.7	3.4	Source (S) – 0.22
Prilled urea (split)	3.3	3.5	3.9	3.6	N level (N) – 0.17 S × N – NS
Lac-coated urea	2.9	3.2	3.6	3.2	Control vs rest – 0.14
Sulfur-coated urea	3.4	3.7	4.0	3.7	
Urea supergranules	3.4	3.9	4.0	3.7	
Mean	3.3	3.5	3.8		
No-N control		2.91			

LCU (34% N) and SCU (36.7% N) having 21% dissolution rate in 7 days were broadcast and incorporated before transplanting. USG were placed 8-10 cm deep between 4 hills immediately after transplanting when the soil began to harden. All plots received a basal dose of 18 kg P and 17 kg K/ha, and a 0.5% $ZnSO_4$ solution with lime was sprayed on the crop at tillering stage. Drought from heading through harvest reduced yield. After harvesting a net area of 10.88 m^2 on 17 Nov grain yield was recorded at 14% moisture.

Averaged over three nitrogen levels, SCU, USG, and split-applied prilled urea produced yields significantly superior to those from basally applied prilled urea and LCU (see table). Grain yield increased significantly with each increase in applied N. Although the interaction between sources and levels of N was not significant, the data indicated that at 29 and 58 kg N/ha, SCU and USG were more efficient than all other sources. At 87 kg N/ha, SCU, USG, and split-applied prilled urea yielded similarly and more than basal prilled urea and LCU. LCU was least efficient at all N levels.

Zn deficiency symptoms increased with higher basal SCU and USG N applications. Drought also affected those treatments more adversely.

Results suggest that application of 58 kg N/ha as SCU or USG produces best yields in drought-prone areas with Zn-deficient calcareous soil. □

Nitrogen fertilization and spacing to maximize upland rice yield

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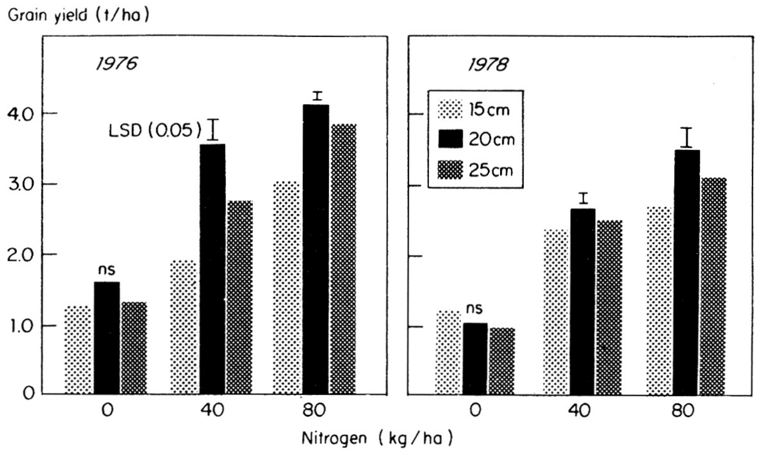
Upland rice is a major crop in eastern Uttar Pradesh, but yields are low because of drought, weeds, poor agronomic practices, and lack of locally adapted improved varieties with good yield potential and high nutrient use efficiency. In 1976 we tested the effect of row spacing and nutrient supply on grain yield of Narendra 1 (IET2232), a semidwarf upland rice.

The crop was grown under natural upland conditions on sandy loam soils at Faizabad at 3 row spacings — 15, 20, and 25 cm — and nitrogen levels — 0, 40, and 80 kg/ha. Fourteen kg P and 25 kg K/ha were applied to all plots. The field was tilled after the first rain in early Jul, and 100 kg seed/ha was direct-seeded in rows. The crop was hand weeded. The experiment was repeated in 1977 and 1978. Weekly rainfall at Faizabad from Jun to Oct 1976 and 1978 is in the table. Total rainfall during the crop season is about 1,000 mm, but is interrupted by drought spells. In 1977 the crop failed because of drought.

Grain yield increased sharply with increased nitrogen, regardless of row spacing (see figure). Yield increased from 1.6 t/ha at 0 kg N to 3.6 t/ha at 40 kg N and to 4.1 t/ha at 80 kg N/ha in 1976. Response to N was similar in 1978. The 20-cm spacing between rows produced maximum grain yields at 40 and 80 kg N/ha. □



Effect of nitrogen levels and row spacings on upland rice yield, Faizabad, India.

Weekly rainfall distribution during crop season at Faizabad, India

Month	Year	Rainfall (mm) Wk 1	Wk 2	Wk 3	Wk 4	Total
Jun	1976	0	21.6	0	8.6	30.6
	1978	0	55.6	61.2	15.2	132.0
Jul	1976	0	81.8	97.6	32.0	211.4
	1978	2.6	3.4	420.0	75.2	501.2
Aug	1976	109.6	218.0	133.6	77.6	538.8
	1978	13.6	115.2	39.2	12.4	180.4
Sep	1976	0	214.6	13.6	84.6	312.8
	1978	33.2	57.8	41.0	64.0	196.0
Oct	1976	0	20.6	0	0	20.6
	1978	15.2	0	0	0	15.2

Total rainfall = 1113.8 in 1976, 1024.8 in 1978.

Effect of amendments and presubmergence on Fe and Mn availability in sodic soil and on rice yield

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A field experiment evaluated the effect of adding 12.5 t gypsum/ha, pyrite (equivalent to gypsum on sulfur basis), 30 t farmyard manure/ha, 30 t rice husk/ha at 0 and 30 days submergence prior to transplanting of rice on Fe and Mn availability and rice yield. The experiment was replicated 4 times in a split-plot design on highly sodic sandy soil with pH 10.6, exchangeable sodium percentage (ESP) 94, exchangeable Ca + Mg 0.4 meq/100 g soil, organic carbon 0.26%, $CaCO_3$ 2.75%, CEC 10.0 meq/100 g soil,

Table 1. Effect of duration of pretransplanting submergence and amendments on rice grain yield.

Duration of preplanting submergence (d)	Grain yield (t/ha) Control	Gypsum	Pyrite	Farmyard manure	Rice husk	Mean
0	0.08	5.19	4.81	3.29	2.70	3.21
30	0.18	5.58	5.43	5.52	4.52	4.24
Mean	0.13	5.38	5.12	4.40	3.6 1	

CD at P = 0.05, Amendments = 0.23; Submergence = 0.13; Amendments × submergence = 0.29.

Table 2. Changes in Mn, Fe, soil pH, and ESP in submerged sodic soil as affected by amendments during the growth period of rice crop (av of 4 replications).

Amendment	Duration of submergence prior to planting (d)	Extractable Mn[a] A (ppm)	B (ppm)	C (ppm)	D (ppm)	Extractable Fe A (ppm)	B (ppm)	C (ppm)	D (ppm)	Soil pH after crop harvest	ESP
None (control)	0	2.2	11.9	11.8	10.5	3.0	14.5	14.5	14.0	10.3	82.8
	30	12.5	11.6	11.5	10.8	12.9	15.6	16.0	15.5	10.1	81.0
Gypsum	0	2.5	14.0	15.5	15.0	2.7	16.8	22.0	18.0	9.5	37.5
	30	15.0	16.5	16.8	15.8	15.5	20.6	25.5	22.6	9.3	35.2
Pyrite	0	2.0	17.5	18.0	17.5	3.5	31.5	32.6	30.8	9.6	39.6
	30	17.8	18.5	18.5	18.0	32.8	33.0	32.6	31.6	9.4	37.5
Farmyard manure	0	2.6	62.8	70.0	68.8	3.4	60.5	64.0	60.5	9.9	72.5
	30	65.7	68.6	78.5	70.5	59.8	65.8	65.5	62.0	9.8	62.0
Rice husk	0	2.4	40.5	48.0	45.5	3.5	44.5	45.3	40.6	10.0	74.5
	30	48.5	50.6	54.6	50.1	45.6	48.5	48.0	45.3	9.9	70.1

[a]A = at the time of transplanting, B = 30 days after transplanting, C = 60 days after transplanting, D = 90 days after transplanting.

and gypsum requirement 25 t/ha at Gudha experimental farm of CSSRI, Karnal.

Amendments were added at flooding except for pyrite, which was applied 3 days before flooding under moist conditions to ensure proper oxidation. Soil was submerged until Jaya was transplanted in standing water 18 Jul 1982, and maintained thus throughout the crop period. Urea at 150 kg N/ha and 40 kg $ZnSO_4$/ha were applied to the crop. One-half the N and all the Zn were applied at transplanting. The remaining N was topdressed in 2 equal splits at 3 and 6 weeks of crop growth. The crop was harvested 30 Oct 1982.

The effect on grain yield of 30 d presubmergence was significant for farmyard manure and rice husk where there had not been previous flooding (Table 1). Gypsum and pyrite reduced pH and ESP more (Table 2) and produced higher yields than other treatments at 0 days submergence, but farmyard manure produced equal yields at 30 d presubmergence.

Extractable Fe and Mn increased with duration of submergence in the following order: farmyard manure, rice husk, pyrite, and gypsum (Table 2). The effect of presubmergence was conspicuous up to 60 d of crop growth but remained constant or declined slightly beyond 60 d. □

Effect of USG placement and planting geometry on yield of random-planted rice

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We evaluated the feasibility of urea supergranule (USG) deep placement in randomly transplanted rice, a planting practice followed by most Indian farmers. We also compared deep placement at 24.5- × 24.5-cm and 20- × 20-cm spacing as an economy measure, and broadcast application of USG vs prilled urea. Treatments were in a randomized block design with three replications.

In random transplanting, deep placement increased Jaya yield by 0.4 t/ha and Govind yield by 1.1 t/ha (Table 1) over yields with broadcast fertilizer. Yield for 6-7 seedlings/hill spaced at 24.5 × 24.5 cm equaled that of 4 seedlings/hill at 20- × 20-cm spacing. The wider spacing could reduce hand point placement cost by 15% (labor). USG yields were significantly superior to those with prilled urea for broadcast and incorporation application (Table 2); however, yield was only 2 t/ha because the crop was late. □

Table 1. Deep placement vs broadcast application of USG at 60 kg N/ha under different planting geometries during 1982 rainy season at Pantnagar, India.

Planting geometry	Seedlings per hill[a]	Grain yield (t/ha) Broadcast[b]	Placement
Jaya (medium Juration)			
Random (farmers' practice)	6-7	5.0	5.4
Row 24.5 × 24.5 cm	6-7	4.2	5.6
Row 20 × 20 cm recommended practice	4[c]	4.1	4.9
Govind (short duration)			
Random - farmers' practice	6-7	3.5	4.6
Row 24.5 × 24.5 cm	6-7	3.7	4.3
Row 20 × 20 cm, recommended practice	4[c]	4.3	4.5
Mean		4.1	4.9
LSD 5% broadcast vs placement		0.4	
CV (%)		12	

[a]To give 100 seedlings/m^2. [b]USG was dissolved and mixed because of light rains following application, however, it was not incorporated. [c]The seedling number was increased from 2 (normal) to 4/hill due to late planting (30 Jul). Late plantings are common with poor farmers.

Table 2. Broadcast and incorporation of USG vs prilled urea at 60 kg N/ha in very late planting during 1982 rainy season at Pantnagar, India.

N fertilizer		Grain yield (t/ha)
Urea supergranule		2.1
Urea		1.5
	LSD 5%	0.5
	CV	8%

Environment and its influence

Photoperiod sensitivity of Rayada rices

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Rayada, unlike traditional deepwater rice varieties, has cold tolerance at seedling stage, lacks seed dormancy, has a very long growth duration (11 mo), and is cultivated in 3.7-6 m water depth.

The Rayada rices in Bangladesh are sown with boro rices as a mixed crop. Boro varieties are photoperiod insensitive and are usually harvested in Apr or May when Rayada plants are vegetative. Rayada rices continue to grow under subsequent deepwater conditions and do not flower until late Sep and Oct when day length is less than 12 hours, Rayada rices do not respond to short photoperiod in Feb and early Mar when planted in Nov, and always flower in Sep and Oct. Is this group of cultivars a photoperiod-sensitive type with a long basic vegetative phase (BVP)? We tried to verify this assumption.

Five strains of Rayada conserved by the IRRI International Rice Germplasm Center were used. Habiganj (HBJ) aman 1, a deepwater rice variety, was the photoperiod-sensitive check and HBJ boro 5 was the insensitive check. Plants received 10, 12, 14, and 16 h photoperiods starting at seeding dates. Plants that did not flower after 140 days of growth were dissected and checked for panicle primordia.

HBJ aman 1 and Rayada strains flowered at 10 and 12 h photoperiod and remained vegetative at 14 and 16 h photoperiods (see table). HBJ boro 5 flowered at all the photoperiod treatments, with similar flowering duration. Based on flowering behavior, both HBJ aman 1 and Rayada strains are strongly photoperiod sensitive with a long photoperiod-sensitive phase (PSP) and critical photoperiod of around 12 hours.

Days to flower, basic vegetative phase (BVP) and photoperiod sensitive phase (PSP) of five strains of Rayada, HBJ aman 1, and HBJ boro 5 at different photoperiods.

Variety, strains	Days to flowering[a] at photoperiod of				BVP	PSP
	10 h	12 h	14 h	16 h		
Rayada 16-02	108	126	–	–	73	140+
Rayada 16-03	108	124	–	–	73	140+
Rayada 16-05	109	126	–	–	74	140+
Rayada 16-06	108	124	–	–	13	140+
Rayada 16-08	105	125	–	–	70	140+
HBJ aman 1	38	80	–	–	3	140+
HBJ bora 5	92	92	97	92	57	5

[a]A dash (–) means the variety did not initiate panicles after 140 days of growth.

The BVP, which is synonymous with insensitive phase or juvenile stage of a variety, can be estimated by subtracting 35 days from the number of days from sowing to flowering when the plants are grown under optimum photoperiod. Although the BVP range reported in the literature varies from 10 to 63 days, none of the strongly photoperiod-sensitive varieties so far tested had a BVP of more than 49 days. Rayada strains had a 70- to 74-day BW.

On the basis of BVP and PSP duration, rice varieties are classified into four types. Type A has a short BVP and PSP, type B has a long BVP and short PSP, and type C has short BVP and long PSP. Type D varieties with long BVP and PSP have not yet been reported, but present observations indicate Rayadas are type D.

Type D varieties were probably eliminated during domestication because they have an unusually long growth duration. That Rayada rices represent less than 10% of the total deepwater rices in Bangladesh substantiates this statement.

Although the different Rayada strains are strongly photoperiod-sensitive with a BVP of around 70 days and a critical photoperiod of around 12 h, they do not respond to shorter Feb and Mar photoperiods when planted in Nov. Low temperatures in Nov, Dec, and Jan may extend the already long BVP so that when the plant is ready for photoinduction, the day length is already longer than the critical photoperiod.

Rice-based cropping systems

Agroeconomic performance of six rice - wheat cropping patterns, Thakurgaon, Bangladesh

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In Bangladesh, 92% of the farmers grow rice on 74% of the cultivable land. Rice is about 93% and wheat is 5% of cereal grains production.

During the 1970s introduction of high yielding rice varieties from BRRI and modern wheat varieties from the Bangladesh Agricultural Research Institute dramatically changed agriculture in Bangladesh. High yielding, short-duration, photoperiod-insensitive rice varieties sometimes perform well in rice - wheat cropping patterns in some wheat-growing areas. Time of transplanted (t.) aman rice harvest, and planting time and growth duration of wheat varieties are critical to this cropping pattern. A late t. aman harvest delays wheat planting, which causes low yield because grain must ripen during hot, dry weather. To attain maximum production and economic return, appropriate rice and wheat varieties must be selected.

Six rice - wheat cropping patterns were tested at three sites of the North Bangladesh Tubewell Project, Thakurgaon, during 1981-82 and agroeconomic analysis was used to determine the most productive, profitable rice - wheat combinations.

BR4, BR10, and Pajam rices yielded more than BR11, Kalam, and Malshara. Pavon wheat yielded more than Balaka, Jupateca, and Sonalika (see table). BR4 - Pavon and Pajam - Pavon rice - wheat combinations yielded more and had higher net return and benefit-cost ratios than BRl0 with Balaka and two local varieties with Sonalika. Cost of growing local rice varieties generally was low, but low yield potential reduced profits. Local photoperiod-sensitive rice varieties also are harvested late, and delayed planting of Sonalika wheat, which reduced its yield. With an assured water supply, BR4 - Pavon and Pajam - Pavon can be grown successfully in the Thakurgaon tubewell project. ☐

Agoeconomic performance of six rice - wheat cropping patterns. Thakurgaon, Bangladesh, 1981–82.

Cropping pattern			Mean yield (t/ha)		Gross return[c] /pattern ($/ha)	Net return /pattern ($/ha)	Benefit-cost ratio
Rice		Wheat	Rice	Wheat			
BR4[a]	–	Pavon	4.4	2.9	1312	792	2.5
BR10[a]	–	Balaka	3.4	2.3	1027	566	2.2
BR11[a]	–	Jupateca	3.0	1.6	822	384	1.9
Pajam	–	Pavon	3.8	2.7	1179	666	2.3
Kalam[b]	–	Sonalika	2.3	1.6	708	244	1.5
Malshara[b]	–	Sonalika	1.7	1.4	562	147	1.3

[a]High-yielding variety. [b]Local variety. [c]Rice price = $160.74/ton; wheat price = $207.62/ton.

Performance of rice-based cropping patterns in the irrigated uplands of Orissa

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Rice, planted on more than 4 million ha, is the major crop in Orissa. We studied the following rice-based cropping at the Bhubaneswar Research Farm in 1981-82:

1. rice (Annapurna) — rice (Jagannath) — rice (Jaya),
2. rice (Annapurna) — groundnut (*Arachis hypogaea,* variety AK12-24) – ragi (*Eleusine coracana,* variety Dibyasingh),
3. rice (Jaya) — potato (*Solanum tuberosum,* variety Kufri Sinduri) — sesamum (*Sesamum indicum,* variety B67),
4. rice (Annapurna) — maize (*Zea mays,* variety Jawahar composite) — cowpea (*Vigna sinensis,* variety SEB2),
5. jute (*Corchorus* sp., variety JRC212) — rice (Jagannath) — groundnut (AK12-24), and
6. rice (Jaya) — knolkhol (*Brassica oleracea,* variety Caulorapa) — lady's finger (*Abelmoschus esculantus,* variety Pusa Sawani).

Annapurna was drilled and Jaya was transplanted. There are three crop seasons: kharif (Jul-Oct), rabi (Nov-Feb), and summer (Mar-Jun). In 1981-82 rainfall was 1,120 mm in kharif, 51 mm in rabi, and 306 mm in summer. Kharif rice and jute were rainfed and the rabi and summer crops received irrigation when necessary.

Of the cropping patterns evaluated, jute - rice - groundnut used the max-

Duration, grain yield, and total dry matter production of crop patterns in Orissa, India.

Cropping pattern no.	Crop	Duration (d)	Yield (t/ha)						Total dry wt (t/ha)
			Grain	Straw	Others[a]				
					Edible		Nonedible		
					F	D	F	D	
1	Rice	70	2.9	4.5	–	–	–	–	7.4
	Rice	98	3.9	5.0	–	–	–	–	8.9
	Rice	115	4.6	6.9	–	–	–	–	11.5
	Total	283	11.4	16.4	–	–	–	–	27.8
2	Rice	110	4.3	6.1	–	–	–	–	10.4
	Groundnut	120	–	–	–	2.6	8.2	2.3	4.9
	Ragi	85	2.4	3.5	–	–	–	–	5.9
	Total	315	6.7	9.6	–	2.6	8.2	2.3	21.2
3	Rice	110	4.6	6.8	–	–	–	–	11.4
	Potato	110	–	–	16.8	3.1	15.1	2.5	5.6
	Sesamum	95	0.8	1.6	–	–	4.5	2.1	4.5
	Total	315	5.4	8.4	16.8	3.1	19.6	4.6	21.5
4	Rice	110	4.5	6.7	–	–	–	–	11.2
	Maize	95	3.8	–	–	–	–	5.0	8.8
	Cowpea	80	–	–	3.6	0.5	4.4	0.8	1.3
	Total	285	8.3	6.7	3.6	0.5	4.4	5.8	21.3
5	Jute	132	–	–	–	–	–	3.0 F[a] 4.5 S[b]	7.5
	Rice	100	3.7	5.5	–	–	–	–	9.2
	Groundnut	120	–	–	–	2.5	–	3.1	5.6
	Total	352	3.1	5.5	–	2.5	–	10.6	22.3
6	Rice	110	4.5	6.6	–	–	–	–	11.1
	Knolkhol	60	–	–	8.3	1.1	5.0	0.8	1.9
	Lady's finger	70	–	–	4.1	0.6	6.7	2.0	2.6
	Total	240	4.5	6.6	13.0	1.7	11.7	2.8	15.6
	CD (0.05)								0.68

[a]F = fiber, D = dry matter. [b]S = sticks.

imum (352) cropped days/year (see table). Rice – rice – rice used 283 days, and rice plus 2 vegetable crops (rice – knolkhol – lady's finger) used 240 days.

Three rice crops produced maximum grain yield (11 t/ha) followed by rice – maize – cowpea, with 8.3 t grain/ha. Rice – rice – rice yielded significantly more dry matter, followed by jute – rice – groundnut. Rice – knolkhol – lady's finger yielded the least dry matter.

Results indicate that three sequential rice crops give highest grain yield, and that rice – maize – cowpea can be grown to obtain reasonable grain yields with more efficient soil and water management. □

Water table depths and dynamics aid interpretation of drought-prone rainfed lowland rice variety trials

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During the 1980 to 1982 wet seasons, we assessed the effects of water table depth in 11 environments in the Philippines on grain yield of elite and advanced breeding materials of the Rainfed Lowland Yield Trial for Drought-Prone Areas.

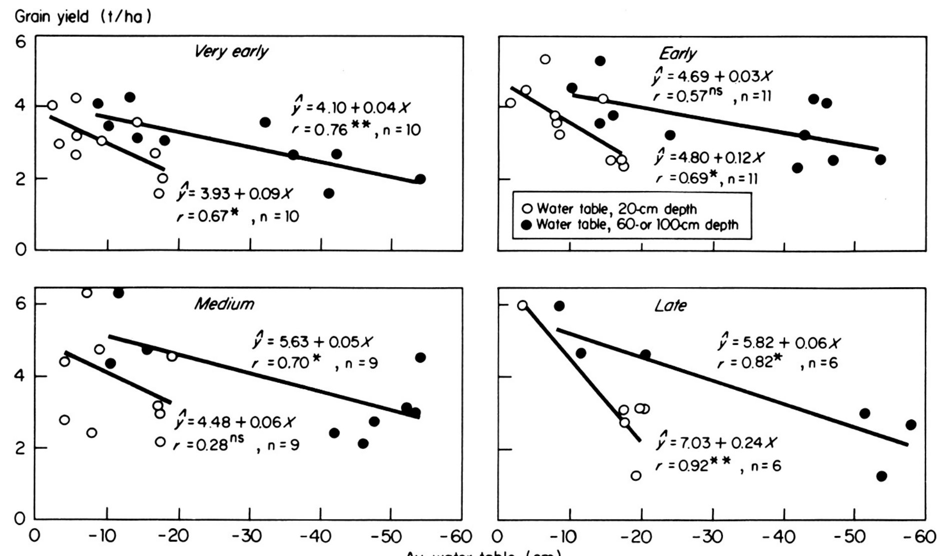
Polyvinylchloride tubes placed in the field to a depth of 20 cm and 60 or 100 cm were observation wells for measuring the water table depth. Average water table depth (AWD) during the yield-determining reproductive and grain-filling stages was calculated by summing the daily values from panicle initiation to 10 d before harvest. Plants are most sensitive to water stress at these stages. Water table depth was summed individually for each maturity class: very early (<105 d), early (105-115 d), medium (115-130 d), and late (>130 d).

Figure 1 shows the relationship of average water table depth and grain yield for each maturity group. Each point is an average of the two highest yielding varieties or lines for each location. By using the highest yielding entries we hoped to negate the effects of other biological and physical-chemical factors that determine growth and yield, and thus focus on the role of subsurface water in rainfed wetland culture.

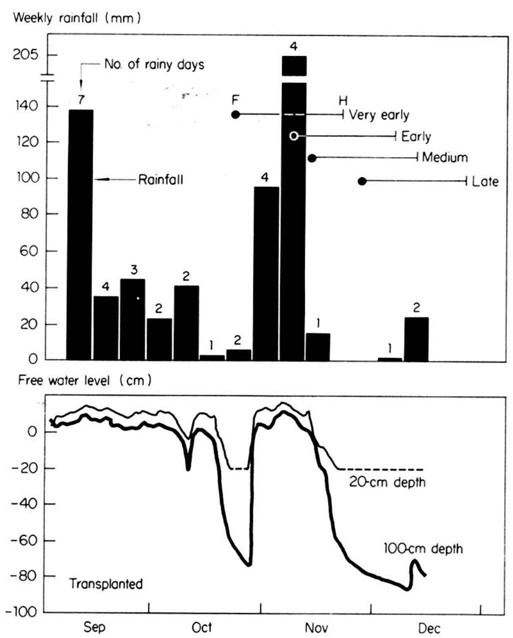
There was a significant correlation for all but the medium-maturity entries in the shallow water table.

In the deeper water table, correlation was significant for all but the early maturing group. Grain yield generally decreased as water table depth decreased regardless of maturity group.

At some sites where water table depth during the crop season was very low, we obtained high grain yield. This might have



1. Relationship between grain yield of the 2 highest yielding entries at each location and average water table depth in the root zone above the hardpan (0 to 20 cm) and below the paddy (0 to 60 or 100 cm) soil surface. The average water table depths were summed from 30 d before flowering to 20 days after flowering based on mean flowering date of each maturity group.



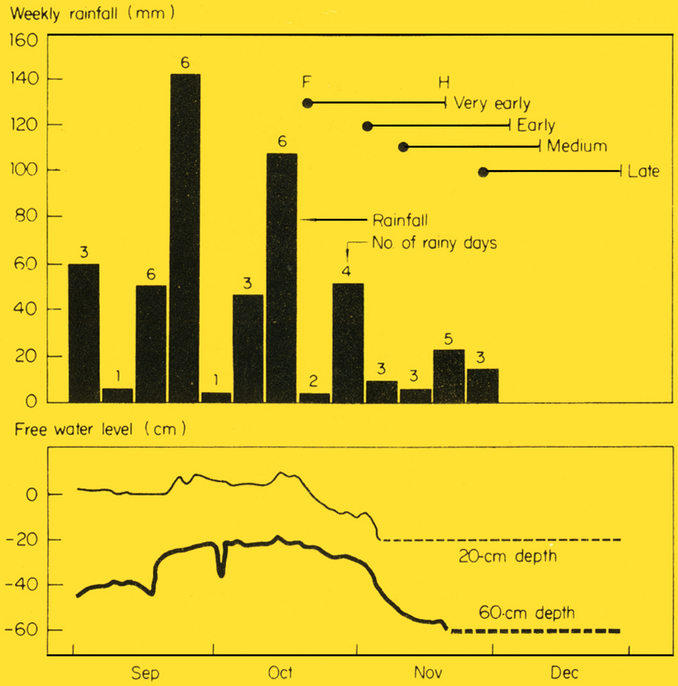
2. Water level in paddy (piezometer at 20 cm) and below the paddy (piezometer at 60 cm), and rainfall at Oton, Iloilo, Philippines, 1981 wet season.

been caused by adequate amount and distribution of rainfall, and not total rainfall. For example, at Iloilo in 1981 wet season (Fig. 2), rainfall was well distributed from 10 d before flowering to 20 d after flowering, with a total rainfall of 154 mm for the early-maturing group and a mean grain yield of 3.9 t/ha.

At Guimba in 1980 wet season, rainfall was high (347 mm) during the same growth stages but mean grain yield was low, 2.1 t/ha, because of a short-term water deficit after flowering in mid-Oct (Fig. 3).

Our results suggest that recording of water table depths within and below the rice field can be a useful indicator of field level hydrology. When used in tandem with meteorological data, especially rainfall, these easily measured parameters allow interpretation of crop water stress at remote sites. They are not only currently practical methods for use in large variety trials where conventional soil or plant water status measurement techniques are impossible. The daily nature of these hydrological values allows interpretation of yield response to water stress for each growth stage of the rice crop.

Although numerous other biological, physical, and chemical factors contribute to site-specific stresses that determine yield, recording field hydrological conditions aids significantly in interpreting differences in nursery performance over years and locations. □



3. Water level in paddy (piezometer at 20 cm) and below the paddy (piezometer at 100 cm), and rainfall in Guimba, Nueva Ecija, Philippines, 1980 wet season.

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